INVESTIGATION ON THE EFFECT OF EXIT BLADE ANGLE IN CENTRIFUGAL PUMPS USING CFD

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Abstract:

The performance and flow of centrifugal pump by varying exit blade angleis usually investigated experimentally. However, due to the high cost and limited data that can be obtained by experiment, currently there is a great need for this effect to be studied numerically by means of computational fluid dynamics (CFD). Here in this work, the impeller model of a submersible pump has been analysed analytically by vaying the exit blade angle. The specification of a commercially available pump in the market is taken as the reference for the study which is 49°.Now we consider two impeller model whose exit blade angle is decreased (model 1) and increased (model 2) by 5^0 to the reference pump. For these two model an analysis is done by using same Computational Fluid Dynamics (CFD) software and it the results shows that the hydraulic efficiency of model 1 as 67.12% and model 2 as 83.35%. It has been seen that by increasing the exit blade angle, the hydraulic efficiency of the impeller gets increased but the pressure head range of the impeller is decreased.

Keywords: Centrifugal Pump, Impeller, blade angle, CFD, hydraulic efficiency.

I. INTRODUCTION

A centrifugal pump uses a impeller to add energy to the fluid there by creating the flow. Centrifugal pump generally utilized for the movement of liquids through piping.Numerous research work are carried out in a pump impeller and the some important research on impeller are taken forreference study. A. manivannan[4], focus on increasing the efficiency of the flow impeller by 18.18% by modifying the inlet and outlet vane angles. Khalid. S. Rababa[7], varied the number of blades and studied its effect on efficiency and performance. E.C. Bacharoudis[5] et al varied the outlet blade angles with fixed outer diameter and studied the impeller performance. Moreover, hydraulic efficiency increases with increasing blade angle at at high flow rates. WANG Yong[3] et al observed that the increasing the blade number enables us to reduce the mixture loss of "jet" and "wake" in centrifugal pump.And so here we made an analysis on the impeller by changing the outlet blade angle from the existing blade. The analysis is made by using Computational Fluid Dynamics (CFD) software by which the hydraulic efficiency has been calculated.

II. COMPUTATIONAL MODEL

Table 1 and 2 shows the specifications of the pump and the primary geometrical dimensions of impellers. The impellershave identical design specifications and meridian shape, however the blade exit angle is varied.As for the existing impeller model, an design optimisation has been planned by changing their number of blades(n), Inlet blade angle(α) and Outlet blade angle (β) using CFD software in terms of Trial and Error method and kept the other specifications as to be constants.

Table 1 Specifications for the pump

Pump type	Ism121
Delivery size (mm)	65
Min.bore size(mm)	150
No.of stages	6
Speed(rpm)	2880
Min submerge (m)	1.5
Total head(m)	44
Discharge (lps)	9

The design optimization has been made on the outlet blade angle as 44° and 49° to compare the hydraulic efficiency of the existing impeller having the outlet blade angle of 54°.

Table 2Geometry of the impeller and volute

Impeller inlet(d_i)	75mm
Impeller outlet(d_o)	105mm
Blade number	6
Inlet blade angle(β_i)	
Outlet blade angle(β_o)	
Blade thickness(t)	1.25mm
Blade inlet height(l_i)	21mm
Blade outlet height(l_o)	16mm

Table 3 Optimum Impeller blade Angle

Impeller design	**Inlet blade angle(β_i)**	**Outlet blade angle(β_o)**
Existing model	69^0	49^0
Impeller 1 (optimum)	69^0	44^0
Impeller 2 (optimum)	69^0	54^0

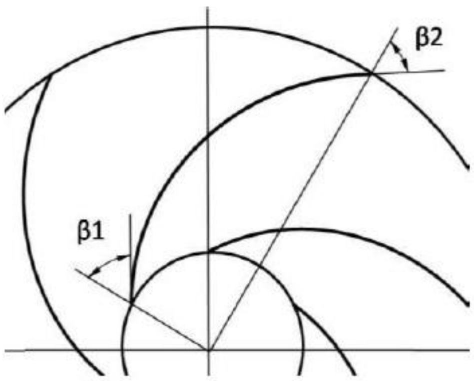


Fig 1 Blade nomenclature

Before the analysis, the meshing of the impeller is very important term to be considered. And the meshing is done by using ANSA (surface mesh) & T GRID software (Volume mesh). And while on surface meshing the impeller has been split into four parts as inlet, outlet, blade outer and blade. After completing surface mesh on these parts the volume mesh on the impeller has been done. Then finally the analysis is made after complete completion of the meshing.

