Computational and optimization of impeller blades effect on centrifugal compressor

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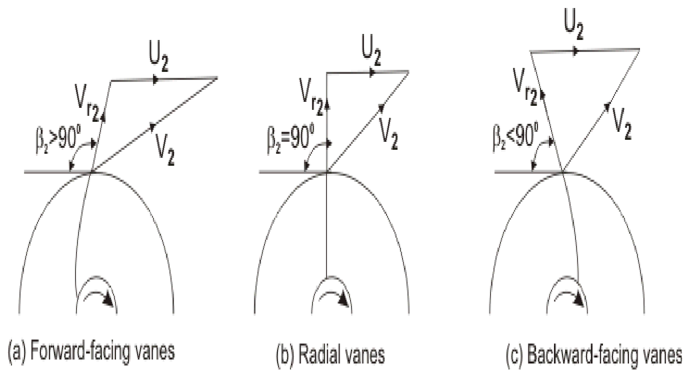
Abstract— Impeller is an rotating part where is used to increase the pressure of an working fluid. In this study, by placing the same dimensions in all type of blades like Forward, Backward and forward- backward type combination, results were analyzed. The cad models are generated using catia v5 and the results were analyzed in ANSYS FLUENT V14.5. New design of forward and backward combination has been undergone in this project.
As the blade width at exit of the impeller increases the performance of centrifugal pump increases. As the exit diameter of the impeller decreases the performance of centrifugal pump increases. As the trailing edge blade angle of the impeller increases the performance of centrifugal pump increases.

***Keywords*: Computational Fluid Dynamic (CFD), Blade design, Ansys, Blade width, Trailing edge blade angle (β2).**

INTRODUCTION

Centrifugal fans and blowers are the turbo machines widely used in present industrial and domestic life. It is important to recognize that the design of any turbo machine is an interdisciplinary process, involving aerodynamics, thermodynamics, fluid dynamics, stress analysis, vibration analysis, the selection of materials, and the requirements for manufacturing. Though centrifugal fans have been developed as highly efficient machines, design is still based on various empirical and semi empirical rules proposed by fan designers. Manufacturing industries of fans and blowers seldom followed optimum design solution for individual fan/blower. Mostly their design and fabrication is based on series of successful past models or derived from fan laws and geometrical similarities. During extensive literature review on design and performance evaluation of pumps, blowers and fans, it is observed that much research work has been carried out on local flow physics, aerodynamics and phenomena of energy transfer. Designing of these turbo machines requires computation with many variables and coefficients. It is also studied that the design methodologies suggested by different researchers differ widely. It has revealed lacuna of explicit design methodology which can give desired performance. One of the objectives of present study is to design and analyze performance of explicit design methodologies as suggested in literature. Three systematic design methodologies for centrifugal fan are traced out after comprehensive literature review. Focusing on these three design methods, comparative assessment is made mathematically and then experiments are carried out to get optimum design solution. These design methodologies are summarized as under and discussed in detail subsequently. In centrifugal compressor, the gases flow enters the impeller in an axial direction and exits in a radial direction.
The gas fluid is forced through the impeller by rapidly rotating impeller blades. The kinetic velocity energy from rotating impeller is converted to pressure energy, partially in the impeller and partially in the stationary diffusers. The diffuser consists of a vane less space, a vane that is tangential to the impeller, or a combination of both. These vane passages diverge to convert the velocity head into pressure energy.



VELOCITY TRIANGLE

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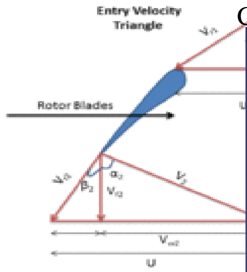
FEATURES OF IMPELLER	(mm)
Overall dia of impeller	500
Eye diamter	150
Hub diameter	55
Inlet blade angle	44.40deg
Outlet blade angle	26.09deg
Blade thickness	6mm
Number of blades	20 to 21
Inlet diameter	130
Inlet blade width	22.2
Outlet blade width	7.7
Shaft diameter	43



METHODOLOGY

The model of three different types of impellers are generated in CATIA V5 i.e(forward type, backward type, and forward and backward type combinations). Then the impellers are meshed by using software called ANSYS MESH V14.1. The different types of mesh models are imported in ansys Fluent and the distribution on pressure and velocity variations are noted. Then the results are compared with our numerical part of calculation.

