International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue14
November 2017

Design Modification and Analysis of Regenerative Centrifugal Pump

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ABSTRACT

In this thesis, the performance of the regenerative centrifugal pump is determined by modifying the design of original model. The original model is modified by changing number of blades on the impeller. Present model has 34 blades; the no. of blades is changed to 38 and 42. The models are done in 3D modeling software Creo 2.0.CFD analysis is done on all the models to determine pressure ratios, outlet velocities and mass flow rates. Static analysis is done by applying the pressures obtained from CFD analysis using different materials for impeller Steel, Aluminum alloy.

INTRODUCTION

A pump is a tool that carries fluids (gases or liquids), or slurries sometimes, by mechanical action. The pumps are often classified into 3 major teams consistent with the tactic they use to maneuver the fluid: direct carry, gravity and displacement gravity pumps. Pumps generally operate using some mechanism (typically rotary or reciprocating), and energy is consumed so that mechanical work is performed by fluid movement. Pumps generally operate via mechanism, together with operating manually, engines, electricity, or utilizing wind power, are available in several sizes, from microscopic to medical applications to giant industrial pumps.

REGENERATIVE PUMP

A regenerative pump consists of a casing with a doughnut-shaped channel and a blade. The blade could be a disc with many, sometimes twenty to fifty, radial vanes at the sting of the disc boundary. These vanes rotate within the doughnut-shaped channel. Through the suction port the fluid is entered in to the channel and is circulated repeatedly through the blade vanes because of a force field action. The flow path approximates a solid helix, almost like the form of a corkscrew. This impact of recurrent circulation is additionally delineated as internal multi-staging, for every passage through the vanes is also considered a standard stage. This multi-staging is wherever the pump has been derived the name of regenerative pump. Through the discharge port the fluid is exited.

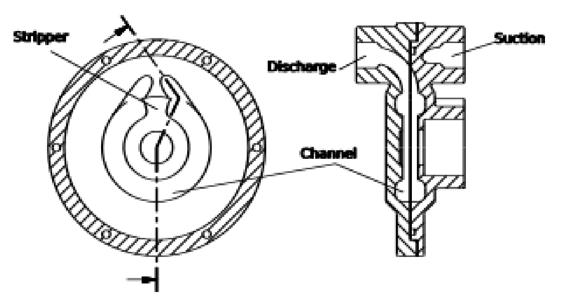

Fig: The regenerative pump

LITERATURE SURVEY

In the paper byJ. Nejadrajabali [1] Regenerative pump may be a rotor dynamic turbo machine with low specific speed which is capable of expanding high heads at low flow rates. During this thesis, a numerical study was meted out so as to analyze the blade angle impact on a regenerative pump performance. 2 teams of impellers were used. The primary kind has trigonal angle blades with identical inlet/outlet angles of ±10∘, ±30∘, and ±50∘ and also the second cluster has non trigonal angle blades within which the body of water angle was set to 0∘ and 6 totally different angles of ±10∘, ±30∘, and ±50∘ were designed for the outlet of the blades. A complete of twelve impellers, still as primary radial blades blade, were investigated during this study. The results showed that everyone forward blade have higher head constants than radial blades blade at style flow coefficient. it had been found that regenerative pumps with trigonal angle forward blades have higher performance than different sorts.In the paper by T. Shigemitsu [5] then, a semi-open blade for the mini pump with 55mm blade diameter is adopted during this analysis to require simplicity and maintenance into thought. Splitter blades are adopted during this analysis to enhance the performance and internal flow condition of mini pump having giant blade outlet angle. The performance tests square measure conducted with these rotors so as to analyze the impact of the splitter blades on the performance and internal flow condition of the mini pump. A 3 dimensional steady numerical flow analysis is conducted to research rotor, volute potency and loss caused by a vortex. It's processed from the experimental results that the performance of the mini pump is improved by the impact of the splitter blades. Flow condition at outlet of the rotor becomes uniform and back flow regions square measure suppressed within the case with the splitter blades.

