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PURDU-WINCOF — A Computer Code for Establishing the Performance of a Fan- Compressor Unit with Water Ingestion

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16. Abstract A model for predicting the performance of a multi-spool axial-flow compressor with a fan during operation with water ingestion has been developed incorporating several two-phase fluid flow effects as follows: (i) ingestion of water, (ii) droplet interaction with blades and resulting changes in blade characteristics, (iii) redistribution of water and water vapor due to centrifugal action, (iv) heat and mass transfer processes and (v) droplet size adjustment due to mass transfer and mechanical stability considerations. A computer program, called the PURDU-WINCOF code, has been generated based on the model utilizing a one-dimensional formulation. An illustrative case serves to show the manner in which the code can be utilized and the nature of the results obtained.			
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NOMENCLATURE

A	compressor flow area
A_p	droplet project area
a	acoustic speed
C_D	drag coefficient
C_{Df}	drag coefficient corresponding to loss due to water film formed on blade surface
C_{Dr}	drag coefficient corresponding to loss due to rough film surface of water on blade surface
C_w	water vapor concentration
C_{wb}	water vapor concentration at droplet surface
c	blade chord length
c_p	specific heat at constant pressure
c_w	specific heat of water
c_s	humid heat for air-water mixture
D	droplet diameter
D_d	droplet diameter
D_v	diffusivity
D_{eq}	equivalent diffusion ratio
D_{eq}^*	equivalent diffusion ratio at minimum loss point
d_{max}	largest stable droplet diameter
g_c	Newton constant relating force and mass
HPC	high pressure compressor
h_h	heat transfer coefficient

h_m	mass transfer coefficient
i	incidence angle
i^*	incidence angle at minimum loss point
J	constant relating heat and work
K_a	thermal conductivity of air
K_d	thermal conductivity of gaseous film surrounding an evaporating droplet
K_v	thermal conductivity of water vapor
k	thermal conductivity
k_g	thermal conductivity of gaseous phase
LPC	low pressure compressor
M	absolute Mach number
M_a	assumed value of Mach number
M_r	relative Mach number
M_c	calculated value of Mach number
\dot{m}	mass flow rate
\dot{m}_{film}	mass flow rate of water film formed on blade surface
mw	molecular weight
N	rotor rotational speed
N_d	number of droplet
Nu	Nusselt number
P_{01}	total pressure at rotor inlet
P_{02}	total pressure at rotor outlet
P_{03}	total pressure at stator outlet
$P_{01,r}$	relative total pressure at rotor outlet
$P_{02,r}$	relative total pressure at rotor outlet
$P_{02,ri}$	ideal relative total pressure at rotor outlet

PR	pressure ratio
Pr	Prandtl number
P_{ref}	reference pressure
P_1	static pressure at rotor inlet
P_2	static pressure at rotor outlet
P_3	static pressure at stator outlet
R	gas constant
Re	reynolds number
r	radius
s	pitch
Sc	Schmidt number
Sh	Sherwood number
SN	stability number
T	static temperature
T_o	total temperature
T_{ref}	reference temperature
$T_{o1,r}$	relative total temperature at rotor inlet
$T_{o2,r}$	relative total temperature at rotor outlet
TR	temperature ratio
U_{tip}	blade tip speed
U	blade speed
V_z	axial velocity
V	absolute velocity
V_θ	tangential component of absolute velocity
V_{film}	velocity of film formed on blade surface
W	relative velocity

W_{θ}	tangential component of relative velocity
We	Weber number
x_g	mass fraction of gas phase
x_w	mass fraction of liquid phase

Greek Letters

α	absolute flow angle
β	relative flow angle
β	bypass ratio
γ	specific heat ratio
η	adiabatic efficiency
ΔH_v	latent heat of vaporization
ΔH_0	rise in total enthalpy
ΔT_0	rise in total temperature
ΔT_g	rise in overall temperature of gaseous phase
$(\Delta T_g)_{ht}$	drop in temperature of gaseous phase due to heat transfer
$(\Delta T_g)_{wk}$	rise in temperature of gaseous phase due to work done
ΔT_w	rise in overall temperature of droplet
$(\Delta T_w)_{ht}$	rise in temperature of droplet due to heat transfer
$(\Delta T_w)_{wk}$	rise in temperature of droplet due to work done
δ	deviation angle
δ	boundary layer displacement thickness
δ	corrected pressure ($\delta=p/p_{ref}$)
θ	boundary layer momentum thickness
θ	corrected temperature ($\theta=T/T_{ref}$)
μ	viscosity
ρ	density

σ	surface tension of droplet
σ	solidity
σ	particulate liquid volume fraction
τ	equivalent temperature ratio
ϕ	flow coefficient
ψ	equivalent pressure ratio
ω	rotor angular velocity
$\bar{\omega}$	total pressure loss coefficient
$\bar{\omega}_{g,R}$	total pressure loss coefficient across rotor due to gas phase
$\bar{\omega}_{g,S}$	total pressure loss coefficient across stator due to gas phase
$\bar{\omega}_{\theta,R}$	total pressure loss coefficient due to the increase of momentum thickness because of the existence of small droplets in the boundary layer over a rotor blade surface
$\bar{\omega}_{\theta,S}$	total pressure loss coefficient due to the increase of momentum thickness because of the existence of small droplets in the boundary layer over a stator blade surface
$\bar{\omega}_{f,R}$	total pressure loss coefficient due to the momentum gained by thick water film moving over a rotor blade surface
$\bar{\omega}_{f,S}$	total pressure loss coefficient due to the momentum gained by thick water film moving over a stator blade surface
$\bar{\omega}_{r,R}$	total pressure loss coefficient due to turbulent flow of mixture over the rough film surface of rotor blade
$\bar{\omega}_{r,S}$	total pressure loss coefficient due to turbulent flow of mixture over the rough film surface of stator blade
$\bar{\omega}_{s,R}$	total pressure loss coefficient due to the Stokesian drag of droplets in rotor passage
$\bar{\omega}_{s,S}$	total pressure loss coefficient due to the Stokesian drag of droplets in stator passage

Subscripts

a	pertaining to assumed value
c	pertaining to calculated value
D	pertaining to design point
g	pertaining to gas phase
i	pertaining to ideal process
l	pertaining to liquid phase
m	pertaining to mixture
r	pertaining to relative value with respect to rotor
ref	pertaining to reference value
R	pertaining to rotor
S	pertaining to stator
w	pertaining to water droplet
0	pertaining to stagnation value
1	pertaining to rotor inlet
2	pertaining to rotor outlet
3	pertaining to stator outlet

Superscripts

*	pertaining to minimum loss point
-	pertaining to average value

SUMMARY

A model for predicting the performance of a multi-spool axial-flow compressor with a fan during operation with water ingestion has been developed incorporating several two-phase fluid flow effects as follows: (i) ingestion of water, (ii) droplet interaction with blades and resulting changes in blade characteristics, (iii) redistribution of water and water vapor due to centrifugal action, (iv) heat and mass transfer processes and (v) droplet size adjustment due to mass transfer and mechanical stability considerations. A computer program, called the PURDU-WINCOF code, has been generated based on the model utilizing a one-dimensional formulation. An illustrative case serves to show the manner in which the code can be utilized and the nature of the results obtained.

CHAPTER I

INTRODUCTION

Water ingestion into axial flow compressors that have been designed originally for operation with air flow causes considerable changes in performance compared with the performance obtained with air flow (References 1-8). These changes affect the performance, operation and control of an aircraft gas turbine engine when the compressor is part of such an engine (Reference 9).

A model for the prediction of performance of axial-flow compressors has been generated (References 3 and 4) which incorporates the following two-phase flow-associated processes:

- (i) ingestion of water;
- (ii) droplet interaction with blades and resulting changes in blade characteristics
- (iii) redistribution of water and water vapor due to centrifugal action;
- (iv) heat and mass transfer processes; and
- (v) droplet size adjustment due to mass transfer and mechanical stability considerations.

A numerical-computational program for prediction of compressor performance has been generated, called the PURDU-WICSTK program (Reference 4). It is applicable to a (single spool) compressor with a constant mass flow between the inlet and outlet sections of the unit.

It is of interest to generate a similar numerical-computational procedure for use in the case of a multi-spool compressor with a fan. In this case, the spools generally operate at different speeds and the mass flow in the compressor stages (low pressure compressor, the LPC, and high pressure compressor, the HPC) differs from the mass flow at inlet to the fan depending upon the bypass ratio employed. A computer code

has been designed for this purpose, namely the PURDU-WINCOF code, and the current report is devoted to a description of that code.

1.1 Compressor Utilized for Illustrating the Use of the PURDU-WINCOF Code

In order to illustrate the manner in which the PURDU-WINCOF code can be utilized, a typical fan-compressor unit has been chosen. Details regarding the unit are provided in Appendix 1 to this report.

1.2 Outline of the Report

A brief description of the PURDU-WINCOF program is provided in Chapter II. The subroutines and external functions of the code are listed in Chapter III. Chapters IV and V provide the details of the input data and the output, respectively. The method of calculation and the nature of the results are illustrated by means of a test case in Chapter VI.

CHAPTER II

OVERALL PROGRAM DESCRIPTION

The PURDU-WINCOF program for the prediction of performance of a fan-compressor unit with water injection is based on the PURDU-WICSTK program (Reference 4) generated for use with a (single spool) constant (mixture) mass flow compressor.

Following a brief description of the PURDU-WICSTK program (Section 2.1), the major modifications introduced in the PURDU-WINCOF program are presented (Section 2.2).

2.1 The PURDU-WICSTK Code

The one-dimensional flow equations for two phase flow in axial compressors have been derived in detail and presented in Reference 3. Those equations are suitable for the calculation of performance of any chosen section along the span of an axial compressor blade row. The PURDU-WICSTK code is based on those equations. For given initial conditions at the entry to a stage, the outlet conditions can be calculated using those equations.

The PURDU-WICSTK code deals with a fluid that may consist of (a) a mixture of three different gases and (b) a mixture of two types of water droplets, distinguished by size. The mixture of gases may consist of air and water vapor along with another gas when necessary. The water droplets may be either "small" or "large" diameter droplets or a mixture of small and large droplets. Small droplets are defined as those that follow the gas flow path and hence absorb work input into the compressor along with the gaseous phase. Large droplets are assumed to move largely independently of the gas phase, with equal probability of motion in all directions, and without absorbing work input but introducing drag losses.

Currently one can only choose the sizes for small and large droplets in an arbitrary fashion; for example if small droplets are assumed to be of mean diameter equal to 10 μm ; large droplets may be assigned a mean size of about 1,000 μm in diameter. In a general two-phase mixture that may become the working fluid in a compressor, the proportion of various constituents, namely; different gases (e.g. air and water vapor) and two types of droplets may be chosen as desired in the initial conditions assumed for a calculation. Thus, to consider humid air carrying large droplets, the content of small droplets is set equal to zero while water vapor content is related to humidity.

The performance of a stage of a compressor is based in the PURDU-WICSTK code on five physical models as follows:

- (i) model for the calculation of stage performance with respect to the gaseous phase and water droplets;
- (ii) model for droplet motion across a blade row from a chosen upstream location to a designated downstream location;
- (iii) model for centrifuging of water droplets;
- (iv) model for heat and mass transfer processes between the two phases; and
- (v) model for droplet break-up and equilibrium with respect to size.

The foregoing five models have been described in detail in References 3 and 4. A further description is included in Appendix 2 of this report regarding the models for the calculation of stage performance with respect to gaseous phase and the air-water droplet mixture.

The performance of a stage is calculated for given initial and operating conditions including the state of the air-water droplet mixture. Regarding droplets, any fraction of their total number may be taken into account depending upon assumptions relating to droplet impingement and rebound processes. Then, at the exit of a blade row, the three major processes, namely (i) centrifugal action on droplets, (ii) heat and mass transfer processes between the two phases and (iii) droplet size adjustment, are taken into account. When the stage performance parameters are "corrected" for the afore-mentioned three processes, one

obtains the final outlet conditions from a stage. The outlet conditions from a stage are modified to account for the geometry of compressor in order to obtain the initial conditions for the next stage, where such exists. Calculations are repeated for subsequent stages based on the well-known concept of stage-stacking. The Code can be used to predict the design point performance as well as off-design performance of a multi-stage compressor.

2.2 Modifications Introduced in the PURDU-WINCOF Code

In the fan-compressor unit, with two spools operating at speeds N_1 and N_2 and with a bypass ratio of β the five streamtubes illustrated in Figure 2.1, represent the five typical streamtubes along which it is of interest to establish the fan-compressor performance.

In the one-dimensional formulation adopted in the PURDU-WICSTK and also the PURDU-WINCOF codes, the streamtubes along which the calculations are desired to be performed have to be pre-located in the unit; and their area changes along the flow path have also to be specified on an appropriate basis. Regarding the latter, in most cases, the variation of annulus area of the machine is known at least corresponding to the design point conditions and this variation of area along the flow path may have to be assumed as applicable under off-design conditions. The extent of the resulting errors that arise on account of such assumptions depends upon the nature of the stage aerodynamic characteristics.

The major modifications introduced in the PURDU-WINCOF code consist of the following changes from one stage to the next:

- (i) modification for speed changes and
- (ii) modification for mass flow changes.

2.2.1 Modification for Speed

The operational speeds can be specified by the following input parameters:

- FND: rotor rotational speed in Fan
- FNDLPC: rotor rotational speed in LPC
- FNDHPC: Rotor rotational speed in HPC

NSF: number of stages in Fan

NSLPC: number of stages in LPC

NSHPC: number of stages in HPC

Utilizing those parameters, the operational speed can be set at the desired value for the next stage as follows:

(i) Rotor speed = FND when

$$1 \leq \text{stage} \leq \text{NSF}$$

(ii) Rotor speed = FNDLPC when

$$(\text{NSF} + 1) \leq \text{stage} \leq (\text{NSF} + \text{NSLPC})$$

(iii) Rotor speed = FNDHPC when

$$(\text{NSF} + \text{NSLPC} + 1) \leq \text{stage} \leq (\text{NSF} + \text{NSLPC} + \text{NSHPC})$$

2.2.2 Modification for Mass Flow Change

The mass flow rate can be altered at the entry to the next stage. In particular at the entry to the low pressure compressor following the fan stages, the mass flow into the low pressure compressor can be adjusted by utilizing the specified value of bypass ratio, β , as follows:

$$\dot{m}_C = \dot{m}_F / (1 + \beta)$$

where \dot{m}_C and \dot{m}_F represent the mass flow rate in the fan part and compressor part, respectively.

CHAPTER III

SUBROUTINES AND EXTERNAL FUNCTIONS

There are 22 subroutines and 13 external functions in this program. The following is the list of subroutines and external functions. Only brief descriptions of these subprograms are given here. A more detailed description of each subprogram is presented in Appendix 3.

Subroutine WICSPB: calculation of stage performance based on the analytical/correlation method for small droplet.

Subroutine WICSPC: calculation of stage performance based on the analytical/correlation method for large droplet.

Subroutine WICSPD: calculation of design point performance.

Subroutine WICGSL: calculation of single-phase (gas) flow loss.

Subroutine WICSDL: calculation of loss for small droplets on account of the change in momentum thickness of boundary layer due to the presence of such droplets.

Subroutine WICSTL: calculation of loss due to Stokesian drag of droplets in the free stream of blade passage.

Subroutine WICFML: calculation of loss due to film formed on blade surface when large droplets are present either by themselves or along with small droplets.

Subroutine WICRSL: calculation of loss due to the rough surface when large droplets are present either by themselves or along with small droplets.

Subroutine WICCEN: calculation of swanwise replacement of droplets due to centrifugal action.

Subroutine WICDMS: calculation of amount of small droplets which is centrifuged.

Subroutine WICDML: calculation of amount of large droplets which is centrifuged.

Subroutine WICDRG: calculation of drag force on droplet.

Subroutine WICMAC: calculation of Mach number.

Function WICASD: calculation of acoustics speed in two phase flow.

Function WICED: calculation of equivalent diffusion.

Function WICMTK: calculation of dimensionless momentum thickness.

Function WICLOS: calculation of total pressure loss coefficient.

Subroutine WICIRS: calculation of droplet impingement and rebound in rotor for small droplet.

Subroutine WICIRL: calculation of droplet impingement and rebound in rotor for large droplet.

Subroutine WICISS: calculation of droplet impingement and rebound in stator for small droplet.

Subroutine WICISL: calculation of droplet impingement and rebound in stator for large droplet.

Subroutine WICWAK: calculation of water reingestion into wake.

Subroutine WICHET: calculation of heat transfer between gaseous phase and droplets.

Subroutine WICMAS: calculation of mass transfer between gaseous phase and droplets.

Function WICMTR: calculation of mass transfer rate.

Function WICPWB: calculation of vapor pressure.

Function WICNEW: calculation of new trial value in the iterative procedure.

Function WICTAN: calculation of the value of tangent function.

Function WICBPT: calculation of boiling point.

Function WICSH: calculation of specific humidity.

Subroutine WICSIZ: calculation of nominal droplet size.

Subroutine WICPRP: calculation of flow properties for gaseous phase.

Function WICCPA: calculation of specific heat at constant pressure for air.

Function WICCPH: calculation of specific heat at constant pressure for vapor.

Function WICCPM: calculation of specific heat at constant pressure for methane.

CHAPTER IV

INPUT DATA

All input data that are needed to utilize the PURDU-WINCOF computer code are described in this section. The input data are presented in the same sequence as they are used in the program. Presently all input data must be in English units unless noted otherwise:

The following is a listing of the input data as they read in MAIN. Figures 4.1 and 4.2 show the geometry of a compressor stage and angles associated with a typical rotor blade element.

<u>Card No.</u>	<u>Input Data</u>	<u>Comment</u>	<u>Format</u>
1	NS	number of stages	I2
1	NSF	number of fan stages	I2
1	NSLPC	number of low pressure compressor stages	I2
1	NSHPC	number of high pressure compressor stages	I2
2	RRHUB(I)	hub radius at Ith stage rotor inlet. I = 1 ~ NS Unit: inch	F5.3
3	RC(I)	chord length of Ith stage rotor I = 1 ~ NS Unit: inch	F5.3
4	RBLADE(I)	number of blades for Ith stage rotor. I = 1 ~ NS	F5.2
5	STAGER(I)	stager angle for Ith stage rotor. I = 1 ~ NS Unit: degree	F5.2

<u>Card No.</u>	<u>Input Data</u>	<u>Comment</u>	<u>Format</u>
6	SRHUB(I)	hub radius at Ith stage stator inlet. I = 1 ~ NS, I = NS + 1 for IGV Unit: inch	F5.3
7	SC(I)	chord length of Ith stage stator. I = 1 ~ NS, I = NS + 1 for IGV Unit: inch	F5.3
8	SBLADE(I)	number of blades for Ith stage stator. I = 1 ~ NS, I = NS + 1 for IGV	F5.2
9	STAGES(I)	stager angle for Ith stage stator. I = 1 ~ NS, I = NS + 1 for IGV Unit: degree	F5.2
10	SIGUMR(I)	solidity of Ith stage rotor	F5.3
11	SIGUMS(I)	solidity of Ith stage stator I = 1 ~ NS, I = NS + 1 for IGV	F5.3
12	BET2SS(I)	stator outlet absolute flowangle at design pt. for Ith stage. I = 1 ~ NS, I = NS + 1 for IGV Unit: degree	F5.2
13	FNF	fraction of design corrected rotor speed for a particular speed	F8.2
14	XDIN	initial water content (mass fraction) of small droplets.	F5.3
14	ICENT	index for centrifugal calculation of small droplets. ICENT = 1 when XDIN = 0.0 otherwise ICENT = 2 ICENT = 3: no heat and mass transfer ICENT = 4: no centrifugal action ICENT = 5: no heat and mass transfer and no centrifugal action ICENT = 6: no mass transfer ICENT = 7: no mass transfer and no centrifugal action	I1
14	XDDIN	initial water content (mass fraction) of large droplets.	F5.3

<u>Card</u> <u>No.</u>	<u>Input</u> <u>Data</u>	<u>Comment</u>	<u>Format</u>
14	IICENT	index for centrifugal calculation of large droplets. IICENT = 1 when XDDIN = 0.0 otherwise IICENT = 2 IICENT = 3: no heat and mass transfer IICENT = 4: no centrifugal action IICENT = 5: no heat and mass transfer and no centrifugal action IICENT = 6: no mass transfer IICENT = 7: no mass transfer and no centrifugal action	I1
14	ICENTV	index for centrifugal calculation of water vapor ICENTV = 0: vapor is centrifuged ICENTV = 1: vapor is not centrifuged	I1
15	TOG	total temperature of gas phase at compressor inlet Unit: Rankine	F7.2
15	TOW	temperature of droplet at compressor inlet. Unit: Rankine	F7.2
15	PO	total pressure at compressor inlet. Unit: lbf/ft ²	F7.2
16	DIN	initial diameter of small droplets. Unit: μm	F6.1
16	DDIN	initial diameter of large droplets. Unit: μm	F6.1
17	FND	rotor corrected speed at design pt. Unit: RPM	F7.1
17	T01D	compressor inlet temperature at design pt. Unit: Rankine	F7.2
17	P01D	compressor inlet pressure at design pt. Unit: lbf/in ²	F7.2
17	FNDLPC	rotor corrected speed of LPC at design pt. Unit: RPM	F7.1

<u>Card No.</u>	<u>Input Data</u>	<u>Comment</u>	<u>Format</u>
17	FNDHPC	rotor corrected speed of HPC at design pt. Unit: RPM	F7.1
18	XCH4	initial methane content (mass fraction)	F5.3
18	RHUMID	initial relative humidity Unit: percent	F10.5
19	FMWA	molecular weight of air	F7.3
19	FMWV	molecular weight of steam	F7.3
19	FMWC	molecular weight of methane	F7.3
20	PREB	percent of water droplets that rebound after impingement on blade surface	F5.1
20	DLIMT	maximum diameter for small droplets Unit: μm	F7.1
21	GAPR(I)	gap between Ith stage rotor and (I - 1)th stage stator. I = 1 ~ NS Unit: inch	F7.5
22	GAPS(I)	gap between rotor blade and stator blade for Ith stage I = 1 ~ NS Unit: inch	F7.5
23	RRTIP(I)	blade tip radius at Ith stage rotor inlet. I = 1 ~ NS Unit: inch	F6.3
24	SRTIP(I)	blade tip radius at Ith stage stator inlet. I = 1 ~ NS, I = NS + 1 for IGV Unit: inch	F6.3
25	IRAD	index for radius at which calculation is carried out. IRAD = 1: performance at fan tip IRAD = 2: performance at HPC mean IRAD = 3: performance at hub IRAD = 4: performance at tip of HPC and LPC	I1

<u>Card No.</u>	<u>Input Data</u>	<u>Comment</u>	<u>Format</u>
26	RT(I)	rotor inlet radius at which tip performance calculation is carried out. I = 1 ~ NS Unit: inch	F5.3
27	RM(I)	rotor inlet radius at which mean line performance calculation is carried out. I = 1 ~ NS Unit: inch	F5.3
28	RH(I)	rotor inlet radius at which hub performance calculation is carried out. I = 1 ~ NS Unit: inch	F5.3
29	ST(I)	stator inlet radius at which tip performance calculation is carried out. I = 1 ~ NS Unit: inch	F5.3
30	SM(I)	stator inlet radius at which mean line performance calculation is carried out. I = 1 ~ NS Unit: inch	F5.3
31	SH(I)	stator inlet radius at which hub performance calculation is carried out. I = 1 ~ NS Unit: inch	F5.3
32	BLOCK(I)	blockage factor for Ith stage rotor. $0 < \text{BLOCK}(I) < 1$ I = 1 ~ NS	F5.3
33	BLOCKS(I)	blockage factor for Ith stage stator $0 < \text{BLOCKS}(I) < 1$ I = 1 ~ NS, I = NS + 1 for IGV	F5.3
34	IDESIN	index for output. IDESIN = 1: both stage and overall performance printed out IDESIN = 2: only overall performance is printed out	I1

<u>Card</u> <u>No.</u>	<u>Input</u> <u>Data</u>	<u>Comment</u>	<u>Format</u>
34	JCENT	index for centrifugal calculation. JCENT = 1: large droplets in rotor free stream are centrifuged in same manner as small droplets. JCENT = 2 (or any other integer): large droplets are taken to have random motion	I1
35	BET1MR(I)	blade metal angle at Ith stage rotor inlet. I = 1 ~ NS Unit: degree	F5.2
36	BET2MR(I)	blade metal angle at Ith stage rotor outlet. I = 1 ~ NS Unit: degree	F5.2
37	BET1MS(I)	blade metal angle at Ith stage stator inlet. I = 1 ~ NS, I = NS + 1 for IGV Unit: degree	F5.2
38	BET2MS(I)	blade metal angle at Ith stage stator outlet. I = 1 ~ NS, I = NS + 1 for IGV Unit: degree	F5.2
39	DSMASS	streamtube design mass flow for fan. Unit: lbm/s	F10.6
39	BYPASS	bypass ratio at design pt.	F10.6
40	PR12D(I)	total pressure ratio for the Ith stage rotor at design pt. I = 1 ~ NS	F5.3
41	PR13D(I)	total pressure ratio for Ith stage at design pt. I = 1 ~ NS	F5.3
42	ETARD(I)	adiabatic efficiency for Ith stage rotor. I = 1 ~ NS	F5.3

<u>Card</u> <u>No.</u>	<u>Input</u> <u>Data</u>	<u>Comment</u>	<u>Format</u>
43	SAREA(I)	stream tube area for Ith stage rotor inlet. I = 1 ~ NS Unit: ft ²	F10.7
44	SAREAS(I)	stream tube area for Ith stage stator inlet. I = 1 ~ NS, I = NS + 1 for IGV Unit: ft ²	F10.7
45	FAI	initial flow coefficient. The user can input as many FAI as one wants. However, each card must contain only one FAI and the last card must be 9.99999.	F7.5

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CHAPTER V

OUTPUT

There are two kinds of output in this program code: regular output and diagnostic output. The regular output consists of four parts as follows:

- (1) output of the inputted data;
- (2) output of design point performance;
- (3) output of stage performance; and
- (4) output of overall performance.

The user can choose the output by setting the value of the input data IDESIN to 1 or 2. By setting IDESIN equal to 1, the detailed output (output of (i) inputted data, (ii) design point performance, (iii) stage performance and (iv) overall performance) can be obtained. On the other hand, the user can obtain the simple output (output of (i) inputted data and (ii) overall performance) by setting IDESIN equal to 2.

5.1 Output of Inputted Data

All of the data inputted can be printed out at the beginning of output.

5.2 Output of Design Point Performance

5.2.1 Compressor Inlet (Design Point Performance)

At the compressor inlet, the following properties can be printed out for the design point performance:

- (1) total temperature at compressor inlet: (R)
- (2) total pressure at compressor inlet: (lbf/ft^2)

- (3) static temperature at compressor inlet: (R)
- (4) static pressure at compressor inlet: (lbf/ft²)
- (5) static density at compressor inlet: (lbm/ft³)
- (6) acoustic speed at compressor inlet: (ft/s)
- (7) axial velocity at compressor inlet: (ft/s)
- (8) Mach number at compressor inlet
- (9) stream tube area at compressor inlet: (ft²)
- (10) flow coefficient at compressor inlet

5.2.2 Stage Performance (Design Point Performance)

At the end of each stage, the following properties can be printed out for the design point performance:

- (1) total temperature: (R)
- (2) total pressure: (lbf/ft²)
- (3) static temperature: (R)
- (4) static pressure: (lbf/ft²)
- (5) static density: (lbm/ft³)
- (6) axial velocity: (ft/s)
- (7) absolute velocity: (ft/s)
- (8) relative velocity: (ft/s)
- (9) tangential component of absolute velocity: (ft/s)
- (10) tangential component of relative velocity: (ft/s)
- (11) rotor wheel speed: (ft/s)
- (12) absolute Mach number
- (13) relative Mach number
- (14) total temperature based on relative Mach number: (R)
- (15) total pressure based on relative Mach number: (lbf/ft²)
- (16) absolute flow angle: (degree)
- (17) relative flow angle: (degree)
- (18) stream tube area: (ft²)
- (19) radius at which calculation is carried out: (ft)
- (20) flow coefficient
- (21) stage total pressure ratio
- (22) stage adiabatic efficiency

- (23) rotor total pressure ratio
- (24) rotor adiabatic efficiency
- (25) stage total temperature ratio

5.2.3 Overall Performance (Design Point Performance)

After all of stage performance is printed out, the following properties can be printed out:

- (1) compressor inlet total temperature: (R)
- (2) compressor inlet total pressure: (lbf/ft²)
- (3) corrected mass flow rate: (lbm/s)
- (4) overall total pressure ratio
- (5) overall total temperature ratio
- (6) overall adiabatic efficiency
- (7) overall temperature rise: (F)
- (8) relative flow angle at rotor inlet: BET1SR(I) (degree)
- (9) relative flow angle at rotor outlet: BET2SR(I) (degree)
- (10) incidence for rotor: AINC SR(I) (degree)
- (11) deviation for rotor: ADEV SR(I) (degree)
- (12) absolute flow angle for stator inlet: BET1SS(I) (degree)
- (13) absolute flow angle for stator outlet: BET2SS(I) (degree)
- (14) incidence for stator: AINC SS(I) (degree)
- (15) deviation for stator: ADEV SS(I) (degree)
- (16) stage inlet temperature: TD(I) (R)
- (17) total pressure loss coefficient for stator: OMEGS(I)
- (18) total pressure loss coefficient for rotor: OMEGR(I)
- (19) momentum thickness for rotor: SITADR(I)
- (20) momentum thickness for stator: SITADS(I)
- (21) equivalent diffusion ratio for rotor: DEQR(I)
- (22) equivalent diffusion ratio for stator: DEQS(I)

5.3 Output of Stage Performance

The performance of a stage is calculated for given initial and operating conditions with respect to the gaseous phase and the water droplets. At the exit of a blade row, the four major processes associated with two phase flow, namely (a) droplet impingement process; (b) centrifugal

action on droplets; (c) heat and mass transfer processes between the two phases; and (d) droplet size adjustment; are taken into account. When the stage performance parameters are corrected for the afore-mentioned four processes, then one obtains the outlet conditions from a stage. The output of stage performance consist of two parts. First the following properties can be printed out before the afore-mentioned four processes are taken into account.

- (1) stage total pressure ratio
- (2) stage total temperature ratio
- (3) stage adiabatic efficiency
- (4) stage flow coefficient
- (5) axial velocity: (ft/sec)
- (6) rotor speed: (ft/sec)
- (7) total pressure: (lbf/ft²)
- (8) static pressure: (lbf/ft²)
- (9) total temperature of gas phase: (R)
- (10) static temperature of gas phase: (R)
- (11) static density of gas phase: (lbm/ft³)
- (12) static density of mixture: (lbm/ft³)
- (13) axial velocity: (ft/s)
- (14) absolute velocity: (ft/s)
- (15) relative velocity: (ft/s)
- (16) blade wheel speed: (ft/s)
- (17) tangential component of absolute velocity: (ft/s)
- (18) tangential component of relative velocity: (ft/s)
- (19) acoustic speed: (ft/sec)
- (20) absolute Mach number
- (21) relative Mach number
- (22) flow coefficient
- (23) stream tube area: (ft²)
- (24) absolute flow angle: (degree)
- (25) relative flow angle: (degree)
- (26) incidence: (degree)
- (27) deviation: (degree)

- (28) equivalent diffusion ratio
- (29) momentum thickness
- (30) pressure loss coefficient of gas only calculation
- (31) total pressure loss coefficient

After the stage parameters are corrected for the afore-mentioned four processes, the following second parts of output of stage performance can be printed out.

- (1) stage total pressure ratio
- (2) stage total temperature ratio
- (3) stage adiabatic efficiency
- (4) water vapor content: XV
- (5) water content of small droplet: XW
- (6) water content of large droplet: XWW
- (7) total water content: XWT
- (8) mass fraction of dry air: XAIR
- (9) mass fraction of methane: XMETAN
- (10) mass fraction of gaseous phase: XGAS
- (11) mass flow rate of small droplet: WMASS(lbm/s)
- (12) mass flow rate of large droplet: WWMASS(lbm/s)
- (13) total mass flow rate of droplet: WTMASS(lbm/s)
- (14) mass flow rate of dry air: AMASS(lbm/s)
- (15) mass flow rate of methane: CHMASS(lbm/s)
- (16) mass flow rate of water vapor: VMASS(lbm/s)
- (17) mass flow rate of gaseous phase: GMASS(lbm/s)
- (18) mass flow rate of mixture: TMASS(lbm/s)
- (19) specific humidity: WS
- (20) density of air: RHOA(lbm/ft³)
- (21) density of mixture: RHOM(lbm/ft³)
- (22) density of gaseous phase: RHOG(lbm/ft³)
- (23) temperature of gaseous phase: TG (R)
- (24) temperature of small droplet: TW (R)
- (25) temperature of large droplet: TWW (R)
- (26) pressure: P(lbf/ft²)
- (27) boiling point: TB (R)
- (28) dew point: TDEW (R)

5.4 Output of Overall Performance

At the end of compressor, the overall performance can be printed out according to the inputed value of IDESIN. If IDESIN=1, the properties to be printed out are as follows:

- (1) initial flow coefficient
- (2) corrected speed of compressor and fraction of design corrected speed
- (3) initial water content of small droplet
- (4) initial water content of large droplet
- (5) initial total water content
- (6) initial relative humidity
- (7) initial methane content
- (8) compressor inlet total temperature: (R)
- (9) compressor inlet total pressure: (lbf/ft²)
- (10) corrected mass flow rate of mixture: (lbm/s)
- (11) corrected mass flow rate of gaseous phase: (lbm/s)
- (12) overall total pressure ratio
- (13) overall total temperature ratio
- (14) overall adiabatic efficiency

After the foregoing overall performance is printed out, the performance of (i) fan, (ii) low pressure compressor (LPC) and (iii) high pressure compressor (HPC) can be printed out and provide the following:

- (1) gas phase corrected mass flow;
- (2) total pressure ratio;
- (3) total temperature ratio; and
- (4) adiabatic efficiency.

If IDESIN=2 the above is printed along with the following:

- (1) flow coefficient of stage: FAIO
- (2) stage
- (3) total pressure ratio of stage: PRATIO
- (4) total temperature ratio of stage: TRATIO
- (5) adiabatic efficiency of stage: ETA
- (6) water vapor content of stage: XV
- (7) water content of small droplet: XW

- (8) water content of large droplet: XWW
- (9) total water content: XWT
- (10) temperature of gaseous phase: TG (R)
- (11) temperature of water droplet: TW (R)

5.5 Diagnostic Printout

At the inlet of each stage, the flow coefficient is calculated. If the flow coefficient gives the value of equivalent pressure ratio which is less than 1.0 or the value of stage adiabatic efficiency which is less than 0.0, the following message will appear: "FAI IS TOO BIG OR TOO SMALL AT STAGE=." If this message appears, the computation for the particular initial flow coefficient will be terminated and the next initial flow coefficient will be read.

The iterative procedure is used to determine the Mach number. If the desired accuracy can not be obtained after 50 times of iteration, the following message will appear: "M DOES NOT CONVERGE AT STAGE=." If this message appears, the final value of Mach number will be used and computation will be continued.

When the axial velocity becomes either higher than local acoustic speed or negative, the following message will appear: "VZ IS TOO HIGH OF TOO LOW." If this message appears, the computation for the particular initial flow coefficient will be terminated and the next initial flow coefficient will be read.

CHAPTER VI

TEST CASE

An illustrative example of the use of the PURDU-WINCOF code is presented in this chapter. The fan-compressor unit employed is described in Appendix 1. The operating conditions under which the performance calculation has been carried out are presented in Table 6.1. The outputs obtained from calculations performed along the streamtube no. 4 in Figure 2.1 are presented in Appendix 5.

Table 6.1

Operating Conditions for Illustrative Examples

Parameter	Values
Corrected Speed	100% Design Speed
Inlet Temperature	518.7 R
Inlet Pressure	14.7 psi
Initial Droplet Diameter	20 μm , 600 μm
Humidity	0.00
Water Content	0.000 for Test Case No. 1 0.010 for Test Case No. 2 0.010 for Test Case No. 3 but, neglecting mass transfer and only printing overall compressor performance.
Flow Coefficient	0.350 for Test Case Nos. 1, 2 0.340 for Test Case No. 3

FIGURES

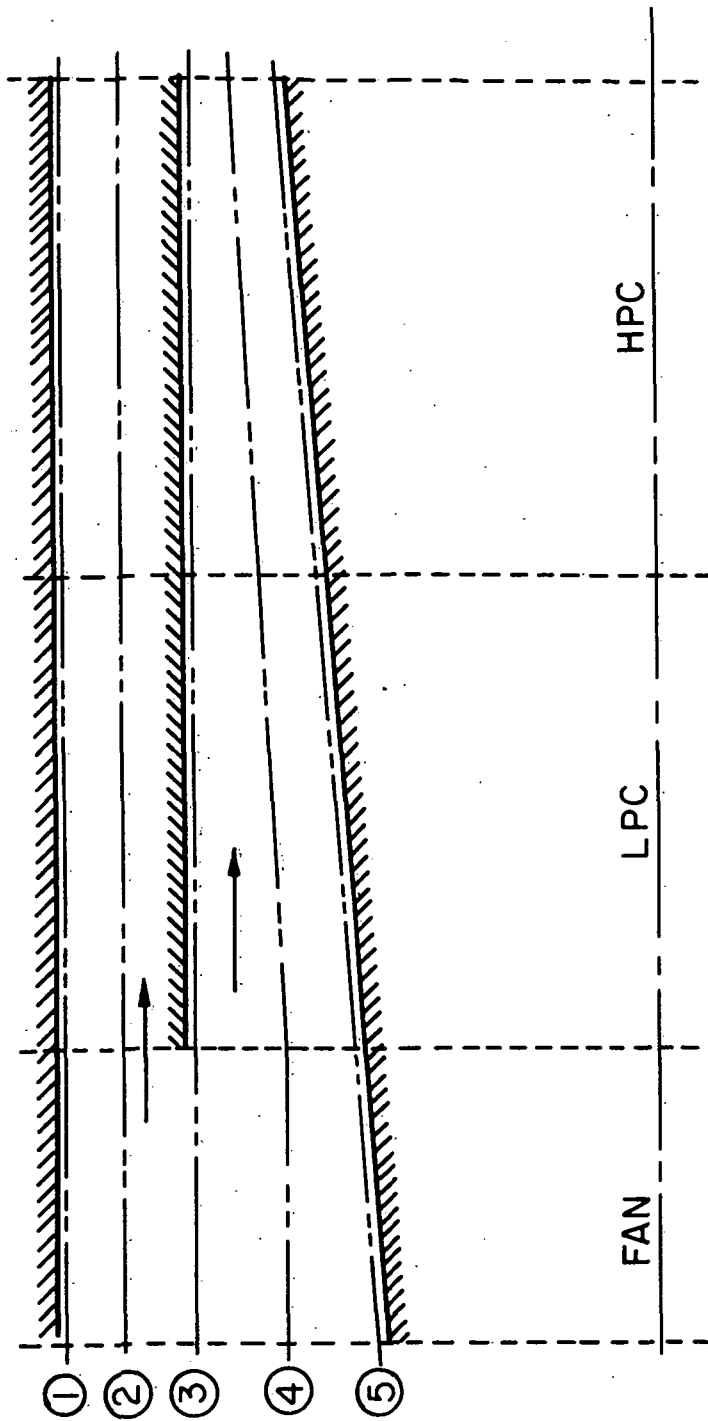


Fig. 2.1. Fan-Compressor Unit Streamtubes

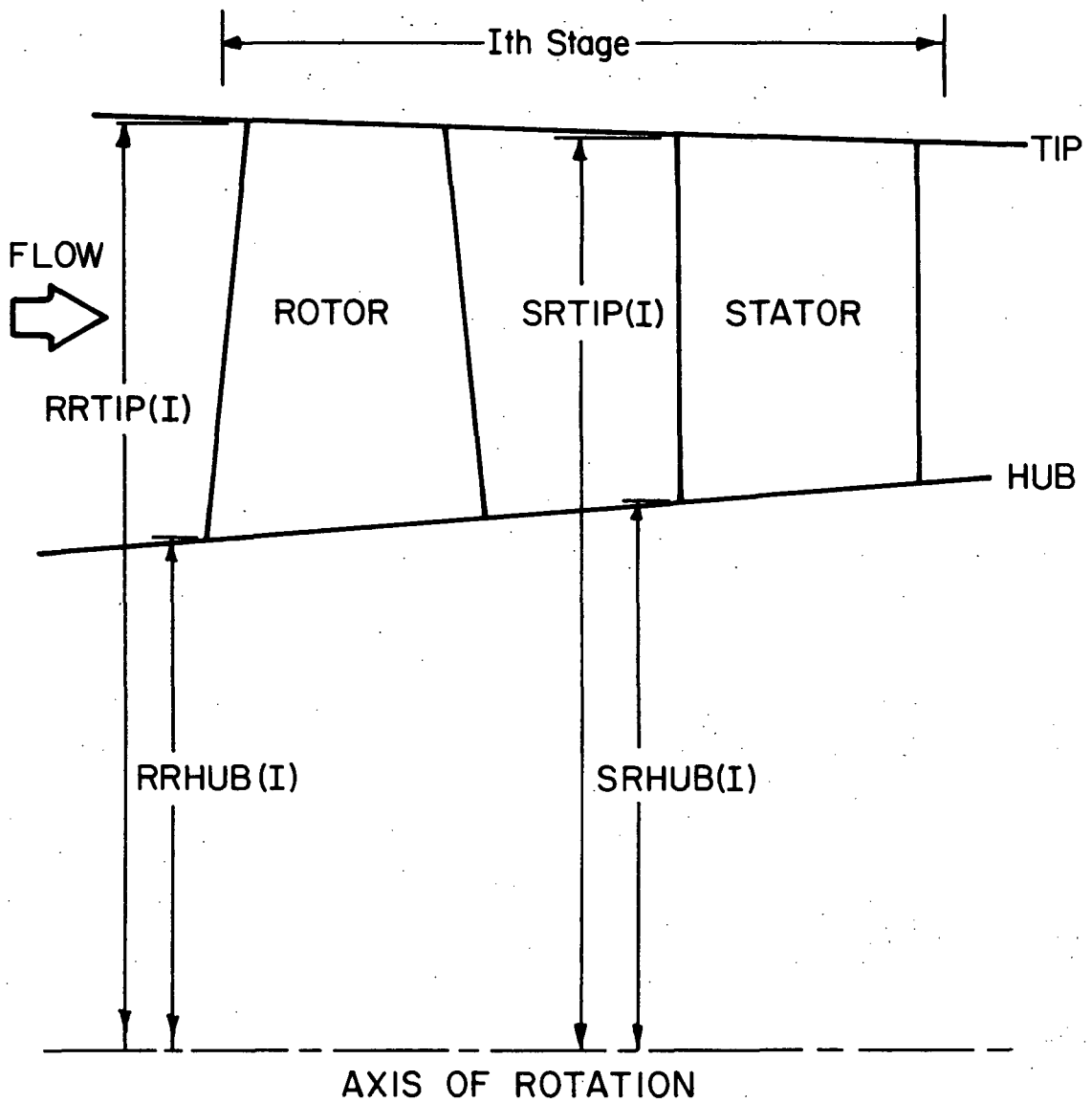
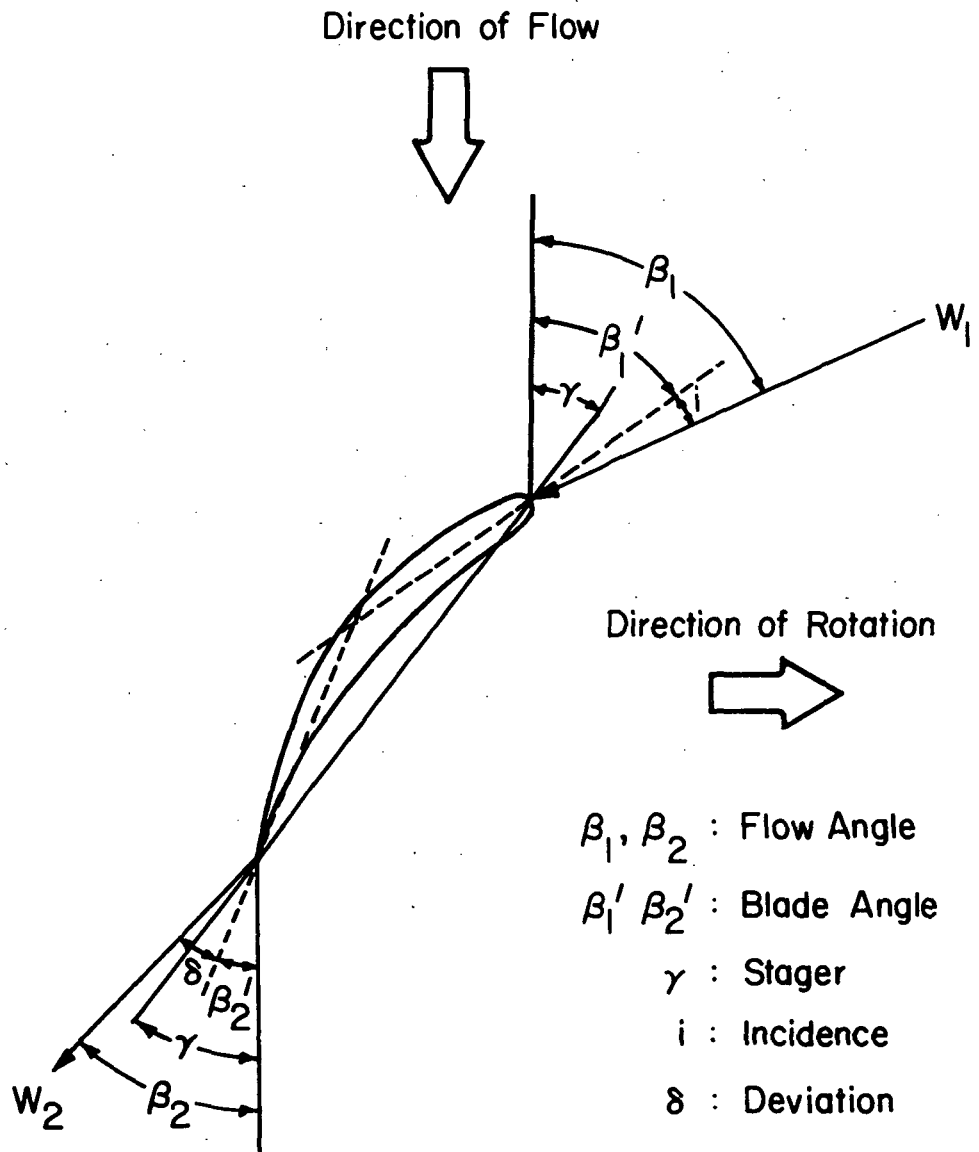


Fig. 4.1 Geometry of Compressor Stage



- β_1, β_2 : Flow Angle
- β_1', β_2' : Blade Angle
- γ : Stager
- i : Incidence
- δ : Deviation

Fig. 4.2 Angles Associated with a Typical Rotor Blade Element

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APPENDICES

APPENDIX 1

Fan-Compressor Unit

A fan-compressor unit with a fan, a low pressure compressor and a high pressure compressor has been chosen for the purpose of demonstrating the application of the PURDU-WINCOF Code. The overall design features for the unit are as follows.

Number of stages:	3 (Fan); 6 (LPC); and 7 (HPC)
Design speed:	9492.1 RPM (Fan and LPC) 14095.5 RPM (HPC)
Design mass flow:	255.0 lbm/sec
Design pressure ratio:	2.1948 (Fan); 2.6365 (LPC); and 2.9823 (HPC)

The basic design data are provided in Tables A.I.1 and A.I.2.

Table A.I.1

Fan-Compressor Unit Design Data

Stators

The values given pertain to the mean section of the LPC and the HPC.

FAN

Stage	Hub Radius	Number of Blades	Design absolute inlet flowangle (α_2^*)	Design absolute outlet flowangle (α_3^*)
IGV	6.220	60	0.00	6.69
1	6.650	60	37.07	6.21
2	6.965	60	36.40	-1.49
3	7.025	60	27.17	0.38

Note: r in inches and α in degrees

Table A.I.1 (continued)

LPC

Stage	Hub Radius	Number of Blades	Design Absolute inlet flowangle (α_2^*)	Design Absolute outlet flowangle (α_3^*)
4	7.025	60	26.78	8.86
5	7.025	60	26.38	1.41
6	7.025	60	32.68	6.55
7	7.025	60	28.41	5.24
8	7.025	60	37.70	16.23
9	7.130	60	36.82	16.50

Note: r in inches and α in degrees

Table A.I.1 (concluded)

HPC

Stage	Hub Radius	Number of Blades	Design absolute inlet flowangle (α_2^*)	Design absolute outlet flowangle (α_3^*)
10	7.449	60	36.41	22.78
11	7.674	60	41.62	24.28
12	7.873	60	42.63	25.79
13	8.053	60	41.94	23.93
14	8.201	60	44.03	20.90
15	8.311	60	38.84	16.87
16	8.378	60	40.40	3.03

Note: r in inches and α in degrees

Table A.I.2

Fan-Compressor Unit Design Data

Rotors

The values given pertain to the mean section of the LPC and the HPC.

FAN

Stage	Hub Radius	Number of Blades	Design relative inlet flowangle (β_1^*)	Design relative outlet flowangle (β_2^*)
1	6.300	60	52.88	40.40
2	6.830	60	55.61	42.36
3	7.020	60	56.07	37.73

Note: r in inches and β in degrees

Table A.I.2 (continued)

LPC

Stage	Hub Radius	Number of Blades	Design relative inlet flowangle (β_1^*)	Design relative outlet flowangle (β_2^*)
4	7.025	60	45.92	29.71
5	7.017	60	39.94	26.76
6	7.037	60	45.69	25.64
7	7.025	60	43.01	24.73
8	7.025	60	42.23	15.25
9	7.025	60	35.14	16.06

Note: r in inches and β in degrees

Table A.I.2 (concluded)

HPC

Stage	Hub Radius	Number of Blades	Design relative inlet flowangle (β_1^*)	Design relative outlet flowangle (β_2^*)
10	7.308	60	49.52	37.92
11	7.553	60	48.02	33.59
12	7.757	60	48.34	33.90
13	7.956	60	47.78	36.39
14	8.123	60	50.02	36.92
15	8.258	60	54.16	45.10
16	8.351	60	56.34	45.48

Note: r in inches and β in degrees

APPENDIX 2

STAGE PERFORMANCE CALCULATION

In the PURDU-WINCOF code, the calculation of stage performance is carried out through the estimation of work done and losses in a stage based on an analytical model. The stage performance calculation being discussed here pertains only to establishing the stage work done, and the consequent temperature and pressure rise, and the stage losses as they occur between the leading and trailing edges of a blade. The final exit conditions from a stage are established after correcting the stage outlet conditions for various two phase flow effects.

In calculating the stage performance, it is necessary to take into account the presence of droplets in the fluid, and their motion, particularly their impact on the blades. Such impaction leads to the formation of a film on the blade surface, composed of water from unrebounded droplets, and a change in the boundary layer and separation characteristics. Thus, the stage characteristics become different for a droplet-laden gas flow from those for a single phase gas. The change in stage characteristics arises through modification of (a) momentum thickness of boundary layer, (b) diffusion factor and (c) deviation angle.

It may be stated at the outset that no correlations of compressor, cascade or even single airfoil performance data are available for two phase flow. It is therefore necessary to model compressor flow based on a number of approximations, in turn related to physical process models.

In order to account for various drop sizes that may arise in a spray, it has been suggested that two classes of droplets be identified, one referred to as "small" and the other as "large." In adjusting droplet sizes for any reason, it is assumed that small droplets may only remain small, while large droplets may become small enough to belong to the small droplet class. From the point of view of blade passage flow, the

principal distinction between small and large droplets is, as has been mentioned earlier, that small droplets are sufficiently small and follow the gas phase streamlines/ but large droplets, which are in order of about 100 μm in diameter, are assumed to have equal probability of motion in all directions in the forward sector. In addition, it is assumed that only small droplets may absorb part of the work input. Other distinctions between the two classes of droplets arise from the foregoing and are taken into account in developing compressor flow models for the two classes of droplets.

In order to simplify calculations of stage losses, three procedures have been developed as follows:

- (1) procedure when the compressor operates with a single (gas) phase;
- (2) procedure when only small droplets are present; and
- (3) procedure when large droplets are present either by themselves or along with small droplets.

Typical velocity diagram for an axial compressor stage is presented in Fig. A.2.1.

A.2.1 Procedure of Gas Phase Operation

The stage performance calculation for gas phase operation is carried out using the analytical/correlation method based on References 10 and 11 as follows:

- (1) From given inlet conditions or the previous stage exit conditions, the total temperature, T_{01} , and total pressure, P_{01} , are obtained.
- (2) Calculate specific heat ratio corresponding to the temperature.
- (3) Calculate the stagnation density.

$$\rho_{01} = P_{01}/RT_{01}$$

- (4) Assume a value for Mach number, M_a .
- (5) Calculate the static density and temperature.

$$\rho_1 = \left\{ 1 + (\gamma-1)M_a^2/2 \right\}^{-1/(\gamma-1)} \rho_{01}$$

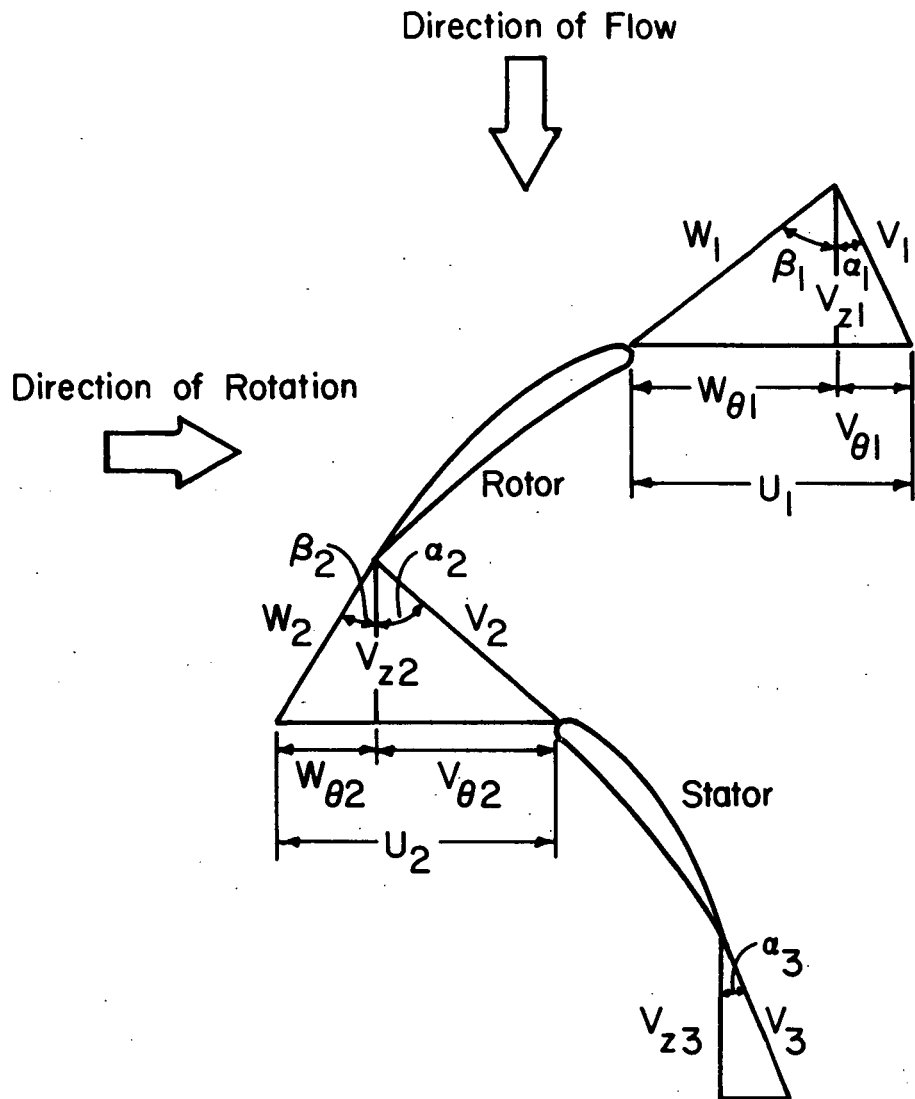


Fig. A.2.1 Typical Velocity Diagram for a Compressor Stage

$$T_1 = \left\{ 1 + (\gamma-1)M_a^2/2 \right\}^{-1} T_{01}$$

- (6) Calculate the acoustic speed.

$$a_1 = (\gamma R T_1 g_c)^{0.5}$$

- (7) Calculate the axial velocity.

$$V_{z1} = \dot{m} / \rho_1 A_1$$

- (8) Calculate the absolute velocity.

$$V_1 = V_{z1} / \cos \alpha_1$$

- (9) Calculate the Mach number, M_c .

$$M_c = V_{z1} / a_1$$

- (10) Compare the assumed value of Mach number, M_a , with the calculated one, M_c . If M_a agrees within prescribed limits with M_c , proceed to the next step. Otherwise, steps (4) to (9) must be repeated.

- (11) Calculate the components of velocity from the velocity diagram at rotor inlet as follows:

$$V_1 = V_{z1} / \cos \alpha_1$$

$$V_{\theta 1} = V_{z1} \tan \alpha_1$$

$$W_{\theta 1} = U_1 - V_{\theta 1}$$

$$W_1 = (V_{z1}^2 + W_{\theta 1}^2)^{0.5}$$

$$\beta_1 = \tan^{-1}(W_{\theta 1} / V_{z1})$$

- (12) Calculate relative Mach number at rotor inlet.

$$M_{r1} = W_1 / a_1$$

- (13) Calculate static pressure at rotor inlet.

$$p_1 = \left\{ (T_{01}/T_1) \right\}^{-\gamma/(\gamma-1)} \cdot P_{01}$$

- (14) Calculate total pressure at rotor inlet based on the relative Mach number, M_r .

$$P_{01,r} = 1 + (\gamma-1)M_{r1}^2/2 \quad \gamma/(\gamma-1) \cdot P_1$$

- (15) Assume V_{z2} to calculate the total pressure loss coefficient across rotor and rotor outlet flow angle.

- (16) Calculate the components of velocity at rotor outlet as follows:

$$W_{\theta 2} = V_{z2} \tan \beta_2$$

where β_2 is an input value at the design point, or is calculated according to the procedure given in Appendix 3, Subroutine WICGSL.

$$V_{\theta 2} = U_2 - W_{\theta 2}$$

$$W_2 = (V_{z2}^2 + W_{\theta 2}^2)^{0.5}$$

$$V_2 = (V_{z2}^2 + V_{\theta 2}^2)^{0.5}$$

$$\alpha_2 = \tan^{-1}(V_{\theta 2}/V_{z2})$$

- (17) Calculate the total temperature at rotor outlet.

$$T_{02} = T_{01} + (U_2 V_{\theta 2} - U_1 V_{\theta 1})/c_p g_c J$$

- (18) Calculate static temperature at rotor outlet.

$$T_2 = T_{02} - V_2^2/2c_p g_c J$$

- (19) Calculate acoustic speed at rotor outlet.

$$a_2 = (\gamma R T_2 g_c)^{0.5}$$

(20) Calculate absolute and relative Mach number at rotor outlet.

$$M_2 = v_2/a_2$$

$$M_{r2} = w_2/a_2$$

(21) Calculate total pressure loss factor across rotor.

$$\frac{P_{02,r}}{P_{01,r}} = \frac{P_{02,ri}}{P_{01,r}} - \omega_R \left(1 - \frac{P_{1,r}}{P_{01,r}} \right)$$

where

$$\begin{aligned} \frac{P_{02,ri}}{P_{01,r}} &= \left(\frac{T_{02,r}}{T_{01,r}} \right)^{\frac{\gamma}{\gamma-1}} \\ &= \left\{ 1 + \frac{\gamma-1}{2} \frac{u_2^2}{RT_{01,r}} \left[1 - \left(\frac{r_1}{r_2} \right)^2 \right] \right\}^{\frac{\gamma}{\gamma-1}} \end{aligned}$$

(22) Calculate total pressure ratio across rotor, and total and static pressure at rotor outlet.

$$\frac{P_{02}}{P_{01}} = \left(\frac{T_{02}}{T_{01}} \right)^{\frac{\gamma}{\gamma-1}} \cdot \left(\frac{P_{02,r}}{P_{01,r}} \right) \cdot \left(\frac{P_{02,ri}}{P_{01,r}} \right)^{-1}$$

$$P_{02} = \left(\frac{P_{02}}{P_{01}} \right) P_{01}$$

$$P_2 = \left(1 + \frac{\gamma-1}{2} M_2^2 \right)^{-\gamma/(\gamma-1)} \cdot P_{02}$$

(23) Calculate density at rotor outlet.

$$\rho_2 = P_2/RT_2$$

- (24) Calculate the axial velocity at rotor outlet.

$$V_{z2} = \dot{m} / \rho_2 A_2$$

- (25) Compare the calculated value of V_{z2} in (24) with the assumed V_{z2} in (15). Iterate steps (15) to (24) until a desired accuracy is obtained.

- (26) Calculate total pressure at rotor outlet.

$$P_{02} = 1 + (\gamma - 1) M_2^2 / 2^{\gamma/(\gamma-1)} \cdot P_2$$

- (27) Calculate the total pressure loss coefficient across stator, $\bar{\omega}_s$, and stator outlet angle α_3 , in a similar fashion as in the rotor case.

- (28) Calculate total pressure loss factor across stator.

$$\frac{P_{03}}{P_{02}} = 1 - \bar{\omega}_s \left(1 - \frac{P_2}{P_{02}} \right)$$

- (29) Calculate the total pressure ratio and total temperature ratio across the stage.

$$PR = \frac{P_{03}}{P_{01}} = \left(\frac{T_{03}}{T_{01}} \right)^{\frac{\gamma}{\gamma-1}} \cdot \left(\frac{P_{02,r}}{P_{01,r}} \right) \cdot \left(\frac{P_{02,ri}}{P_{01,r}} \right)^{-1} \cdot \left(\frac{P_{03}}{P_{02}} \right)$$

$$TR = T_{03}/T_{01}$$

- (30) Obtain total pressure and temperature at stator outlet.

$$P_{03} = \left(\frac{P_{03}}{P_{02}} \right) \cdot P_{02}$$

$$T_{03} = T_{02}$$

- (31) Calculate the average value of specific heat ratio.

- (32) Calculate the stage efficiency.

$$\eta = \frac{PR^{(\gamma-1)/\gamma} - 1}{TR - 1}$$

A.2.2 Procedure when Small Droplets are Present

When all of the droplets present at entry to a stage can be categorized as small droplets, the following assumptions are introduced.

- (1) Droplets follow gas phase streamlines.
- (2) A fraction of the droplets impacting the blades undergo rebound. The balance of impacting droplets move over the blade surface in the form of a thin film. The momentum of the thin film is negligible.
- (3) The development of the boundary layer over the blade surface can be based on Reference 12. The following assumptions are made in that Reference: (i) droplets do not interact with one another; (ii) a two phase boundary layer exists; and (iii) the momentum thickness for the two phases can be superposed after they are obtained in two parts.
- (4) The deviation angle remains the same in two phase flow as in single phase flow. The reasoning is that diffusion and transport of particles can be neglected as being small and, in any case, as balancing each other.
- (5) The loss coefficient for two phase flow is thus the sum of the loss coefficient for each phase. The loss coefficient for the liquid phase may also be added in an appropriate form to the stage efficiency for a stage obtained during operation with air in order to obtain the stage efficiency for two phase flow.
- (6) Considering a blade passage flow, between two neighboring blades, away from solid boundaries, the drag due to droplets can be calculated assuming Stokes drag relation. The number of droplets suffering such drag is the sum of the number of non-impacting droplets and the number of rebound droplets.
- (7) The overall loss is obtained by adding the losses described under (5) and (6).

In using the analytical/correlation method for the flow of a mixture with small droplets, the basic procedure is the same as the procedure utilized in gas phase operation (Section A.2.1). The pressure rise for the gas phase and the temperature rise of water are determined from the

mixture turning angle over a blade. The losses are established based on (a) the relation between the loss coefficient and the pressure loss; the loss coefficient in turn related to the momentum thicknesses of the blade boundary layer due to the gas phase and the droplets; and (b) the Stokesian drag of droplets in the free stream. The latter, of course, is zero for small droplets, by definition.

The stage performance calculation for a mixture with small droplets is carried out using the analytical/correlation method as follows:

- (1) From the given inlet condition or the previous stage properties, the gas phase total temperature, $T_{01,g}$, and total pressure, $P_{01,g}$ are obtained.
- (2) Calculate the gas constant, R_g , specific heat constant pressure, c_{pg} and specific heat ratio of gas phase, γ .
- (3) Calculate the stagnation density of gas phase.

$$\rho_{01,g} = P_{01,g} / R_g T_{01,g}$$

- (4) Assume a value for Mach number, M_a .
- (5) Calculate the static density and temperature of gas phase.

$$\rho_{g1} = \left[1 + (\gamma - 1) M_a^2 / 2 \right]^{-1/(\gamma-1)} \cdot \rho_{01,g}$$

$$T_{g1} = \left[1 + (\gamma - 1) M_a^2 / 2 \right] \cdot T_{01,g}$$

- (6) Calculate the acoustic speed in the gas phase a_{g1} .

$$a_{g1} = (\gamma R_g T_{g1} g_c)^{0.5}$$

- (7) Calculate the acoustic speed in the mixture, a_1 , as shown in Appendix 3, Function WICASD.
- (8) Calculate the density of the mixture.

$$\rho_m = \left(\frac{x_g}{\rho_g} + \frac{x_w}{\rho_w} \right)^{-1}$$

- (9) Calculate the axial velocity.

$$V_{z1} = \dot{m}_m / \rho_1 A_1$$

- (10) Calculate the absolute velocity.

$$V_1 = V_{z1} / \cos \alpha_1$$

- (11) Calculate the Mach number, M_C .

$$M_C = V_1 / a_1$$

- (12) Compare the assumed Mach number, M_a , with the calculated one, M_C . If M_a agrees within prescribed limits with M_C , proceed to the next step. Otherwise, steps (4) to (11) must be repeated.

- (13) Calculate the components of velocity at rotor inlet as follows:

$$V_1 = V_{z1} / \cos \alpha_1$$

$$V_{\theta 1} = V_{z1} / \tan \alpha_1$$

$$W_{\theta i} = U_1 - V_{\theta 1}$$

$$W_1 = (V_{z1}^2 + W_{\theta 1}^2)^{1/2}$$

$$\beta_1 = \tan^{-1}(W_{\theta 1} / V_{z1})$$

- (14) Calculate relative Mach number at rotor inlet.

$$M_{r1} = W_1 / a_1$$

- (15) Calculate static pressure at rotor inlet.

$$p_1 = \left(T_{01,g} / T_{g1} \right)^{-\gamma / (\gamma - 1)} \cdot P_{01}$$

- (16) Calculate total pressure at rotor inlet based on the relative Mach number, M_{r1} .

$$P_{01,r} = \left[1 + (\gamma - 1) M_{r1}^2 / 2 \right]^{\gamma / (\gamma - 1)} \cdot p_1$$

- (17) Assume V_{z2} to calculate the total pressure loss coefficient across rotor due to gas phase, $\bar{\omega}_{g,R}$, and rotor outlet angle β_2 , where β_2 is calculated according to the procedure given in Appendix 3, Subroutine WICGSL.
- (18) Obtain the total pressure loss coefficient due to the increase of momentum thickness because of the existence of small droplets in the boundary layer over a rotor blade surface $\bar{\omega}_{\theta,R}$, as shown in Appendix 3, Subroutine WICSDL.
- (19) Obtain the total pressure loss across rotor due to the Stokesian drag of water droplets outside boundary layer $\bar{\omega}_{s,R}$, as shown in Appendix 3, Subroutine WICSTL.
- (20) Calculate the components of velocity at rotor outlet as follows:

$$W_{\theta 2} = V_{z2} \tan \beta_2$$

$$V_{\theta 2} = U_2 - W_{\theta 2}$$

$$W_2 = (V_{z2}^2 + W_{\theta 2}^2)^{0.5}$$

$$V_2 = (V_{z2}^2 + V_{\theta 2}^2)^{0.5}$$

$$\alpha_2 = \tan^{-1}(V_{\theta 2}/V_{z2})$$

- (21) Calculate the work input.

$$\Delta H_0 = (U_2 V_{\theta 2} - U_1 V_{\theta 1})/g_c J$$

- (22) Apportion work input to the mixture constituents as described in item (14) of A.2.2.1 of Reference (4).
- (23) Calculate static temperature of gas phase at rotor outlet.

$$T_{g2} = T_{02,g} - V_2^2/c_{pg} g_c J$$

- (24) Calculate acoustic speed in gas phase.

$$a_{g2} = (\gamma R_g T_{g2} g_c)^{0.5}$$

- (25) Assume $\rho_{g2} = \rho_{g1}$ and calculate the acoustic speed in the mixture, a_2 , as shown in Appendix 3, Function WICASD.
- (26) Calculate absolute and relative Mach numbers at rotor outlet.

$$M_2 = V_2/a_2$$

$$M_{r2} = W_2/a_2$$

- (27) Calculate total pressure loss factor across rotor.

$$\frac{P_{02,r}}{P_{01,r}} = \frac{P_{02,ri}}{P_{01,r}} - (\bar{\omega}_{g,R} + \bar{\omega}_{\theta,R} + \bar{\omega}_{s,R}) \cdot \left(1 - \frac{P_1}{P_{01,r}}\right)$$

- (28) Calculate total pressure ratio across rotor, and total and static pressures at rotor outlet.

$$\frac{P_{02}}{P_{01}} = \left(\frac{T_{02,g}}{T_{01,g}}\right)^{\frac{\gamma}{\gamma-1}} \cdot \left(\frac{P_{02,r}}{P_{01,r}}\right) \cdot \left(\frac{P_{02,ri}}{P_{01,r}}\right)^{-1}$$

$$P_{02} = \left(\frac{P_{02}}{P_{01}}\right) P_{01}$$

$$P_2 = \left(1 + \frac{\gamma-1}{2} M_2^2\right)^{\frac{-\gamma}{\gamma-1}} P_{02}$$

- (29) Calculate static density at rotor outlet.

$$\rho_{g2} = P_2/R_g T_{g2}$$

- (30) Compare the calculated value of ρ_{g2} in (29) with the assumed value of ρ_{g2} in (25). Iterate steps (25) to (29) until a desired accuracy is obtained.
- (31) Calculate the density of mixture at rotor outlet.

$$\rho_{m2} = \left(\frac{x_g}{\rho_{g2}} + \frac{x_w}{\rho_w}\right)^{-1}$$

(32) Calculate the axial velocity at rotor outlet.

$$V_{z2} = \dot{m}_m / \rho_{m2} A$$

(33) Compare the calculated value of V_{z2} in (32) with the assumed value of V_{z2} in (17). Iterate steps (17) to (32) until a desired accuracy is obtained.