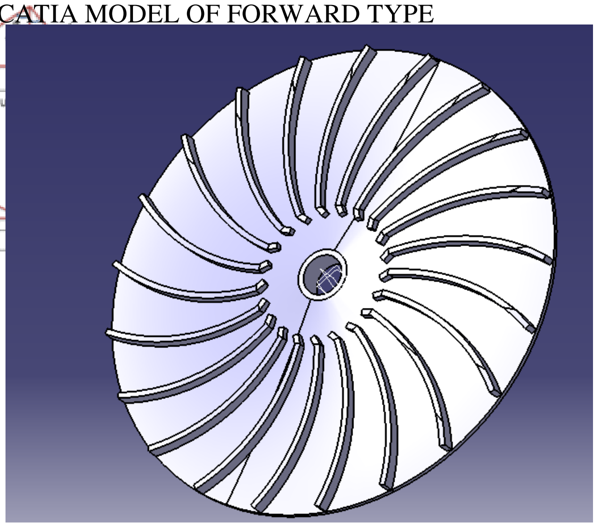
IMPELLER DIMENSIONS HAS BEEN CALCULATE BASED ON THE FOLLOWING DATAS

The below datas has been taken from base paper and some

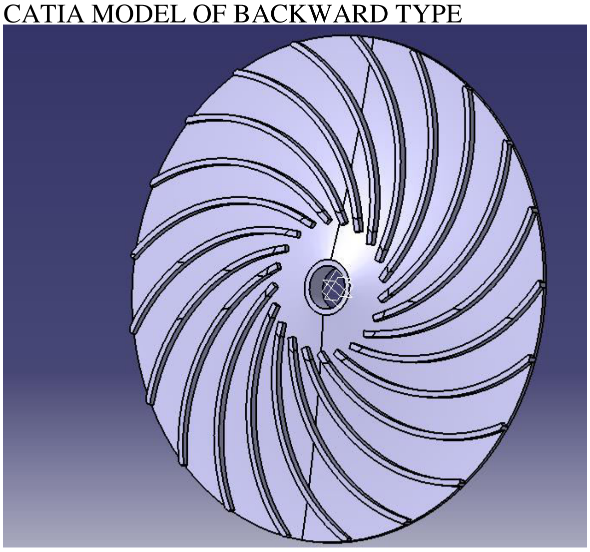
Power input factor	**1.04**
Speed	310rev/sec
Slip factor	0.9
Eye dia	150mm
overall dia of impeller	500mm
Mass flow rate	9kg/s
Isentropic efficiency	0.78
T_{01}	295k
P_{01}	1.1bar