In the paper by Won Chul Choi, Su Yoo, alphabetic character Ryong Park [6] the regenerative pump may be a quite turbo machine that's capable of developing a air mass rise at comparatively low flow rates compared to the centrifugal and axial pumps. Though the potency of regenerative pumps is way under different turbo machines, they need still been wide utilized in several industrial applications for top heads at low flow rates. There are a couple of theoretical models to research the performance of regenerative pumps, though; the impact of the blade angle has not been enclosed in any analysis model up to now. During this study, the influence of the blade angle and its form on regenerative pump performance has been by experimentation investigated. Straight blades with inclined blade angles of $0°, \pm 15°, \pm 30°$ and $\pm 45°$ were tested. Additionally radial chevron impellers with chevron angles of 15°, 30° and 45° were conjointly enclosed within the gift experiments. Thus a complete of ten blade configurations was examined.

MODELING OF REGENERATIVE CENTRIFUGAL PUMP

For modeling, software is used – Creo 2.0. The chosen model is Centrifugal Pump.

The dimensions are taken from the following journal: - Experimental and Numerical Investigation of Regenerative Centrifugal Pump using CFD for Performance Enhancement by AnkitaMaity, VigneshChandrashekharan and Muhammad WasimAfzal, International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161 specified as [1] in References chapter.

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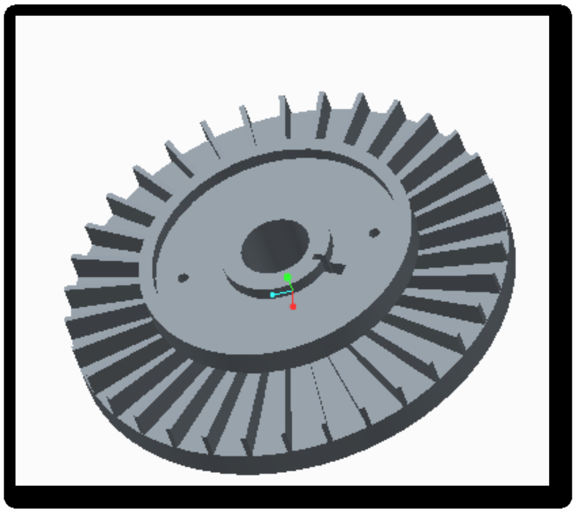