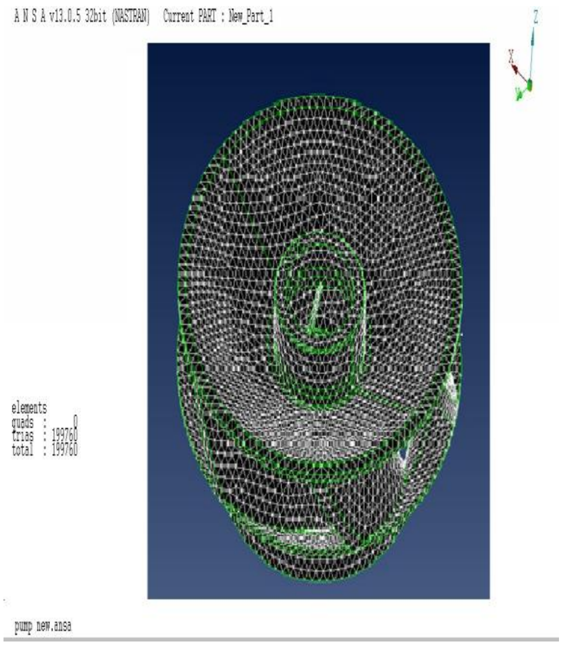


Fig 2 Meshed model

The above figure show the meshing of the existing impeller and it has a total mesh count of 199760 elements. As like this the two impeller model also have some mesh elements which is shown below.

Table 4 Mesh Size

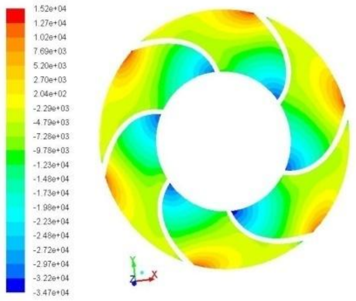
Impeller models	**Number of elements while mesh**
Existing model (β_2) = 49^0	199760
Impeller model 1 (β_2) =44^0	199710
Impeller model 2 (β_2) = 54^0	199770

III. RESULTS

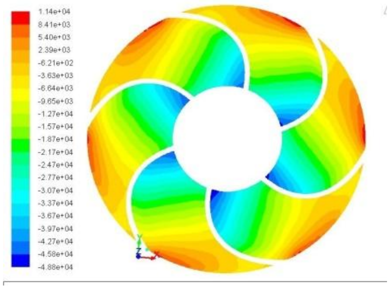
In the impeller model 2 which is having the outlet blade angle 54° the hydraulic efficiency is obtained by means of Computational Fluid Dynamics (CFD) software is 83.5%. This hydraulic efficiency is higher than existing model which is having the outlet angle is 49° and the impeller model 1 which is having the outlet blade angle is 44°.

i) Static Pressure in Pascal

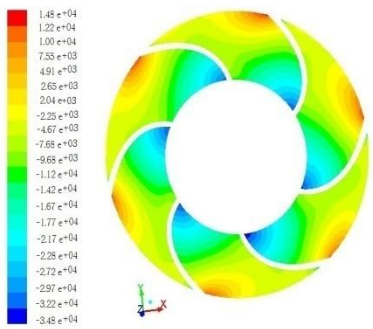
Reference model



Model 1

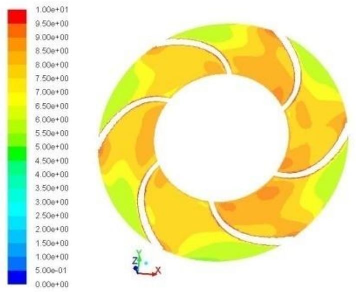


Model 2

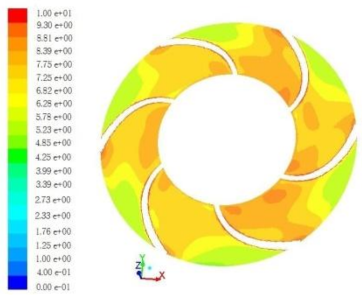


ii) Velocity magnitude (m/s)

Reference model



Model 1



Model 2

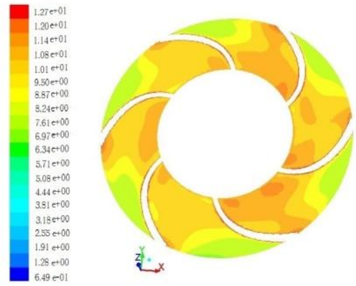


Fig 3 Analysis of pressure and velocity

Table 5 Post processing Results

Model	**Pressure Head (pa)**	**Hydraulic Efficiency (%)**
Reference model	45415.718	73.5
Model 1	43895.167	67.12
Model 2	44996.174	83.35

IV. DISCUSSION

In fig 4 we can find that at 54^0 outlet blade angle the discharge and head will be maximum when compared to the outlet blade angle 44^0 and 49^0.