(34) Calculate total pressure at rotor outlet.

$$P_{02} = \left[1 + (\gamma - 1) M_2^2 / 2 \right]^{\gamma / (\gamma - 1)} \cdot P_2$$

(35) Calculate the total pressure loss coefficient across stator due to gas phase, $\bar{\omega}_{g,S}$, and stator outlet angle, α_3 , as shown in Appendix 3, Subroutine WICGSL.

(36) Obtain the total pressure loss coefficient due to the increase of momentum thickness because of the existence of small droplets in the boundary layer on a stator blade surface, $\bar{\omega}_{\theta,S}$, as shown in Appendix 3, Subroutine WICSDL.

(37) Obtain the total pressure loss across stator due to the Stokesian drag of water droplets in the free stream outside boundary layer $\bar{\omega}_{s,S}$; as shown in Appendix 3, Subroutine WICSTL, it may be noted that Stokesian drag is zero in the case of small droplets by definition.

(38) Calculate total pressure loss factor across stator.

$$\frac{P_{03}}{P_{02}} = 1 - (\bar{\omega}_{g,S} + \bar{\omega}_{\theta,S} + \bar{\omega}_{s,S}) \left(1 - \frac{P_2}{P_{02}} \right)$$

(39) Calculate the total pressure ratio and gas phase total temperature ratio across stage.

$$PR = \frac{P_{03}}{P_{01}} = \left(\frac{T_{03,g}}{T_{01,g}} \right)^{\frac{\gamma}{\gamma-1}} \cdot \left(\frac{P_{02,r}}{P_{01,r}} \right) \left(\frac{P_{02,ri}}{P_{01,r}} \right)^{-1} \cdot \left(\frac{P_{03}}{P_{02}} \right)$$

$$TR = T_{03,g} / T_{01,g}$$

- (40) Obtain total pressure and gas phase total temperature at stator outlet.

$$P_{03} = \left(\frac{P_{03}}{P_{02}} \right) P_{02}$$

$$T_{03,g} = T_{02,g}$$

- (41) Calculate the average value of specific heat ratio.
(42) Calculate the stage efficiency.

$$\eta = \frac{PR^{(\gamma-1)/\gamma} - 1}{TR - 1}$$

A.2.3 Procedure when Large or Large and Small Droplets are Present

It is postulated that when large droplets are present, they always play the more dominant role.

The following assumptions are introduced.

- (1) Droplets move with equal probability in all directions in the forward sector.
- (2) A fraction of the droplets impacting the droplets undergo rebound. The balance of impacting droplets move over the blade surface in the form of a thick film. The momentum of the thick film is appreciable and represents a loss of mixture momentum.
- (3) The development of the boundary layer can be estimated based on the following reasoning: (a) the thick film presents a continuous rough surface; (b) the roughness is at most of the order of droplet thickness; and (c) the boundary layer is fully turbulent and extends over the chord length. A coefficient of friction for the flow can then be based on Reference 13.
- (4) The deviation angle remains the same as in the case of single phase flow.

- (5) Considering a blade passage flow, between two neighboring blades, away from solid boundaries, the drag due to droplets can be calculated assuming Stokes drag relation. The number of droplets suffering such drag is the sum of the number of non-impacting droplets and the number of rebound droplets.
- (6) The overall loss is therefore obtained by adding the losses described under (2), (3) and (5).

The stage performance, when large droplets are present, with or without small droplets, is carried out as follows. It may be pointed out that the determination of stage pressure ratio follows the same procedure as in the case of a mixture with small droplets only, Appendix Section A.2.2. The determination of the loss coefficient when large droplets are present is wholly different.

- (1) From given initial conditions or from the previous stage properties the gas phase total temperature, $T_{01,g}$ and total pressure, P_{01} , are obtained.
- (2) Calculate the gas constant, R_g , specific heat at constant pressure, c_{pg} , and specific heat ratio, γ .
- (3) Calculate the stagnation density of gas phase.

$$\rho_{01,g} = P_{01}/R_g T_{01,g}$$

- (4) Assume a value for Mach number, M_a .
- (5) Calculate the static density, and temperature of gas phase, as follows:

$$\rho_1 = \left[1 + (\gamma - 1)M_a^2/2 \right]^{-1/(\gamma-1)} \cdot \rho_{01,g}$$

$$T_{g1} = \left[1 + (\gamma - 1)M_a^2/2 \right]^{-1} T_{01,g}$$

- (6) Calculate the acoustic speed in the gas phase, a_{g1} .

$$a_{g1} = (\gamma R_g T_{g1} G_c)^{0.5}$$

- (7) Calculate the acoustic speed in the mixture, a_1 , as shown in Appendix 3, Function WICASD.

(8) Calculate the density of the mixture.

$$\rho_m = \left(\frac{x_g}{\rho_g} + \frac{x_w}{\rho_w} \right)^{-1}$$

(9) Calculate the axial velocity.

$$V_{z1} = \dot{m}_m / \rho_m A$$

(10) Calculate the absolute velocity.

$$V_1 = V_{z1} / \cos \alpha_1$$

(11) Calculate the Mach number, M_c .

$$M_c = V_1 / a_1$$

(12) Compare the assumed Mach number, M_a , with the calculated one, M_c . If M_a agrees within prescribed limits with M_c , proceed to the next step. Otherwise steps (4) to (11) must be repeated.

(13) Calculate the components of velocity at rotor inlet as follows:

$$V_1 = V_{z1} / \cos \alpha_1$$

$$V_{\theta 1} = V_{z1} \tan \alpha_1$$

$$W_{\theta 1} = U_1 - V_{\theta 1}$$

$$W_1 = (V_{z1}^2 + W_{\theta 1}^2)^{1/2}$$

$$\beta_1 = \tan^{-1}(W_{\theta 1} / V_{z1})$$

(14) Calculate relative Mach number at rotor inlet.

$$M_{r1} = W_1 / a_1$$

- (15) Calculate static pressure at rotor inlet.

$$P_1 = \left[\left(T_{01,g} / T_g \right) \right]^{-\gamma / (\gamma - 1)} \cdot P_{01}$$

- (16) Calculate the total pressure at rotor inlet based on M_r .

$$P_{01,r} = \left[1 + (\gamma - 1) M_{r1}^2 / 2 \right]^{\gamma / (\gamma - 1)} \cdot P_1$$

- (17) Assume V_{z2} to calculate the total pressure loss due to gas phase, $\bar{\omega}_{g,R}$, and rotor outlet angle β_2 , as shown in Appendix 3, Subroutine WICGSL.
- (18) Calculate the total pressure loss coefficient due to the momentum gained by thick water film moving over the rotor blade surface $\bar{\omega}_{f,R}$, as shown in Appendix 3, Subroutine WICFML.
- (19) Calculate the total pressure loss coefficient due to turbulent flow of mixture over the rough film surface of rotor blade, $\bar{\omega}_{r,R}$, as shown in Appendix 3, Subroutine WICRSL.
- (20) Calculate the total pressure loss coefficient due to the Stokesian drag of water droplets in rotor passage, $\bar{\omega}_{s,R}$, as shown in Appendix 3, Subroutine WICSTL.
- (21) Calculate the components of velocity diagram at rotor outlets as follows:

$$W_{\theta 2} = V_{z2} \tan \beta_2$$

$$V_{\theta 2} = U_2 - W_{\theta 2}$$

$$W_2 = \left(V_{z2}^2 + W_{\theta 2}^2 \right)^{0.5}$$

$$V_2 = \left(V_{z2}^2 + V_{\theta 2}^2 \right)^{0.5}$$

$$\alpha_2 = \tan^{-1} (V_{\theta 2} / V_{z2})$$

- (22) Calculate the work input.

$$\Delta H_0 = (U_2 V_{\theta 2} - U_1 V_{\theta 1}) / g_c J$$

- (23) Apportion the energy input in the mixture as described in item (15) of A.2.2.1, of Reference (4).

- (24) Calculate static temperature of gas phase at rotor outlet.

$$T_{g2} = T_{02,g} - V_2^2 / 2c_{pg} g_c J$$

- (25) Calculate the acoustic speed in gas phase.

$$a_{g2} = (\gamma R_g T_{g2} g_c)^{0.5}$$

- (26) Assume $\rho_{g2} = \rho_{g1}$ and calculate the acoustic speed in the mixture a_2 , as shown in Appendix 3, Function WICASD.

- (27) Calculate absolute and relative Mach number at rotor outlet.

$$M_2 = V_2 / a_2$$

$$M_{r2} = W_2 / a_2$$

- (28) Calculate total pressure loss factor across rotor.

$$\frac{P_{02,r}}{P_{01,r}} = \frac{P_{02,ri}}{P_{01,r}} - \left[\bar{\omega}_{g,R} + \bar{\omega}_{f,R} + \bar{\omega}_{r,R} + \bar{\omega}_{s,R} \right] \left(1 - \frac{P_{01}}{P_{01,r}} \right)$$

- (29) Calculate total pressure ratio across rotor, and total static pressure at rotor outlet.

$$\frac{P_{02}}{P_{01}} = \left(\frac{T_{02,g}}{T_{01,g}} \right)^{\frac{\gamma}{\gamma-1}} \left(\frac{P_{02,r}}{P_{01,r}} \right) \left(\frac{P_{02,ri}}{P_{01,r}} \right)^{-1}$$

$$P_{02} = \left(\frac{P_{02}}{P_{01}} \right) P_{01}$$

$$p_2 = \left(1 + \frac{\gamma - 1}{2} M_2^2 \right)^{\frac{-\gamma}{\gamma - 1}} p_{02}$$

- (30) Calculate static density at rotor outlet.

$$\rho_{g2} = p_2 / R_g T_{g2}$$

- (31) Compare the calculated ρ_{g2} in (27) with the assumed ρ_{g2} in (23). Iterate steps (23) to (27) until a desired accuracy is obtained.
- (32) Calculate the density of mixture.

$$\rho_{m2} = \left(\frac{x_g}{g} + \frac{x_w}{w} \right)^{-1}$$

- (33) Calculate the axial velocity at rotor outlet.

$$V_{z2} = \dot{m}_m / \rho_m A_2$$

- (34) Compare the calculated V_{z2} in (33) with the assumed V_{z2} in (34). Iterate steps (17) to (33) until the desired accuracy is obtained.
- (35) Calculate total pressure at rotor outlet.

$$p_{02} = \left[1 + (\gamma - 1) M_2^2 / 2 \right]^{\gamma / (\gamma - 1)} p_2$$

- (36) Calculate the total pressure loss coefficient across stator due to gas phase, $\bar{\omega}_{g,S}$, and stator outlet angle, α_3 , as shown in Appendix 3, Subroutine WICGSL.
- (37) Calculate the total pressure loss coefficient due to the momentum gained by thick water film on the stator blade surface, $\bar{\omega}_{f,S}$, as shown in Appendix 3, Subroutine WICFML.
- (38) Calculate the total pressure loss coefficient due to turbulent friction over a rough film surface over the stator blade, $\bar{\omega}_{r,S}$, as shown in Appendix 3, Subroutine WICRSL.

(39) Obtain the total pressure loss across stator due to Stokesian drag of large water droplets in the free stream outside boundary layer, $\bar{\omega}_{s,S}$, as shown in Appendix 3, Subroutine WICSTL.

(40) Calculate total pressure loss factor across the stator.

$$\frac{P_{03}}{P_{02}} = 1 - \left(\bar{\omega}_{g,S} + \bar{\omega}_{f,S} + \bar{\omega}_{r,S} + \bar{\omega}_{s,S} \right) \left(1 - \frac{P_2}{P_{02}} \right)$$

(41) Calculate the total pressure ratio and gas phase total temperature ratio across stage.

$$PR = P_{03}/P_{01} = \left(\frac{T_{03,g}}{T_{01,g}} \right)^{\frac{\gamma}{\gamma-1}} \left(\frac{P_{02,r}}{P_{01,r}} \right) \left(\frac{P_{02,ri}}{P_{01,r}} \right)^{-1} \left(\frac{P_{03}}{P_{02}} \right)$$

$$TR = T_{03,g}/T_{01,g}$$

(42) Obtain total pressure and gas phase total temperature at stator outlet.

$$P_{03} = \left(\frac{P_{03}}{P_{02}} \right) P_{02}$$

$$T_{03,g} = T_{02,g}$$

(43) Calculate the average value of the specific heat ratio.

(44) Calculate the stage efficiency.

$$\eta = \frac{PR^{(\gamma-1)/\gamma} - 1}{TR - 1}$$

APPENDIX 3

DETAILED DESCRIPTION OF SUBROUTINES AND EXTERNAL FUNCTIONS

There are 22 subroutines and 13 external functions in this program. Brief descriptions of these subprograms are presented in Chapter III. A more detailed description of each subprogram is presented here. Each of the subroutines and external functions is presented as follows:
(1) Description, (2) Input variables, (3) Output variables, and (4) Usage.

SUBROUTINE WICSPB

(1) Description:

The subroutine WICSPB is used for the calculation of stage performance based on the analytical/correlation method for small droplet. A detailed description of calculation procedure is presented in Appendix 2.

(2) Input Variables:

FAIO	initial flow coefficient
ISTAGE	stage at which performance calculation is carried out
MMASS	mass flow rate of mixture
ALFA1	absolute flow angle at outlet of the previous stage stator
DAV	nominal diameter of small droplets
DELV	relative velocity between gas phase and large droplets
WMAS	mass flow rate of small droplets
N	station number
AK1	constant in Eq. (A.3.6)'

AK2	constant in Eq. (A.3.7)' and (A.3.8)'
AK3	constant in Eq. (A.3.1)' and (A.3.2)'
(3) Output Variables:	
OMEGA1	total pressure loss coefficient due to single-phase (gas) flow profile loss in rotor
OMEGA2	total pressure loss coefficient due to loss for small droplets on account of the change in momentum thickness of boundary layer due to the presence of such droplets in rotor
OMEGA3	total pressure loss coefficient due to Stokesian drag of small droplets in the free stream of blade passage in rotor
OMEGA4	total pressure loss coefficient due to single-phase (gas) flow profile loss in stator
OMEGA5	total pressure loss coefficient due to loss for small droplets on account of the change in momentum thickness of boundary layer due to the presence of such droplets in stator
OMEGA6	total pressure loss coefficient due to Stokesian drag of small droplets in the free stream of blade passage in stator
OMEGAT	sum of total pressure loss coefficients
BETA1	relative flow angle at rotor inlet
BETA2	relative flow angle at rotor outlet
VZ	axial velocity
ALFA2	absolute flow angle at stator inlet
ALFA3	absolute flow angle at stator outlet
DELTA	rise in total temperature of gas phase across a stage
DELTA	rise in temperature of small droplet across a stage
W1	relative velocity at rotor inlet
W2	relative velocity at rotor outlet
V1	absolute velocity at rotor inlet

V2 absolute velocity at stator inlet
V3 absolute velocity at stator outlet

(4) Usage:

CALL WICSPB (FAIO, ISTAGE, Mmass, ALFA1, WKDONE, DAV, DELV,
WMAS, N, OMEGA1, OMEGA2, OMEGA3, OMEGA4, OMEGA5,
OMEGA6, OMEGAT, BETA1, BETA2, VZ, ALFA2, ALFA3,
DELTG, DELTW, W1, W2, V1, V2, V3, AK1, AK2, AK3)

SUBROUTINE WICSPC

(1) Description:

The subroutine WICSPC is used for the calculation of stage performance based on the analytical/correlation method for large droplet. A detailed description of calculation procedure is presented in Appendix 2.

(2) Input Variables:

FAIO initial flow coefficient
ISTAGE stage at which performance calculation is
 carried out
Mmass mass flow rate of mixture
ALFA1 absolute flow angle at outlet of the
 previous stage stator
WKDONE work done factor
DAV nominal diameter of large droplets
DELV relative velocity between gas phase and
 large droplets
WMAS mass flow rate of large droplets
N station number (Fig. 5.1)
REAVE average Reynolds number
DELVU2 relative velocity between gas phase and droplet
DELVL2 relative velocity between gas phase and droplet
AK1 constant in Eq. (A.3.6)'
AK2 constant in Eq. (A.3.7)' and (A.3.8)'
AK3 constant in Eq. (A.3.1)' and (A.3.2)'

(3) Output Variables:

OMEGA1	total pressure loss coefficient due to the mixture boundary layer formed over rough film surface in rotor
OMEGA2	total pressure loss coefficient due to film formed on rotor blade surface
OMEGA3	total pressure loss coefficient due to Stokesian drag of large droplets in the free stream of blade passage in rotor
OMEGA4	total pressure loss coefficient due to the mixture boundary layer formed over rough film surface in stator
OMEGA5	total pressure loss coefficient due to film formed on stator blade surface
OMEGA6	total pressure loss coefficient due to Stokesian drag of large droplets in the free stream of blade passage in stator
OMEGAT	sum of total pressure loss coefficient
BETA1	relative flow angle at rotor inlet
BETA2	relative flow angle at rotor outlet
VZ	axial velocity
ALFA2	absolute flow angle at stator inlet
ALFA3	absolute flow angle at stator outlet
DELTG	rise in total temperature of gas phase across a stage
DELTW	rise in temperature of small droplet across a stage
W1	relative velocity at rotor inlet
W2	relative velocity at rotor outlet
V1	absolute velocity at rotor inlet
V2	absolute velocity at stator inlet
V3	absolute velocity at stator outlet

(4) Usage:

CALL WICSPC (FAIO, Istage, Mmass, ALFA1, WKDONE, DAV, DELV,
WMAS, WWMAS, N, OMEGA1, OMEGA2, OMEGA3, OMEGA4,

OMEGA5, OMEGA6, OMEGAT, BETA1, BETA2, VZ, ALFA2,
ALFA3, DELTG, DELTW, W1, W2, V1, V2, V3, REAVE,
DELVU2, DELVL2, AK1, AK2, AK3)

SUBROUTINE WICSPD

(1) Description

The subroutine WICSPD is used for the calculation of design point performance. The properties obtained in this subroutine become reference properties for calculation of off-design performance.

(2) Input Variables

AMASS mass flow rate
ISTAGE stage at which performance calculation is
 carried out

(3) Output Variables:

none

(4) Usage:

CALL WICSPD (AMASS, ISTAGE)

SUBROUTINE WICGSL

(1) Description:

The subroutine WICGSL is used for the calculation of single-phase (gas) flow loss. In the current model, the concept of the equivalent diffusion ratio by Lieblein (Ref. 10) and Swan's correlation (Ref. 11) have been employed in order to estimate the blade outlet flow angle and loss due to turbulent flow of gaseous phase over the rigid blade surface. In the event that a different model is to be employed, for the estimation of the blade outlet angles of the gaseous phase, subroutine WICGSL, function WICED, and if needed subroutine WICSPD should be modified to incorporate the new correlation.

Lieblein has shown that the design point loading factor, the Diffusion Factor, does not represent a suitable criterion for loading at off-design conditions, except possibly at other

minimum loss points. This is due to the fact that the basic derivation of the Diffusion Factor has been based on a flow model which corresponds to operation at or near minimum loss. He has therefore suggested a generalized loading parameter. This parameter, the Equivalent Diffusion Ratio, is based on the ratio of the maximum suction surface velocity and trailing edge velocity for a given section cascade. Lieblein has deduced an expression which approximates this velocity ratio in terms of measured overall performance. The Equivalent Diffusion Ratio is suitable for correlation of low speed data. For the general case where the axial velocity ratio may be large, such as in a rotor or stator cascade, the Equivalent Diffusion Ratio, D_{eq} , has been defined as follows:

$$D_{eq} = \frac{\cos\beta_2 V_{z1}}{\cos\beta_1 V_{z2}} \left[1.12 + k(i-i^*)^{1.43} + 0.61 \frac{\cos^2\beta_1}{\sigma} \cdot K \right] \quad (A.3.1)$$

$$\text{where } K = \tan\beta_1 - \frac{r_2}{r_1} \frac{V_{z2}}{V_{z1}} \cdot \tan\beta_2 - \frac{\omega r_1}{V_{z1}} \left(1 - \frac{r_2^2}{r_1^2} \right)$$

and $k = 0.0117$ for the NACA 65 (A_{10}) blades and $k = 0.007$ for the C_4 circular-arc blades. The Equivalent Diffusion Ratio at minimum loss, D_{eq}^* , is obtained by dropping the term representing the incidence angle effects, that is as follows:

$$D_{eq}^* = \frac{\cos\beta_2 V_{z1}}{\cos\beta_1 V_{z2}} \left\{ 1.12 + 0.61 \frac{\cos^2\beta_1}{\sigma} \cdot K \right\} \quad (A.3.2)$$

The wake momentum thickness can be expressed nondimensionally as follows:

$$\left(\frac{\theta}{c} \right) = \frac{\omega \cos\beta_2}{2\sigma} \left(\frac{\cos\beta_2}{\cos\beta_1} \right)^2 \quad (A.3.3)$$

where c is the chord length of the blades.

At minimum loss, Eq. (A.3.3) yields

$$\left(\frac{\theta}{c}\right)^* = \frac{\bar{\omega}^* \cos \beta_2}{2\sigma} \left(\frac{\cos \beta_2^*}{\cos \beta_1^*} \right)^2 \quad (\text{A.3.4})$$

Also, from Eq. (A.3.3), the total pressure loss coefficient $\bar{\omega}$, can be expressed as follows:

$$\bar{\omega} = \left(\frac{\theta}{c}\right) \frac{2\sigma}{\cos \beta_2} \left(\frac{\cos \beta_1}{\cos \beta_2} \right)^2 \quad (\text{A.3.5})$$

From the cascade test data, the deviation angle, δ , and the non-dimensional wake momentum thickness, $\left(\frac{\theta}{c}\right)$, are expressed in terms of the D_{eq} , D_{eq}^* , $\left(\frac{\theta}{c}\right)^*$, and inlet Mach number, M , as follows (see Swan Ref. 11):

$$\delta = \delta^* + [6.40 - 9.45(M_1 - 0.60)] (D_{eq} - D_{eq}^*) \cdot \text{AK1} \quad (\text{A.3.6})$$

$$\left(\frac{\theta}{c}\right) = \left(\frac{\theta}{c}\right)^* + (0.827M_1 - 2.692M_1^2 - 2.675M_1^3) (D_{eq} - D_{eq}^*)^2 \cdot \text{AK2} \quad (\text{A.3.7})$$

for $D_{eq} > D_{eq}^*$

$$\left(\frac{\theta}{c}\right) = \left(\frac{\theta}{c}\right)^* + (2.89M_1 - 8.71M_1^2 + 9.36M_1^3) (D_{eq} - D_{eq}^*)^2 \cdot \text{AK2} \quad (\text{A.3.8})$$

for $D_{eq} < D_{eq}^*$

Using these empirical expressions, the air angle at blade outlet and total pressure loss coefficient at an off-design point can be determined as follows:

- (i) Calculate the inlet angle, β_1 , and the inlet Mach number, M_1 .
- (ii) Calculate the Equivalent Diffusion ratio at minimum loss, D_{eq}^* .
- (iii) Calculate the nondimensional wake momentum thickness at minimum loss, $\left(\frac{\theta}{c}\right)^*$.
- (iv) Assume the fluid outlet angle, $(\beta_2)_a$.

- (v) Calculate the incidence angle, i , $i = \beta_1 - \beta_1^* + i^*$.
- (vi) Calculate the Equivalent Diffusion Ratio D_{eq} .
- (vii) Calculate the deviation angle, δ .
- (viii) Calculate the fluid outlet angle, $(\beta_2)_c$, $(\beta_2)_c = \beta_2^* - \delta^* + \delta$.
- (ix) Compare the assumed value of fluid outlet angle, $(\beta_2)_a$, with the calculated value of that, $(\beta_2)_c$ to check if $|(\beta_2)_a - (\beta_2)_c| < \epsilon$ where ϵ is the desired accuracy. Iterate step (iv) to step (ix) until satisfactory accuracy is obtained.
- (x) Calculate the nondimensional wake momentum thickness, $(\frac{\theta}{c})$.
- (xi) Calculate the total pressure loss coefficient $\bar{\omega}$.

Figure (A.3.1) shows the flow chart of the calculation procedure to predict the outlet angle and total pressure loss coefficient.

The program also includes a provision for modifying the equations given in Ref. 10 and 11. Equations (A.3.1), (A.3.2), (A.3.6), (A.3.7), and (A.3.8) can be modified by introducing constants AK1, AK2, and AK3 as follows.

$$D_{eq} = \frac{\cos \beta_2}{\cos \beta_1} \frac{V_{z1}}{V_{z2}} \left[1.12 + k(i - i^*)^{1.43} + 0.61 \frac{\cos^2 \beta_1}{\sigma} K \right] \cdot AK3 \quad (A.3.1)'$$

$$D_{eq}^* = \frac{\cos \beta_2}{\cos \beta_1} \frac{V_{z1}}{V_{z2}} \left[1.12 + 0.61 \frac{\cos^2 \beta_1}{\sigma} \right] \cdot AK3 \quad (A.3.2)'$$

$$\delta = \delta^* + \left[6.40 - 9.45 (M_1 - 0.60) \right] (D_{eq} - D_{eq}^*) \cdot AK1 \quad (A.3.6)'$$

$$\left(\frac{\theta}{c}\right) = \left(\frac{\theta}{c}\right)^* + (0.827M_1 - 2.692M_1^2 - 2.675M_1^3) (D_{eq} - D_{eq}^*)^2 \cdot AK2 \quad (A.3.7)'$$

$$\text{for } D_{eq} > D_{eq}^*$$

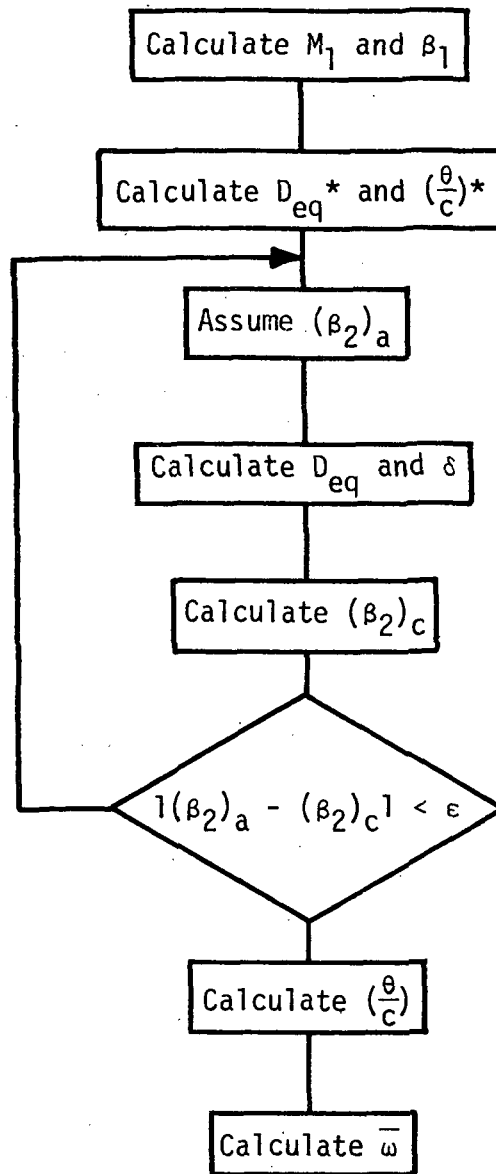


Fig. A.3.1 Procedure for Prediction of Total Pressure Loss Coefficient and Blade Outlet Flow Angle

$$\left(\frac{\theta}{c}\right) = \left(\frac{\theta}{c}\right)^* + (2.80M_1 - 8.71M_1^2 + 9.36M_1^3) (D_{eq} - D_{eq}^*)^2 \cdot AK2 \quad (A.3.8)'$$

for $D_{eq} < D_{eq}^*$.

(2) Input Variables

SIGUMA	solidity
BET1S	blade inlet flow angle at design point
BET2S	blade outlet flow angle at design point
AINCIS	incidence at design point
ADEVIS	deviation at design point
AMACH1	blade inlet Mach number
BET1	blade inlet flow angle
DEQS	equivalent diffusion ratio at design point, D_{eq}^*
SITACS	dimensionless momentum thickness at design point, $\left(\frac{\theta}{c}\right)^*$
X	Mach number below which the effect of Mach number disappears in estimating deviation angle. The value of 0.6 is recommended by Swan (Ref. 11).
AK1	constant in Eq. (A.3.6)'
AK2	constant in Eq. (A.3.7)'' and (A.3.8)'
AK3	constant in Eq. (A.3.1)'' and (A.3.2)''
VZ1	axial velocity at blade inlet
VZ2	axial velocity at blade outlet
UR1	rotor blade speed at blade inlet
R1	radius at blade inlet
R2	radius at blade outlet

(3) Output Variables:

DEQN	equivalent diffusion ratio, D_{eq}
SITACN	dimensionless momentum thickness, $\left(\frac{\theta}{c}\right)$
BET2N	blade outlet angle
OMEGAN	total pressure loss coefficient

(4) Usage:

CALL WICGSL (SIGUMA, BET1S, BET2S, AINCIS, ADEVIS, AMACH1,
BET1, DEQS, DEQN, SITACS, SITACN, BET2N, OMEGAN,
X, AK1, AK2, AK3, VZ1, VZ2, UR1, R1, R2)

SUBROUTINE WICSDL

(1) Description:

The subroutine WICSDL is used for the calculation of loss for small droplets on account of the change in momentum thickness of the boundary layer due to the presence of such droplets.

In order to estimate the loss pertaining to the increase of momentum thickness due to the existence of small droplets in the boundary layer, Soo's boundary layer analysis for a gas-solids suspension is introduced (Ref. 12). In an isothermal incompressible system, Soo has derived the following equation for suspended particles under the assumption that the number of collisions among particles is negligible when compared to that with the wall,

$$a = \left(\frac{a}{b}\right) \left(\frac{\delta}{x}\right) - \frac{4a^2}{3b^2} \left(\frac{\delta}{x}\right)^{3/4} + \frac{4a^3}{3b^3} \left(\frac{\delta}{x}\right)^{1/2} - \frac{4a^4}{b} \left(\frac{\delta}{x}\right)^{1/4} + \frac{4a^5}{b^5} \ln \left[1 + \frac{b}{a} \left(\frac{\delta}{x}\right)^{1/4} \right] \quad (\text{A.3.9})$$

where

$$a = \frac{0.0225 \left(\frac{\bar{\mu}}{U\rho_0 x} \right)^{1/4}}{0.1402 \left(\frac{\rho_p \rho_0}{\rho_0} \right) + 0.0972}$$

$$b = \frac{\frac{1}{2\sqrt{\pi}} \frac{\rho_{p0}}{\rho_0} \frac{U_{pw}}{U^2} \langle U_{pw}^2 \rangle}{0.1402 \left(\frac{\rho_{p0}}{\rho} \right) + 0.0972}$$

Neglecting shear due to impact of solid particles, Soo derived the following equation.

$$\frac{\delta}{x} = 0.37 \left(\frac{Ux\rho_0}{\mu} \right)^{-1/5} / (1 + 1.442\rho_{p0}/\rho_0)^{0.8} \quad (\text{A.3.10})$$

The boundary layer thickness, δ , can be obtained from Eqs. (A.3.9) or (A.3.10). In the present model, Eq. (A.3.10) was used.

The momentum thickness, due to liquid phase, θ_p , is given by

$$\begin{aligned} \frac{\theta_p}{\delta} = & \left(\frac{U_p - U_{pw}}{U_p} \right)^2 \frac{m}{(1+m)(2+m)} - \left(\frac{\rho_{p0} - \rho_{pw}}{\rho_{p0}} \right) \cdot \frac{U_{pw}}{U_p} \cdot \frac{1}{\alpha + 1} \\ & + \left(\frac{\rho_{p0} - \rho_{pw}}{\rho_{p0}} \right) \left(\frac{U_p - U_{pw}}{U_p} \right)^2 \\ & \cdot \left[\frac{\Gamma(\frac{2}{m} + 1) \cdot \Gamma(\alpha + 1)}{\Gamma(\frac{2}{m} + \alpha + 2)} - \frac{\Gamma(\frac{1}{m} + 1) \cdot \Gamma(\alpha + 1)}{\Gamma(\frac{1}{m} + \alpha + 2)} \right] \quad (\text{A.3.10}) \end{aligned}$$

where α and m are constants associated with distribution of velocity and density of liquid phase in the boundary layer namely

$$u_p = U_{pw} + (U_p - U_{pw}) \left(\frac{y}{\delta} \right)^{1/m}$$

$$\rho_p = \rho_{pw} - (\rho_{p0} - \rho_{pw}) \left(1 - \frac{y}{\delta}\right)^\alpha$$

For the case of solid, spherical particles of 100 and 200 μm in diameter in air moving at room conditions with a velocity of 50 to 100 fps, Soo has obtained the following values for the various quantities.

$$n = 7, m = 1.25, \alpha = 2.30,$$

$$\frac{U_p - U_{pw}}{U_p} = 0.812, \quad \frac{\rho_{pw}}{\rho_{p0}} = 1.451$$

Utilizing the above values, Eq. (A.3.10) becomes

$$\frac{\theta_p}{\delta} = 0.1402$$

Following the procedure of Lieblein, the total pressure loss coefficient due to the increase of momentum thickness, $\theta_{p,R}$, because of the existence of small droplets in the boundary layer over rotor blade surface, $\bar{\omega}_{\theta,R}$, can be expressed as follows:

$$\bar{\omega}_{\theta,R} = \left(\frac{\theta_{p,r}}{c}\right) \frac{2 \sigma}{\cos\beta_2} \left(\frac{\cos\beta_1}{\cos\beta_2}\right)^2$$

Similarly, the total pressure loss coefficient due to the increase of momentum thickness, $\theta_{p,s}$, because of the existence of small droplets in the boundary layer on stator blade surface $\bar{\omega}_{\theta,s}$, can be expressed as follows:

$$\bar{\omega}_{\theta,s} = \left(\frac{\theta_{p,s}}{c}\right) \frac{2 \sigma}{\cos\alpha_3} \left(\frac{\cos\alpha_2}{\cos\alpha_3}\right)^2$$

The stagnation pressure losses corresponding to $\bar{\omega}_{\theta,r}$ and $\bar{\omega}_{\theta,s}$ can be written as follows.

$$\Delta P_{\theta,R} = \frac{1}{2} \rho_1 W_1^2 \bar{\omega}_{\theta,R}$$

$$\Delta P_{\theta,S} = \frac{1}{2} \rho_2 V_2^2 \bar{\omega}_{\theta,S}$$

Thus, the total pressure loss across a stage due to the increase of momentum thickness because of the existence of small droplets in a boundary layer is given by

$$\Delta P_{\theta} = \Delta P_{\theta,R} + \Delta P_{\theta,S}$$

(2) Input Variables

CHORD	chord length
SIGUMA	solidity
BETA1	blade inlet flow angle
BETA2	blade outlet flow angle
UG	average flow velocity
RHOG	density
AMASSW	mass flow rate
AREA	flow area
VZ	axial velocity

(3) Output Variables:

OMEGAP	total pressure loss coefficient
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(4) Usage:

CALL WICSDL (CHORD, SIGUMA, BETA1, BETA2, UG, RHOG, AMASSW, AREA, VZ, OMEGAP)

SUBROUTINE WICSTL

(1) Description:

The subroutine WICSTL is used for the calculation of loss

due to Stokesian drag of droplets in the free stream of blade passage.

In view of the assumption pertaining to motion of small droplets (with zero relative velocity with respect to gas phase), the total pressure loss due to Stokesian drag becomes zero for small droplets.

For large droplets, the model introduced is described below.

The large droplets move with substantial relative velocity with respect to the gas phase and have equal probability of motion in all directions. However, regarding the latter aspect, the droplets are divided into two subclasses with a direction of motion for each class, specified with respect to the gas phase velocity vector. The number of droplets impacting on the blade surface is then proportional to the blade surface area projection normal to the velocity vectors for the two subclasses of droplets.

Referring to Fig. A.3.2, the two subclasses are shown as (1) and (2) which have direction of motion given by γ_1 , and γ_2 relative to the gas phase velocity vector. The total number of droplets in subclass (1) is proportional to angle $2\gamma_1$ and those in subclass (2) is proportional to angle $2\gamma_2$ ($180 - 2\gamma_1$). The relative velocity between the gas phase and droplets of subclass (1) is given by the difference between V_{g1} and the component of V_{p1} (the velocity of droplets in subclass (1) in the direction of V_{g1}). Similarly the relative velocity between the gas phase and the droplets of subclass (2) is given by the difference between V_{g1} and the component of V_{p2} in the direction of V_{g1} . Thus for droplets of subclass (1) the relative velocity is given by the relation,

$$V_{g1} = V_{p1} \cos \gamma_1$$

and for droplets of subclass (2), the relative velocity is

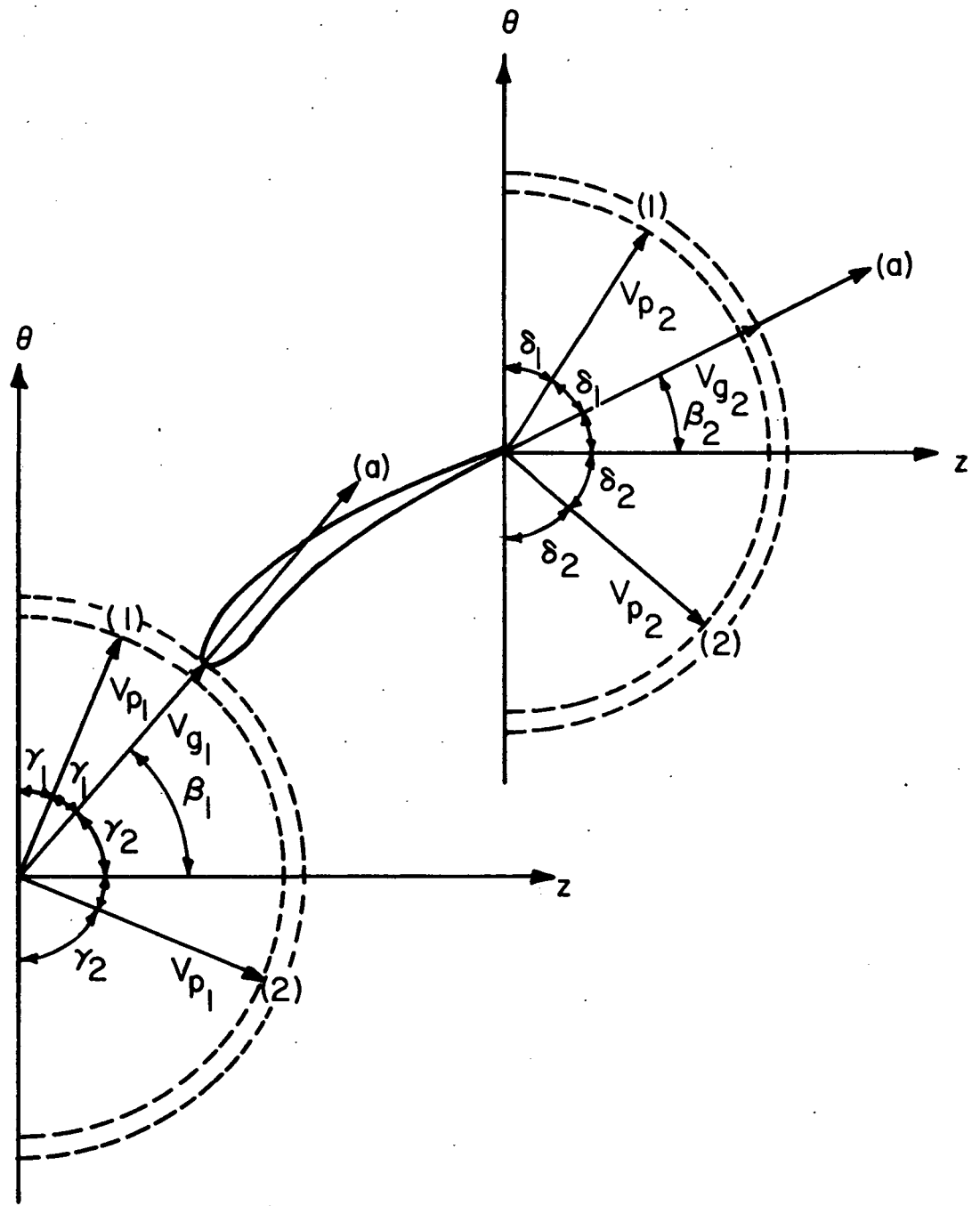


Fig. A.3.2 Model for Motion of Large Droplet

given by the relation,

$$V_{g1} = V_{p1} \cos \gamma_2$$

In Fig. A.3.2, the blade outlet conditions are also shown. As at the blade inlet section the relative velocities between the gas phase and droplets of subclasses (1) and (2) may be written as follows:

$$V_{g2} - V_{p1} \cos \delta_1 \text{ for subclass (1), and}$$

$$V_{g2} - V_{p2} \cos \delta_2 \text{ for subclass (2).}$$

where δ_1 is the inclination of the mean velocity vector for subclass (1) and δ_2 , the inclination of the mean velocity vector at outlet, designated V_{g2} . Once again, at the outlet section, the number of droplets in subclass (1) is proportional to angle $2\delta_1$, and the number of droplets in subclass (2) is proportional to angle $2\delta_2$, or $(180 - 2\delta_1)$. It is clear that the total number of droplets is divided into two new subclasses at the outlet, based on the directions of motion of droplets relative to the gas phase velocity. The two subclasses at the outlet are the output from the blade row for the given initial and operating conditions. Based on the foregoing model of motion of large droplets the total pressure loss coefficient due to the Stokesian drag of large water droplets in a rotor passage, $\bar{w}_{s,R}$, can be estimated as follows:

The Stokesian drag of water droplets across a rotor blade is given by

$$D = c_D \frac{1}{2} \rho_{g1} (W_{g1} - W_{p1})^2 A_p N_{d,r}$$

where W_{g1} and W_{p1} are relative velocities of gaseous phase and droplets at rotor inlet, A_p , the project area of a droplet,

and $N_{d,r}$, the number of droplets that exist in rotor passage. Referring to Fig. A.3.3, the Stokesian drag, D , can also be written as

$$D = (P_{01,r} - P_{02,r}) A_R$$

where $P_{01,r}$ and $P_{02,r}$ are total pressure at station (1) and (2) in rotor coordinate system, and A_R is the average flow area in a rotor blade passage.

From the above equations, the total pressure loss across a rotor blade due to the Stokesian drag, $\Delta P_{s,r}$ becomes

$$P_{s,R} = c_D \frac{1}{2} \rho_{g1} (W_{g1} - W_{p1})^2 A_p N_{d,R} / A_R = D / A_R$$

By definition, the total pressure loss coefficient across a rotor blade due to Stokesian drag, $\bar{\omega}_{s,R}$, can be obtained as follows:

$$\bar{\omega}_{s,R} = \frac{\Delta P_{s,R}}{1/2 \rho_1 W_{g1}^2} = c_D (W_{g1} - W_{p1})^2 A_p N_{d,R} / W_{g1}^2 A_R = \frac{D / A_R}{1/2 \rho_1 W_{g1}^2}$$

Similarly, the total pressure loss across a stator blade due to Stokesian drag, $\Delta P_{s,S}$ becomes

$$\Delta P_{s,S} = c_D \frac{1}{2} \rho_{g2} (V_{g2}^2 - V_{p2}^2) A_p N_{d,S} / A_S$$

and the total pressure loss coefficient across a stator blade due to the Stokesian drag, $\bar{\omega}_{s,S}$, can be obtained as follows:

$$\bar{\omega}_{s,S} = \frac{\Delta P_{s,S}}{1/2 \rho_2 V_2^2} = c_D (V_{g2}^2 - V_{p2}^2) A_p N_{d,S} / A_S$$

Thus, the total pressure loss across a stage due to Stokesian drag is given by

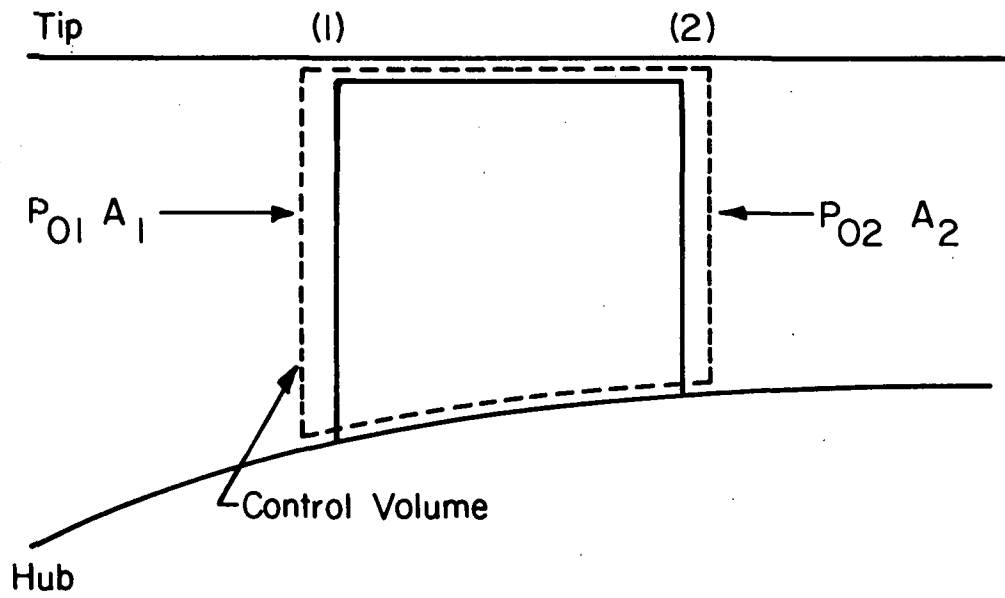


Fig. A.3.3 Control Volume across a Blade

$$\Delta P_S = \Delta P_{S,R} + \Delta P_{S,S}$$

(2) Input Variables:

ISTAGE	stage at which performance calculation is carried out
IROTOR	index for rotor or stator
DAV	nominal droplet diameter
W1	relative velocity at rotor inlet
W2	relative velocity at rotor outlet
DELV	relative velocity between gas phase and droplet
V2	absolute velocity at stator inlet
V3	absolute velocity at stator outlet
WMASS	mass flow rate of droplet
VZ	axial velocity
N	station number (Fig. 5.1)
BETA1	relative flow angle at rotor inlet
BETA2	relative flow angle at rotor outlet
ALFA2	absolute flow angle at stator inlet
ALFA3	absolute flow angle at stator outlet

(3) Output Variables:

DELVU2	relative velocity between gas phase and large droplet in subclass (1) at blade outlet
DELVL2	relative velocity between gas phase and large droplet in subclass (2) at blade outlet
OMEGRU	total pressure loss coefficient across rotor due to Stokesian drag in subclass (1)
OMEGRL	total pressure loss coefficient across rotor due to Stokesian drag in subclass (2)
OMEGSU	total pressure loss coefficient across stator due to Stokesian drag in subclass (1)
OMEGSL	total pressure loss coefficient across stator due to Stokesian drag in subclass (2)
DRAGRU	drag force due to large droplet in subclass (1)
DRAGRL	drag force due to large droplet in subclass (2)

DRAGSU drag force due to small droplet in subclass (1)
 DRAGSL drag force due to small droplet in subclass (2)
 REAVE average Reynolds number

(4) Usage:

CALL WICSTL (ISTAGE, IROTOR, DAV, W1, W2, DELV, V2, V3, WMASS,
 VZ, N, BETA1, BETA2, ALFA2, ALFA3, DELVU2, DELVL2,
 OMEGRU, OMEGRL, OMEGSU, OMEGSL, DRAGRU, DRAGRL,
 DRAGSU, DRAGSL, REAVE)

SUBROUTINE WICFML

(1) Description:

The subroutine WICFML is used for the calculation of loss due to film formed on blade surface when large droplets are present either by themselves or along with small droplets.

The momentum gained by the thick water film on the rotor blade surface is given by $\dot{m}_{film} V_{film}$ per unit blade length, where \dot{m}_{film} is the mass flow rate of water film on the rotor blade per unit blade length and V_{film} is the mean velocity of water film.

Considering the difference in viscosity between the two phases, the velocity of water film can be estimated as follows:

$$V_{film} = \frac{1}{2} \bar{W}_g \frac{\mu_g}{\mu_l}$$

where \bar{W}_g is the mean velocity of gaseous phase, and μ_g and μ_l are the viscosities of gaseous and liquid phases, respectively.

The foregoing momentum can be transformed into an equivalent drag coefficient as follows.

$$c_{D_f} = \dot{m}_{film} V_{film} / \frac{1}{2} \rho_{g1} \bar{W}_g^2 c$$

where ρ_{g1} is blade inlet density of gaseous phase, and c is the chord length of the blade.

The drag coefficient can then be expressed in the form of a total pressure loss coefficient as follows:

$$c_{D_f} \frac{1}{2} \rho_{g1} \bar{W}_{g1}^2 c = \Delta P_f \cdot s \cdot \cos \beta_m$$

where s is the blade pitch and β_m is mean flow angle. Noting that $V_z = \bar{W}_g \cos \beta_m$, one obtains the relation, namely

$$\Delta P_f / \frac{1}{2} \rho_{g1} V_z^2 = c_{D_f} \left(\frac{c}{s}\right) \frac{1}{\cos^3 \beta_m}$$

Since $\bar{W}_{g1} = V_z / \cos \beta_1$, the total pressure loss coefficient due to the momentum gained by the thick film on the rotor blade surface can be written as follows:

$$\bar{\omega}_f = \Delta P_f / \frac{1}{2} \rho_{g1} \bar{W}_{g1}^2 = c_{D_f} \left(\frac{c}{s}\right) \frac{\cos^2 \beta_m}{\cos^3 \beta_m}$$

(2) Input Variables:

WG1	flow velocity at blade inlet
WG2	flow velocity at blade outlet
FMASS	mass flow rate of water film on blade surface per unit blade length
RHOG1	density
CHORD	chord length
SIGUMA	solidity
BETA1	blade inlet flow angle
BETA2	blade outlet flow angle

(3) Output Variables:

CDF	drag coefficient
OMEGAF	total pressure loss coefficient

(4) Usage:

CALL WICFML (WG1, WG2, FMASS, RHOG1, CHORD, SIGUMA, BETA1, BETA2, CDF, OMEGAF)

SUBROUTINE WICRSL

(1) Description:

The subroutine WICRSL is used for the calculation of loss due to the rough surface when large droplets are presented either by themselves or along with small droplets.

Using the experimental results on pipes roughened with sand, L. Prandtl and H. Schlichting carried out a correlation to obtain the friction coefficient on a rough plate (Ref. 13). The correlation was based on the logarithmic velocity distribution law for rough pipes in the form, namely

$$\frac{u}{v^*} = 2.5 \ln\left(\frac{y}{k}\right) + B$$

where v^* is friction velocity; k is roughness of surface, and B is a roughness function which depends on the roughness parameter, v^*k/r .

In the completely rough regime, they obtained the following relation for the drag coefficient for a plate.

$$c_{Dr} = (1.81 + 1.62 \log_{10} \frac{x}{k})^{-2.5}$$

In the present case, x is replaced by the chord length, c , and the surface roughness k is assumed to be the same as the order of mean diameter of large droplets.

Thus, the total pressure loss coefficient due to turbulent friction over a rough film surface on a rotor becomes the following.

$$\bar{\omega}_r = c_{Dr} \left(\frac{c}{s}\right) \frac{\cos^2 \beta_1}{\cos^3 \beta_m}$$

(2) Input Variables:

SIGUMA solidity
BETA1 blade inlet flow angle

BETA2 blade outlet flow angle
CHORD chord length
DL droplet diameter

(3) Output Variables:

CDR drag coefficient
OMEGAR total pressure loss coefficient

(4) Usage:

CALL WICRSL (SIGUMA, BETA1, BETA2, CHORD, DL, CDR, OMEGAR)

SUBROUTINE WICCEN

(1) Description:

The subroutine WICCEN is used for the calculation of spanwise replacement of droplets due to centrifugal action.

Three forces act on a droplet moving through a fluid: (1) the external force consisting of gravitational and centrifugal forces; (2) the buoyancy force, which acts parallel to the external force, but in the opposite direction; and (3) the drag force, which appears whenever there is relative motion between the droplet and the fluid, and acts parallel to the direction of motion but in the opposite direction. In the present case, the direction of motion of a droplet relative to the fluid is not parallel to the direction of the external and buoyant forces, and therefore the drag force makes an angle with the other two forces. However, under the one-dimensional approximation, the lines of action of all forces acting on the droplet are co-linear and therefore the forces may be added in obtaining a balance of momentum, as follows:

$$\frac{m}{g_c} \frac{du}{dt} = F_e - F_b - F_D$$

where F_e , F_b and F_D are the external, buoyancy and drag forces respectively.

The external force can be expressed as the product of mass and acceleration, a_e , of the droplet due to this force, and therefore

$$F_e = \frac{m}{g_c} a_e$$

In the present case, because of the large rotor speeds, the centrifugal acceleration is far larger than the gravitational acceleration. Thus

$$a_e = r\omega^2$$

where r is the radius and ω , the angular velocity. The acceleration can also be written as follows:

$$a_e = V_\theta^2/r$$

where V_θ is the circumferential velocity of the droplet. For droplets passing through a rotor blade passage, the circumferential component of the relative velocity, W_θ , should be used in place of V_θ . When there is a large change in whirl velocity between the inlet and outlet of a blade row, a mean value of velocity may be more applicable.

The buoyancy force is, by Archimedes' Principle, the product of the mass of the fluid displaced by the droplet and the acceleration from the external force. The mass of fluid displaced is $(m/\rho_w)\rho_g$, where ρ_w is the density of water and ρ_g is the density of the surrounding fluid. The buoyancy force is then given

$$F_b = m\rho_g a_e / \rho_w g_c$$

The drag force is expressed by the relation,

$$F_d = c_D \frac{\rho_g u_2^2}{2 g_c} A_p$$

where c_D is the drag coefficient and A_p is the projected area of the droplet measured in a plane perpendicular to the direction of motion of the droplet. The drag coefficient c_D can be expressed in a general form as follows:

$$c_D = b_1 / \text{Re}^n$$

where Re is the Reynolds number based on relative velocity between gas and droplet. The constants b_1 and n are as follows.

$$b_1 = 24.0, \quad n = 1.0 \text{ when } \text{Re} < 1.9$$

$$b_1 = 18.5, \quad n = 0.6 \text{ when } 1.9 < \text{Re} < 500$$

$$b_1 = 0.44, \quad n = \text{when } 500 < \text{Re} < 200,000.$$

The equation of droplet motion then becomes the following:

$$\frac{du}{dt} = A/r - B u^{2-n}$$

where

$$A = (W_\theta)_{\text{ave}}^2 \cdot (1 - \rho_g/\rho_w),$$

$$B = 3 u^n b_1 \rho_g^{1-n} / 4 \rho_w D^{1+n}, \text{ and}$$

D being the average droplet diameter. Over a small time interval, the equation of motion can be written as follows:

$$\Delta u = (A/r - B u^{2-n}) \Delta t$$

This equation can be used to determine the radial location of a droplet in a stage as follows:

- (i) Select the initial values for u_1 and r_1 .
- (ii) Calculate the Reynolds number to determine the values of b_1 and n .
- (iii) Calculate A and B.
- (iv) Calculate the change of u during time interval Δt .
- (v) Calculate the new velocity u_2 .
$$u_2 = u_1 + \Delta u$$
- (vi) Calculate the change in location of droplet in terms of Δr .
$$\Delta r = (u_1 + u_2) / 2.0 \cdot \Delta t$$
- (vii) Calculate the new radial location.
$$r_2 = r_1 + \Delta r$$
- (viii) Repeat the calculation for new value of u_2 and r_2 and progressively extend the calculation.

The time interval should be sufficiently small in order to obtain reasonable accuracy. As stated in Section 2.1.3 in Chapter II of Reference 3, the length between the leading and trailing edges of a blade is divided into ten steps. The time interval Δt is then given by the relation, namely

$$\Delta t = \frac{\text{chord}}{V} \times \frac{1}{10}$$

where V is the velocity of mixture in the blade passage.

(2) Input Variables:

RZERO	droplet spanwise location at rotor inlet
VZERO	droplet spanwise velocity at rotor inlet
DD	droplet diameter
VZ	axial velocity
DELZZ	axial length of a stage
ALFAAV	average flow angle
FN	rotor blade rotational speed

IRS	index for rotor or stator
RHOGAS	density
RHUB	radius at hub
XG	mass fraction of gas phase
XA	mass fraction of dry air
XVV	mass fraction of vapor
XCH4	mass fraction of methane
RTIPIN	radius at blade tip
IPRINT	index for printout

(3) Output Variables:

R2	droplet spanwise location blade outlet
U2	droplet spanwise velocity at blade outlet
ITIP	index for droplet spanwise location
VZTIME	time in which flow pass through a stage

(4) Usage:

CALL WICCEN (RZERO, VZERO, DD, VZ, DELZZ, ALFAAV, FN, IRS,
RHOGAS, RHUB, R2, U2, ITIP, VZTIME, XG, XA,
XVV, XCH4, RTIPIN, IPRINT)

SUBROUTINE WICDMS

(1) Description:

The subroutine WICDMS is used for the calculation of amount of small droplets which is centrifuged.

(2) Input Variables:

IPRINT	index for printout
IRAD	index for spanwise location
AMASW1	mass flow rate of water at rotor inlet
AMASWT	mass flow rate of droplet
AMASW	mass flow rate of droplet
R1	droplet spanwise location rotor inlet
R2	droplet spanwise location at rotor outlet
STAREA	streamtube area
RSTAVE	radius of streamtube at its center
RTIP	radius at blade tip

(3) Output Variables:

DMIN amount of water that is centrifuged and enters
 into a streamtube
DMOUT amount of water that is centrifuged and leaves
 from a streamtube
AMASW2 mass fraction of water at rotor outlet after
 correction for centrifugal action
DELMAS net amount of water that is centrifuged

(4) Usage:

CALL WISDMS (IPRINT, IRAD, AMASW1, AMASWT, AMASW, R1, R2,
 STAREA, RSTAVE, RTIP, DMIN, DMOUT, AMASW2, DELMAS)

SUBROUTINE WICDML

(1) Description:

The subroutine WICDML is used for the calculation of amount
of large droplets which is centrifuged.

(2) Input Variables:

IPRINT index for printout
IRAD index for spanwise location
AMASW1 mass flow rate of water at rotor inlet
AMASWT mass flow rate of droplet
AMASW mass flow rate of droplet
R1 droplet spanwise location rotor inlet
R2 droplet spanwise location at rotor outlet
STAREA streamtube area
RSTAVE radius of streamtube at its center
RTIP radius at blade tip

(3) Output Variables:

DMIN amount of water taht is centrifuged and enters
 into a streamtube
DMOUT amount of water that is centrifuged and left
 from a streamtube
AMASW2 mass fraction of water at rotor outlet after
 correction for centrifugal action

- DELMAS net amount of water that is centrifuged
- (4) CALL WICDML (IPRINT, IRAD, AMASW1, AMASWT, AMASW, R1, R2, STAREA, RSTAVE, RTIP, DMIN, DMOUT, AMASW2, DELMAS)

SUBROUTINE WICDRG

(1) Description:

The subroutine WICDRG is used for the calculation of drag force on droplet.

(2) Input Variables:

D droplet nominal diameter
 DELV1 relative velocity between droplet and gas phase at blade inlet
 RHGAS1 density of gas phase at blade inlet
 RHGAS2 density of gas phase at blade outlet

(3) Output Variables:

CD2 drag coefficient
 DEVL2 relative velocity between droplet and gas phase at blade outlet
 DRAG1 drag force
 RE Reynolds number

(4) Usage:

CALL WICDRG (D, DELV1, RHGAS1, RHGAS2, CD2, DEVL2, DRAG1, RE)

SUBROUTINE WICMAC

(1) Description:

Subroutine WICMAC calculates the Mach number in the gas-water droplet mixture. First the acoustic speed in gaseous phase is determined by iteration as follows:

- (i) Assume Mach number and calculate static temperature and density.

$$t = \left(1 + \frac{\gamma - 1}{2} M^2 \right)^{-1} T_{01}$$

$$\rho = \left(1 - \frac{\gamma-1}{2} M^2 \right)^{-1/(\gamma-1)} P_{01}/RT_{01}$$

(ii) Calculate acoustic speed in gaseous phase

$$a_g = (\gamma R t_{g_c})^{0.5}$$

(iii) Calculate the axial velocity

$$V_z = \dot{m}/\rho A$$

(iv) Calculate absolute velocity

$$V_1 = V_z / \cos \alpha_1$$

(v) Calculate Mach number

$$M_1 = V_1 / a_g$$

Compare the calculated Mach number with the assumed value in (i). Iterate steps (i) to (v) until the desired accuracy is obtained. After determining the acoustic speed in gaseous phase, Function WICASD is called to determine the acoustic speed in droplet-laden gas flow.

(2) Input Variables:

ISTAGE	stage number
AMASSM	mixture mass flow rate
TOIG	total temperature of gaseous phase
PRES	total pressure
XW1	total water content
ALFA	stator outlet angle of the previous stage
RMIX	gas content of gaseous phase
CPMIX	specific heat at constant pressure for gaseous phase
AREA1	streamtube area of IGV outlet

(3) Output Variables:

M	Mach number
---	-------------

VZ axial velocity
 C acoustic speed in mixture

(4) Usage:

CALL WICMAC (ISTAGE, AMASSM, TOIG, PRES, M, VZ, C, XW1,
 ALFA, RMIX, CPMIX, AREA1)

FUNCTION WICASD

(1) Description:

Function WICASD calculates the acoustic speed in droplet-laden gas flow. The following equation is used (Ref. 14).

$$a = \left\{ \left\{ (1 - \sigma_v) \rho_g + \sigma_v \rho_w \right\} \left\{ \frac{1 - \sigma_v}{\rho_g a_g^2} + \frac{\sigma_v}{\rho_w a_w^2} \right\} \right\}^{-1/2}$$

where

a_g = acoustic speed in gaseous phase

a_w = acoustic speed in water

ρ_g = density of gaseous phase

ρ_w = density of water

σ_v = particulate liquid volume fraction

x_w = particulate liquid mass fraction

$$\sigma_v = x_w \rho_g / \left[\rho_w - x_w (\rho_w - \rho_g) \right]$$

(2) Input Variables:

XW total water content

RHOG density of gas phase

CG acoustic speed of gaseous phase

(3) Output Variable:

WICASD acoustic speed in gas-water droplet mixture

(4) Usage:

WICASD (XW, RHOG, CG)

FUNCTION WICED

(1) Description:

Function WICED is called in Subroutine WICGSL. The equivalent diffusion ratio is obtained from the following equation.

$$D_{eq} = \frac{\cos\beta_2}{\cos\beta_1} \frac{V_{z1}}{V_{z2}} \left(1.12 + k (i - i^*)^{1.43} + 0.61 \frac{\cos\beta_1}{\sigma} K \right) \cdot AK3$$

where

$$K = \tan\beta_1 - \frac{r_2}{r_1} \frac{V_{z2}}{V_{z1}} \tan\beta_1 - \frac{\omega r_1}{V_{z1}} \left(1 - \frac{r_2^2}{r_1^2} \right)$$

and where $k = 0.0117$ for NACA 65 (A_{10}) blades and $k = 0.007$ for the C4 airfoils.

(2) Input Variables:

AK3	constant, normally one
VZ1	axial velocity at blade inlet
VZ2	axial velocity at blade outlet
UR1	rotor blade speed at rotor inlet
R1	radius at blade inlet
R2	radius at blade outlet
BET1	blade inlet flow angle
BET2	blade outlet flow angle
SIGUMA	solidity
AINCIS	incidence at design point
AINCI	incidence

(3) Output Variable:

WICED	equivalent diffusion ratio
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(4) Usage:

WICED (AK3, VZ1, VZ2, UR1, R1, R2, BET1, BET2, SIGUMA, AINCIS, AINCI)

FUNCTION WICMTK

(1) Description:

Function WICMTK is called in Subroutine WICGSL. The ratio of wake momentum thickness and chord are obtained from the following equations.

$$\left(\frac{\theta}{c}\right) = \left(\frac{\theta}{c}\right)^* + (0.827 M_1 - 2.692 M_1^2 + 2.675 M_1^3) (D_{eq} - D_{eq}^*)^2 \cdot AK2$$

$$\text{for } D_{eq} > D_{eq}^*$$

$$\left(\frac{\theta}{c}\right) = \left(\frac{\theta}{c}\right)^* + (2.80 M_1 - 8.71 M_1^2 + 9.36 M_1^3) (D_{eq} - D_{eq}^*) \cdot AK2$$

$$\text{for } D_{eq} < D_{eq}^*$$

(2) Input Variables:

AK2	constant, normally one
SITACS	ratio of wake momentum thickness to chord at design point
AMACH1	blade inlet Mach number
DELDEQ	difference between equivalent diffusion ratio and equivalent diffusion ratio at design point

(3) Output Variables:

WICMTK	ratio of wake momentum thickness to chord
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(4) Usage:

WICMTK (SITACS, AMACH1, DELDEQ, AK2)

FUNCTION WICLOS

(1) Description:

Function WICLOS is called in Subroutine WICGSL and calculates the total pressure loss coefficient from the following equation:

$$\bar{\omega} = \left(\frac{\theta}{c}\right) \frac{2\sigma}{\cos\beta_2} \left(\frac{\cos\beta_1}{\cos\beta_2}\right)^2$$

(2) Input Variables:

BET1 blade inlet flow angle
BET2 blade outlet flow angle
SIGUMA solidity
SITA ratio of momentum thickness to chord

(3) Output Variable:

WICLOS total pressure loss coefficient

(4) Usage:

WICLOS (BET1, BET2, SIGUMA, SITA)

SUBROUTINE WICIRS

(1) Description:

Subroutine WICIRS is called at outlet of rotor and performs the calculation of droplet impingement and rebound in rotor passage for small droplet.

(2) Input Variables:

ISTAGE stage number
R blade radius of streamline
XW1 mass fraction of small droplet
XG mass fraction of gaseous phase
RHOG1 density of gaseous phase
BETA1 rotor inlet relative flow angle
W1 rotor inlet relative velocity

(3) Output Variables:

WW1 amount of water that impacts stagnation
WW2 amount of water that impact aft of blade
WW total amount of water that impact blade

(4) Usage:

CALL WICIRS (ISTAGE, R, XW1, XG, RHOG1, BETA1, W1, WW1, WW2,
 WW)

SUBROUTINE WICIRL

(1) Description:

Subroutine WICIRL is called at outlet of rotor and performs the calculation of droplet impingement and rebound in rotor passage for large droplet.

(2) Input Variables:

ISTAGE stage number
R blade radius of streamline
XW1 mass fraction of large droplet
RHOG1 density of gaseous phase
BETA1 rotor inlet relative flow angle
W1 rotor inlet relative velocity

(3) Output Variables:

WW1 amount of water that impacts upper surface of
 blade
WW2 amount of water that impact lower surface of
 blade
WW total amount of water that impact blade surface

(4) Usage:

CALL WICIRL (ISTAGE, R, XW1, XG, RHOG1, BETA1, W1, WW1,
 WW2, WW)

SUBROUTINE WICISS

(1) Description:

Subroutine WICISS is called outlet of stator and performs the calculation of droplet impingement and rebound in stator passage for small droplet.

(2) Input Variables:

ISTAGE stage number
R blade radius at streamline
XW mass fraction of small droplet
XG mass fraction of gaseous phase
RHOG1 density of gaseous phase

ALFA2 stator inlet absolute flow angle
W1 stator inlet absolute velocity

(3) Output Variables:

WW1 amount of water that impact stagnation region
 of blade
WW2 amount of water that impact off of blade
WW total amount of water that impact the blade

(4) Usage:

CALL WICISS (ISTAGE, R, XW, XG, RHOG1, ALFA2, W1, WW1, WW2,
 WW)

SUBROUTINE WICISL

(1) Description:

Subroutine WICISL is called at outlet of stator and performs the calculation of droplet impingement and rebound in stator passage for large droplet.

(2) Input Variables:

ISTAGE stage number
R blade radius at streamline
XW mass fraction of large droplet
XG mass fraction of gaseous phase
RHOG1 density of gaseous phase
ALFA2 stator inlet absolute flow angle
W1 stator inlet absolute velocity

(3) Output Variables:

WW1 amount of water that impact upper surface of
 blade
WW2 amount of water that impact lower surface of
 blade
WW total amount of water that impact on blade
 surface

- (4) Usage: CALL WICISL (ISTAGE, R, XW, XG, RHOG1, ALFA2, W1, WW1, WW2, WW)

SUBROUTINE WICWAK

(1) Description:

Subroutine WICWAK is called at rotor outlet and stator outlet, and calculates the droplet size of water that is re-entrained at trailing edge of rotor and stator blades.

The size of droplet which is re-entrained into the wake at the blade trailing edge is calculated as follows:

(i) Assume a value for a droplet diameter, d , that is re-entrained into wake.

(ii) Calculate the stability number, SN.

$$SN = \mu_f^2 / \rho_g \sigma d g_c$$

(iii) Calculate the critical Weber number

$$W_e = 12 \left[1 + (SN)^{0.36} \right]$$

(iv) Calculate the largest stable droplet diameter

$$d_{\max} = \frac{W_e}{\rho_g} \frac{\sigma g_c}{V_g^2}$$

(v) Compare the assumed droplet diameter with the calculated one. Iterate entire steps until the satisfactory agreement is obtained.