Fig: 3D model of impeller with 34 blades

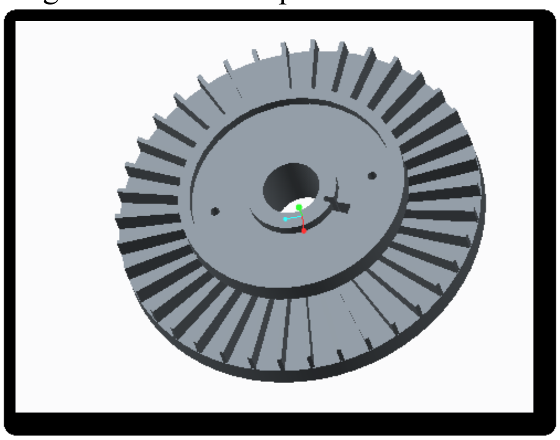

Fig: 3D model of impeller with 38 blades

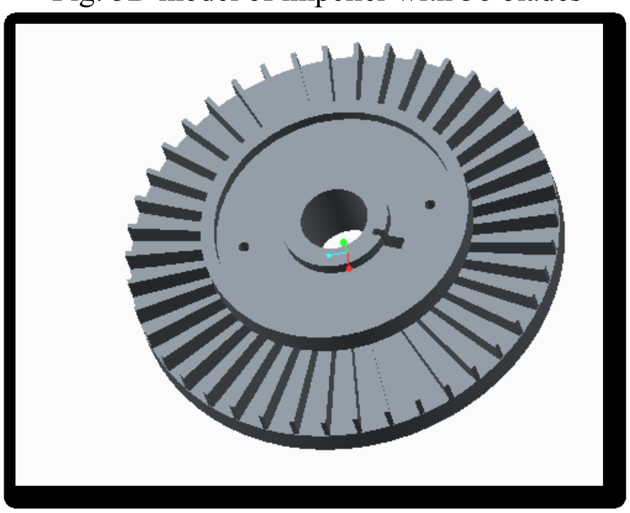

Fig: 3D model of impeller with 42 blades

CFD AND STRUCTURAL ANALYSIS OF REGENERATIVE CENTRIFUGAL PUMP

The boundary condition for the analysis are taken from the following journal: - Experimental and Numerical Investigation of Regenerative Centrifugal Pump using CFD for Performance Enhancement by AnkitaMaity, VigneshChandrashekharan and Muhammad WasimAfzal, International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161 specified as [1] in References chapter.

CFD ANALYSIS

AIR

NO. OF BLADES - 38

Boundary conditions

Select Boundary conditions option ----select inlet---select type as Mass Flow Rate----Select edit

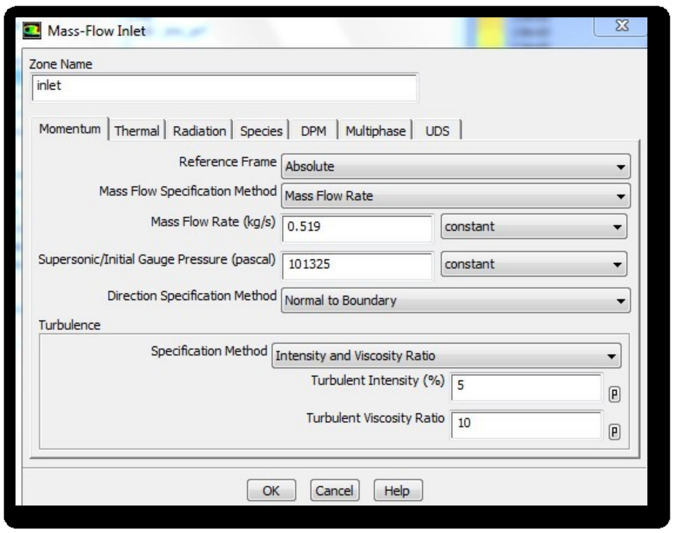

Fig: Mass Flow rate

Impeller rotational speed

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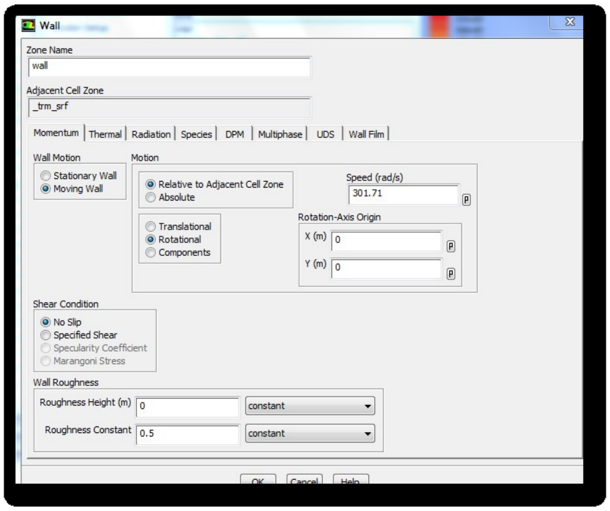
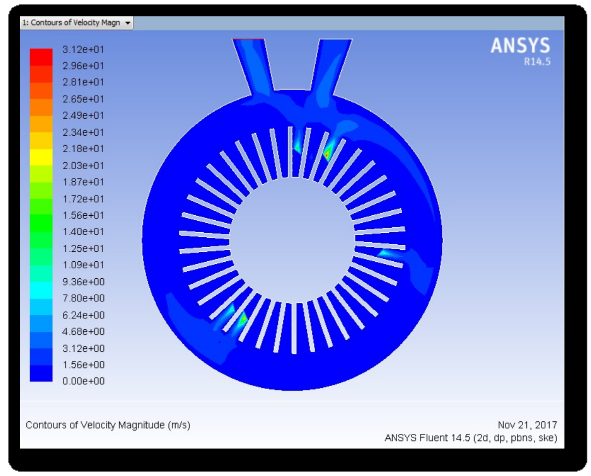


