EXPERIMENTAL VERIFICATION AND ANALYSIS OF FLOW THROUGH DIFFUSER USING CFD

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Abstract— **Diffuser is the important feature of turbo machinery, which is used for the efficient conversion of kinetic energy into pressure energy. Among the various types of diffusers, least attention has been given to diffusers because of the number of geometric parameters that needed to be considered. 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 diffusers. Diffuser model of ratio 1:4, 1:6 and 1:10 has been chosen for analysis whichever gives better pressure recovery that model will be optimized. ICEM CFD is used for modelling and meshing and CFX is used for analysis. Results has been obtained in post CFD**

Keywords— **Diffuser, pressure recovery, CFD**

Introduction:

A diffuser is a device that increases the pressure of a fluid at the expense of its kinetic energy. The cross-section area of diffuser increases in the direction of flow, therefore fluid is decelerated as it flows through it causing a rise in static pressure along the stream. Such a process is known as diffusion. The flow process near the diffuser walls is subjected to greater retardation due to the formation and development of the boundary layer. A study of the parameters governing the development of the boundary layer and their relationship with diffuser performance is, therefore vital in optimizing the design of a diffuser.

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 turbo machinery performance.

EXPERIMENTAL SETUP

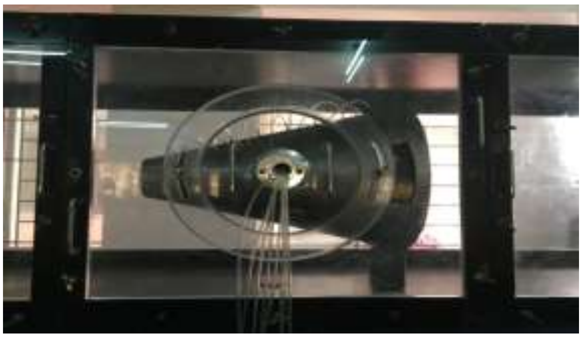
The experimental setup has been done. The models with different area ratios are being fabricated and tested in wind tunnel for the different velocities like 10, 20 m/s for each model. The model ratios are chosen has 1:10, 1:6, 1:4.

The wind tunnel is used here is the subsonic wind tunnel; its maximum speed is 45m/s. It has the test section dimensions of 600*600*100 mm.

The following will show the experimental setup of the diffuser.

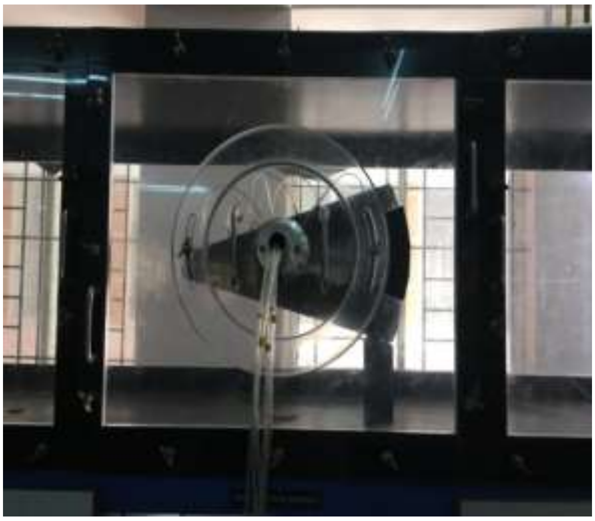
SUBSONIC WIND TUNNEL

Dia ratio model 1:4



Model mounted inside the wind tunnel and connected to water manometer through pressure ports.

Diffuser Model-dia ratio is 1:6



Model mounted inside the wind tunnel and connected to water manometer through pressure ports.

Diffuser Model- dia ratio is 1:10

Model mounted inside the wind tunnel and connected to water manometer through pressure ports.

