Design and Optimization of Centrifugal Pump Guide Vanes

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Abstract

In this we proposes a Centrifugal pump design is a most common pump used in industries agriculture and domestic applications. Its impeller design demands a detailed understanding of the internal flow at rated and part load operating conditions. For the cost – effective design of pumps it is very crucial to predict their performance in advance before manufacturing them which requires understanding of the flow behavior in different parts of the pump. In this paper an impeller of a centrifugal pump is designed and modeled in 3D modeling software Pro/Engineer. The present model has 5 blades and angle of blade is 20^0 in this thesis the number blades are chnaged to 6 and 7 and angle od blades is changed to 30^0 and 50^0. Materials used are steel and aluminum. Structural analysis frequency analysis and CFD analysis are performed. The optimzation of the impeller design is done by observing the results obtained from the analysis performed. The results considered are stress frequency velocity pressure flow rates.Analysis is done in Ansys.

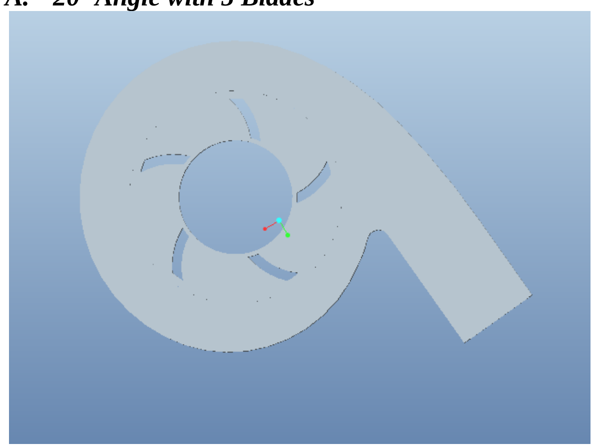
I. INTRODUCTION OF CENTRIFUGAL PUMP

Centrifugal pump is one of the basic and a superb piece of equipment possessing numerous benefits over its contemporaries. The main advantages of a centrifugal pump includes its higher discharging capacity higher operating speeds lifting highly viscous liquids such as oils muddy and sewage water paper pulp sugar molasses chemicals etc. against the reciprocating pumps which can handle relatively small quantity of liquid operating at comparative slower range of speeds that is limited to pure water or less viscous liquids free from impurities limited from the considerations of separation cavitation and frequent choking troubles. The overall maintenance cost of a centrifugal pump is also comparatively lesser due to less wear and tear. While major disadvantage includes vulnerability to a complexities of eddies formations noise and vibrations and inability to generate higher pressures as executed by the reciprocating pumps.

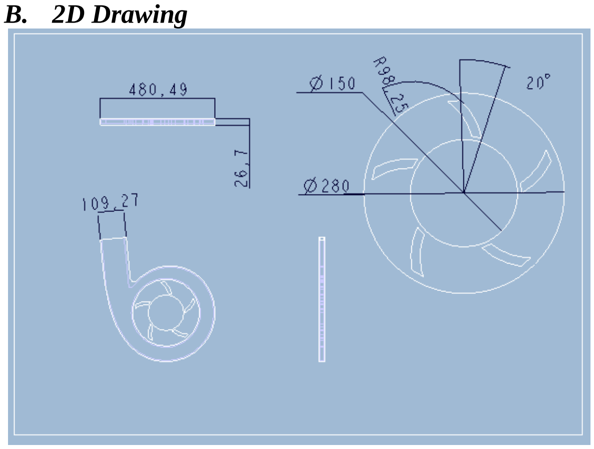
II. LITERATURE REVIEW

In the paper by E.C. Bacharoudis etal [1] describes the simulation of the flow into the impeller of a laboratory pump in a parametric manner. In this study the performance of impellers with the same outlet diameter having different outlet blade angles is thoroughly evaluated. In the paper by A. Akhras etal [2] This paper provides the results of a detailed flow investigation within a centrifugal pump equipped with a vaned diffuser. In the paper by Amit Suhane[3] experimental study work carried out on a single stage diffuser type centrifugal pump.