Fig:-Impeller Rotational Speed - 301.71 rad/s

Fig: - pressure of 38 blades impeller



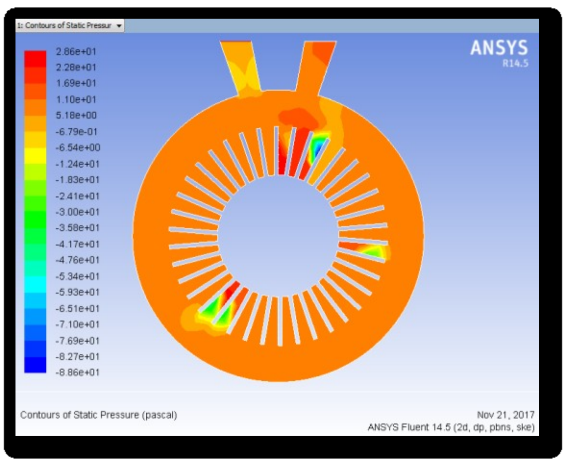


Fig: - velocity of 38 blades impeller

Mass Flow Rate	(kg/s)
inlet	0.519
interior-____face	-1.6735448
outlet	-0.52022674
wall	0
wall-____face	0
Net	-0.0012267434

Fig: - mass flow rate of 38 blades impeller

CFD ANALYSIS RESULTS TABLE

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	NO. OF BLADES		
	34	38	42
Pressure(Pa)	1.18e-01	5.18e+00	7.47e+00
Velocity(m/s)	4.79e+00	4.68e+00	3.88e+00
Mass flow rate(Kg/s)	0.0017255744	0.0012267434	0.001065835