Experimental readings:

For 1:4-velocity-20 m/s

Ports no	h_w (mm)	h_a (m)	P(pa)
1	9.2	7.66	90.17
2	12.0	10.0	117.72
3	15.4	12.83	151.034
4	17.6	14.66	172.57
5	19.1	15.91	187.2
6	21.0	17.5	206.01
7	22.0	18.33	215.78
8	24.6	20.5	241.32

For 1:6-velocity-10 m/s

Ports no	h_w (mm)	h_a (m)	P(pa)
1	6.4	5.33	62.74
2	7.1	5.91	69.57
3	8.0	6.66	78.4
4	10.0	8.33	98.06
5	12.0	10.0	117.72
6	14.0	11.66	137.26
7	17.0	14.16	166.69
8	19.6	16.33	192.23

For 1:6-velocity-20 m/s

Ports no	h_w (mm)	h_a (m)	P(pa)
1	6.2	5.161	60.75
2	7.9	6.58	77.45
3	8.2	6.83	80.40
4	10.6	8.83	103.94
5	12.1	10.08	118.66
6	14.2	11.83	139.26
7	16.0	13.33	156.92
8	17.6	14.66	172.57

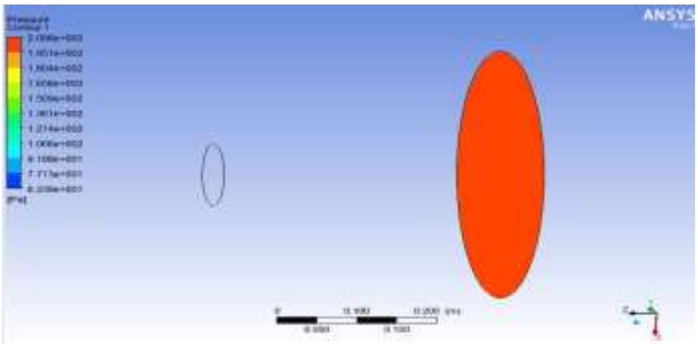
For 1:10-velocity-10 m/s

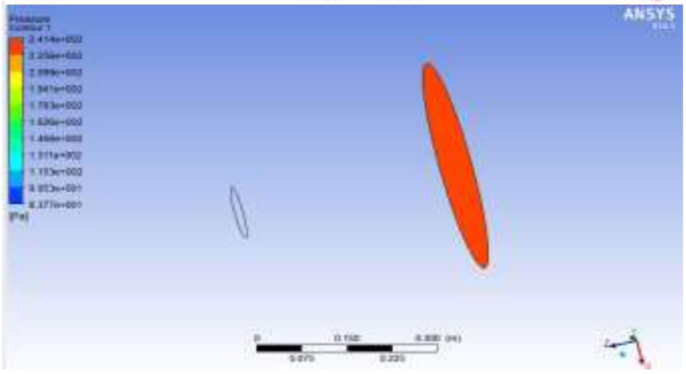
Ports no	h_w (mm)	h_a (m)	P(pa)
1	8.6	7.166	84.36
2	11.00	9.166	107.91
3	14.1	11.75	138.32
4	15.8	13.166	154.990
5	17.9	14.91	175.52
6	20.1	16.75	197.18
7	23.4	19.5	229.55
8	25.4	21.166	249.17

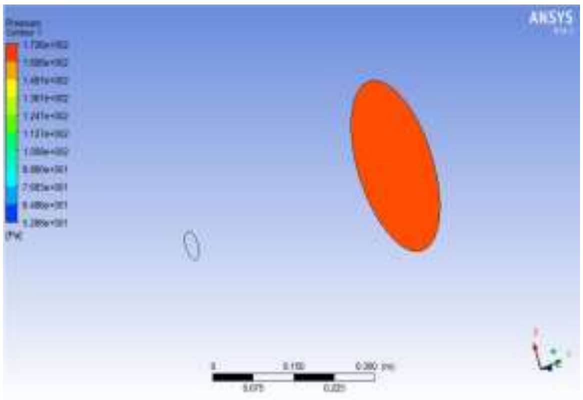
For 1:10-velocity-20 m/s

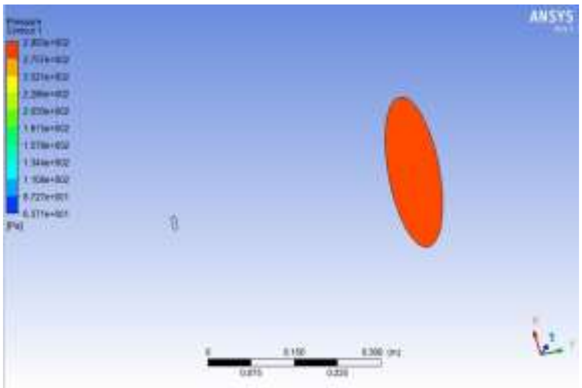
Ports no	h_w (mm)	h_a (m)	P(pa)
1	9	7.5	88.29
2	12.1	10.08	118.66
3	14.8	12.33	145.15
4	16.2	13.5	158.92
5	18.2	15.16	178.53
6	20.8	17.33	204.04
7	23.9	19.91	234.45
8	26.6	22.16	264.93

