

FLOW OVER A ROTATING BODY OF REVOLUTION

by

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Applied Mechanics Department

A Thesis

Submitted for the award of the degree

of

DOCTOR OF PHILOSOPHY

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

August, 1977

CERTIFICATE

This is to certify that the thesis entitled 'FLOW OVER A ROTATING BODY OF REVOLUTION' by Ashok Kumar Raghava has been prepared under our supervision in conformity with the rules and regulations of the Indian Institute of Technology, Delhi. We further certify that the thesis has attained a standard required for a Ph.D. degree of the Institute. The research report and results presented in the thesis have not been submitted, in part or full, to any other University for any degree or diploma.



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### ACKNOWLEDGEMENTS

The author wishes to express his sincere gratitude to Professor R. C. Malhotra and Dr. K. L. Kumar for their guidance, continuous encouragement and valuable discussions during the course of this investigation.

The author's sincere thanks are also due to Prof. J. H. Whitelaw for constructive criticism and advice on experimental aspect of the problem during his short-stay at the Institute, to Prof. Noor Afzal for valuable comments and advice at the initial stages and Dr. N. Chandrashekhar for several important and fruitful discussions.

Thanks are also due to the author's friends, in particular, Dr. B. B. Gupta, Dr. D. P. Agrawal and Dr. S. Z. Haider for the help in one way or the other, and also due to the friends in undergraduate and postgraduate courses for making the stay in IIT Delhi more lively.

Thanks are extended to the staff of the Fluid Mechanics Laboratories and Workshops for assistance in fabrication and installation of the experimental rig.

## ABSTRACT

Studies on the turbulent flow over a rotating body of revolution have been conducted by way of extensive experimentation and theoretical analysis.

The experimental programme was concerned with the data-collection and analysis for the mean-flow and turbulence parameters over a range of free-stream velocity and speed of rotation of the body. Three-tube pressure probes and single-sensor hot-wire probes, specially designed and fabricated, were mounted on a suitable versatile traverse gear for traversing in the flow. A pressure transfer unit was designed and made for measuring the wall-static pressures on the rotating body. The body was constructed in two halves, front and rear, to allow access to the components located within it. The tests were conducted by mounting the body centrally in the test-section of a subsonic wind tunnel having a flexible coiling. The measuring instruments were frequently calibrated to ensure the accuracy and reproducibility of the measurements. The objective of the mean-flow measurements were to obtain the pressure distribution and velocity profiles for the axial and azimuthal velocity components. The measurements were analysed to establish the validity of the similarity laws and to determine the effects of rotation and surface curvature on the mean-flow parameters. The turbulence measurements were planned to provide an insight into the structure of turbulence.

This was achieved by evaluating the Reynolds stresses, the space correlation functions and the energy density function. It was inferred from the variation of the space correlation and the energy spectra with rotation that there is an increase in the micro-scale of turbulence, a decrease in the macro-scale of turbulence and a widening of the range of energy-containing eddies with rotation. The experimental programme has resulted in a number of useful conclusions.

Viscous incompressible turbulent flow over a rotating body of revolution, of spheroidal shape, has been considered on the basis of the Navier-Stokes equations and then the conventional boundary layer theory has been embedded into a systematic expansion scheme. Analysis of the flow has been carried out, to a first approximation, by employing the method of asymptotic expansions. The maximum possible information has been extracted from the underdetermined system of equations for the mean motion without actually resorting to any closure hypothesis. The results thus obtained contain considerable information. However, it is difficult to identify some of this information with the experimental observations. An attempt was also made to predict the distributions of the axial and the azimuthal components of the mean velocity by employing an updated version of the Patankar-Spalding GENMIX 4 computer programme. Introduction of a modified mixing-length model in the programme resulted in obtaining satisfactory predictions for the axial-velocity profiles.

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