INVESTIGATIONS ON VANED RADIAL DIFFUSERS WITH DIVERGING WALLS

BY

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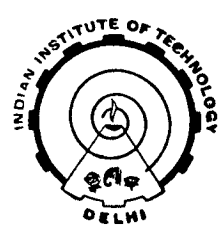
A thesis submitted in
fulfilment of the requirements for
the degree of
DOCTOR OF PHILOSOPHY



Department of Mechanical Engineering
INDIAN INSTITUTE OF TECHNOLOGY, DELHI
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Dedicated To

my Parents,

wife Padmaja

and Children

Suneeta and Anant

CERTIFICATE

This is to certify that the thesis entitled,"INVESTIGATIONS ON VANED RADIAL DIFFUSERS WITH DIVERGING WALLS" being submitted by Mr. Purushottam Shrikrishna Utgikar 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

The existing literature indicates the growing need of developing a compact and efficient diffuser for converting the kinetic energy of the fluid discharged by a centrifugal impeller into pressure energy. A vaned diffuser with diverging side walls offers high potential to the problem. Realizing this fact, the present work was undertaken to understand the detailed flow characteristics of the 6^{o}-included angle diverging wall vaned radial diffuser and to evaluate its overall performance through an exhaustive experimentation so as to arrive at the optimum geometric dimensions of this new type of the diffuser.

The significant geometric and fluid-dynamic parameters affecting the performance of a vaned diffuser were identified through a review of the existing literature. The experimental programme was concerned with data collection in terms of total pressure, static pressure, velocity and flow angle profiles and vane and wall static pressure distributions. For this purpose, a large size test rig was designed and fabricated. A centrifugal blower supplied air to the test diffuser and swirl was imparted at the diffuser entry by means of a double wire-gauze rotor. The diffuser vanes were straight, made out of 3 mm thick m.s. plate, with the vane leading edge angle of 45^{o}. A 3-hole probe, mounted on a suitable gear, was traversed in the flow field. Tests were conducted on a number of diffusers for variou values of incidence (-15^{o} to $+15^{o}$), Reynolds number (0.95×10^{5} to 2.6×10^{5}) and area ratio (1.0 to 3.96).

Experimental results indicated that the number and aspect ratio of the vanes, area ratio, incidence and inlet blockage have a strong influence on the diffuser performance. Diffuser VD-8 with 12 vanes of aspect ratio 0.25 (solidity = 2.27, equivalent cone angle = 14.8^{o}), gave the best performance in the range of experimentation. Maximum values of C_{pr} and ε of

0.69 and 0.76 respectively and minimum value of $\bar{\zeta}$ of 0.22, were obtained at an incidence of -5° in this diffuser. It was observed that the number of vanes less than the optimum deteriorated the diffuser performance more, as compared to the number of vanes, a little more than the optimum. Velocity profiles at the diffuser exit improved with increase in the vane aspect ratio; however, optimum performance did not occur in the diffuser with highest aspect ratio, due to the increased skin friction losses. Practically all of the vane loading occurred from the initial 60% length of the vane. Increase in C_{pr} and ϵ with area ratio was little for $AR > 3$. Flow visualization with tuft probe traverses indicated the existence of secondary flow in the downstream part of the diffuser channel. All diffusers showed stall patches, the presence of stall depended largely on incidence and Reynolds number. Regions of fixed stall appearing at the inlet region and on the inner wall, in some diffusers, indicated premature flow separations at this wall.

Comparison of some of the experimentally obtained vane surface pressure distributions with those of theoretically predicted results of the 3-D potential flow analysis using finite element method, showed a reasonably close agreement between the two in 20 to 40% length of the vane from the leading edge, while there was a large deviation at the leading and trailing edges. An improvement of about 10% in C_{pr} and reduction of about 25% in $\bar{\zeta}$ was possible by introducing splitter vanes in the upstream portion of the diffuser.

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