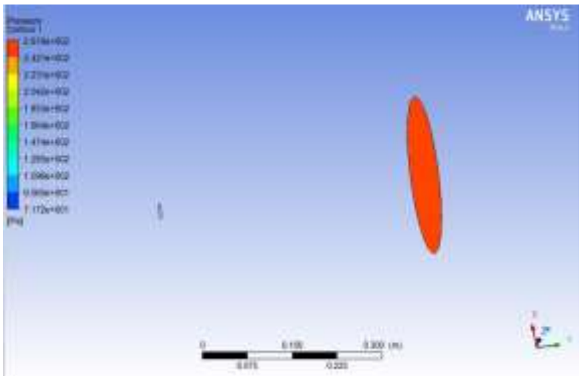
CFD ANALYSIS











THE ABOVE FIGURE SHOWS PRESSURE CONTOUR FOR OUTLET FOR 1:4,1:6 AND 1:10 WHICH VALIDATES EXPERIMENTAL VALUES

CONCLUSIONS

Subsonic turbulent flows inside the various diffusers of different geometric are analysed. The pressure recovery within the diffuser increases as the flow proceeds; the rate of increase reduces with an increases in the distance from the inlet.

1. For no swirl condition, there is no separation observed at the casing wall
2. With increases in inlet velocity, there is a marginal increase in pressure recovery, since the entrance losses increases with velocity.
3. For the small value of Mach No., there is small change in press recovery upto cone angle of 15º. With further increases in angle, it reduces at high rate due to high divergence of passage.

The static pressure distribution increases uniformly along the length of diffuser for both hub and casing walls, since there is no separation or recirculation on the walls.

4. With increase in area ratio pressure recovery increases due to higher rate of diffusion but pressure recovery loss also increases. The model of 1: 10 dia ratio model has been optimized.

REFERENCES

1. Ackert J., 1967. *"Aspect of Internal Flow"*. Fluid Mechanics of Internal Flow, Ed. Sovran G., Elsevier Amsterdum, pp1.
2. Adkins R.C., Jacobsen O.H., Chevalier P., 1983. *"A Premilary Study of Annular Diffuser with Constant Diameter Outer Wall"*. ASME Paper No. 83-GT-218.
3. Adkins R.C., 1983. *"A simple Method for Design Optimum Annular Diffusers"*. ASME Paper No. 83-GT-42.
4. Awai T., Nakagawa T., Sakai T., 1986. *"Study of Axially Curved Mixed Flow Vane less Diffuser"*. Bull JSME 29, 1759-1764.
5. Cockrell D.J., Markland E., 1963. *"A Review of Incompressible Diffuser Flow"*. Aircraft Engg. Volume 35, pp 286.
6. Coladipietro R., Schneider J. M., Sridhar K., 1974. *"Effects of Inlet Flow Conditions on the Performance of Equiangular Annular Diffusers"*. Trans. CSME 3 (2), pp 75-82.
7. Dovzhik S. A., Kartavenko V. M., 1975. *"Measurement of the Effect of Flow Swirl on the Efficiency of Annular Ducts and exhaust Nozzles of Axial Turbomachines"*. Fluid Mechanics/Soviet Research 4(4), 156-172.
8. Goebel J. H., Japikse D., 1981. *"The Performance of an Annular Diffuser Subject to Various Inlet Blockage and Rotor Discharge Effects"*. Consortium Final Report, Creare TN-325.
9. Hesterman R., Kim S., Ban Khalid A., Witting S., 1995. *"Flow Field and Performances Characteristics of Combustor Diffusers: A Basic Study"*. Trans. ASME Journal Engineering for Gas Turbine and Power 117, pp 686-694.

