View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by NASA Technical Reports Server

July 1969

Brief 69-10112

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Prediction of Friction Coefficients for Gases

There has long been a need for a means of correlating both laminar and turbulent friction coefficients for gases, with large variations in the physical properties, flowing through smooth tubes. In recent years, the generally accepted relations used to predict friction coefficients for laminar and turbulent flow have undergone extensive experimental investigation. Observed coefficients were found to be as much as three times the predicted value.

Since 1967, empirical relations have been in use for laminar and turbulent flow wherein the friction coefficient based on bulk temperature is a function of modified Reynolds number based on surface temperature.

For modified surface *Reynolds numbers less than 3000* (corresponding to laminar flow), local and average friction coefficients can be predicted within ±20 percent for $1 < T_S/T_b < 4.1$ by the expression:

$$\frac{f}{2} = \frac{8}{Re_S}$$

where: f = friction coefficient
T_S = surface temperature
T_b = bulk temperature
Re_S = surface Reynolds number

For modified surface *Reynolds number of 3000 and greater* (corresponding to turbulent flow), local and average friction coefficients for both cooling and heating ($0.35 < T_S/T_b < 7.4$) can be predicted within ±10 percent by the expression:

$$\frac{f}{2} = \left(0.0007 + \frac{0.0625}{Re_s^{0.32}}\right)\left(\frac{T_S}{T_b}\right)^{-0.5}$$

These relations have been used to correlate friction coefficients for hydrogen, helium, nitrogen, carbon dioxide and air.

Notes:

1. These prediction methods apply to any of the problems of predicting friction pressure loss through a passage. It is applicable from the most simple piece of tube to the complex cooling passages of a regeneratively-cooled rocket nozzle.
2. Documentation is available from:
   Clearinghouse for Federal Scientific and Technical Information
   Springfield, Virginia 22151
   Price $3.00
   Reference: TSP69-10112
3. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B69-10112

Patent status:

No patent action is contemplated by NASA.

Source: Maynard F. Taylor
Lewis Research Center
(LEW-10774)

Category 02

This document was prepared under the sponsorship of the National Aeronautics and Space Administration. Neither the United States Government nor any person acting on behalf of the United States Government assumes any liability resulting from the use of the information contained in this document, or warrants that such use will be free from privately owned rights.