A. 20^0 Angle with 5 Blades

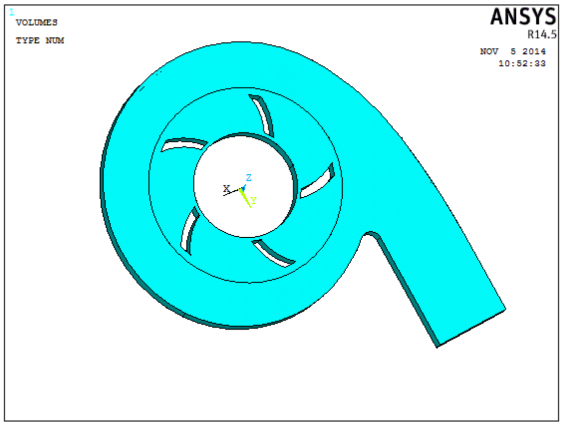


B. 2D Drawing



III. ANALYSIS OF CENTRIFUGAL PUMP MATERIAL-STEEL STRUCTURAL ANALYSIS 5-BLADES WITH 20˚ ANGLE

Imported Model



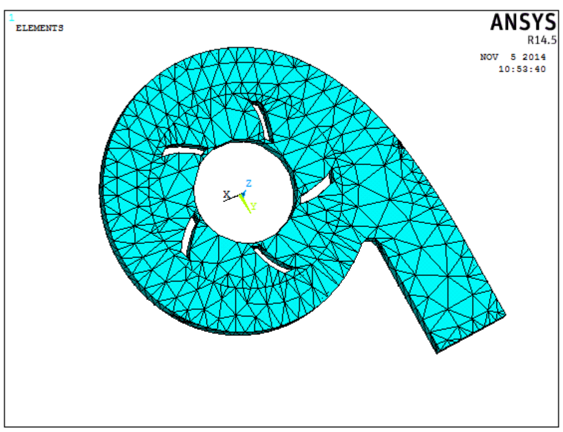
Steel Material Properties

Young's modulus=205000MPa

Poisson's ratio=0.29

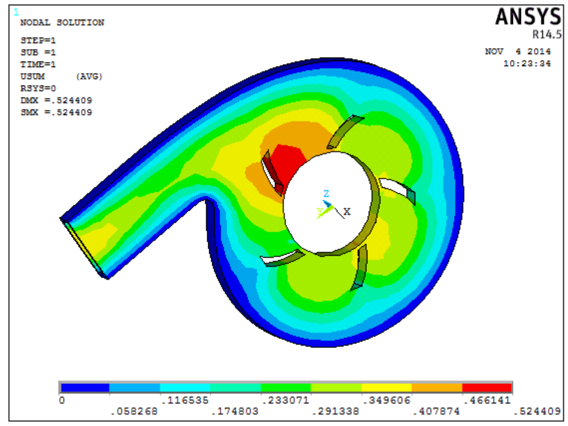
Density=0.00000785kg/mm^3

Meshed Model



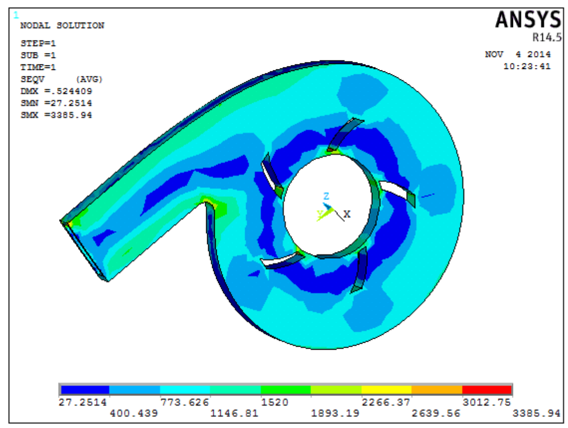
Angular velocity=96.8657rad/sec

Displacement



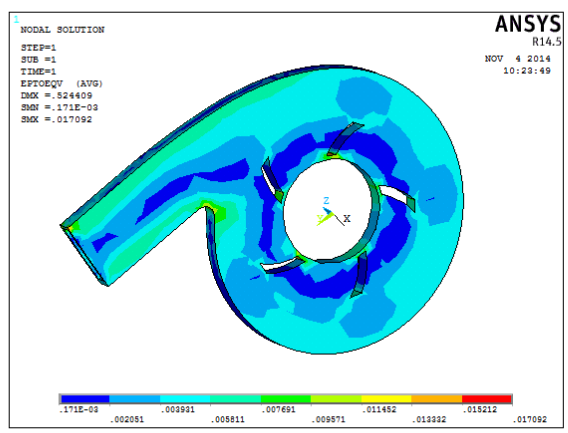
According to this the minimum value for displacement is 0.116535mm and maximum value is 0.524409mm

Stress



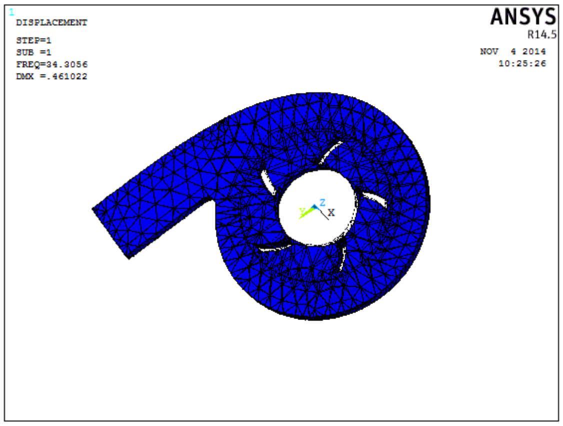
According to this the minimum value for stress is 27.2514 N/mm^2 and maximum value is 3385.94 N/mm^2

Strain



According to this the minimum value for strain is 0.171E-03 and maximum value is 0.17092

