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FLOW ANALYSIS OF ANNULAR DIFFUSERS

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ABSTRACT

Diffusers are extensively used in centrifugal compressors, axial flow compressors, ram jets, combustion chambers, inlet portions of jet engines etc. The energy transfer in these turbo machineries involves the exchange of significant levels of kinetic energy in order to accomplish the intended purpose. As a consequence, very large levels of residual kinetic energy frequently accompany the work input and work extraction processes, sometime as much as 50% of the total energy transferred. A small change in pressure recovery can increases the efficiency significantly. Therefore diffusers are absolutely essential for good turbomachinery performance The geometric limitations in aircraft applications where the diffusers need to be specially designed so as to achieve maximum pressure recovery within the shortest possible length led to the development of annular diffusers. In the present study the performance of a series of annular diffusers of divergence angles (9º, 15º, 21º and 27º) are determined. . A 3-d annular diffuser model was done in PRO-E and the analysis was carried out in ANSYS FLUENT. The results are indicated in the form of velocity diagram, pressure diagram, static pressure distributaries and static pressure recovery coefficient along hub and casing wall. The results show some striking features as the divergence angle increases the pressure recovery also increases considerably.

Keywords:Flowanalysis,Annulardiffuser,Pressure recovery,Divergence angle,Reynolds number.

I INTRODUCTION

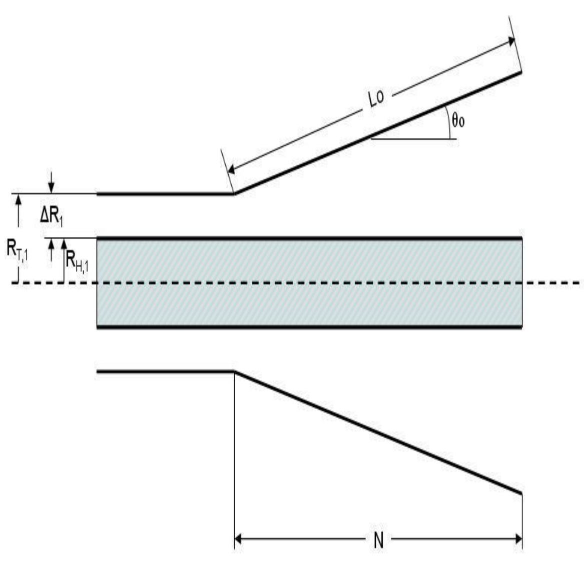
Today, and for the majority of the near future, turbines will dominate the field of energy production that today turbo-powered electricity generation dominates the market at over 96 percent of all means of electricity generation. In fact, the turbine market will not even drop one percent by the year 2030. These efforts have been under way for some time now, with advancements in turbine technologies coming out quite regularly. Improvements are usually sought in areas where efficiencies can be raised; and this often leads to research in aerodynamic losses from current designs. The penalty from aerodynamic losses can be quite large, and even a one percent rise in turbine efficiency can be a substantial improvement in the turbine industry. Following these principles, the current research focused on characterizing the flow in a specific portion of the turbine where aerodynamic losses are impeding technology advancements. The diffuser portion at the exit of the compressor as the flow makes its way into the combustor was studied.

II METHODOLOGY ADOPTED TO MEET THE OBJECTIVES

- Collection of the basic geometrical data of an annular diffuser from the literature survey and creation of 3-D model of the diffuser using cad software PRO-E.
- Calculating the boundary conditions
- CFD modelling (generation of grid) using ICEM CFD.
- Analysis using Ansys **Fluent**.
- Obtaining flow field results using the CFD solvers.

III PROBLEM DESCRIPTION

A 3 d model of diffuser is generated using pro e ,a cad software and and meshing is done with icem cfd and analysis is carried out using ANSYS FLUENT.