(2) Input Variables:

RHOG density of gaseous phase

V velocity of gaseous phase for small droplet or relative velocity between droplet and gaseous phase for large droplet

(3) Output Variables:

DWAKE droplet size that re-entrained at trailing edge
 in (ft³)

DWAKEM droplet size that re-entrained at trailing edge
 in (μm)

(4) Usage:

CALL WICWAK (RHOG, V, DWAKE, DWAKEM)

SUBROUTINE WICHET

(1) Description:

Subroutine WICHET is called at end of stage to perform the heat transfer calculation between water droplet and gaseous phase. The heat transfer rate can be determined from the following equation:

$$\frac{dh}{dt} = h_h A (T_g - T_w)$$

where h_h is the heat transfer coefficient, A , the droplet surface area, T_w , the droplet surface temperature, and T_g , the temperature of the surrounding gas. The heat transfer coefficient can be expressed as follows:

$$h_h = \frac{k_a}{D_d} \cdot Nu$$

where k_a is the thermal conductivity of air, and Nu , the Nusselt number. The Nusselt number can be expressed in terms of the dimensionless groups as follows (Ref. 16):

$$Nu = 2.0 + 0.6 (Re)^{0.50} (Pr)^{0.33}$$

where Re is the Reynolds number based on the relative velocity between the droplet and the surrounding air, and Pr is the Prandtl number.

After calculating the temperature rise of the water and gas phase due to the work done by the rotor, the heat transfer

calculation is carried out as follows:

- (i) Calculate the average droplet diameter, D_d .
- (ii) Calculate the number of droplets, N_d .

$$N_d = \frac{\dot{m}_w}{\rho_w \frac{4}{3} \pi (D_d/2)^3} \cdot \frac{\Delta z}{V_z}$$

where \dot{m}_w is the mass flow rate of water phase, ρ_w , the density of water, V_z , the axial direction velocity, and Δz , the axial length of one stage.

- (iii) Calculate the droplet surface area, A .
- (iv) Calculate the Nusselt number, Nu .
- (v) Calculate the heat transfer coefficient, h_h .
- (vi) Calculate the stage outlet temperature for droplet and gas without heat transfer, that is

$$T_{g2} = T_{g1} + (\Delta T_g)_{wk}$$

$$T_{w2} = T_{w1} + (\Delta T_w)_{wk}$$

where $(\Delta T_g)_{wk}$ and $(\Delta T_w)_{wk}$ are the temperature rise of gas and water due to work done by rotor.

- (vii) Calculate the amount of heat transferred from the gas to the droplet.

$$\Delta H = h_h A (T_{g2} - T_{w2})$$

- (viii) Calculate the temperatures rise of the droplet and the temperature drop of the surrounding gas.

$$(\Delta H_g)_{ht} = H/m_g C_s$$

$$(\Delta H_w)_{ht} = H/m_w C_w$$

where C_w is the specific heat for water and C_s is the humid heat for air-water mixture.

- (ix) Calculate the stage outlet temperature for droplet and gas.

$$T_{g2} = T_{g1} + (\Delta T_g)_{wk} - (\Delta T_g)_{ht}$$

$$T_{w2} = T_{w1} + (\Delta T_w)_{wk} + (\Delta T_w)_{ht}$$

- (x) Using the temperature calculated in step (ix), repeat the steps (vii) to (ix) until a desired accuracy is obtained.

(2) Input Variables:

TG1	temperature of gaseous phase at stage inlet
TG3	temperature of gaseous phase at stage outlet
TW1	temperature of droplet at stage inlet
TW3	temperature of droplet at stage outlet
DAVEN2	droplet nominal diameter at stage inlet
DAVEN	droplet nominal diameter at stage outlet
DELZI	length of stage
VZ	axial velocity
WMASS1	mass flow rate of water
VMASS1	mass flow rate of vapor
AMASS	mass flow rate of dry air
CHMASS	mass flow rate of methane
CPG	specific heat constant pressure to gaseous phase
CPW	specific heat of water
RE	Reynolds number based on relative velocity between droplet and gaseous phase

(3) Output Variables:

DELIGH	temperature drop in gaseous phase due to heat transfer between water droplet and gaseous phase
DELTWH	temperature rise in droplet due to heat transfer between water droplet and gaseous phase

(4) Usage:

CALL WICHET (TG1, TG3, TW3, DAVEN2, DAVEN, DELZI, VZ, WMASS1,
VMASS1, AMASS, CHMASS, CPG, CPW, DELIGH, DELTWH,
RE)

SUBROUTINE WICMAS

(1) Description:

Subroutine WICMAS is called at end of stage to perform the mass transfer calculation between water droplet and gas phases.

The mass transfer rate can be calculated by the following equation:

$$\frac{dm}{dt} = h_m A (C_{wb} - C_w)$$

where h_m is the mass transfer coefficient, A , the droplet surface area, C_{wb} , the water vapor concentration at droplet surface, and C_w , the water vapor concentration in fluid flow around droplet.

Since the density represents the mass concentration, and the vapor is almost a perfect gas, the mass transfer rate can be expressed in terms of vapor pressure as follows:

$$\frac{dm}{dt} = h_m A (\rho_{wb} - \rho_w)$$

or

$$\frac{dm}{dt} = h_m A \left(\frac{P_{wb}}{T_{wb}} - \frac{P_w}{T_w} \right) \cdot \frac{T}{R_v}$$

where R_v is the gas constant for water vapor, P_{wb} , the vapor pressure at droplet surface, P_w , the vapor pressure in fluid flowing around droplet, T_{wb} , the vapor temperature at droplet surface, and T_w , the vapor temperature in fluid flowing around droplet.

The surface area, A , for the droplet cloud is given by the relation,

$$A = \pi D_d^2 N_d$$

where D_d is the average droplet diameter, and N_d , the number of droplets.

The mass transfer coefficient, h_m is expressed as follows:

$$h_m = \frac{D_v}{D_d} \cdot Sh$$

A semi-empirical equation for the diffusion coefficient in gases is given by the following (Ref. 15):

$$D_v = 435.7 \frac{T^{3/2}}{p(V_A^{1/3} + V_B^{1/3})^2} \left(\frac{1}{M_A} + \frac{1}{M_B} \right)^{1/2}$$

where D_v is in square centimeters per second, T is in degree Kelvin, p is the total system pressure in Newtons per square meter, and V_A and V_B are the molecular volumes of constituents A and B as calculated from the atomic volumes. M_A and M_B are the molecular weights of constituents A and B. For water-air systems, the numerical values of V_A , V_B , M_A , and M_B are given as follows:

$$V_A = V_{\text{air}} = 29.9 \quad M_A = M_{\text{air}} = 28.9$$

$$V_B = M_{\text{water}} = 18.8 \quad M_B = M_{\text{water}} = 18.0$$

When the relative velocity between a single droplet and the surrounding fluid approaches zero, the following relationship is used to determine the mass transfer rate: $Sh = 2.0$.

Mass transfer rates increase with increase in relative velocity between the droplet and the surrounding air due to the additional mass transfer caused by the convection in the boundary layer around the droplet. The mass transfer coefficient from a spherical droplet can be expressed in terms of dimensionless groups

as follows:

$$Sh = 2.0 + k (Re)^x (Sc)^y$$

where Re is the Reynolds number based on relative velocity, which expresses the ratio of inertial force to viscous force, and Sc is the Schmidt number, which expressed the ratio of kinetic viscosity to molecular diffusivity.

There is much discussion over the values of x, y, and k. The form most widely applied is the Ranz and Marshall equation (Ref. 16) which is:

$$Sh = 2.0 + 0.6 (Re)^{0.50} (Sc)^{0.33}$$

The procedure for determining the mass transfer rate is as follows.

- (i) Calculate the Sherwood number, Sh.
- (ii) Calculate the diffusion coefficient, D_v .
- (iii) Calculate the average droplet size, D_d .
- (iv) Calculate the mass transfer coefficient, h_m .
- (v) Calculate the total number of droplets, N_d .
- (vi) Calculate the total surface area for all droplets.
- (vii) Calculate the water vapor pressure at droplet surface, P_{wb} , based on the droplet surface temperature, T_s .
- (viii) Assume the vapor pressure, p_w , and set $p_w = (p_w)_a$.
- (ix) Calculate the mass transfer rate, $\frac{dm}{dt}$.
- (x) Calculate the new value of water mass flow rate.

$$\dot{m}_w = \dot{m}_v = \frac{dm}{dt}$$

- (xi) Calculate the new value of vapor mass flow rate.

$$\dot{m}_v = \dot{m}_v + \frac{dm}{dt}$$

(xii) Calculate the specific humidity, W .

$$W = \dot{m}_v / \dot{m}_a$$

where \dot{m}_a is the air mass flow rate.

(xiii) Calculate the vapor pressure.

(xiv) Compare the calculated value, $(p_w)_c$, with the assumed value $(p_w)_a$. If $(p_w)_c$ agrees reasonably well with the assumed value $(p_w)_a$ proceed to step (xv). Otherwise, steps (viii) to (xiv) should be repeated.

(xv) Using the determined p_w , the mass transfer rate is calculated. Also, the specific humidity can be determined by the following equation:

$$W = 0.6219 \frac{p_w}{p - p_w}$$

(2) Input Variables:

HW1	specific humidity at stage inlet
TW1	temperature of droplet at stage inlet
TW2	temperature of droplet at stage outlet
PP1	pressure of gaseous phase stage inlet
PP2	pressure of gaseous phase at stage outlet
TG1	temperature of gaseous phase at stage inlet
TG2	temperature of gaseous phase at stage outlet
DZ	length of stage
VZ	axial velocity
DDAVE1	droplet nominal diameter at stage inlet
DDAVE2	droplet nominal diameter at stage outlet
AMASS	mass flow rate of air
RE	Reynolds number based on relative velocity between droplet and gaseous phase
VMASS1	mass flow rate of water vapor at stage inlet
WMASS1	mass flow rate of water droplet at stage outlet

(3) Output Variables:

HW2 specific humidity at stage outlet
VMASS2 mass flow rate of water vapor at stage outlet
WMASS2 mass flow rate of water droplet at stage outlet
DMDTAV average mass transfer rate across stage

(4) Usage:

CALL WICMAS (HW1, TW1, TW2, PP1, PP2, TG1, TG2, DZ, PWB1,
PWB2, PW1, PW2, VZ, DDAVE1, DDAVE2, HW2, VMASS1,
VMASS2, WMASS1, WMASS2, DMDTAV, AMASS, RE)

FUNCTION WICMTR

(1) Description:

Function WICMTR is called in Subroutine WICMTR and calculates the mass transfer rate.

(2) Input Variables:

TTG temperature of gaseous phase
TTW temperature of water droplet
PPP pressure of gaseous phase
DAVW droplet nominal diameter
VZ axial velocity
DZ length of stage
MMASS mass flow rate of mixture
PW vapor pressure
RE Reynolds number based on relative velocity
 between droplet and gaseous phase

(3) Output Variable:

DMDT mass transfer rate

(4) Usage:

WICMTR (TTG, TTW, PPP, DAVE, VZ, DZ, MMASS, PW, RE)

FUNCTION WICPWB

(1) Description:

Function WICPWB calculates the saturation pressure for water vapor is a function at temperature as follows:

$$\log_{10} p_s = A - B/T$$

where units are (Kg/cm^2) for p_s and (K) for T. The values of constant A and B are given as follows:

$$A = 5.97780, \quad B = 2224.4 \text{ when } 20^\circ \text{C} < T < 100^\circ \text{C}$$

$$A = 5.64850, \quad B = 2101.1 \text{ when } 100^\circ \text{C} < T < 200^\circ \text{C}$$

$$A = 5.45142, \quad B = 2010.8 \text{ when } 200^\circ \text{C} < T < 350^\circ \text{C}$$

(2) Input Variable:

TWB temperature of gaseous phase

(3) Output Variable:

WICPWB saturation pressure for water vapor

(4) Usage:

WICPWB (TWB)

FUNCTION WICNEW

(1) Description:

Function WICNEW is used to estimate the new trial value in the iteration procedure.

(2) Input Variables:

X1 first trial value

Y1 calculated value corresponds to X1

X2 second trial value

Y2 calculated value corresponds to X2

(3) Output Variable:

WICNEW new trial value

(4) Usage:

WICNEW (X1, Y1, X2, Y2)

FUNCTION WICTAN

- (1) Description:
Function WICTAN(X) is used to obtain the ratio of SINE(X) to COSINE(X), that is, TAN(X).
- (2) Input Variable:
X angle
- (3) Output Variable:
WICTAN value of TAN(X)
- (4) Usage:
WICTAN(X)

FUNCTION WICBPT

- (1) Description:
Function WICBPT calculates the temperature at boiling point.
- (2) Input Variables:
TSTAG temperature
PSTAG pressure
- (3) Output Variable:
WICBPT temperature at boiling point
- (4) Usage:
WICBPT (TSTAG, PSTAG)

FUNCTION WICSH

- (1) Description:
Function WICSH calculates the specific humidity.
- (2) Input Variables:
TSTAG temperature
PSTAG pressure
- (3) Output Variable:
WICSH specific humidity

- (4) Usage:
WICSH (TSTAG, PSTAG)

SUBROUTINE WICSIZ

(1) Description:

Subroutine WICSIZ is called at outlet of rotor and stator to determine the nominal droplet sizes. It is assumed that two kinds of droplets exist at inlet of compressor; namely, small droplet and large droplet. However, at trailing edge of each blade, the new droplets are re-entrained into blade wake. The droplets which are larger than DLIMIT are treated as large droplets and droplets which are smaller than DLIMIT are treated as small droplets. Each droplet size weighted based on its mass fraction in determining the nominal droplet size. Therefore, at outlet of each blade row, Subroutine WICSIZ gives two nominal diameters; one for small droplet and one for large droplet. It may be noted that only two classes of droplets are recognized in the model.

(2) Input Variables:

WMASSL	mass flow rate of large droplet
WMASSS	mass flow rate of small droplet
AMING1	amount of water which is to be re-entrained into wake, originally small droplet
AMING2	amount of water which is to be re-entrained into wake, originally large droplet and upper part
AMING3	amount of water which is to be re-entrained into wake, originally large droplet and lower part
DL	droplet nominal size for large droplet before impingement
DS	droplet nominal size for small droplet before impingement
D1	droplet size associated with AMING1

D2 droplet size associated with AMING2
D3 droplet size associated with AMING3
DLIMIT largest droplet diameter which can be treated
 as small droplet

(3) Output Variables:

AMSL mass flow rate of small droplet after re-entrain-
 ment
AMLGE mass flow rate of large droplet after re-entrain-
 ment
DSLL droplet nominal size for small droplet
DLGE droplet nominal size for large droplet

(4) Usage:

CALL WICSIZ (WMASL, WMASS, AMING1, AMING2, AMING3, DL, DS,
 D1, D2, D3, DLIMIT, AMSL, AMLGE, DSLL, DLGE)

SUBROUTINE WICPRP

(1) Description:

Subroutine WICPRP determines the flow properties such as gas constant specific, heat ratio, and specific heat at constant pressure for the gaseous mixture. The working equations are as follows:

$$R_{mix} = x_a \cdot R_a + x_v \cdot R_v + x_c \cdot R_c$$

$$c_{pmix} = x_a \cdot c_{pa} + x_v \cdot c_{pv} + x_c \cdot c_{pc}$$

$$\gamma_{mix} = \left(1.0 - \frac{R_{mix}}{c_{pmix} J} \right)^{-1}$$

where

x_a = mass fraction of air in gaseous mixture

x_v = mass fraction of water vapor in gaseous mixture

x_c = mass fraction of methane in gaseous mixture

$$x_a + x_v + x_c = 1$$

R_a = gas constant of air

R_v = gas constant of water vapor

R_c = gas constant of methane

R_{mix} = gas constant of mixture

c_{pa} = specific heat constant pressure for air

c_{pv} = specific heat constant pressure for water vapor

c_{pc} = specific heat at constant pressure for methane

c_{pmix} = specific heat at constant pressure for mixture

r_{mix} = specific heat ratio for mixture

(2) Input Variables:

XAIR	mass fraction of air in gaseous mixture
XH2O	mass fraction of water vapor in gaseous mixture
XCH4	mass fraction of methane in gaseous mixture
T	temperature of gaseous mixture

(3) Output Variables:

RMIX	gas constant of gaseous mixture
CPMIX	specific heat constant pressure for gaseous mixture
GAMMA	specific heat ratio of gaseous mixture
G1	value for $GAMMA/(GAMMA - 1.0)$
G2	value for $(GAMMA - 1.0)/2.0$
G3	value for $-1.0/(GAMMA - 1.0)$

(4) Usage:

CALL WICPRP (XAIR, XH2O, XCH4, T, RMIX, CPMIX, GAMMA, G1, G2, G3)

FUNCTION WICCPA

(1) Description:

Function WICCPA calculates the specific heat at constant pressure for air as a function of temperature as follows (Ref. 17):

$$c_p = (a + aT + cT^2 + dT^3 + eT^4)R$$

where units are (J/kg - K) for c_p , (K) for T, and (J/kg - K) for R. The values of coefficients a, b, c, d, and e are as follows:

$$\begin{aligned}a &= 3.65359 \\b &= -1.33736 \times 10^{-3} \\c &= 3.29421 \times 10^{-6} \\d &= -1.91142 \times 10^{-9} \\e &= 0.275462 \times 10^{-12}\end{aligned}$$

(2) Input Variable:

T temperature

(3) Output Variable:

WICCPA specific heat constant pressure

(4) Usage:

WICCPA (T)

FUNCTION WICCPH

(1) Description:

Function WICCPH calculates the specific heat at constant pressure for water vapor as a function of temperature as follows (Ref. 17):

$$c_p = (a + bT + cT^2 + dT^3 + eT^4)R$$

where units are (J/kg - K) for c_p , (K) for T, and (J/kg - K) for R. The values of coefficients a, b, c, d, and e are as follows:

$$\begin{aligned}a &= 4.07013 \\b &= -1.10845 \times 10^{-3} \\c &= 4.15212 \times 10^{-6} \\d &= -2.96374 \times 10^{-9} \\e &= 0.807021 \times 10^{-12}\end{aligned}$$

(2) Input Variable:

T temperature

(3) Output Variable:

WICCPH specific heat at constant pressure

(4) Usage:

WICCPH (T)

FUNCTION WICCPH

(1) Description:

Function WICCPH calculates the specific heat at constant pressure for methane as a function of temperature as follows (Ref. 17):

$$c_p = (a + bT + cT^2 + dT^3 + eT^4)R$$

where units are (J/kg - k) for c_p , (K) for T, and (J/kg - K) for R. The values of coefficients a, b, c, d, and e are as follows:

$$a = 3.82619$$

$$b = -3.97946 \times 10^{-3}$$

$$c = 24.5583 \times 10^{-6}$$

$$d = -22.7329 \times 10^{-9}$$

$$e = 6.92760 \times 10^{-12}$$

(2) Input Variable:

T temperature

(3) Output Variable:

WICCPH specific heat constant pressure

(4) Usage:

WICCPH (T)

APPENDIX 4

PROGRAM SOURCE LIST

MNFFTN(E=3)

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1. 000000B      PROGRAM MAIN(INPUT,OUTPUT,TAPES=INPUT,TAPES=OUTPUT)
C+++++
C PROGRAM PURDU-WINCOF
C+++++
C ABSTRACT:
C THIS PROGRAM CODE HAS BEEN PRODUCED FOR THE STUDY OF AN AXIAL FLOW
C FAN-COMPRESSOR PERFORMANCE DURING A GAS-WATER DROPLET MIXTURE FLOW.
C THE MIXTURE MAY CONSIST OF TWO TYPES OF DROPLET SIZES AND THREE
C KINDS OF GASEOUS PHASES.THIS PROGRAM CODE IS WRITTEN ESPECIALLY
C FOR AIR+WATER-VAPOR+METHANE+SMALL DROPLET+LARGE DROPLET.
C THIS FORTRAN COMPUTER CODE CAN PREDICT THE DESIGN AND OFF-DESIGN
C PERFORMANCE UTILIZING A STAGE-BY-STAGE CALCULATION.
C THIS COMPUTER PROGRAM CODE HAS BEEN DEVELOPED AT PURDUE UNIVERSITY,
C THERMAL SCIENCE AND PROPULSION CENTER,WEST LAFAYETTE,INDIANA 47906.
C THE AUTHOR OF THIS PROGRAM CODE IS TOSHIAKI TSUCHIYA,
C PURDUE UNIVERSITY , DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS,
C GRADUATE INSTRUCTOR IN RESEARCH.
C +++++
C+++++
2. 002131B      REAL ND,NU,KA,M,MMASS,MMASS1
3. 002131B      REAL MMASSO
4. 002131B      COMMON JPERFM,RHOG(3),RERUP,RERLOW,RESUP,RESLOW
      ^,PREB,RRTIP(20),SRTIP(20),AAA1,AAA2,AAA3,SAREA(20),SAREAS(20)
      ^,P(3),TG(3),XA,XU(3),XCH4,XW(3),XWW(3),XWT(3),TW(3),TWW(3)
      ^,OMEGS(20),OMEGR(20),GAPR(20),GAPS(20)
      ^,RRHUB(20) , RC(20) , RBLADE(20) , STAGER(20)
      ^,SRHUB(20) , SC(20) , SBLADE(20),STAGES(20)
      ^,SIGUMR(20) , BET1SR(20) , BET2SR(20) , AINCSR(20) , ADEUSR(20)
      ^,SIGUMS(20) , BET1SS(20) , BET2SS(20) , AINCSS(20) , ADEVSS(20)
      ^,UTIPG(20),UTIP(20),UTIPD(20),UOU(20),UMEAN(20),UHUB(20),U(20),FAI
      ^,AREA(20),AREAS(20),UU2(20),UTIP2(20),UMEAN2(20),UHUB2(20),IPRINT
      ^,ICENT,IICENT,FMR1(20),FMA2(20),IDESIN,FAID
      ^,NS,NSF,NSLPC,BYPASS,NS1,RT(20),RM(20),RH(20),ST(20),SM(20),SH(20)
      ^,DSMASS,AAREA(20),AAREAS(20),PR12D(20),PR13D(20),ETARD(20)
      ^,DR(20),DS(20),DEQR(20),DEQS(20),BLOCK(20),BLOCKS(20)
      ^,BET1MR(20),BET2MR(20),BET1MS(20),BET2MS(20),RADI1(20),RADI2(20)
      ^,FAIRIN(20),FAIOUT(20),ETASG(20),PSID(20),TAUD(20),SITADR(20)
      ^,SITADS(20),WWD(20),UVD(20)
5. 002131B      DIMENSION D(20,3) , XD(20,3) , XXD(20,3),
      ^,WS(3),WMASS(3),UMASS(3),RHOA(3),RHOM(3),TB(3)
6. 002131B      DIMENSION TD(20),DELZ(20),ETAA(20)
7. 002131B      DIMENSION XXA(3),XXU(3),DAVE(20)
8. 002131B      DIMENSION TDEW(3)
9. 002131B      DIMENSION DDAVE(20),WMASS(3),WTMASS(3)
10. 002131B     DIMENSION TMASS(3),GMASS(3),XAIR(3),XMETAN(3),XGAS(3),FAISTL(20)
11. 002131B     DIMENSION XBLEED(20)
12. 002131B     DIMENSION PPREF(20),TRREF(20),ETAREF(20)
C +++++
C INPUT DATA
C NS      NUMBER OF STAGE (TOTAL)
C NSF     NUMBER OF STAGE(FAN)
C NSLPC   NUMBER OF STAGE ( LOW PRESSURE COMPRESSOR )
C NSHPC   NUMBER OF STAGE ( HIGH PRESSURE COMPRESSOR )
C RRHUB(I) ROTOR INLET RUDIUS AT HUB FOR I-TH STAGE IN INCH
C RC(I)   ROTOR CHORD FOR I-TH STAGE IN INCH
C RBLADE(I) NUMBER OF ROTOR BLADE FOR I-TH STAGE

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C STAGER(I) ROTOR STAGER ANGLE FOR I-TH STAGE IN DEGREE.
C SRHUB(I) STATOR INLET RADIUS AT HUB FOR I-TH STAGE IN INCH
C SC(I) STATOR CHORD FOR I-TH STAGE IN INCH(I=NS+1,IGU)
C SBLADE(I) NUMBER OF STATOR BLADE FOR I-TH STAGE (I=NS+1 FOR IGU)
C STAGES(I) STATOR STAGER ANGLE FOR I-TH STAGE IN DEGREE (I=NS+1 FOR
C IGU)
C SIGUMR(I) SOLIDITY OF ROTOR FOR I-TH STAGE
C SIGUMS(I) SOLIDITY OF STATOR FOR I-TH STAGE
C BET2SS(I) STATOR OUTLET ABSOLUTE FLOW ANGLE AT DESIGN POINT FOR I-TH
C STAGE IN DEGREE
C FNF FRACTION OF DESIGN CORRECTED ROTOR SPEED FOR A PARTICULAR
C SPEED
C XDIN INITIAL WATER CONTENT (MASS FRACTION) OF SMALL DROPLET
C XDDIN INITIAL WATER CONTENT (MASS FRACTION) OF LARGE DROPLET
C ICENT INDEX FOR CENTRIFUGAL CALCULATION (ICENT=1 WHEN XDIN=0
C OTHERWISE ICENT=2)
C IICENT SAME AS ICENT
C ICENT=3,IICENT=3: NO HEAT AND MASS TRANSFER
C ICENT=4,IICENT=4: NO CENTRIFUGAL ACTION
C ICENT=5,IICENT=5: NO HEAT AND MASS TRANSFER;AND
C NO CENTRIFUGAL ACTION
C ICENT=6,IICENT=6: NO MASS TRANSFER
C ICENT=7,IICENT=7: NO MASS TRANSFER;AND
C NO CENTRIFUGAL ACTION
C ICENTV INDEX FOR CENTRIFUGAL ACTION OF VAPOR
C ICENTV=0: VAPOR IS CENTRIFUGED
C ICENTV=1: VAPOR IS NOT CENTRIFUGED
C TOG TOTAL TEMPERATURE AT COMPRESSOR INLET IN RANKIN
C TOW WATER DROPLET TEMPERATURE AT COMPRESSOR INLET IN RANKIN
C P0 TOTAL PRESSURE AT COMPRESSOR INLET IN LB/FT**2
C DIN INITIAL WATER DROPLET DIAMETER IN MICRON(SMALL DROPLET)
C DDIN INITIAL WATER DROPLET DIAMETER IN MICRON(LARGE DROPLET)
C FND ROTOR ROTATIONAL SPEED AT DESIGN SPEED IN RPM
C (FAN AND LOW PRESSURE COMPRESSOR)
C FNDLPC ROTOR ROTATIONAL SPEED AT DESIGN SPEED IN RPM
C (LOW PRESSURE COMPRESSOR)
C FNDHPC ROTOR ROTATIONAL SPEED AT DESIGN SPEED IN RPM
C (HIGH PRESSURE COMPRESSOR)
C TOID DESIGN VALUE FOR COMPRESSOR INLET TOTAL TEMPERATURE
C POID DESIGN VALUE FOR COMPRESSOR INLET TOTAL PRESSURE
C XCH4 INITIAL METHANE CONTENT
C RHUMID INITIAL RELATIVE HUMIDITY
C FMWA MOLECULAR WEIGHT OF AIR
C FMWV MOLECULAR WEIGHT OF WATER VAPOR
C FMWC MOLECULAR WEIGHT OF METHANE
C PREB PERCENT OF WATER THAT REBOUND AFTER IMPINGEMENT
C DLIMIT MAX. DIAMETER FOR SMALL DROPLET
C GAPR(I) GAP BETWEEN I TH STAGE ROTOR AND I-1 TH STAGE STATOR
C GAPS(I) GAP BETWEEN I TH STAGE STATOR AND I-1 TH STAGE ROTOR
C RRTIP(I) ROTOR INLET TIP RADIUS FOR I-TH STAGE
C SRTIP(I) STATOR INLET TIP RADIUS FOR I-TH STAGE
C IRAD INDEX FOR RADIUS AT WHICH CALCULATION IS CARRIED OUT
C IRAD=1: TIP
C IRAD=2: MEAN
C IRAD=3: HUB
C IRAD=4: MEAN FOR FAN AND TIP FOR LPC,HPC
C RT(I) ROTOR INLET RADIUS AT WHICH TIP PERFORMANCE CALCULATION
C IS CARRIED OUT.
C RM(I) ROTOR INLET RADIUS AT WHICH MEAN LINE PERFORMANCE
C CALCULATION IS CARRIED OUT.

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C RH(I)      ROTOR INLET RADIUS AT WHICH HUB PERFORMANCE CALCULATION
C            IS CARRIED OUT.
C ST(I)      STATOR INLET RADIUS AT WHICH TIP PERFORMANCE CALCULATION
C            IS CARRIED OUT.
C SM(I)      STATOR INLET RADIUS AT WHICH MEAN LINE PERFORMANCE
C            CALCULATION IS CARRIED OUT.
C SH(I)      STATOR INLET RADIUS AT WHICH HUB PERFORMANCE CALCULATION
C            IS CARRIED OUT.
C BLOCK(I)   BLOCKAGE FACTOR FOR I-TH STAGE ROTOR
C BLOCKS(I)  BLOCKAGE FACTOR FOR I-TH STAGE STATOR
C IDESIN     INDEX FOR OUTPUT
C            IDESIN=1: BOTH STAGE AND OVERALL PERFORMANCE MAY BE
C            PRINTED OUT
C            IDESIN=2: ONLY OVERALL PERFORMANCE MAY BE PRINTED OUT
C JCENT      INDEX FOR CENTRIFUGAL CALCULATION OF LARGE DROPLET
C            JCENT=0: LARGE DROPLETS IN ROTOR FREE STREAM ARE NOT
C            CENTRIFUGED.
C            JCENT=1: LARGE DROPLETS IN ROTOR FREE STREAM ARE
C            CENTRIFUGED.
C BET1MR(I)  BLADE METAL ANGLE AT ROTOR INLET FOR I-TH STAGE
C BET2MR(I)  BLADE METAL ANGLE AT ROTOR OUTLET FOR I-TH STAGE
C BET1MS(I)  BLADE METAL ANGLE AT STATOR INLET FOR I-TH STAGE
C BET2MS(I)  BLADE METAL ANGLE AT STATOR OUTLET FOR I-TH STAGE
C DSMASS     DESIGN MASS FLOW RATE FOR FAN PART (STREAMTUBE)
C BYPASS     BYPASS RATIO
C PR12D(I)   DESIGN TOTAL PRESSURE RATIO FOR I-TH STAGE ROTOR
C PR13D(I)   DESIGN TOTAL PRESSURE RATIO FOR I-TH STAGE
C ETARD(I)   DESIGN ADIABATIC EFFICIENCY FOR I-TH STAGE ROTOR
C SAREA(I)   FLOW AREA AT I-TH STAGE ROTOR INLET (STREAMTUBE)
C SAREAS(I)  FLOW AREA AT I-TH STAGE STATOR INLET (STREAMTUBE)
C+++++

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13. 002131B READ(5,99) NS , NSF, NSLPC, NSHPC
14. 003023B 99 FORMAT(4I2)
15. 003023B IF(NSF.EQ.0) NS1=NS+1
16. 003026B IF(NSF.GT.0) NS1=NSF+NSLPC+NSHPC+1
17. 003032B IF(NSF.GT.0) NS=NSF+NSLPC+NSHPC
18. 003036B READ(5,100) (RRHUB(I),I=1,NS)
19. 003046B 100 FORMAT (16F5.3)
20. 003046B READ(5,111)(RC(I),I=1,NS)
21. 003056B 111 FORMAT(16F5.3)
22. 003056B READ(5,112) (RBLADE(I),I=1,NS)
23. 003066B 112 FORMAT(16F5.2)
24. 003066B READ(5,113)(STAGER(I) ,I=1,NS)
25. 003076B 113 FORMAT(16F5.2)
26. 003076B READ(5,114)(SRHUB(I),I=1,NS1)
27. 003106B 114 FORMAT(16F5.3)
28. 003106B READ(5,115) (SC(I),I=1,NS1)
29. 003116B 115 FORMAT(16F5.3)
30. 003116B READ(5,116)(SBLADE(I),I=1,NS1)
31. 003126B 116 FORMAT(16F5.2)
32. 003126B READ(5,140) (STAGES(I),I=1,NS1)
33. 003136B 140 FORMAT(16F5.2)
34. 003136B READ(5,117)(SIGUMR(I),I=1,NS)
35. 003146B 117 FORMAT(16F5.3)
36. 003146B READ(5,122)(SIGUMS(I) ,I=1,NS1)
37. 003156B 122 FORMAT(16F5.3)
38. 003156B READ(5,124)(BET2SS(I),I=1,NS1)
39. 003166B 124 FORMAT(16F5.2)
40. 003166B READ(5,127) FNF
41. 003172B 127 FORMAT(F8.2)

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42.	003172B	READ(5,128) XDIN, ICENT, XDDIN, IICENT, ICENTU
43.	003202B	128 FORMAT(F5.3, I1, F5.3, I1, I1)
44.	003202B	READ(5,129) TOG, TOW, PO
45.	003210B	129 FORMAT(3F7.2)
46.	003210B	READ(5,130) DIN, DDIN
47.	003215B	130 FORMAT(2F6.1)
48.	003215B	READ(5,132) FND, T01D, P01D, FNDLPC, FNDHPC
49.	003225B	132 FORMAT(F7.1, 2F7.2, 2F7.1)
50.	003225B	READ(5,133) XCH4, RHUMID
51.	003232B	133 FORMAT(F5.3, F10.5)
52.	003232B	READ(5,134) FMWA, FMWU, FMWC
53.	003240B	134 FORMAT(3F7.3)
54.	003240B	READ(5,135) PREB, DLIMIT
55.	003245B	135 FORMAT(F5.1, F7.1)
56.	003245B	READ(5,141) (GAPR(I), I=1, NS)
57.	003255B	141 FORMAT(11F7.5)
58.	003255B	READ(5,142) (GAPS(I), I=1, NS)
59.	003265B	142 FORMAT(11F7.5)
60.	003265B	READ(5,146) (RRTIP(I), I=1, NS)
61.	003275B	146 FORMAT(13F6.3)
62.	003275B	READ(5,147) (SRTIP(I), I=1, NS1)
63.	003305B	147 FORMAT(13F6.3)
64.	003305B	READ(5,1491) IRAD
65.	003311B	1491 FORMAT(I1)
66.	003311B	READ(5,1492) (RT(I), I=1, NS)
67.	003321B	1492 FORMAT(16F5.3)
68.	003321B	READ(5,1493) (RM(I), I=1, NS)
69.	003331B	1493 FORMAT(16F5.3)
70.	003331B	READ(5,1494) (RH(I), I=1, NS)
71.	003341B	1494 FORMAT(16F5.3)
72.	003341B	READ(5,1495) (ST(I), I=1, NS)
73.	003351B	1495 FORMAT(16F5.3)
74.	003351B	READ(5,1496) (SM(I), I=1, NS)
75.	003361B	1496 FORMAT(16F5.3)
76.	003361B	READ(5,1497) (SH(I), I=1, NS)
77.	003371B	1497 FORMAT(16F5.3)
78.	003371B	READ(5,1498) (BLOCK(I), I=1, NS)
79.	003401B	1498 FORMAT(16F5.3)
80.	003401B	READ(5,1499) (BLOCKS(I), I=1, NS1)
81.	003411B	1499 FORMAT(16F5.3)
82.	003411B	READ(5,1500) IDESIN, JCENT
83.	003416B	1500 FORMAT(2I1)
84.	003416B	READ(5,1502) (BET1MR(I), I=1, NS)
85.	003426B	1502 FORMAT(16F5.2)
86.	003426B	READ(5,1503) (BET2MR(I), I=1, NS)
87.	003436B	1503 FORMAT(16F5.2)
88.	003436B	READ(5,1504) (BET1MS(I), I=1, NS1)
89.	003446B	1504 FORMAT(16F5.2)
90.	003446B	READ(5,1505) (BET2MS(I), I=1, NS1)
91.	003456B	1505 FORMAT(16F5.2)
92.	003456B	READ(5,1506) DSMASS, BYPASS
93.	003463B	1506 FORMAT(2F10.6)
94.	003463B	READ(5,1507) (PR12D(I), I=1, NS)
95.	003473B	1507 FORMAT(16F5.3)
96.	003473B	READ(5,1508) (PR13D(I), I=1, NS)
97.	003503B	1508 FORMAT(16F5.3)
98.	003503B	READ(5,1509) (ETARD(I), I=1, NS)
99.	003513B	1509 FORMAT(16F5.3)
100.	003513B	READ(5,1511) (SAREA(I), I=1, NS)
101.	003523B	1511 FORMAT(8F10.7)

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102. 003523B      READ(5,1512) (SAREAS(I),I=1,NS1)
103. 003533B      1512 FORMAT(8F10.7)
C *****
C OTHER INPUT DATA
104. 003533B      IF(RHUMID.LT.1.0E-5) RHUMID=1.0E-5
105. 003536B      IPRINT=1
106. 003536B      RU=1545.3
107. 003537B      RHOW=62.54
108. 003541B      CPW=1.000
109. 003542B      WKDONE=1.0
110. 003543B      AAAIGU=SAREAS(NS1)
111. 003545B      AK1=1.0
112. 003546B      AK2=1.0
113. 003547B      AK3=1.0
114. 003550B      DO 153 I=1,NS
115. 003552B      FMR1(I)=0.6
116. 003552B      FMA2(I)=0.6
117. 003553B      153 CONTINUE
118. 003555B      FNFN=FN*100.0
119. 003556B      RA=RU/FMW
120. 003560B      RU=RU/FMW
121. 003561B      RCH=RU/FMW
122. 003563B      DELU=0.0
123. 003564B      DELVU2=10.0
124. 003565B      DELUL2=10.0
125. 003565B      GC=32.0
126. 003567B      AJ=778.1G
127. 003570B      PAI=3.1415926
128. 003572B      DO 150 I=1,NS
129. 003574B      AAREA(I)=PAI*((RRTIP(I)/12.0)**2-(RRHUB(I)/12.0)**2)*BLOCK(I)
130. 003601B      AAREAS(I)=PAI*(SRTIP(I)**2-SRHUB(I)**2)/144.0*BLOCKS(I)
131. 003606B      DELZ(I)=(RC(I)+SC(I))/12.0
132. 003611B      150 CONTINUE
133. 003613B      NS1=NS+1
134. 003614B      AAREAS(NS1)=PAI*(SRTIP(NS1)**2-SRHUB(NS1)**2)/144.0*BLOCKS(NS1)
135. 003621B      AARIT=AAREA(1)
136. 003623B      DO 152 I=1,NS
137. 003625B      AREA(I)=SAREA(I)
138. 003625B      AREAS(I)=SAREAS(I)
139. 003627B      152 CONTINUE
140. 003631B      AREAS(NS1)=SAREAS(NS1)
141. 003632B      FN=FND*FNF*SQRT(TOG/518.7)
142. 003641B      P01FAN=P0
143. 003642B      T01FAN=TOG
144. 003643B      OT01G=TOG
145. 003644B      OT01D=TOW
146. 003646B      OP01=P0
147. 003647B      CRPM=FN*FND
148. 003650B      FNDFAN=FND
149. 003651B      DO 151 I=1,NS
150. 003653B      IF (I.GT.NSF.AND.I.LE.(NSF+NSLPC)) FND=FNDLPC
151. 003662B      IF (I.GT.(NSF+NSLPC)) FND=FNDHPC
152. 003666B      UTIP(I)=RT(I)/12.0*2.0*PAI*FND/60.0
153. 003671B      UTIPG(I)=RRTIP(I)/12.0*2.0*PAI*FND/60.0
154. 003675B      UTIP2(I)=ST(I)/12.0*2.0*PAI*FND/60.0
155. 003701B      UTIPD(I)=RT(I)/12.0*2.0*PAI*FND/60.0
156. 003705B      UOU(I)=(UTIP(I)/UTIPD(I))**2
157. 003707B      UMEAN(I)=RM(I)/12.0*2.0*PAI*FND/60.0
158. 003713B      UMEAN2(I)=SM(I)/12.0*2.0*PAI*FND/60.0
159. 003717B      UHUB(I)=RH(I)/12.0*2.0*PAI*FND/60.0

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160. 003723B      UHUB2(I)=SH(I)/12.0*2.0*PAI*FND/60.0
161. 003727B      IF(IRAD.EQ.1) U(I)=UTIP(I)
162. 003734B      IF(IRAD.EQ.2) U(I)=UMEAN(I)
163. 003740B      IF(IRAD.EQ.3) U(I)=UHUB(I)
164. 003743B      IF(IRAD.EQ.4.AND.I.LE.NSF) U(I)=UMEAN(I)
165. 003750B      IF(IRAD.EQ.4.AND.I.GT.NSF) U(I)=UTIP(I)
166. 003756B      IF(IRAD.EQ.1) UU2(I)=UTIP2(I)
167. 003762B      IF(IRAD.EQ.2) UU2(I)=UMEAN2(I)
168. 003765B      IF(IRAD.EQ.3) UU2(I)=UHUB2(I)
169. 003770B      IF(IRAD.EQ.4.AND.I.LE.NSF) UU2(I)=UMEAN2(I)
170. 003775B      IF(IRAD.EQ.4.AND.I.GT.NSF) UU2(I)=UTIP2(I)
171. 004003B      IF(IRAD.EQ.1) RAD11(I)=RT(I)
172. 004006B      IF(IRAD.EQ.1) RAD12(I)=ST(I)
173. 004011B      IF(IRAD.EQ.2) RAD11(I)=RM(I)
174. 004014B      IF(IRAD.EQ.2) RAD12(I)=SM(I)
175. 004017B      IF(IRAD.EQ.3) RAD11(I)=RH(I)
176. 004022B      IF(IRAD.EQ.3) RAD12(I)=SH(I)
177. 004025B      IF(IRAD.EQ.4.AND.I.LE.NSF) RAD11(I)=RM(I)
178. 004032B      IF(IRAD.EQ.4.AND.I.LE.NSF) RAD12(I)=SM(I)
179. 004040B      IF(IRAD.EQ.4.AND.I.GT.NSF) RAD11(I)=RT(I)
180. 004045B      IF(IRAD.EQ.4.AND.I.GT.NSF) RAD12(I)=ST(I)
181. 004053B      151 CONTINUE
182. 004055B      C ++++++
      FND=FNDFAN
      C PRINT OUT OF INPUT DATA
183. 004056B      WRITE(6,1600)
184. 004062B      1600 FORMAT(1H1,5X,***** INPUT DATA *****
      $*****$)
185. 004062B      WRITE(6,1610) NS
186. 004066B      1610 FORMAT(1H0,1X,=NS(NUMBER OF STAGE)=,I2)
187. 004066B      IF(IRAD.EQ.1) WRITE(6,1604)
188. 004073B      1604 FORMAT(1H,1X,=PERFORMANCE AT TIP=)
189. 004073B      IF(IRAD.EQ.2) WRITE(6,1605)
190. 004100B      1605 FORMAT(1H,1X,=PERFORMANCE AT MEAN=)
191. 004100B      IF(IRAD.EQ.3) WRITE(6,1606)
192. 004105B      1606 FORMAT(1H,1X,=PERFORMANCE AT HUB=)
193. 004105B      IF(IRAD.EQ.4) WRITE(6,1613)
194. 004112B      1613 FORMAT(1H,1X,=PERFORMANCE AT MEAN FOR FAN AND AT TIP FOR LPC,
      ^HPC=)
195. 004112B      IF(ICENT.EQ.3.AND.IICENT.EQ.3) WRITE(6,1607)
196. 004121B      1607 FORMAT(1H0,1X,=NO CENTRIFUGAL ACTION=)
197. 004121B      IF(ICENT.EQ.6.AND.IICENT.EQ.6) WRITE(6,1615)
198. 004130B      1615 FORMAT(1H0,1X,=NO MASS TRANSFER=)
199. 004130B      IF(ICENT.EQ.7.AND.IICENT.EQ.7) WRITE(6,1614)
200. 004137B      1614 FORMAT(1H0,1X,=NO MASS TRANSFER AND NO CENTRIFUGAL ACTION=)
201. 004137B      IF(ICENT.EQ.4.AND.IICENT.EQ.4) WRITE(6,1608)
202. 004146B      1608 FORMAT(1H0,1X,=NO CENTRIFUGAL ACTION=)
203. 004146B      IF(ICENT.EQ.5.AND.IICENT.EQ.5) WRITE(6,1609)
204. 004155B      1609 FORMAT(1H0,1X,=NO HEAT AND MASS TRANCEFER;AND NO CENTRIFUGAL
      $ ACTION=)
205. 004155B      IF(JCENT.EQ.1) WRITE(6,1612)
206. 004162B      1612 FORMAT(1H0,1X,=LARGE DROPLETS IN ROTOR FREE STREAM ARE CENTRIFUG
      $ED=)
207. 004162B      IF(JCENT.NE.1) WRITE(6,1611)
208. 004167B      1611 FORMAT(1H0,1X,=LARGE DROPLETS IN ROTOR FREE STREAM ARE NOT CENTRIF
      $UGED=)
      WRITE(6,1620)
209. 004167B
210. 004172B      1620 FORMAT(1H0,14X,=1=,5X,=2=,5X,=3=,5X,=4=,5X,=5=,5X,=6=,
      $ 5X,=7=,5X,=8=,5X,=9=,5X,=10=,4X,=11=,4X,=12=,4X,=13=,
      $ 4X,=14=,4X,=15=,4X,=16=)

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211. 004172B WRITE(6,1630) (RRHUB(I),I=1,NS)
212. 004202B 1630 FORMAT(1H,1X,RRHUB(I),3X,20(F5.3,1X))
213. 004202B WRITE(6,1640) (RC(I),I=1,NS)
214. 004212B 1640 FORMAT(1H,1X,RC(I),6X,20(F5.3,1X))
215. 004212B WRITE(6,1650) (RBLADE(I),I=1,NS)
216. 004222B 1650 FORMAT(1H,1X,RBLADE(I),2X,20(F5.2,1X))
217. 004222B WRITE(6,1660) (STAGER(I),I=1,NS)
218. 004232B 1660 FORMAT(1H,1X,STAGER(I),2X,20(F5.2,1X))
219. 004232B WRITE(6,1661) (STAGES(I),I=1,NS)
220. 004242B 1661 FORMAT(1H,1X,STAGES(I),2X,20(F5.2,1X))
221. 004242B WRITE(6,1670) (SRHUB(I),I=1,NS1)
222. 004252B 1670 FORMAT(1H,1X,SRHUB(I),3X,20(F5.3,1X))
223. 004252B WRITE(6,1680) (SC(I),I=1,NS)
224. 004262B 1680 FORMAT(1H,1X,SC(I),6X,20(F5.3,1X))
225. 004262B WRITE(6,1690) (SBLADE(I),I=1,NS)
226. 004272B 1690 FORMAT(1H,1X,SBLADE(I),2X,20(F5.2,1X))
227. 004272B WRITE(6,1700) (SIGUMR(I),I=1,NS)
228. 004302B 1700 FORMAT(1H,1X,SIGUMR(I),2X,20(F5.3,1X))
229. 004302B WRITE(6,1750) (SIGUMS(I),I=1,NS)
230. 004312B 1750 FORMAT(1H,1X,SIGUMS(I),2X,20(F5.3,1X))
231. 004312B WRITE(6,1770) (BET2SS(I),I=1,NS1)
232. 004322B 1770 FORMAT(1H,1X,BET2SS(I),2X,20(F5.2,1X))
233. 004322B WRITE(6,1795) (GAPR(I),I=1,NS)
234. 004332B 1795 FORMAT(1H,1X,GAPR(I),4X,20(F5.3,1X))
235. 004332B WRITE(6,1796) (GAPS(I),I=1,NS)
236. 004342B 1796 FORMAT(1H,1X,GAPS(I),4X,20(F5.3,1X))
237. 004342B WRITE(6,1798) (RRTIP(I),I=1,NS)
238. 004352B 1798 FORMAT(1H,1X,RRTIP(I),3X,20(F5.2,1X))
239. 004352B WRITE(6,1799) (SRTIP(I),I=1,NS1)
240. 004362B 1799 FORMAT(1H,1X,SRTIP(I),3X,20(F5.2,1X))
241. 004362B WRITE(6,1801) (RT(I),I=1,NS)
242. 004372B 1801 FORMAT(1H,1X,RT(I),6X,20(F5.2,1X))
243. 004372B WRITE(6,1802) (RM(I),I=1,NS)
244. 004402B 1802 FORMAT(1H,1X,RM(I),6X,20(F5.2,1X))
245. 004402B WRITE(6,1803) (RH(I),I=1,NS)
246. 004412B 1803 FORMAT(1H,1X,RH(I),6X,20(F5.2,1X))
247. 004412B WRITE(6,1804) (ST(I),I=1,NS)
248. 004422B 1804 FORMAT(1H,1X,ST(I),6X,20(F5.2,1X))
249. 004422B WRITE(6,1805) (SM(I),I=1,NS)
250. 004432B 1805 FORMAT(1H,1X,SM(I),6X,20(F5.2,1X))
251. 004432B WRITE(6,1806) (SH(I),I=1,NS)
252. 004442B 1806 FORMAT(1H,1X,SH(I),6X,20(F5.2,1X))
253. 004442B WRITE(6,1807) (BLOCK(I),I=1,NS)
254. 004452B 1807 FORMAT(1H,1X,BLOCK(I),3X,20(F5.3,1X))
255. 004452B WRITE(6,1808) (BLOCKS(I),I=1,NS1)
256. 004462B 1808 FORMAT(1H,1X,BLOCKS(I),2X,20(F5.3,1X))
257. 004462B WRITE(6,1811) (BET1MR(I),I=1,NS)
258. 004472B 1811 FORMAT(1H,1X,BET1MR(I),2X,20(F5.2,1X))
259. 004472B WRITE(6,1812) (BET2MR(I),I=1,NS)
260. 004502B 1812 FORMAT(1H,1X,BET2MR(I),2X,20(F5.2,1X))
261. 004502B WRITE(6,1813) (BET1MS(I),I=1,NS1)
262. 004512B 1813 FORMAT(1H,1X,BET1MS(I),2X,20(F5.2,1X))
263. 004512B WRITE(6,1814) (BET2MS(I),I=1,NS1)
264. 004522B 1814 FORMAT(1H,1X,BET2MS(I),2X,20(F5.2,1X))
265. 004522B WRITE(6,1815) (PR12D(I),I=1,NS)
266. 004532B 1815 FORMAT(1H,1X,PR12D(I),3X,20(F5.3,1X))
267. 004532B WRITE(6,1816) (PR13D(I),I=1,NS)
268. 004542B 1816 FORMAT(1H,1X,PR13D(I),3X,20(F5.3,1X))
269. 004542B WRITE(6,1817) (ETARD(I),I=1,NS)
270. 004552B 1817 FORMAT(1H,1X,ETARD(I),3X,20(F5.3,1X))

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271. 004552B WRITE(6,1818)
272. 004555B 1818 FORMAT(1H1,5X,***** INPUT DATA *****
      $*****$)
273. 004555B WRITE(6,1800) FNF
274. 004561B 1800 FORMAT(1H0,1X,=FNF(FRACTION OF DESIGN CORRECTED SPEED)=,F5.3)
275. 004561B WRITE(6,1810) XDIN,XDDIN,RHUMID,XCH4
276. 004570B 1810 FORMAT(1H0,1X,=XDIN(INITIAL WATER CONTENT OF SMALL DROPLET)=,F5.3
      $,/,2X,=XDDIN(INITIAL WATER CONTENT OF LARGE DROPLET)=,F5.3,/,
      $2X,=RHUMID(INITIAL RELATIVE HUMIDITY)=,F6.2,1X,=PER CENT=,/,
      $2X,=XCH4(INITIAL METHANE CONTENT)=,F5.3)
277. 004570B WRITE(6,1820) TOG,TOW,P0
278. 004576B 1820 FORMAT(1H0,1X,=TOG(COMPRESSOR INLET TOTAL TEMPERATURE OF GAS)=,
      $F7.2,/,2X,=TOW(COMPRESSOR INLET TEMPERATURE OF DROPLET)=,F7.2,/,
      $2X,=P0(COMPRESSOR INLET TOTAL PRESSURE)=,F7.2)
279. 004576B WRITE(6,1830) DIN,DDIN
280. 004603B 1830 FORMAT(1H0,1X,=DIN(INITIAL DROPLET DIAMETER OF SMALL DROPLET)=,
      $F6.1,/,2X,=DDIN(INITIAL DROPLET DIAMETER OF LARGE DROPLET)=,F6.1)
281. 004603B WRITE(6,1850) FND
282. 004607B 1850 FORMAT(1H0,1X,=FND(DESIGN ROTATIONAL SPEED)=,F7.1)
283. 004607B WRITE(6,1851) DSMASS
284. 004613B 1851 FORMAT(1H0,1X,=DSMASS(DESIGN MASS FLOW RATE)=,F10.4)
285. 004613B WRITE(6,1852) BYPASS
286. 004617B 1852 FORMAT(1H0,1X,=BYPASS RATIO = ,F10.4)
287. 004617B WRITE(6,1860) TOG
288. 004623B 1860 FORMAT(1H0,1X,=COMPRESSOR INLET TOTAL TEMPERATURE(GAS PHASE)=,
      $F7.2,1X,=R=)
289. 004623B WRITE(6,1870) P0
290. 004627B 1870 FORMAT(1H0,1X,=COMPRESSOR INLET TOTAL PRESSURE=,F7.2,1X,=LB/FT**2
      $=)
291. 004627B WRITE(6,1880) PREB
292. 004633B 1880 FORMAT(1H0,1X,=PREB(PERCENT OF WATER THAT REBOUND AFTER IMPINGEMEN
      $T)=,F5.1,1X,=PERCENT=)
293. 004633B WRITE(6,1900) FN
294. 004637B 1900 FORMAT(1H0,1X,=ROTOR SPEED=,F7.1,1X,=RPM=)
295. 004637B WRITE(6,1910) CRPM,FNFN
296. 004644B 1910 FORMAT(1H0,1X,=CORRECTED ROTOR SPEED= ,F7.1,1X,=RPM=,(=,2X,F5.1,
      $=PER CENT OF DESIGN CORRECTED SPEED)=)
297. 004644B TG(1)=T01D
298. 004644B P(1)=P01D
299. 004646B CALL WICSPD(DSMASS,ISTAGE)
300. 004651B C ++++++
301. 004653B DO 1533 I=1,NS
302. 004665B IF (I.LE.NSF) FN=FNDFAN*FNF*SQRT(TOG/518.7)
      IF (I.GT.NSF.AND.I.LE.(NSF+NSLPC))
      $ FN=FNDLPC*FNF*SQRT(TOG/518.7)
      IF(I.GT.(NSF+NSLPC)) FN=FNDHPC*FNF*SQRT(TOG/518.7)
      IF(I.LE.NSF) FND=FNDFAN
      IF(I.GT.NSF.AND.I.LE.(NSF+NSLPC)) FND=FNDLPC
      IF(I.GT.(NSF+NSLPC)) FND=FNDHPC
303. 004701B UTIP(I)=RT(I)/12.0*2.0*PAI*FN/60.0
304. 004713B UTIPG(I)=RRTIP(I)/12.0*2.0*PAI*FN/60.0
305. 004717B UTIP2(I)=ST(I)/12.0*2.0*PAI*FN/60.0
306. 004725B UTIPD(I)=RT(I)/12.0*2.0*PAI*FND/60.0
307. 004730B UOU(I)=(UTIP(I)/UTIPD(I))**2
308. 004733B UMEAN(I)=RM(I)/12.0*2.0*PAI*FN/60.0
309. 004740B UMEAN2(I)=SM(I)/12.0*2.0*PAI*FN/60.0
310. 004745B UHUB(I)=RH(I)/12.0*2.0*PAI*FN/60.0
311. 004751B UHUB2(I)=SH(I)/12.0*2.0*PAI*FN/60.0
312. 004753B IF(IRAD.EQ.1) U(I)=UTIP(I)
313. 004757B IF(IRAD.EQ.2) U(I)=UMEAN(I)
314. 004764B
315. 004771B
316. 004776B
317. 005003B

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318. 005007B      IF(IRAD.EQ.3) U(I)=UHUB(I)
319. 005013B      IF(IRAD.EQ.4.AND.I.LE.NSF) U(I)=UMEAN(I)
320. 005021B      IF(IRAD.EQ.4.AND.I.GT.NSF) U(I)=UTIP(I)
321. 005027B      IF(IRAD.EQ.1) UU2(I)=UTIP2(I)
322. 005033B      IF(IRAD.EQ.2) UU2(I)=UMEAN2(I)
323. 005037B      IF(IRAD.EQ.3) UU2(I)=UHUB2(I)
324. 005043B      IF(IRAD.EQ.4.AND.I.LE.NSF) UU2(I)=UMEAN2(I)
325. 005051B      IF(IRAD.EQ.4.AND.I.GT.NSF) UU2(I)=UTIP2(I)
326. 005060B      IF(IRAD.EQ.1) RADI1(I)=RT(I)
327. 005063B      IF(IRAD.EQ.1) RADI2(I)=ST(I)
328. 005066B      IF(IRAD.EQ.2) RADI1(I)=RM(I)
329. 005072B      IF(IRAD.EQ.2) RADI2(I)=SM(I)
330. 005076B      IF(IRAD.EQ.3) RADI1(I)=RH(I)
331. 005102B      IF(IRAD.EQ.3) RADI2(I)=SH(I)
332. 005106B      IF(IRAD.EQ.4.AND.I.LE.NSF) RADI1(I)=RM(I)
333. 005114B      IF(IRAD.EQ.4.AND.I.LE.NSF) RADI2(I)=SM(I)
334. 005123B      IF(IRAD.EQ.4.AND.I.GT.NSF) RADI1(I)=RT(I)
335. 005131B      IF(IRAD.EQ.4.AND.I.GT.NSF) RADI2(I)=ST(I)
336. 005140B      1533 CONTINUE
337. 005142B      UTIPG(NS+1)=UTIPG(NS)

C MASS FLOWRATE
338. 005143B      NNPFI = 1
339. 005144B      901 READ(5,200) FAI
340. 005151B      200 FORMAT(F7.5)
341. 005151B      ISTAGE=0
342. 005151B      N=1
343. 005152B      IF(FAI.GT.1.0) GO TO 998
344. 005155B      IF(IPRINT.EQ.2) WRITE(6,197) FAI
345. 005163B      197 FORMAT(1H1,2X,=FAI=,F7.5)
346. 005163B      FAIO=FAI
347. 005163B      UZ=UTIPG(1)*FAI
348. 005165B      TG(1)=OT01G
349. 005166B      UZERO=0.0
350. 005167B      UUZERO=0.0
351. 005170B      UUZERO=0.0
352. 005171B      URZERO=RRTIP(1)
353. 005172B      RZERO=RRHUB(1)
354. 005173B      RRZERO=RRHUB(1)
355. 005174B      ITIP=0
356. 005175B      IITIP=0
357. 005176B      DAVE(N)=0.0
358. 005177B      DDAVE(N)=0.0
359. 005200B      TW(1)=OT01D
360. 005201B      TWW(1)=OT01D
361. 005202B      IF(XDIN.GT.0.0) DAVE(N)=DIN
362. 005207B      IF(XDDIN.GT.0.0) DDAVE(N)=DDIN
363. 005213B      IF(XDIN.GT.0.0) TW(1)=OT01D
364. 005217B      IF(XDDIN.GT.0.0) TWW(1)=OT01D
365. 005223B      P(1)=OP01
366. 005223B      TB(1) = WICBPT(TG(1), P(1))
367. 005226B      WS(1) = WICSH(TG(1), P(1))*RHUMID/100.0
368. 005231B      PW=WS(1)*P(1)/(WS(1)+0.6219)
369. 005235B      TDEW(1)=WICBPT(TG(1),PW)
370. 005240B      XW(1)=XDIN
371. 005241B      XWW(1)=XDDIN
372. 005242B      XWT(1)=XW(1)+XWW(1)
373. 005244B      XWTO=XWT(1)
374. 005245B      XU(1)=WS(1)/(1.0+WS(1))*(1.0-XWT(1)-XCH4)
375. 005252B      XA=1.0-XWT(1)-XU(1)-XCH4
376. 005256B      XG=XA+XU(1)+XCH4

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377. 005257B XAIN=XA
378. 005260B XCH4IN=XCH4
379. 005262B ISTAGE=1
380. 005263B CALL WICPRP(XA,XU(1),XCH4,TG(1),RMIX,CPMIX,GAMMA,G1,G2,G3)
381. 005266B GAMMAI=GAMMA
382. 005266B RHOG(1)=P(1)/RMIX/TG(1)
383. 005271B RHOA(1)=P(1)/RA/TG(1)
384. 005273B AMASS=-1.0
C AAAIGU=STREAM TUBE AREA AT IGU OUTLET
385. 005274B AAA2=AAAIGU
386. 005276B AAA3=AAAIGU
387. 005277B CALL WICMAC(ISTAGE,AMASSM,TG(1),P(1),M,UZ,C,XWT(1),BET2SS(NS1),
$RMIX,CPMIX,AAA3)
388. 005303B RHOG(1)=(1.0+G2*M**2)**G3*RHOG(1)
389. 005311B RHOM(1)=1.0/((1.0-XWT(1))/RHOG(1)+XWT(1)/RHOW)
390. 005316B MMASS = RHOM(1)*FAI*UTIPG(1)*AAA3
391. 005321B MMASSO=MMASS
392. 005322B WMASSO=MMASSO*XDIN
393. 005323B WWMASO=MMASSO*XDDIN
394. 005325B IF(IPRINT.EQ.2) WRITE(6,5558) MMASSO,XDIN,WMASSO,MMASS
395. 005337B 5558 FORMAT(1H0,2X,4(F10.5,2X))
396. 005337B DAMY=OT01G/518.7
397. 005340B DAMY2=OP01/(14.7*144.0)
398. 005342B CMASS=MMASS*SQRT(DAMY)/DAMY2
399. 005346B AMASS = XA * MMASS
400. 005350B WMASS(1)=XW(1)*MMASS
401. 005351B WWMASS(1)=XWW(1)*MMASS
402. 005353B WTMASS(1)=XWT(1)*MMASS
403. 005354B UMASS(1)=XU(1)*MMASS
404. 005356B CHMASS=XCH4*MMASS
405. 005357B GMASS(1)=MMASS-WTMASS(1)
406. 005361B CMASS2=GMASS(1)*SQRT(DAMY)/DAMY2
407. 005365B AMO=AMASS
408. 005367B UMO=UMASS(1)
409. 005370B CMO=CHMASS
410. 005372B GMO=GMASS(1)
411. 005373B WMO=WMASS(1)
412. 005374B WWMO=WWMASS(1)
413. 005375B WTMO=WTMASS(1)
414. 005377B TLMO=GMO+WTMO
415. 005401B TWMAS=WMASSO*AAAR1T/AAAIGU
416. 005403B TWWMAS=WWMASO*AAAR1T/AAAIGU
417. 005405B WMASTL=TWMAS+TWWMAS
418. 005407B UMASTL=UMO*AAAR1T/AAAIGU+WMASTL
419. 005411B UMASTT=UMO*AAAR1T/AAAIGU
C INITIAL VALUES
420. 005413B TG(3)=TG(1)
421. 005414B TW(3)=TW(1)
422. 005415B TWW(3)=TWW(1)
423. 005417B P(3)=P(1)
424. 005420B TB(3)=TB(1)
425. 005422B WS(3)=WS(1)
426. 005423B TDEW(3)=TDEW(1)
427. 005425B XU(3)=XU(1)
428. 005426B XG=XA+XU(3)+XCH4
429. 005431B XW(3)=XW(1)
430. 005432B XWW(3)=XWW(1)
431. 005434B UMASS(3)=UMASS(1)
432. 005435B WMASS(3)=WMASS(1)
433. 005436B WWMASS(3)=WWMASS(1)

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434. 005437B      WCENT=WMASSO
435. 005441B      WWCENT=WWMASO
436. 005442B      UCENT=0.0
437. 005443B      DMDTA1=0.0
438. 005444B      DMDTA2=0.0
C ++++++
C IGV IMPINGEMENT
439. 005445B      CALL WICISS(7,RADI1(1), XW(1) , XC , RHOG(1),0.0,UZ,WW1,WW2,WW)
440. 005447B      AMIMPS=WW
441. 005447B      AMWAKS = AMIMPS * (1.0-PREB)
442. 005452B      AMREBS=AMIMPS*PREB
C ++++++
C IGV WAKE
443. 005453B      N=2
444. 005454B      DAVE(2)=DAVE(1)
445. 005455B      DDAVE(2)=DDAVE(1)
446. 005457B      ALFA3=BET2SS(NS1)*(FAID/FAI)**(1.0/7.0)
447. 005465B      DWAKEM=0.0
448. 005466B      IF(XDIN.GT.0.0.OR.XDDIN.GT.0.0) GO TO 628
449. 005472B      GO TO 629
450. 005472B      628 CALL WICWAK(RHOG(1),UZ,DWAKE,DWAKEM)
451. 005475B      629 CONTINUE
C ++++++
C IGV OUTLET
452. 005475B      IF(IDESIN.EQ.2) GO TO 322
453. 005476B      WMASS(3) = WMASS(1)
454. 005477B      XW(3) = XW(1)
455. 005501B      PRATIO=1.0
456. 005502B      TRATIO=1.0
457. 005503B      EFF=1.0
458. 005504B      AMIMPR=0.0
459. 005504B      AMREBR=0.0
460. 005505B      AMWAKR=0.0
461. 005506B      DELTGW=0.0
462. 005506B      DELTDW=0.0
463. 005507B      DELTGH=0.0
464. 005507B      DELTDH=0.0
465. 005510B      DELT=0.0
466. 005510B      DELP=0.0
467. 005511B      DMDTAU=0.0
468. 005511B      XU(3)=XU(1)
469. 005512B      XW(3)=XW(1)
470. 005513B      XWW(3)=XWW(1)
471. 005515B      WMASS(3) = WMASS(1)
472. 005516B      WWMASS(3)=WWMASS(1)
473. 005520B      UMASS(3) = UMASS(1)
474. 005521B      WS(3) = WS(1)
475. 005523B      TDEW(3)=TDEW(1)
476. 005524B      RHOA(3) = RHOA(1)
477. 005526B      RHOM(3) = RHOM(1)
478. 005527B      RHOG(3) = RHOG(1)
479. 005531B      TG(3) = TG(1)
480. 005532B      TW(3) = TW(1)
481. 005534B      TWW(3)=TWW(1)
482. 005535B      P(3) = P(1)
483. 005537B      TB(3) = TB(1)
484. 005540B      XU(2)=0.0
485. 005541B      XW(2) = 0.0
486. 005542B      XWW(2)=0.0
487. 005543B      WMASS(2) = 0.0

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488. 005543B      WWMASS(2)=0.0
489. 005544B      UMASS(2) = 0.0
490. 005544B      WS(2) = 0.0
491. 005545B      RHOA(2)=0.0
492. 005545B      RHOM(2) = 0.0
493. 005546B      RHOG(2)= 0.0
494. 005546B      TG(2)=0.0
495. 005547B      TW(2) =0.0
496. 005547B      TWW(2)=0.0
497. 005550B      P(2) = 0.0
498. 005550B      TB(2) = 0.0
499. 005551B      TDEW(2)=0.0
500. 005551B      GAMMAQ=GAMMA
C ++++++
C IGV OUTLET
501. 005552B      IF(IPRINT.EQ.2) WRITE(6,300) ISTAGE
502. 005562B      300 FORMAT(1H0,5X,≠ISTAGE=≠,11,2X,≠(IGU)≠)
503. 005562B      IF(IPRINT.EQ.2) WRITE(6,301) PRATIO,TRATIO,EFF
504. 005572B      301 FORMAT(1H0,5X,3(F12.5,5X))
505. 005572B      IF(IPRINT.EQ.2) WRITE(6,302) FAI, UZ, XA
506. 005602B      302 FORMAT(1H0,5X,3(F12.5,5X))
507. 005602B      IF(IPRINT.EQ.2) WRITE(6,303) MMASS, AMASS, AMIMPS, AMREBS, AMWAKS,
      1AMIMPR, AMREBR, AMWAKR
508. 005617B      303 FORMAT(1H0,5X,8(F12.5,2X))
509. 005617B      IF(IPRINT.EQ.2) WRITE(6,304) DELTGW, DELTDW, DELTGH, DELTDH, DMDTAU,
      $DELT, DELP
510. 005633B      304 FORMAT(1H0,5X,7(F12.5,2X))
511. 005633B      IF(IPRINT.EQ.2) WRITE(6,305) XU(1), XU(2), XU(3)
512. 005643B      305 FORMAT(1H0,5X,≠XU=≠,3(F20.10,5X))
513. 005643B      IF(IPRINT.EQ.2) WRITE(6,306) XW(1), XW(2), XW(3)
514. 005653B      306 FORMAT(1H0,5X,≠XW=≠,3(F20.10,5X))
515. 005653B      IF(IPRINT.EQ.2) WRITE(6,307) WMASS(1), WMASS(2), WMASS(3)
516. 005663B      307 FORMAT(1H0,5X,≠WMASS=≠,3(F20.10,5X))
517. 005663B      IF(IPRINT.EQ.2) WRITE(6,308) UMASS(1), UMASS(2), UMASS(3)
518. 005673B      308 FORMAT(1H0,5X,≠UMASS=≠,3(F20.10,5X))
519. 005673B      IF(IPRINT.EQ.2) WRITE(6,309) WS(1), WS(2), WS(3)
520. 005703B      309 FORMAT(1H0,5X,≠WS=≠,3(F20.10,5X))
521. 005703B      IF(IPRINT.EQ.2) WRITE(6,310) RHOA(1), RHOA(2), RHOA(3)
522. 005713B      310 FORMAT(1H0,5X,≠RHOA=≠,3(F20.10,5X))
523. 005713B      IF(IPRINT.EQ.2) WRITE(6,311) RHOM(1), RHOM(2),RHOM(3)
524. 005723B      311 FORMAT(1H0,5X,≠RHOM=≠,3(F20.10,5X))
525. 005723B      IF(IPRINT.EQ.2) WRITE(6,312) RHOG(1),RHOG(2),RHOG(3)
526. 005733B      312 FORMAT(1H0,5X,≠RHOG=≠,3(F20.10,5X))
527. 005733B      IF(IPRINT.EQ.2) WRITE(6,313) TG(1),TG(2),TG(3)
528. 005743B      313 FORMAT(1H0,5X,≠TG=≠,3(F20.10,5X))
529. 005743B      IF(IPRINT.EQ.2) WRITE(6,314) TW(1),TW(2),TW(3)
530. 005753B      314 FORMAT(1H0,5X,≠TW=≠,3(F20.10,5X))
531. 005753B      IF(IPRINT.EQ.2) WRITE(6,315) P(1),P(2),P(3)
532. 005763B      315 FORMAT(1H0,5X,≠P=≠,3(F20.10,5X))
533. 005763B      IF(IPRINT.EQ.2) WRITE(6,316) TB(1),TB(2),TB(3)
534. 005773B      316 FORMAT(1H0,5X,≠TB=≠,3(F20.10,5X))
535. 005773B      IF(IPRINT.EQ.2) WRITE(6,321) TDEW(1),TDEW(2),TDEW(3)
536. 006003B      321 FORMAT(1H0,5X,≠TDEW=≠,3(F20.10,5X))
537. 006003B      322 RHOG(2)=RHOG(1)
C ++++++
C ROTOR INLET
538. 006003B      900 ISTAGE=ISTAGE+1
539. 006006B      TG(1)=TG(3)
540. 006007B      TW(1)=TW(3)
541. 006010B      TWW(1)=TWW(3)