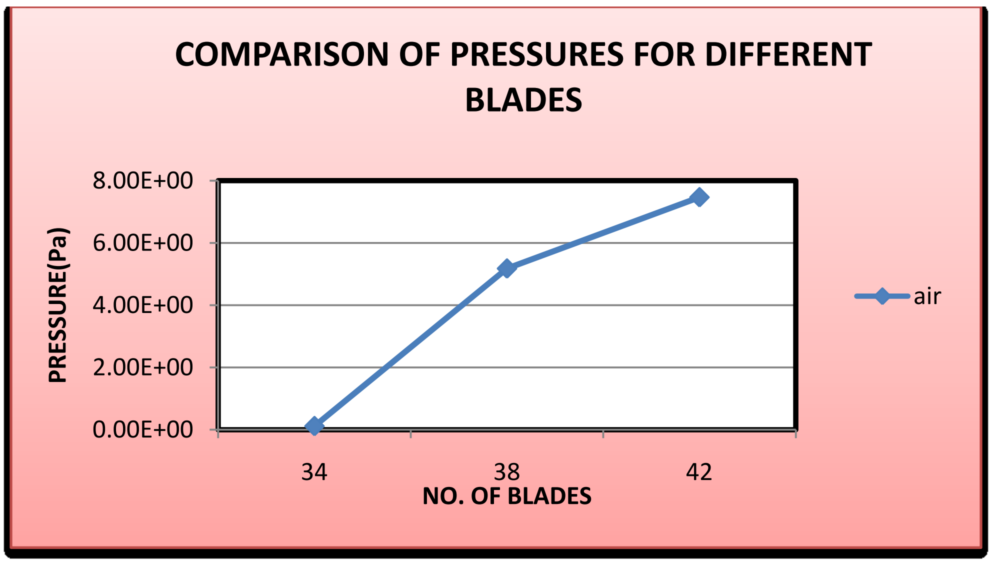

Fig: Comparison of Pressures for Different Blades

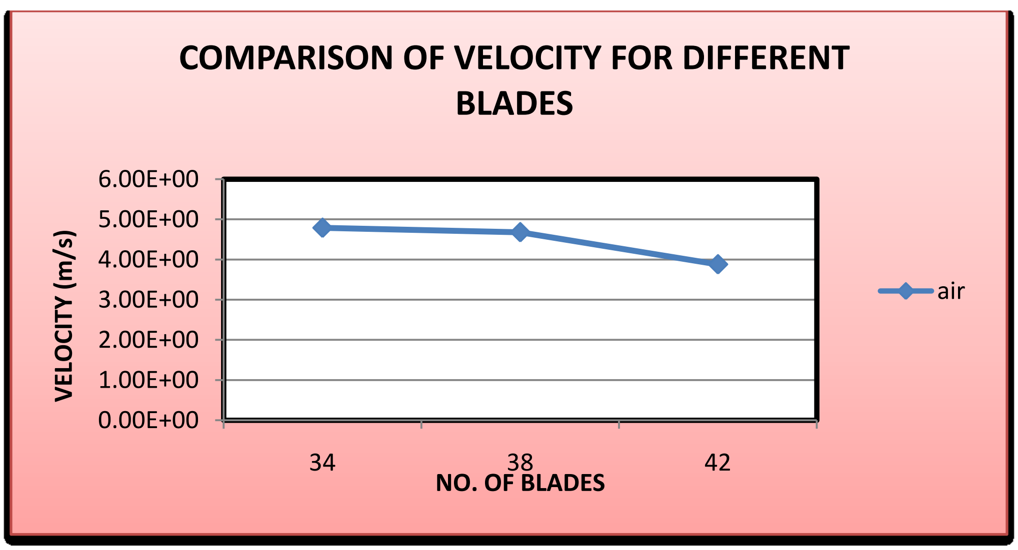

Fig: Comparison of Velocity for Different Blades

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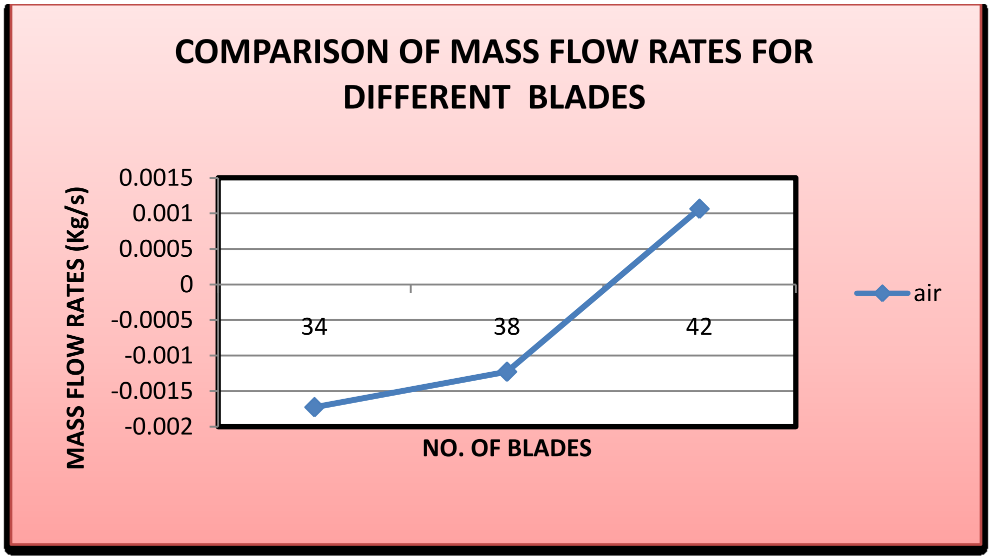

Fig: Comparison of Mass Flow Rates for Different Blades

STATIC STRUCTURAL ANALYSIS

NO. OF BLADES – 38

MATERIAL – ALUMINUM ALLOY

The pressure applied on the impeller in static structural analysis is taken from the results of CFD analysis.