	Diffuser 1	Diffuser 2	Diffuser 3	Diffuser 4
θ_0	9^0	15^0	21^0	27^0
R_{H1}	2.108 cm	2.108 cm	2.108 cm	2.108 cm
R_{TI}	3.896 cm	3.896 cm	3.896 cm	3.896 cm
ΔR_1	1.788 cm	1.788 cm	1.788 cm	1.788 cm
R_{H2}	3.594 cm	4.843 cm	6.164 cm	7.597 cm
L0	11.542cm	11.802 cm	12.21 cm	12.79 cm
N	11.4 cm	11.4 cm	11.4 cm	11.4 cm

IV MATERIAL PROPERTIES AND BOUNDARY CONDITIONS

1. MESH MODEL:
   Solver type: pressure based
   Problem model: Standard k epsilon
2. MATERIAL :
   Fluid: Water vapour
   Casing material: Aluminium
3. BOUNDARY CONDITIONS:
   INLET:
   Mass flow rate: 0.02259kg/s
   Turbulence intensity :
   for reynolds number 50000: 5%
   Hydraualic diameter: 0.01788m
   OUTLET:
   Pressure: Atmospheric pressure (101.325)

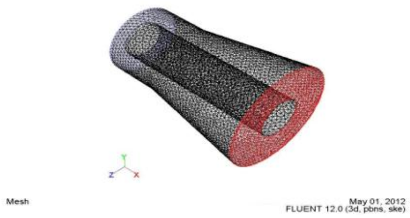
4.RESULTS:

The results that are taken for the present thesis work are as follows:

- Static pressure
- Pressure coefficient
- Velocity magnitude

V RESULTS AND DISCUSSIONS

This chapter gives an insight of the findings that are obtained from the analysis of the 3-D annular diffuser done in CFD. Different modifications on the basic geometry were investigated to optimize the performance of the diffuser. First a model for the base diffuser was developed by taking its geometric data from literature and the performance data serve as a reference for comparing the performance of the modified. In order to find the optimum performance results of the annular diffuser geometric parameters has been varied and these results are projected below. It is assumed that the flow is exhausted to atmosphere, so pressure at exit of diffuser is assumed to be atmospheric. The meshed model of the annular diffuser is shown in below figure



Figures below represent the results generated by FLUENT. In these figures the fluid characteristics like velocity, pressure and turbulent kinetic energy are shown by different color.

A particular color does not give single value of these characteristics, but show the range of these values. If the value of a characteristic at a particular point falls in this range, there will be color of that range.

I. PRESSURE COEFFICIENT

The static pressure coefficient distribution along the diffuser is shown in the below figures at different divergence angles (9◦, 15◦, 21◦, 27◦)