DIMENSIONS HAS BEEN NOTED ACCORDING TO CALCULATIONS

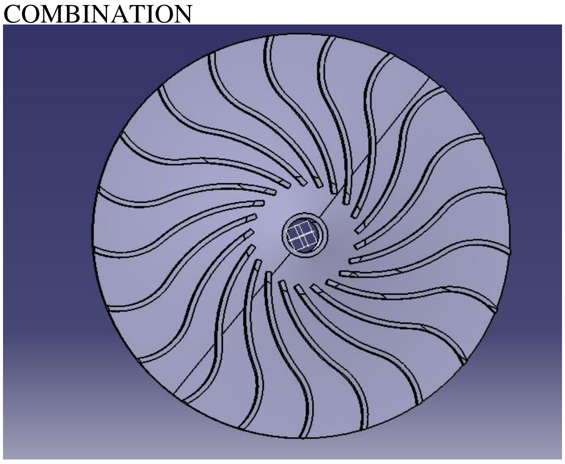
CATIA MODEL OF FORWARD TYPE



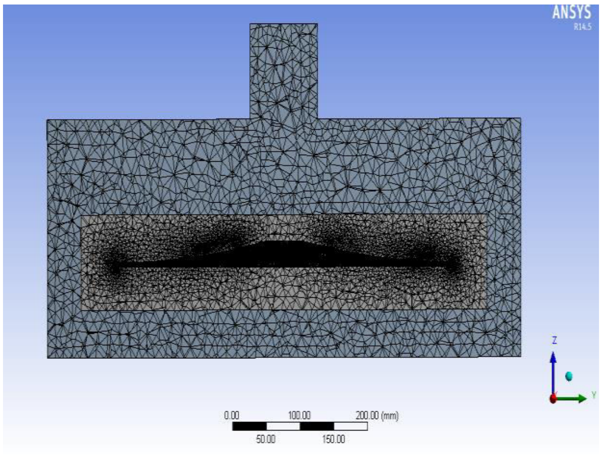
CATIA MODEL OF BACKWARD TYPE



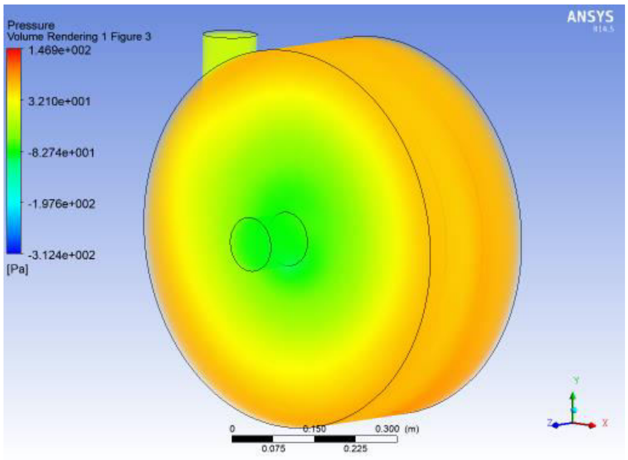
CATIA MODEL OF FORWARD-BACKWARD COMBINATION



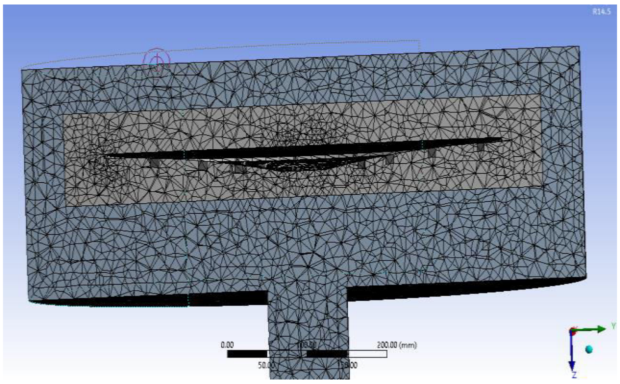
MESHING MODEL OF FORWARD TYPE WITH DOMAIN CREATION



