STUDY OF SWIRLING COMPRESSIBE FLOW THROUGH ANNULAR DIFFUSER

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A Thesis submitted in
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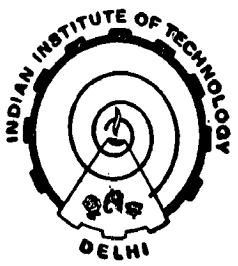

to the

DEPARTMENT OF MECHANICAL ENGINEERING
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Dedicated to

My dear Mother

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Rupinder Pal Singh Suker-Chakia

CERTIFICATE

This is to certify that the thesis entitled "STUDY OF SWIRLING COMPRESSIBLE FLOW THROUGH ANNULAR DIFFUSER" being submitted by Mr. Rupinder Pal Singh Suker-Chakia to the Indian Institute of Technology, Delhi, for the award of the degree of 'Doctor of Philosophy' in Mechanical Engineering is a record of bona fide research work carried out by him. He has worked under our guidance and supervision and has fulfilled the requirements for the submission of this thesis which, to our knowledge, has reached the requisite standard.

The results contained in this thesis have not been submitted, in part or in full, to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

Annular diffusers are likely to operate with varying amounts of swirl as they more often than not, operate in conjunction with turbomachines. Diffuser design, and study for the compressibility effects have become equally vital now with the aircraft and automotive industry's switch over to high pressure ratio turbomachines resulting in very high compressor exit Mach numbers. This involves the problem of successful integration of such advanced compressors with annular diffusers. The work described in this report is mainly an experimental investigation of the swirling, compressible, turbulent flows through annular diffusers with cylindrical hub and straight walled diverging casing. Suitable experimental set up was designed and fabricated and tests were conducted for a Mach range of 0.3 to 0.8 at diffuser inlet with swirl vane settings within 0° to 20°, from the radial direction. Stagnation temperature, and pressure head recorded by the yaw tube alongwith total pressure were recorded by the 3-hole, stagnation temperature and stagnation pressure probes respectively. The recording was done at various diffuser cross-sections with different area ratios which were considered to be the exit sections of various diffusers formed out of the same conical casing. The diffuser characteristics such as performance parameters ($\bar{C}_{PR}, \bar{\xi}, \bar{\eta}, \bar{\zeta}$), and density, temperature, pressure, tangential and axial velocities, and Mach number distributions in the flow field and the Reynolds number at various cross-sections were then computed from the experimental observations. An attempt has been made to establish the effects of inlet swirl and Mach number on the diffuser performance.

In the lower range of Mach number , a few degrees of swirl improved the pressure recovery to some optimum value and substantially reduced the chances of separation on the casing; this angle for optimum performance however decreased with increase in Mach number. Larger swirl angles were detrimental to diffuser performance and shifted the separation from casing to the hub. In the higher range of Mach number diffuser performance was very sensitive to swirl and optimum performance occured for non-swirling flows. In the lower range of Mach numbers, longer diffusers gave better performance while shorter diffusers were found more suitable for high Mach values. In general, substantial part of recovery occured in the initial stages of diffusion.

A finite-difference program developed by Mach for turbulent compressible flows through ducts of various shapes was remodelled to suit non-swirl flows through axisymmetric, annular diffusers. This was used to establish the performance of test diffusers for zero swirl case. The computed results were found to be in fairly good agreement with experimental data in the lower range of Mach numbers. There was departure between the two results at higher Mach numbers, which increased with increase in Mach number due to the known limitations of the program which was developed only for the isentropic flow.

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