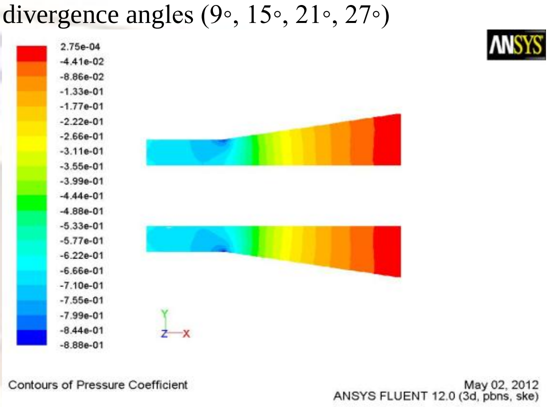


Fig1:Pressure Coefficient distribution at a divergence angle of 9◦

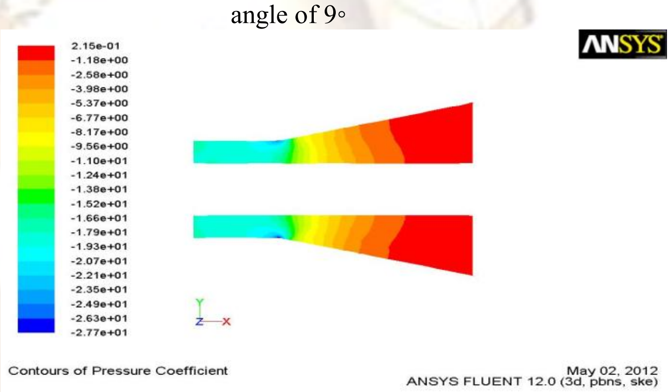


Fig2:Pressure Coefficient distribution at a divergence angle of 15^0

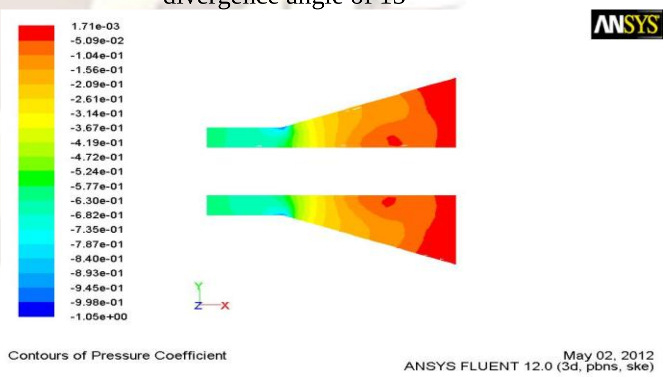


Fig3:Pressure Coefficient distribution at a divergence angle of 21^0

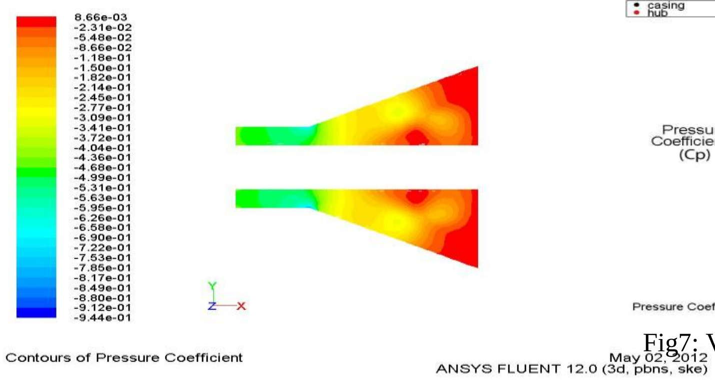


Fig4:Pressure Coefficient distribution at a divergence angle of 27^0 .

The pressure coefficient is a dimensionless number which describes the relative pressures throughout a flow field in fluid dynamics. Every point in a fluid flow field has its own unique pressure coefficient. The distribution of the pressure coefficient along the diffuser is presented in the above figures.The pressure coefficient increases as the fluid flows but at the initial stages the pressure coefficient remains near constant.

II. GRAPHICAL REPRESENTATION OF PRESSURE COEEFICIENT:

The variation of the pressure coefficient with X/L is shown in the below figures at different divergence angles (9◦, 15◦, 21◦, 27◦)