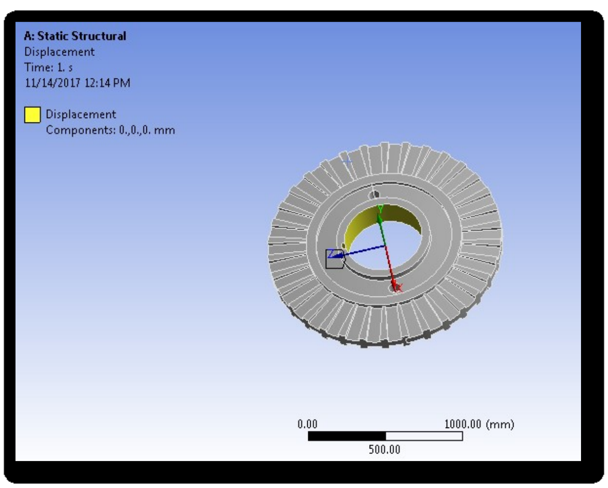

Fig: Displacement is applied on the inside the hub

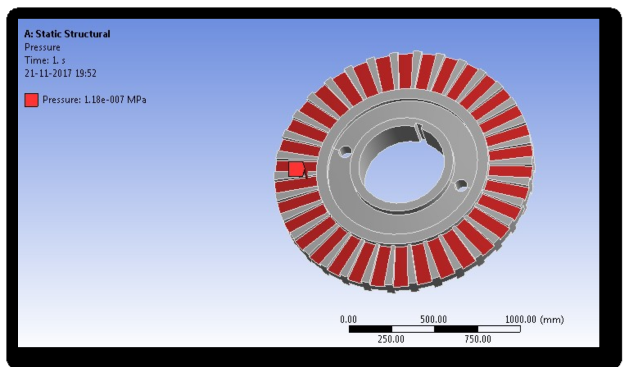

Fig: Pressure is applied on impeller blades

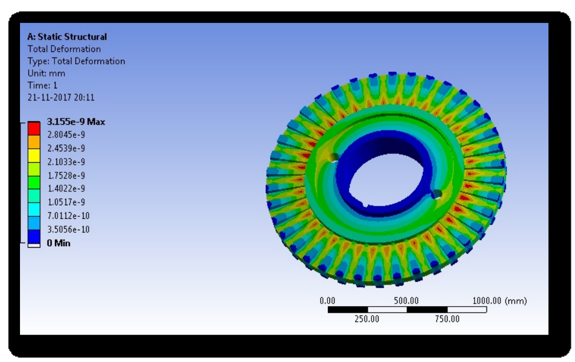

Fig: Total Deformation for 38 baldes impeller using Aluminum alloy at 5.18e-006MPa

