SOME STUDIES ON AERODYNAMIC PERFORMANCE OF A RADIAL COMPRESSOR STAGE

by

S. K. BANSAL

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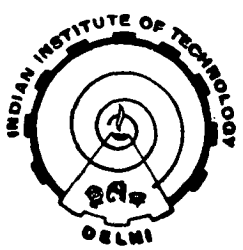
DOCTOR OF PHILOSOPHY



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CERTIFICATE

This is to certify that the dissertation entitled "Studies on Aerodynamic Performance of A Radial Compressor Stage" which is being submitted by Mr. Surinder Kumar Bansal to the Indian Institute of Technology, Delhi, is a record of the bonafide research work carried out by him under our guidance and supervision. In our opinion, this dissertation has reached the standard fulfilling the requirements of all the regulations relating to the degree. The results contained in it 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

Centrifugal compressors play a vital role in providing compressed air and gas supply in a variety of industrial as well as gas-turbine propulsion applications. The aerodynamic performance of a compressor stage generally depends on a number of factors. These factors include the design as well as operating parameters for impeller and diffuser, besides inlet and exit boundary conditions. The developement of a high efficiency compressor stage is greatly dependent on a proper understanding of the influence of these factors on the performance characteristics and operating stability.

In the present work, a study of aerodynamic performance of a radial compressor stage has been carried out. The investigation includes some tests on a single stage radial compressor referred as compressor - A, to illustrate the aerodynamic performance of a radial compressor as is affected by impeller blade stagger, number of impeller blades, number of diffusers vanes, and different intake configurations. Further some tests have been carried out on another compressor, referred as compressor - B, to examine the effect of impeller blade profile and exit boundary conditions.

The impeller of compressor - A is tested with 9 or 18 aerofoil shaped blades for two stagger setting of 32 and 45 degrees with respect to radial direction. The diffuser tested

with these impeller configurations are vaneless diffuser of 89 mm or 72 mm width and vaned diffuser of 72 mm width fitted with 10 or 20 wedge shaped vanes. The effect of these factors has been examined for two type of intakes, i.e., an inlet-ring with area-ratio of 5.94 and a straight inlet pipe with L/D ratio of 4.8. Various combinations of these diffusers and impeller configurations in different compressor builds have been tested.

The compressor - B has been tested with three types of impeller blade profiles to examine the effect of impeller blade shape on the compressor performance. This compressor has also been tested with two types of throttling arrangements to examine the effect of exit boundary conditions (BC I and BC II) on its stalling behaviour and performance characteristics. The exit boundary condition, BC I, refers to a discharge through a throttle valve, installed at the exit of a long discharge ducting. Whereas the exit boundary condition, BC II, implies that the flow through the compressor is regulated by a closely coupled throttle installed at the exit of the diffuser vane row.

The performance of the compressor stage is obtained from the measurement of static-to-total pressure rise. The flow rate is measured using an orifice plate installed in the discharge duct. The total pressure, velocity and flow angle traverses are carried out at various locations which included the impeller and the diffuser exit. A miniature pressure transducer of semi strain gauge type is used for wall static pressure

fluctuation measurements. Hot wire probes are used to measure the instantaneous velocities and flow directions at the exit of the impeller employing a phase-lock averaging technique and a data acquisition system. Turbulence intensity is also measured at the exit of the impeller using a single Hotwire probe. Spectral analysis of pressure and hot wire signals is also carried out. The results of the experimental investigations are analysed to illustrate the effect of various parameters on the performance of a radial stage.

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