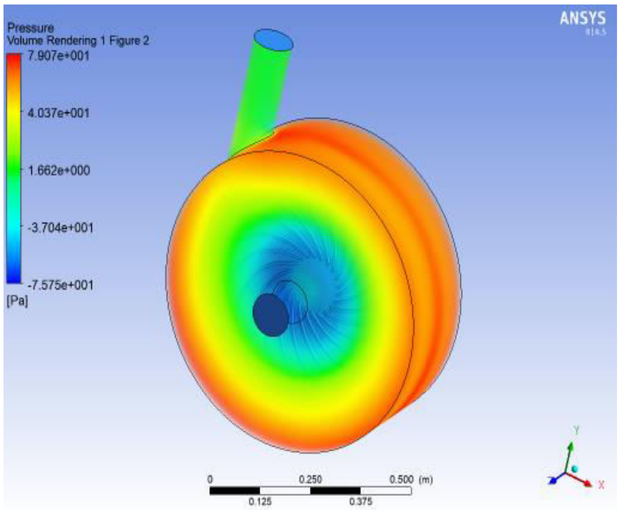
PRESSURE DISTRIBUTION ON FORWARD TYPE



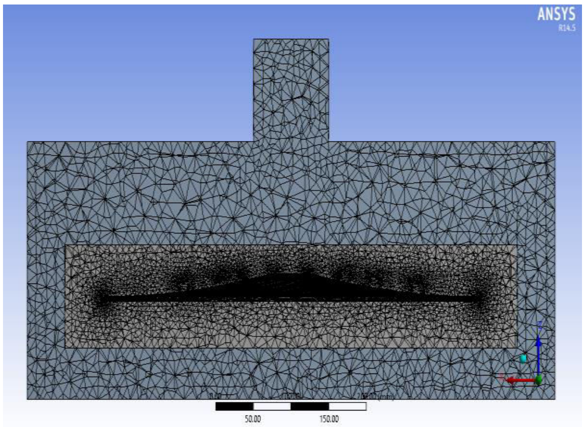
MESHING MODEL OF BACKWARD TYPE WITH DOMAIN CREATION



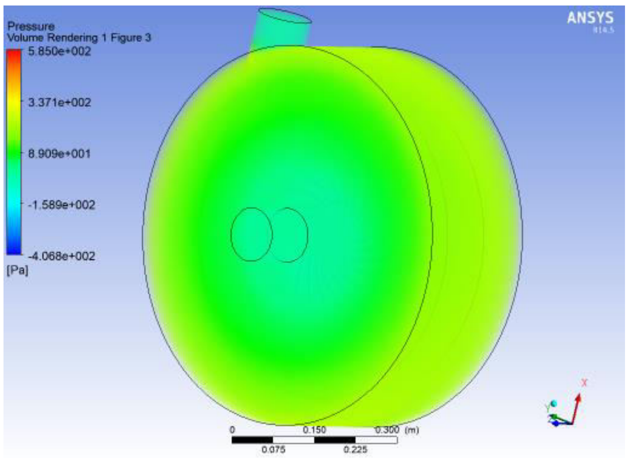
PRESSURE DISTRIBUTION ON BACKWARD TYPE



MESHING MODEL OF FORWARD-BACKWARD COMBINATION WITH DOMAIN



PRESSURE DISTRIBUTION ON FORWARD-BACKWARD TYPE



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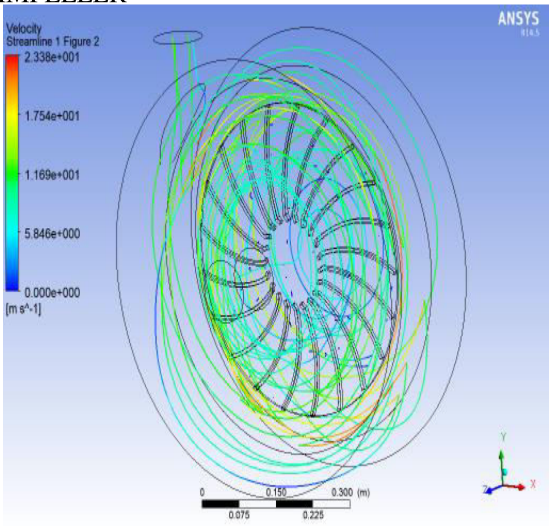
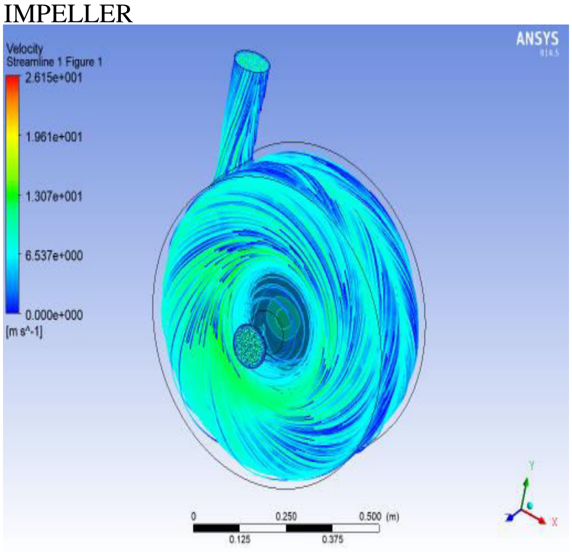
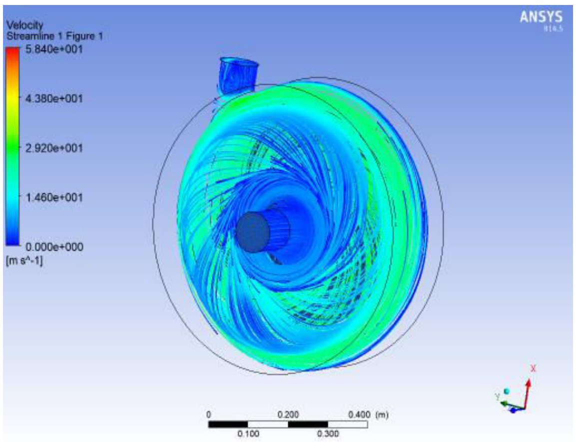
VELOCITY DISTRIBUTION ON FORWARD IMPELLER



VELOCITY DISTRIBUTION ON BACKWARD IMPELLER



VELOCITY DISTRIBUTION ON FOR-BACK IMPELLER



SCOPE/APPLICATIONS

More pressure is produced when compared to axial compressor.

Pressure produced per stage is higher.

Shows a good performance in GTE.

NUMERICAL ANALYSIS

The following contours are to be analyzed in numerical simulation, namely,

Pressure distribution of three different types of impellers.

Velocity distribution of three different types of impellers.

CONCLUSION

Thus the three different types of impeller like forward , backward and forward-backward combination.

Since forward-backward combination is our new design and this particular design produce higher pressure when compared to forward and backward type impellers. The results are discussed above and the pressure distribution on three different types of impeller are shown.

FUTURE WORK

In this paper, we can analyse some of the things in Future. In forward-backward combination, if the exit tip forward stage velocity is lesser than the backward stage which is starting from the root, then the length of backward stage blade should be increased. If increase of backward stage blade increase, then overall exit velocity of blade gets increased.

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