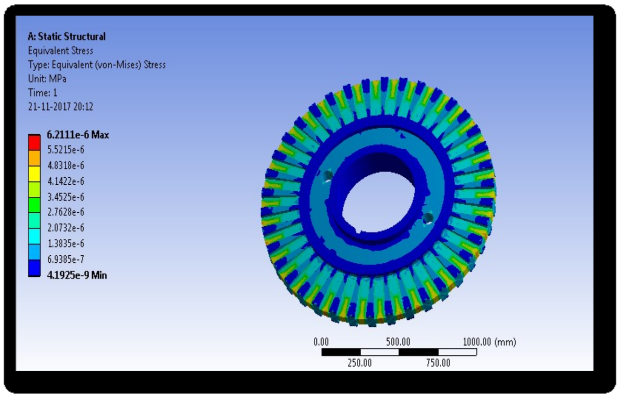

Fig: Stressfor 38 baldes impeller using Aluminum alloy at 5.18e-006MPa

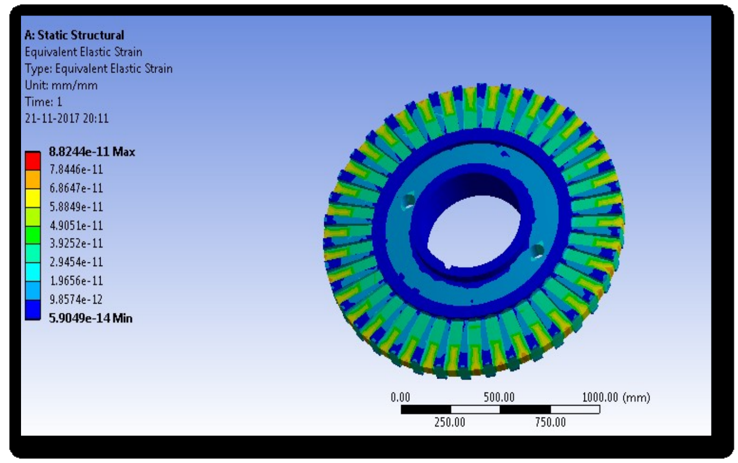

Fig: Strainfor 38 baldes impeller using Aluminum alloy at 5.18e-006MPa

STATIC STRUCTURAL ANALYSIS RESULTS TABLE

MATERIAL - STEEL

	NO. OF BLADES		
	34	**38**	**42**
Deformation (mm)	2.847e-11	1.2098e-9	1.6526e-9
Stress (MPa)	1.2891e-7	6.1996e-6	8.6264e-6
Strain	6.4911e-13	3.1278e-11	4.3367e-11

MATERIAL - ALUMINUM ALLOY

	NO. OF BLADES		
	34	**38**	**42**
Deformation (mm)	7.3862e-11	3.155e-9	4.3196e-9
Stress (MPa)	1.2883e-7	6.2111e-6	8.6087e-6
Strain	1.827e-12	8.8244e-11	1.2192e-10

e-ISSN: 2348-6848
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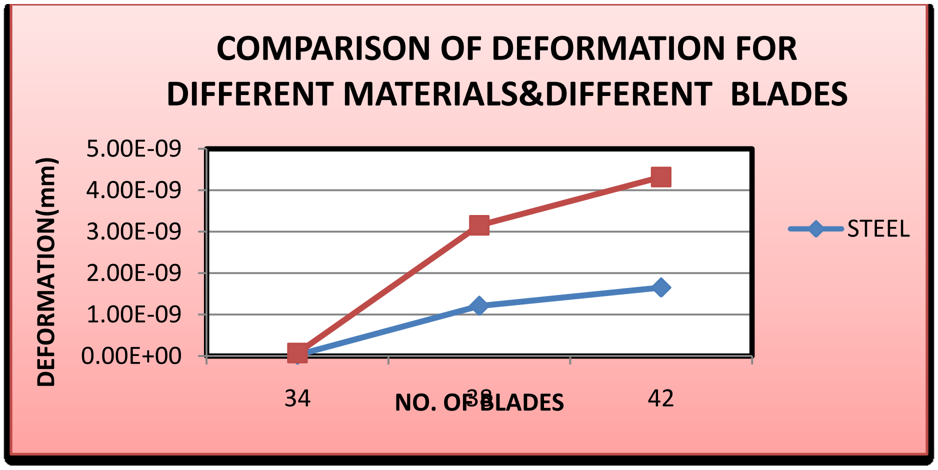