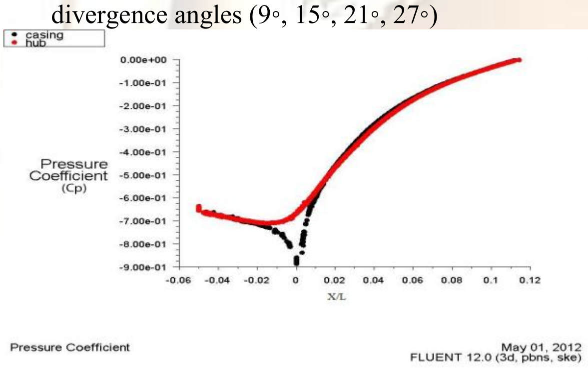


Fig5:Variation of Pressure coefficient with X/L at divergence angle of 9^0

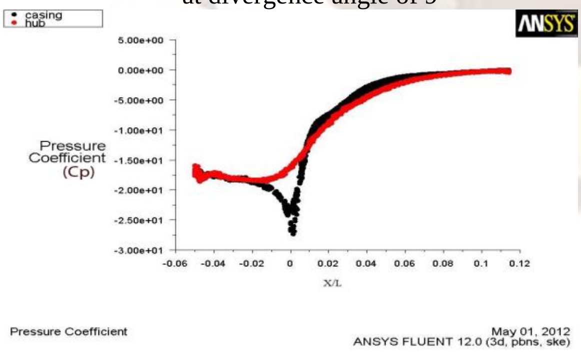


Fig6:Variation of Pressure coefficient with X/L at divergence angle of 15◦

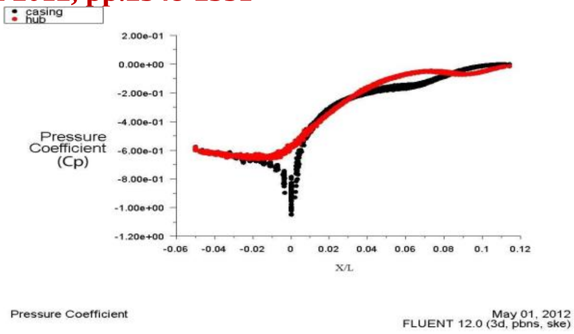


Fig7: Variation of Pressure coefficient with X/L at divergence angle of 21^0

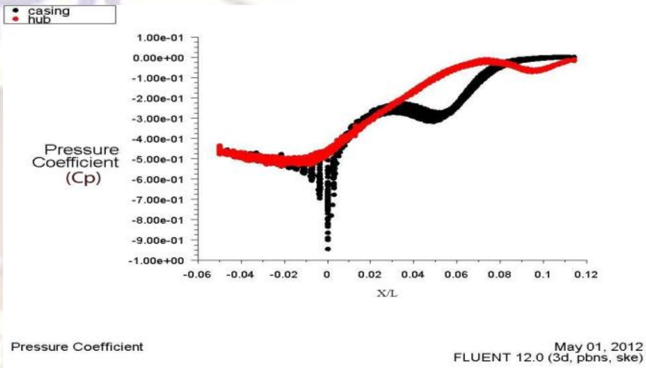


Fig8:Variation of Pressure coefficient with X/L at divergence angle of 27^0

Near the entrance region, the value of Cp is negative for the casing wall due to entrance static pressure disturbance. As the value of divergence angle increases, this negative value of Cp at hub wall also increases.

III IMPACT OF DIVERGENCE ANGLE ON PRESSURE RECOVERY IN DIFUSER

Graphs are plotted taking X/L on X-axis and Pressure coefficient on Y-axis to know the impact of divergence angle on the pressure coefficient. The graphs are shown below,

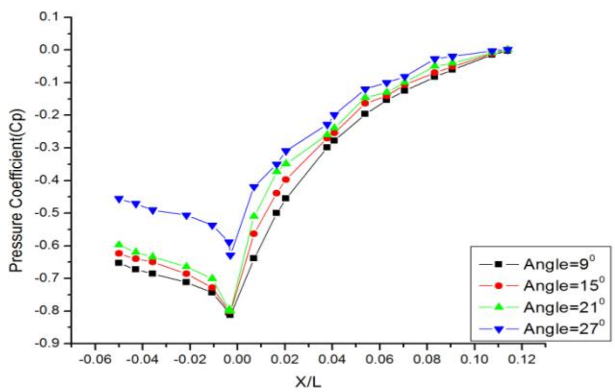


Fig9:Variation of Pressure coefficient (Cp) with different divergence angles

From the above figure we can observe that pressure coefficient increases as the angle of divergence increases. Due to this increase in pressure coefficient the pressure recovery increases which is very essential for a diffuser. We can increase the divergence angle further but from the above figures we can observe that the pressure coefficient increase in divergence angle from 21^0 to 27^0 is very less even though initial stages it's more. So there is no much use in increasing the divergence angle further.

VI CONCLUSIONS

It is a major issue to increase the fluid pressure with minimum decrease in flow velocity in turbo machinery. A diffuser is a component found in all turbo machines and is used to decrease flow velocity while increasing fluid pressure. As geometrically simple as the diffuser may be, it is actually a quite complex aspect of the turbine to create high flow pressure with minimum flow velocity. Flows with high adverse pressure gradients produce many problems in modelling and design. So an attempt was made through this project to achieve high pressure with low flow velocity. For this an annular diffuser was considered and a 3-d model of the same was generated using PRO-E. Turbulent flow inside the annular diffusers with variation in divergence angles are analyzed using the Ansys Fluent. On the basis of the findings incurred from the analysis the following conclusions can be drawn:

1. The pressure recovery within the diffuser increases as the flow proceeds except at the initial stage of the diffuser whereas the velocity decreases as the flow proceeds.
2. The static pressure and the pressure coefficient follow the same strategy as the flow proceeds. Both the static pressure and the pressure coefficient increases as the flow proceeds.
3. Graphs are drawn for the pressure coefficient for casing and hub along the X/L which shows the increase in pressure coefficient.
4. The impact of the divergence angle is clearly noticed on the pressure coefficient. Different divergence angles (9^0, 15^0, 21^0, 27^0) are considered for the present work. As the divergence angles increases the pressure coefficient also increases leading to high pressure recovery.
5. Increasing divergence more than 27^0 has no use as the pressure coefficient increase between the angles is seen to be decreasing at 21^0 .

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