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542. 006011B P(1)=P(3)
543. 006013B TB(1)=TB(3)
544. 006014B RHOA(1)=P(1)/RA/TG(1)
545. 006017B WS(1)=WS(3)
546. 006021B TDEW(1)=TDEW(3)
547. 006022B XU(1)=XU(3)
548. 006024B XCH4=CHMASS/MMASS
549. 006026B XA=AMASS/MMASS
550. 006027B XG=XA+XU(1)+XCH4
551. 006032B XAIR(1)=XA
552. 006033B XMETAN(1)=XCH4
553. 006035B XGAS(1)=XG
554. 006036B XW(1)=XW(3)
555. 006040B XWW(1)=XWW(3)
556. 006041B XWT(1)=XW(1)+XWW(1)
557. 006043B UMASS(1)=UMASS(3)
558. 006044B WMASS(1)=WMASS(3)
559. 006046B WWMASS(1)=WWMASS(3)
560. 006047B NSF1=NSF+1
561. 006051B IF(ISTAGE.EQ.NSF1) GO TO 948
562. 006053B GO TO 949
563. 006054B 948 AMASS=AMASS/(1.0+BYPASS)
564. 006056B CHMASS=CHMASS/(1.0+BYPASS)
565. 006057B UMASS(1)=UMASS(1)/(1.0+BYPASS)
566. 006061B WMASS(1)=WMASS(1)/(1.0+BYPASS)
567. 006063B WWMASS(1)=WWMASS(1)/(1.0+BYPASS)
568. 006065B 949 CONTINUE
569. 006066B WTMASS(1)=WMASS(1)+WWMASS(1)
570. 006067B MMASS=AMASS+CHMASS+UMASS(1)+WTMASS(1)
571. 006073B TMASS(1)=MMASS
572. 006073B GMASS(1)=TMASS(1)-WTMASS(1)
573. 006075B IF(ISTAGE.EQ.1) AMFAN=GMASS(1)
574. 006101B IF(ISTAGE.EQ.(NSF+1)) AMLPC=GMASS(1)
575. 006105B IF(ISTAGE.EQ.(NSF+NSLPC+1)) AMHPC=GMASS(1)
576. 006112B ALFA1=ALFA3
577. 006112B CALL WICPRP(XA,XU(1),XCH4,TG(1),RMIX,CPMIX,GAMMA,G1,G2,G3)
578. 006115B GAMMAS=GAMMA
579. 006115B AAA1=AAA3
580. 006117B IF(NSF.NE.0.AND.ISTAGE.EQ.(NSF+1)) AAA1=AREA(ISTAGE)
581. 006125B IF(NSF.NE.0.AND.ISTAGE.EQ.(NSF+NSLPC+1)) AAA1=AREA(ISTAGE)
C ++++++
C STAGE PERFORMANCE CALCULATION
582. 006133B JPERFM=2
583. 006133B DAMY=0.0
584. 006134B IF(WTMASS(1).GT.1.0E-4)
$DAMY=WWMASS(1)/WTMASS(1)
585. 006140B IF(DAMY.GT.0.20) JPERFM=3
586. 006143B IF(JPERFM.EQ.2) GO TO 1301
587. 006144B IF(JPERFM.EQ.3) GO TO 1302
588. 006146B 1301 CALL WICSPB(FAIO,ISTAGE,MMASS,ALFA1,WKDONE,DAVE(N),DELU,WMASS(1)
$,N,OMEGA1,
$OMEGA2,OMEGA3,OMEGA4,OMEGA5,OMEGA6,OMEGAT,BETA1,BETA2,UZ,ALFA2,
$ALFA3,DELTA,DELTA,W1,W2,U1,U2,U3,AK1,AK2,AK3)
GO TO 1303
589. 006152B 1302 CALL WICSPC(FAIO,ISTAGE,MMASS,ALFA1,WKDONE,DDAVE(N),DELU,WMASS(
$1),WWMASS(1),N,OMEGA1
$,OMEGA2,OMEGA3,OMEGA4,OMEGA5,OMEGA6,OMEGAT,BETA1,BETA2,UZ,ALFA2,
$ALFA3,DELTA,DELTA,W1,W2,U1,U2,U3,REAVE,DELU2,DELU2,AK1,AK2,
$AK3)
591. 006156B 1303 CONTINUE

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592. 006156B DELTG1=DELTG
593. 006156B DELTW1=DELTW
594. 006160B IF(UZ.LT.0.0.OR.UZ.GT.1000.0) WRITE(6,1304) UZ
595. 006171B 1304 FORMAT(1H0,1X,=AXIAL VELOCITY IS TOO HIGH OR TOO LOW=,=UZ=,
      $F10.5)
596. 006171B IF(UZ.LT.0.0.OR.UZ.GT.1000.0) GO TO 901
597. 006174B AAA2=AREAS(ISTAGE)
598. 006175B AAA3=AREA(ISTAGE+1)
599. 006177B IF(ISTAGE.EQ.NS) AAA3=AAA2
C ++++++
C ROTOR IMPINGEMENT(SMALL DROPLET)
600. 006203B IF(IPRINT.EQ.2) WRITE(6,8010)
601. 006210B 8010 FORMAT(1H1,= ROTOR IMPINGEMENT(SMALL DROPLET)=)
602. 006210B CALL WICIRS(ISTAGE,RADI1(ISTAGE),XW(1),XG,RHOG(1),BETA1,W1,WW1,
      $WW2,WW)
603. 006213B AMIMPR=WW
604. 006213B IF(AMIMPR.LT.0.0) AMIMPR=0.0
605. 006217B IF(AMIMPR.GT.WMASS(1)) AMIMPR=WMASS(1)
606. 006222B AMREBR=AMIMPR*PREB/100.0
607. 006223B AMWAKR=AMIMPR*(1.0-PREB/100.0)
608. 006226B AMNOIR=WMASS(1)-AMIMPR
609. 006230B XWNOIR=AMNOIR/MMASS
610. 006231B XWREBR=AMREBR/MMASS
611. 006232B XWWAKR=AMWAKR/MMASS
612. 006234B IF(IPRINT.EQ.2) WRITE(6,609) AMIMPR,AMREBR,AMWAKR,AMNOIR,
      $XWNOIR,XWREBR,XWWAKR
613. 006251B 609 FORMAT(1H ,7(F12.5,1X))
C ++++++
C ROTOR IMPINGEMENT(LARGE DROPLET)
614. 006251B IF(IPRINT.EQ.2) WRITE(6,8020)
615. 006256B 8020 FORMAT(1H0,= ROTOR IMPINGEMENT(LARGE DROPLET)=)
616. 006256B CALL WICIRL(ISTAGE,RADI1(ISTAGE),XWW(1),XG,RHOG(1),BETA1,W1,WW1,WW
      $2,WW)
617. 006261B BMIMPR=WW
618. 006261B IF(BMIMPR.LT.0.0) BMIMPR=0.0
619. 006265B IF(BMIMPR.GT.WWMASS(1)) BMIMPR=WWMASS(1)
620. 006270B BMREBR=BMIMPR*PREB/100.0
621. 006271B BMWAKR=BMIMPR*(1.0-PREB/100.0)
622. 006274B BMNOIR=WWMASS(1)-BMIMPR
623. 006276B XWWB=0.0
624. 006276B IF(WWMASS(1).GT.1.0E-6) XWWB=BMWAKR/WWMASS(1)
625. 006302B XWWNOR=BMNOIR/MMASS
626. 006303B XWWRER=BMREBR/MMASS
627. 006304B XWWWAR=BMWAKR/MMASS
628. 006306B IF(IPRINT.EQ.2) WRITE(6,6090) BMIMPR,BMREBR,BMWAKR,BMNOIR,XWWNOR,
      $XWWRER,XWWWAR
629. 006323B 6090 FORMAT(1H ,7(F12.5,1X))
C ++++++
C ROTOR WAKE
630. 006323B IF(IPRINT.EQ.2) WRITE(6,8030)
631. 006330B 8030 FORMAT(1H0,= ROTOR WAKE=)
632. 006330B N=N+1
633. 006331B ALFA=BETA2
634. 006332B DWAKEM=0.0
635. 006332B IF(AMWAKR.GT.0.0) GO TO 630
636. 006335B GO TO 631
637. 006336B 630 CALL WICWAK(RHOG(1),W2,DWAKE,DWAKEM)
638. 006340B 631 D1=DWAKEM
639. 006340B IF(D1.LT.0.0) D1=0.0
640. 006344B IF(D1.GT.DIN) D1=DIN

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641. 006347B AMING1=AMWAKR
642. 006347B ALFA=BETA2
643. 006351B RDELU1=DELUU2
644. 006352B DWAKEM=0.0
645. 006353B IF(BMWAKR.GT.0.0) GO TO 6310
646. 006356B GO TO 6311
647. 006357B 6310 CALL WICWAK(RHOG(1),RDELU1,DWAKE,DWAKEM)
648. 006361B 6311 D2=DWAKEM
649. 006361B IF(D2.LT.0.0) D2=0.0
650. 006365B IF(D2.GT.DDIN) D2=DDIN
651. 006370B RUP2=(90.0-BETA2)/180.0
652. 006372B AMING2=BMWAKR*RUP2
653. 006373B RDELU2=DELUL2
654. 006375B DWAKEM=0.0
655. 006376B IF(BMWAKR.GT.0.0) GO TO 6312
656. 006400B GO TO 6313
657. 006400B 6312 CALL WICWAK(RHOG(1),RDELU2,DWAKE,DWAKEM)
658. 006403B 6313 D3=DWAKEM
659. 006403B IF(D3.LT.0.0) D3=0.0
660. 006407B IF(D3.GT.DDIN) D3=DDIN
661. 006412B RLOW2=(90.0+BETA2)/180.0
662. 006414B AMING3=BMWAKR*RLOW2
663. 006415B WMASSS=WMASS(1)-AMWAKR
664. 006420B WMASSL=WMASS(1)-BMWAKR
665. 006422B CALL WICSIZ(WMASSL,WMASSS,AMING1,AMING2,AMING3,DDAVE(1
$,DAVE(1),D1,D2,D3,DLIMIT,AMSSL,AMLGE,DSLL,DLGE)
666. 006424B WMASS(2)=AMLGE
667. 006424B WMASS(2)=AMSSL
668. 006426B IF(WMASS(2).LT.0.0) WMASS(2)=0.0
669. 006431B IF(WMASS(2).LT.0.0) WMASS(2)=0.0
670. 006433B WTMASS(2)=WMASS(2)+WMASS(2)
671. 006434B UMASS(2)=WMASS(1)
672. 006435B MMASS=AMASS+CHMASS+UMASS(2)+WTMASS(2)
673. 006441B TMASS(2)=MMASS
674. 006442B GMASS(2)=TMASS(2)-WTMASS(2)
675. 006443B DAVE(N)=DSLL
676. 006444B DDAVE(N)=DLGE
677. 006446B XW(2)=WMASS(2)/MMASS
678. 006450B XWW(2)=WMASS(2)/MMASS
679. 006451B XWT(2)=WTMASS(2)/MMASS
680. 006452B XU(2)=XU(1)
681. 006453B XCH4=CHMASS/MMASS
682. 006455B XA=AMASS/MMASS
683. 006457B XG=XA+XU(2)+XCH4
684. 006462B XAIR(2)=XA
685. 006463B XMETAN(2)=XCH4
686. 006464B XGAS(2)=XG
687. 006465B WS(2)=UMASS(2)/AMASS
688. 006467B PW=WS(2)*P(2)/(WS(2)+0.6219)
689. 006473B IF(PW.LT.1.0E-8) PW=1.0E-8
690. 006476B TDEW(2)=WICBPT(TG(2),PW)
691. 006500B RHOA(2)=P(2)/RA/TG(2)
692. 006502B CALL WICPRP(XA,XU(2),XCH4,TG(2),RMIX,CPMIX,GAMMA,G1,G2,G3)
693. 006505B RHO(2)=P(2)/RMIX/TG(2)
694. 006507B IF(JPERFM.NE.3) BMASS=MMASS
695. 006513B IF(JPERFM.EQ.3) BMASS=GMASS(2)
696. 006516B CALL WICMAC(ISTAGE,BMASS,TG(2),P(2),M,UZ,C,XWT(2),ALFA2,
$RMIX,CPMIX,AAA2)
697. 006520B RHO(2)=(1.0+G2*M**2)**G3*RHO(2)
698. 006526B RHO(2)=1.0/((1.0-XWT(2))/RHO(2)+XWT(2)/RHOW)

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699. 006533B      RHOA(2)=(1.0+G2*M**2)**G3*RHOA(2)
700. 006542B      IF(IPRINT.EQ.2) WRITE(6,614) UZ,ALFA,D1,D2,D3,WMASS(2),
          $WMASS(2),UMASS(2),XW(2),XU(2)
701. 006562B      614 FORMAT(1H,10(F12.5,1X))
702. 006562B      IF(IPRINT.EQ.2) WRITE(6,615)WS(2),DAVE(N),DDAVE(N),RHOM(2),RHOA
          $(2),RHOM(2),RHOG(2)
703. 006600B      615 FORMAT(1H,7(F12.5,1X))
704. 006600B      IF(UZ.LT.0.0.OR.UZ.GT.1500.0) WRITE(6,6150)
705. 006607B      6150 FORMAT(1H0,=UZ IS TOO HIGH OR TOO LOW: UZ=,F10.4)
          C ++++++
          C CENTRIFUGAL EFFECT IN (VAPOR)
706. 006607B      IF(IPRINT.EQ.2) WRITE(6,8041)
707. 006614B      8041 FORMAT(1H0,=CENTRIFUGAL ACTION IN ROTOR (VAPOR)=)
708. 006614B      DELMU=0.0
709. 006614B      DELMAS=0.0
710. 006614B      AMASU=UMASTT+DMDTA1+DMDTA2
711. 006620B      IF(ICENTV.NE.0) GO TO 8042
712. 006621B      DELZZ=RC(ISTAGE)/12.0
713. 006623B      ALFAAU=(BETA1+BETA2)/2.0
714. 006626B      IRS=3
715. 006627B      RHOGAS=RHOG(2)
716. 006630B      RHUB=RRHUB(ISTAGE)
717. 006632B      CALL WICCEN(URZERO,UJZERO,10.0,UZ,DELZZ,ALFAAU,FN,IRS,RHOGAS,RHUB,
          $R2,U2,ITIP,UZTIME,XG,XA,XU(2),XCH4,RRTIP(ISTAGE),IPRINT)
          IRADD=IRAD
718. 006636B      IF(IRAD.EQ.4.AND.ISTAGE.LE.NSF) IRAD=2
719. 006636B      IF(IRAD.EQ.4.AND.ISTAGE.GT.NSF) IRAD=1
720. 006645B      CALL WICDMV(IPRINT,IRAD,UMASS(1),UMASTL,UMASTL,URZERO,R2,
          $AAREA(ISTAGE),RADI1(ISTAGE),DELMAS)
722. 006656B      IRAD=IRADD
723. 006656B      UCENT=UCENT+ABS(DELMAS)
724. 006662B      URZERO=R2
725. 006663B      UJZERO=0.0
726. 006663B      8042 DELMU=DELMAS
727. 006665B      UM=UMASS(2)
728. 006667B      UMASS(2)=UMASS(2)+DELMAS
729. 006670B      IF(UMASS(2).LT.1.0E-8) UMASS(2)=1.0E-8
730. 006673B      DELMAS=UMASS(2)-UM
731. 006674B      DELVUM=28.964/18.043*DELMAS
732. 006675B      AMASS=AMASS-DELVUM
733. 006677B      MMASS=MMASS-DELVUM+DELMAS
          C ++++++
          C CENTRIFUGAL EFFECT IN ROTOR (SMALL DROPLET)
734. 006702B      IF(IPRINT.EQ.2) WRITE(6,8040)
735. 006710B      8040 FORMAT(1H0,=CENTRIFUGAL ACTION IN ROTOR (SMALL DROPLET)=)
736. 006710B      DELMW=0.0
737. 006710B      DELMAS=0.0
738. 006710B      RW=0.0
739. 006711B      RWW=0.0
740. 006712B      IF(WTMASS(1).GT.1.0E-6) RW=WMASS(1)/WTMASS(1)
741. 006716B      IF(WTMASS(1).GT.1.0E-6) RWW=WMASS(1)/WTMASS(1)
742. 006721B      AMASW=(WMASTL-WCENT-WWCENT)*RW
743. 006724B      IF(JCENT.EQ.1) AMASW=(WMASTL-WCENT-WWCENT)*(RW+RWW*(1.0-XWWB))
744. 006736B      BMASW=(WMASTL-WCENT-WWCENT)*RWW*XWWB
745. 006741B      IF(ICENT.EQ.4.OR.ICENT.EQ.5) GO TO 996
746. 006745B      IF(ICENT.EQ.7)GO TO 996
747. 006747B      IF(DAVE(N-1).LT.1.0E-6) GO TO 996
748. 006752B      IF(WMASS(2).LT.1.0E-6) GO TO 996
749. 006754B      DD=DAVE(N-1)
750. 006755B      DELZZ=RC(ISTAGE)/12.0

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751. 006760B ALFAAU=(BETA1+BETA2)/2.0
752. 006763B IRS=2
753. 006764B RHOGAS=RHOG(2)
754. 006765B RHUB=RRHUB(ISTAGE)
755. 006767B CALL WICCEN(RZERO,UZERO,DD,UZ,DELZZ,ALFAAU ,FN,IRS,RHOGAS,
1RHUB,R2,U2,ITIP,UZTIME,XG,XA,XU(2),XCH4,RRTIP(ISTAGE),IPRINT)
756. 006773B IRADD=IRAD
757. 006773B IF(IRAD.EQ.4.AND.ISTAGE.LE.NSF) IRAD=2
758. 007002B IF(IRAD.EQ.4.AND.ISTAGE.GT.NSF) IRAD=1
759. 007007B CALL WICDMS(IPRINT,IRAD,WMASS(1),AMASW,AMASW,RZERO,R2,AAREA(ISTA
$GE),RADI1(ISTAGE),RRTIP(ISTAGE),DMIN,DMOUT,AMASW2,DELMAS)
760. 007014B IRAD=IRADD
761. 007014B WCENT=DELMAS
762. 007016B RZERO=R2
763. 007017B UZERO=U2
764. 007021B 996 DELMW=DELMAS
765. 007022B RWRWW=RW+RWW*(1.0-XWWB)
766. 007027B IF(JCENT.EQ.1) DELMW=0.0
767. 007033B IF(JCENT.EQ.1.AND.RWRWW.GT.1.0E-6) DELMW=DELMAS*RW/RWRWW
768. 007040B IF(JCENT.EQ.1) DELMW=DELMAS-DELMW
C+++++
C CENTRIFUGAL EFFECT IN ROTOR(LARGE DROPLET)
769. 007044B IF(IPRINT.EQ.2) WRITE(6,8050)
770. 007051B 8050 FORMAT(1H0,≠ CENTRIFUGAL ACTION IN ROTOR (LARGE DROPLET)≠)
771. 007051B DELMAS=0.0
772. 007051B DELMWW=0.0
773. 007051B IF(IICENT.EQ.4.OR.IICENT.EQ.5) GO TO 9996
774. 007055B IF(IICENT.EQ.7)GO TO 9996
775. 007057B IF(DDAVE(N-1).LT.1.0E-6) GO TO 9996
776. 007062B IF(WWMASS(2).LT.1.0E-6) GO TO 9996
777. 007064B DD=DDAVE(N-1)
778. 007065B DELZZ=RC(ISTAGE)/12.0
779. 007070B ALFAAU=0.0
780. 007071B IIRS=2
781. 007072B RHOGAS=RHOG(2)
782. 007073B RHUB=RRHUB(ISTAGE)
783. 007074B CALL WICCEN(RRZERO,UZERO,DD,UZ,DELZZ,ALFAAU ,FN,IIRS,RHOGAS,
1RHUB,R2,U2,ITIP,UZTIME,XG,XA,XU(2),XCH4,RRTIP(ISTAGE),IPRINT)
784. 007100B IRADD=IRAD
785. 007100B IF(IRAD.EQ.4.AND.ISTAGE.LE.NSF) IRAD=2
786. 007107B IF(IRAD.EQ.4.AND.ISTAGE.GT.NSF) IRAD=1
787. 007114B CALL WICDML(IPRINT,IRAD,WMASS(1),BMASS,BMASS,RRZERO,R2,AAREA(IS
$TAGE),RADI1(ISTAGE),RRTIP(ISTAGE),DMIN,DMOUT,AMASW2,DELMAS)
788. 007121B IRAD=IRADD
789. 007121B RRZERO=R2
790. 007123B UZERO=U2
791. 007124B 9996 DELMWW=DELMAS
792. 007126B IF(JCENT.EQ.1) DELMWW=DELMWW+DELMAS
793. 007133B WM=WMASS(2)
794. 007133B WWM=WWMASS(2)
795. 007135B WMASS(2)=WMASS(2)+DELMW
796. 007137B WWMASS(2)=WWMASS(2)+DELMWW
797. 007140B WTMASS(2)=WMASS(2)+WWMASS(2)
798. 007141B IF(WTMASS(2).GT.WMASTL) TT=WTMASS(2)/WMASTL
799. 007145B IF(WTMASS(2).GT.WMASTL) WMASS(2)=WMASS(2)/TT
800. 007150B IF(WTMASS(2).GT.WMASTL) WWMASS(2)=WWMASS(2)/TT
801. 007154B DELMW=WMASS(2)-WM
802. 007155B DELMWW=WWMASS(2)-WWM
803. 007157B WTMASS(2)=WMASS(2)+WWMASS(2)
804. 007160B DELMAS=WTMASS(2)-WTMASS(1)

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805. 007162B      MMASS=MMASS+DELMAS
806. 007163B      XW(2)=WMASS(2)/MMASS
807. 007164B      XWW(2)=WWMASS(2)/MMASS
808. 007165B      XU(2)=UMASS(2)/MMASS
809. 007167B      XA=AMASS/MMASS
810. 007170B      XCH4=CHMASS/MMASS
811. 007172B      XG=XA+XU(2)+XCH4
812. 007174B      DELVUM=RHO(2)/RHOW*DELMAS
813. 007177B      AMASS=AMASS-DELVUM*(AMASS/GMASS(2))
814. 007202B      UMASS(2)=UMASS(2)-DELVUM*(UMASS(2)/GMASS(2))
815. 007205B      CHMASS=CHMASS-DELVUM*(CHMASS/GMASS(2))
816. 007211B      MMASS=AMASS+UMASS(2)+CHMASS+WTMASS(2)
817. 007214B      WS(2)=UMASS(2)/MMASS
818. 007215B      WCENT=WCENT+DELMW
819. 007217B      WWCENT=WWCENT+DELMWW
820. 007221B      IF(WMASS(2).LT.1.0E-6) DAVE(N)=0.0
821. 007226B      IF(WWMASS(2).LT.1.0E-6) DDAVE(N)=0.0
C ++++++
C STATOR IMPINGEMENT(SMALL DROPLET)
822. 007231B      IF(IPRINT.EQ.2) WRITE(6,8060)
823. 007236B      8060 FORMAT(1H0,≠ STATOR IMPINGEMENT (SMALL DROPLET)≠)
824. 007236B      CALL WICISS(ISTAGE,RADI2(ISTAGE),XW(2),XG,RHO(2),ALFA2,U2,
      $WW1,WW2,WW)
825. 007241B      AMIMPS=WW
826. 007241B      IF(AMIMPS.GT.WMASS(2)) AMIMPS=WMASS(2)
827. 007245B      IF(AMIMPS.LT.0.0) AMIMPS=0.0
828. 007250B      AMREBS=AMIMPS*PREB/100.0
829. 007251B      AMWAKS=AMIMPS*(1.0-PREB/100.0)
830. 007254B      IF(IPRINT.EQ.2) WRITE(6,617) XW(2),XG,RHO(2),U2,WW,AMIMPS,AMRE
      $BS,AMWAKS
831. 007272B      617 FORMAT(1H ,8(F12.5,1X))
C ++++++
C STATOR IMPINGEMENT(LARGE DROPLET)
832. 007272B      IF(IPRINT.EQ.2) WRITE(6,8070)
833. 007277B      8070 FORMAT(1H0,≠ STATOR IMPINGEMENT (LARGE DROPLET)≠)
834. 007277B      CALL WICISL(ISTAGE,RADI2(ISTAGE),XWW(2),XG,RHO(2),ALFA2,U2,WW1
      $,WW2,WW)
835. 007302B      BMIMPS=WW
836. 007302B      IF(BMIMPS.LT.0.0) BMIMPS=0.0
837. 007306B      IF(BMIMPS.GT.WWMASS(2)) BMIMPS=WWMASS(2)
838. 007311B      BMREBS=BMIMPS*PREB/100.0
839. 007312B      BMWAKS=BMIMPS*(1.0-PREB/100.0)
840. 007315B      IF(IPRINT.EQ.2) WRITE(6,6617) XWW(2),XA,RHO(2),U2,WW,BMIMPS,BM
      $REBS,BMWAKS
841. 007334B      6617 FORMAT(1H ,8(F12.5,1X))
C ++++++
C STATOR WAKE
842. 007334B      IF(IPRINT.EQ.2) WRITE(6,8080)
843. 007341B      8080 FORMAT(1H0,≠ STATOR WAKE≠)
844. 007341B      N=N+1
845. 007342B      ALFA=ALFA3
846. 007343B      DWAKEM=0.0
847. 007343B      IF(AMWAKS.GT.0.0) GO TO 632
848. 007346B      GO TO 633
849. 007347B      632 CALL WICIAK(RHO(2),U3,DWAKE,DWAKEM)
850. 007351B      633 D1=DWAKEM
851. 007351B      IF(D1.LT.0.0) D1=0.0
852. 007355B      IF(D1.GT.DIN) D1=DIN
853. 007360B      AMING1=AMWAKS
854. 007360B      ALFA=ALFA3

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855. 007362B SDELV1=DELUV2
856. 007363B DWAKEM=0.0
857. 007364B IF(BMWAKS.GT.0.0) GO TO 6330
858. 007367B GO TO 6331
859. 007370B 6330 CALL WICWAK(RHOG(2),SDELV1,DWAKE,DWAKEM)
860. 007372B 6331 D2=DWAKEM
861. 007372B IF(D2.LT.0.0) D2=0.0
862. 007376B IF(D2.GT.DDIN) D2=DDIN
863. 007401B SUP2=(90.0-ALFA3)/180.0
864. 007403B AMING2=BMWAKS*SUP2
865. 007404B SDELV2=DELUL2
866. 007406B DWAKEM=0.0
867. 007407B IF(BMWAKS.GT.0.0) GO TO 6332
868. 007411B GO TO 6333
869. 007411B 6332 CALL WICWAK(RHOG(2),SDELV2,DWAKE,DWAKEM)
870. 007414B 6333 D3=DWAKEM
871. 007414B IF(D3.LT.0.0) D3=0.0
872. 007420B IF(D3.GT.DDIN) D3=DDIN
873. 007423B SLOW2=(90.0+ALFA3)/180.0
874. 007425B AMING3=BMWAKS*SLOW2
875. 007426B WMASSS=WMASS(2)-AMWAKS
876. 007431B WMASSL=WMASS(2)-BMWAKS
877. 007433B IF(WMASSS.LT.0.0) WMASSS=0.0
878. 007436B IF(WMASSL.LT.0.0) WMASSL=0.0
879. 007440B CALL WICSIZ(WMASSL,WMASS,AMING1,AMING2,AMING3,DDAVE(2),DAVE(
$2),D1,D2,D3,DLIMIT,AMSL,AMLGE,DSLL,DLGE)
880. 007442B WMASS(3)=AMLGE
881. 007442B WMASS(3)=AMSL
882. 007444B IF(WMASS(3).LT.0.0) WMASS(3)=0.0
883. 007447B IF(WMASS(3).LT.0.0) WMASS(3)=0.0
884. 007451B WTMASS(3)=WMASS(2)+WMASS(2)
885. 007452B UMASS(3)=UMASS(2)
886. 007453B MMASS=AMASS+CHMASS+UMASS(3)+WTMASS(3)
887. 007457B TMASS(3)=MMASS
888. 007460B GMASS(3)=TMASS(3)-WTMASS(3)
889. 007461B DAVE(N)=USLL
890. 007462B DDAVE(N)=DLGE
891. 007464B XW(3)=WMASS(3)/MMASS
892. 007466B XWW(3)=WMASS(3)/MMASS
893. 007467B XWT(3)=WTMASS(3)/MMASS
894. 007470B XU(3)=XU(2)
895. 007472B XA=AMASS/MMASS
896. 007474B XCH4=CHMASS/MMASS
897. 007475B XG=XA+XU(3)+XCH4
898. 007500B XAIR(3)=XA
899. 007500B XMETAN(3)=XCH4
900. 007502B XGAS(3)=XG
901. 007503B IF(WMASSO.LT.1.0E-6) WMASSO=WMASS(3)
902. 007510B IF(WWMASSO.LT.1.0E-6) WWMASSO=WWMASS(3)
903. 007513B IF(WTMASS(3).GT.0.0) RW=WMASS(3)/WTMASS(3)
904. 007517B IF(WTMASS(3).GT.0.0) RWW=WWMASS(3)/WTMASS(3)
905. 007522B TG(3)=TG(2)
906. 007522B TW(3)=TW(2)
907. 007524B IF(IPRINT.EQ.2) WRITE(6,619) RHOA(2),UZ,ALFA,D1,D2,WWMASS(3)
$,WMASS(3),UMASS(3),XW(3),XU(3)
908. 007544B 619 FORMAT(1H,10(F12.5,1X))
909. 007544B IF(IPRINT.EQ.2) WRITE(6,620) DAVE(N),TG(3),TW(3)
910. 007555B 620 FORMAT(1H,3(F12.5,1X))
911. 007555B IF(WMASS(2).GT.0.0.AND.WMASS(2).GT.0.0) GO TO 951
912. 007561B IF(WMASS(2).GT.0.0) GO TO 951

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913. 007563B IF(WWMASS(2).GT.0.0) GO TO 951
914. 007565B WS(3)=WS(2)
915. 007565B TB(3)=TB(2)
916. 007567B TDEW(3)=TDEW(2)
917. 007570B DELTG2=0.0
918. 007571B DELTG3=0.0
919. 007572B DELTW2=0.0
920. 007573B TRATIO=TG(3)/TG(1)
921. 007574B DAVE(N)=0.0
922. 007575B RHOA(3)=P(3)/RA/TG(3)
923. 007600B CALL WICPRP(XA,XU(3),XCH4,TG(3),RMIX,CPMIX,GAMMA,G1,G2,G3)
924. 007603B RHOG(3)=P(3)/RMIX/TG(3)
925. 007605B IF(JPERFM.NE.3) BMASS=MMASS
926. 007611B IF(JPERFM.EQ.3) BMASS=GMASS(3)
927. 007614B CALL WICMAC(ISTAGE,BMASS,TG(3),P(3),M,UZ,C,XWT(3),ALFA3,
$RMIX,CPMIX,AAA3)
928. 007616B RHOG(3)=(1.0+G2*M**2)**G3*RHOG(3)
929. 007624B RHOM(3)=1.0/((1.0-XWT(3))/RHOG(3)+XWT(3)/RHOW)
930. 007631B RHOA(3)=(1.0+G2*M**2)**G3*RHOA(3)
931. 007640B GO TO 950
932. 007640B 951 CONTINUE
933. 007642B WTMASS(3)=WMASS(3)+WWMASS(3)
C+++++
C HEAT-TRANSFER (SMALL DROPLET)
934. 007643B IF(IPRINT.EQ.2) WRITE(6,8120)
935. 007651B 8120 FORMAT(1H0,= HEAT TRANSFER=)
936. 007651B DELTGH=0.0
937. 007651B DELTWH=0.0
938. 007651B IF(ICENT.EQ.3.OR.ICENT.EQ.5) GO TO 8122
939. 007655B IF(DAVE(N-2).GT.0.0.AND.DAVE(N).GT.0.0) GO TO 8121
940. 007662B GO TO 8122
941. 007662B 8121 RE=0.0
942. 007663B XU1=(XU(1)+XU(3))/2.0
943. 007666B XW1=(XW(1)+XW(3))/2.0
944. 007671B WMASS1=(WMASS(1)+WMASS(3))/2.0
945. 007674B UMASS1=(UMASS(1)+UMASS(3))/2.0
946. 007677B CPG1=XA*WICCPA(TG(1))+XU(1)*WICCPH(TG(1))+XCH4*WICCCPC(TG(1))
947. 007712B CPG3=XA*WICCPA(TG(3))+XU(3)*WICCPH(TG(3))+XCH4*WICCCPC(TG(3))
948. 007725B CPG=(CPG1+CPG3)/2.0
949. 007730B CALL WICHET(TG(1),TG(3),TW(1),TW(3),DAVE(N-2),DAVE(N)
$,DELZ(ISTAGE),UZ,WMASS1,UMASS1,AMASS,CHMASS,CPG,CPW,DELTGH
$,DELTWH,RE)
950. 007737B 8122 DELTG2=DELTGH
951. 007737B DELTW2=DELTWH
C+++++
C HEAT TRANSFER(LARGE DROPLET)
952. 007741B DELTGH=0.0
953. 007742B DELTWH=0.0
954. 007742B IF(IICENT.EQ.3.OR.IICENT.EQ.5) GO TO 8124
955. 007745B IF(DDAVE(N-2).GT.0.0.AND.DAVE(N).GT.0.0) GO TO 8123
956. 007753B GO TO 8124
957. 007753B 8123 RE=0.0
958. 007754B IF(DDAVE(N-1).GT.0.0) RE=REAVE
959. 007761B XU1=(XU(1)+XU(3))/2.0
960. 007763B XW1=(XW(1)+XW(3))/2.0
961. 007766B WMASS1=(WMASS(1)+WMASS(3))/2.0
962. 007771B UMASS1=(UMASS(1)+UMASS(3))/2.0
963. 007774B CPG1=XA*WICCPA(TG(1))+XU(1)*WICCPH(TG(1))+XCH4*WICCCPC(TG(1))
964. 010007B CPG3=XA*WICCPA(TG(1))+XU(3)*WICCPH(TG(3))+XCH4*WICCCPC(TG(3))
965. 010022B CPG=(CPG1+CPG3)/2.0

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966. 010025B      CALL WICHET(TG(1),TG(3),TWW(1),TWW(3),DDAVE(N-2),DDAVE(N)
      $,DELZ(ISTAGE),UZ,WMASS1,UMASS1,AMASS,CHMASS,CPG,CPW,DELTCG
      $,DELTWH,RE)
967. 010034B      8124 DELTG3=DELTGH
968. 010034B      DELTW3=DELTWH
969. 010036B      TG(3)=TG(1)+DELTG1-DELTG2-DELTG3
970. 010042B      TW(3)=TW(1)+DELTW1+DELTW2
971. 010045B      TWW(3)=TWW(1)+DELTW3
972. 010047B      TRATIO=TG(3)/TG(1)
973. 010051B      IF(IPRINT.EQ.2) WRITE(6,627) DELTG2,DELTW2,DELTG3,DELTW3,TG(3),
      $TW(3),TWW(3),TRATIO
974. 010067B      627 FORMAT(1H,8(F15.6,1X))
      C ++++++
      C MASS-TRANSFER
975. 010067B      IF(IPRINT.EQ.2) WRITE(6,8130)
976. 010074B      8130 FORMAT(1H0,= MASS TRANSFER=)
977. 010074B      DAVEN2=DAVE(N-2)
978. 010075B      DAVEN=DAVE(N)
979. 010076B      DZ=DELZ(ISTAGE)
980. 010100B      RE=0.0
981. 010101B      DMDTAU=0.0
982. 010102B      IF(ICENT.EQ.3.OR.ICENT.EQ.5) GO TO 637
983. 010106B      IF(ICENT.EQ.6.OR.ICENT.EQ.7) GO TO 637
984. 010111B      IF(DAVE(N-2).GT.0.0.AND.DAVE(N).GT.0.0) GO TO 636
985. 010116B      GO TO 637
986. 010116B      636 CALL WICMAS(WS(1),TW(1),TW(3),P(1),P(3),TG(1),TG(3),DZ,PWB1,PWB2
      $,PW1,PW2,UZ,DAVEN2,DAVEN,HW2,UMASS(1),UMASS2,WMASS(1),WMASS2,
      $DMDTAU,AMASS,RE)
987. 010121B      637 DMDTA1=DMDTAU
988. 010121B      IF(DMDTA1.LT.0.0) DMDTA1=0.0
989. 010125B      DAVEN2=DDAVE(N-2)
990. 010126B      DAVEN=DDAVE(N)
991. 010127B      DZ=DELZ(ISTAGE)
992. 010131B      RE=0.0
993. 010132B      DMDTAU=0.0
994. 010133B      IF(IICENT.EQ.3.OR.IICENT.EQ.5) GO TO 6370
995. 010137B      IF(IICENT.EQ.6.OR.IICENT.EQ.7) GO TO 6370
996. 010142B      IF(DDAVE(N-1).GT.0.0.AND.DDAVE(N).GT.0.0) RE=REAVE
997. 010151B      IF(DDAVE(N-2).GT.0.0.AND.DDAVE(N).GT.0.0) GO TO 6360
998. 010154B      GO TO 6370
999. 010154B      6360 CALL WICMAS(WS(1),TWW(1),TWW(3),P(1),P(3),TG(1),TG(3),DZ,PWB1,PWB2
      $,PW1,PW2,UZ,DAVEN2,DAVEN,HW2,UMASS(1),UMASS2,WMASS(1),WMASS2,
      $DMDTAU,AMASS,RE)
1000. 010157B      6370 DMDTA2=DMDTAU
1001. 010157B      IF(DMDTA2.LT.0.0) DMDTA2=0.0
1002. 010163B      WMASS(3)=WMASS(3)-DMDTA1
1003. 010164B      WWMASS(3)=WWMASS(3)-DMDTA2
1004. 010166B      WMASTL=WMASTL-(DMDTA1+DMDTA2)*AAREAS(ISTAGE)/AA2
1005. 010172B      IF(WMASTL.LT.0.0) WMASTL=0.0
1006. 010175B      IF(WMASS(3).LT.0.0) WMASS(3)=0.0
1007. 010177B      IF(WWMASS(3).LT.0.0) WWMASS(3)=0.0
1008. 010201B      WTMASS(3)=WMASS(3)+WWMASS(3)
1009. 010202B      UMASS(3)=UMASS(3)+DMDTA1+DMDTA2
1010. 010205B      MMASS=AMASS+CHMASS+UMASS(3)+WTMASS(3)
1011. 010210B      TMASS(3)=MMASS
1012. 010211B      GMASS(3)=TMASS(3)-WTMASS(3)
1013. 010212B      XW(3)=WMASS(3)/MMASS
1014. 010213B      XWW(3)=WWMASS(3)/MMASS
1015. 010214B      XWT(3)=WTMASS(3)/MMASS
1016. 010216B      XU(3)=UMASS(3)/MMASS

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1017. 010217B      XA=AMASS/MMASS
1018. 010221B      XCH4=CHMASS/MMASS
1019. 010222B      XG=XA+XU(3)+XCH4
1020. 010225B      XAIR(3)=XA
1021. 010225B      XMETAN(3)=XCH4
1022. 010227B      XGAS(3)=XG
1023. 010230B      WS(3)=UMASS(3)/AMASS
1024. 010232B      PW=WS(3)*P(3)/(WS(3)+0.6219)
1025. 010236B      IF(PW.LT.1.0E-8) PW=1.0E-8
1026. 010241B      TDEW(3)=WICBPT(TG(3),PW)
1027. 010243B      RHOA(3)=P(3)/RA/TG(3)
1028. 010245B      CALL WICPRP(XA,XU(3),XCH4,TG(3),RMIX,CPMIX,GAMMA,G1,G2,G3)
1029. 010305B      RHOG(3)=P(3)/RMIX/TG(3)
1030. 010252B      IF(JPERFM.NE.3) BMASS=MMASS
1031. 010256B      IF(JPERFM.EQ.3) BMASS=GMMASS(3)
1032. 010261B      CALL WICMAC(ISTAGE,BMASS,TG(3),P(3),M,UZ,C,XWT(3),ALFA3,
      $RMIX,CPMIX,AAA3)
1033. 010263B      RHOG(3)=(1.0+G2*M**2)**G3*RHOG(3)
1034. 010271B      RHOM(3)=1.0/((1.0-XNT(3))/RHOG(3)+XWT(3)/RHOW)
1035. 010276B      RHOA(3)=(1.0+G2*M**2)**G3*RHOG(3)
1036. 010305B      TB(3)=WICBPT(TG(3),P(3))
1037. 010310B      IF(IPRINT.EQ.2) WRITE(6,624) WMASS(3),XW(3),DDAVE(N),WMASS(3),
      $UMASS(3),XW(3),XU(3),WS(3),DAVE(N)
1038. 010331B      624 FORMAT(1H ,9(F12.5,1X))
1039. 010331B      IF(IPRINT.EQ.2) WRITE(6,625) RHOA(3),RHOM(3),RHOG(3),DMDTA1,DMD
      $TA2,PW2,TW(3),TG(3)
1040. 010346B      625 FORMAT(1H ,8(F12.5,1X))
1041. 010346B      950 DELTGW=DELTG1
1042. 010346B      DELTDW=DELTW1
1043. 010350B      DELTGH=-DELTG2-DELTG3
1044. 010353B      DELTDH=DELTW2
1045. 010354B      DELP=P(3)-P(1)
1046. 010356B      GAMMAO=GAMMA
1047. 010357B      TB(3)=WICBPT(TG(3),P(3))
C+++++
C OUTPUT(STAGE PERFORMANCE)
1048. 010362B      IF(IDESIN.EQ.2) GO TO 475
1049. 010364B      WRITE(6,400) FAIO,ISTAGE
1050. 010372B      400 FORMAT(1H1,1X,***** 1X,
      $=INITIAL FLOW COEFFICIENT=,1X,F5.3,1X,=(ISTAGE=,I2,1X,
      $=),2X,*****
1051. 010372B      475 CONTINUE
1052. 010372B      PRATIO=P(3)/P(1)
1053. 010373B      TRATIO=TG(3)/TG(1)
1054. 010375B      GAMMAU=(GAMMAS+GAMMAO)/2.0
1055. 010400B      G4=(GAMMAU-1.0)/GAMMAU
1056. 010402B      ETAA(ISTAGE)=(PRATIO**G4-1.0)/(TRATIO-1.0)
1057. 010410B      IF(IDESIN.EQ.2) GO TO 470
1058. 010413B      WRITE(6,402) JPERFM
1059. 010420B      402 FORMAT(1H0,5X,=STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT=,
      $=(JPERFM=,I1,=)
1060. 010420B      WRITE(6,401) PRATIO,TRATIO,ETAA(ISTAGE)
1061. 010427B      401 FORMAT(1H0,5X,=STAGE TOTAL PRESSURE RATIO=,F12.5,/,
      $6X,=STAGE TOTAL TEMPERATURE RATIO=,F12.5,/,
      $6X,=STAGE ADIABATIC EFFICIENCY=,F12.5)
1062. 010427B      WRITE(6,4025)
1063. 010432B      4025 FORMAT(1H0,12X,=STAGE INLET=,4X,=STAGE OUTLET=,
      $4X,=STAGE OUTLET=)
1064. 010432B      WRITE(6,4026)
1065. 010435B      4026 FORMAT(1H ,33X,=(BEFORE INTER=,6X,=(AFTER INTER=)

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1066. 010435B WRITE(6,4027)
1067. 010440B 4027 FORMAT(1H ,34X, #STAGE ADJUST=#,7X, #STAGE ADJUST=#)
1068. 010440B WRITE(6,4028)
1069. 010443B 4028 FORMAT(1H ,34X, #MENT) #, 15X, #MENT) #)
1070. 010443B WRITE(6,405) XU(1), XU(1), XU(3)
1071. 010451B 405 FORMAT(1H ,5X, #XU=#,3(F15.5,5X))
1072. 010451B WRITE(6,406) XW(1), XW(1) , XW(3)
1073. 010457B 406 FORMAT(1H ,5X, #XW=#,3(F15.5,5X))
1074. 010457B WRITE(6,4060) XWW(1),XWW(1),XWW(3)
1075. 010465B 4060 FORMAT(1H ,5X, #XWW=#,3(F15.5,5X))
1076. 010465B WRITE(6,4061) XWT(1),XWT(1),XWT(3)
1077. 010473B 4061 FORMAT(1H ,5X, #XWT=#,3(F15.5,5X))
1078. 010473B WRITE(6,4062) XAIR(1),XAIR(1),XAIR(3)
1079. 010501B 4062 FORMAT(1H ,5X, #XAIR=#,3(F15.5,5X))
1080. 010501B WRITE(6,4063) XMETAN(1),XMETAN(1),XMETAN(3)
1081. 010507B 4063 FORMAT(1H ,5X, #XMETAN=#,3(F15.5,5X))
1082. 010507B WRITE(6,4064) XGAS(1),XGAS(1),XGAS(3)
1083. 010515B 4064 FORMAT(1H ,5X, #XGAS=#,3(F15.5,5X))
1084. 010515B WRITE(6,407) WMASS(1), WMASS(1) , WMASS(3)
1085. 010523B 407 FORMAT(1H ,5X, #WMASS=#,3(F15.5,5X))
1086. 010523B WRITE(6,4070) WWMASS(1),WWMASS(1),WWMASS(3)
1087. 010531B 4070 FORMAT(1H ,5X, #WWMASS=#,3(F15.5,5X))
1088. 010531B WRITE(6,4071) WTMASS(1),WTMASS(1),WTMASS(3)
1089. 010537B 4071 FORMAT(1H ,5X, #WTMASS=#,3(F15.5,5X))
1090. 010537B WRITE(6,4072) AMASS,AMASS,AMASS
1091. 010545B 4072 FORMAT(1H ,5X, #AMASS=#,3(F15.5,5X))
1092. 010545B WRITE(6,4073) CHMASS,CHMASS,CHMASS
1093. 010553B 4073 FORMAT(1H ,5X, #CHMASS=#,3(F15.5,5X))
1094. 010553B WRITE(6,408) UMASS(1) , UMASS(1) , UMASS(3)
1095. 010561B 408 FORMAT(1H ,5X, #UMASS=#,3(F15.5,5X))
1096. 010561B WRITE(6,4080) GMASS(1),GMASS(1),GMASS(3)
1097. 010567B 4080 FORMAT(1H ,5X, #GMASS=#,3(F15.5,5X))
1098. 010567B WRITE(6,4081) TMASS(1),TMASS(1),TMASS(3)
1099. 010575B 4081 FORMAT(1H ,5X, #TMASS=#,3(F15.5,5X))
1100. 010575B WRITE(6,409) WS(1) , WS(1) , WS(3)
1101. 010603B 409 FORMAT(1H ,5X, #WS=#,3(F15.5,5X))
1102. 010603B WRITE(6,410) RHOA(1) , RHOA(2) , RHOA(3)
1103. 010611B 410 FORMAT(1H ,5X, #RHOA=#,3(F15.5,5X))
1104. 010611B WRITE(6,411) RHOM(1), RHOM(2),RHOM(3)
1105. 010617B 411 FORMAT(1H ,5X, #RHOM=#,3(F15.5,5X))
1106. 010617B WRITE(6,412) RHOG(1),RHOG(2),RHOG(3)
1107. 010625B 412 FORMAT(1H ,5X, #RHOG=#,3(F15.5,5X))
1108. 010625B WRITE(6,413) TG(1),TG(2),TG(3)
1109. 010633B 413 FORMAT(1H ,5X, #TG=#,3(F15.5,5X))
1110. 010633B WRITE(6,414) TW(1),TW(2),TW(3)
1111. 010641B 414 FORMAT(1H ,5X, #TW=#,3(F15.5,5X))
1112. 010641B WRITE(6,4140) TWW(1),TWW(2),TWW(3)
1113. 010647B 4140 FORMAT(1H ,5X, #TWW=#,3(F15.5,5X))
1114. 010647B WRITE(6,415) P(1),P(2),P(3)
1115. 010655B 415 FORMAT(1H ,5X, #P=#,3(F15.5,5X))
1116. 010655B WRITE(6,416) TB(1),TB(2),TB(3)
1117. 010663B 416 FORMAT(1H ,5X, #TB=#,3(F15.5,5X))
1118. 010663B WRITE(6,422) TDEW(1),TDEW(2),TDEW(3)
1119. 010671B 422 FORMAT(1H ,5X, #TDEW=#,3(F15.5,5X))
1120. 010671B 470 CONTINUE
1121. 010671B IF (IDESIN.EQ.2.AND.ISTAGE.EQ.1) WRITE(6,474)
1122. 010700B 474 FORMAT(1H1, # ***** STAGE PERFORMANCE ***** #)
1123. 010700B IF (IDESIN.EQ.2.AND.ISTAGE.EQ.1) WRITE(6,471)
1124. 010707B 471 FORMAT(1H0,1X, #FAIO=#,2X, #STAGE=#,2X, #PRATIO=#,
$3X, #ETA=#,5X, #XU=#,5X, #XW=#,5X, #XWW=#,4X, #XWT=#,4X, #TG=#,5X, #TW=#)

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1125. 010707B      IF(IDESIN.EQ.2) WRITE(6,472) FAIO,ISTAGE,PRATIO,TRATIO,
      $ETAA(ISTAGE),XU(1),XW(1),XWW(1),XWT(1),TG(1),TW(1)
1126. 010730B      472 FORMAT(1H0,F6.3,2X,I2,3X,7F7.4,2X,F7.2,2X,F7.2)
      C+++++
      C REPEAT
1127. 010730B      IF(NSF.EQ.0) GO TO 457
1128. 010731B      IF(ISTAGE.EQ.NSF) T02FAN=TG(3)
1129. 010735B      IF(ISTAGE.EQ.NSF) P02FAN=P(3)
1130. 010740B      IF(ISTAGE.EQ.NSF) T01LPC=T02FAN
1131. 010743B      IF(ISTAGE.EQ.NSF) P01LPC=P02FAN
1132. 010746B      NSFLPC=NSF+NSLPC
1133. 010746B      IF(ISTAGE.EQ.NSFLPC) T02LPC=TG(3)
1134. 010752B      IF(ISTAGE.EQ.NSFLPC) P02LPC=P(3)
1135. 010755B      IF(ISTAGE.EQ.NSFLPC) T01HPC=T02LPC
1136. 010760B      IF(ISTAGE.EQ.NSFLPC) P01HPC=P02LPC
1137. 010763B      IF(ISTAGE.EQ.NS) T02HPC=TG(3)
1138. 010767B      IF(ISTAGE.EQ.NS) P02HPC=P(3)
1139. 010772B      457 CONTINUE
1140. 010772B      IF(ISTAGE.EQ.NS) GO TO 902
1141. 010773B      GO TO 900
1142. 010774B      902 OVALPR=P(3)/OP01
1143. 010776B      OVALTR=TG(3)/OT01G
1144. 011000B      GAMMAU=(GAMMAI+GAMMAO)/2.0
1145. 011003B      G4=(GAMMAU-1.0)/GAMMAU
1146. 011005B      OVALEF=(OVALPR**G4-1.0)/(OVALTR-1.0)
1147. 011013B      ODELTG=TG(3)-OT01G
1148. 011016B      ODELTW=0.0
1149. 011016B      DELTWW=0.0
1150. 011017B      DELMT=0.0
1151. 011020B      DELMWT=0.0
1152. 011020B      DELMG=0.0
1153. 011021B      IF(XDIN.GT.0.0) ODELTW=TW(3)-OT01D
1154. 011026B      IF(XDDIN.GT.0.0) DELTWW=TW(3)-OT01D
1155. 011032B      DELMT=(MMASS-TLMO)/TLMO
1156. 011033B      IF(WTMO.GT.0.0) DELMWT=(WTMASS(3)-WTMO)/WTMO
1157. 011041B      DELMG=(GMASS(3)-GMO)/GMO
1158. 011042B      IF(NSF.EQ.0) GO TO 458
1159. 011044B      PRFAN=P02FAN/P01FAN
1160. 011045B      TRFAN=T02FAN/T01FAN
1161. 011047B      PRLPC=P02LPC/P01LPC
1162. 011051B      TRLPC=T02LPC/T01LPC
1163. 011053B      PRHPC=P02HPC/P01HPC
1164. 011055B      TRHPC=T02HPC/T01HPC
1165. 011057B      PTREF=2116.80/SQRT(518.7)
1166. 011062B      CMFAN=AMFAN*SQRT(T01FAN)/P01FAN*PTREF
1167. 011067B      CMLPC=AMLPC*SQRT(T01LPC)/P01LPC*PTREF
1168. 011074B      CMHPC=AMHPC*SQRT(T01HPC)/P01HPC*PTREF
1169. 011101B      CMFANT=CMFAN*AAAR1T/AAAIGU
1170. 011104B      CMLPCT=CMLPC*AAAR1T/AAAIGU
1171. 011107B      CMHPCT=CMHPC*AAAR1T/AAAIGU
1172. 011110B      EFFAN=(PRFAN**G4-1.0)/(TRFAN-1.0)
1173. 011116B      EFLPC=(PRLPC**G4-1.0)/(TRLPC-1.0)
1174. 011124B      EFHPC=(PRHPC**G4-1.0)/(TRHPC-1.0)
1175. 011132B      458 CONTINUE
      C+++++
      C OUTPUT (OVERALL PERFORMANCE)
1176. 011134B      IF(IDESIN.NE.2) WRITE(6,421)
1177. 011141B      421 FORMAT(1H1,***** OVERALL PERFORMANCE *****)
1178. 011141B      IF(IDESIN.EQ.2) WRITE(6,473)
1179. 011146B      473 FORMAT(1H1,***** OVERALL PERFORMANCE *****)

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1180. 011146B WRITE(6,4220) FAIO
1181. 011152B 4220 FORMAT(1H0,1X,=INITIAL FLOW COEFFICIENT=,F5.3)
1182. 011152B WRITE(6,423) CRPM,FNF
1183. 011157B 423 FORMAT(1H0,1X,=CORRECTED SPEED=,F7.1,5X,F5.3,1X,
$=FRACTION OF DEIGN CORRECTED SPEED=)
1184. 011157B WRITE(6,424)XDIN,XDDIN,XWTO,RHUMID,XCH4IN
1185. 011167B 424 FORMAT(1H0,1X,=INITIAL WATER CONTENT(SMALL DROPLET)=,F5.3,/,
$2X,=INITIAL WATER CONTENT(LARGE DROPLET)=,F5.3,/,
$2X,=INITIAL WATER CONTENT(TOTAL)=,F5.3,/,
$2X,=INITIAL RELATIVE HUMIDITY=,F5.1,1X,=PER CENT=,/,
$2X,=INITIAL METHANE CONTENT=,F5.3)
1186. 011167B WRITE(6,425) TOG
1187. 011173B 425 FORMAT(1H0,1X,=COMPRESSOR INLET TOTAL TEMPERATURE=,F8.2)
1188. 011173B WRITE(6,426) P0
1189. 011177B 426 FORMAT(1H0,1X,=COMPRESSOR INLET TOTAL PRESSURE=,F8.2)
1190. 011177B CCMASS=CMASS*AAAR1T/AAAIGU
1191. 011201B C2MASS=CMASS2*AAAR1T/AAAIGU
1192. 011202B WRITE(6,427) CCMASS
1193. 011207B 427 FORMAT(1H0,1X,=CORRECTED MASS FLOW RATE OF MIXTURE=,F7.3)
1194. 011207B WRITE(6,428) C2MASS
1195. 011213B 428 FORMAT(1H0,1X,=CORRECTED MASS FLOW RATE OF GAS PHASE =,F7.3)
1196. 011213B WRITE(6,429) OUALPR
1197. 011217B 429 FORMAT(1H0,1X,=OVERALL TOTAL PRESSURE RATIO=,F7.4)
1198. 011217B WRITE(6,430) OUALTR
1199. 011223B 430 FORMAT(1H0,1X,=OVERALL TOTAL TEMPERATURE RATIO=,F6.4)
1200. 011223B WRITE(6,431) OUALF
1201. 011227B 431 FORMAT(1H0,1X,=OVERALL ADIABATIC EFFICIENCY=,F6.4)
1202. 011227B IF(NSF.EQ.0) GO TO 459
1203. 011230B WRITE(6,445)
1204. 011233B 445 FORMAT(1H0,=***** PERFORMANCE OF FAN,LPC,HPC *****=)
1205. 011233B WRITE(6,446)
1206. 011236B 446 FORMAT(1H0,7X,=GAS PHASE STAGNATION STAGNATION ADIABATIC=)
1207. 011236B WRITE(6,447)
1208. 011241B 447 FORMAT(1H0,7X,=CORRECTED PRESSURE TEMPERATURE EFFICIENCY=)
1209. 011241B WRITE(6,448)
1210. 011244B 448 FORMAT(1H0,7X,=MASS FLOW RATIO RATIO=)
1211. 011244B WRITE(6,442) CMFANT,PRFAN,TRFAN,EFFAN
1212. 011253B WRITE(6,443) CMLPCT,PRLPC,TRLPC,EFLPC
1213. 011262B WRITE(6,444) CMHPCT,PRHPC,TRHPC,EHPC
1214. 011271B 442 FORMAT(1H0,1X,=FAN=,2X,4(F10.4,2X))
1215. 011271B 443 FORMAT(1H0,1X,=LPC=,2X,4(F10.4,2X))
1216. 011271B 444 FORMAT(1H0,1X,=HPC=,2X,4(F10.4,2X))
1217. 011271B 459 CONTINUE
1218. 011271B GO TO 901
1219. 011271B 998 STOP
1220. 011273B END

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1. 000000B SUBROUTINE WICSPB(FAIO,ISTAGE,MMASS,ALFA1,WKDONE,DAU,DELU,WMAS,N,
$OMEGA1,OMEGA2,OMEGA3,OMEGA4,OMEGAS,OMEGAG,OMEGAT,
$BETA1,BETA2,UZ,ALFA2,ALFA3,DELTA,DELTA,W1,W2,U1,U2,U3,AK1,AK2,
$AK3)
2. 000000B REAL M,MMASS
3. 000000B COMMON JPERFM,RHOG(3),RERUP,RERLOW,RESUP,RESLOW
^,PREB,RRIP(20),SRTIP(20),AAA1,AAA2,AAA3,SAREA(20),SAREAS(20)
^,P(3),TG(3),XA,XU(3),XCH4,XW(3),XWW(3),XWT(3),TW(3),TWW(3)
^,OMEGS(20),OMEGR(20),GAPR(20),GAPS(20)
^,RRHUB(20),RC(20),RBLADE(20),STAGER(20)
^,SRHUB(20),SC(20),SBLADE(20),STAGES(20)
^,SIGUMR(20),BET1SR(20),BET2SR(20),AINCSR(20),ADEUSR(20)

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^,SIGUMS(20) , BET1SS(20) , BET2SS(20) , AINCSS(20) , ADEVSS(20)
^,UTIPG(20),UTIP(20),UTIPD(20),UOU(20),UMEAN(20),UHUB(20),U(20),FAI
^,AREA(20),AREAS(20),UU2(20),UTIP2(20),UMEAN2(20),UHUB2(20),IPRINT
^,ICENT, IICENT, FMR1(20),FMA2(20),IDESIN,FAID
^,NS,NSF,NSLPC,BYPASS,NS1,RT(20),RM(20),RH(20),ST(20),SM(20),SH(20)
^,DSMASS,AAREA(20),AAREAS(20),PR12D(20),PR13D(20),ETARD(20)
^,DR(20),DS(20),DEQR(20),DEQS(20),BLOCK(20),BLOCKS(20)
^,BET1MR(20),BET2MR(20),BET1MS(20),BET2MS(20),RADI1(20),RADI2(20)
^,FAIRIN(20),FAIOUT(20),ETASC(20),PSID(20),TAUD(20),SITADR(20)
^,SITADS(20),WWD(20),UUD(20)
4. 000000B DIMENSION RHOM(3),ETAA(20)
5. 000000B AJ=778.26
6. 000030B PAI=3.1415926
7. 000032B CPW=1.0
8. 000033B RHOW=62.3
9. 000035B GC=32.174
10. 000036B CALL WICPRP(XA,XU(1),XCH4,TG(1),RMIX,CPMIX,GAMMA,G1,G2,G3)
11. 000041B GAMMA1=GAMMA
12. 000041B RHOG(1)=P(1)/RMIX/TG(1)
13. 000044B BMASS=MMASS
14. 000046B AAA2=AREAS(ISTAGE)
15. 000050B AAA3=AREA(ISTAGE+1)
16. 000051B IF(NSF.NE.0.AND.ISTAGE.EQ.NSF) AAA3=AAA2
17. 000056B IF(NSF.NE.0.AND.ISTAGE.EQ.(NSF+NSLPC)) AAA3=AAA2
18. 000063B IF(ISTAGE.EQ.NS) AAA3=AAA2
19. 000066B CALL WICMAC(ISTAGE,BMASS,TG(1),P(1),M,UZ,C,XWT(1),ALFA1,
$RMIX,CPMIX,AAA1)
20. 000073B ASPEED=C
21. 000073B ASPED1=ASPEED
22. 000074B RHOG(1)=(1.0+G2*M **2)**G3*RHOG(1)
23. 000103B RHOM(1)=1.0/((1.0-XWT(1))/RHOG(1)+XWT(1)/RHOW)
24. 000110B UZ1=UZ
25. 000111B FAI1=UZ1/UTIPG(ISTAGE)
26. 000113B ALFA1R = ALFA1 * PAI / 180.0
27. 000116B U1 = UZ / COS ( ALFA1R )
28. 000121B US1 = UZ * TAN ( ALFA1R )
29. 000124B WS1 = U(ISTAGE)- US1
30. 000127B T = WS1 / UZ
31. 000127B BETA1R = ATAN ( T )
32. 000132B BETA1 = BETA1R * 180.0 / PAI
33. 000134B TT = UZ **2 + WS1 **2
34. 000136B W1 = SQRT ( TT )
35. 000141B AMACH1 = W1 / ASPEED
36. 000142B AMAC1=U1/ASPEED
37. 000143B TS1=TG(1)/(1.0+G2*AMAC1**2)
38. 000147B PS1=(TG(1)/TS1)**(-G1)*P(1)
39. 000156B PREL1=(1.0+G2*AMACH1**2)**G1*PS1
40. 000165B TREL1=(1.0+G2*AMACH1**2)*TS1
41. 000171B JJJ=1
42. 000173B 2000 UZ2AS=UZ
43. 000174B CALL WICGSL(SIGUMR(ISTAGE),BET1SR(ISTAGE),BET2SR(IST
$AGE),AINCSR(ISTAGE),ADEUSR(ISTAGE),AMACH1,BETA1,
$DEQR(ISTAGE),DEQN,SITADR(ISTAGE),
$SITACN,BET2N,OMEGAN,FMR1(ISTAGE),AK1,AK2,AK3,UZ1,UZ2AS,
$U(ISTAGE),RADI1(ISTAGE),RADI2(ISTAGE))
44. 000217B IF(IPRINT.EQ.2) WRITE(6,190) OMEGR(ISTAGE),SIGUMR(ISTAGE),
$BET1SR(ISTAGE),BET2SR(ISTAGE),AINCSR(ISTAGE),ADEUSR(ISTAGE),
$AMACH1,BETA1,DEQR(ISTAGE),DEQN,SITADR(ISTAGE),SITACN,BET2N,OMEGAN
45. 000252B 190 FORMAT(1H0,1X,14(F7.3,2X))
46. 000252B DEQRR=DEQN

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47. 000252B SITACR=SITACN
48. 000254B AINCIR=BETA1-BET1MR(ISTAGE)
49. 000257B ADEVIR=BET2N-BET2MR(ISTAGE)
50. 000261B IF(IPRINT.EQ.2) WRITE(6,191) AINCIR,AINC SR(ISTAGE),ADEVIR,
$ADEUSR(ISTAGE)
51. 000275B 191 FORMAT(1H0,1X,4(F7.3,2X))
52. 000275B OMEGA1=OMEGAN
53. 000275B BETA2=BET2N
54. 000277B BETA2R=BETA2*PAI/180.0
55. 000301B W2=UZ/COS(BETA2R)
56. 000304B UG=(W1+W2)/2.0
57. 000307B OMEGAP=0.0
58. 000310B IF(XW(1).GT.0.0)
$CALL WICSDL(RC(ISTAGE),SIGUMR(ISTAGE),BETA1,BETA2,UG,RHOG(1),
$WMAS,AAA1,UZ,OMEGAP)
59. 000323B OMEGA2=OMEGAP
60. 000323B OMEGA3=0.0
61. 000324B DELP3=0.0
62. 000325B BETA2R = BETA2 * PAI / 180.0
63. 000330B JJ=1
64. 000331B 200 UZAS=UZ
65. 000332B WS2 = UZ * TAN ( BETA2R )
66. 000335B US2 = UU2(ISTAGE) - WS2
67. 000340B IF(US2.LT.0.0) GO TO 999
68. 000342B TTT=US2/UZ
69. 000343B ALFA2R = ATAN ( TTT )
70. 000346B ALFA2 = ALFA2R * 180.0 / PAI
71. 000350B TTTT = UZ ** 2 + WS2 ** 2
72. 000352B W2 = SQRT ( TTTT )
73. 000355B TTTTT = UZ ** 2 + US2 ** 2
74. 000357B U2 = SQRT ( TTTTT )
75. 000362B DELH=WKDONE*(UU2(ISTAGE)*US2-U(ISTAGE)*US1)/GC/AJ
76. 000370B XG=1.0-XWT(1)
77. 000372B CALL WICIRS(ISTAGE,RR TIP(ISTAGE),XW(1),XG,RHOG(1),BETA1,W1,WW1,
$WW2,WW)
78. 000401B AMIMPR=WW
79. 000401B IF(AMIMPR.GT.WMAS) AMIMPR=WMAS
80. 000405B PREB=50.0
81. 000405B AMREBR=AMIMPR*PREB/100.0
82. 000410B AMWAKR=AMIMPR*(1.0-PREB/100.0)
83. 000412B AMNOIR=WMAS-AMIMPR
84. 000413B XWNOIR=AMNOIR/MMASS
85. 000414B XWREBR=AMREBR/MMASS
86. 000416B XWWAKR=AMWAKR/MMASS
87. 000417B XW1=0.0
88. 000420B XW2=0.0
89. 000421B XW3=0.0
90. 000422B IF(WMAS.GT.0.0) XW1=AMNOIR/WMAS
91. 000426B IF(WMAS.GT.0.0) XW2=AMWAKR/WMAS
92. 000431B IF(WMAS.GT.0.0) XW3=AMREBR/WMAS
93. 000434B DELTG=DELH/CPMIX
94. 000435B DELTW1=DELH/CPW
95. 000436B DELTW2=DELH/CPW
96. 000437B DELTW3=0.0
97. 000440B DELTW=XW1*DELTW1+XW2*DELTW2+XW3*DELTW3
98. 000446B TW(2)=TW(1)+DELTW
99. 000450B TG(2)=TG(1)+DELTG
100. 000452B TS2=TG(2)-U2**2/(2.0*CPMIX*GC*AJ)
101. 000457B AG2=(GAMMA*RMIX*TS2*GC)**0.5
102. 000465B ASPEED=WICASD(XWT(1),RHOG(1),AG2)

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103. 000467B      AMAC2=U2/ASPEED
104. 000470B      AMACH2=W2/ASPEED
105. 000471B      PP1=GAMMA*RMIX*TREL1*GC
106. 000475B      PP2=(UU2(ISTAGE)/U(ISTAGE))**2-1.0
107. 000501B      PP3=1.0+G2*U(ISTAGE)**2/PP1*PP2
108. 000505B      PP=PP3**G1
109. 000510B      PRREL=PP-(OMEGA1+OMEGA2+OMEGA3)*(1.0-PS1/PREL1)
110. 000517B      PR12=(TG(2)/TG(1))**G1*PRREL/PP
111. 000525B      P(2)=PR12*P(1)
112. 000527B      PS2=(1.0+G2*AMAC2**2)**(-G1)*P(2)
113. 000537B      RHOG2=PS2/RMIX/TS2
114. 000542B      RHOG(2)=RHOG2
115. 000542B      RHOM2=1.0/(XG/RHOG2+XWT(1)/RHOW)
116. 000547B      UZ=BMASS/RHOM2/AAA2
117. 000551B      UZ2=UZ
118. 000551B      EPS=1.0E-4
119. 000552B      IF(JJ.EQ.2) GO TO 201
120. 000555B      IF(JJ.GT.2) GO TO 202
121. 000557B      X1=UZAS
122. 000560B      Y1=UZ2
123. 000561B      UZ=UZ2
124. 000562B      JJ=JJ+1
125. 000564B      GO TO 200
126. 000565B      201 X2=UZAS
127. 000566B      Y2=UZ2
128. 000570B      UZ=WICNEW(X1,Y1,X2,Y2)
129. 000573B      IF(IPRINT.EQ.2) WRITE(6,203) JJ,UZ
130. 000603B      203 FORMAT(1H ,1X,I1,2X,=UZ2=,F10.5)
131. 000603B      JJ=JJ+1
132. 000604B      IF(UZ.LT.0.0.OR.UZ.GT.ASPEED) GO TO 999
133. 000610B      GO TO 200
134. 000610B      202 IF(ABS((UZAS-UZ2)/UZAS).LT.EPS) GO TO 300
135. 000615B      X1=X2
136. 000615B      Y1=Y2
137. 000617B      X2=UZAS
138. 000620B      Y2=UZ2
139. 000622B      UZ=WICNEW(X1,Y1,X2,Y2)
140. 000624B      IF(IPRINT.EQ.2) WRITE(6,204) JJ,UZ
141. 000634B      204 FORMAT(1H0,1X,I1,2X,=UZ2=,F10.5)
142. 000634B      JJ=JJ+1
143. 000635B      IF(UZ.LT.0.0.OR.UZ.GT.ASPEED) GO TO 999
144. 000641B      IF(JJ.EQ.20) GO TO 300
145. 000642B      GO TO 200
146. 000643B      300 UZ2CL=UZ
147. 000644B      IF(JJJ.EQ.2) GO TO 2010
148. 000647B      IF(JJJ.GT.2) GO TO 2020
149. 000651B      XX1=UZ2AS
150. 000652B      YY1=UZ2CL
151. 000653B      JJJ=JJJ+1
152. 000655B      GO TO 2000
153. 000656B      2010 XX2=UZ2AS
154. 000657B      YY2=UZ2CL
155. 000661B      UZ=WICNEW(XX1,YY1,XX2,YY2)
156. 000664B      IF(IPRINT.EQ.2) WRITE(6,2030) JJJ,UZ
157. 000674B      2030 FORMAT(1H ,1X,I2,=UZ22=,F10.5)
158. 000674B      JJJ=JJJ+1
159. 000675B      GO TO 2000
160. 000675B      2020 IF(ABS((UZ2AS-UZ2CL)/UZ2AS).LT.EPS) GO TO 3000
161. 000702B      XX1=XX2
162. 000702B      YY1=YY2

