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Research Conducted Under

NASA GRANT NO. NSG 3036

# ACOUSTIC PROPERTIES OF TURBOFAN INLETS

FINAL TECHNICAL REPORT

SEPTEMBER 1, 1974 - OCTOBER 31, 1981

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# INTRODUCTION

The research conducted under NASA Grant NSG 3036 was concerned primarily with two objectives: The primary objective was to develop analytical procedures for estimating the acoustic properties of turbofan inlets. The secondary objective was the education of two students in the field of aeroacoustics. The achievements of this project can thus be summarized into two sections, each culminating in the doctoral dissertation of the appropriate student.

# DUCT ACOUSTICS

The analytical procedures developed between September 1,1974 and February 28, 1978, were concerned with prediction of the acoustic field within a duct containing a non-uniform steady flow. This analysis used the finite element method to calculate the velocity potential within the duct. Intermediate results obtained during the course of the research were presented at two AIAA conferences[1,2] and published in the AIAA Journal[3]. The development of the finite element method as a powerful technique in aeroacoustics was presented in Dr. Rudramuni Majjigi's Ph.D. thesis[4] and as a NASA Interim Technical Report[5].

In related research, the finite element method developed during this period was used to predict the admittance of supercritical rocket nozzles[6,7].

## INLET ACOUSTIC FIELDS

The second phase of the research, conducted between March 1, 1978 and March 1, 1982, dealt with the problem of describing the acoustic field of a turbofan inlet; i. e., both the acoustic propagation within the finite length inlet duct and the radiation to the surrounding enviornment. This analysis utilized the previously developed finite element method for propagation within the duct and an integral technique for predicting the acoustic field in the surrounding environment. The finite element method was improved substantially by the use of more advanced Hermite interpolating functions and a new assembly procedure was introduced which drastically reduced computation times. The two solution techniques are matched at an interface surrounding the inlet using an iteration scheme. The combined solutions thus provide a continuous description of the acoustic field surrounding the inlet. It was found that "optimum" values of the acoustic liners in ducts (i.e. liner impedance values which provide maximum sound attenuation) as computed using the matched solution technique, differ from those computed using the assumption of no reflection at the inlet entrance.

Results obtained during this period have been presented in two AIAA papers[8,9] and will be published in the AIAA Journal[10]. A detailed description of the analytical techniques developed during this period are presented in the Ph.D dissertation[11] of Dr. Scott J. Horowitz. It was originally intended that this thesis would serve as a final report. However, because of high printing costs, only a single copy of the thesis was sent to the contract monitor, Dr. Kenneth J. Baumeister. Additional copies are available from University Microfilms.

Finally, the authors would like to express their appreciation to Dr. Kenneth J. Baumeister and Dr. Charles E. Feiler of NASA-Lewis Research Center. Their advice and encouragement is greatly appreciated.

It should be noted that Dr. Scott Ho·owitz was awarded the Sigma Xi award for outstanding thesis for his Ph.D. dissertation[11].

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