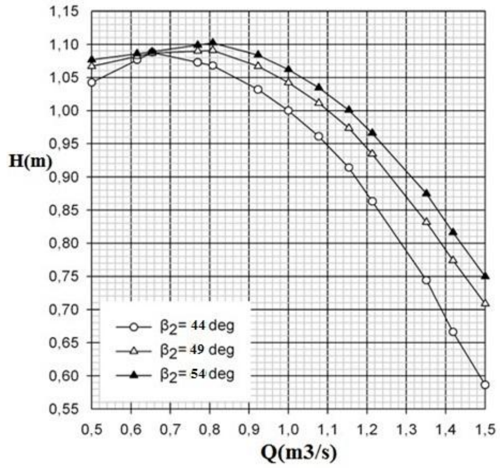


Fig 4 Head and Discharge Curve

And hence it is conclude that at 54^0 angle the head and discharge will be higher than the other angles 44^0 and 49^0.The above fig 5 represents the curve between pressure(P) and discharge(Q). It shows that at greater the discharge the pressure will be very high at 54^0 angle compared to the the 44^0 and 49^0 angles.But here our objective is to increase the discharge and so no matter the pressure should be considered.

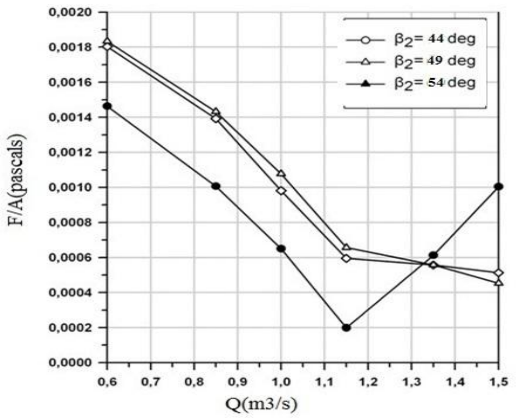


Fig 5 Pressure and Discharge Curve

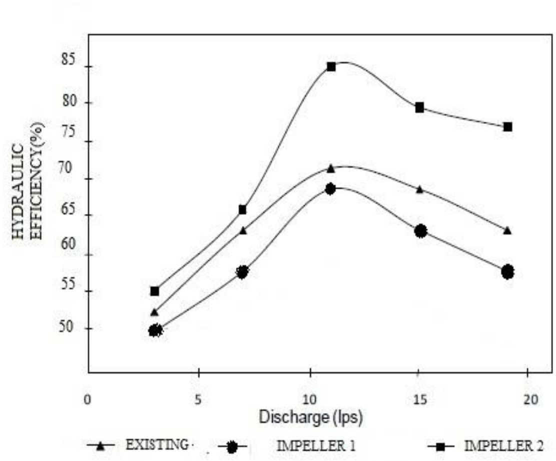


Fig 6 Hydraulic Efficiency and Discharge

Table 6 Comparision on models

Impeller models	Inlet blade angle (β_1)	Outlet blade angle(β_2)	Hydraulic efficiency (η_h)
Existing Model	69^0	49^0	73.5%
Model 1	69^0	44^0	67.12%
Model 2	69^0	54^0	83.35%

The above fig 6 shows that the graph between hydraulic efficiency and discharge. The maximum efficiency point is given by the impeller model 2 which is having the outlet blade angle 54^0.By means of the Computational Fluid Dynamics(CFD) analysis on an impeller it has been found that the hydraulic efficiency of the impeller model 2 is high which is 83.35% when compared to the hydraulic efficiency of the existing impeller model and impeller model 1 which has the efficiency of 73.5% and 67.12%.

V. CONCLUSION

The hydraulic performance of a centrifugal pump for varying exit blade angle was studied.and it shows the results of hydraulic efficiency as 67.12% for model 1 and 83.35% for model 2. It has been seen that by increasing the blade angle the hydraulic efficiency of the impeller gets incresed but the pressure head range of the impeller is decreased when compared to the existing model and optimum model 1. Thus by increasing the outlet blade angle the hydraulic efficiency has been increased by 9.8% when compared to the existing model.The flow in the impeller with a large exit blade angle acquires a separated structure near the pressure side. Such turbulent flow pattern models at various working conditions is a challenge for hydrodynamics researchers.

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