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163. 000704B      XX2=UZ2AS
164. 000705B      YY2=UZ2CL
165. 000707B      UZ=WICNEU(XX1,YY1,XX2,YY2)
166. 000711B      IF(IPRINT.EQ.2) WRITE(6,2040) JJJ,UZ
167. 000721B 2040 FORMAT(1H ,1X,I2,=UZ22=,F10.5)
168. 000721B      JJJ=JJJ+1
169. 000722B      IF(JJJ.EQ.20) GO TO 3000
170. 000723B      GO TO 2000
171. 000724B 3000 UZ2=UZ2CL
172. 000724B      FAI2=UZ2/UTIPG(ISTAGE)
173. 000726B      P(2)=(1.0+G2*AMAC2**2)**G1*PS2
174. 000735B      JJJJ=1
175. 000737B 3001 UZ3AS=UZ
176. 000740B      IF(ISTAGE.EQ.NS) RADI1(ISTAGE+1)=RADI2(ISTAGE)
177. 000745B      CALL WICGSL(SIGUMS(ISTAGE),BET1SS(ISTAGE),
      $BET2SS(ISTAGE),AINCSS(ISTAGE),ADEUSS(ISTAGE),AMAC2,ALFA2,
      $DEQS(ISTAGE),DEQN,SITADS(ISTAGE),
      $SITACN,BET2N,OMEGAN,FMA2(ISTAGE),AK1,AK2,AK3,
      $UZ2,UZ3AS,0.0,RADI2(ISTAGE),RADI1(ISTAGE+1))
      ASPED2=ASPEED
178. 000765B      DEQSS=DEQN
179. 000765B      SITACS=SITACN
180. 000767B      DEQT=DEQER+DEQSS
181. 000770B      SITACT=SITACR+SITACS
182. 000772B      AINCIS=ALFA2-BET1MS(ISTAGE)
183. 000774B      ADEUIS=BET2N-BET2MS(ISTAGE)
184. 000777B      IF(IPRINT.EQ.2) WRITE(6,302) AINCIS,AINCSS(ISTAGE),ADEUIS,
185. 001001B      $ADEUSS(ISTAGE)
      302 FORMAT(1H0,1X,4(F7.3,2X))
186. 001015B      OMEGA4=OMEGAN
187. 001015B      ALFA3=BET2N
188. 001015B      ALFA3R=ALFA3*PAI/180.0
189. 001017B      U3=UZ/COS(ALFA3R)
190. 001021B      UG=(U2+U3)/2.0
191. 001024B      OMEGAP=0.0
192. 001027B      IF(XW(1).GT.0.0)
193. 001030B      $CALL WICSDL(SC(ISTAGE),SIGUMS(ISTAGE),ALFA2,ALFA3,UG,RHOG(2)
      $,WMAS,AAA2,UZ,OMEGAP)
      OMEGA5=OMEGAP
194. 001043B      OMEGA6=0.0
195. 001043B      PR23=1.0-(OMEGA4+OMEGA5+OMEGA6)*(1.0-PS2/P(2))
196. 001044B      PR13=(TG(2)/TG(1))**G1*PRREL*PR23/PP
197. 001054B      P(3)=PR13*P(1)
198. 001063B      TG(3)=TG(2)
199. 001065B      TS3=TG(3)-U3**2/(2.0*CPMIX*GC*AJ)
200. 001066B      AG3=(GAMMA*RMIX*TS3*GC)**0.5
201. 001074B      ASPEED=WICASD(XWT(1),RHOG(2),AG3)
202. 001102B      ASPED3=ASPEED
203. 001104B      AMAC3=U3/ASPEED
204. 001104B      PS3=(1.0+G2*AMAC3**2)**(-G1)*P(3)
205. 001106B      RHOG3=PS3/RMIX/TS3
206. 001116B      RHOG(3)=RHOG3
207. 001121B      RHOM3=1.0/(XG/RHOG3+XWT(1)/RHOG)
208. 001121B      UZ=BMASS/RHOM3/AAA3
209. 001126B      UZ3CL=UZ
210. 001130B      IF(JJJJ.EQ.2) GO TO 3010
211. 001130B      IF(JJJJ.GT.2) GO TO 3020
212. 001132B      XXX1=UZ3AS
213. 001134B      YYY1=UZ3CL
214. 001135B      JJJJ=JJJJ+1
215. 001137B

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216. 001140B      GO TO 3001
217. 001141B      3010 XXX2=UZ3AS
218. 001142B      YYY2=UZ3CL
219. 001144B      UZ=WICNEW(XXX1,YYY1,XXX2,YYY2)
220. 001147B      IF(IPRINT.EQ.2) WRITE(6,3030) JJJJ,UZ
221. 001157B      3030 FORMAT(1H ,1X,I2,2X,=UZ33=,F10.5)
222. 001157B      JJJJ=JJJJ+1
223. 001150B      GO TO 3001
224. 001160B      3020 IF(ABS((UZ3AS-UZ3CL)/UZ3AS).LT.EPS) GO TO 4000
225. 001165B      XXX1=XXX2
226. 001165B      YYY1=YYY2
227. 001167B      XXX2=UZ3AS
228. 001170B      YYY2=UZ3CL
229. 001172B      UZ=WICNEW(XXX1,YYY1,XXX2,YYY2)
230. 001174B      IF(IPRINT.EQ.2) WRITE(6,3040) JJJJ,UZ
231. 001204B      3040 FORMAT(1H ,1X,I2,=UZ33=,F10.5)
232. 001204B      JJJJ=JJJJ+1
233. 001205B      IF(JJJJ.EQ.20) GO TO 999
234. 001206B      GO TO 3001
235. 001207B      4000 UZ3=UZ3CL
236. 001207B      FAI3=UZ3/UTIPG(ISTAGE+1)
237. 001211B      TW(3)=TW(2)
238. 001213B      OMEGTR=OMEGA1+OMEGA2+OMEGA3
239. 001216B      OMEGTS=OMEGA4+OMEGA5+OMEGA6
240. 001221B      PRATIO=P(3)/P(1)
241. 001223B      TRATIO=TG(3)/TG(1)
242. 001225B      CALL WICPRP(XA,XU(3),XCH4,TG(3),RMIX,CPMIX,GAMMA,G1,G2,G3)
243. 001230B      GAMMA2=GAMMA
244. 001230B      GAMMAU=(GAMMA1+GAMMA2)/2.0
245. 001233B      G4=(GAMMAU-1.0)/GAMMAU
246. 001235B      ETAA(ISTAGE)=(PRATIO**G4-1.0)/(TRATIO-1.0)
247. 001243B      PSI=GC*AJ*CPMIX*ETAA(ISTAGE)*(TG(2)-TG(1))/(UTIPG(ISTAGE)**2)
248. 001254B      IF(IDESIN.EQ.2) GO TO 999
249. 001257B      WRITE(6,404) FAI0,ISTAGE
250. 001265B      404 FORMAT(1H1,1X,=***** =,1X,
      $=INITIAL FLOW COEFFICIENT=,1X,F5.3,1X,=(STAGE=,I2,1X,
      $)=,2X,=*****=)
      WRITE(6,401) PRATIO,TRATIO,ETAA(ISTAGE)
251. 001265B
252. 001274B      401 FORMAT(1H0,5X,=STAGE TOTAL PRESSURE RATIO=,F12.5,/,
      $6X,=STAGE TOTAL TEMPERATURE RATIO=,F12.5,/,
      $6X,=STAGE ADIABATIC EFFICIENCY=,F12.5)
      WRITE(6,402) FAI1,UZ1,UTIPG(ISTAGE)
253. 001274B
254. 001303B      402 FORMAT(1H0,5X,=STAGE FLOW COEFFICIENT=,F5.3,/,
      $6X,=AXIAL VELOCITY=,F7.2,/,
      $6X,=ROTOR SPEED=,F7.2,/)
      WRITE(6,405)
255. 001303B      405 FORMAT(1H0,24X,=*ROTOR INLET* *ROTOR OUTLET* *STATOR OUTLET*=)
256. 001306B      WRITE(6,406) P(1),P(2),P(3)
257. 001306B
258. 001314B      406 FORMAT(1H ,1X,=TOTAL PRESSURE=,10X,3(F10.4,5X))
259. 001314B      WRITE(6,407) PS1,PS2,PS3
260. 001322B      407 FORMAT(1H ,1X,=STATIC PRESSURE=,9X,3(F10.4,5X))
261. 001322B      WRITE(6,408) TG(1),TG(2),TG(3)
262. 001330B      408 FORMAT(1H ,1X,=TOTAL TEMPERATURE(GAS)=,3X,3(F10.4,5X))
263. 001330B      WRITE(6,409) TS1,TS2,TS3
264. 001336B      409 FORMAT(1H ,1X,=STATIC TEMPERATURE(GAS)=,1X,3(F10.4,5X))
265. 001336B      WRITE(6,410) RHOG(1),RHOG2,RHOG3
266. 001344B      410 FORMAT(1H ,1X,=STATIC DENSITY(GAS)=,5X,3(F10.4,5X))
267. 001344B      WRITE(6,411) RHOM(1),RHOM2,RHOM3
268. 001352B      411 FORMAT(1H ,1X,=STATIC DENSITY(MIXTURE)=,1X,3(F10.4,5X))
269. 001352B      WRITE(6,412) UZ1,UZ2,UZ3

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270. 001360B 412 FORMAT(1H0,1X, #AXIAL VELOCITY#, 10X, 3(F10.4, 5X))
271. 001360B WRITE(6, 413) U1, U2, U3
272. 001366B 413 FORMAT(1H , 1X, #ABSOLUTE VELOCITY#, 7X, 3(F10.4, 5X))
273. 001366B WRITE(6, 414) W1, W2
274. 001373B 414 FORMAT(1H , 1X, #RELATIVE VELOCITY#, 7X, 2(F10.4, 5X))
275. 001373B WRITE(6, 415) U(ISTAGE), UU2(ISTAGE), U(ISTAGE+1)
276. 001404B 415 FORMAT(1H , 1X, #BLADE SPEED#, 13X, 3(F10.4, 5X))
277. 001404B WRITE(6, 416) US1, US2
278. 001411B 416 FORMAT(1H , 1X, #TANG. COMP. OF ABS. VEL. #, 2(F10.4, 5X))
279. 001411B WRITE(6, 417) WS1, WS2
280. 001416B 417 FORMAT(1H , 1X, #TANG. COMP. OF REL. VEL. #, 2(F10.4, 5X))
281. 001416B WRITE(6, 418) ASPEL1, ASPEL2, ASPEL3
282. 001424B 418 FORMAT(1H , 1X, #ACOUSTIC SPEED#, 10X, 3(F10.4, 5X))
283. 001424B WRITE(6, 419) AMAC1, AMAC2, AMAC3
284. 001432B 419 FORMAT(1H , 1X, #ABSOLUTE MACH NUMBER#, 4X, 3(F10.4, 5X))
285. 001432B WRITE(6, 420) AMACH1, AMACH2
286. 001437B 420 FORMAT(1H , 1X, #RELATIVE MACH NUMBER#, 4X, 2(F10.4, 5X))
287. 001437B WRITE(6, 421) FAI1, FAI2, FAI3
288. 001445B 421 FORMAT(1H0, 1X, #FLOW COEFFICIENT#, 8X, 3(F10.4, 5X))
289. 001445B WRITE(6, 422) AAA1, AAA2, AAA3
290. 001453B 422 FORMAT(1H , 1X, #FLOW AREA#, 15X, 3(F10.4, 5X))
291. 001453B WRITE(6, 423) ALFA1, ALFA2, ALFA3
292. 001461B 423 FORMAT(1H0, 1X, #ABSOLUTE FLOW ANGLE#, 5X, 3(F10.4, 5X))
293. 001461B WRITE(6, 424) BETA1, BETA2
294. 001466B 424 FORMAT(1H , 1X, #RELATIVE FLOW ANGLE#, 5X, 3(F10.4, 5X))
295. 001466B WRITE(6, 425) AINCIR, AINCIS
296. 001473B 425 FORMAT(1H , 1X, #INCIDENCE#, 16X, 2(F10.4, 5X))
297. 001473B WRITE(6, 426) ADEVIR, ADEVIS
298. 001500B 426 FORMAT(1H , 1X, #DEVIATION#, 31X, 2(F10.4, 5X))
299. 001500B WRITE(6, 430) DEQRR, DEQSS
300. 001505B 430 FORMAT(1H , 1X, #DIFFUSION RATIO#, 25X, 2(F10.4, 5X))
301. 001505B WRITE(6, 427) SITACR, SITACS
302. 001512B 427 FORMAT(1H , 1X, #MOMENTUM THICKNESS#, 21X, 2(F10.4, 5X))
303. 001512B WRITE(6, 428) OMEGA1, OMEGA4
304. 001517B 428 FORMAT(1H , 1X, #OMEGA (GAS)#, 31X, 2(F10.5, 5X))
305. 001517B WRITE(6, 429) OMEGTR, OMEGTS
306. 001524B 429 FORMAT(1H , 1X, #OMEGA (TOTAL)#, 30X, 2(F10.5, 5X))
307. 001524B 999 RETURN
308. 001526B END

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1. 000000B SUBROUTINE WICSPC(FAID, ISTAGE, MMASS, ALFA1, WKDONE, DAV, DELU, WMAS,
$WMAS, N,
$OMEGA1, OMEGA2, OMEGA3, OMEGA4, OMEGA5, OMEGA6, OMEGAT,
$BETA1, BETA2, UZ, ALFA2, ALFA3, DELTG, DELTW, W1, W2, U1, U2, U3, REAVE,
$DELU2, DELUL2, AK1, AK2, AK3)
2. 000000B REAL M, MMASS
3. 000000B COMMON JPERFM, RHOG(3), RERUP, RERLOW, RESUP, RESLOW
^, PREB, RRTIP(20), SRTIP(20), AAA1, AAA2, AAA3, SAREA(20), SAREAS(20)
^, P(3), TG(3), XA, XU(3), XCH4, XW(3), XWW(3), XWT(3), TW(3), TWW(3)
^, OMEGS(20), OMEGR(20), GAPR(20), GAPS(20)
^, RRHUB(20), RC(20), RBLADE(20), STAGER(20)
^, SRHUB(20), SC(20), SBLADE(20), STAGES(20)
^, SIGUMR(20), BET1SR(20), BET2SR(20), AINC SR(20), ADEVSR(20)
^, SIGUMS(20), BET1SS(20), BET2SS(20), AINC SS(20), ADEVSS(20)
^, UTIPG(20), UTIP(20), UTIPB(20), UOU(20), UMEAN(20), UHUB(20), U(20), FAI
^, AREA(20), AREAS(20), UU2(20), UTIP2(20), UMEAN2(20), UHUB2(20), IPRINT
^, ICENT, IICENT, FMR1(20), FMA2(20), IDESIN, FAID
^, NS, NSF, NSLPC, BYPASS, NS1, RT(20), RM(20), RH(20), ST(20), SM(20), SH(20)
^, DSMASS, AAREA(20), AAREAS(20), PR12D(20), PR13D(20), ETARD(20)

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^, DR(20), DS(20), DEQR(20), DEQS(20), BLOCK(20), BLOCKS(20)
^, BET1MR(20), BET2MR(20), BET1MS(20), BET2MS(20), RAD11(20), RAD12(20)
^, FAIRIN(20), FAIOUT(20), ETASG(20), PSID(20), TAUD(20), SITADR(20)
^, SITADS(20), WWD(20), UUD(20)
4. 000000B DIMENSION RHOM(3), ETAA(20)
5. 000000B CPW=1.0
6. 000030B RHOW=62.3
7. 000032B GC=32.174
8. 000033B AJ=778.26
9. 000035B PAI=3.1415926
10. 000036B CALL WICPRP(XA, XU(1), XCH4, TG(1), RMIX, CPMIX, GAMMA, G1, G2, G3)
11. 000041B GAMMA1=GAMMA
12. 000041B RHOG(1)=P(1)/RMIX/TG(1)
13. 000044B BMASS=MMASS-WMAS-WWMAS
14. 000050B AAA2=AREAS(ISTAGE)
15. 000051B AAA3=AREA(ISTAGE+1)
16. 000053B IF(NSF.NE.0.AND.ISTAGE.EQ.NSF) AAA3=AAA2
17. 000057B IF(NSF.NE.0.AND.ISTAGE.EQ.(NSF+NSLPC)) AAA3=AAA2
18. 000064B IF(ISTAGE.EQ.NS) AAA3=AAA2
19. 000067B CALL WICMAC(ISTAGE, BMASS, TG(1), P(1), M, UZ, C, XWT(1), ALFA1,
$RMIX, CPMIX, AAA1)
20. 000074B ASPEED=C
21. 000074B ASPED1=ASPEED
22. 000075B RHOG(1)=(1.0+G2*M **2)**G3*RHOG(1)
23. 000104B RHOM(1)=1.0/((1.0-XWT(1))/RHOG(1)+XWT(1)/RHOW)
24. 000111B UZ1=UZ
25. 000112B UZZ=UZ
26. 000113B FAI1=UZ1/UTIPG(ISTAGE)
27. 000115B ALFA1R = ALFA1 * PAI / 180.0
28. 000120B U1 = UZ / COS ( ALFA1R )
29. 000123B VS1 = UZ * TAN ( ALFA1R )
30. 000126B WS1 = U(ISTAGE)- VS1
31. 000131B T = WS1 / UZ
32. 000131B BETA1R = ATAN ( T )
33. 000134B BETA1 = BETA1R * 180.0 / PAI
34. 000136B TT = UZ **2 + WS1 **2
35. 000140B W1 = SQRT ( TT )
36. 000143B AMACH1 = W1 / ASPEED
37. 000144B AMAC1=U1/ASPEED
38. 000145B TS1=TG(1)/(1.0+G2*AMAC1**2)
39. 000151B PS1=(TG(1)/TS1)**(-G1)*P(1)
40. 000160B PREL1=(1.0+G2*AMACH1**2)**G1*PS1
41. 000167B TREL1=(1.0+G2*AMACH1**2)*TS1
42. 000173B TG(2)=TG(1)
43. 000175B P(2)=P(1)
44. 000176B ALFA2=BET1SS(ISTAGE)
45. 000200B JJJ=1
46. 000202B 2000 UZ2AS=UZ
47. 000203B CALL WICGSL(SIGUMR(ISTAGE), BET1SR(ISTAGE), BET2SR(
$ISTAGE), AINCSR(ISTAGE), ADEVSR(ISTAGE), AMACH1, BETA1,
$DEQR(ISTAGE), DEQN, SITADR(ISTAGE),
$SITACN, BET2N, OMEGAN, FMR1(ISTAGE), AK1, AK2, AK3, UZ1,
$UZ2AS, U(ISTAGE), RAD11(ISTAGE), RAD12(ISTAGE))
48. 000226B DEQRR=DEQN
49. 000226B SITACR=SITACN
50. 000230B OMEGA7=OMEGAN
51. 000231B BETA2=BET2N
52. 000233B BETA1R=BETA1*PAI/180.0
53. 000236B BETA2R=BETA2*PAI/180.0
54. 000237B BETAUE=(BETA1R+BETA2R)/2.0

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55. 000241B TANGT=WICTAN(BETA1R)-WICTAN(BETA2R)
56. 000247B CSAU=COS(BETAUE)
57. 000251B CS1=COS(BETA1R)
58. 000253B CL=2.0/SIGUMR(ISTAGE)*TANGT*CSAU
59. 000256B CDS=0.018*(CL**2)
60. 000260B OMEGSE=CDS*SIGUMR(ISTAGE)*(CS1**2)/(CSAU**3)
61. 000265B H=RRIP(ISTAGE)-RRHUB(ISTAGE)
62. 000270B SHR=RC(ISTAGE)/H/SIGUMR(ISTAGE)
63. 000271B CDA=0.020*SHR
64. 000273B OMEGAN=CDA*SIGUMR(ISTAGE)*(CS1**2)/(CSAU**3)
65. 000300B IF(IPRINT.EQ.2) WRITE(6,2001) OMEGA1, OMEGSE, OMEGAN, OMEGA7, CDS, CDA
66. 000315B 2001 FORMAT(1H0,6F10.6)
67. 000315B OMEGA1=OMEGAN
68. 000315B AINCIR=BETA1-BET1MR(ISTAGE)
69. 000320B ADEVIR=BETA2N-BET2MR(ISTAGE)
70. 000323B BETA2R=BETA2*PAI/180.0
71. 000325B W2=UZ/COS(BETA2R)
72. 000330B UG=(W1+W2)/2.0
73. 000333B CALL WICRSL(SIGUMR(ISTAGE), BETA1, BETA2, RC(ISTAGE), DAV, CDR, OMEGAR)
74. 000343B OMEGA1=OMEGAR
75. 000343B DELP1=OMEGA1*0.5*RHOG(1)/GC*(W1**2)
76. 000351B IF(IPRINT.EQ.2) WRITE(6,2002) OMEGA1, DELP1
77. 000351B 2002 FORMAT(1H ,1X,=OMEGA1=,2F10.5)
78. 000361B XG=1.0-XWT(1)
79. 000362B CALL WICIRL(ISTAGE, RRTIP(ISTAGE), XWW(1), XG, RHOG(1), BETA1, W1, WW1, WW
    $2, WW)
80. 000371B BMIMPR=WW
81. 000371B IF(BMIMPR.GT.WWMAS) BMIMPR=WWMAS
82. 000375B BMREBR=BMIMPR*PREB/100.0
83. 000377B BMWAKR=BMIMPR*(1.0-PREB/100.0)
84. 000401B BMNOIR=WWMAS-BMIMPR
85. 000402B XWWNOR=BMNOIR/MMASS
86. 000403B XWWRER=BMREBR/MMASS
87. 000405B XWWWAR=BMWAKR/MMASS
88. 000406B IF(IPRINT.EQ.2) WRITE(6,6090) BMIMPR, BMREBR, BMWAKR, BMNOIR, XWWNOR,
    $XWWRER, XWWWAR
89. 000424B 6090 FORMAT(1H ,7(F12.5,1X))
90. 000424B RST1=RADI1(ISTAGE)**2-AAA1*144.0/2.0/PAI
91. 000430B RST1=SQRT(RST1)
92. 000433B RST2=2.0*RADI1(ISTAGE)**2-RST1**2
93. 000435B RST2=SQRT(RST2)
94. 000440B DELR=(RST2-RST1)/12.0
95. 000442B FMASSR=BMWAKR/DELR
96. 000443B CALL WICFML(W1, W2, FMASSR, RHOG(1), RC(ISTAGE), SIGUMR(ISTAGE), BETA1,
    $BETA2, CDF, OMEGAF)
97. 000455B OMEGA2=OMEGAF
98. 000455B DELP2=OMEGA2*0.5*RHOG(1)/GC*(W1**2)
99. 000463B IF(IPRINT.EQ.2) WRITE(6,6091) OMEGA2, DELP2
100. 000473B 6091 FORMAT(1H ,1X,=OMEGA2=,2F10.5)
101. 000473B U2=0.0
102. 000473B U3=0.0
103. 000473B ALFA=0.0
104. 000474B ALFA3=0.0
105. 000475B CALL WICSTL(ISTAGE, 1, DAV, W1, W2, DELU, U2, U3, WWMAS, UZ, N, BETA1, BETA2,
    $ALFA2, ALFA3, DELVU2, DELVL2, OMEGRU, OMEGRL, OMEGSU, OMEGSL,
    $DRAGRU, DRAGRL, DRAGSU, DRAGSL, REAVE)
106. 000520B OMEGA3=OMEGRU+OMEGRL
107. 000521B DELP3=OMEGA3*0.5*RHOG(1)/GC*(W1**2)
108. 000526B IF(IPRINT.EQ.2) WRITE(6,6092) OMEGA3, DELP3
109. 000536B 6092 FORMAT(1H ,1X,=OMEGA3=,2F10.5)

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110. 000536B REAVE1=REAVE
111. 000536B BETA2R = BETA2 * PAI / 180.0
112. 000541B JJ=1
113. 000543B 200 UZAS=UZ
114. 000544B WS2 = UZ * TAN ( BETA2R )
115. 000547B US2 = UU2(ISTAGE) - WS2
116. 000552B TTT=US2/UZ
117. 000552B ALFA2R = ATAN ( TTT )
118. 000555B ALFA2 = ALFA2R * 180.0 / PAI
119. 000557B TTTT = UZ ** 2 + WS2 ** 2
120. 000561B W2 = SQRT ( TTTT )
121. 000564B TTTT = UZ ** 2 + US2 ** 2
122. 000566B U2 = SQRT ( TTTT )
123. 000571B DELH=WKDONE*(UU2(ISTAGE)*US2-U(ISTAGE)*US1)/GC/AJ
124. 000577B CALL WICIRS(ISTAGE,RRIP(ISTAGE),XW(1),XG,RHOG(1),BETA1,W1,WW1,
$WW2,WW)
125. 000606B AMIMPR=WW
126. 000606B IF(AMIMPR.GT.WMAS) AMIMPR=WMAS
127. 000612B PREB=50.0
128. 000612B AMREBR=AMIMPR*PREB/100.0
129. 000615B AMWAKR=AMIMPR*(1.0-PREB/100.0)
130. 000617B AMNOIR=WMAS-AMIMPR
131. 000620B XW1=0.0
132. 000621B XW2=0.0
133. 000621B XW3=0.0
134. 000622B IF(WMAS.GT.0.0) XW1=AMNOIR/WMAS
135. 000626B IF(WMAS.GT.0.0) XW2=AMWAKR/WMAS
136. 000631B IF(WMAS.GT.0.0) XW3=AMREBR/WMAS
137. 000634B DELTG=DELH/CPMIX
138. 000635B DELTW1=DELH/CPW
139. 000636B DELTW2=DELH/CPW
140. 000637B DELTW3=0.0
141. 000640B DELTW=XW1*DELTW1+XW2*DELTW2+XW3*DELTW3
142. 000646B DETWW1=0.0
143. 000647B DETWW2=0.0
144. 000647B DETWW3=0.0
145. 000650B DELTWW=0.0
146. 000650B TW(2)=TW(1)+DELTW
147. 000652B TWW(2)=TWW(1)+DELTWW
148. 000654B TG(2)=TG(1)+DELTG
149. 000656B TS2=TG(2)-U2**2/(2.0*CPMIX*GC*AJ)
150. 000664B AG2=(GAMMA*RMIX*TS2*GC)**0.5
151. 000672B ASPEED=WICASD(XWT(1),RHOG(1),AG2)
152. 000674B ASPED2=ASPEED
153. 000674B AMAC2=U2/ASPEED
154. 000676B AMACH2=W2/ASPEED
155. 000677B PP1=GAMMA*RMIX*TREL1*GC
156. 000703B PP2=(UU2(ISTAGE)/U(ISTAGE))**2-1.0
157. 000707B PP3=1.0+G2*U(ISTAGE)**2/PP1*PP2
158. 000713B PP=PP3**G1
159. 000716B PRREL=PP-(OMEGA7+OMEGA1+OMEGA2+OMEGA3)*(1.0-PS1/PREL1)
160. 000726B PR12=(TG(2)/TG(1))**G1*PRREL/PP
161. 000734B ETAR=(PR12**((1.0/G1)-1.0)/(TG(2)/TG(1))-1.0)
162. 000745B P(2)=PR12*P(1)
163. 000747B PS2=(1.0+G2*AMAC2**2)**(-G1)*P(2)
164. 000760B RHOG2=PS2/RMIX/TS2
165. 000763B RHOG(2)=RHOG2
166. 000763B RHOM2=1.0/(XG/RHOG2+XWT(1)/RHOG)
167. 000770B UZ=EMASS/RHOG2/AAA2
168. 000772B UZ2=UZ

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169. 000772B      EPS=1.0E-4
170. 000773B      IF(JJ.EQ.2) GO TO 201
171. 000776B      IF(JJ.GT.2) GO TO 202
172. 001000B      X1=UZAS
173. 001001B      Y1=UZ2
174. 001002B      UZ=UZ2
175. 001003B      JJ=JJ+1
176. 001005B      IF(UZ.LT.0.0.OR.UZ.GT.ASPEED) GO TO 999
177. 001011B      GO TO 200
178. 001012B      201 X2=UZAS
179. 001012B          Y2=UZ2
180. 001014B          UZ=WICNEW(X1,Y1,X2,Y2)
181. 001017B          IF(IPRINT.EQ.2) WRITE(6,203) JJ,UZ
182. 001027B      203 FORMAT(1H ,1X, I1,2X, #UZ2=#,F10.5)
183. 001027B          JJ=JJ+1
184. 001030B          IF(UZ.LT.0.0.OR.UZ.GT.ASPEED) GO TO 999
185. 001034B          GO TO 200
186. 001034B      202 IF(ABS((UZAS-UZ2)/UZAS).LT.EPS) GO TO 300
187. 001041B          X1=X2
188. 001041B          Y1=Y2
189. 001043B          X2=UZAS
190. 001044B          Y2=UZ2
191. 001046B          UZ=WICNEW(X1,Y1,X2,Y2)
192. 001050B          IF(IPRINT.EQ.2) WRITE(6,204) JJ,UZ
193. 001060B      204 FORMAT(1H0,1X, I1,2X, #UZ2=#,F10.5)
194. 001060B          JJ=JJ+1
195. 001061B          IF(UZ.LT.0.0.OR.UZ.GT.ASPEED) GO TO 999
196. 001065B          IF(JJ.EQ.20) GO TO 999
197. 001066B          GO TO 200
198. 001067B      300 UZ2CL=UZ
199. 001070B          IF(JJJ.EQ.2) GO TO 2010
200. 001073B          IF(JJJ.GT.2) GO TO 2020
201. 001075B          XX1=UZ2AS
202. 001076B          YY1=UZ2CL
203. 001077B          JJJ=JJJ+1
204. 001101B          GO TO 2000
205. 001102B      2010 XX2=UZ2AS
206. 001103B          YY2=UZ2CL
207. 001105B          UZ=WICNEW(XX1,YY1,XX2,YY2)
208. 001110B          IF(IPRINT.EQ.2) WRITE(6,2030) JJJ,UZ
209. 001120B      2030 FORMAT(1H ,1X, I2, #UZ22=#,F10.5)
210. 001120B          JJJ=JJJ+1
211. 001121B          GO TO 2000
212. 001121B      2020 IF(ABS((UZ2AS-UZ2CL)/UZ2AS).LT.EPS) GO TO 3000
213. 001126B          XX1=XX2
214. 001126B          YY1=YY2
215. 001130B          XX2=UZ2AS
216. 001131B          YY2=UZ2CL
217. 001133B          UZ=WICNEW(XX1,YY1,XX2,YY2)
218. 001135B          IF(IPRINT.EQ.2) WRITE(6,2040) JJJ,UZ
219. 001145B      2040 FORMAT(1H ,1X, I2, #UZ22=#,F10.5)
220. 001145B          JJJ=JJJ+1
221. 001146B          IF(JJJ.EQ.20) GO TO 3000
222. 001147B          GO TO 2000
223. 001150B      3000 UZ2=UZ2CL
224. 001150B          FAI2=UZ2/UTIPG(ISTAGE)
225. 001152B          P(2)=(1.0+G2*AMAC2**2)**G1*PS2
226. 001161B          JJJJ=1
227. 001163B      3001 UZ3AS=UZ
228. 001164B          IF(ISTAGE.EQ.NS) RADI1(ISTAGE+1)=RADI2(ISTAGE)

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229. 001171B      CALL WICGSL(SIGUMS(ISTAGE), BET1SS(ISTAGE), BET2SS
      $(ISTAGE), AINCSS(ISTAGE), ADEVSS(ISTAGE), AMAC2, ALFA2,
      $DEQS(ISTAGE), DEQN, SITADS(ISTAGE),
      $SITACN, BET2N, OMEGAN, FMA2(ISTAGE), AK1, AK2, AK3, UZ2,
      $UZ3AS, 0.0, RAD12(ISTAGE), RAD11(ISTAGE+1))

230. 001211B      DEQSS=DEQN
231. 001211B      SITACS=SITACN
232. 001213B      DEQT=DEQRR+DEQSS
233. 001215B      SITACT=SITACR+SITACS
234. 001217B      OMEGA8=OMEGAN
235. 001220B      ALFA3=BET2N
236. 001221B      ALFA1R=ALFA2*PAI/180.0
237. 001224B      ALFA2R=ALFA3*PAI/180.0
238. 001226B      ALFAAV=(ALFA1R+ALFA2R)/2.0
239. 001230B      TANGT=WICTAN(ALFA1R)-WICTAN(ALFA2R)
240. 001236B      CSAU=COS(ALFAAV)
241. 001240B      CS1=COS(ALFA1R)
242. 001242B      CL=2.0/SIGUMS(ISTAGE)*TANGT*CSAU
243. 001245B      CDS=0.018*(CL**2)
244. 001247B      OMEGSE=CDS*SIGUMS(ISTAGE)*(CS1**2)/(CSAU**3)
245. 001254B      H=SR TIP(ISTAGE)-SRHUB(ISTAGE)
246. 001257B      SHR=SC(ISTAGE)/H/SIGUMR(ISTAGE)
247. 001261B      CDA=0.020*SHR
248. 001263B      OMEGAN=CDA*SIGUMS(ISTAGE)*(CS1**2)/(CSAU**3)
249. 001270B      IF(IPRINT.EQ.2) WRITE(6,3002)
      $OMEGA4, OMEGSE, OMEGAN, OMEGA8, CDS, CDA
3002 FORMAT(1H0,6F10.5)
250. 001305B      OMES2=OMEGSE
251. 001305B      OMEGA2=OMEGAN
252. 001305B      AINCIS=ALFA2-BET1MS(ISTAGE)
253. 001307B      ADEVIS=BET2N-BET2MS(ISTAGE)
254. 001312B      ALFA3R=ALFA3*PAI/180.0
255. 001314B      U3=UZ/COS(ALFA3R)
256. 001317B      CALL WICRSL(SIGUMS(ISTAGE), ALFA2, ALFA3, SC(ISTAGE), DAU, CDR, OMEGAR)
257. 001321B      OMEGA4=OMEGAR
258. 001332B      DELP4=OMEGA4*0.5*RHOG(2)/GC*(U2**2)
259. 001332B      IF(IPRINT.EQ.2) WRITE(6,3003) OMEGA4, DELP4
3003 FORMAT(1H ,1X,=OMEGA4=,2F10.5)
260. 001340B      CALL WICISL(ISTAGE, SR TIP(ISTAGE), XWW(2), XG, RHOG(2), ALFA2, U2, WW1
261. 001350B      $, WW2, WW)
262. 001350B      BMIMPS=WW
      IF(BMIMPS.GT.WWMAS) BMIMPS=WWMAS
263. 001356B      BMREBS=BMIMPS*PREB/100.0
264. 001356B      BMWAKS=BMIMPS*(1.0-PREB/100.0)
265. 001362B      IF(IPRINT.EQ.2) WRITE(6,6616)
266. 001364B      6616 FORMAT(1H ,1X,=IMPINS=)
267. 001366B      IF(IPRINT.EQ.2) WRITE(6,6617) XWW(2), XA, RHOG(2), UZ, WW, BMIMPS, BM
268. 001374B      $REBS, BMWAKS
269. 001374B      6617 FORMAT(1H ,8(F12.5,1X))
270. 001411B      RST1=RADI2(ISTAGE)**2-AA2*144.0/2.0/PAI
271. 001411B      RST1=SQRT(RST1)
272. 001415B      RST2=2.0*RADI2(ISTAGE)**2-RST1**2
273. 001420B      RST2=SQRT(RST2)
274. 001422B      DELR=(RST2-RST1)/12.0
275. 001425B      FMASSS=BMWAKS/DELR
276. 001427B      CALL WICFML(U2, U3, FMASSS, RHOG2, SC(ISTAGE), SIGUMS(ISTAGE), BETA1,
277. 001430B      $BETA2, CDF, OMEGAF)
      OMEGA5=OMEGAF
278. 001442B      DELP5=OMEGA5*0.5*RHOG(2)/GC*(U2**2)
279. 001442B      IF(IPRINT.EQ.2) WRITE(6,6618) OMEGA5, DELP5
280. 001450B

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281. 001460B 6618 FORMAT(1H ,1X, #OMEGA5=#,2F10.5)
282. 001460B CALL WICSTL(ISTAGE,2,DAU,W1,W2,DELU,U2,U3,WMAS,UZ,N,BETA1,BETA2,
$ALFA2,ALFA3,DELUU2,DELUL2,OMEGRU,OMEGRL,OMEGSU,OMEGSL,
$DRAGRU,DRAGRL,DRAGSU,DRAGSL,REAVE)
OMEGA6=OMEGSU+OMEGSL
283. 001503B DELP6=OMEGA6*0.5*RHOG(2)/GC*(U2**2)
284. 001504B IF(IPRINT.EQ.2) WRITE(6,6619) OMEGA6,DELP6
285. 001511B 6619 FORMAT(1H ,1X, #OMEGA5=#,2F10.5)
286. 001521B REAVE2=REAVE
287. 001521B REAVE=(REAVE1+REAVE2)*0.5
288. 001521B PR23=1.0-(OMEGA8+OMEGA4+OMEGA5+OMEGA6)*(1.0-PS2/P(2))
289. 001524B PR13=(TG(2)/TG(1))**G1*PREL*PR23/PP
290. 001534B P(3)=PR13*P(1)
291. 001543B TG(3)=TG(2)
292. 001545B TS3=TG(3)-U3**2/(2.0*CPMIX*GC*AJ)
293. 001546B AG3=(GAMMA*RMIX*TS3*GC)**0.5
294. 001554B ASPEED=WICASD(XWT(1),RHOG(2),AG3)
295. 001562B ASPED3=ASPEED
296. 001564B AMAC3=U3/ASPEED
297. 001564B PS3=(1.0+G2*AMAC3**2)**(-G1)*P(3)
298. 001566B RHOG3=PS3/RMIX/TS3
299. 001576B RHOG(3)=RHOG3
300. 001601B RHOM3=1.0/(XG/RHOG3+XWT(1)/RHOW)
301. 001601B UZ=BMASS/RHOG3/AAA3
302. 001606B UZ3CL=UZ
303. 001610B IF(JJJJ.EQ.2) GO TO 3010
304. 001610B IF(JJJJ.GT.2) GO TO 3020
305. 001612B XXX1=UZ3AS
306. 001614B YYY1=UZ3CL
307. 001615B JJJJ=JJJJ+1
308. 001617B GO TO 3001
309. 001620B 3010 XXX2=UZ3AS
310. 001621B YYY2=UZ3CL
311. 001622B UZ=WICNEW(XXX1,YYY1,XXX2,YYY2)
312. 001624B IF(IPRINT.EQ.2) WRITE(6,3030) JJJJ,UZ
313. 001627B 3030 FORMAT(1H ,1X, I2, 2X, #UZ33=#,F10.5)
314. 001637B JJJJ=JJJJ+1
315. 001637B GO TO 3001
316. 001640B 3020 IF(ABS((UZ3AS-UZ3CL)/UZ3AS).LT.EPS) GO TO 4000
317. 001640B XXX1=XXX2
318. 001645B YYY1=YYY2
319. 001645B XXX2=UZ3AS
320. 001647B YYY2=UZ3CL
321. 001650B UZ=WICNEW(XXX1,YYY1,XXX2,YYY2)
322. 001652B IF(IPRINT.EQ.2) WRITE(6,3040) JJJJ,UZ
323. 001654B 3040 FORMAT(1H ,1X, I2, #UZ33=#,F10.5)
324. 001664B JJJJ=JJJJ+1
325. 001664B IF(JJJJ.EQ.20) GO TO 4000
326. 001665B GO TO 3001
327. 001666B 4000 UZ3=UZ3CL
328. 001667B FAI3=UZ3/UTIPG(ISTAGE+1)
329. 001667B TW(3)=TW(2)
330. 001671B TWW(3)=TW(2)
331. 001673B OMEGTR=OMEGA1+OMEGA2+OMEGA3+OMEGA7
332. 001674B OMEGTS=OMEGA4+OMEGA5+OMEGA6+OMEGA8
333. 001700B PRATIO=P(3)/P(1)
334. 001704B TRATIO=TG(3)/TG(1)
335. 001706B CALL WICPRP(XA,XU(3),XCH4,TG(3),RMIX,CPMIX,GAMMA,G1,G2,G3)
336. 001710B GAMMA2=GAMMA
337. 001713B GAMMAU=(GAMMA1+GAMMA2)/2.0
338. 001713B

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339. 001716B      G4=(GAMMAU-1.0)/GAMMAU
340. 001720B      ETAA(ISTAGE)=(PRATIO**G4-1.0)/(TRATIO-1.0)
341. 001726B      PSI=GC*AJ*CPMIX*ETAA(ISTAGE)*(TG(2)-TG(1))/(UTIPG(ISTAGE)**2)
342. 001737B      TAU=PSI/ETAA(ISTAGE)
343. 001740B      IF(IDESIN.EQ.2) GO TO 999
344. 001743B      WRITE(6,404) FAIO,ISTAGE
345. 001751B      404 FORMAT(1H1,1X,*****          =,1X,
          $=INITIAL FLOW COEFFICIENT=,1X,F5.3,1X,(STAGE=,I2,1X,
          $=),2X,*****          )
346. 001751B      WRITE(6,401) PRATIO,TRATIO,ETAA(ISTAGE)
347. 001760B      401 FORMAT(1H0,5X,=STAGE TOTAL PRESSURE RATIO=,F12.5,/,
          $6X,=STAGE TOTAL TEMPERATURE RATIO=,F12.5,/,
          $6X,=STAGE ADIABATIC EFFICIENCY=,F12.5)
348. 001760B      WRITE(6,402) FAI1,UZ1,UTIPG(ISTAGE)
349. 001767B      402 FORMAT(1H0,5X,=STAGE FLOW COEFFICIENT=,F5.3,/,
          $6X,=AXIAL VELOCITY=,F7.2,/,
          $6X,=ROTOR SPEED=,F7.2,/)
          WRITE(6,405)
350. 001767B      405 FORMAT(1H0,24X,=*ROTOR INLET* *ROTOR OUTLET* *STATOR OUTLET*=)
351. 001772B      WRITE(6,406) P(1),P(2),P(3)
352. 001772B      406 FORMAT(1H ,1X,=TOTAL PRESSURE=,10X,3(F10.4,5X))
353. 002000B      WRITE(6,407) PS1,PS2,PS3
354. 002000B      407 FORMAT(1H ,1X,=STATIC PRESSURE=,9X,3(F10.4,5X))
355. 002006B      WRITE(6,408) TG(1),TG(2),TG(3)
356. 002006B      408 FORMAT(1H ,1X,=TOTAL TEMPERATURE(GAS)=,3X,3(F10.4,5X))
357. 002014B      WRITE(6,409) TS1,TS2,TS3
358. 002014B      409 FORMAT(1H ,1X,=STATIC TEMPERATURE(GAS)=,1X,3(F10.4,5X))
359. 002022B      WRITE(6,410) RHOG(1),RHOG2,RHOG3
360. 002022B      410 FORMAT(1H ,1X,=STATIC DENSITY(GAS)=,5X,3(F10.4,5X))
361. 002030B      WRITE(6,411) RHOM(1),RHOM2,RHOM3
362. 002030B      411 FORMAT(1H ,1X,=STATIC DENSITY(MIXTURE)=,1X,3(F10.4,5X))
363. 002036B      WRITE(6,412) UZ1,UZ2,UZ3
364. 002036B      412 FORMAT(1H0,1X,=AXIAL VELOCITY=,10X,3(F10.4,5X))
365. 002044B      WRITE(6,413) U1,U2,U3
366. 002044B      413 FORMAT(1H ,1X,=ABSOLUTE VELOCITY=,7X,3(F10.4,5X))
367. 002052B      WRITE(6,414) W1,W2
368. 002052B      414 FORMAT(1H ,1X,=RELATIVE VELOCITY=,7X,2(F10.4,5X))
369. 002057B      WRITE(6,415) U(ISTAGE),UU2(ISTAGE),U(ISTAGE+1)
370. 002057B      415 FORMAT(1H ,1X,=BLADE SPEED=,13X,3(F10.4,5X))
371. 002070B      WRITE(6,416) VS1,VS2
372. 002070B      416 FORMAT(1H ,1X,=TANG. COMP. OF ABS. VEL.=,2(F10.4,5X))
373. 002075B      WRITE(6,417) WS1,WS2
374. 002075B      417 FORMAT(1H ,1X,=TANG. COMP. OF REL. VEL.=,2(F10.4,5X))
375. 002102B      WRITE(6,418) ASPED1,ASPED2,ASPED3
376. 002102B      418 FORMAT(1H ,1X,=ACOUSTIC SPEED=,10X,3(F10.4,5X))
377. 002110B      WRITE(6,419) AMAC1,AMAC2,AMAC3
378. 002110B      419 FORMAT(1H ,1X,=ABSOLUTE MACH NUMBER=,4X,3(F10.4,5X))
379. 002116B      WRITE(6,420) AMACH1,AMACH2
380. 002116B      420 FORMAT(1H ,1X,=RELATIVE MACH NUMBER=,4X,2(F10.4,5X))
381. 002123B      WRITE(6,421) FAI1,FAI2,FAI3
382. 002123B      421 FORMAT(1H0,1X,=FLOW COEFFICIENT=,8X,3(F10.4,5X))
383. 002131B      WRITE(6,422) AAA1,AAA2,AAA3
384. 002131B      422 FORMAT(1H ,1X,=FLOW AREA=,15X,3(F10.4,5X))
385. 002137B      WRITE(6,423) ALFA1,ALFA2,ALFA3
386. 002137B      423 FORMAT(1H0,1X,=ABSOLUTE FLOW ANGLE=,5X,3(F10.4,5X))
387. 002145B      WRITE(6,424) BETA1,BETA2
388. 002145B      424 FORMAT(1H ,1X,=RELATIVE FLOW ANGLE=,5X,3(F10.4,5X))
389. 002152B      WRITE(6,425) AINCIR,AINCIS
390. 002152B      425 FORMAT(1H ,1X,=INCIDENCE=,16X,2(F10.4,5X))
391. 002157B      WRITE(6,426) ADEVIR,ADEVIS
392. 002157B      426

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393. 002164B 426 FORMAT(1H , 1X, #DEVIATION#, 30X, 2(F10.4, 5X))
394. 002164B 999 RETURN
395. 002166B END

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1. 000000B SUBROUTINE WICMAC(ISTAGE, AMASSM, T01G, PRES, M, UZ, C, XW1, ALFA,
$RMIX, CPMIX, AREA1)
2. 000000B REAL M , MA1, MC1, MA2, MC2, MANEW, MCNEW
3. 000000B COMMON JPERFM, RHOG(3), RERUP, RERLOW, RESUP, RESLOW
^, PREB, RRTIP(20), SRTIP(20), AAA1, AAA2, AAA3, SAREA(20), SAREAS(20)
^, P(3), TG(3), XA, XU(3), XCH4, XW(3), XWW(3), XWT(3), TW(3), TWW(3)
^, OMEGS(20), OMEGR(20), GAPR(20), GAPS(20)
^, RRHUB(20) , RC(20) , RBLADE(20) , STAGER(20)
^, SRHUB(20) , SC(20) , SBLADE(20), STAGES(20)
^, SIGUMR(20) , BET1SR(20) , BET2SR(20) , AINCSR(20) , ADEUSR(20)
^, SIGUMS(20) , BET1SS(20) , BET2SS(20) , AINCSS(20) , ADEVSS(20)
^, UTIPG(20), UTIP(20), UTIPD(20), UOU(20), UMEAN(20), UHUB(20), U(20), FAI
^, AREA(20), AREAS(20), UU2(20), UTIP2(20), UMEAN2(20), UHUB2(20), IPRINT
^, ICENT, ICENT, FMR1(20), FMA2(20), IDESIN, FAID
^, NS, NSF, NSLPC, BYPASS, NS1, RT(20), RM(20), RH(20), ST(20), SM(20), SH(20)
^, DSMASS, AAREA(20), AAREAS(20), PR12D(20), PR13D(20), ETARD(20)
^, DR(20), DS(20), DEQR(20), DEQS(20), BLOCK(20), BLOCKS(20)
^, BET1MR(20), BET2MR(20), BET1MS(20), BET2MS(20), RAD11(20), RAD12(20)
^, FAIRIN(20), FAIOUT(20), ETASG(20), PSID(20), TAUD(20), SITADR(20)
^, SITADS(20), WWD(20), UUD(20)
4. 000000B GAMMA=1.0/(1.0-RMIX/CPMIX/778.0)
5. 000011B G2=(GAMMA-1.0)/2.0
6. 000013B G3=-1.0/(GAMMA-1.0)
7. 000015B MA1=0.5
8. 000016B RHOG1=PRES/RMIX/T01G
9. 000020B RHOGS=(1.0+G2*MA1**2)**G3*RHOG1
10. 000027B RHOW=62.4
11. 000031B RHOMS=1.0/((1.0-XW1)/RHOGS+XW1/RHOW)
12. 000036B TS=T01G/(1.0+G2*MA1**2)
13. 000041B A=SQRT(GAMMA*RMIX*TS*32.174)
14. 000047B C=WICASD(XW1, RHOGS, A)
15. 000052B IF(JPERFM.NE.3) UZ=AMASSM/RHOMS/AREA1
16. 000060B IF(JPERFM.EQ.3) UZ=AMASSM/RHOGS/AREA1
17. 000064B IF(AMASSM.LT.0.001) UZ=UTIPG(ISTAGE)*FAI
18. 000071B ALFAR=ALFA*3.1415927/180.0
19. 000073B MC1=UZ/C/COS(ALFAR)
20. 000076B MA2=0.6
21. 000100B RHOGS=(1.0+G2*MA2**2)**G3*RHOG1
22. 000106B RHOMS=1.0/((1.0-XW1)/RHOGS+XW1/RHOW)
23. 000113B TS=T01G/(1.0+G2*MA2**2)
24. 000117B A=SQRT(GAMMA*RMIX*TS*32.174)
25. 000125B C=WICASD(XW1, RHOGS, A)
26. 000130B IF(JPERFM.NE.3) UZ=AMASSM/RHOMS/AREA1
27. 000136B IF(JPERFM.EQ.3) UZ=AMASSM/RHOGS/AREA1
28. 000142B IF(AMASSM.LT.0.001) UZ=UTIPG(ISTAGE)*FAI
29. 000147B MC2=UZ/C/COS(ALFAR)
30. 000152B J=1
31. 000154B 300 MANEW=WICNEW(MA1, MC1, MA2, MC2)
32. 000157B RHOGS=(1.0+G2*MANEW**2)**G3*RHOG1
33. 000165B RHOMS=1.0/((1.0-XW1)/RHOGS+XW1/RHOW)
34. 000172B TS=T01G/(1.0+G2*MANEW**2)
35. 000176B A=SQRT(GAMMA*RMIX*TS*32.174)
36. 000204B C=WICASD(XW1, RHOGS, A)
37. 000207B IF(JPERFM.NE.3) UZ=AMASSM/RHOMS/AREA1
38. 000215B IF(JPERFM.EQ.3) UZ=AMASSM/RHOGS/AREA1

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39. 000221B      IF(AMASSM.LT.0.001) UZ=UTIPG(ISTAGE)*FAI
40. 000226B      MCNEW=UZ/C/COS(ALFAR)
41. 000231B      ERROR=ABS(MANEW-MCNEW)
42. 000234B      ERROR=ERROR/MANEW
43. 000235B      EPS=1.0E-6
44. 000236B      IF(ERROR.LT.EPS) GO TO 200
45. 000237B      MA1=MA2
46. 000240B      MC1=MC2
47. 000242B      MA2=MANEW
48. 000243B      MC2=MCNEW
49. 000245B      J=J+1
50. 000246B      IF(J.LT.50) GO TO 300
51. 000247B      WRITE(6,403) ISTAGE
52. 000254B      403 FORMAT(1H0, #MZ DOES NOT CONVERGE AT STAGE=#, I1)
53. 000254B      GO TO 998
54. 000254B      200 M=MANEW
55. 000255B      IF(AMASSM.LT.0.001) ISTAGE=0
56. 000262B      998 RETURN
57. 000264B      END

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1. 000000B      FUNCTION WICASD ( XW , RHOG , CG )
2. 000000B      RHOW=62.2567
3. 000001B      CW = 4956.04
4. 000003B      SIGUMA = ( XW * RHOG ) / ( RHOW - XW * ( RHOW - RHOG ) )
5. 000007B      A1 = ( 1.0-SIGUMA ) * RHOG + SIGUMA * RHOW
6. 000012B      A2 = ( 1.0- SIGUMA ) / ( RHOG * CG* CG )
7. 000016B      A3 = SIGUMA / ( RHOW * CW* CW)
8. 000017B      A4 = A1 * ( A2 + A3)
9. 000021B      WICASD = 1.0/ SQRT ( A4 )
10. 000024B      RETURN
11. 000027B      END

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C+++++
C ++++++
C ++++++

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1. 000000B      FUNCTION WICED(AK3,UZ1,UZ2,UR1,R1,R2,BET1,BET2,SIGUMA,AINCI,
2. 000000B      $AINCI)
3. 000001B      C1=180.0/3.1415926
4. 000003B      BET1R=BET1/C1
5. 000004B      BET2R=BET2/C1
6. 000007B      CSB1=COS(BET1R)
7. 000011B      CSB2=COS(BET2R)
8. 000014B      CSCS=CSB2/CSB1*(UZ1/UZ2)
9. 000017B      TNB1=WICTAN(BET1R)
10. 000026B      TNB2=WICTAN(BET2R)*(UZ2/UZ1)*(R2/R1)
11. 000035B      TNTN=TNB1-TNB2-(UR1/UZ1)*(1.0-(R2/R1)**2)
12. 000044B      DEQ1=0.0117*(ABS(AINCI-AINCIS))**1.43
13. 000051B      DEQ2=0.61*(CSB1**2 0)/SIGUMA*TNTN
14. 000056B      WICED=CSCS*AK3*(1.12+DEQ1+DEQ2)
15. 000060B      RETURN
16. 000060B      END

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C ++++++

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1. 000000B      FUNCTION WICMTK(SITACS,AMACH1,DELDEQ,AK2)
2. 000000B      IF(DELDEQ.LT.0.0) GO TO 10
3. 000003B      A1=0.827*AMACH1
4. 000004B      A2=2.692*(AMACH1**2)
5. 000005B      A3=2.675*(AMACH1**3)
6. 000007B      A=A1-A2+A3

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7. 000012B WICMTK=SITACS+A*(DELDEQ**2)*AK2
8. 000016B GO TO 11
9. 000017B 10 B1=2.80*AMACH1
10. 000020B B2=8.71*(AMACH1**2)
11. 000021B B3=9.36*(AMACH1**3)
12. 000023B B=B1-B2+D3
13. 000026B WICMTK=SITACS+B*(DELDEQ**2)*AK2
14. 000032B 11 RETURN
15. 000036B END

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C ++++++

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1. 000000B FUNCTION WICLOS(BET1,BET2,SIGUMA,SITA)
2. 000000B C1=180.0/3.1415926
3. 000001B BET1R=BET1/C1
4. 000003B BET2R=BET2/C1
5. 000004B CSB1=COS(BET1R)
6. 000007B CSB2=COS(BET2R)
7. 000011B CSCS=CSB1/CSB2
8. 000012B WICLOS=SITA*2.0*SIGUMA/CSB2*(CSCS**2)
9. 000016B RETURN
10. 000020B END

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C ++++++

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1. 000000B SUBROUTINE WICIRS(ISTAGE,R,XW1,XG,RHOG1,BETA1,W1,
2. 1WW1, WW2, WW)
3. 000000B REAL LWC
3. 000000B COMMON JPERFM,RHOG(3),RERUP,RERLOW,RESUP,RESLOW
^,PREB,RRTIP(20),SRTIP(20),AAA1,AAA2,AAA3,SAREA(20),SAREAS(20)
^,P(3),TG(3),XA,XU(3),XCH4,XW(3),XWW(3),XWT(3),TW(3),TWW(3)
^,OMEGS(20),OMEGR(20),GAPR(20),GAPS(20)
^,RRHUB(20),RC(20),RBLADE(20),STAGER(20)
^,SRHUB(20),SC(20),SBLADE(20),STAGES(20)
^,SIGUMR(20),BET1SR(20),BET2SR(20),AINCSP(20),ADEUSR(20)
^,SIGUMS(20),BET1SS(20),BET2SS(20),AINCSS(20),ADEUSS(20)
^,UTIPG(20),UTIP(20),UTIPD(20),UQU(20),UMEAN(20),UHUB(20),U(20),FAI
^,AREA(20),AREAS(20),UU2(20),UTIP2(20),UMEAN2(20),UHUB2(20),IPRINT
^,ICENT,IICENT,FMR1(20),FMA2(20),IDESIN,FAID
^,NS,NSF,NSLPC,BYPASS,NS1,RT(20),RM(20),RH(20),ST(20),SM(20),SH(20)
^,DSMSS,AAREA(20),AAREAS(20),PR12D(20),PR13D(20),ETARD(20)
^,DR(20),DS(20),DEGR(20),DEGS(20),BLOCK(20),BLOCKS(20)
^,BET1MR(20),BET2MR(20),BET1MS(20),BET2MS(20),RADI1(20),RADI2(20)
^,FAIRIN(20),FAIOUT(20),ETASG(20),PSID(20),TAUD(20),SITADR(20)
^,SITADS(20),WWD(20),UUD(20)
4. 000000B N = ISTAGE
5. 000001B PAI = 3.1415926
6. 000003B B1 = 1.0
7. 000004B B2R = ( 90.0 - BETA1 + STAGER ( N ) ) * PAI / 180.0
8. 000012B B2 = COS ( B2R )
9. 000014B LWC=XW1/XG*RHOG1
10. 000016B DS1=0.07*RC(N)
11. 000021B BETA1R = BETA1* PAI / 180.0
12. 000024B DS2 = 2.0 * PAI * R / RBLADE(N) * COS ( BETA1R ) /
$COS(B2R)
13. 000034B IF(DS2.GE.RC(N)) DS2=RC(N)
14. 000037B H=(AAA1*144.0)/(2.0*PAI*R)
15. 000041B A1=DS1*H*RBLADE(N)/144.0
16. 000044B A2=DS2*H*RBLADE(N)/144.0
17. 000046B WW1 = LWC * W1 * B1 * A1
18. 000052B WW2 = LWC * W1 * B2 * A2
19. 000055B WW = WW1 + WW2

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20. 000057B      RETURN
21. 000061B      END
C ++++++

1. 000000B      SUBROUTINE WICIRL(ISTAGE,R,XW1,XG,RHOG1,BETA1,W1,
                1WW1 , WW2 , WW )
2. 000000B      REAL LWC
3. 000000B      COMMON JPERFM,RHOG(3),RERUP,RERLOW,RESUP,RESLOW
                ^,PREB,RRTIP(20),SRTIP(20),AAA1,AAA2,AAA3,SAREA(20),SAREAS(20)
                ^,P(3),TG(3),XA,XU(3),XCH4,XW(3),XWW(3),XWT(3),TW(3),TWW(3)
                ^,OMEGS(20),OMEGR(20),GAPR(20),GAPS(20)
                ^,RRHUB(20) , RC(20) , RBLADE(20) , STAGER(20)
                ^,SRHUB(20) , SC(20) , SBLADE(20),STAGES(20)
                ^,SIGUMR(20) , BET1SR(20) , BET2SR(20) , AINCSR(20) , ADEVSR(20)
                ^,SIGUMS(20) , BET1SS(20) , BET2SS(20) , AINCSS(20) , ADEVSS(20)
                ^,UTIPG(20),UTIP(20),UTIPD(20),UOU(20),UMEAN(20),UHUB(20),U(20),FAI
                ^,AREA(20),AREAS(20),UU2(20),UTIP2(20),UMEAN2(20),UHUB2(20),IPRINT
                ^,ICENT,IICENT,FMR1(20),FMA2(20),IDESIN,FAID
                ^,NS,NSF,NSLPC,BYPASS,NS1,RT(20),RM(20),RH(20),ST(20),SM(20),SH(20)
                ^,DSMASS,AAREA(20),AAREAS(20),PR12D(20),PR13D(20),ETARD(20)
                ^,DR(20),DS(20),DEQR(20),DEQS(20),BLOCK(20),BLOCKS(20)
                ^,BET1MR(20),BET2MR(20),BET1MS(20),BET2MS(20),RADI1(20),RADI2(20)
                ^,FAIRIN(20),FAIOUT(20),ETASG(20),PSID(20),TAUD(20),SITADR(20)
                ^,SITADS(20),WWD(20),UUD(20)
4. 000000B      N = ISTAGE
5. 000001B      PAI = 3.1415926
6. 000003B      LWC=XW1/XG/RHOG1
7. 000006B      ALFA=(90.0-BETA1)/2.0*PAI/180.0
8. 000012B      BETA=(90.0+BETA1)/2.0*PAI/180.0
9. 000016B      B1=SIN(ALFA)
10. 000021B     B2=SIN(BETA)
11. 000023B     U1=W1*COS(ALFA)
12. 000025B     U2=W1*COS(BETA)
13. 000030B     S=2.0*PAI*RRTIP(ISTAGE)/RBLADE(ISTAGE)/2.0
14. 000035B     GSI=BETA1+(90.0-BETA1)/2.0
15. 000040B     GSIR=GSI*PAI/180.0
16. 000042B     STAGR=STAGER(ISTAGE)*PAI/180.0
17. 000045B     Y2=GAPR(ISTAGE)/2.0*(WICTAN(STAGR)-WICTAN(GSIR))+S
18. 000056B     DAMY1=(90.0-GSI)*PAI/180.0
19. 000062B     Y1=Y2*SIN(DAMY1)
20. 000064B     DAMY2=(GSI-STAGER(ISTAGE))*PAI/180.0
21. 000071B     DS1=Y1/SIN(DAMY2)
22. 000073B     IF(DS1.GT.RC(ISTAGE)) DS1=RC(ISTAGE)
23. 000077B     DAMY3=(90.-(90.0+BETA1)/2.0)*PAI/180.0
24. 000103B     DAMY4=STAGER(ISTAGE)*PAI/180.0
25. 000106B     DAMY5=BETA1*PAI/180.0
26. 000110B     DAMY6=S-GAPR(ISTAGE)/2.0*(WICTAN(DAMY5)-WICTAN(DAMY3))
27. 000120B     DAMY7=COS(DAMY4)*WICTAN(DAMY3)+SIN(DAMY4)
28. 000131B     DS2=DAMY6/DAMY7
29. 000132B     IF(DS2.GT.RC(ISTAGE)) DS2=RC(ISTAGE)
30. 000136B     H=(AAA1*144.0)/(2.0*PAI*R)
31. 000142B     A1=DS1*H*RBLADE(N)/144.0
32. 000146B     A2=DS2*H*RBLADE(N)/144.0
33. 000150B     WW1 = LWC * U1 * B1 * A1
34. 000154B     WW2 = LWC * U2 * B2 * A2
35. 000160B     WW = WW1 + WW2
36. 000162B     RETURN
37. 000164B     END
C ++++++

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1. 000000B   SUBROUTINE WICISS( ISTAGE ,R ,XW1, XG , RHOGAS ,ALFA2,U1 ,
$WW1,WW2,WW)
2. 000000B   REAL LWC
3. 000000B   COMMON JPERFM,RHOG(3),RERUP,RERLOW,RESUP,RESLOW
^,PREB,RRTIP(20),SRTIP(20),AAA1,AAA2,AAA3,SAREA(20),SAREAS(20)
^,P(3),TG(3),XA,XU(3),XCH4,XW(3),XWW(3),XWT(3),TW(3),TWW(3)
^,OMEGS(20),OMEGR(20),GAPR(20),GAPS(20)
^,RRHUB(20) , RC(20) , RBLADE(20) , STAGER(20)
^,SRHUB(20) , SC(20) , SBLADE(20),STAGES(20)
^,SIGUMR(20) , BET1SR(20) , BET2SR(20) , AINCSR(20) , ADEUSR(20)
^,SIGUMS(20) , BET1SS(20) , BET2SS(20) , AINCSS(20) , ADEVSS(20)
^,UTIPG(20),UTIP(20),UTIPD(20),UOU(20),UMEAN(20),UHUB(20),U(20),FAI
^,AREA(20),AREAS(20),UU2(20),UTIP2(20),UMEAN2(20),UHUB2(20),IPRINT
^,ICENT,IICENT,FMR1(20),FMA2(20),IDESIN,FAID
^,NS,NSF,NSLPC,BYPASS,NS1,RT(20),RM(20),RH(20),ST(20),SM(20),SH(20)
^,DSMASS,AAREA(20),AREAS(20),PR12D(20),PR13D(20),ETARD(20)
^,DR(20),DS(20),DEQR(20),DEQS(20),BLOCK(20),BLOCKS(20)
^,BET1MR(20),BET2MR(20),BET1MS(20),BET2MS(20),RADI1(20),RADI2(20)
^,FAIRIN(20),FAIOUT(20),ETASG(20),PSID(20),TAUD(20),SITADR(20)
^,SITADS(20),WWD(20),UUD(20)
4. 000000B   LWC = XW1 / XG * RHOGAS
5. 000003B   DS1=( 0.06 * SC ( ISTAGE ) ) / 12.0
6. 000006B   PAI=3.1415926
7. 000007B   B1=1.0
8. 000010B   B2R=(90.0-ALFA2+STAGES(ISTAGE))*PAI/180.0
9. 000015B   B2=COS(B2R)
10. 000020B   ALFA2R=ALFA2*PAI/180.0
11. 000022B   DS2=2.0*PAI*R/SBLADE(ISTAGE)*COS(ALFA2R)/COS(B2R)
12. 000033B   IF(DS2.GT.SC(ISTAGE)) DS2=SC(ISTAGE)
13. 000036B   H=(AAA2*144.0)/(2.0*PAI*R)
14. 000040B   A1=DS1*H*SBLADE(ISTAGE)/144.0
15. 000043B   A2=DS2*H*SBLADE(ISTAGE)/144.0
16. 000045B   WW1=LWC*U1*B1*A1
17. 000051B   WW2=LWC*U1*B2*A2
18. 000054B   WW=WW1+WW2
19. 000056B   RETURN
20. 000060B   END

```

C ++++++

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1. 000000B   SUBROUTINE WICISL(ISTAGE,R,XW1,XG,RHOG1,ALFA2,W1,WW1,WW2,WW)
2. 000000B   REAL LWC
3. 000000B   COMMON JPERFM,RHOG(3),RERUP,RERLOW,RESUP,RESLOW
^,PREB,RRTIP(20),SRTIP(20),AAA1,AAA2,AAA3,SAREA(20),SAREAS(20)
^,P(3),TG(3),XA,XU(3),XCH4,XW(3),XWW(3),XWT(3),TW(3),TWW(3)
^,OMEGS(20),OMEGR(20),GAPR(20),GAPS(20)
^,RRHUB(20) , RC(20) , RBLADE(20) , STAGER(20)
^,SRHUB(20) , SC(20) , SBLADE(20),STAGES(20)
^,SIGUMR(20) , BET1SR(20) , BET2SR(20) , AINCSR(20) , ADEUSR(20)
^,SIGUMS(20) , BET1SS(20) , BET2SS(20) , AINCSS(20) , ADEVSS(20)
^,UTIPG(20),UTIP(20),UTIPD(20),UOU(20),UMEAN(20),UHUB(20),U(20),FAI
^,AREA(20),AREAS(20),UU2(20),UTIP2(20),UMEAN2(20),UHUB2(20),IPRINT
^,ICENT,IICENT,FMR1(20),FMA2(20),IDESIN,FAID
^,NS,NSF,NSLPC,BYPASS,NS1,RT(20),RM(20),RH(20),ST(20),SM(20),SH(20)
^,DSMASS,AAREA(20),AREAS(20),PR12D(20),PR13D(20),ETARD(20)
^,DR(20),DS(20),DEQR(20),DEQS(20),BLOCK(20),BLOCKS(20)
^,BET1MR(20),BET2MR(20),BET1MS(20),BET2MS(20),RADI1(20),RADI2(20)
^,FAIRIN(20),FAIOUT(20),ETASG(20),PSID(20),TAUD(20),SITADR(20)
^,SITADS(20),WWD(20),UUD(20)
4. 000000B   PAI=3.1415926
5. 000001B   LWC = XW1 / XG * RHOG1

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6. 000004B ALFA=(90.0-ALFA2)/2.0*PAI/180.0
7. 000011B BETA=(90.0+ALFA2)/2.0*PAI/180.0
8. 000015B B1=SIN(ALFA)
9. 000020B B2=SIN(BETA)
10. 000022B U1=W1*COS(ALFA)
11. 000024B U2=W1*COS(BETA)
12. 000027B S=2.0*PAI*SRTIP(ISTAGE)/SBLADE(ISTAGE)/2.0
13. 000034B GSI=ALFA2+(90.0-ALFA2)/2.0
14. 000037B GSIR=GSI*PAI/180.0
15. 000041B STAGR=STAGES(ISTAGE)*PAI/180.0
16. 000044B Y2=GAPS(ISTAGE)/2.0*(WICTAN(STAGR)-WICTAN(GSIR))+S
17. 000055B DAMY1=(90.0-GSI)*PAI/180.0
18. 000061B Y1=Y2*SIN(DAMY1)
19. 000063B DAMY2=(GSI-STAGES(ISTAGE))*PAI/180.0
20. 000070B DS1=Y1/SIN(DAMY2)
21. 000072B IF(DS1.GT.SC(ISTAGE)) DS1=SC(ISTAGE)
22. 000076B DAMY3=(90.-(90.0+ALFA2)/2.0)*PAI/180.0
23. 000102B DAMY4=STAGES(ISTAGE)*PAI/180.0
24. 000105B DAMY5=ALFA2*PAI/180.0
25. 000107B DAMY6=S-GAPS(ISTAGE)/2.0*(WICTAN(DAMY5)-WICTAN(DAMY3))
26. 000117B DAMY7=COS(DAMY4)*WICTAN(DAMY3)+SIN(DAMY4)
27. 000130B DS2=DAMY6/DAMY7
28. 000131B IF(DS2.GT.SC(ISTAGE)) DS2=SC(ISTAGE)
29. 000135B H=(AA2*144.0)/(2.0*PAI*R)
30. 000141B A1=DS1*H*SBLADE(ISTAGE)/144.0
31. 000144B A2=DS2*H*SBLADE(ISTAGE)/144.0
32. 000147B WW1=LWC*U1*B1*A1
33. 000152B WW2=LWC*U2*B2*A2
34. 000156B WW=WW1+WW2
35. 000160B RETURN
36. 000162B END

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C ++++++

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1. 000000B SUBROUTINE WICWAK ( RHOG , U , DWAKE , DWAKEM )
2. 000000B VISCOF=1.20E-3
3. 000000B SIGUMA = 4.6534E-3
4. 000002B GC = 32.174
5. 000003B WE=21.0
6. 000005B DWAKE1 = ( WE * SIGUMA * GC ) / RHOG / U ** 2
7. 000012B SN=VISCOF**2/(RHOG*SIGUMA*DWAKE1*GC)
8. 000015B WELIMT=12.0*(1.0+SN**0.36)
9. 000022B D1=WELIMT*SIGUMA*GC/(RHOG*U**2)
10. 000027B WE=22.0
11. 000030B DWAKE2=(WE*SIGUMA*GC)/RHOG/U**2
12. 000034B SN=VISCOF**2/(RHOG*SIGUMA*DWAKE2*GC)
13. 000037B WELIMT=12.0*(1.0+SN**0.36)
14. 000044B D2=WELIMT*SIGUMA*GC/(RHOG*U**2)
15. 000051B XXXX=WICNEW(DWAKE1, D1, DWAKE2, D2)
16. 000054B SN=VISCOF**2/(RHOG*SIGUMA*XXXX*GC)
17. 000060B WELIMT=12.0*(1.0+SN**0.36)
18. 000065B DWAKE=WELIMT*SIGUMA*GC/(RHOG*U**2)
19. 000072B DWAKEM = DWAKE / 3.2802 * 1.0E6
20. 000074B RETURN
21. 000077B END