Fig: Comparison of Deformation for Different Materials &Different Blades

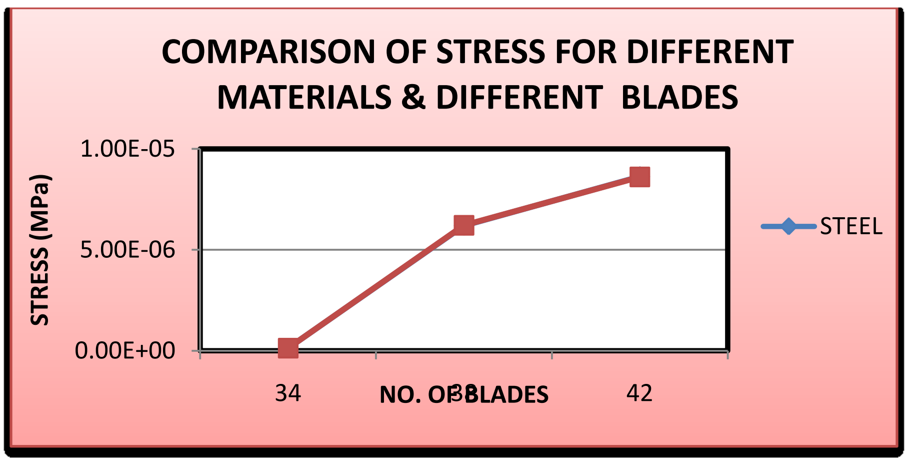

Fig: Comparison of stress for Different Materials &Different Blades

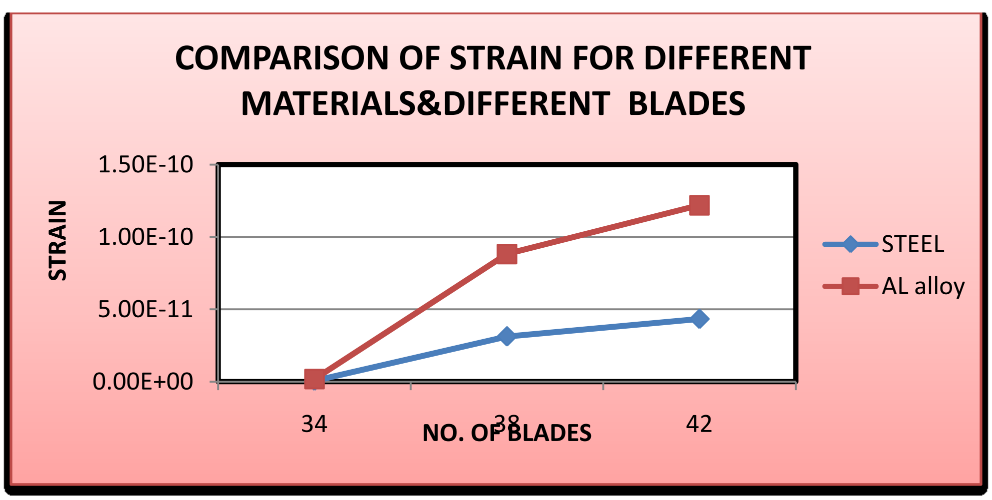

Fig: Comparison of strain for Different Materials &Different Blades

CONCLUSION

By observing CFD analysis results, the pressure is increasing for impeller with 42 blades when compared with that of 38 and 34 blades impeller. The pressure is increasing for 42 blades impeller by about 30.65% when compared with that of 38 blades impeller and by about 97.4% when compared with that of 34 blades impeller. The outlet velocity is increasing by decreasing the no. of blades. The pressure is decreasing for 34 blades impeller by about 2.29% when compared with that of 38 blades impeller and by about 18.99% when compared with that of 42 blades impeller. The mass flow rate is increasing for impeller with 42 blades when compared with that of 38 and 34 blades impeller. The mass flow rate is increasing for 42 blades impeller by about 15% when compared with that of 38 blades impeller and by about 61% when compared with that of 34 blades impeller.By observing the Static Structural analysis results, the deformations and stresses are reducing by reducing no. of blades due to reduction in pressure. The stress values for both materials are less than their respective yield stress values. Using Aluminum alloy for impeller is better due to its light weight.Though the impeller with 42 blades produces more pressure, the weight increases when compared with that of impeller with 38 and 34 blades which may decrease the mechanical efficiency of pump

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