```

C ++++++

```

1. 000000B SUBROUTINE WICHET(TG1, TG3, TW1, TW3, DAVEN2, DAVEN,
2. 000000B $DELZI, UZ, WMASS1, UMASS1, AMASS, CHMASS, CPG, CPW, DELTGH, DELTWH, RE)
3. 000000B DIMENSION DELHET(51)
REAL ND , KA , NU , MMASS, NU

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4. 000000B DELTGH=0.0
5. 000070B DELTWH=0.0
6. 000070B IF(WMASS1.LT.1.0E-6) GO TO 11
7. 000073B PAI = 3.1415927
8. 000074B DAVEAU=(DAVEN2+DAVEN)/2.0*1.0E-6*3.2802
9. 000100B IF(DAVEAU.LT.1.0E-6) GO TO 11
10. 000103B RHOW = 62.54
11. 000103B ND = WMASS1 / ( RHOW * 4.0 / 3.0 * PAI * ( DAVEAU / 2.0 ) ** 3)
12. 000112B KA = 0.015 / 3600.0
13. 000113B PR=0.7
14. 000115B NU=2.0+0.6*SQRT(RE)*PR**0.33
15. 000127B HCONVE = KA / DAVEAU * NU
16. 000131B J = 1
17. 000132B 10 DELT=((TG1-TW1)+(TG3-TW3))/2.0
18. 000140B DELHH = HCONVE * 4.0 * PAI * ( DAVEAU / 2.0 ) **2*DELT *
$ND*DELZI/UZ
19. 000150B GMASS1=UMASS1+AMASS+CHMASS
20. 000154B DELTGH=DELHH/(GMASS1*CPG)
21. 000156B DELTWH=DELHH/(WMASS1*CPW)
22. 000160B TG3=TG3-DELTGH
23. 000162B TW3=TW3+DELTWH
24. 000164B DELHET(J)=DELHH
25. 000165B J=J+1
26. 000167B IF(J.EQ.2) GO TO 10
27. 000170B EROR=ABS(DELHET(J-1)-DELHET(J-2))
28. 000173B EPS=0.0001
29. 000174B IF(J.GT.50) GO TO 11
30. 000176B IF(EROR.GT.EPS) GO TO 10
31. 000176B 11 RETURN
32. 000203B END

```

C ++++++

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1. 000000B SUBROUTINE WICMAS( HW1 , TW1 , TW2 , PP1 , PP2 , TG1 , TG2 , DZ ,
1 PWB1 , PWB2 , PW1 , PW2 , UZ , DDAVE1 , DDAVE2 , HW2 , UMASS1 ,
2 UMASS2 , WMASS1 , WMASS2 , DMDTAU , AMASS ,RE)
3 PWB1 = WICPWB(TW1)*144.0
4 PWB2 = WICPWB(TW2)*144.0
5 PW1 = ( HW1 * PP1 ) / ( HW1 + 0.6219 )
6 DMDT1 = WICMTR( TG1 , TW1 , PP1 , DDAVE1 , UZ , DZ , WMASS1 ,
7 1PW1 ,RE)
8 PW2AS1 = PW1
9 DMDT2 = WICMTR( TG 2 , TW 2 , PP2 , DDAVE2 , UZ , DZ , WMASS1 ,
10 1PW2AS1 ,RE)
11 DMDTAU = ( DMDT1 + DMDT2 ) / 2.0
12 IF(DMDTAU.LT.0.0) DMDTAU=0.0
13 WMASS2 = WMASS1 - DMDTAU
14 IF(WMASS2.LT.0.0) WMASS2=0.0
15 DMDTAU=WMASS1-WMASS2
16 UMASS2=UMASS1+DMDTAU
17 HW2=UMASS2/AMASS
18 PW2CL1 = ( HW2 * PP2 ) / ( HW2 + 0.6219 )
19 PW2AS2 = PW1 * 1.05
20 DMDT2 = WICMTR( TG2 , TW2 , PP2 , DDAVE2 , UZ , DZ , WMASS2 ,
21 1PW2AS2 ,RE)
22 DMDTAU = ( DMDT1 + DMDT2 ) / 2.0
23 IF(DMDTAU.LT.0.0) DMDTAU=0.0
24 WMASS2 = WMASS1 - DMDTAU
25 IF(WMASS2.LT.0.0) WMASS2=0.0
26 DMDTAU=WMASS1-WMASS2
27 UMASS2=UMASS1+DMDTAU

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```

24. 000113B      HW2 = UMASS2 / AMASS
25. 000114B      PW2CL2 = ( HW2 * PP2 ) / ( HW2 + 0.6219 )
26. 000120B      J=0
27. 000121B      2 PW2ASN = WICNEW ( PW2AS1 , PW2CL1 , PW2AS2 , PW2CL2 )
28. 000125B      PW2AS1 = PW2AS2
29. 000126B      PW2CL1 = PW2CL2
30. 000127B      PW2AS2 = PW2ASN
31. 000131B      DMDT2 = WICMTR( TG2 , TW2 , PP2 , DDAVE2 , UZ , DZ , WMASS2 , PW
12AS2 ,RE)
32. 000143B      DMDTAU = ( DMDT1 + DMDT2 ) / 2.0
33. 000145B      IF(DMDTAU.LT.0.0) DMDTAU=0.0
34. 000150B      WMASS2 = WMASS1 - DMDTAU
35. 000151B      IF(WMASS2.LT.0.0) WMASS2=0.0
36. 000154B      DMDTAU=WMASS1-WMASS2
37. 000155B      UMASS2=WMASS1+DMDTAU
38. 000156B      HW2 = UMASS2 / AMASS
39. 000157B      PW2CL2 = ( HW2 * PP2 ) / ( HW2 + 0.6219 )
40. 000163B      ERROR = ABS ( PW2AS2 - PW2CL2 )/(PW2AS2+1.0)
41. 000170B      J=J+1
42. 000172B      IF(J.GT.10) GO TO 3
43. 000173B      EPS = 0.01
44. 000174B      IF ( ERROR . GT . EPS ) GO TO 2
45. 000176B      3 PW2 = PW2AS2
46. 000177B      RETURN
47. 000202B      END

```

C ++++++

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1. 000000B      FUNCTION WICMTR(TTG,TTW,PPP,DAVE,UZ,DZ,MMASS,PW,RE)
2. 000000B      REAL KG , ND , MMASS
3. 000000B      IF(DAVE.LT.1.0E-6) WICMTR=0.0
4. 000006B      IF(DAVE.LT.1.0E-6) GO TO 10
5. 000007B      DD=DAVE*1.0E-6*3.2802
6. 000011B      T = ( TTG + TTW ) / 2.0
7. 000013B      PAI = 3.1415926
8. 000015B      RHOW = 62.2567
9. 000016B      RR = DD / 2.0
10. 000020B      TT = T * 5.0 / 9.0
11. 000023B      PP = PPP * 47.880258
12. 000025B      DV=4.24028E-3*(TT**1.5)/PP
13. 000031B      SCT=0.60
14. 000033B      SH=2.0+0.60*SQRT(RE)*SCT**0.33
15. 000045B      KG = DV / DD * SH
16. 000047B      HV=1115.3279-0.6840909*(TTW-460.0)
17. 000053B      PWBB=PW+29.0/18.0*0.45/HV*PPP*(TTG-TTW)
18. 000060B      R = 85.78
19. 000061B      ND = MMASS / ( RHOW * 4.0 / 3.0 * PAI * RR ** 3 )
20. 000070B      WICMTR = KG * 4.0 * PAI * RR ** 2 * ( PWBB / TTW - PW / TTG ) / R
21. 000102B      1 * ND * DZ / UZ
22. 000107B      10 RETURN
      END

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C ++++++

```

1. 000000B      FUNCTION WICPWB(TWB)
2. 000000B      TSTAG=TWB
3. 000001B      TSTAGC=(TSTAG-492.0)/1.8
4. 000004B      IF(TSTAGC.LT.100.0) GO TO 40
5. 000006B      IF(TSTAGC.GE.100.0.AND.TSTAGC.LT.200.0) GO TO 41
6. 000012B      A=5.45142
7. 000012B      B=2010.8
8. 000014B      GO TO 42

```

```

9. 000015B 40 A=5.9778
10. 000016B B=2224.4
11. 000020B GO TO 42
12. 000021B 41 A=5.6485
13. 000022B B=2101.1
14. 000024B 42 AA=A-B/(TSTAGC+273.0)
15. 000030B PS=10.0**AA
16. 000033B PS=PS/4.88247E-4
17. 000034B WICPWB=PS/144.0
18. 000035B RETURN
19. 000040B END

```

C ++++++

```

1. 000000B FUNCTION WICNEW(X1,Y1,X2,Y2)
2. 000000B T=ABS((X2-X1)/X1)
3. 000003B IF(T.LT.1.0E-6) WICNEW=(Y1+Y2)/2.0
4. 000011B IF(T.LT.1.0E-6) GO TO 100
5. 000013B WICNEW=X2-(((Y2-X2)/(((Y2-X2)-(Y1-X1))/(X2-X1))))
6. 000023B 100 RETURN
7. 000027B END

```

C ++++++

```

1. 000000B FUNCTION WICBPT(TSTAG,PSTAG)
2. 000000B TSTAGC=(TSTAG-492.0)/1.8
3. 000003B IF(TSTAGC.LT.100.0) GO TO 20
4. 000005B IF(TSTAGC.GE.100.0.AND.TSTAGC.LT.200.0) GO TO 21
5. 000011B A=5.45142
6. 000011B B=2010.8
7. 000013B GO TO 22
8. 000014B 20 A=5.9778
9. 000015B B=2224.4
10. 000017B GO TO 22
11. 000020B 21 A=5.6485
12. 000021B B=2101.1
13. 000023B 22 PS=PSTAG*4.88247E-4
14. 000025B TBOILK=B/(A-ALOG10(PS))
15. 000031B WICBPT=TBOILK*1.8
16. 000033B RETURN
17. 000036B END

```

C ++++++

```

1. 000000B FUNCTION WICSH(TSTAG,PSTAG)
2. 000000B TSTAGC=(TSTAG-492.0)/1.8
3. 000003B IF(TSTAGC.LT.100.0) GO TO 40
4. 000005B IF(TSTAGC.GE.100.0.AND.TSTAGC.LT.200.0) GO TO 41
5. 000011B A=5.45142
6. 000011B B=2010.8
7. 000013B GO TO 42
8. 000014B 40 A=5.9778
9. 000015B B=2224.4
10. 000017B GO TO 42
11. 000020B 41 A=5.6485
12. 000021B B=2101.1
13. 000023B 42 AA=A-B/(TSTAGC+273.0)
14. 000027B PS=10.0**AA
15. 000032B PS=PS/4.88247E-4
16. 000033B WICSH=0.6218847*PS/(PSTAG-PS)
17. 000035B RETURN
18. 000041B END

```

C ++++++

```

1. 000000B      FUNCTION WICTAN(X)
2. 000000B      A=COS(X)
3. 000004B      B=SIN(X)
4. 000007B      WICTAN=B/A
5. 000010B      RETURN
6. 000013B      END
C ++++++
1. 000000B      SUBROUTINE WICCEN(RZERO,UZERO,DD,UZ,DELZZ,ALFAAU, FN, IRS,RHOGAS,
                1RHUB,R2,U2,ITIP,VZTIME,XG,XA,XUU,XCH4,RTIPIN,IPRINT)
C IRS=1:STATOR
C IRS=2:ROTOR
C IRS=3:CENTRIFUGAL ACTION FOR VAPOR
2. 000000B      REAL N
3. 000000B      PAI=3.1415926
4. 000001B      ALFAAR=ALFAAU*PAI/180.0
5. 000004B      IF(DD.LT.1.0E-6) GO TO 12
6. 000006B      D=DD*1.0E-6*3.2802
7. 000010B      RHOA=RHOGAS
8. 000012B      RHOD=62.37
9. 000013B      XXAA=XA/XG
10. 000015B     XXUU=XUU/XG
11. 000017B     XXCC=XCH4/XG
12. 000020B     VISCO=(XXAA*0.05715+XXUU*0.03293+XXCC*0.035)/3600.0
13. 000027B     ENDTIM=DELZZ/UZ
14. 000030B     JJ=10
15. 000032B     DELTIM=ENDTIM/FLOAT(JJ)
16. 000033B     R1=RZERO
17. 000035B     U1=UZERO
18. 000036B     TIME=0.0
19. 000037B     JJJ=1
20. 000041B     11 RE=D*U1/VISCO
21. 000044B     B1=0.44
22. 000045B     N=0.0
23. 000046B     IF(RE.LT.1.9) B1=24.0
24. 000052B     IF(RE.LT.1.9) N=1.0
25. 000055B     IF(RE.GT.1.9.AND.RE.LT.500.0) B1=18.5
26. 000062B     IF(RE.GT.1.9.AND.RE.LT.500.0) N=0.6
27. 000067B     B=((VISCO**N)*B1*PAI*(RHOA**(1.0-N))*6.0)/(8.0*RHOD*PAI)
28. 000105B     C=B/(D**(1.0+N))
29. 000113B     IF(IRS.EQ.3) C=0
30. 000117B     UW1=R1/12.0*2.0*PAI*FN/60.0
31. 000122B     IF(R1.GT.RTIPIN) UW1=RTIPIN/12.0*2.0*PAI*FN/60.0
32. 000130B     UW2=UZ*WICTAN(ALFAAR)
33. 000132B     IF(ALFAAU.LT.1.0) UW=UW1
34. 000137B     IF(ALFAAU.GT.1.0) UW=UW1/2.0
35. 000142B     IF(IRS.EQ.3) RHOA=23.964
36. 000146B     IF(IRS.EQ.3) RHOD=16.043
37. 000151B     A=UW*UW*(1.0-RHOA/RHOD)
38. 000155B     IF(IRS.EQ.3) DELU=A/R1*12.0*DELTIM
39. 000163B     IF(IRS.NE.3) DELU=(A/R1*12.0-C*U1**(2.0-N))*DELTIM
40. 000176B     IF(IRS.NE.3.AND.DELU.LT.0.0) DELU=0.0
41. 000203B     U11=U1
42. 000203B     U2=U1+DELU
43. 000205B     DELU=U2-U11
44. 000207B     UAVE=U1+DELU/2.0
45. 000210B     DELR=UAVE*DELTIM*12.0
46. 000212B     R2=R1+DELR
47. 000214B     TIME=TIME+DELTIM

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```

48. 000216B      IF(IPRINT.EQ.2)
      $WRITE(6,101) R1,UW,A,U1,DELU,U2,UAVE,DELR,R2,TIME
49. 000236B 101 FORMAT(1H ,7(F11.4,2X),E10.4,2X,F10.4,2X,E10.4)
50. 000236B      U1=U2
51. 000236B      R1=R2
52. 000240B      JJJ=JJJ+1
53. 000241B      UZTIME=UZ*TIME*12.0
54. 000244B      IF(TIME.GT.ENDTIM) GO TO 12
55. 000247B      IF(JJJ.EQ.JJ) GO TO 12
56. 000250B      GO TO 11
57. 000250B      12 RETURN
58. 000254B      END

```

C ++++++

```

1. 000000B      SUBROUTINE WICDMU(IPRINT,IRAD,AMASU1,AMASUT,AMASU,R1,R2,
      $STAREA,RSTAVE,DELMAS)
2. 000000B      PAI=3.1415926
3. 000000B      RST1=RSTAVE
4. 000002B      A1=STAREA
5. 000003B      A2=PAI*(R1**2-R2**2)/144.0
6. 000010B      A2=A2*0.5
7. 000011B      DMCENT=A2/A1*AMASU
8. 000013B      IF(DMCENT.LT.0.0) DMCENT=0.0
9. 000016B      IF(DMCENT.GT.AMASU) DMCENT=AMASU
10. 000021B      IF(DMCENT.LT.0.0) DMCENT=0.0
11. 000024B      IF(IRAD.EQ.1) DMIN=0.0
12. 000027B      IF(IRAD.EQ.1) DMOUT=DMCENT
13. 000031B      IF(IRAD.EQ.2) DMIN=DMCENT
14. 000034B      IF(IRAD.EQ.2) DMOUT=DMCENT
15. 000037B      IF(IRAD.EQ.3) DMIN=DMCENT
16. 000042B      IF(IRAD.EQ.3) DMOUT=0.0
17. 000045B      AMASU2=AMASU1+DMIN-DMOUT
18. 000047B      IF(AMASU2.LT.0.0) AMASU2=0.0
19. 000052B      IF(AMASU2.GT.AMASUT) AMASU2=AMASUT
20. 000055B      DELMAS=AMASU2-AMASU1
21. 000056B      IF(IPRINT.EQ.2) WRITE(6,200) AMASU1,AMASU2,DMIN,DMOUT,DMCENT,
      $AMASUT,AMASU,DELMAS
22. 000074B 200 FORMAT(1H0,8(F10.5,3X))
23. 000074B      RETURN
24. 000076B      END

```

C ++++++

```

1. 000000B      SUBROUTINE WICDMS(IPRINT,IRAD,AMASW1,AMASWT,AMASW,R1,R2,STAREA,
      $RSTAVE,RTIP,DMIN,DMOUT,AMASW2,DELMAS)
C      AMASW1: MASS FLOW RATE OF WATER IN A STREAM TUBE IN INTEREST
C      AMASWT: TOTAL MASS FLOW RATE OF WATER WHICH ENTER THE COMPRESSOR
C      AMASW: TOTAL MASS FLOW RATE OF WATER WHICH IS SUBJECT TO
C              CENTRIFUGAL FORCE
C      IRAD=1: TIP
C      IRAD=2: MEAN
C      IRAD=3: HUB
2. 000000B      PAI=3.1415926
3. 000000B      RST1=RSTAVE
4. 000002B      A1=STAREA
5. 000003B      A2=PAI*(R2**2-R1**2)/144.0
6. 000010B      A2=A2*0.5
7. 000011B      DMCENT=A2/A1*AMASW
8. 000013B      IF(DMCENT.LT.0.0) DMCENT=0.0
9. 000016B      IF(DMCENT.GT.AMASWT) DMCENT=AMASWT
10. 000021B      IF(R1.GT.RST1) GO TO 110

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```

11. 000023B C R1.LT.RST1
12. 000023B DMIN=DMCENT
13. 000024B DMOUT=DMCENT
14. 000024B GO TO 100
15. 000026B 110 CONTINUE
16. 000026B C R1.GT.RST1
17. 000027B DMIN=0.0
18. 000034B 100 IF(IRAD.EQ.1) DMOUT=0.0
19. 000037B IF(IRAD.EQ.3) DMIN=0.0
20. 000041B AMASW2=AMASW1+DMIN-DMOUT
21. 000044B IF(AMASW2.LT.0.0) AMASW2=0.0
22. 000045B DELMAS=AMASW2-AMASW1
IF(IPRINT.EQ.2) WRITE(6,200) AMASW2,AMASW1,DMIN,DMOUT,DMCENT,
$AMASW1,AMASW,DELMAS
23. 000063B 200 FORMAT(1H0,8(F10.5,3X))
24. 000063B RETURN
25. 000065B END
C ++++++

1. 000000B SUBROUTINE WICDML(IPRINT,IRAD,AMASW1,AMASWT,AMASW,R1,R2,STAREA,
$RSTAVE,RTIP,DMIN,DMOUT,AMASW2,DELMAS)
C AMASW1:MASS FLOW RATE OF WATER IN A STREAM TUBE IN INTEREST
C AMASWT:TOTAL MASS FLOW RATE OF WATER WHICH ENTER THE COMPRESSOR
C AMASW:TOTAL MASS FLOW RATE OF WATER WHICH IS SUBJECT TO
C CENTRIFUGAL FORCE
C IRAD=1:TIP
C IRAD=2:MEAN
C IRAD=3:HUB
2. 000000B PAI=3.1415926
3. 000000B RST1=RSTAVE
4. 000002B A1=STAREA
5. 000003B A2=PAI*(R2**2-R1**2)/144.0
6. 000010B A2=A2*0.5
7. 000011B DMCENT=A2/A1*AMASW
8. 000013B IF(DMCENT.LT.0.0) DMCENT=0.0
9. 000016B IF(DMCENT.GT.AMASWT) DMCENT=AMASWT
10. 000021B IF(R1.GT.RST1) GO TO 110
11. 000023B DMIN=DMCENT
12. 000023B DMOUT=DMCENT
13. 000024B GO TO 100
14. 000024B 110 CONTINUE
15. 000026B DMIN=0.0
16. 000026B DMOUT=DMCENT
17. 000027B 100 IF(IRAD.EQ.1) DMOUT=0.0
18. 000034B IF(IRAD.EQ.3) DMIN=0.0
19. 000037B AMASW2=AMASW1+DMIN-DMOUT
20. 000041B IF(AMASW2.LT.0.0) AMASW2=0.0
21. 000044B DELMAS=AMASW2-AMASW1
22. 000045B IF(IPRINT.EQ.2) WRITE(6,200) AMASW2,AMASW1,DMIN,DMOUT,DMCENT,
$AMASW1,AMASW,DELMAS
23. 000063B 200 FORMAT(1H0,8(F10.5,3X))
24. 000063B RETURN
25. 000065B END
C ++++++

1. 000000B SUBROUTINE WICDRG(D,DELUV1,RHGAS1,RHGAS2,CD2,DELUV2,DRAG1,RE)
2. 000000B REAL N,N1
3. 000000B GC=32.174
4. 000002B IP=1

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5. 000004B      VISCOG=12.0E-6
6. 000005B      PAI=3.1415927
7. 000006B      IF(D.GT.0.0) GO TO 300
8. 000011B      CD2=0.0
9. 000011B      DELU2=0.0
10. 000012B     DRAG1=0.0
11. 000013B     RE=0.0
12. 000013B     GO TO 301
13. 000014B     300 RE1=(RHGAS1*D*DELU1)/VISCOG
14. 000017B     RE=RE1
15. 000020B     B11=0.44
16. 000021B     N1=0.0
17. 000022B     IF(RE.LT.1.9) B11=24.0
18. 000027B     IF(RE.LT.1.9) N1=1.0
19. 000032B     IF(RE.GT.1.9.AND.RE.LT.500.0) B11=18.5
20. 000037B     IF(RE.GT.1.9.AND.RE.LT.500.0) N1=0.6
21. 000044B     CD1=B11/(RE1**N1)
22. 000046B     DRAG1=0.5**RHGAS1*(DELU1**2)*(PAI*D**2)*CD1
      $/GC
23. 000056B     DAMY=DRAG1*GC/(CD1*0.5**RHGAS2*(PAI*D**2))
24. 000065B     IF(IP.EQ.2) WRITE(6,200) D,DELU1,RHGAS1,RHGAS2,RE1,B11,N1,
      $CD1,DRAG1,DAMY
25. 000105B     200 FORMAT(1H0,10(F10.5,2X))
26. 000105B     DELU2=SQRT(DAMY)
27. 000107B     RE2=RHGAS2*D*DELU2/VISCOG
28. 000111B     B1=0.44
29. 000113B     N=0.0
30. 000114B     IF(RE2.LT.1.9) B1=24.0
31. 000120B     IF(RE2.LT.1.9) N=1.0
32. 000123B     IF(RE2.GT.1.9.AND.RE2.LT.500.0) B1=18.5
33. 000130B     IF(RE2.GT.1.9.AND.RE2.LT.500.0) N=0.6
34. 000135B     CD2=B1/(RE2**N)
35. 000137B     IF(IP.EQ.2) WRITE(6,101) RE1,B11,N1,CD1,DELU1,RE2,B1,N,CD2,
      $DELU2
36. 000160B     101 FORMAT(1H0,2X,10(F10.5,2X))
37. 000160B     RE=(RE1+RE2)/2.0
38. 000162B     301 RETURN
39. 000165B     END
C *****

1. 000000B      SUBROUTINE WICSIZ(WMASSL,WMASSS,AMING1,AMING2,AMING3,DL,DS,D1,D2,
      $D3,DLIMIT,AMSL,AMLGE,DSLL,DLGE)
2. 000000B      TMASS1=WMASSL+WMASSS+AMING1+AMING2+AMING3
3. 000004B      AML=0.0
4. 000005B      AMS=0.0
5. 000005B      IF(DL.GT.DLIMIT) AML=AML+WMASSL
6. 000013B      IF(DL.LT.DLIMIT) AMS=AMS+WMASSL
7. 000017B      IF(DS.GT.DLIMIT) AML=AML+WMASSS
8. 000023B      IF(DS.LT.DLIMIT) AMS=AMS+WMASSS
9. 000027B      IF(D1.GT.DLIMIT) AML=AML+AMING1
10. 000033B     IF(D1.LT.DLIMIT) AMS=AMS+AMING1
11. 000036B     IF(D2.GT.DLIMIT) AML=AML+AMING2
12. 000041B     IF(D2.LT.DLIMIT) AMS=AMS+AMING2
13. 000044B     IF(D3.GT.DLIMIT) AML=AML+AMING3
14. 000050B     IF(D3.LT.DLIMIT) AMS=AMS+AMING3
15. 000054B     TMASS2=AML+AMS
16. 000055B     ERROR=ABS(TMASS1-TMASS2)
17. 000057B     IF(ERROR.LT.1.0E-6) GO TO 100
18. 000062B     IF(TMASS2.LT.1.0E-6) GO TO 100
19. 000064B     TT=TMASS1/TMASS2

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20. 000065B      IF(TT.LT.1.0) AML=AML/TT
21. 000071B      IF(TT.LT.1.0) AMS=AMS/TT
22. 000074B      IF(TT.GT.1.0) AML=AML*TT
23. 000077B      IF(TT.GT.1.0) AMS=AMS*TT
24. 000102B      100 AMLGE=AML
25. 000102B      AMSLL=AMS
26. 000104B      ADL=0.0
27. 000105B      ADS=0.0
28. 000105B      IF(DL.GT.DLIMIT.AND.AML.GT.0.0) ADL=ADL+DL*(WMASSL/AML)
29. 000114B      IF(DL.LT.DLIMIT.AND.AMS.GT.0.0) ADS=ADS+DL*(WMASSL/AMS)
30. 000122B      IF(DS.GT.DLIMIT.AND.AML.GT.0.0) ADL=ADL+DS*(WMASSS/AML)
31. 000131B      IF(DS.LT.DLIMIT.AND.AMS.GT.0.0) ADS=ADS+DS*(WMASSS/AMS)
32. 000140B      IF(D1.GT.DLIMIT.AND.AML.GT.0.0) ADL=ADL+D1*(AMING1/AML)
33. 000147B      IF(D1.LT.DLIMIT.AND.AMS.GT.0.0) ADS=ADS+D1*(AMING1/AMS)
34. 000156B      IF(D2.GT.DLIMIT.AND.AML.GT.0.0) ADL=ADL+D2*(AMING2/AML)
35. 000165B      IF(D2.LT.DLIMIT.AND.AMS.GT.0.0) ADS=ADS+D2*(AMING2/AMS)
36. 000174B      IF(D3.GT.DLIMIT.AND.AML.GT.0.0) ADL=ADL+D3*(AMING3/AML)
37. 000203B      IF(D3.LT.DLIMIT.AND.AMS.GT.0.0) ADS=ADS+D3*(AMING3/AMS)
38. 000212B      DLGE=ADL
39. 000212B      DSSL=ADS
40. 000214B      IF(DL.GT.0.0.AND.DLGE.GT.DL) DLGE=DL
41. 000221B      IF(DS.GT.0.0.AND.DSSL.GT.DS) DSSL=DS
42. 000225B      RETURN
43. 000227B      END

```

C ++++++

```

1. 000000B      SUBROUTINE WICPRP(XAIR,XH2O,XCH4,T,RMIX,CPMIX,GAMMA,G1,G2,G3)
      C T IN R
      C CPMIX IN BTU/LBM-R
      C RMIX IN LBF-FT/LBM-R
2. 000000B      RAIR=1545.3/28.964
3. 000000B      RH2O=1545.3/18.016
4. 000002B      RCH4=1545.3/16.043
5. 000003B      XXAIR=XAIR/(XAIR+XH2O+XCH4)
6. 000007B      XXH2O=XH2O/(XAIR+XH2O+XCH4)
7. 000011B      XXCH4=XCH4/(XAIR+XH2O+XCH4)
8. 000012B      RMIX=XXAIR*RAIR+XXH2O*RH2O+XXCH4*RCH4
9. 000020B      CPMIX=XXAIR*WICCPA(T)+XXH2O*WICCPH(T)+XXCH4*WICPCP(T)
10. 000036B      GAMMA=1.0/(1.0-RMIX/CPMIX/778.0)
11. 000042B      G1=GAMMA/(GAMMA-1.0)
12. 000043B      G2=(GAMMA-1.0)/2.0
13. 000046B      G3=-1.0/(GAMMA-1.0)
14. 000050B      RETURN
15. 000053B      END

```

C ++++++

```

1. 000000B      FUNCTION WICCPA(T)
      C T IN R
      C CPAIR IN BTU/LBM-R
2. 000000B      TK=5.0/9.0*T
3. 000002B      A=3.65359
4. 000003B      B=-1.33736E-3
5. 000005B      C=3.29421E-6
6. 000006B      D=-1.91142E-9
7. 000010B      E=0.275462E-12
8. 000011B      R=8314.3/28.964
9. 000013B      CP=(A+B*TK+C*TK**2+D*TK**3+E*TK**4)*R
10. 000023B      WICCPA=CP*2.3885E-4
11. 000025B      RETURN
12. 000030B      END

```

```

C ++++++
1. 000900B      FUNCTION WICCPH(T)
C T IN R
C CPH20 IN BTU/LBM-R
2. 000000B      TK=5.0/9.0*T
3. 000002B      A=4.07013
4. 000003B      B=-1.10845E-3
5. 000005B      C=4.15212E-6
6. 000006B      D=-2.96374E-9
7. 000010B      E=0.807021E-12
8. 000011B      R=8314.3/18.016
9. 000013B      CP=(A+B*TK+C*TK**2+D*TK**3+E*TK**4)*R
10. 000023B     WICCPH=CP*2.3E85E-4
11. 000025B     RETURN
12. 000030B     END
C ++++++
1. 000000B      FUNCTION WICCPH(T)
C T IN R
C CPCH4 IN BTU/LBM-R
2. 000000B      TK=5.0/9.0*T
3. 000002B      A=3.82619
4. 000003B      B=-3.97946E-3
5. 000005B      C=24.5583E-6
6. 000006B      D=-22.7329E-9
7. 000010B      E=6.96270E-12
8. 000011B      R=8314.3/16.043
9. 000013B      CP=(A+B*TK+C*TK**2+D*TK**3+E*TK**4)*R
10. 000023B     WICCPH=CP*2.3885E-4
11. 000025B     RETURN
12. 000030B     END
C ++++++
1. 000000B      SUBROUTINE WICGSL(SIGUMA, BET1S, BET2S, AINCIS, ADEVIS, AMACH1,
1BET1, DEQS, DEQN, SITACS, SITACN, BET2N, OMEGAN, X, AK1, AK2, AK3
2,UZ1, UZ2, UR1, R1, R2)
AINCI=BET1-BET1S+AINCIS
BET2A=BET2S
X1=BET2A
DELDEQ=WICED(AK3, UZ1, UZ2, UR1, R1, R2, BET1, X1, SIGUMA, AINCIS, AINCI)
$-DEQS
ADEVI=ADEVIS+(6.40-9.45*AMACH1+9.45*X)*DELDEQ*AK1
IF(AMACH1.LT.X) ADEVI=ADEVIS+6.40*DELDEQ*AK1
BET2C=BET2S-ADEVIS+ADEV1
Y1=BET2C
N=1
12 IF(N.GT.1) GO TO 10
BET2A=BET2S*1.1
10 X2=BET2A
DEQN=WICED(AK3, UZ1, UZ2, UR1, R1, R2, BET1, X2, SIGUMA, AINCIS, AINCI)
DELDEQ=DEQN-DEQS
ADEVI=ADEVIS+(6.40-9.45*AMACH1+9.45*X)*DELDEQ*AK1
IF(AMACH1.LT.X) ADEVI=ADEVIS+6.40*DELDEQ*AK1
BET2C=BET2S-ADEVIS+ADEV1
Y2=BET2C
DELBET=ABS((X2-Y2)/X2)
EPS=1.0E-6
IF(DELBET.LE.EPS) GO TO 11
BET2A=WICNEW(X1, Y1, X2, Y2)

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24. 000111B      X1=X2
25. 000112B      Y1=Y2
26. 000113B      N=N+1
27. 000115B      IF(N.GT.50) GO TO 13
28. 000117B      GO TO 12
29. 000120B      11 BET2N=X2
30. 000120B      GO TO 14
31. 000122B      13 WRITE(6,201)
32. 000125B      201 FORMAT(1H0,=DO NOT CONVERGE=)
33. 000125B      GO TO 15
34. 000125B      14 SITACN=WICMTK(SITACS,AMACH1,DELDEQ,AK2)
35. 000133B      OMEGAN=WICLOS(BET1,BET2N,SIGUMA,SITACN)
36. 000141B      15 RETURN
37. 000144B      END

```

C+++++

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1. 000000B      SUBROUTINE WICSDL(CHORD,SIGUMA,BETA1,BETA2,UG,RHOG,
$AMASSW,AREA,UZ,OMEGAP)
2. 000000B      PAI=3.1415926
3. 000000B      RHOG0=RHOG
4. 000002B      RHOP0=AMASSW/AREA/UZ
5. 000005B      RR=RHOP0/RHOG0
6. 000006B      VISCOG=0.128E-4
7. 000007B      C=CHORD/12.0
8. 000011B      RE=UG*C*RHOG0/VISCOG
9. 000014B      DELC=0.37/(RE**0.2)/(1.0+1.442*RR)**0.8
10. 000027B      DELP=0.1402*DELC
11. 000031B      BETA1R=BETA1*PAI/180.0
12. 000034B      BETA2R=BETA2*PAI/180.0
13. 000036B      OMEGAP=DELP*2.0*SIGUMA/COS(BETA2R)*(COS(BETA1R)/COS(BETA2R))**2
14. 000045B      RETURN
15. 000050B      END

```

C+++++

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1. 000000B      SUBROUTINE WICSTL(ISTAGE,IROTOR,DAU,W1,W2,DELU,U2,U3,WMASS,UZ,N
$,BETA1,BETA2,ALFA2,ALFA3,DELU2,DELU2,
$OMEGRU,OMEGRL,OMEGSU,OMEGSL,DRAGRU,DRAGRL,DRAGSU,DRAGSL,REAVE)
C IROTOR=1 ROTOR
C IROTOR=2 STATOR
2. 000000B      REAL M,MMASS
3. 000000B      COMMON JPERFM,RHOG(3),RERUP,RERLOW,RESUP,RESLOW
^,PREB,RR TIP(20),SRTIP(20),AAA1,AAA2,AAA3,SAREA(20),SAREAS(20)
^,P(3),TG(3),XA,XU(3),XCH4,XW(3),XWW(3),XWT(3),TW(3),TWW(3)
^,OMEGS(20),OMEGR(20),GAPR(20),GAPS(20)
^,RRHUB(20),RC(20),RBLADE(20),STAGER(20)
^,SRHUB(20),SC(20),SBLADE(20),STAGES(20)
^,SIGUMR(20),BET1SR(20),BET2SR(20),AINC SR(20),ADEUSR(20)
^,SIGUMS(20),BET1SS(20),BET2SS(20),AINC SS(20),ADEUSS(20)
^,UTIPG(20),UTIP(20),UTIPD(20),UOU(20),UMEAN(20),UHUB(20),U(20),FAI
^,AREA(20),AREAS(20),UU2(20),UTIP2(20),UMEAN2(20),UHUB2(20),IPRINT
^,ICENT,IICENT,FMR1(20),FMA2(20),IDESIN,FAID
^,NS,NSF,NSLPC,BYPASS,NS1,RT(20),RM(20),RH(20),ST(20),SM(20),SH(20)
^,DSMASS,AAREA(20),AAREAS(20),PR12D(20),PR13D(20),ETARD(20)
^,DR(20),DS(20),DEQR(20),DEQS(20),BLOCK(20),BLOCKS(20)
^,BET1MR(20),BET2MR(20),BET1MS(20),BET2MS(20),RADI1(20),RADI2(20)
^,FAIRIN(20),FAIOUT(20),ETASG(20),PSID(20),TAUD(20),SITADR(20)
^,SITADS(20),WWD(20),UUD(20)
4. 000000B      PAI=3.1415927
5. 000002B      GC=32.174
6. 000004B      RHOW=62.3

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7. 000005B C ++++++
      IF(IROTOR.EQ.2) GO TO 100
C DROPLET DRAG IN ROTOR
8. 000010B DD=DAU*1.0E-6*3.28
9. 000012B UG1=W1
10. 000014B UP1=UG1-DELV
11. 000016B A1=WMASS*RC(ISTAGE)/12.0/UZ
12. 000022B A2=RHOG*4.0/3.0*PAI*(DD/2.0)**3
13. 000030B TN=0.0
14. 000031B IF(WMASS.GT.0.0) GO TO 2000
15. 000034B GO TO 2001
16. 000034B 2000 TN=A1/A2
17. 000036B 2001 UAVE=(W1+W2)/2.0
18. 000041B GMU1=(90.0-BETA1)/2.0*PAI/180.0
19. 000045B DELVU1=UG1-UP1*COS(GMU1)
20. 000052B IF(N.GT.2) DELVU1=DELVU2
21. 000056B TNU=TN*(180.0-BETA1-BETA2)/360.0
22. 000062B XW(2)=XW(1)
23. 000063B XWT(2)=XWT(1)
24. 000064B XU(2)=XU(1)
25. 000066B CALL WICPRP(XA,XU(2),XCH4,TG(2),RMIX,CPMIX,GAMMA,G1,G2,G3)
26. 000071B IF(IPRINT.EQ.2) WRITE(6,4000)
27. 000076B 4000 FORMAT(1H0,=DROPLET DRAG IN ROTOR (UPPER PART)=)
28. 000076B CALL WICDRG(DD,DELVU1,RHOG(1),RHOG(2),CD2,DELV2,DRAG1,RE)
29. 000100B DELVU2=DELV2
30. 000100B CDRU=CD2
31. 000102B RERUP=RE
32. 000103B DRAGRU=DRAG1*TNU
33. 000105B AREA1=PAI*(RRIP(ISTAGE)**2-RRHUB(ISTAGE)**2)/144.0/10.0
34. 000112B DELPRU=DRAGRU/AREA1
35. 000113B OMEGRU=DELPRU/(0.5*RHOG(1)/GC*W1**2)
36. 000120B CDRUU=CDRU*DELVU2**2*PAI/4.0*DD**2*TNU/UAVE**2/RC(ISTAGE)*12.0
37. 000131B GML1=(90.0+BETA1)/2.0*PAI/180.0
38. 000136B DELL1=UG1-UP1*COS(GML1)
39. 000143B IF(N.GT.2) DELL1=DELL2
40. 000147B TNL=TN*(180.0+BETA1+BETA2)/360.0
41. 000153B IF(IPRINT.EQ.2) WRITE(6,4001)
42. 000160B 4001 FORMAT(1H0,=DROPLET DRAG IN ROTOR (LOWER PART)=)
43. 000160B CALL WICDRG(DD,DELL1,RHOG(1),RHOG(2),CD2,DELV2,DRAG1,RE)
44. 000162B DELL2=DELV2
45. 000162B CDRL=CD2
46. 000164B RERLOW=RE
47. 000165B DRAGRL=DRAG1*TNU
48. 000167B DELPRL=DRAGRL/AREA1
49. 000171B OMEGRL=DELPRL/(0.5*RHOG(1)/GC*W1**2)
50. 000175B CDRL1=CDRL*DELL2**2*PAI/4.0*DD**2*TNL/UAVE**2/RC(ISTAGE)*12.0
51. 000207B IF(IPRINT.EQ.2) WRITE(6,2002)
52. 000215B 2002 FORMAT(1H0,=DROPLET DRAG SUMMARY=)
53. 000215B IF(IPRINT.EQ.2) WRITE(6,720)DELVU1,DELVU2,DELL1,DELL2,CDRU,CD
      $RUU,CDRL,CDRL1
      $,DRAGRU,DRAGRL
54. 000234B 720 FORMAT(1H0,10(F10.5,2X))
55. 000234B RUP1=(90.0-BETA1)/180.0
56. 000236B RLOW1=(90.0+BETA1)/180.0
57. 000237B RUP2=(90.0-BETA2)/180.0
58. 000241B RLOW2=(90.0+BETA2)/180.0
59. 000242B REAVE=RERUP*(RUP1+RUP2)*0.5+RERLOW*(RLOW1+RLOW2)*0.5
60. 000252B IF(IPRINT.EQ.2) WRITE(6,2010) RUP1,RUP2,RLOW1,RLOW2
61. 000264B 2010 FORMAT(1H0,4(F10.5,2X))
62. 000264B GO TO 200

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C ++++++
C DROPLET DRAG IN STATOR
63. 000264B 100 DD=DAV*1.0E-6*3.28
64. 000267B    VG1=W1
65. 000270B    UP1=VG1-DELU
66. 000272B    A1=WMASS*SC(ISTAGE)/12.0/UZ
67. 000276B    A2=RHOW*4.0/3.0*PAI*(DD/2.0)**3
68. 000304B    TN=0.0
69. 000305B    IF(WMASS.GT.0.0) GO TO 5002
70. 000310B    GO TO 5003
71. 000310B 5002 TN=A1/A2
72. 000312B 5003 UAVE=(U3+U2)/2.0
73. 000315B    DELVU1=DELVU2
74. 000316B    TNU=TN*(180.0-ALFA2-ALFA3)/360.0
75. 000323B    IF(IPRINT.EQ.2) WRITE(6,2005)
76. 000332B 2005 FORMAT(1H0,=DROPLET DRAG IN STATOR (UPPER PART)=)
77. 000332B    CALL WICDRG(DD,DELVU1,RHOG(2),RHOG(2),CD2,DELV2,DRAG1,RE)
78. 000334B    DELVU2=DELV2
79. 000334B    CDSU=CD2
80. 000336B    RESUP=RE
81. 000337B    DRAGSU=DRAG1*TNU
82. 000341B    AREA2=PAI*(SRTIP(ISTAGE)**2-SRHUB(ISTAGE)**2)/144.0/10.0
83. 000346B    DELPSU=DRAGSU/AREA2
84. 000347B    OMEGSU=DELPSU/(0.5*RHOG(2)/GC*U2**2)
85. 000354B    CDSUU=CDSU*DELVU2**2*PAI/4.0*DD**2*TNU/UAVE**2/SC(ISTAGE)*12.0
86. 000365B    DELVL1=DELVL2
87. 000367B    TNL=TN*(180.0+ALFA2+ALFA3)/360.0
88. 000374B    IF(IPRINT.EQ.2) WRITE(6,2006)
89. 000402B 2006 FORMAT(1H0,=DROPLET DRAG IN STATOR (LOWER PART)=)
90. 000402B    CALL WICDRG(DD,DELVL1,RHOG(2),RHOG(2),CD2,DELV2,DRAG1,RE)
91. 000404B    DELVL2=DELV2
92. 000404B    CDSL=CD2
93. 000406B    RESLOW=RE
94. 000407B    DRAGSL=DRAG1*TNL
95. 000411B    DELPSL=DRAGSL/AREA2
96. 000413B    OMEGSL=DELPSL/(0.5*RHOG(2)/GC*U2**2)
97. 000417B    CDSL=CDSL*DELVL2**2*PAI/4.0*DD**2*TNL/UAVE**2/SC(ISTAGE)*12.0
98. 000431B    IF(IPRINT.EQ.2) WRITE(6,2007)
99. 000437B 2007 FORMAT(1H0,=DROPLET DRAG IN STATOR (SUMMARY)=)
100. 000437B    IF(IPRINT.EQ.2) WRITE(6,721) DELVU1,DELVU2,DELVL1,DELVL2,CDSU,CD
    $SUU,CDSL,CDSL
    ^,DRAGSU,DRAGSL
101. 000456B 721 FORMAT(1H0,10(F10.5,2X))
102. 000456B    SUP1=(90.0-ALFA2)/180.0
103. 000460B    SLOW1=(90.0+ALFA2)/180.0
104. 000461B    SUP2=(90.0-ALFA3)/180.0
105. 000463B    SLOW2=(90.0+ALFA3)/180.0
106. 000464B    REAVE=RESUP*(SUP1+SUP2)*0.5+RESLOW*(SLOW1+SLOW2)*0.5
107. 000474B    IF(IPRINT.EQ.2) WRITE(6,2011) SUP1,SUP2,SLOW1,SLOW2
108. 000506B 2011 FORMAT(1H0,4(F10.5,2X))
109. 000506B 200 RETURN
110. 000510B    END
C ++++++
1. 000000B    SUBROUTINE WICFML(WG1,WG2,FMASS,RHOG1,CHORD,SIGUMA,BETA1,BETA2,
    $CDF,OMEGAF)
2. 000000B    PAI=3.1415926
3. 000000B    VISCOG=0.128E-4
4. 000002B    VISCOL=6.500E-4
5. 000003B    C=CHORD/12.0

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6. 000005B WGAUE=0.5*(WG1*WG2)
7. 000010B UFILM=0.5*WGAUE*VISCOG/VISCOL
8. 000013B CDF=FMASS*UFILM/(0.5*RHO*WG1*WG1*C)
9. 000021B BETA1R=BETA1*PAI/180.0
10. 000024B BETA2R=BETA2*PAI/180.0
11. 000026B BETA3R=0.5*(BETA1R+BETA2R)
12. 000030B CS1=COS(BETA1R)**2
13. 000032B CS2=COS(BETA3R)**3
14. 000035B OMEGAR=CDF*SIGUMA*CS1/CS2
15. 000041B RETURN
16. 000043B END

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C+++++

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1. 000000B SUBROUTINE WICRSL(SIGUMA,BETA1,BETA2,CHORD,DL,CDR,OMEGAR)
2. 000000B PAI=3.1415926
3. 000000B IF(DL.LT.1.0E-6) CDR=0.0
4. 000005B IF(DL.LT.1.0E-6) OMEGAR=0.0
5. 000007B IF(DL.LT.1.0E-6) GO TO 10
6. 000010B BETA1R=BETA1*PAI/180.0
7. 000012B BETA2R=BETA2*PAI/180.0
8. 000013B BETA3R=0.5*(BETA1R+BETA2R)
9. 000015B CS1=COS(BETA1R)**2
10. 000020B CS2=COS(BETA3R)**3
11. 000023B C=CHORD*2.54*0.01*1.0E6
12. 000027B A=C/DL
13. 000031B IF(A.LT.100.0) A=100.0
14. 000034B CDR=1.89*1.62*ALOG10(A)
15. 000040B CDR=1.0/CDR**2.5
16. 000044B OMEGAR=CDR*SIGUMA*CS1/CS2
17. 000047B 10 RETURN
18. 000053B END

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C+++++
C+++++

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1. 000000B SUBROUTINE WICSPD(AMASS,ISTAGE)
2. 000000B REAL M,MIN,M1,M2,M1REL,M2REL
3. 000000B COMMON JPERFM,RHOG(3),RERUP,RERLOW,RESUP,RESLOW
^,PREB,RRTIP(20),SRTIP(20),AAA1,AAA2,AAA3,SAREA(20),SAREAS(20)
^,P(3),TG(3),XA,XU(3),XCH4,XW(3),XWW(3),XWT(3),TW(3),TWW(3)
^,OMEGS(20),OMEGR(20),GAPR(20),GAPS(20)
^,RRHUB(20),RC(20),RBLADE(20),STAGER(20)
^,SRHUB(20),SC(20),SBLADE(20),STAGES(20)
^,SIGUMR(20),BET1SR(20),BET2SR(20),AINCSR(20),ADEUSR(20)
^,SIGUMS(20),BET1SS(20),BET2SS(20),AINCSS(20),ADEUSS(20)
^,UTIPG(20),UTIP(20),UTIPD(20),UOU(20),UMEAN(20),UHUB(20),U(20),FAI
^,AREA(20),AREAS(20),UU2(20),UTIP2(20),UMEAN2(20),UHUB2(20),IPRINT
^,ICENT,IICENT,FMR1(20),FMA2(20),IDESIN,FAID
^,NS,NSF,NSLPC,BYPASS,NS1,RT(20),RM(20),RH(20),ST(20),SM(20),SH(20)
^,DSMASS,AAREA(20),AAREAS(20),PR12D(20),PR13D(20),ETARD(20)
^,DR(20),DS(20),DEQR(20),DEQS(20),BLOCK(20),BLOCKS(20)
^,BET1MR(20),BET2MR(20),BET1MS(20),BET2MS(20),RADI1(20),RADI2(20)
^,FAIRIN(20),FAIOUT(20),ETASG(20),PSID(20),TAUD(20),SITADR(20)
^,SITADS(20),WWD(20),UUD(20)
4. 000000B DIMENSION TD(20)
5. 000000B AJ=778.26
6. 000032B AMASSS=AMASS
7. 000034B PAI=3.1415926
8. 000035B GC=32.174
9. 000037B TREF=518.70
10. 000040B PREF=14.7*144.0

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11. 000042B AAAR1T=PAI*(RR TIP(1)**2-RRHUB(1)**2)/144.0*BLOCK(1)
12. 000047B CMASS=AMASS*SQRT(TG(1)/TREF)/(P(1)/PREF)*AAAR1T/SAREA(1)
C IGV INLET
13. 000061B ISTAGE=NS1
14. 000063B CALL WICPRP(1.0,0.0,0.0,TG(1),RMIX,CPMIX,GAMMA,G1,G2,G3)
15. 000066B CALL WICMAC(ISTAGE,AMASS,TG(1),P(1),M,UZ,C,0.0,0.0,RMIX,CPMIX,
$AREAS(NS1))
16. 000073B UZIN=UZ
17. 000073B AIN=C
18. 000075B MIN=M
19. 000076B TOIN=TG(1)
20. 000100B POIN=P(1)
21. 000101B PSIN=P(1)/(1.0+G2*M**2)**G1
22. 000110B TSIN=TG(1)/(1.0+G2*M**2)
23. 000114B RHOGIN=PSIN/RMIX/TSIN
24. 000117B FAIN=UZIN/UTIPG(1)
25. 000120B FAID=FAIIN
26. 000121B GAMAIN=GAMMA
27. 000122B TOIN=TG(1)
28. 000123B POIN=P(1)
C IGV INLET PRINTOUT
29. 000124B IF(IDESIN.EQ.2) GO TO 99
30. 000127B WRITE(6,1000)
31. 000133B 1000 FORMAT(1H1,***** DESIGN POINT INFORMATION *****
$***)
32. 000133B WRITE(6,1010)
33. 000136B 1010 FORMAT(1H0,1X,***** COMPRESSOR INLET *****)
34. 000135B WRITE(6,1020) TOIN,POIN,TSIN,PSIN,RHOGIN
35. 000146B 1020 FORMAT(1H0,1X,=TOTAL TEMPERATURE AT COMPRESSOR INLET=,F10.5,/,
$2X,=TOTAL PRESSURE AT COMPRESSOR INLET=,F10.2,/,
$2X,=STATIC TEMPERATURE AT COMPRESSOR INLET=,F10.5,/,
$2X,=STATIC PRESSURE AT COMPRESSOR INLET=,F10.2,/,
$2X,=STATIC DENSITY AT COMPRESSOR INLET=,F10.5)
WRITE(6,1030) AIN,UZIN,MIN,AREAS(NS1),FAIIN
36. 000146B
37. 000157B 1030 FORMAT(1H0,1X,=ACOUSTIC SPEED AT COMPRESSOR INLET=,F10.5,/,
$2X,=AXIAL VELOCITY AT COMPRESSOR INLET=,F10.5,/,
$2X,=MACH NUMBER AT COMPRESSOR INLET=,F10.5,/,
$2X,=STREAMTUBE AREA AT COMPRESSOR INLET=,F10.5,/,
$2X,=FLOW COEFFICIENT AT COMPRESSOR INLET=,F10.5)
38. 000157B 99 CONTINUE
C ROTOR INLET
39. 000157B I=NS1
40. 000157B ISTAGE=1
41. 000161B ALFA1=BET2SS(I)
42. 000162B ADEVSS(I)=ALFA1-BET2MS(I)
43. 000164B IF(ADEVSS(I).LT.1.0E-6) ADEVSS(I)=0.01
44. 000170B NSF1=NSF+1
45. 000171B 100 IF(ISTAGE.EQ.NSF1) AMASS=AMASS/(1.0+BYPASS)
46. 000177B CALL WICMAC(ISTAGE,AMASS,TG(1),P(1),M,UZ,C,0.0,ALFA1,
$RMIX,CPMIX,AREA(ISTAGE))
47. 000204B CPMIX1=CPMIX
48. 000204B GAMMA1=GAMMA
49. 000206B UZ1=UZ
50. 000207B A1=C
51. 000211B M1=M
52. 000212B PS1=P(1)/(1.0+G2*M1**2)**G1
53. 000221B TS1=TG(1)/(1.0+G2*M1**2)
54. 000225B RHOGS1=PS1/RMIX/TS1
55. 000230B IF(ISTAGE.NE.NS1) FAIRIN(ISTAGE)=UZ1/UTIPG(ISTAGE)
56. 000235B IF(ISTAGE.EQ.NS1) FAIRIN(ISTAGE)=UZ1/UTIPG(ISTAGE-1)

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57. 000242B ALFA1R=ALFA1*PAI/180.0
58. 000244B V1=UZ1/COS(ALFA1R)
59. 000246B US1=UZ1*WICTAN(ALFA1R)
60. 000251B IF(ISTAGE.NE.NS1) WS1=U(ISTAGE)-US1
61. 000257B IF(ISTAGE.EQ.NS1) WS1=U(ISTAGE-1)-US1
62. 000262B WU=WS1/UZ1
63. 000263B BETA1R=ATAN(WU)
64. 000266B BETA1=BETA1R*180.0/PAI
65. 000270B IF(ISTAGE.EQ.NS1) GO TO 102
66. 000272B BET1SR(ISTAGE)=BETA1
67. 000273B AINCSR(ISTAGE)=BETA1-BET1MR(ISTAGE)
68. 000275B 102 W1=UZ1/COS(BETA1R)
69. 000301B M1REL=W1/A1
70. 000303B TREL1=(1.0+G2*M1REL**2)*TS1
71. 000306B PREL1=(1.0+G2*M1REL**2)**G1*PS1
C ROTOR OUTLET
72. 000314B P(2)=PR12D(ISTAGE)*P(1)
73. 000317B TR12=(PR12D(ISTAGE)**(1.0/G1)-1.0)/ETARD(ISTAGE)+1.0
74. 000326B TG(2)=TR12*TG(1)
75. 000330B CALL WICPRP(1.0,0.0,0.0,TG(2),RMIX,CPMIX,GAMMA,G1,G2,G3)
76. 000333B GAMMA2=GAMMA
77. 000333B CPMIX2=CPMIX
78. 000335B GAMMAU=(GAMMA1+GAMMA2)/2.0
79. 000337B CPMIXU=(CPMIX1+CPMIX2)/2.0
80. 000342B G1AU=GAMMAU/(GAMMAU-1.0)
81. 000344B G2AU=(GAMMAU-1.0)/2.0
82. 000346B DELT=TG(2)-TG(1)
83. 000350B US2=(U(ISTAGE)*US1+DELT*CPMIXU*GC*AJ)/UU2(ISTAGE)
84. 000356B JJ=1
85. 000357B UZ2AS=UZ1
86. 000360B 200 US2UZ2=US2/UZ2AS
87. 000363B ALFA2R=ATAN(US2UZ2)
88. 000366B U2=UZ2AS/COS(ALFA2R)
89. 000370B TS2=TG(2)-U2**2/(2.0*CPMIX2*GC*AJ)
90. 000376B A2=SQRT(GAMMA2*RMIX*TS2*GC)
91. 000403B M2=U2/A2
92. 000404B PS2=P(2)/(1.0+G2*M2**2)**G1
93. 000412B RHOGS2=PS2/RMIX/TS2
94. 000415B UZ2CL=AMASS/(RHOGS2*AREAS(ISTAGE))
95. 000417B IF(JJ.EQ.2) GO TO 201
96. 000422B IF(JJ.GT.2) GO TO 202
97. 000424B X1=UZ2AS
98. 000425B Y1=UZ2CL
99. 000426B UZ2AS=UZ2CL
100. 000427B JJ=JJ+1
101. 000431B GO TO 200
102. 000432B 201 X2=UZ2AS
103. 000432B Y2=UZ2CL
104. 000434B UZ2AS=WICNEW(X1,Y1,X2,Y2)
105. 000437B JJ=JJ+1
106. 000440B GO TO 200
107. 000441B 202 IF((ABS(UZ2AS-UZ2CL)/UZ2AS).LT.1.0E-6) GO TO 300
108. 000446B X1=X2
109. 000446B Y1=Y2
110. 000450B X2=UZ2AS
111. 000451B Y2=UZ2CL
112. 000453B UZ2AS=WICNEW(X1,Y1,X2,Y2)
113. 000455B JJ=JJ+1
114. 000456B GO TO 200
115. 000457B 300 UZ2=UZ2CL

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116. 000460B      WS2=UU2(ISTAGE)-US2
117. 000463B      WS2VZ2=WS2/VZ2AS
118. 000464B      BETA2R=ATAN(WS2VZ2)
119. 000467B      BETA2=BETA2R*180.0/PAI
120. 000471B      BET2SR(ISTAGE)=BETA2
121. 000471B      ADEUSR(ISTAGE)=BETA2-BET2MR(ISTAGE)
122. 000474B      W2=VZ2AS/COS(BETA2R)
123. 000477B      M2REL=W2/A2
124. 000501B      TREL2=(1.0+G2*M2REL**2.0)*TS2
125. 000504B      PREL2=(1.0+M2REL**2.0)**G1*PS2
126. 000512B      FAIOUT(ISTAGE)=VZ2/UTIPG(ISTAGE)
127. 000515B      DR(ISTAGE)=1.0-W2/W1+ABS(WS1-WS2)/2.0/SIGUMR(ISTAGE)/W1
128. 000525B      DEQR(ISTAGE)=COS(BETA2R)/COS(BETA1R)*
$(UZ1/UZ2)*
$(1.12+0.61*COS(BETA1R)**2/SIGUMR(ISTAGE)*
$(WICTAN(BETA1R)-(RADI2(ISTAGE)/RADI1(ISTAGE))*
$(VZ2/UZ1)*WICTAN(BETA2R))-U(ISTAGE)/UZ1*
$(1.0-(RADI2(ISTAGE)/RADI1(ISTAGE)**2))
129. 000563B      PRRELI=(1.0+G2AU*U(ISTAGE)**2/(GAMMAU*RMIX*TREL1*GC)
$*((UU2(ISTAGE)/U(ISTAGE))**2-1.0)**G1AU
PLOSSR=PR12D(ISTAGE)/(TG(2)/TG(1))**G1AU*PRRELI
130. 000601B      IF(PRRELI.LT.PLOSSR) PRRELI=1.0
131. 000610B      OMEGR(ISTAGE)=(PRRELI-PLOSSR)/(1.0-PS1/PREL1)
132. 000613B      SITADR(ISTAGE)=OMEGR(ISTAGE)*COS(BETA2R)**3.0
133. 000620B      $/(2.0*SIGUMR(ISTAGE)*COS(BETA1R)**2.0)
134. 000632B      ALFA2=ALFA2R*180.0/PAI
135. 000635B      BET1SS(ISTAGE)=ALFA2
136. 000635B      AINCSS(ISTAGE)=ALFA2-BET1MS(ISTAGE)
C STATOR OUTLET
137. 000637B      ADEVSS(ISTAGE)=0.1
138. 000641B      PLOSSS=PR13D(ISTAGE)/PR12D(ISTAGE)
139. 000642B      PR13=(TG(2)/TG(1))**G1AU*PLOSSR*PLOSSS/PRRELI
140. 000652B      OMEGS(ISTAGE)=(1.0-PLOSSS)/(1.0-PS2/P(2))
141. 000660B      ETASG(ISTAGE)=(PR13**((1.0/G1AU)-1.0)/(TR12-1.0)
142. 000670B      P(3)=PR13*P(1)
143. 000673B      TG(3)=TG(2)
144. 000674B      TD(ISTAGE)=TG(1)
145. 000676B      PSID(ISTAGE)=CC*AJ*CPMIXU*ETASG(ISTAGE)*(TG(2)-TG(1))/
$(UTIPG(ISTAGE)**2)
146. 000705B      TAUD(ISTAGE)=PSID(ISTAGE)/ETASG(ISTAGE)
147. 000706B      ALFA3=BET2MS(ISTAGE)+ADEVSS(ISTAGE)
148. 000711B      ALFA3R=ALFA3*PAI/180.0
149. 000713B      CALL WICPRP(1.0,0.0,0.0,TG(3),RMIX,CPMIX,GAMA,G1,G2,G3)
150. 000715B      JJ=1
151. 000715B      UZ3AS=UZ2
152. 000716B      350 U3=UZ3AS/COS(ALFA3R)
153. 000722B      TS3=TG(3)-U3**2.0/(2.0*CPMIX*GC*AJ)
154. 000730B      A3=SQRT(GAMA*RMIX*TS3*GC)
155. 000735B      M3=U3/A3
156. 000736B      PS3=P(3)/((1.0+G2*M3**2.0)**G1)
157. 000747B      RHOGS3=PS3/RMIX/TS3
158. 000752B      IF(ISTAGE.EQ.NS)AREA(ISTAGE+1)=AREAS(ISTAGE)
159. 000756B      UZ3CL=AMASS/(RHOGS3*AREA(ISTAGE+1))
160. 000760B      IF(JJ.EQ.2)GO TO 351
161. 000762B      IF(JJ.GT.2)GO TO 352
162. 000764B      X1=UZ3AS
163. 000765B      Y1=UZ3CL
164. 000766B      UZ3AS=UZ3CL
165. 000767B      JJ=JJ+1
166. 000771B      GO TO 350

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167. 000772B 351 X2=UZ3AS
168. 000772B Y2=UZ3CL
169. 000774B UZ3AS=WICNEW(X1,Y1,X2,Y2)
170. 000777B JJ=JJ+1
171. 001000B GO TO 350
172. 001001B 352 IF((ABS(UZ3AS-UZ3CL)/UZ3CL).LT.1.0E-6)GO TO 400
173. 001006B X1=X2
174. 001006B Y1=Y2
175. 001010B X2=UZ3AS
176. 001011B Y2=UZ3CL
177. 001013B UZ3AS=WICNEW(X1,Y1,X2,Y2)
178. 001015B JJ=JJ+1
179. 001016B GO TO 350
180. 001017B 400 UZ3=UZ3CL
181. 001020B IF(ISTAGE.EQ.NS)RADI1(ISTAGE+1)=RADI2(ISTAGE)
182. 001025B DEOS(ISTAGE)=COS(ALFA3R)/COS(ALFA2R)*(UZ2/UZ3)*
$(1.12+0.61*COS(ALFA2R)**2.0/SIGUMS(ISTAGE)*
$(WICTAN(ALFA2R)-WICTAN(ALFA3R)*(RADI1(ISTAGE+1)/RADI2(ISTAGE))*
$(UZ3/UZ2))
183. 001054B SITADS(ISTAGE)=OMEGS(ISTAGE)*COS(ALFA3R)/(2.0*SIGUMS(ISTAGE))*
$(COS(ALFA3R)/COS(ALFA2R))**2.0
184. 001067B US3=UZ2*WICTAN(ALFA3R)
185. 001072B DS(ISTAGE)=1.0-U2/U3+ABS(US2-US3)/2.0/SIGUMS(ISTAGE)/U2
186. 001102B WWD(ISTAGE)=W1/W2
C PRINTOUT OF STAGE PERFORMANCE
187. 001105B IF(IDESIN.EQ.2) GO TO 1231
188. 001107B WRITE(6,1000)
189. 001113B WRITE(6,1100) ISTAGE
190. 001117B 1100 FORMAT(1H0,1X,***** STAGE=#,I2,# *****#)
191. 001117B WRITE(6,1101)
192. 001122B 1101 FORMAT(1H0,16X,#TOTAL#,8X,#TOTAL#,7X,#STATIC#,7X,#STATIC#,7X,
$#STATIC#/,17X,#TEMP#,7X,#PRESSURE#,7X,#TEMP#,7X,#PRESSURE#,6X,
$#DENSITY#)
WRITE(6,1110) TG(1),P(1),TS1,PS1,RHOGS1
193. 001122B 1110 FORMAT(1H0,1X,#ROTOR INLET#,1X,5(F10.3,3X))
194. 001132B WRITE(6,1120) TG(2),P(2),TS2,PS2,RHOGS2
195. 001132B 1120 FORMAT(1H ,1X,#ROTOR OUTLET#,5(F10.3,3X))
196. 001142B WRITE(6,1111)
197. 001142B 1111 FORMAT(1H0,16X,#AXIAL#,6X,#ABSOLUTE#,5X,#RELATIVE#,5X,#TAN COMP#,
$5X,#TAN COMP#/,15X,#VELOCITY#,5X,#VELOCITY#,5X,#VELOCITY#,4X,
$#OF ABS VEL#,3X,#OF REL VEL#)
WRITE(6,1130) UZ1,U1,W1,US1,WS1
199. 001145B 1130 FORMAT(1H0,1X,#ROTOR INLET#,1X,5(F10.5,3X))
200. 001155B WRITE(6,1140) UZ2,U2,W2,US2,WS2
201. 001155B 1140 FORMAT(1H ,1X,#ROTOR OUTLET#,5(F10.5,3X))
202. 001165B WRITE(6,1141)
203. 001165B 1141 FORMAT(1H0,15X,#ROTOR#,7X,#ABS MACH#,5X,#REL MACH#,5X,#REL TOTAL#,
$4X,#REL TOTAL#/,16X,#SPEED#,8X,#NUMBER#,7X,#NUMBER#,7X,#TEMP#,8X,
$#PRESSURE#)
WRITE(6,1150) U(ISTAGE),M1,M1REL,TREL1,PREL1
205. 001170B 1150 FORMAT(1H0,1X,#ROTOR INLET#,1X,5(F10.3,3X))
206. 001201B WRITE(6,1160) UU2(ISTAGE),M2,M2REL,TREL2,PREL2
207. 001201B 1160 FORMAT(1H ,1X,#ROTOR OUTLET#,5(F10.3,3X))
208. 001212B I=ISTAGE
209. 001212B IF(ISTAGE.EQ.1) I=NS1+1
210. 001212B WRITE(6,1161)
211. 001217B 1161 FORMAT(1H0,14X,#ABS FLOW#,5X,#REL FLOW#,4X,#STREAMTUBE#,18X,
$#FLOW#/,16X,#ANGLE#,8X,#ANGLE#,8X,#AREA#,9X,#RADIUS#,5X,
$#COEFFICIENT#)
212. 001222B WRITE(6,1170) BET2SS(I-1),BET1SR(ISTAGE),AREA(ISTAGE),
213. 001222B

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                $RADI1(ISTAGE),FAIRIN(ISTAGE)
214. 001237B 1170 FORMAT(1H0,1X, #ROTOR INLET#,1X,5(F10.5,3X))
215. 001237B      WRITE(6,1180) BET1SS(ISTAGE),BET2SR(ISTAGE),AREAS(ISTAGE),
                $RADI2(ISTAGE),FAIOUT(ISTAGE)
216. 001254B 1180 FORMAT(1H ,1X, #ROTOR OUTLET#,5(F10.5,3X))
217. 001254B      WRITE(6,1190) PR13,ETASG(ISTAGE),PR12D(ISTAGE),ETARD(ISTAGE),TR12
218. 001267B 1190 FORMAT(1H0,1X, #STAGE TOTAL PRESSURE RATIO AT DESIGN POINT=#,F10.5,
                $/,2X, #STAGE ADIABATIC EFFICIENCY AT DESIGN POINT=#,F10.5,/,2X,
                $ #ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT=#,F10.5,/,2X,
                $ #ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT=#,F10.5,/,2X,
                $ #ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT=#,F10.5)
219. 001267B 1231 CONTINUE
                C REPEAT
220. 001267B      TG(1)=TG(3)
221. 001267B      P(1)=P(3)
222. 001271B      ALFA1=BET2MS(ISTAGE)+ADEUSS(ISTAGE)
223. 001274B      ISTAGE=ISTAGE+1
224. 001275B      IF(ISTAGE.LE.NS)GO TO 100
                C OVERALL PERFORMANCE AT DESIGN POINT
225. 001277B      OUALPR=P(3)/POIN
226. 001300B      OUALTR=TG(3)/TOIN
227. 001302B      GAMMAU=(GAMAIN+GAMMA)/2.0
228. 001305B      G1AU=GAMMAU/(GAMMAU-1.0)
229. 001310B      OUALEF=(OUALPR**(1.0/G1AU)-1.0)/(OUALTR-1.0)
230. 001317B      OUALDT=TG(3)-TOIN
                C PRINTOUT OF OVERALL PERFORMANCE AT DESIGN POINT
231. 001322B      IF(IDESIN.EQ.2) GO TO 433
232. 001324B      WRITE(6,1000)
233. 001330B      WRITE(6,421)
234. 001333B      421 FORMAT(1H0, #***** OVERALL PERFORMANCE AT DESIGN POINT ****
                $*****#)
235. 001333B      WRITE(6,425) TOIN
236. 001337B      425 FORMAT(1H0,1X, #COMPRESSOR INLET TOTAL TEMPERATURE=#,F8.2)
237. 001337B      WRITE(6,426) POIN
238. 001343B      426 FORMAT(1H0,1X, #COMPRESSOR INLET TOTAL PRESSURE=#,F10.2)
239. 001343B      WRITE(6,427) CMASS
240. 001347B      427 FORMAT(1H0,1X, #CORRECTED MASS FLOW RATE=#,F8.3)
241. 001347B      WRITE(6,429) OUALPR
242. 001353B      429 FORMAT(1H0,1X, #OVERALL TOTAL PRESSURE RATIO=#,F8.4)
243. 001353B      WRITE(6,430) OUALTR
244. 001357B      430 FORMAT(1H0,1X, #OVERALL TOTAL TEMPERATURE RATIO=#,F6.4)
245. 001357B      WRITE(6,431) OUALEF
246. 001363B      431 FORMAT(1H0,1X, #OVERALL ADIABATIC EFFICIENCY=#,F6.4)
247. 001363B      WRITE(6,432) OUALDT
248. 001367B      432 FORMAT(1H0,1X, #OVERALL TEMPERATURE RISE=#,F8.3)
249. 001367B      WRITE(6,1621)
250. 001372B 1621 FORMAT(1H0,14X, #1#,5X, #2#,5X, #3#,5X, #4#,5X, #5#,5X, #6#,5X,
                $ #7#,5X, #8#,5X, #9#,4X, #10#,4X, #11#,4X, #12#,4X, #13#,4X, #14#,
                $4X, #15#,4X, #16#)
                WRITE(6,1710) (BET1SR(I), I=1, NS)
251. 001372B 1710 FORMAT(1H ,1X, #BET1SR(I)#,2X,17(F5.2,1X))
252. 001402B      WRITE(6,1720) (BET2SR(I), I=1, NS)
253. 001402B 1720 FORMAT(1H ,1X, #BET2SR(I)#,2X,17(F5.2,1X))
254. 001412B      WRITE(6,1730) (AINCSR(I), I=1, NS)
255. 001412B 1730 FORMAT(1H ,1X, #AINCSR(I)#,2X,17(F5.2,1X))
256. 001422B      WRITE(6,1740) (ADEUSR(I), I=1, NS)
257. 001422B 1740 FORMAT(1H ,1X, #ADEUSR(I)#,2X,17(F5.2,1X))
258. 001432B      WRITE(6,1760) (BET1SS(I), I=1, NS)
259. 001432B 1760 FORMAT(1H ,1X, #BET1SS(I)#,2X,17(F5.2,1X))
260. 001442B      WRITE(6,1770) (BET2SS(I), I=1, NS)
261. 001442B 1770 FORMAT(1H ,1X, #BET2SS(I)#,2X,17(F5.2,1X))

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262. 001452B 1770 FORMAT(1H ,1X, #BET2SS(I)#,2X,17(F5.2,1X))
263. 001452B      WRITE(6,1780) (AINCSS(I),I=1,NS)
264. 001462B 1780 FORMAT(1H ,1X, #AINCSS(I)#,2X,17(F6.2))
265. 001462B      WRITE(6,1790) (ADEUSS(I),I=1,NS)
266. 001472B 1790 FORMAT(1H ,1X, #ADEUSS(I)#,2X,17(F5.2,1X))
267. 001472B      WRITE(6,1791) (TD(I),I=1,NS)
268. 001502B 1791 FORMAT(1H ,1X, #TD(I)#,6X,17(F5.0,1X))
269. 001502B      WRITE(6,1793) (OMEGR(I),I=1,NS)
270. 001512B 1793 FORMAT(1H ,1X, #OMEGR(I)#,3X,17(F5.3,1X))
271. 001512B      WRITE(6,1794) (OMEGS(I),I=1,NS)
272. 001522B 1794 FORMAT(1H ,1X, #OMEGS(I)#,3X,17(F5.3,1X))
273. 001522B      WRITE(6,1795) (SITADR(I),I=1,NS)
274. 001532B 1795 FORMAT(1H ,1X, #SITADR(I)#,3X,17(F5.4,1X))
275. 001532B      WRITE(6,1796) (SITADS(I),I=1,NS)
276. 001542B 1796 FORMAT(1H ,1X, #SITADS(I)#,3X,17(F5.4,1X))
277. 001542B      WRITE(6,1797) (DEQR(I),I=1,NS)
278. 001552B 1797 FORMAT(1H ,1X, #DEQR(I)#,5X,17(F5.3,1X))
279. 001552B      WRITE(6,1798) (DEQS(I),I=1,NS)
280. 001562B 1798 FORMAT(1H ,1X, #DEQS(I)#,5X,17(F5.3,1X))
281. 001562B      433 CONTINUE
282. 001562B      AMASS=AMASSS
283. 001562B      RETURN
284. 001565B      END

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APPENDIX 5

TEST CASE

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TEST CASE NO. 1

(Air Only)

***** INPUT DATA *****

NS(NUMBER OF STAGE)=16
 PERFORMANCE AT MEAN

LARGE DROPLETS IN ROTOR FREE STREAM ARE NOT CENTRIFUGED

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
RRHUB(I)	6.300	6.830	7.020	7.025	7.017	7.037	7.025	7.025	7.025	7.308	7.553	7.757	7.956	8.123	8.258	8.351
RC(I)	3.708	2.786	2.360	1.193	1.084	1.539	1.530	1.483	1.419	1.627	1.389	1.338	1.292	1.211	1.289	1.481
RBLADE(I)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
STAGER(I)	46.64	48.93	46.90	37.82	33.35	34.67	33.87	28.74	25.60	43.72	40.81	41.12	42.09	43.47	49.63	50.91
STAGES(I)	21.64	17.46	13.78	17.82	13.90	19.62	16.83	26.97	26.66	29.60	32.95	34.21	32.94	32.47	27.86	21.72
SRHUB(I)	6.650	6.965	7.025	7.025	7.025	7.025	7.025	7.025	7.130	7.449	7.674	7.873	8.053	8.201	8.311	8.378
SC(I)	1.920	1.813	1.560	1.378	.814	1.115	.961	.976	2.663	1.015	.962	.877	.937	.895	.880	1.211
SBLADE(I)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
SIGUMR(I)	1.357	1.357	1.401	1.078	1.128	1.179	1.398	1.387	1.457	1.162	1.120	1.098	1.152	1.129	1.087	1.009
SIGUMS(I)	1.299	1.274	1.456	1.405	1.427	1.504	1.544	1.369	1.489	1.185	1.284	1.322	1.372	1.434	1.527	2.197
BET2SS(I)	6.21	-1.49	.38	8.86	1.41	6.55	5.24	16.23	16.50	22.78	24.28	25.79	23.93	20.90	16.87	3.03
GAPR(I)	.637	.612	.607	.453	.373	.339	.300	.300	.300	.300	.300	.300	.300	.300	.300	.300
GAPS(I)	.900	.760	2.395	.641	.390	.300	.300	.300	.300	.300	.300	.300	.300	.300	.300	.300
ERTIP(I)	18.29	17.09	16.32	11.11	10.70	10.44	10.23	9.94	9.69	9.56	9.55	9.55	9.55	9.55	9.55	9.55
SRTIP(I)	17.53	16.70	16.32	10.88	10.56	10.33	10.06	9.80	9.65	9.55	9.55	9.55	9.55	9.55	9.55	9.55
RT(I)	18.29	17.09	16.32	11.11	10.70	10.70	10.44	10.23	9.94	9.69	9.56	9.55	9.55	9.55	9.55	9.55
RM(I)	10.60	10.51	10.17	9.31	9.03	8.93	8.79	8.62	8.46	8.47	8.64	8.74	8.80	8.89	8.96	8.99
RH(I)	6.30	6.83	7.02	7.03	7.02	7.04	7.03	7.03	7.03	7.31	7.55	7.76	7.96	8.12	8.26	8.35
ST(I)	17.53	16.70	16.32	10.88	10.56	10.33	10.07	9.80	9.65	9.55	9.55	9.55	9.55	9.55	9.55	9.55
SM(I)	10.51	10.39	9.58	9.15	8.94	8.85	8.67	8.49	8.48	8.54	8.68	8.76	8.84	8.92	8.97	9.00
SH(I)	6.65	6.97	7.03	7.03	7.03	7.03	7.03	7.03	7.13	7.45	7.67	7.87	8.05	8.20	8.31	8.38
BLOCK(I)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BLOCKS(I)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BELMR(I)	52.88	55.61	56.07	48.92	39.94	45.69	43.01	42.23	45.14	49.52	48.02	48.34	47.78	50.02	54.16	55.34
BETMR(I)	40.40	42.36	37.73	29.71	26.76	26.64	24.73	15.25	16.06	33.92	33.59	33.90	36.39	35.92	45.10	45.40
BETMS(I)	37.07	36.40	37.17	26.78	30.38	32.68	23.41	37.70	36.82	36.41	41.62	42.63	41.94	44.03	38.84	40.40
BETMS(I)	6.21	-1.49	.38	8.86	1.41	6.55	5.24	15.23	16.50	22.78	24.28	25.79	23.93	20.90	16.87	3.03
PR12D(I)	1.343	1.300	1.305	1.227	1.201	1.174	1.163	1.209	1.141	1.199	1.207	1.191	1.157	1.180	1.134	1.166
PR13D(I)	1.335	1.293	1.301	1.223	1.194	1.161	1.152	1.177	1.134	1.192	1.197	1.180	1.145	1.173	1.129	1.159
ETARD(I)	.933	.933	.991	.885	.939	.879	.950	.867	.950	.910	.934	.924	.937	.928	.929	.934

***** INPUT DATA *****

FNF(FRACTION OF DESIGN CORRECTED SPEED)=1.000
XDIN(INITIAL WATER CONTENT OF SMALL DROPLET)= 0
XDDIN(INITIAL WATER CONTENT OF LARGE DROPLET)= 0
RHUMID(INITIAL RELATIVE HUMIDITY)= .00 PER CENT
XCH4(INITIAL METHANE CONTENT)= 0
TOG(COMPRESSOR INLET TOTAL TEMPRATURE OF GAS)= 518.70
TOW(COMPRESSOR INLET TEMPERATURE OF DROPLRET)= 513.70
PO(COMPRESSOR INLET TOTAL PRESSURE)=2116.80
DIN(INITIIL DROPLET DIAMETER OF SMALL DROPLET)= 20.0
DDIN(INITIAL DROPLET DIAMETER OF LARGE DROPLET)= 600.0
FND(DESIGN ROTATIONAL SPEED)= 9492.1
DSMASS(DESIGN MASS FLOW RATE)= 25.5000
BYPASS RATIO = 1.0050
COMPRESSOR INLET TOTAL TEMPRATURE(GAS PHASE) 518.70 R
COMPRESSOR INLET TOTAL PRESSURE=2116.80 LB/FT**2
PREB(PERCENT OF WATER THAT REBOUND AFTER IMPINGEMENT)= 50.0 PERCENT
ROTOR SPEED= 9492.1 RPM
CORRECTED ROTOR SPEED= 9492.1 RPM(100.0PER CENT OF DESIGN CORRECTED SPEED)

***** DESIGN POINT INFORMATION *****

***** COMPRESSOR INLET *****

TOTAL TEMPERATURE AT COMPRESSOR INLET= 518.70000
TOTAL PRESSURE AT COMPRESSOR INLET= 2116.80
STATIC TEMPERATURE AT COMPRESSOR INLET= 489.23241
STATIC PRESSURE AT COMPRESSOR INLET= 1725.23
STATIC DENSITY AT COMPRESSOR INLET= .06610

ACOUSTIC SPEED AT COMPRESSOR INLET=1084.47473
AXIAL VELOCITY AT COMPRESSOR INLET= 594.81337
MACH NUMBER AT COMPRESSOR INLET= .54848
STREAMTUBE AREA AT COMPRESSOR INLET= .64861
FLOW COEFFICIENT AT COMPRESSOR INLET= .39261

***** DESIGN POINT INFORMATION ***** ***

***** STAGE= 1 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	518.700	2116.800	487.912	1709.001	.066
ROTOR OUTLET	567.614	2842.862	526.582	2185.821	.078
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	603.84985	607.98966	1008.08131	70.82921	807.21328
ROTOR OUTLET	571.04901	702.43644	734.24570	403.04717	461.54024
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	878.042	.561	.931	572.552	2990.253
ROTOR OUTLET	870.587	.624	.653	571.429	7574.884
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	6.69000	53.20104	.64323	10.60000	.39857
ROTOR OUTLET	35.61433	38.94625	.57395	10.51000	.37692

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.33500
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .91272
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.34300
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .93300
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.09430

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 2 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	567.614	2825.928	539.274	2361.973	.082
ROTOR OUTLET	614.949	3673.706	578.855	2371.117	.096
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	580.14010	593.67613	993.42989	64.15055	806.43686
ROTOR OUTLET	527.36882	659.43115	702.93351	395.89255	464.75477
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	870.587	.513	.873	621.370	3879.399
ROTOR OUTLET	860.647	.559	.596	619.862	8636.952
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	6.21000	54.26926	.53542	10.51000	.40981
ROTOR OUTLET	36.89530	41.38875	.50261	10.39000	.37253

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.29300
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .91221
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.30000
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .93300
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.08339

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 3 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	614.949	3653.925	591.261	3183.551	.101
ROTOR OUTLET	663.870	4768.372	636.907	4121.153	.121
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	533.97030	534.12747	1008.36504	-12.95670	855.38049
ROTOR OUTLET	444.47534	570.67312	622.59028	357.92386	435.95909
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	842.424	.448	.846	675.687	5084.668
ROTOR OUTLET	793.883	.462	.504	669.010	9128.642
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	-1.49000	58.02558	.47320	10.17000	.39511
ROTOR OUTLET	38.84355	44.44581	.47305	9.58400	.32889

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.30100
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .97785
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.30500
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .99100
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.07955

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 4 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	663.870	4753.756	625.256	3850.416	.115
ROTOR OUTLET	708.797	5832.859	663.054	4609.573	.130
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	682.78673	682.81069	1025.73688	5.72023	765.46614
ROTOR OUTLET	649.18309	744.35899	759.38906	364.18558	393.99573
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	771.186	.558	.838	712.395	6092.426
ROTOR OUTLET	758.181	.591	.603	710.679	13741.777
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	.38000	48.26742	.16138	9.31000	.74226
ROTOR OUTLET	29.29201	31.25397	.15035	9.15300	.70573
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.22300					
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .88919					
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.22700					
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .88500					
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.06767					

***** DESIGN POINT INFORMATION *****

***** STAGE= 5 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	708.797	5813.844	671.028	4792.780	.134
ROTOR OUTLET	746.614	6982.427	699.441	5542.742	.149
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	668.00784	676.26003	926.96150	105.32404	642.66876
ROTOR OUTLET	632.44913	756.94816	711.05048	415.90662	324.95245
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	747.993	.533	.731	741.990	6832.319
ROTOR OUTLET	740.869	.585	.550	741.081	14096.645
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	8.86000	43.89245	.14222	9.03000	.75389
ROTOR OUTLET	33.32942	27.19481	.13539	8.94400	.71376
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.19400					
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .96495					
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.20100					
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .99900					
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.05335					

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 6 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	746.614	6941.730	713.972	5926.540	.156
ROTOR OUTLET	766.028	8149.591	747.285	6811.243	.171
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	629.34161	629.56023	958.38077	16.58931	722.78824
ROTOR OUTLET	594.91699	637.07378	711.05095	343.72036	389.44462
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	739.378	.482	.733	789.618	8462.191
ROTOR OUTLET	733.165	.514	.532	788.793	16491.997
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	1.41000	48.95347	.12989	8.92600	.72753
ROTOR OUTLET	30.01772	33.20956	.12514	8.85100	.68774

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.16100
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .81537
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.17400
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .87900
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.05279

***** DESIGN POINT INFORMATION *****

***** STAGE= 7 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	786.028	8059.348	755.219	6993.435	.174
ROTOR OUTLET	822.002	9373.022	781.033	7813.181	.188
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	608.46583	612.58727	895.72552	70.94005	657.33822
ROTOR OUTLET	598.43691	707.65127	688.43869	377.68185	340.32497
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	728.278	.456	.667	821.089	9408.952
ROTOR OUTLET	718.007	.518	.504	819.821	17494.804
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	6.55000	47.21108	.12043	8.79200	.71839
ROTOR OUTLET	32.25659	29.62645	.11335	8.66800	.70655

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.15200
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .88759
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.16300
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .95000
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.04577

***** DESIGN POINT INFORMATION *****

***** STAGE= 8 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	822.002	9284.369	790.955	8095.411	.192
ROTOR OUTLET	873.933	11224.802	822.825	9047.821	.206
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	613.25442	615.92757	898.46478	57.32174	656.62621
ROTOR OUTLET	605.81241	792.32318	635.68878	510.65385	192.52565
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	713.948	.448	.654	857.020	10770.488
ROTOR OUTLET	703.180	.566	.454	855.732	17685.797
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	5.24000	46.95613	.10811	8.61900	.74443
ROTOR OUTLET	40.12835	17.63013	.10186	8.48900	.73540

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.17700
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .73978
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.20900
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .86700
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.06318

***** DESIGN POINT INFORMATION ***** **

***** STAGE= 9 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	873.933	10927.702	839.963	9482.936	.212
ROTOR OUTLET	908.493	12468.508	858.171	10161.577	.222
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	619.79666	645.85147	808.72977	181.59355	519.51509
ROTOR OUTLET	621.17319	787.58012	658.29178	484.17601	217.92665
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	701.109	.457	.572	893.227	11815.435
ROTOR OUTLET	702.103	.551	.461	893.339	20274.187
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	16.23000	39.96982	.09697	8.46400	.77257
ROTOR OUTLET	37.93478	19.33244	.09225	8.47600	.77429

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.13400
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .90329
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.14100
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .95000
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.03954

***** DESIGN POINT INFORMATION *****

***** STAGE=10 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	908.493	12392.015	868.068	10524.261	.227
ROTOR OUTLET	960.272	14858.025	904.614	11976.885	.248
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	676.36161	705.77656	1078.73177	201.63215	840.35541
ROTOR OUTLET	659.51612	830.57551	855.63381	504.87043	545.11255
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	1041.988	.491	.751	962.504	15246.275
ROTOR OUTLET	1049.983	.567	.584	963.701	34518.645
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	16.50000	51.17109	.08275	8.47100	.57535
ROTOR OUTLET	37.43465	39.57489	.07771	8.53600	.56102

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.19200
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .87744
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.19900
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .91000
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.05699

***** DESIGN POINT INFORMATION ***** **

***** STAGE=11 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	960.272	14771.281	917.855	12548.939	.256
ROTOR OUTLET	1015.289	17828.937	952.427	14134.824	.278
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	667.92072	724.95970	1027.77536	281.86605	781.15561
ROTOR OUTLET	650.50780	885.42704	801.07480	600.68346	467.50446
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	1063.022	.491	.696	1003.108	17291.099
ROTOR OUTLET	1068.188	.589	.533	1003.899	35080.785
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	22.78000	49.46817	.07431	8.64200	.56888
ROTOR OUTLET	42.71960	35.70390	.07029	8.68400	.55405
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.19700					
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .88885					
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.20700					
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .93400					
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.05729					

***** DESIGN POINT INFORMATION ***** **

***** STAGE=12 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	1015.289	17681.224	975.525	15293.334	.294
ROTOR OUTLET	1069.470	21058.337	1008.283	16977.947	.316
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	641.30607	704.09145	1013.41041	290.63945	784.68285
ROTOR OUTLET	634.24236	876.33443	790.93392	604.73025	472.56016
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	1075.322	.463	.667	1057.900	20528.324
ROTOR OUTLET	1077.290	.568	.512	1058.142	39801.685
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	24.28000	50.74154	.06749	8.74200	.54621
ROTOR OUTLET	43.63548	36.68899	.06354	8.75800	.54020
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.18000					
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .87100					
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.19100					
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .92400					
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.05337					

***** DESIGN POINT INFORMATION ***** **

***** STAGE=13 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	1069.470	20863.844	1029.939	18180.869	.331
ROTOR OUTLET	1115.935	24139.468	1058.174	19855.060	.352
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	633.58192	704.26631	1000.50439	307.51420	774.32744
ROTOR OUTLET	631.31546	853.83022	813.16051	574.86258	512.51435
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	1081.842	.451	.641	1109.721	23879.938
ROTOR OUTLET	1087.377	.541	.515	1110.581	47102.224
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	25.79000	50.70876	.06067	8.79500	.53963
ROTOR OUTLET	42.32034	39.07038	.05728	8.84000	.53770

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.14500
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .86629
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.15700
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .93700
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.04345

***** DESIGN POINT INFORMATION ***** **

***** STAGE=14 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	1115.935	23889.101	1077.633	21011.397	.365
ROTOR OUTLET	1171.330	28189.140	1112.238	23273.804	.392
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	634.92439	695.17343	1030.02084	283.08439	811.05730
ROTOR OUTLET	623.19394	866.55711	795.76814	602.12170	494.84973
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	1094.142	.436	.646	1161.720	27693.438
ROTOR OUTLET	1096.971	.536	.492	1162.086	51903.412
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	23.93000	51.94490	.05481	8.89500	.54078
ROTOR OUTLET	44.01476	38.45148	.05203	8.91800	.53079

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.17300
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .89082
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.18000
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .92800
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.04964

***** DESIGN POINT INFORMATION ***** **

***** STAGE=15 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	1171.330	28021.916	1137.219	25119.100	.414
ROTOR OUTLET	1214.915	31776.853	1168.097	27453.245	.441
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	614.55554	658.27809	1061.68927	235.90577	865.73991
ROTOR OUTLET	600.59056	773.42782	860.18593	487.32081	615.80095
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	1101.646	.402	.649	1225.949	33169.434
ROTOR OUTLET	1103.122	.467	.519	1226.027	66767.670
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	20.90000	54.63052	.04999	8.95600	.52343
ROTOR OUTLET	39.05597	45.71642	.04807	8.96800	.51153

STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.12900
 STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .89336
 ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.13400
 ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .92900
 ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.03721

***** DESIGN POINT INFORMATION *****

***** STAGE=16 *****

	TOTAL TEMP	TOTAL PRESSURE	STATIC TEMP	STATIC PRESSURE	STATIC DENSITY
ROTOR INLET	1214.915	31636.743	1184.174	28759.551	.455
ROTOR OUTLET	1269.735	36888.442	1225.530	32301.589	.494
	AXIAL VELOCITY	ABSOLUTE VELOCITY	RELATIVE VELOCITY	TAN COMP OF ABS VEL	TAN COMP OF REL VEL
ROTOR INLET	599.32926	626.61344	1100.66508	182.89025	923.18366
ROTOR OUTLET	564.18324	754.11217	828.10710	500.38227	606.18366
	ROTOR SPEED	ABS MACH NUMBER	REL MACH NUMBER	REL TOTAL TEMP	REL TOTAL PRESSURE
ROTOR INLET	1106.074	.376	.660	1279.023	38306.884
ROTOR OUTLET	1106.566	.445	.489	1278.854	72079.393
	ABS FLOW ANGLE	REL FLOW ANGLE	STREAMTUBE AREA	RADIUS	FLOW COEFFICIENT
ROTOR INLET	16.87000	57.00844	.04662	8.99200	.51046
ROTOR OUTLET	41.57028	47.05527	.04563	8.99600	.48053
STAGE TOTAL PRESSURE RATIO AT DESIGN POINT= 1.15900					
STAGE ADIABATIC EFFICIENCY AT DESIGN POINT= .89353					
ROTOR TOTAL PRESSURE RATIO AT DESIGN POINT= 1.16600					
ROTOR ADIABATIC EFFICIENCY AT DESIGN POINT= .93400					
ROTOR TOTAL TEMPERATURE RATIO AT DESIGN POINT= 1.04512					

***** DESIGN POINT INFORMATION *****

***** OVERALL PERFORMANCE AT DESIGN POINT *****

COMPRESSOR INLET TOTAL TEMPERATURE= 518.70

COMPRESSOR INLET TOTAL PRESSURE= 2116.80

CORRECTED MASS FLOW RATE= 255.000

OVERALL TOTAL PRESSURE RATIO= 17.3219

OVERALL TOTAL TEMPERATURE RATIO=2.4479

OVERALL ADIABATIC EFFICIENCY= .8293

OVERALL TEMPERATURE RISE= 751.035

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
BET1SR(I)	53.20	54.27	58.03	48.27	43.89	48.95	47.21	46.96	39.97	51.17	49.47	50.74	50.71	51.94	54.63	57.01
BET2SR(I)	38.95	41.39	44.45	31.25	27.19	33.21	29.63	17.63	19.33	39.57	35.70	36.69	39.07	38.45	45.72	47.06
AINCSR(I)	.32	-1.34	1.96	-.65	3.95	3.26	4.20	4.73	-5.17	1.65	1.45	2.40	2.93	1.92	.47	.67
ADEVSR(I)	-1.45	-.97	6.72	1.54	4.43	6.57	4.90	2.38	3.27	1.65	2.11	2.79	2.68	1.53	.62	1.68
BET1SS(I)	35.61	36.90	38.84	29.29	33.33	30.02	32.26	40.13	37.93	37.43	42.72	43.64	42.32	44.01	39.06	41.57
BET2SS(I)	6.21	-1.49	.38	8.86	1.41	6.55	5.24	16.23	16.50	22.78	24.28	25.79	23.93	20.90	16.87	3.00
AINCSS(I)	-1.46	.50	1.67	2.51	2.95	-2.66	3.85	2.43	1.11	1.02	1.10	1.01	.38	-.02	.22	1.11
ADEVSS(I)	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
TD(I)	519.	568.	615.	664.	709.	747.	786.	822.	874.	908.	960.	1015.	1069.	1116.	1171.	1215.
OMEGR(I)	.047	.046	.007	.069	.001	.072	.031	.114	.036	.058	.049	.057	.042	.054	.040	.048
OMEGS(I)	.026	.028	.023	.016	.028	.067	.057	.136	.033	.030	.040	.048	.058	.034	.032	.048
SITADR(I)	.0227	.0211	.0032	.0453	.0009	.0413	.0158	.0761	.0175	.0250	.0279	.0334	.0213	.0303	.0188	.029
SITADS(I)	.0147	.0173	.0128	.0070	.0142	.0293	.0254	.0743	.0158	.0158	.0218	.0251	.0297	.0187	.0154	.019
DEQR(I)	1.632	1.664	1.693	1.649	1.608	1.644	1.552	1.754	1.527	1.554	1.594	1.581	1.506	1.593	1.482	1.61
DEQS(I)	1.863	1.905	.736	1.656	1.823	1.619	1.665	1.778	1.620	1.663	1.809	1.765	1.724	1.836	1.688	1.89

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 1) *****

STAGE TOTAL PRESSURE RATIO= 1.39545
 STAGE TOTAL TEMPERATURE RATIO= 1.11005
 STAGE ADIABATIC EFFICIENCY= .90768

STAGE FLOW COEFFICIENT= .350
 AXIAL VELOCITY= 530.30
 ROTOR SPEED=1515.04

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	2116.8000	2972.3039	2953.8901
STATIC PRESSURE	1796.7061	2336.4786	2595.6467
TOTAL TEMPERATURE(GAS)	518.7000	575.7813	575.7813
STATIC TEMPERATURE(GAS)	494.9447	537.4990	554.8911
STATIC DENSITY(GAS)	.0680	.0815	.0877
STATIC DENSITY(MIXTURE)	.0680	.0815	.0877
AXIAL VELOCITY	530.3012	500.4600	498.5308
ABSOLUTE VELOCITY	534.0588	678.0785	500.9018
RELATIVE VELOCITY	972.1732	648.9066	
BLADE SPEED	878.0425	870.5874	870.5874
TANG. COMP. OF ABS. VEL.	63.2411	457.5262	
TANG. COMP. OF REL. VEL.	814.8014	413.0612	
ACOUSTIC SPEED	1090.7875	1154.9161	1154.9567
ABSOLUTE MACH NUMBER	.4896	.5955	.4337
RELATIVE MACH NUMBER	.8913	.5709	
FLOW COEFFICIENT	.3500	.3303	.3522
FLOW AREA	.6486	.5739	.5354
ABSOLUTE FLOW ANGLE	6.8007	42.4339	5.5782
RELATIVE FLOW ANGLE	56.9425	39.5350	
INCIDENCE	4.0625	5.3639	
DEVIATION		-.8650	-.6318
DIFFUSION RATIO		1.7936	1.7640
MOMENTUM THICKNESS		.0355	.0202
OMEGA (GAS)		.06249	.02896
OMEGA (TOTAL)		.06249	.02896

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 1) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.39545
 STAGE TOTAL TEMPERATURE RATIO= 1.11005
 STAGE ADIABATIC EFFICIENCY= .90768

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XWJ=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS	1.00000	1.00000	1.00000
WMASS=	0	0	0
WMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	23.40301	23.40301	23.40301
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	23.40301	23.40301	23.40301
TMASS=	23.40301	23.40301	23.40301
WS=	.00000	.00000	.00000
RHOA=	.07649	.08147	.08767
RHOM=	.06805	.08147	.08767
RHOG=	.06804	.08147	.08767
TG=	518.70000	575.78131	575.78131
TW=	513.70000	513.70000	513.70000
TWJ=	513.70000	0	513.70000
P=	2116.80000	2972.30393	2953.89015
TB=	671.40656	0	688.10465
TDEW=	271.99506	274.74640	274.74640

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 2) *****

STAGE TOTAL PRESSURE RATIO= 1.34535
 STAGE TOTAL TEMPERATURE RATIO= 1.09898
 STAGE ADIABATIC EFFICIENCY= .89189

STAGE FLOW COEFFICIENT= .352
 AXIAL VELOCITY= 498.56
 ROTOR SPEED=1415.64

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	2953.8901	3989.4603	3974.0164
STATIC PRESSURE	2595.6148	3295.0394	3616.3800
TOTAL TEMPERATURE(GAS)	575.7813	632.7695	632.7695
STATIC TEMPERATURE(GAS)	554.9133	599.1572	615.9652
STATIC DENSITY(GAS)	.0877	.1031	.1100
STATIC DENSITY(MIXTURE)	.0877	.1031	.1100
AXIAL VELOCITY	498.5569	451.7273	449.4317
ABSOLUTE VELOCITY	500.9291	635.8535	449.5905
RELATIVE VELOCITY	961.2856	612.1701	
BLADE SPEED	870.5874	860.6473	842.4238
TANG. COMP. OF ABS. VEL.	48.6927	447.4953	
TANG. COMP. OF REL. VEL.	821.8948	413.1520	
ACOUSTIC SPEED	1154.6320	1216.4674	1216.4916
ABSOLUTE MACH NUMBER	.4338	.5300	.3696
RELATIVE MACH NUMBER	.8325	.5102	
FLOW COEFFICIENT	.3522	.3191	.3326
FLOW AREA	.5354	.5026	.4732
ABSOLUTE FLOW ANGLE	5.5782	44.7303	-1.5264
RELATIVE FLOW ANGLE	58.7592	42.4462	
INCIDENCE	3.1492	8.3303	
DEVIATION		.0862	-.0364
DIFFUSION RATIO		1.9159	1.8989
MOMENTUM THICKNESS		.0442	.0173
OMEGA (GAS)		.08039	.02224
OMEGA (TOTAL)		.08039	.02224

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 2) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.34535
 STAGE TOTAL TEMPERATURE RATIO= 1.09898
 STAGE ADIABATIC EFFICIENCY= .89189

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XVW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS=	1.00000	1.00000	1.00000
WMASS=	0	0	0
WVMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	23.40301	23.40301	23.40301
CMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	23.40301	23.40301	23.40301
TMASS=	23.40301	23.40301	23.40301
WS=	.00000	.00000	.00000
RHOA=	.09616	.10306	.11004
RHOM=	.06805	.10306	.11004
RHOC=	.08767	.10306	.11004
TG=	575.78131	632.76945	632.76945
TW=	513.70000	513.70000	513.70000
TVW=	513.70000	0	513.70000
P=	2953.89015	3989.46031	3974.01641
TB=	688.10465	0	703.68519
TDEW=	274.74640	277.17752	277.17752

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 3) *****

STAGE TOTAL FRESSURE RATIO= 1.26049
 STAGE TOTAL TEMPERATURE RATIO= 1.08331
 STAGE ADIABATIC EFFICIENCY= .81684

STAGE FLOW COEFFICIENT= .333
 AXIAL VELOCITY= 449.46
 ROTOR SPEED=1351.44

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	3974.0164	5101.3211	5009.2002
STATIC PRESSURE	3616.3429	4476.3401	4707.2567
TOTAL TEMPERATURE(GAS)	632.7635	685.4855	685.4855
STATIC TEMPERATURE(GAS)	615.9983	660.4465	673.4583
STATIC DENSITY(GAS)	.1100	.1270	.1310
STATIC DENSITY(MIXTURE)	.1100	.1270	.1310
AXIAL VELOCITY	449.4604	389.4365	377.6287
ABSOLUTE VELOCITY	449.6199	549.4712	380.8195
RELATIVE VELOCITY	965.4090	562.7624	
BLADE SPEED	842.4238	793.8829	771.1864
TANG. COMP. OF ABS. VEL.	-11.9766	387.6310	
TANG. COMP. OF REL. VEL.	854.4004	406.2519	
ACOUSTIC SPEED	1215.9342	1271.3542	1271.3809
ABSOLUTE MACH NUMBER	.3698	.4364	.2995
RELATIVE MACH NUMBER	.7940	.4470	
FLOW COEFFICIENT	.3326	.2882	.4105
FLOW AREA	.4732	.4730	.4730
ABSOLUTE FLOW ANGLE	-1.5264	44.8669	7.4246
RELATIVE FLOW ANGLE	62.2532	46.2107	
INCIDENCE	6.1832	7.6969	
DEVIATION		8.4807	7.0446
DIFFUSION RATIO		2.0791	1.8366
MOMENTUM THICKNESS		.0478	.0983
OMEGA (GAS)		.08753	.14740
OMEGA (TOTAL)		.08753	.14740

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 3) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.26049
 STAGE TOTAL TEMPERATURE RATIO= 1.08331
 STAGE ADIABATIC EFFICIENCY= .81684

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS	1.00000	1.00000	1.00000
WMASS=	0	0	0
NWMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	23.40301	23.40301	23.40301
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	23.40301	23.40301	23.40301
TMASS=	23.40301	23.40301	23.40301
WS=	.00000	.00000	.00000
RHOA=	.11771	.12702	.10097
RHOM=	.06805	.12702	.10097
RHOG=	.11004	.12702	.10097
TG=	632.76945	685.48553	685.48553
TW=	513.70000	513.70000	513.70000
TWW=	513.70000	0	513.70000
P=	3974.01641	5101.32106	5009.20024
TB=	703.68519	0	718.99503
TDEW=	277.17752	269.96289	269.96289

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 4) *****

STAGE TOTAL PRESSURE RATIO= 1.19662
 STAGE TOTAL TEMPERATURE RATIO= 1.06136
 STAGE ADIABATIC EFFICIENCY= .85105

STAGE FLOW COEFFICIENT= .641
 AXIAL VELOCITY= 589.39
 ROTOR SPEED= 919.87

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	5009.2002	6024.8334	5994.1247
STATIC PRESSURE	4296.7782	4884.1440	5185.4606
TOTAL TEMPERATURE(GAS)	685.4855	727.5442	727.5442
STATIC TEMPERATURE(GAS)	656.2649	685.4610	698.2213
STATIC DENSITY(GAS)	.1227	.1336	.1392
STATIC DENSITY(MIXTURE)	.1227	.1336	.1392
AXIAL VELOCITY	589.3897	581.3061	589.6111
ABSOLUTE VELOCITY	594.3731	713.4135	595.5118
RELATIVE VELOCITY	910.7935	675.7753	
BLADE SPEED	771.1864	758.1814	747.9928
TANG. COMP. OF ABS. VEL.	76.8057	413.5722	
TANG. COMP. OF REL. VEL.	634.3807	344.6092	
ACOUSTIC SPEED	1254.2993	1293.9674	1293.7731
ABSOLUTE MACH NUMBER	.4739	.5565	.4603
RELATIVE MACH NUMBER	.7261	.5272	
FLOW COEFFICIENT	.6407	.6319	.6654
FLOW AREA	.1614	.1503	.1422
ABSOLUTE FLOW ANGLE	7.4246	35.4301	8.0825
RELATIVE FLOW ANGLE	49.6754	30.6603	
INCIDENCE	.7554	8.6501	
DEVIATION		.9503	-.7775
DIFFUSION RATIO		1.5354	1.5344
MOMENTUM THICKNESS		.0587	.0140
OMEGA (GAS)		.08319	.02692
OMEGA (TOTAL)		.08319	.02692

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 4) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.19662
 STAGE TOTAL TEMPERATURE RATIO= 1.06136
 STAGE ADIABATIC EFFICIENCY= .85105

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS	1.00000	1.00000	1.00000
WMASS=	0	0	0
NWMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.67233	11.67233	11.67233
CMASS=	0	0	0
VMASS=	.00000	.00000	.00000
GMASS=	11.67233	11.67233	11.67233
TMASS=	11.67233	11.67233	11.67233
WS=	.00000	.00000	.00000
RHOA=	.13697	.13353	.13918
RHOM=	.06805	.13353	.13918
RHOG=	.12272	.13353	.13918
TC=	685.48553	727.54417	727.54417
TW=	513.70000	513.70000	513.70000
TWW=	513.70000	0	513.70000
P=	5009.20024	6024.83343	5994.12468
TB=	718.99503	0	729.81122
TDEW=	269.96289	271.36263	271.36263

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 5) *****

STAGE TOTAL PRESSURE RATIO= 1.21939
 STAGE TOTAL TEMPERATURE RATIO= 1.06099
 STAGE ADIABATIC EFFICIENCY= .94550

STAGE FLOW COEFFICIENT= .666
 AXIAL VELOCITY= 589.69
 ROTOR SPEED= 886.08

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	5994.1247	7378.6209	7309.1765
STATIC PRESSURE	5185.2528	6059.6616	6507.5573
TOTAL TEMPERATURE(GAS)	727.5442	771.9195	771.9195
STATIC TEMPERATURE(GAS)	698.2860	730.0673	746.9501
STATIC DENSITY(GAS)	.1392	.1556	.1633
STATIC DENSITY(MIXTURE)	.1392	.1556	.1633
AXIAL VELOCITY	589.6894	554.1730	550.3157
ABSOLUTE VELOCITY	595.6058	712.4715	550.3157
RELATIVE VELOCITY	898.2358	626.9037	
BLADE SPEED	747.9928	740.8691	739.3780
TANG. COMP. OF ABS. VEL.	83.7419	447.7811	
TANG. COMP. OF REL. VEL.	664.2509	293.0880	
ACOUSTIC SPEED	1293.1012	1337.3196	1337.4010
ABSOLUTE MACH NUMBER	.4606	.5389	.4115
RELATIVE MACH NUMBER	.6869	.4741	
FLOW COEFFICIENT	.6655	.6254	.6362
FLOW AREA	.1422	.1354	.1299
ABSOLUTE FLOW ANGLE	8.0825	38.9388	.1833
RELATIVE FLOW ANGLE	48.4029	27.8732	
INCIDENCE	8.4629	8.5588	
DEVIATION		1.1132	-1.2267
DIFFUSION RATIO		1.7298	1.6313
MOMENTUM THICKNESS		.0033	.0305
OMEGA (GAS)		.00475	.05265
OMEGA (TOTAL)		.00475	.05265

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 5) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.21939
 STAGE TOTAL TEMPERATURE RATIO= 1.06099
 STAGE ADIABATIC EFFICIENCY= .94550

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS=	1.00000	1.00000	1.00000
WMASS=	0	0	0
WWMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.67233	11.67233	11.67233
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	11.67233	11.67233	11.67233
TMASS=	11.67233	11.67233	11.67233
WS=	.00000	.00000	.00000
RHOA=	.15442	.15554	.16328
RHOM=	.06805	.15554	.16328
RHOG=	.13918	.15554	.16328
TG=	727.54417	771.91951	771.91951
TW=	513.70000	513.70000	513.70000
TWW=	513.70000	0	513.70000
P=	5994.12468	7378.62087	7309.17654
TB=	729.81122	0	742.14795
TDEW=	271.36263	273.08753	273.08753

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 6) *****

STAGE TOTAL PRESSURE RATIO= 1.19654
 STAGE TOTAL TEMPERATURE RATIO= 1.05985
 STAGE ADIABATIC EFFICIENCY= .86607

STAGE FLOW COEFFICIENT= .636
 AXIAL VELOCITY= 550.38
 ROTOR SPEED= 865.04

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	7309.1765	8816.6235	8745.7076
STATIC PRESSURE	6507.4014	7587.3587	7924.8089
TOTAL TEMPERATURE(GAS)	771.9195	818.1164	818.1164
STATIC TEMPERATURE(GAS)	747.0210	784.1867	795.6827
STATIC DENSITY(GAS)	.1633	.1813	.1867
STATIC DENSITY(MIXTURE)	.1633	.1813	.1867
AXIAL VELOCITY	550.3811	514.3482	519.2021
ABSOLUTE VELOCITY	550.3839	642.6013	522.5194
RELATIVE VELOCITY	920.3250	620.9920	
BLADE SPEED	739.3780	733.1655	728.2783
TANG. COMP. OF ABS. VEL.	1.7611	385.2043	
TANG. COMP. OF REL. VEL.	737.6170	347.9612	
ACOUSTIC SPEED	1336.5625	1379.4584	1379.4083
ABSOLUTE MACH NUMBER	.4118	.4693	.3788
RELATIVE MACH NUMBER	.6886	.4535	
FLOW COEFFICIENT	.6363	.5946	.6130
FLOW AREA	.1293	.1251	.1204
ABSOLUTE FLOW ANGLE	.1833	36.8302	6.4617
RELATIVE FLOW ANGLE	53.2711	34.0787	
INCIDENCE	7.5811	4.1502	
DEVIATION		7.4387	-.0883
DIFFUSION RATIO		1.8002	1.6048
MOMENTUM THICKNESS		.0454	.0294
OMEGA (GAS)		.06738	.05769
OMEGA (TOTAL)		.06738	.05769

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 6) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.19654
 STAGE TOTAL TEMPERATURE RATIO= 1.05985
 STAGE ADIABATIC EFFICIENCY= .86607

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XWV=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XCAS	1.00000	1.00000	1.00000
WMASS=	0	0	0
WMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.67233	11.67233	11.67233
CMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	11.67233	11.67233	11.67233
TMASS=	11.67233	11.67233	11.67233
WS=	.00000	.00000	.00000
RHOA=	.17748	.18132	.18666
RHOM=	.06805	.18132	.18666
RHOG=	.16328	.18132	.18666
TC=	771.91951	818.11642	818.11642
TW=	513.70000	513.70000	513.70000
TWV=	513.70000	0	513.70000
P=	7309.17654	8816.62355	8745.70762
TB=	742.14795	0	753.67291
TDEW=	273.08753	274.62091	274.62091

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 7) *****

STAGE TOTAL PRESSURE RATIO= 1.17549
 STAGE TOTAL TEMPERATURE RATIO= 1.05078
 STAGE ADIABATIC EFFICIENCY= .91379

STAGE FLOW COEFFICIENT= .613
 AXIAL VELOCITY= 519.26
 ROTOR SPEED= 846.98

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	8745.7076	10348.6746	10280.4694
STATIC PRESSURE	7924.6568	8923.0614	9380.7059
TOTAL TEMPERATURE(GAS)	818.1164	859.6583	859.6583
STATIC TEMPERATURE(GAS)	795.7587	824.5923	837.8175
STATIC DENSITY(GAS)	.1867	.2028	.2099
STATIC DENSITY(MIXTURE)	.1867	.2028	.2099
AXIAL VELOCITY	519.2616	507.7313	514.4858
ABSOLUTE VELOCITY	522.5814	654.5692	516.5907
RELATIVE VELOCITY	847.2421	592.2380	
BLADE SPEED	728.2783	718.0068	713.9479
TANG. COMP. OF ABS. VEL.	58.8109	413.1220	
TANG. COMP. OF REL. VEL.	669.4674	304.8848	
ACOUSTIC SPEED	1378.4024	1414.4220	1414.3603
ABSOLUTE MACH NUMBER	.3791	.4665	.3652
RELATIVE MACH NUMBER	.6147	.4221	
FLOW COEFFICIENT	.6131	.5995	.6245
FLOW AREA	.1204	.1133	.1081
ABSOLUTE FLOW ANGLE	6.4617	39.1340	5.1777
RELATIVE FLOW ANGLE	52.2016	30.9842	
INCIDENCE	9.1916	10.7240	
DEVIATION		6.2542	-.0623
DIFFUSION RATIO		1.7690	1.6550
MOMENTUM THICKNESS		.0210	.0254
OMEGA (GAS)		.03508	.04784
OMEGA (TOTAL)		.03508	.04784

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 7) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.17549
 STAGE TOTAL TEMPERATURE RATIO= 1.05078
 STAGE ADIABATIC EFFICIENCY= .91379

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XNW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS=	1.00000	1.00000	1.00000
WMASS=	0	0	0
WNMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.67233	11.67233	11.67233
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	11.67233	11.67233	11.67233
TMASS=	11.67233	11.67233	11.67233
WS=	.00000	.00000	.00000
RHOA=	.20037	.20279	.20984
RHOM=	.06805	.20279	.20984
RHOG=	.18656	.20279	.20984
TG=	818.11642	859.65826	859.65826
TW=	513.70000	513.70000	513.70000
TWW=	513.70000	0	513.70000
P=	8745.70762	10348.67456	10280.46937
TB=	753.67291	0	761.86427
TDEW=	274.62091	268.00787	268.00787

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 8) *****

STAGE TOTAL PRESSURE RATIO= 1.20089
 STAGE TOTAL TEMPERATURE RATIO= 1.06425
 STAGE ADIABATIC EFFICIENCY= .81624

STAGE FLOW COEFFICIENT= .625
 AXIAL VELOCITY= 514.54
 ROTOR SPEED= 823.79

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	10280.4694	12568.8515	12345.6935
STATIC PRESSURE	9380.5524	10557.9338	11281.4781
TOTAL TEMPERATURE(GAS)	859.6583	914.8877	914.8877
STATIC TEMPERATURE(GAS)	837.8900	871.3159	892.0935
STATIC DENSITY(GAS)	.2098	.2271	.2370
STATIC DENSITY(MIXTURE)	.2098	.2271	.2370
AXIAL VELOCITY	514.5387	504.5486	507.8209
ABSOLUTE VELOCITY	516.6469	731.0673	528.7699
RELATIVE VELOCITY	842.6568	533.7524	
BLADE SPEED	713.9479	703.1795	701.1086
TANG. COMP. OF ABS. VEL.	46.6247	529.0464	
TANG. COMP. OF REL. VEL.	667.3233	174.1331	
ACOUSTIC SPEED	1413.3527	1458.3792	1458.3516
ABSOLUTE MACH NUMBER	.3655	.5072	.3626
RELATIVE MACH NUMBER	.5962	.3703	
FLOW COEFFICIENT	.6246	.6125	.6330
FLOW AREA	.1081	.1019	.0970
ABSOLUTE FLOW ANGLE	5.1777	46.3577	16.1822
RELATIVE FLOW ANGLE	52.3660	19.0409	
INCIDENCE	10.1360	8.6577	
DEVIATION		3.7909	-.0478
DIFFUSION RATIO		1.9747	1.7700
MOMENTUM THICKNESS		.0811	.0743
OMEGA (GAS)		.09931	.11097
OMEGA (TOTAL)		.09931	.11097

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 8) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.20089
 STAGE TOTAL TEMPERATURE RATIO= 1.06425
 STAGE ADIABATIC EFFICIENCY= .81624

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XKW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS=	1.00000	1.00000	1.00000
WMASS=	0	0	0
WMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.67233	11.67233	11.67233
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	11.67233	11.67233	11.67233
TMASS=	11.67233	11.67233	11.67233
WS=	.00000	.00000	.00000
RHOA=	.22415	.22704	.23699
RHOM=	.06805	.22704	.23699
RHOG=	.20984	.22704	.23699
TC=	859.65826	914.88771	914.88771
TW=	513.70000	513.70000	513.70000
TW=	513.70000	0	513.70000
P=	10280.46937	12568.85149	12345.69354
TE=	761.86427	0	774.83081
TDEW=	268.00787	269.69355	269.69355

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 9) *****

STAGE TOTAL PRESSURE RATIO= 1.15536
 STAGE TOTAL TEMPERATURE RATIO= 1.04450
 STAGE ADIABATIC EFFICIENCY= .91990

STAGE FLOW COEFFICIENT= .633
 AXIAL VELOCITY= 507.90
 ROTOR SPEED= 802.25

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	12345.6935	14336.6902	14263.7226
STATIC PRESSURE	11281.2350	12232.4808	13193.2043
TOTAL TEMPERATURE(GAS)	914.8877	955.6015	955.6015
STATIC TEMPERATURE(GAS)	892.2055	914.3024	935.0742
STATIC DENSITY(GAS)	.2370	.2508	.2645
STATIC DENSITY(MIXTURE)	.2370	.2508	.2645
AXIAL VELOCITY	507.8956	504.5532	478.4400
ABSOLUTE VELOCITY	528.8486	713.7256	503.1838
RELATIVE VELOCITY	751.3761	541.7559	
BLADE SPEED	701.1086	702.1027	1041.9876
TANG. COMP. OF ABS. VEL.	147.3867	504.8072	
TANG. COMP. OF REL. VEL.	553.7220	197.2955	
ACOUSTIC SPEED	1456.8748	1491.3003	1491.4642
ABSOLUTE MACH NUMBER	.3630	.4839	.3374
RELATIVE MACH NUMBER	.5157	.3673	
FLOW COEFFICIENT	.6331	.6289	.4070
FLOW AREA	.0970	.0923	.0923
ABSOLUTE FLOW ANGLE	16.1822	45.0144	18.0493
RELATIVE FLOW ANGLE	47.4717	21.3570	
INCIDENCE	2.3317	8.1944	
DEVIATION		5.2970	1.5493
DIFFUSION RATIO		1.8431	1.8616
MOMENTUM THICKNESS		.0252	.0200
OMEGA (GAS)		.04159	.03468
OMEGA (TOTAL)		.04159	.03468

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 9) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.15536
 STAGE TOTAL TEMPERATURE RATIO= 1.04450
 STAGE ADIABATIC EFFICIENCY= .91990

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS=	1.00000	1.00000	1.00000
WMASS=	0	0	0
WMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.67233	11.67233	11.67233
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	11.67233	11.67233	11.67233
TMASS=	11.67233	11.67233	11.67233
WS=	.00000	.00000	.00000
RHOA=	.25293	.25071	.26017
RHOM=	.06805	.25071	.26017
RHOG=	.23699	.25071	.26017
TG=	914.88771	955.60152	955.60152
TW=	513.70000	513.70000	513.70000
TWW=	513.70000	0	513.70000
P=	12345.69354	14336.69023	14263.72260
TB=	774.83081	0	785.37543
TDEW=	269.69355	270.84699	270.84699

***** INITIAL FLOW COEFFICIENT= .350 (STAGE=10) *****

STAGE TOTAL PRESSURE RATIO= 1.25604
 STAGE TOTAL TEMPERATURE RATIO= 1.07347
 STAGE ADIABATIC EFFICIENCY= .88429

STAGE FLOW COEFFICIENT= .461
 AXIAL VELOCITY= 542.18
 ROTOR SPEED=1175.57

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	14253.7226	18032.6041	17915.7526
STATIC PRESSURE	12899.8540	15068.4044	16329.5258
TOTAL TEMPERATURE(GAS)	955.6015	1025.8110	1025.8110
STATIC TEMPERATURE(GAS)	929.3445	976.0088	999.7922
STATIC DENSITY(GAS)	.2602	.2834	.3061
STATIC DENSITY(MIXTURE)	.2602	.2834	.3061
AXIAL VELOCITY	542.1761	519.0677	513.1280
ABSOLUTE VELOCITY	570.2372	785.4702	567.7388
RELATIVE VELOCITY	1021.1334	693.8723	
BLADE SPEED	1041.9876	1049.9830	1063.0217
TANG. COMP. OF ABS. VEL.	176.6793	589.5185	
TANG. COMP. OF REL. VEL.	865.3083	460.4645	
ACOUSTIC SPEED	1485.6443	1540.8844	1540.9245
ABSOLUTE MACH NUMBER	.3838	.5159	.3684
RELATIVE MACH NUMBER	.6873	.4557	
FLOW COEFFICIENT	.4612	.4415	.4370
FLOW AREA	.0827	.0777	.0743
ABSOLUTE FLOW ANGLE	18.0493	48.6363	25.3368
RELATIVE FLOW ANGLE	57.9300	41.5762	
INCIDENCE	8.4100	12.2263	
DEVIATION		3.6562	2.5568
DIFFUSION RATIO		1.9129	2.0621
MOMENTUM THICKNESS		.0503	.0281
OMEGA (GAS)		.07877	.03942
OMEGA (TOTAL)		.07877	.03942

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 10) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.25604
 STAGE TOTAL TEMPERATURE RATIO= 1.07347
 STAGE ADIABATIC EFFICIENCY= .88429

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XV=	0	0	0
XW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XCAS	1.00000	1.00000	1.00000
WMASS=	0	0	0
WKMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.67233	11.67233	11.67233
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	0	0	11.67233
TMASS=	11.67233	11.67233	11.67233
WS=	.00000	.00000	.00000
RHOA=	.27977	.28923	.30607
RHOM=	.06805	.28923	.30607
RHOG=	.26017	.28923	.30607
TG=	955.60152	1025.81100	1025.81100
TW=	513.70000	513.70000	513.70000
TKW=	513.70000	0	513.70000
P=	14263.72260	18032.60411	17915.75259
TB=	785.37543	0	802.61749
TDEW=	270.84699	272.88102	272.88102

***** INITIAL FLOW COEFFICIENT= .350 (STAGE=11) *****

STAGE TOTAL PRESSURE RATIO= 1.25237
 STAGE TOTAL TEMPERATURE RATIO= 1.07175
 STAGE ADIABATIC EFFICIENCY= .88590

STAGE FLOW COEFFICIENT= .437
 AXIAL VELOCITY= 513.24
 ROTOR SPEED=1174.10

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	17915.7526	22640.3524	22437.1803
STATIC PRESSURE	16328.9933	18741.6775	20760.1544
TOTAL TEMPERATURE(GAS)	1025.8110	1099.4133	1099.4133
STATIC TEMPERATURE(GAS)	999.9774	1043.7464	1076.1803
STATIC DENSITY(GAS)	.3061	.3366	.3616
STATIC DENSITY(MIXTURE)	.3061	.3366	.3616
AXIAL VELOCITY	513.2398	493.4343	478.3162
ABSOLUTE VELOCITY	567.8636	833.7243	538.6128
RELATIVE VELOCITY	967.3850	632.7889	
BLADE SPEED	1063.0217	1068.1879	1075.3223
TANG. COMP. OF ABS. VEL.	243.0102	672.0259	
TANG. COMP. OF REL. VEL.	820.0114	396.1620	
ACOUSTIC SPEED	1538.7427	1596.2306	1596.2960
ABSOLUTE MACH NUMBER	.3690	.5303	.3374
RELATIVE MACH NUMBER	.6287	.4025	
FLOW COEFFICIENT	.4371	.4203	.4074
FLOW AREA	.0743	.0703	.0675
ABSOLUTE FLOW ANGLE	25.3368	53.7121	27.3717
RELATIVE FLOW ANGLE	57.9578	38.7598	
INCIDENCE	9.9378	12.0921	
DEVIATION		5.1698	3.0917
DIFFUSION RATIO		2.0930	2.2918
MOMENTUM THICKNESS		.0579	.0406
OMEGA (GAS)		.07694	.05211
OMEGA (TOTAL)		.07694	.05211

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 11) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.25237
 STAGE TOTAL TEMPERATURE RATIO= 1.07175
 STAGE ADIABATIC EFFICIENCY= .88590

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	0	0	1.00000
XMETAN=	0	0	0
XCAS	1.00000	1.00000	1.00000
WMASS=	0	0	0
WMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.67233	11.67233	11.67233
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	11.67233	11.67233	11.67233
TMASS=	11.67233	11.67233	11.67233
WS=	.00000	.00000	.00000
RHOA=	.32735	.33637	.36150
RHOM=	.06805	.33637	.36150
RHOG=	.30607	.33637	.36150
TG=	1025.81100	1099.41328	1099.41328
TW=	513.70000	513.70000	513.70000
TWW=	513.70000	0	513.70000
P=	17915.75259	22640.35240	22437.18026
TB=	802.61749	0	820.39758
TDEW=	0	274.92943	274.92943

***** INITIAL FLOW COEFFICIENT= .350 (STAGE=12) *****

STAGE TOTAL PRESSURE RATIO= 1.23130
 STAGE TOTAL TEMPERATURE RATIO= 1.06707
 STAGE ADIABATIC EFFICIENCY= .86622

STAGE FLOW COEFFICIENT= .407
 AXIAL VELOCITY= 478.41
 ROTOR SPEED=1174.10

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	22437.1803	27930.5652	27626.9676
STATIC PRESSURE	20759.6128	23509.9181	25763.5860
TOTAL TEMPERATURE(GAS)	1099.4133	1173.1539	1173.1539
STATIC TEMPERATURE(GAS)	1076.3649	1119.3351	1151.0370
STATIC DENSITY(GAS)	.3615	.3937	.4195
STATIC DENSITY(MIXTURE)	.3615	.3937	.4195
AXIAL VELOCITY	478.4108	466.6581	458.5859
ABSOLUTE VELOCITY	538.7252	823.3543	527.8149
RELATIVE VELOCITY	955.9602	613.9485	
BLADE SPEED	1075.3223	1077.2904	1081.8416
TANG. COMP. OF ADS. VEL.	247.6853	678.3381	
TANG. COMP. OF REL. VEL.	827.6370	398.9523	
ACOUSTIC SPEED	1593.8072	1648.1415	1648.1650
ABSOLUTE MACH NUMBER	.3360	.5066	.3202
RELATIVE MACH NUMBER	.5938	.3777	
FLOW COEFFICIENT	.4075	.3975	.3906
FLOW AREA	.0675	.0635	.0607
ABSOLUTE FLOW ANGLE	27.3717	55.4742	29.6763
RELATIVE FLOW ANGLE	59.9702	40.5276	
INCIDENCE	11.6302	12.8442	
DEVIATION		6.6276	3.8863
DIFFUSION RATIO		2.1810	2.3725
MOMENTUM THICKNESS		.0711	.0530
OMEGA (GAS)		.06902	.06868
OMEGA (TOTAL)		.06902	.06868

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 12) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.23130
 STAGE TOTAL TEMPERATURE RATIO= 1.06707
 STAGE ADIABATIC EFFICIENCY= .86622

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS	1.00000	1.00000	1.00000
WMASS=	0	0	0
WMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.67233	11.67233	11.67233
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	11.67233	11.67233	11.67233
TMASS=	11.67233	11.67233	11.67233
WS=	.00000	.00000	.00000
RKQA=	.38252	.39347	.41945
RHOM=	.06805	.39347	.41945
RHOG=	.36150	.39347	.41945
TG=	1099.41328	1173.15394	1173.15394
TW=	513.70000	513.70000	513.70000
TWW=	513.70000	0	513.70000
P=	22437.18026	27930.56525	27626.96760
TB=	820.39758	0	837.55275
TDEW=	274.92943	0	0

***** INITIAL FLOW COEFFICIENT= .350 (STAGE=13) *****

STAGE TOTAL PRESSURE RATIO= 1.19601
 STAGE TOTAL TEMPERATURE RATIO= 1.05853
 STAGE ADIABATIC EFFICIENCY= .84287

STAGE FLOW COEFFICIENT= .391
 AXIAL VELOCITY= 458.67
 ROTOR SPEED=1174.10

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	27626.9676	33500.3482	33042.2239
STATIC PRESSURE	25763.0679	28736.5816	31067.9866
TOTAL TEMPERATURE(GAS)	1173.1539	1241.8209	1241.8209
STATIC TEMPERATURE(GAS)	1151.2208	1191.4240	1221.3274
STATIC DENSITY(GAS)	.4195	.4521	.4768
STATIC DENSITY(MIXTURE)	.4195	.4521	.4768
AXIAL VELOCITY	458.6683	450.7370	446.6390
ABSOLUTE VELOCITY	527.9110	800.3580	510.3760
RELATIVE VELOCITY	939.9750	620.1988	
BLADE SPEED	1081.8416	1087.3769	1094.1423
TANG. COMP. OF ABS. VEL.	261.3683	661.3691	
TANG. COMP. OF REL. VEL.	820.4733	426.0078	
ACOUSTIC SPEED	1645.5231	1694.8805	1694.8869
ABSOLUTE MACH NUMBER	.3208	.4781	.3011
RELATIVE MACH NUMBER	.5712	.3705	
FLOW COEFFICIENT	.3907	.3839	.3804
FLOW AREA	.0607	.0573	.0548
ABSOLUTE FLOW ANGLE	29.6763	55.7247	28.9412
RELATIVE FLOW ANGLE	60.7935	43.3844	
INCIDENCE	13.0135	13.7847	
DEVIATION		6.9944	5.0112
DIFFUSION RATIO		2.1805	2.5072
MOMENTUM THICKNESS		.0633	.0741
OMEGA (GAS)		.09051	.09617
OMEGA (TOTAL)		.09051	.09617

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 13) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.19601
 STAGE TOTAL TEMPERATURE RATIO= 1.05853
 STAGE ADIABATIC EFFICIENCY= .84287

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS	1.00000	1.00000	1.00000
WMASS=	0	0	0
WMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.67233	11.67233	11.67233
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	11.67233	11.67233	11.67233
TMASS=	11.67233	11.67233	11.67233
WS=	.00000	.00000	.00000
RHOA=	.44139	.45189	.47672
RHOM=	.06805	.45189	.47672
RHOG=	.41945	.45189	.47672
TG=	1173.15394	1241.82085	1241.82085
TW=	513.70000	513.70000	513.70000
TWW=	513.70000	0	513.70000
P=	27626.96760	33500.34820	33042.22392
TB=	837.55275	0	852.89500
TLEW=	0	278.52962	278.52962

***** INITIAL FLOW COEFFICIENT= .350 (STAGE=14) *****

STAGE TOTAL PRESSURE RATIO= 1.20835
 STAGE TOTAL TEMPERATURE RATIO= 1.06105
 STAGE ADIABATIC EFFICIENCY= .84769

STAGE FLOW COEFFICIENT= .380
 AXIAL VELOCITY= 446.70
 ROTOR SPEED=1174.10

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	33042.2239	40440.0863	39926.4297
STATIC PRESSURE	31067.5444	34810.6428	37946.7124
TOTAL TEMPERATURE(GAS)	1241.8209	1317.6382	1317.6382
STATIC TEMPERATURE(GAS)	1221.4893	1265.7922	1299.8148
STATIC DENSITY(GAS)	.4767	.5155	.5472
STATIC DENSITY(MIXTURE)	.4767	.5155	.5472
AXIAL VELOCITY	446.7045	435.1859	426.7369
ABSOLUTE VELOCITY	510.4511	815.2649	478.0087
RELATIVE VELOCITY	957.6915	596.2404	
BLADE SPEED	1094.1423	1096.9714	1101.6457
TANG. COMP. OF ABS. VEL.	247.0130	689.3984	
TANG. COMP. OF REL. VEL.	847.1293	407.5731	
ACOUSTIC SPEED	1692.3317	1745.7425	1745.7474
ABSOLUTE MACH NUMBER	.3016	.4732	.2738
RELATIVE MACH NUMBER	.5659	.3461	
FLOW COEFFICIENT	.3805	.3707	.3635
FLOW AREA	.0548	.0520	.0500
ABSOLUTE FLOW ANGLE	28.9412	57.7376	26.7806
RELATIVE FLOW ANGLE	62.1966	43.1234	
INCIDENCE	12.1766	13.7076	
DEVIATION		6.2034	5.8806
DIFFUSION RATIO		2.3230	2.7547
MOMENTUM THICKNESS		.0787	.0794
OMEGA (GAS)		.09938	.09124
OMEGA (TOTAL)		.09938	.09124

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 14) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.20835
 STAGE TOTAL TEMPERATURE RATIO= 1.06105
 STAGE ADIABATIC EFFICIENCY= .84769

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0 0	0 0	0 0
XGAS	0	0	1.00000
WMASS=	0	0	0
WMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.67233	11.67233	11.67233
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	11.67233	11.67233	11.67233
TMASS=	11.67233	11.67233	11.67233
WS=	.00000	.00000	.00000
RHOA=	.49872	.51523	.54712
RHOM=	.06805	.51523	.54712
RHOG=	.47672	.51523	.54712
TG=	1241.82085	1317.63819	1317.63819
TW=	513.70000	513.70000	513.70000
TWW=	513.70000	0	513.70000
P=	33042.22392	40440.08626	39926.42968
TB=	852.89500	0	869.73392
TDEW=	278.52962	280.29321	280.29321

***** INITIAL FLOW COEFFICIENT= .350 (STAGE=15) *****

STAGE TOTAL PRESSURE RATIO= 1.16446
 STAGE TOTAL TEMPERATURE RATIO= 1.05096
 STAGE ADIABATIC EFFICIENCY= .80561

STAGE FLOW COEFFICIENT= .364
 AXIAL VELOCITY= 426.79
 ROTOR SPEED=1174.10

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	39926.4297	47283.7933	46492.7712
STATIC PRESSURE	37946.3135	42119.2447	44527.4672
TOTAL TEMPERATURE(GAS)	1317.6382	1384.7899	1384.7899.
STATIC TEMPERATURE(GAS)	1299.9723	1342.9465	1369.0145
STATIC DENSITY(GAS)	.5471	.5879	.6096
STATIC DENSITY(MIXTURE)	.5471	.5879	.6096
AXIAL VELOCITY	426.7931	413.0504	410.7180
ABSOLUTE VELOCITY	478.0720	735.8883	451.8444
RELATIVE VELOCITY	983.6514	643.9989	
BLADE SPEED	1101.6457	1103.1218	1106.0739
TANG. COMP. OF ABS. VEL.	215.4077	609.0327	
TANG. COMP. OF REL. VEL.	886.2380	494.0890	
ACOUSTIC SPEED	1742.8492	1788.5335	1788.5323
ABSOLUTE MACH NUMBER	.2743	.4154	.2526
RELATIVE MACH NUMBER	.5644	.3635	
FLOW COEFFICIENT	.3635	.3518	.3498
FLOW AREA	.0500	.0481	.0466
ABSOLUTE FLOW ANGLE	26.7806	55.8546	24.6351
RELATIVE FLOW ANGLE	64.2855	50.1049	
INCIDENCE	10.1255	17.0146	
DEVIATION		5.0049	7.7651
DIFFUSION RATIO		2.1681	2.9009
MOMENTUM THICKNESS		.0612	.1196
OMEGA (GAS)		.09491	.15316
OMEGA (TOTAL)		.09491	.15316

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 15) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.16446
 STAGE TOTAL TEMPERATURE RATIO= 1.05096
 STAGE ADIABATIC EFFICIENCY= .80561

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XUW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS=	1.00000	1.00000	1.00000
WMASS=	0	0	0
WMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.67233	11.67233	11.67233
CMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	11.67233	11.67233	11.67233
TMASS=	11.67233	11.67233	11.67233
WS=	.00000	.00000	.00000
RHOA=	.56795	.58769	.60957
RHOM=	.06805	.58769	.60957
RHOG=	.54712	.58769	.60957
TG=	1317.63819	1384.78992	1384.78992
TW=	513.70000	513.70000	513.70000
TRW=	513.70000	0	513.70000
P=	33926.42968	47283.79333	46492.77117
TB=	869.73992	0	883.78289
TDEW=	280.29321	281.77485	281.77485

***** INITIAL FLOW COEFFICIENT= .350 (STAGE=16) *****

STAGE TOTAL PRESSURE RATIO= 1.16948
 STAGE TOTAL TEMPERATURE RATIO= 1.05362
 STAGE ADIABATIC EFFICIENCY= .78082

STAGE FLOW COEFFICIENT= .350
 AXIAL VELOCITY= 410.76
 ROTOR SPEED=1174.10

	:ROTOR INLET	*:ROTOR OUTLET*	*:STATOR OUTLET*
TOTAL PRESSURE	46492.7712	55815.5588	54372.1431
STATIC PRESSURE	44527.1812	50016.5613	52788.5105
TOTAL TEMPERATURE(GAS)	1384.7839	1459.0445	1459.0445
STATIC TEMPERATURE(GAS)	1369.1368	1417.5392	1447.7427
STATIC DENSITY(GAS)	.6096	.6613	.6834
STATIC DENSITY(MIXTURE)	.6096	.6613	.6834
AXIAL VELOCITY	410.7573	386.7880	374.2861
ABSOLUTE VELOCITY	451.8876	735.9604	384.0394
RELATIVE VELOCITY	1005.4420	616.7886	
BLADE SPEED	1106.0739	1106.5659	I
TANG. COMP. OF ABS. VEL.	188.3636	626.1252	
TANG. COMP. OF REL. VEL.	917.7103	480.4407	
ACOUSTIC SPEED	1785.9457	1836.5226	1836.4983
ABSOLUTE MACH NUMBER	.2530	.4050	.2091
RELATIVE MACH NUMBER	.5630	.3394	
FLOW COEFFICIENT	.3498	.3294	.3188
FLOW AREA	.0466	.0456	.0456
ABSOLUTE FLOW ANGLE	24.6351	58.2944	12.9369
RELATIVE FLOW ANGLE	65.8872	51.1635	
INCIDENCE	9.5472	17.8944	
DEVIATION		5.7635	9.9069
DIFFUSION RATIO		2.2586	3.4054
MOMENTUM THICKNESS		.0605	.1899
OMEGA (GAS)		.08267	.24891
OMEGA (TOTAL)		.08267	.24891

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 16) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.16948
 STAGE TOTAL TEMPERATURE RATIO= 1.05362
 STAGE ADIABATIC EFFICIENCY= .78082

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00000
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	1.00000	1.00000	1.00000
XMETAN=	0	0	0
XGAS=	1.00000	1.00000	1.00000
WMASS=	0	0	0
WMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.67233	11.67233	11.67233
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00000
GMASS=	11.67233	11.67233	11.67233
TMASS=	0	0	11.67233
WS=	.00000	.00000	.00000
RHOA=	.62928	.66115	.68338
RHOM=	.06805	.66115	.68338
RHOG=	.60957	.66115	.68338
TC=	1384.78992	1459.04452	1459.04452
TW=	513.70000	513.70000	513.70000
TWW=	513.70000	0	513.70000
P=	46492.77117	55815.55880	54372.14309
TB=	883.78289	0	898.70299
TDEW=	281.77485	283.36412	283.36412

***** OVERALL PERFORMANCE *****

INITIAL FLOW COEFFICIENT= .350

CORRECTED SPEED= 9492.1 1.000 FRACTION OF DEIGN CORRECTED SPEED

INITIAL WATER CONTENT(SMALL DROPLET)= 0

INITIAL WATER CONTENT(LARGE DROPLET)= 0

INITIAL WATER CONTENT(TOTAL)= 0

INITIAL RELATIVE HUMIDITY= .0 PER CENT

INITIAL METHANE CONTENT= 0

COMPRESSOR INLET TOTAL TEMPERATURE= 518.70

COMPRESSOR INLET TOTAL PRESSURE= 2116.80

CORRECTED MASS FLOW RATE OF MIXTURE=232.089

CORRECTED MASS FLOW RATE OF GAS PHASE 232.089

OVERALL TOTAL PRESSURE RATIO=25.6860

OVERALL TOTAL TEMPERATURE RATIO=2.8129

OVERALL ADIABATIC EFFICIENCY= .7890

***** PERFORMANCE OF FAN,LPC,HPC *****

	GAS PHASE CORRECTED MASS FLOW	STAGNATION PRESSURE RATIO	STAGNATION TEMPERATURE RATIO	ADIABATIC EFFICIENCY
FAN	232.0886	2.3664	1.3215	.8265
LPC	56.2331	2.8475	1.3941	.8412
HPC	23.3167	3.8119	1.5268	.8392

TEST CASE NO. 2

(1.0% Small Droplet Ingestion, Detail Printout)

NS(NUMBER OF STAGE)=16
 PERFORMANCE AT MEAN

LARGE DROPLETS IN ROTOR FREE STREAM ARE NOT CENTRIFUGED

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
RRHUB(I)	6.300	6.830	7.020	7.025	7.017	7.037	7.025	7.025	7.025	7.308	7.553	7.757	7.956	8.123	8.258	8.351
RC(I)	3.708	2.786	2.360	1.139	1.084	1.339	1.530	1.483	1.419	1.627	1.389	1.338	1.292	1.211	1.289	1.481
RBLADE(I)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
STAGER(I)	46.64	48.99	46.90	37.82	33.35	34.67	33.67	28.74	25.60	43.72	40.81	41.12	42.09	43.47	49.63	50.91
STAGES(I)	21.64	17.46	13.78	17.82	13.90	19.62	16.63	26.97	26.66	29.60	32.95	34.21	32.94	32.47	27.86	21.72
SRHUB(I)	6.650	6.965	7.025	7.025	7.025	7.025	7.025	7.025	7.130	7.449	7.674	7.873	8.053	8.201	8.311	8.378
SC(I)	1.920	1.813	1.560	1.378	.814	1.115	.961	.976	2.663	1.015	.962	.877	.937	.895	.880	1.211
SBLADE(I)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
SIGUMR(I)	1.357	1.357	1.401	1.078	1.128	1.179	1.398	1.387	1.457	1.162	1.120	1.098	1.152	1.129	1.087	1.009
SIGUMS(I)	1.299	1.274	1.456	1.405	1.427	1.504	1.544	1.389	1.489	1.185	1.284	1.322	1.372	1.434	1.527	2.197
DETESS(I)	6.21	-1.49	.38	8.86	1.41	6.55	5.24	16.23	16.50	22.78	24.28	25.73	23.93	20.90	16.87	3.03
LAPR(I)	.637	.612	.607	.453	.373	.339	.300	.300	.300	.300	.300	.300	.300	.300	.300	.300
GAPS(I)	.900	.760	2.395	.641	.390	.300	.300	.300	.300	.300	.300	.300	.300	.300	.300	.300
ERTIP(I)	18.29	7.09	16.32	11.11	10.70	10.44	10.23	9.94	9.69	9.56	9.55	9.55	9.55	9.55	9.55	9.55
SRTIP(I)	17.53	16.70	16.32	10.88	10.56	10.33	10.06	9.80	9.65	9.55	9.55	9.55	9.55	9.55	9.55	9.55
RT(I)	18.29	17.09	16.32	11.11	10.70	10.70	10.44	10.23	9.94	9.69	9.56	9.55	9.55	9.55	9.55	9.55
RM(I)	10.60	10.51	10.17	9.31	9.03	8.93	8.79	8.62	8.46	8.47	8.64	8.74	8.80	8.89	8.96	8.99
RH(I)	6.30	6.83	7.02	7.03	7.02	7.04	7.03	7.03	7.03	7.31	7.55	7.76	7.96	8.12	8.26	8.35
ST(I)	17.53	16.70	16.32	10.88	10.56	10.33	10.07	9.80	9.65	9.55	9.55	9.55	9.55	9.55	9.55	9.55
SM(I)	10.51	10.39	9.53	9.15	8.94	8.85	8.67	8.49	8.48	8.54	8.68	8.76	8.84	8.92	8.97	9.00
SH(I)	6.65	6.97	7.03	7.03	7.03	7.03	7.03	7.03	7.13	7.45	7.67	7.87	8.05	8.20	8.31	8.38
BLOCK(I)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BLOCKS(I)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BETIMR(I)	52.88	55.61	56.07	48.92	39.94	45.69	43.01	42.23	45.14	49.52	48.02	48.34	47.78	50.02	54.16	55.34
BETMR(I)	40.40	42.36	37.73	29.71	26.76	26.64	24.73	15.25	16.06	37.92	33.55	33.90	36.39	36.92	45.10	45.40
BETIMS(I)	37.07	36.40	37.17	26.78	30.38	32.68	23.41	37.70	36.82	36.41	41.62	42.63	41.94	44.03	38.84	40.40
BETEMS(I)	6.21	-1.49	.38	8.86	1.41	6.55	5.24	16.23	16.50	22.78	24.28	25.73	23.93	20.90	16.87	3.03
PR12D(I)	1.343	1.300	1.300	1.227	1.201	1.174	1.163	1.109	1.141	1.199	1.207	1.191	1.157	1.180	1.134	1.166
PR13D(I)	1.335	1.293	1.301	1.223	1.194	1.161	1.152	1.177	1.134	1.192	1.197	1.180	1.145	1.173	1.129	1.159
ETARD(I)	.933	.933	.991	.865	.999	.879	.950	.867	.950	.910	.934	.924	.937	.928	.929	.934

***** INPUT DATA *****

FNF(FRACTION OF DESIGN CORRECTED SPEED)=1.000
XDIN(INITIAL WATER CONTENT OF SMALL DROPLET)= .010
XDDIN(INITIAL WATER CONTENT OF LARGE DROPLET)= 0
RHUMID(INITIAL RELATIVE HUMIDITY)= .00 PER CENT
XCH4(INITIAL METHANE CONTENT)= 0
TOG(COMPRESSOR INLET TOTAL TEMPRATURE OF GAS)= 518.70
TOW(COMPRESSOR INLET TEMPERATURE OF DROPLRET)= 513.70
PO(COMPRESSOR INLET TOTAL PRESSURE)=2116.80
DIN(INITIIL DROPLET DIAMETER OF SMALL DROPLET)= 20.0
DDIN(INITIAL DROPLET DIAMETER OF LARGE DROPLET)= 600.0
FND(DESIGN ROTATIONAL SPEED)= 9492.1
DSMASS(DESIGN MASS FLOW RATE)= 25.5000
BYPASS RATIO = 1.0050
COMPRESSOR INLET TOTAL TEMPERATURE(GAS PHASE) 518.70 R
COMPRESSOR INLET TOTAL PRESSURE=2116.80 LB/FT**2
PREB(PERCENT OF WATER THAT REBOUND AFTER IMPINGEMENT)= 50.0 PERCENT
ROTOR SPEED= 9492.1 RPM
CORRECTED ROTOR SPEED= 9492.1 RPM(100.0PER CENT OF DESIGN CORRECTED SPEED)

***** DESIGN POINT INFORMATION *****

***** COMPRESSOR INLET *****

TOTAL TEMPERATURE AT COMPRESSOR INLET= 518.70000
TOTAL PRESSURE AT COMPRESSOR INLET= 2116.80
STATIC TEMPERATURE AT COMPRESSOR INLET= 489.23241
STATIC PRESSURE AT COMPRESSOR INLET= 1725.23
STATIC DENSITY AT COMPRESSOR INLET= .06610

ACOUSTIC SPEED AT COMPRESSOR INLET=1084.47473
AXIAL VELOCITY AT COMPRESSOR INLET= 594.81337
MACH NUMBER AT COMPRESSOR INLET= .54848
STREAMTUBE AREA AT COMPRESSOR INLET= .64861
FLOW COEFFICIENT AT COMPRESSOR INLET= .39261

At this point the program would again output the design point information for stages 1 through 16. In order to conserve space, this part is omitted, and the reader is referred to pages 185 - 201.

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 1) *****

STAGE TOTAL PRESSURE RATIO= 1.38859
 STAGE TOTAL TEMPERATURE RATIO= 1.10969
 STAGE ADIABATIC EFFICIENCY= .89654

STAGE FLOW COEFFICIENT= .350
 AXIAL VELOCITY= 530.30
 ROTOR SPEED=1515.04

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	2116.8000	2963.4889	2939.3674
STATIC PRESSURE	1793.6677	2322.7007	2575.6199
TOTAL TEMPERATURE(GAS)	518.7000	575.5954	575.5954
STATIC TEMPERATURE(GAS)	494.7052	537.2341	554.4704
STATIC DENSITY(GAS)	.0680	.0810	.0871
STATIC DENSITY(MIXTURE)	.0686	.0819	.0879
AXIAL VELOCITY	530.3018	502.5744	501.4220
ABSOLUTE VELOCITY	534.0594	678.7781	503.7088
RELATIVE VELOCITY	972.1734	651.3535	
BLADE SPEED	878.0425	870.5874	870.5874
TANG. COMP. OF ABS. VEL.	63.2412	456.2442	
TANG. COMP. OF REL. VEL.	814.8013	414.3433	
ACOUSTIC SPEED	1085.0632	1148.7209	1148.7468
ABSOLUTE MACH NUMBER	.4922	.6003	.4385
RELATIVE MACH NUMBER	.8960	.5760	
FLOW COEFFICIENT	.3500	.3317	.3542
FLOW AREA	.6486	.5739	.5354
ABSOLUTE FLOW ANGLE	6.8007	42.2336	5.4621
RELATIVE FLOW ANGLE	56.9425	39.5036	
INCIDENCE	4.0625	5.1636	
DEVIATION		-.8964	-.7479
DIFFUSION RATIO		1.7868	1.7458
MOMENTUM THICKNESS		.0347	.0225
OMEGA (GAS)		.06104	.03247
OMEGA (TOTAL)		.06641	.03764

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 1) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.38859
 STAGE TOTAL TEMPERATURE RATIO= 1.10968
 STAGE ADIABATIC EFFICIENCY= .89656

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00000	.00000	.00009
XW=	.01000	.01000	.00991
XNW=	0	0	0
XWT=	.01000	.01000	.00991
XAIR=	.99000	.99000	.99000
XMETAN=	0	0	0
XGAS	.99000	.99000	.99009
WMASS=	.23611	.23611	.23406
WNWMASS=	0	0	0
WTMASS=	.23611	.23611	.23406
AMASS=	23.37452	23.37452	23.37452
CHMASS=	0	0	0
UMASS=	.00000	.00000	.00205
GMASS=	23.37452	23.37452	23.37656
TMASS=	23.61062	23.61062	23.61062
WS=	.00000	.00000	.00009
RHOA=	.07649	.08110	.07925
RHOM=	.06865	.08191	.08796
RHOC=	.06796	.08110	.08709
TG=	518.70000	575.59544	575.59326
TW=	513.70000	521.31958	521.37095
TWW=	513.70000	0	513.70000
P=	2116.80000	2963.48895	2939.36745
TB=	671.40656	0	687.85162
TDEW=	271.99506	274.72208	413.95332

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 2) *****

STAGE TOTAL PRESSURE RATIO= 1.34080
 STAGE TOTAL TEMPERATURE RATIO= 1.09864
 STAGE ADIABATIC EFFICIENCY= .88422

STAGE FLOW COEFFICIENT= .354
 AXIAL VELOCITY= 501.32
 ROTOR SPEED=1415.64

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	2939.3674	3960.6534	3941.0927
STATIC PRESSURE	2575.6881	3262.7022	3576.6373
TOTAL TEMPERATURE(GAS)	575.5933	632.3722	632.3722
STATIC TEMPERATURE(GAS)	554.2925	598.6532	615.2651
STATIC DENSITY(GAS)	.0871	.1021	.1090
STATIC DENSITY(MIXTURE)	.0880	.1032	.1100
AXIAL VELOCITY	501.3185	455.3373	453.4281
ABSOLUTE VELOCITY	503.6051	636.8834	453.6386
RELATIVE VELOCITY	993.3660	616.3188	
BLADE SPEED	870.5874	860.6473	842.4238
TANG. COMP. OF ABS. VEL.	47.9369	445.2959	
TANG. COMP. OF REL. VEL.	822.6505	415.3514	
ACOUSTIC SPEED	1148.2949	1209.7844	1209.8071
ABSOLUTE MACH NUMBER	.4386	.5337	.3750
RELATIVE MACH NUMBER	.8390	.5165	
FLOW COEFFICIENT	.3541	.3216	.3355
FLOW AREA	.5354	.5026	.4732
ABSOLUTE FLOW ANGLE	5.4621	44.3612	-1.7478
RELATIVE FLOW ANGLE	58.6421	42.3706	
INCIDENCE	3.0321	7.9612	
DEVIATION		.0106	-.2578
DIFFUSION RATIO		1.9013	1.8643
MOMENTUM THICKNESS		.0423	.0180
OMEGA (GAS)		.07715	.02344
OMEGA (TOTAL)		.08279	.02803

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 2) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.34080
 STAGE TOTAL TEMPERATURE RATIO= 1.09864
 STAGE ADIABATIC EFFICIENCY= .88427

	***STAGE INLET**	***STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	***STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00009	.00009	.00030
XW=	.00991	.00991	.00970
XUW=	0	0	0
XWT=	.00991	.00991	.00970
XAIR=	.99000	.99000	.99000
XMETAN=	0	0	0
XGAS	.99009	.99009	.99030
WMASS=	.23406	.23406	.22897
WWMASS=	0	0	0
WTMASS=	.23406	.23406	.22897
AMASS=	23.37452	23.37452	23.37452
CHMASS=	0	0	0
UMASS=	.00205	.00205	.00714
GMASS=	23.37656	23.37656	23.38165
TMASS=	23.61062	23.61062	23.61062
HS=	.00009	.00009	.00031
RHOA=	.09572	.10220	.10165
RHOM=	.06865	.10322	.11003
RHOG=	.08709	.10220	.10896
TG=	575.59326	632.37216	632.36701
TW=	521.37095	530.16119	530.28344
TWW=	513.70000	0	513.70000
P=	2939.36745	3960.65335	3941.09266
TB=	687.85162	0	703.23864
TDEW=	413.95332	419.57136	444.74623

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 3) *****

STAGE TOTAL PRESSURE RATIO= 1.25863
 STAGE TOTAL TEMPERATURE RATIO= 1.08322
 STAGE ADIABATIC EFFICIENCY= .81227

STAGE FLOW COEFFICIENT= .336
 AXIAL VELOCITY= 453.49
 ROTOR SPEED=1351.44

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	3941.0927	5052.1100	4960.3923
STATIC PRESSURE	3576.5694	4425.1846	4652.8906
TOTAL TEMPERATURE(GAS)	632.3670	684.9353	684.9953
STATIC TEMPERATURE(GAS)	615.1273	659.8735	672.7450
STATIC DENSITY(GAS)	.1090	.1257	.1296
STATIC DENSITY(MIXTURE)	.1100	.1269	.1309
AXIAL VELOCITY	453.4937	393.3181	381.3665
ABSOLUTE VELOCITY	453.7047	550.4457	384.3807
RELATIVE VELOCITY	958.9383	567.2865	
BLADE SPEED	842.4238	793.8829	771.1864
TANG. COMP. OF ABS. VEL.	-13.8384	385.0861	
TANG. COMP. OF REL. VEL.	856.2622	408.7969	
ACOUSTIC SPEED	1209.2869	1264.6281	1264.6584
ABSOLUTE MACH NUMBER	.3752	.4395	.3039
RELATIVE MACH NUMBER	.8012	.4529	
FLOW COEFFICIENT	.3356	.2910	.4146
FLOW AREA	.4732	.4730	.4730
ABSOLUTE FLOW ANGLE	-1.7478	44.3941	7.1827
RELATIVE FLOW ANGLE	62.0934	46.1055	
INCIDENCE	6.0234	7.2241	
DEVIATION		8.3755	6.8027
DIFFUSION RATIO		2.0616	1.7988
MOMENTUM THICKNESS		.0454	.0925
OMEGA (GAS)		.08370	.14084
OMEGA (TOTAL)		.08935	.14630

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 3) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL FRESSURE RATIO= 1.25863
 STAGE TOTAL TEMPERATURE RATIO= 1.08321
 STAGE ADIABATIC EFFICIENCY= .81235

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER- STAGE ADJUST- MENT)	**STAGE OUTLET** (AFTER INTER- STAGE ADJUST- MENT)
XU=	.00030	.00030	.00066
XW=	.00970	.00970	.00934
XWW=	0	0	0
XWT=	.00970	.00970	.00934
XAIR=	.99000	.99000	.99000
XMETAN=	0	0	0
XGAS	.99030	.99030	.99066
WMASS=	.22897	.22897	.22063
WWMASS=	0	0	0
WTMASS=	.22897	.22897	.22063
AMASS=	23.37452	23.37452	23.37452
CHMASS=	0	0	0
UMASS=	.00714	.00714	.01547
GMASS=	23.38165	23.38165	23.38999
TMASS=	23.61062	23.61062	23.61062
WS=	.00031	.00031	.00066
RHOA=	.11681	.12573	.10361
RHOM=	.06865	.12694	.11968
RHOG=	.10896	.12571	.11856
TG=	632.36701	684.99527	684.98735
TW=	530.28344	536.74693	536.93993
TWW=	513.70000	0	513.70000
P=	3941.09266	5052.10998	4960.39231
TB=	703.23864	0	718.41424
TDEW=	444.74623	441.53377	459.10895

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 4) *****

STAGE TOTAL PRESSURE RATIO= 1.17985
 STAGE TOTAL TEMPERATURE RATIO= 1.06061
 STAGE ADIABATIC EFFICIENCY= .79214

STAGE FLOW COEFFICIENT= .649
 AXIAL VELOCITY= 597.02
 ROTOR SPEED= 919.87

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	4960.3923	5915.8244	5852.5316
STATIC PRESSURE	4231.6744	4764.0483	5010.2461
TOTAL TEMPERATURE(GAS)	684.9874	726.5016	726.5016
STATIC TEMPERATURE(GAS)	654.7733	683.5756	695.4355
STATIC DENSITY(GAS)	.1211	.1306	.1350
STATIC DENSITY(MIXTURE)	.1222	.1318	.1363
AXIAL VELOCITY	597.0157	594.2406	607.7142
ABSOLUTE VELOCITY	601.7378	720.7186	613.1243
RELATIVE VELOCITY	916.9367	689.8393	
BLADE SPEED	771.1864	758.1814	747.9928
TANG. COMP. OF ABS. VEL.	75.2373	407.8154	
TANG. COMP. OF REL. VEL.	695.9491	350.3661	
ACOUSTIC SPEED	1247.2434	1285.7753	1285.3897
ABSOLUTE MACH NUMBER	.4825	.5655	.4770
RELATIVE MACH NUMBER	.7352	.5413	
FLOW COEFFICIENT	.6490	.6460	.6858
FLOW AREA	.1614	.1503	.1422
ABSOLUTE FLOW ANGLE	7.1827	34.4610	7.6483
RELATIVE FLOW ANGLE	49.3756	30.5237	
INCIDENCE	.4556	7.6810	
DEVIATION		.8137	-1.2117
DIFFUSION RATIO		1.5068	1.4665
MOMENTUM THICKNESS		.0671	.0246
OMEGA (GAS)		.09592	.04828
OMEGA (TOTAL)		.10081	.05495

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 4) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.17985
 STAGE TOTAL TEMPERATURE RATIO= 1.06060
 STAGE ADIABATIC EFFICIENCY= .79220

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00066	.00066	.00086
XW=	.00934	.00934	.00914
XWW=	0	0	0
XWT=	.00934	.00934	.00914
XAIR=	.99000	.99000	.99000
XMETAN=	0	0	0
XCAS	.99066	.99066	.99086
WMASS=	.11004	.11004	.10759
WWMASS=	0	0	0
WTMASS=	.11004	.11004	.10759
AMASS=	11.65811	11.65811	11.65811
CHMASS=	0	0	0
UMASS=	.00772	.00772	.01017
GMASS=	11.66583	11.66583	11.66828
TMASS=	11.77587	11.77587	11.77587
WS=	.00066	.00066	.00087
RHOA=	.13573	.13069	.12076
RHOM=	.06855	.13187	.13624
RHOG=	.12109	.13064	.13500
TG=	684.98735	726.50156	726.49720
TW=	536.93993	544.82405	544.93474
TWW=	513.70000	0	513.70000
P=	4960.39231	5915.82441	5852.53159
TB=	718.41424	0	728.35202
TDEW=	459.10895	463.41245	470.03573

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 5) *****

STAGE TOTAL PRESSURE RATIO= 1.20554
 STAGE TOTAL TEMPERATURE RATIO= 1.06053
 STAGE ADIABATIC EFFICIENCY= .89626

STAGE FLOW COEFFICIENT= .686
 AXIAL VELOCITY= 607.76
 ROTOR SPEED= 886.08

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	5852.5316	7187.5968	7055.4687
STATIC PRESSURE	5009.9874	5855.3853	6207.9745
TOTAL TEMPERATURE(GAS)	726.4972	770.4732	770.4732
STATIC TEMPERATURE(GAS)	695.2200	727.4180	743.3088
STATIC DENSITY(GAS)	.1350	.1508	.1565
STATIC DENSITY(MIXTURE)	.1362	.1522	.1579
AXIAL VELOCITY	607.7622	571.5426	574.1788
ABSOLUTE VELOCITY	613.2175	722.8873	574.1925
RELATIVE VELOCITY	901.9067	644.6847	
BLADE SPEED	747.9928	740.8691	739.3780
TANG. COMP. OF ABS. VEL.	81.6139	442.6116	
TANG. COMP. OF REL. VEL.	666.3789	293.2574	
ACOUSTIC SPEED	1284.6769	1328.4398	1328.3680
ABSOLUTE MACH NUMBER	.4773	.5501	.4323
RELATIVE MACH NUMBER	.7020	.4906	
FLOW COEFFICIENT	.6859	.6450	.6638
FLOW AREA	.1422	.1354	.1299
ABSOLUTE FLOW ANGLE	7.6483	37.7548	-.4174
RELATIVE FLOW ANGLE	47.6340	27.5576	
INCIDENCE	7.6940	7.3743	
DEVIATION		.7976	-1.8274
DIFFUSION RATIO		1.6750	1.5374
MOMENTUM THICKNESS		.0017	.0519
OMEGA (GAS)		.00244	.09259
OMEGA (TOTAL)		.00750	.09918

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 5) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.20554
 STAGE TOTAL TEMPERATURE RATIO= 1.06053
 STAGE ADIABATIC EFFICIENCY= .89631

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00086	.00086	.00106
XW=	.00914	.00914	.00894
XUW=	0	0	0
XWT=	.00914	.00914	.00894
XAIR=	.99000	.99000	.99000
XMETAN=	0	0	0
XGAS	.99086	.99086	.99106
WMASS=	.10759	.10759	.10525
UWMASS=	0	0	0
WTMASS=	.10759	.10759	.10525
AMASS=	11.65811	11.65811	11.65811
CHMASS=	0	0	0
UMASS=	.01017	.01017	.01251
GMASS=	11.66828	11.66828	11.67062
TMASS=	11.77587	11.77587	11.77587
WS=	.00087	.00087	.00107
RHOA=	.15099	.15093	.14273
RHOM=	.06865	.15224	.15788
RHOG=	.13500	.15085	.15647
TC=	726.49720	770.47316	770.46923
TW=	544.93474	553.16879	553.27132
TUW=	513.70000	0	513.70000
P=	5852.53159	7187.59676	7055.46868
TB=	728.35202	0	739.92026
TDEW=	470.03573	475.30736	480.23426

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 6) *****

STAGE TOTAL PRESSURE RATIO= 1.18814
 STAGE TOTAL TEMPERATURE RATIO= 1.05936
 STAGE ADIABATIC EFFICIENCY= .83795

STAGE FLOW COEFFICIENT= .664
 AXIAL VELOCITY= 574.25
 ROTOR SPEED= 865.04

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	7055.4687	8483.2978	8382.8980
STATIC PRESSURE	6207.8032	7244.4473	7512.3139
TOTAL TEMPERATURE(GAS)	770.4632	816.2033	816.2033
STATIC TEMPERATURE(GAS)	743.1425	780.9621	791.5621
STATIC DENSITY(GAS)	.1585	.1738	.1778
STATIC DENSITY(MIXTURE)	.1579	.1753	.1794
AXIAL VELOCITY	574.2506	536.7638	545.1638
ABSOLUTE VELOCITY	574.2659	655.1738	547.8504
RELATIVE VELOCITY	939.4932	644.9105	
BLADE SPEED	739.3780	733.1655	728.2783
TANG. COMP. OF ABS. VEL.	-4.1834	375.6824	
TANG. COMP. OF REL. VEL.	743.5614	357.4831	
ACOUSTIC SPEED	1327.5334	1370.2288	1370.1024
ABSOLUTE MACH NUMBER	.4326	.4814	.3999
RELATIVE MACH NUMBER	.7077	.4739	
FLOW COEFFICIENT	.6638	.6205	.6437
FLOW AREA	.1299	.1251	.1204
ABSOLUTE FLOW ANGLE	-.4174	34.9883	5.6849
RELATIVE FLOW ANGLE	52.3212	33.6535	
INCIDENCE	6.6312	2.3083	
DEVIATION		7.0235	-.8651
DIFFUSION RATIO		1.7283	1.4834
MOMENTUM THICKNESS		.0427	.0361
OMEGA (GAS)		.06517	.07403
OMEGA (TOTAL)		.07004	.08104

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 6) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.18814
 STAGE TOTAL TEMPERATURE RATIO= 1.05935
 STAGE ADIABATIC EFFICIENCY= .83802

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00106	.00106	.00139
XW=	.00894	.00894	.00861
XWW=	0	0	0
XWT=	.00894	.00894	.00861
XAIR=	.99000	.99000	.99000
XMETAN=	0	0	0
XGAS	.99106	.99106	.99139
WMASS=	.10525	.10525	.10136
WWMASS=	0	0	0
WTHASS=	.10525	.10525	.10136
AMASS=	11.65811	11.65811	11.65811
CHMASS=	0	0	0
UMASS=	.01251	.01251	.01640
GMASS=	11.67062	11.67062	11.67451
TMASS=	11.77587	11.77587	11.77587
WS=	.00107	.00107	.00141
RHOA=	.17164	.17391	.16427
RHOM=	.06865	.17536	.17929
RHOG=	.15647	.17380	.17775
TG=	770.46923	816.20331	816.19706
TW=	553.27132	560.23663	560.40405
TWW=	513.70000	0	513.70000
P=	7055.46868	8483.29781	8382.89797
TB=	739.92026	0	750.91936
TDEW=	480.23426	485.16514	492.25926

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 7) *****

STAGE TOTAL PRESSURE RATIO= 1.16834
 STAGE TOTAL TEMPERATURE RATIO= 1.05032
 STAGE ADIABATIC EFFICIENCY= .88637

STAGE FLOW COEFFICIENT= .644
 AXIAL VELOCITY= 545.39
 ROTOR SPEED= 846.98

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	8382.8980	9898.1373	9794.0340
STATIC PRESSURE	7511.8546	8460.5242	8832.8928
TOTAL TEMPERATURE(GAS)	816.1971	857.2672	857.2672
STATIC TEMPERATURE(GAS)	791.4182	820.5982	832.9542
STATIC DENSITY(GAS)	.1778	.1931	.1986
STATIC DENSITY(MIXTURE)	.1793	.1948	.2003
AXIAL VELOCITY	545.3897	533.4645	543.8031
ABSOLUTE VELOCITY	548.0853	669.7228	545.3371
RELATIVE VELOCITY	897.0107	618.5630	
BLADE SPEED	728.2783	718.0068	713.9479
TANG. COMP. OF ABS. VEL.	54.2919	404.9002	
TANG. COMP. OF REL. VEL.	673.9864	313.1066	
ACOUSTIC SPEED	1369.2681	1404.8882	1404.7433
ABSOLUTE MACH NUMBER	.4003	.4803	.3882
RELATIVE MACH NUMBER	.6332	.4436	
FLOW COEFFICIENT	.6439	.6298	.6601
FLOW AREA	.1204	.1133	.1081
ABSOLUTE FLOW ANGLE	5.6849	37.1985	4.3143
RELATIVE FLOW ANGLE	51.0202	30.4100	
INCIDENCE	8.0102	8.7885	
DEVIATION		5.6800	-.9257
DIFFUSION RATIO		1.6809	1.5201
MOMENTUM THICKNESS		.0178	.0332
OMEGA (GAS)		.03071	.06560
OMEGA (TOTAL)		.03600	.07241

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 7) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.16834
 STAGE TOTAL TEMPERATURE RATIO= 1.05031
 STAGE ADIABATIC EFFICIENCY= .88648

	***STAGE INLET**	***STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	***STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00139	.00139	.00179
XW=	.00861	.00861	.00821
XWW=	0	0	0
XWT=	.00861	.00861	.00821
XAIR=	.99000	.99000	.99000
XMETAN=	0	0	0
XCAS	.99139	.99139	.99179
WMASS=	.10136	.10136	.09665
WWMASS=	0	0	0
WTMASS=	.10136	.10136	.09665
AMASS=	11.65811	11.65811	11.65811
CHMASS=	0	0	0
UMASS=	.01640	.01640	.02111
GMASS=	11.67451	11.67451	11.67923
TMASS=	11.77587	11.77587	11.77587
WS=	.00141	.00141	.00181
RHOA=	.19251	.19329	.18432
RHOM=	.06865	.19480	.20020
RHOG=	.17775	.19313	.19856
TG=	816.19706	857.26715	857.25995
TW=	560.40405	566.27814	566.47941
TWW=	513.70000	0	513.70000
P=	8382.89797	9898.13726	9794.03401
TB=	750.91936	0	758.50323
TDEW=	492.25926	488.21208	495.21127

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 8) *****

STAGE TOTAL PRESSURE RATIO= 1.19433
 STAGE TOTAL TEMPERATURE RATIO= 1.06479
 STAGE ADIABATIC EFFICIENCY= .78429

STAGE FLOW COEFFICIENT= .660
 AXIAL VELOCITY= 544.10
 ROTOR SPEED= 823.79

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	9794.0340	11971.7421	11697.3285
STATIC PRESSURE	8832.2419	9945.2950	10559.2522
TOTAL TEMPERATURE(GAS)	857.2600	912.8051	912.8051
STATIC TEMPERATURE(GAS)	832.8133	867.0049	887.2369
STATIC DENSITY(GAS)	.1986	.2148	.2228
STATIC DENSITY(MIXTURE)	.2002	.2165	.2247
AXIAL VELOCITY	544.1029	533.8952	540.5290
ABSOLUTE VELOCITY	545.6491	750.0474	560.4086
RELATIVE VELOCITY	865.3566	562.2729	
BLADE SPEED	713.9479	703.1795	701.1086
TANG. COMP. OF ABS. VEL.	41.0483	526.8084	
TANG. COMP. OF REL. VEL.	672.8997	176.3711	
ACOUSTIC SPEED	1404.0006	1449.2436	1449.1529
ABSOLUTE MACH NUMBER	.3886	.5236	.3867
RELATIVE MACH NUMBER	.6164	.3925	
FLOW COEFFICIENT	.6605	.6481	.6738
FLOW AREA	.1081	.1019	.0970
ABSOLUTE FLOW ANGLE	4.3143	44.6172	15.3086
RELATIVE FLOW ANGLE	51.0412	18.2809	
INCIDENCE	8.8112	6.9172	
DEVIATION		3.0309	-.9214
DIFFUSION RATIO		1.8585	1.6335
MOMENTUM THICKNESS		.0773	.0830
OMEGA (GAS)		.09906	.13021
OMEGA (TOTAL)		.10296	.13542

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 8) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.19433
 STAGE TOTAL TEMPERATURE RATIO= 1.06478
 STAGE ADIABATIC EFFICIENCY= .78435

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00179	.00179	.00227
XW=	.00821	.00821	.00773
XWV=	0	0	0
XWT=	.00821	.00821	.00773
XAIR=	.99000	.99000	.99000
XMETAN=	0	0	0
XGAS	.99179	.99179	.99227
WMASS=	.09665	.09665	.09102
WVMASS=	0	0	0
WTMASS=	.09665	.09665	.09102
AMASS=	11.65811	11.65811	11.65811
CHMASS=	0	0	0
UMASS=	.02111	.02111	.02674
GMASS=	11.67923	11.67923	11.68486
TMASS=	11.77587	11.77587	11.77587
WS=	.00181	.00181	.00229
RHOA=	.21414	.21503	.20689
RHOM=	.06855	.21657	.22449
RHOC=	.19856	.21480	.22276
TG=	857.25995	912.80515	912.79698
TW=	566.47941	573.29128	573.53202
TWV=	513.70000	0	513.70000
P=	9794.03401	11971.74213	11697.32848
TB=	758.50323	0	770.96403
TDEW=	495.21127	501.19053	507.67596

***** INITIAL FLOW COEFFICIENT= .350 (STAGE= 9) *****

STAGE TOTAL PRESSURE RATIO= 1.15314
 STAGE TOTAL TEMPERATURE RATIO= 1.04406
 STAGE ADIABATIC EFFICIENCY= .91622

STAGE FLOW COEFFICIENT= .674
 AXIAL VELOCITY= 540.94
 ROTOR SPEED= 802.25

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	11697.3285	13562.4981	13488.7085
STATIC PRESSURE	10558.2369	11438.2002	12345.8699
TOTAL TEMPERATURE(GAS)	912.7970	953.0108	953.0108
STATIC TEMPERATURE(GAS)	887.1377	909.2209	929.9980
STATIC DENSITY(GAS)	.2228	.2355	.2485
STATIC DENSITY(MIXTURE)	.2245	.2373	.2504
AXIAL VELOCITY	540.9379	537.9299	509.7709
ABSOLUTE VELOCITY	550.8377	735.6089	533.2668
RELATIVE VELOCITY	773.6048	574.0298	
BLADE SPEED	701.1086	702.1027	1041.9876
TANG. COMP. OF ABS. VEL.	148.0712	501.7488	
TANG. COMP. OF REL. VEL.	553.0375	200.3538	
ACOUSTIC SPEED	1448.0275	1482.3597	1482.5966
ABSOLUTE MACH NUMBER	.3873	.5018	.3597
RELATIVE MACH NUMBER	.5342	.3916	
FLOW COEFFICIENT	.6743	.6705	.4336
FLOW AREA	.0970	.0923	.0923
ABSOLUTE FLOW ANGLE	15.3086	43.0069	17.0804
RELATIVE FLOW ANGLE	45.6337	20.4280	
INCIDENCE	.4937	6.1869	
DEVIATION		4.3680	.5804
DIFFUSION RATIO		1.6979	1.7102
MOMENTUM THICKNESS		.0199	.0164
OMEGA (GAS)		.03440	.02985
OMEGA (TOTAL)		.03966	.03474

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 9) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.15314
 STAGE TOTAL TEMPERATURE RATIO= 1.04405
 STAGE ADIABATIC EFFICIENCY= .91628

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00227	.00227	.00323
XW=	.00773	.00773	0
XWW=	0	0	0
XWT=	.00773	.00773	0
XAIR=	.99000	.99000	.99677
XMETAN=	0	0	0
XGAS	.99227	.99227	1.00000
WMASS=	.09102	.09102	0
WWMASS=	0	0	0
WTMASS=	.09102	.09102	0
AMASS=	11.65843	11.65843	11.65843
CHMASS=	0	0	0
UMASS=	.02674	.02674	.03775
GMASS=	11.68486	11.68486	11.69618
TMASS=	11.77587	11.77587	11.69618
WS=	.00229	.00229	.00324
RHOA=	.24019	.23584	.22455
RHOM=	.06865	.23734	.24383
RHOG=	.22276	.23551	.24383
TG=	912.79698	953.01083	953.00241
TW=	573.53202	579.35901	579.85191
TWW=	513.70000	0	513.70000
P=	11697.32848	13562.49810	13488.70848
TB=	770.96403	0	781.26234
TDEW=	507.67596	512.29293	523.15571

***** INITIAL FLOW COEFFICIENT= .350 (STAGE=10) *****

STAGE TOTAL PRESSURE RATIO= 1.25133
 STAGE TOTAL TEMPERATURE RATIO= 1.07043
 STAGE ADIABATIC EFFICIENCY= .90632

STAGE FLOW COEFFICIENT= .493
 AXIAL VELOCITY= 579.69
 ROTOR SPEED=1175.57

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	13488.7083	16955.7969	16878.8813
STATIC PRESSURE	12035.8382	14079.4285	15214.1927
TOTAL TEMPERATURE(GAS)	953.0024	1020.1251	1020.1251
STATIC TEMPERATURE(GAS)	923.3843	963.9355	991.2079
STATIC DENSITY(GAS)	.2438	.2718	.2871
STATIC DENSITY(MIXTURE)	.2438	.2718	.2871
AXIAL VELOCITY	579.6851	553.7134	548.2050
ABSOLUTE VELOCITY	606.4326	797.3829	599.3135
RELATIVE VELOCITY	1040.3398	730.3217	
BLADE SPEED	1041.9876	1049.9830	1063.0217
TANG. COMP. OF ABS. VEL.	178.1171	573.7779	
TANG. COMP. OF REL. VEL.	863.8704	476.2051	
ACOUSTIC SPEED	1482.1341	1535.5486	1535.6019
ABSOLUTE MACH NUMBER	.4092	.5252	.3903
RELATIVE MACH NUMBER	.7019	.4810	
FLOW COEFFICIENT	.4931	.4710	.4669
FLOW AREA	.0827	.0777	.0743
ABSOLUTE FLOW ANGLE	17.0804	46.0195	23.8340
RELATIVE FLOW ANGLE	56.1371	40.6962	
INCIDENCE	6.6171	9.6095	
DEVIATION		2.7762	1.0540
DIFFUSION RATIO		1.7602	1.8273
MOMENTUM THICKNESS		.0367	.0179
OMEGA (GAS)		.06069	.02674
OMEGA (TOTAL)		.06069	.02674

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 10) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.25133
 STAGE TOTAL TEMPERATURE RATIO= 1.07043
 STAGE ADIABATIC EFFICIENCY= .90632

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00323	.00323	.00323
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	.99677	.99677	.99677
XMETAN=	0	0	0
XGAS=	1.00000	1.00000	1.00000
WMASS=	0	0	0
WWMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.65843	11.65843	11.65843
CHMASS=	0	0	0
UMASS=	.03775	.03775	.03775
GMASS=	0	0	11.69618
TMASS=	11.69618	11.69618	11.69618
WS=	.00324	.00324	.00323
RHOA=	.26529	.27222	.28763
RHOM=	.06865	.27169	.28706
RHOG=	.24383	.27169	.28706
TG=	953.00241	1020.12508	1020.12508
TW=	579.85191	579.85191	579.85191
TWW=	513.70000	0	513.70000
P=	13488.70848	16955.79693	16878.88133
TB=	781.26234	0	798.03560
TDEW=	523.15571	530.77756	530.77756

***** INITIAL FLOW COEFFICIENT= .350 (STAGE=11) *****

STAGE TOTAL PRESSURE RATIO= 1.25400
 STAGE TOTAL TEMPERATURE RATIO= 1.07040
 STAGE ADIABATIC EFFICIENCY= .90808

STAGE FLOW COEFFICIENT= .467
 AXIAL VELOCITY= 548.33
 ROTOR SPEED=1174.10

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	16878.8813	21306.9086	21166.0901
STATIC PRESSURE	15213.5873	17529.1223	19417.6666
TOTAL TEMPERATURE(GAS)	1020.1251	1091.9402	1091.9402
STATIC TEMPERATURE(GAS)	991.4025	1034.9083	1066.3684
STATIC DENSITY(GAS)	.2871	.3168	.3406
STATIC DENSITY(MIXTURE)	.2871	.3168	.3406
AXIAL VELOCITY	548.3345	525.1969	508.7548
ABSOLUTE VELOCITY	599.4562	844.8455	565.7171
RELATIVE VELOCITY	987.0988	664.0872	
BLADE SPEED	1063.0217	1068.1879	1075.3223
TANG. COMP. OF ABS. VEL.	242.2334	661.7644	
TANG. COMP. OF REL. VEL.	820.7883	406.4235	
ACOUSTIC SPEED	1533.5405	1590.3555	1590.4641
ABSOLUTE MACH NUMBER	.3909	.5392	.3557
RELATIVE MACH NUMBER	.6437	.4238	
FLOW COEFFICIENT	.4670	.4473	.4333
FLOW AREA	.0743	.0703	.0675
ABSOLUTE FLOW ANGLE	23.8340	51.5634	25.9343
RELATIVE FLOW ANGLE	56.2548	37.7345	
INCIDENCE	8.2348	9.9434	
DEVIATION		4.1445	1.6543
DIFFUSION RATIO		1.9336	2.0672
MOMENTUM THICKNESS		.0429	.0273
OMEGA (GAS)		.05990	.03728
OMEGA (TOTAL)		.05990	.03728

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 11) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.25400
 STAGE TOTAL TEMPERATURE RATIO= 1.07040
 STAGE ADIABATIC EFFICIENCY= .90808

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00323	.00323	.00323
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	0	0	.99677
XMETAN=	0	0	0
XGAS	1.00000	1.00000	1.00000
WMASS=	0	0	0
WMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.65843	11.65843	11.65843
CHMASS=	0	0	0
UMASS=	.03775	.03775	.03775
GMASS=	11.69618	11.69618	11.69618
TMASS=	11.69618	11.69618	11.69618
WS=	.00323	.00323	.00323
RHOA=	.31012	.31729	.34123
RHOM=	.06865	.31667	.34056
RHOG=	.28706	.31667	.34056
TG=	1020.12508	1091.94022	1091.94022
TW=	579.85191	579.85191	579.85191
TWW=	513.70000	0	513.70000
P=	16878.88133	21306.90856	21166.09012
TE=	798.03560	0	815.71467
TDEW=	0	538.61312	538.61312

***** INITIAL FLOW COEFFICIENT= .350 (STAGE=12) *****

STAGE TOTAL FRESSURE RATIO= 1.23417
 STAGE TOTAL TEMPERATURE RATIO= 1.06608
 STAGE ADIABATIC EFFICIENCY= .88937

STAGE FLOW COEFFICIENT= .433
 AXIAL VELOCITY= 508.87
 ROTOR SPEED=1174.10

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	21166.0901	26339.5226	26122.4493
STATIC PRESSURE	19417.0367	22058.6228	24191.6179
TOTAL TEMPERATURE(GAS)	1091.9402	1164.0924	1164.0924
STATIC TEMPERATURE(GAS)	1066.5648	1109.1614	1139.9845
STATIC DENSITY(GAS)	.3406	.3720	.3970
STATIC DENSITY(MIXTURE)	.3406	.3720	.3970
AXIAL VELOCITY	508.8650	494.8160	485.6343
ABSOLUTE VELOCITY	565.8483	832.6739	551.6271
RELATIVE VELOCITY	971.7434	641.0692	
BLADE SPEED	1075.3223	1077.2904	1081.8416
TANG. COMP. OF ABS. VEL.	247.4687	669.7037	
TANG. COMP. OF REL. VEL.	827.8536	407.5867	
ACOUSTIC SPEED	1588.0611	1641.7676	1641.8106
ABSOLUTE MACH NUMBER	.3563	.5142	.3360
RELATIVE MACH NUMBER	.6119	.3959	
FLOW COEFFICIENT	.4334	.4214	.4136
FLOW AREA	.0675	.0635	.0607
ABSOLUTE FLOW ANGLE	25.9343	53.5409	28.3138
RELATIVE FLOW ANGLE	58.4218	39.4788	
INCIDENCE	10.0818	10.9109	
DEVIATION		5.5788	2.5238
DIFFUSION RATIO		2.0250	2.1596
MOMENTUM THICKNESS		.0552	.0371
OMEGA (GAS)		.07232	.05071
OMEGA (TOTAL)		.07232	.05071

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 12) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.23417
 STAGE TOTAL TEMPERATURE RATIO= 1.06608
 STAGE ADIABATIC EFFICIENCY= .88937

	***STAGE INLET**	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00323	.00323	.00323
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	.99677	.99677	.99677
XMETAN=	0	0	0
XGAS	1.00000	1.00000	1.00000
WMASS=	0	0	0
WWMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.65843	11.65843	11.65843
CHMASS=	0	0	0
UMASS=	.03775	.03775	.03775
GMASS=	11.69618	11.69618	11.69618
TMASS=	11.69618	11.69618	11.69618
WS=	.00323	.00323	.00323
RHOA=	.36332	.37257	.39767
RHOM=	.06865	.37184	.39690
RHOQ=	.34056	.37184	.39690
TC=	1091.94022	1164.09235	1164.09235
TW=	579.85191	579.85191	579.85191
TWW=	513.70000	0	513.70000
P=	21166.09012	26339.52256	26122.44926
TB=	815.71467	0	832.86573
TDEW=	538.61312	0	0

***** INITIAL FLOW COEFFICIENT= .350 (STAGE=13) *****

STAGE TOTAL PRESSURE RATIO= 1.19922
 STAGE TOTAL TEMPERATURE RATIO= 1.05747
 STAGE ADIABATIC EFFICIENCY= .87183

STAGE FLOW COEFFICIENT= .414
 AXIAL VELOCITY= 485.73
 ROTOR SPEED=1174.10

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	26122.4493	31661.6344	31326.6191
STATIC PRESSURE	24191.0301	27055.7035	29290.5888
TOTAL TEMPERATURE(GAS)	1164.0924	1230.9900	1230.9900
STATIC TEMPERATURE(GAS)	1140.1793	1179.8090	1208.8454
STATIC DENSITY(GAS)	.3969	.4290	.4533
STATIC DENSITY(MIXTURE)	.3969	.4290	.4533
AXIAL VELOCITY	485.7291	475.9732	470.7799
ABSOLUTE VELOCITY	551.7369	807.3125	531.0324
RELATIVE VELOCITY	953.1966	645.0096	
BLADE SPEED	1081.8416	1087.3769	1094.1423
TANG. COMP. OF ABS. VEL.	261.6886	652.0759	
TANG. COMP. OF REL. VEL.	820.1531	435.3010	
ACOUSTIC SPEED	1639.2478	1687.8717	1687.8872
ABSOLUTE MACH NUMBER	.3366	.4841	.3146
RELATIVE MACH NUMBER	.5815	.3868	
FLOW COEFFICIENT	.4137	.4054	.4010
FLOW AREA	.0607	.0573	.0548
ABSOLUTE FLOW ANGLE	28.3138	53.8730	27.5588
RELATIVE FLOW ANGLE	59.3642	42.4445	
INCIDENCE	11.5842	11.9330	
DEVIATION		6.0545	3.6288
DIFFUSION RATIO		2.0337	2.2912
MOMENTUM THICKNESS		.0481	.0531
OMEGA (GAS)		.07162	.07274
OMEGA (TOTAL)		.07162	.07274

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 13) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.19922
 STAGE TOTAL TEMPERATURE RATIO= 1.05747
 STAGE ADIABATIC EFFICIENCY= .87183

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00323	.00323	.00323
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	.99677	.99677	.99677
XMETAN=	0	0	0
XGAS	1.00000	1.00000	1.00000
WMASS=	0	0	0
WWMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.65843	11.65843	11.65843
CMASS=	0	0	0
UMASS=	.03775	.03775	.03775
GMASS=	11.69618	11.69618	11.69618
TMASS=	11.69618	11.69618	11.69618
WS=	.00323	.00323	.00323
RHOA=	.42060	.42965	.45408
RHOM=	.06865	.42881	.45319
RHOG=	.39690	.42881	.45319
TG=	1164.09235	1230.99003	1230.99003
TW=	579.85191	579.85191	579.85191
TKW=	513.70000	0	513.70000
P=	26122.44926	31661.63440	31326.61915
TB=	832.86573	0	848.26644
TDEW=	0	552.76242	552.76242

***** INITIAL FLOW COEFFICIENT= .350 (STAGE=14) *****

STAGE TOTAL PRESSURE RATIO= 1.21348
 STAGE TOTAL TEMPERATURE RATIO= 1.06059
 STAGE ADIABATIC EFFICIENCY= .87416

STAGE FLOW COEFFICIENT= .401
 AXIAL VELOCITY= 470.85
 ROTOR SPEED=1174.10

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	31326.6191	38376.2820	38014.2054
STATIC PRESSURE	29290.0980	32928.1181	35979.4058
TOTAL TEMPERATURE(GAS)	1230.9900	1305.5736	1305.5736
STATIC TEMPERATURE(GAS)	1209.0153	1253.1074	1286.4745
STATIC DENSITY(GAS)	.4532	.4916	.5232
STATIC DENSITY(MIXTURE)	.4532	.4916	.5232
AXIAL VELOCITY	470.8539	457.2813	447.2369
ABSOLUTE VELOCITY	531.1164	820.8047	495.2298
RELATIVE VELOCITY	970.3164	617.7523	
BLADE SPEED	1094.1423	1096.9714	1101.6457
TANG. COMP. OF ABS. VEL.	245.7258	681.6261	
TANG. COMP. OF REL. VEL.	848.4164	415.3453	
ACOUSTIC SPEED	1685.4136	1738.5498	1738.5660
ABSOLUTE MACH NUMBER	.3151	.4784	.2848
RELATIVE MACH NUMBER	.5757	.3600	
FLOW COEFFICIENT	.4010	.3895	.3809
FLOW AREA	.0548	.0520	.0500
ABSOLUTE FLOW ANGLE	27.5588	56.1436	25.4331
RELATIVE FLOW ANGLE	60.9706	42.2486	
INCIDENCE	10.9506	12.1136	
DEVIATION		5.3286	4.5331
DIFFUSION RATIO		2.1864	2.5441
MOMENTUM THICKNESS		.0635	.0550
OMEGA (GAS)		.08328	.06646
OMEGA (TOTAL)		.08328	.06646

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 14) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.21348
 STAGE TOTAL TEMPERATURE RATIO= 1.06059
 STAGE ADIABATIC EFFICIENCY= .87416

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00323	.00323	.00323
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	.99677	.99677	.99677
XMETAN=	0	0	0
XGAS=	0	0	1.00000
WMASS=	0	0	0
WNMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.65843	11.65843	11.65843
CHMASS=	0	0	0
UMASS=	.03775	.03775	.03775
GMASS=	11.69618	11.69618	11.69618
TMASS=	11.69618	11.69618	11.69618
WS=	.00323	.00323	.00323
RHOA=	.47699	.49230	.52413
RHOM=	.06865	.49133	.52310
RHOG=	.45319	.49133	.52310
TG=	1230.99003	1305.57364	1305.57364
TW=	579.85191	579.85191	579.85191
TWW=	513.70000	0	513.70000
P=	31326.61915	38376.28195	38014.20544
TE=	848.26644	0	865.30796
TDEW=	552.76242	559.90494	559.90494

***** INITIAL FLOW COEFFICIENT= .350 (STAGE=15) *****

STAGE TOTAL PRESSURE RATIO= 1.16952
 STAGE TOTAL TEMPERATURE RATIO= 1.05037
 STAGE ADIABATIC EFFICIENCY= .83916

STAGE FLOW COEFFICIENT= .381
 AXIAL VELOCITY= 447.30
 ROTOR SPEED=1174.10

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	38014.2054	45028.2277	44458.2810
STATIC PRESSURE	35978.9591	40042.8265	42448.3242
TOTAL TEMPERATURE(GAS)	1305.5736	1371.3395	1371.3395
STATIC TEMPERATURE(GAS)	1286.6405	1329.2931	1354.6053
STATIC DENSITY(GAS)	.5231	.5635	.5862
STATIC DENSITY(MIXTURE)	.5231	.5635	.5862
AXIAL VELOCITY	447.3002	431.7760	428.0096
ABSOLUTE VELOCITY	495.3010	738.2349	465.7277
RELATIVE VELOCITY	995.1300	663.9065	
BLADE SPEED	1101.6457	1103.1218	1106.0739
TANG. COMP. OF ABS. VEL.	212.7102	598.7990	
TANG. COMP. OF REL. VEL.	888.9355	504.3227	
ACOUSTIC SPEED	1735.7243	1780.9766	1780.9779
ABSOLUTE MACH NUMBER	.2854	.4184	.2615
RELATIVE MACH NUMBER	.5733	.3763	
FLOW COEFFICIENT	.3810	.3678	.3645
FLOW AREA	.0500	.0481	.0466
ABSOLUTE FLOW ANGLE	25.4331	54.2058	23.2179
RELATIVE FLOW ANGLE	63.2891	49.4315	
INCIDENCE	9.1291	15.3658	
DEVIATION		4.3315	6.3479
DIFFUSION RATIO		2.0629	2.6795
MOMENTUM THICKNESS		.0503	.0849
OMEGA (GAS)		.08026	.11432
OMEGA (TOTAL)		.08026	.11432

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 15) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.16952
 STAGE TOTAL TEMPERATURE RATIO= 1.05037
 STAGE ADIABATIC EFFICIENCY= .83916

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00323	.00323	.00323
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	.99677	.99677	.99677
XMETAN=	0	0	0
XGAS	1.00000	1.00000	1.00000
WMASS=	0	0	0
WWMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.65843	11.65843	11.65843
CHMASS=	0	0	0
UMASS=	.03775	.03775	.03775
GMASS=	11.69618	11.69618	11.69618
TMASS=	11.69618	11.69618	11.69618
WS=	.00323	.00323	.00323
RHOA=	.54575	.56445	.58729
RHOM=	.06865	.56335	.58614
RHOG=	.52310	.56335	.58614
TG=	1305.57364	1371.33948	1371.33948
TW=	579.85191	579.85191	579.85191
TWW=	513.70000	0	513.70000
P=	38014.20544	45028.22772	44458.28098
TB=	865.30796	0	879.60912
TDEW=	559.90494	565.98312	565.98312

***** INITIAL FLOW COEFFICIENT= .350 (STAGE=16) *****

STAGE TOTAL PRESSURE RATIO= 1.17690
 STAGE TOTAL TEMPERATURE RATIO= 1.05353
 STAGE ADIABATIC EFFICIENCY= .81490

STAGE FLOW COEFFICIENT= .365
 AXIAL VELOCITY= 428.05
 ROTOR SPEED=1174.10

	ROTOR INLET	*ROTOR OUTLET*	*STATOR OUTLET*
TOTAL PRESSURE	44458.2810	53428.4011	52322.9747
STATIC PRESSURE	42448.0138	47828.3978	50698.5131
TOTAL TEMPERATURE(GAS)	1371.3395	1444.7504	1444.7504
STATIC TEMPERATURE(GAS)	1354.7327	1403.2506	1432.8059
STATIC DENSITY(GAS)	.5861	.6376	.6619
STATIC DENSITY(MIXTURE)	.5861	.6376	.6619
AXIAL VELOCITY	428.0530	402.0117	387.2411
ABSOLUTE VELOCITY	465.7750	736.4269	395.0845
RELATIVE VELOCITY	1016.9302	633.4593	
BLADE SPEED	1106.0739	1106.5659	I
TANG. COMP. OF ABS. VEL.	183.6220	617.0180	
TANG. COMP. OF REL. VEL.	922.4520	489.5480	
ACOUSTIC SPEED	1778.4451	1828.9923	1828.9732
ABSOLUTE MACH NUMBER	.2619	.4069	.2160
RELATIVE MACH NUMBER	.5718	.3500	
FLOW COEFFICIENT	.3646	.3424	.3298
FLOW AREA	.0466	.0456	.0456
ABSOLUTE FLOW ANGLE	23.2179	56.9142	11.4328
RELATIVE FLOW ANGLE	65.1069	50.6075	
INCIDENCE	8.7669	16.5142	
DEVIATION		5.2075	8.4028
DIFFUSION RATIO		2.1718	3.1704
MOMENTUM THICKNESS		.0522	.1420
OMEGA (GAS)		.07298	.19740
OMEGA (TOTAL)		.07298	.19740

***** INITIAL FLOW COEFFICIENT= .350 (ISTAGE= 16) *****

STAGE PERFORMANCE AFTER INTER-STAGE ADJUSTMENT(JPERFM=2)

STAGE TOTAL PRESSURE RATIO= 1.17690
 STAGE TOTAL TEMPERATURE RATIO= 1.05353
 STAGE ADIABATIC EFFICIENCY= .81490

	STAGE INLET	**STAGE OUTLET** (BEFORE INTER-STAGE ADJUSTMENT)	**STAGE OUTLET** (AFTER INTER-STAGE ADJUSTMENT)
XU=	.00323	.00323	.00323
XW=	0	0	0
XWW=	0	0	0
XWT=	0	0	0
XAIR=	.99677	.99677	.99677
XMETAN=	0	0	0
XGAS	1.00000	1.00000	1.00000
WMASS=	0	0	0
WWMASS=	0	0	0
WTMASS=	0	0	0
AMASS=	11.65843	11.65843	11.65843
CHMASS=	0	0	0
UMASS=	.03775	.03775	.03775
GMASS=	11.69618	11.69618	11.69618
TMASS=	0	0	11.69618
WS=	.00323	.00323	.00323
RHOA=	.60765	.63866	.66317
RHOM=	.06865	.63741	.66187
RHOG=	.58614	.63741	.66187
TG=	1371.33948	1444.75041	1444.75041
TW=	579.85191	579.85191	579.85191
TWW=	513.70000	0	513.70000
P=	44458.28098	53428.40108	52322.97472
TE=	879.60912	0	894.99536
TDEW=	565.98312	572.63516	572.63516

***** OVERALL PERFORMANCE *****

INITIAL FLOW COEFFICIENT= .350
 CORRECTED SPEED= 9492.1 1.000 FRACTION OF DEIGN CORRECTED SPEED
 INITIAL WATER CONTENT(SMALL DROPLET)= .010
 INITIAL WATER CONTENT(LARGE DROPLET)= 0
 INITIAL WATER CONTENT(TOTAL)= .010
 INITIAL RELATIVE HUMIDITY= .0 PER CENT
 INITIAL METHANE CONTENT= 0
 COMPRESSOR INLET TOTAL TEMPERATURE= 518.70
 COMPRESSOR INLET TOTAL PRESSURE= 2116.80
 CORRECTED MASS FLOW RATE OF MIXTURE=234.147
 CORRECTED MASS FLOW RATE OF GAS PHASE 231.806
 OVERALL TOTAL PRESSURE RATIO=24.7180
 OVERALL TOTAL TEMPERATURE RATIO=2.7853
 OVERALL ADIABATIC EFFICIENCY= .7873

***** PERFORMANCE OF FAN,LPC,HPC *****

	GAS PHASE CORRECTED MASS FLOW	STAGNATION PRESSURE RATIO	STAGNATION TEMPERATURE RATIO	ADIABATIC EFFICIENCY
FAN	231.8060	2.3433	1.3206	.8186
LPC	56.7342	2.7193	1.3913	.8048
HPC	24.6731	3.8790	1.5160	.8704

Test Case No. 3
(1.0 Large Droplet Ingestion, No Mass Transfer,
Overall Performance Only Printout)

***** INPUT DATA *****

NS(NUMBER OF STAGE)=16
 PERFORMANCE AT MEAN

NO MASS TRANSFER

LARGE DROPLETS IN ROTOR FREE STREAM ARE CENTRIFUG ED

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
RRHUB(I)	6.300	6.830	7.020	7.025	7.017	7.037	7.025	7.025	7.025	7.308	7.553	7.757	7.956	8.123	8.258	8.351
RC(I)	3.708	2.786	2.360	1.199	1.084	1.339	1.530	1.483	1.419	1.627	1.389	1.338	1.292	1.211	1.289	1.481
RBLADE(I)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
STAGER(I)	46.64	48.99	46.90	37.82	33.35	34.67	33.87	28.74	25.60	43.72	40.81	41.12	42.09	43.47	49.63	50.91
STAGES(I)	21.64	17.46	13.78	17.82	13.90	19.62	16.83	26.97	26.66	29.60	32.95	34.21	32.94	32.47	27.86	21.72
SRHUB(I)	6.650	6.965	7.025	7.025	7.025	7.025	7.025	7.025	7.130	7.449	7.674	7.873	8.053	8.201	8.311	8.378
SC(I)	1.920	1.813	1.560	1.378	.814	1.115	.961	.976	2.663	1.015	.962	.877	.937	.895	.880	1.211
SBLADE(I)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
SIGUMR(I)	1.357	1.357	1.401	1.078	1.128	1.179	1.398	1.387	1.457	1.162	1.120	1.098	1.152	1.129	1.087	1.009
SIGUMS(I)	1.299	1.274	1.456	1.405	1.427	1.504	1.544	1.389	1.489	1.185	1.284	1.322	1.372	1.434	1.527	2.197
BET2SS(I)	6.21	-1.49	.38	8.86	1.41	6.55	5.24	16.23	16.50	22.78	24.28	25.79	23.93	20.90	16.87	3.03
GAPR(I)	.637	.612	.607	.453	.373	.339	.300	.300	.300	.300	.300	.300	.300	.300	.300	.300
GAPS(I)	.900	.760	2.395	.641	.390	.300	.300	.300	.300	.300	.300	.300	.300	.300	.300	.300
RRTIP(I)	18.29	17.09	16.32	11.11	10.70	10.44	10.23	9.94	9.69	9.56	9.55	9.55	9.55	9.55	9.55	9.55
SRTIP(I)	17.53	16.70	16.32	10.88	10.56	10.33	10.06	9.80	9.65	9.55	9.55	9.55	9.55	9.55	9.55	18.33
RT(I)	18.29	17.09	16.32	11.11	10.70	10.70	10.44	10.23	9.94	9.69	9.56	9.55	9.55	9.55	9.55	9.55
RM(I)	10.60	10.51	10.17	9.31	9.03	8.93	8.79	8.62	8.46	8.47	8.64	8.74	8.80	8.89	8.96	8.99
RH(I)	6.30	6.83	7.02	7.03	7.02	7.04	7.03	7.03	7.03	7.31	7.55	7.76	7.96	8.12	8.26	8.35
ST(I)	17.53	16.70	16.32	10.88	10.56	10.33	10.07	9.80	9.65	9.55	9.55	9.55	9.55	9.55	9.55	9.55
SM(I)	10.51	10.39	9.58	9.15	8.94	8.85	8.67	8.49	8.48	8.54	8.68	8.76	8.84	8.92	8.97	9.00
SH(I)	6.65	6.97	7.03	7.03	7.03	7.03	7.03	7.03	7.13	7.45	7.67	7.87	8.05	8.20	8.31	8.38
BLOCK(I)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BLOCKS(I)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BET1MR(I)	52.88	55.61	56.07	48.92	39.94	45.69	43.01	42.23	45.14	49.52	48.02	48.34	47.78	50.02	54.16	56.34
BET2MR(I)	40.40	42.36	37.73	29.71	26.76	26.64	24.73	15.25	16.06	37.92	33.59	33.90	36.39	36.92	45.10	45.40
BET1MS(I)	37.07	36.40	37.17	26.78	30.38	32.68	28.41	37.70	36.82	36.41	41.62	42.63	41.94	44.03	38.84	40.40
BET2MS(I)	6.21	-1.49	.38	8.86	1.41	6.55	5.24	16.23	16.50	22.78	24.28	25.79	23.93	20.90	16.87	3.03
PRI2D(I)	1.343	1.300	1.305	1.227	1.201	1.174	1.163	1.209	1.141	1.199	1.207	1.191	1.157	1.180	1.134	1.166
PRI3D(I)	1.335	1.293	1.301	1.223	1.194	1.161	1.152	1.177	1.134	1.192	1.197	1.180	1.145	1.173	1.129	1.159
ETARD(I)	.933	.933	.991	.885	.999	.879	.950	.867	.950	.910	.934	.924	.937	.928	.929	.934

***** INPUT DATA *****

FNF(FRACTION OF DESIGN CORRECTED SPEED)=1.000
XDIN(INITIAL WATER CONTENT OF SMALL DROPLET)= 0
XDDIN(INITIAL WATER CONTENT OF LARGE DROPLET)= .010
RHUMID(INITIAL RELATIVE HUMIDITY)= .00 PER CENT
XCH4(INITIAL METHANE CONTENT)= 0
TOG(COMPRESSOR INLET TOTAL TEMPRATURE OF GAS)= 518.70
TOW(COMPRESSOR INLET TEMPERATURE OF DROPLRET)= 513.70
PO(COMPRESSOR INLET TOTAL PRESSURE)=2116.80
DIN(INITIIL DROPLET DIAMETER OF SMALL DROPLET)= 20.0
DDIN(INITIAL DROPLET DIAMETER OF LARGE DROPLET)= 600.0
FND(DESIGN ROTATIONAL SPEED)= 9492.1
DSMASS(DESIGN MASS FLOW RATE)= 25.5000
BYPASS RATIO = 1.0050
COMPRESSOR INLET TOTAL TEMPERATURE(GAS PHASE) 518.70 R
COMPRESSOR INLET TOTAL PRESSURE=2116.80 LB/FT**2
PREB(PERCENT OF WATER THAT REBOUND AFTER IMPINGEMENT)= 50.0 PERCENT
ROTOR SPEED= 9492.1 RPM
CORRECTED ROTOR SPEED= 9492.1 RPM(100.0PER CENT OF DESIGN CORRECTED SPEED)

***** STAGE PERFORMANCE *****

FAIO	STAGE	PRATIO	TRATIO	ETA	XU	XW	XWW	XWT	TG	TW
.340	1	1.3790	1.1113	.8645	.0000	0	.0100	.0100	518.70	513.70
.340	2	1.3274	1.0983	.8560	.0000	.0043	.0057	.0100	576.41	513.70
.340	3	1.2474	1.0827	.7848	.0000	.0068	.0032	.0100	633.05	522.65
.340	4	1.1775	1.0605	.7836	.0000	.0058	0	.0058	685.39	529.49
.340	5	1.2033	1.0604	.8892	.0000	.0058	0	.0058	726.86	537.90
.340	6	1.1869	1.0592	.8349	.0000	.0058	0	.0058	770.77	547.65
.340	7	1.1673	1.0502	.8836	.0000	.0058	0	.0058	816.42	557.26
.340	8	1.1935	1.0649	.7808	.0000	.0058	0	.0058	857.40	566.25
.340	9	1.1531	1.0440	.9182	.0000	.0058	0	.0058	913.00	576.60
.340	10	1.2477	1.0701	.8997	.0000	.0058	0	.0058	953.16	585.87
.340	11	1.2517	1.0701	.9050	.0000	.0058	0	.0058	1019.97	598.81
.340	12	1.2325	1.0660	.8858	.0000	.0058	0	.0058	1091.50	615.84
.340	13	1.1978	1.0573	.8698	.0000	.0058	0	.0058	1163.52	625.63
.340	14	1.2129	1.0605	.8741	.0000	.0058	0	.0058	1230.16	634.85
.340	15	1.1691	1.0502	.8409	.0000	.0058	0	.0058	1304.61	645.28
.340	16	1.1777	1.0534	.8219	.0000	.0058	0	.0058	1370.12	654.94

***** OVERALL PERFORMANCE *****

INITIAL FLOW COEFFICIENT= .340

CORRECTED SPEED= 9492.1 1.000 FRACTION OF DEIGN CORRECTED SPEED

INITIAL WATER CONTENT(SMALL DROPLET)= 0

INITIAL WATER CONTENT(LARGE DROPLET)= .010

INITIAL WATER CONTENT(TOTAL)= .010

INITIAL RELATIVE HUMIDITY= .0 PER CENT

INITIAL METHANE CONTENT= 0

COMPRESSOR INLET TOTAL TEMPERATURE= 518.70

COMPRESSOR INLET TOTAL PRESSURE= 2116.80

CORRECTED MASS FLOW RATE OF MIXTURE=229.012

CORRECTED MASS FLOW RATE OF GAS PHASE 226.721

OVERALL TOTAL PRESSURE RATIO=23.7528

OVERALL TOTAL TEMPERATURE RATIO=2.7824

OVERALL ADIABATIC EFFICIENCY= .7747

***** PERFORMANCE OF FAN,LPC,HPC *****

	GAS PHASE CORRECTED MASS FLOW	STAGNATION PRESSURE RATIO	STAGNATION TEMPERATURE RATIO	ADIABATIC EFFICIENCY
FAN	226.7215	2.2834	1.3214	.7894
LPC	56.9264	2.7016	1.3907	.8006
HPC	24.8488	3.8505	1.5141	.8685

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