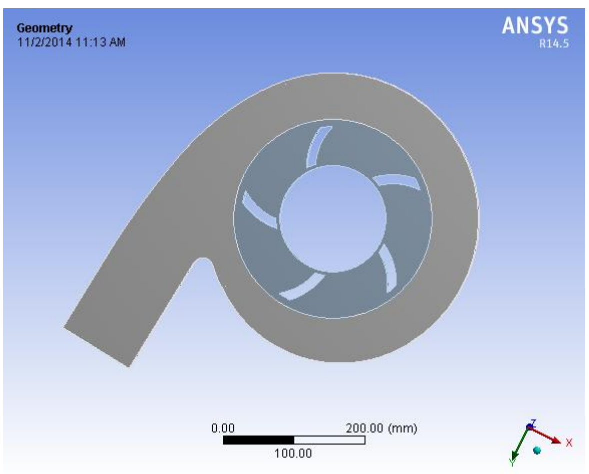
MODAL ANALYSIS

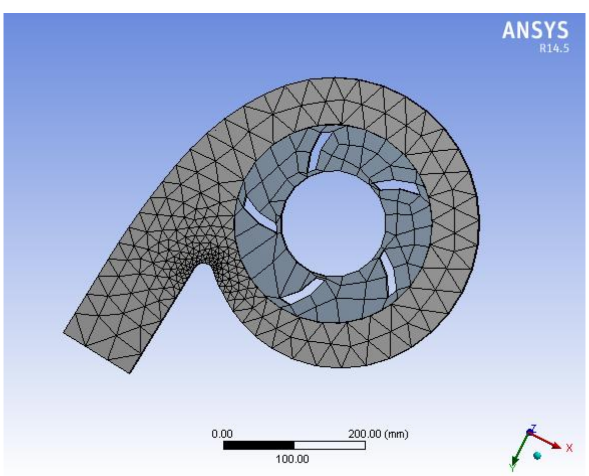


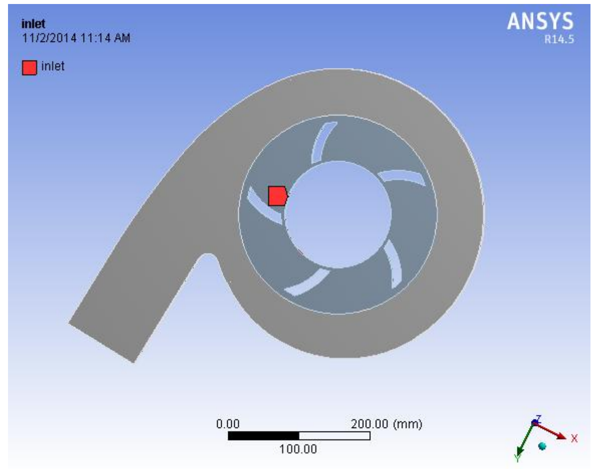
CFD ANALYSIS OF IMPELLER IN CENTRIFUGAL PUMP

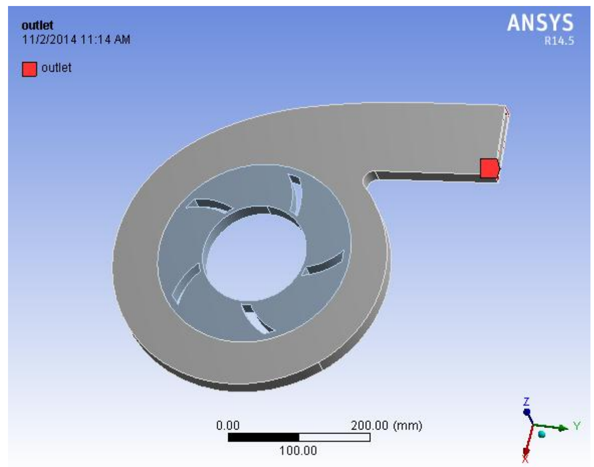
5 BLADES WITH 20˚ ANGLE

Mass flow rate – 0.0125m^3/sec







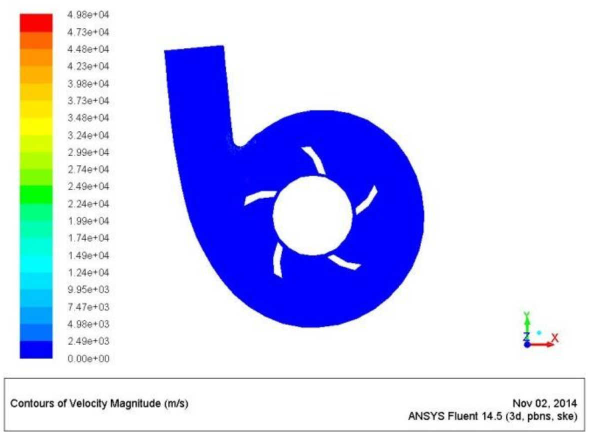


Materials → new → create or edit → specify Fluid material → Air

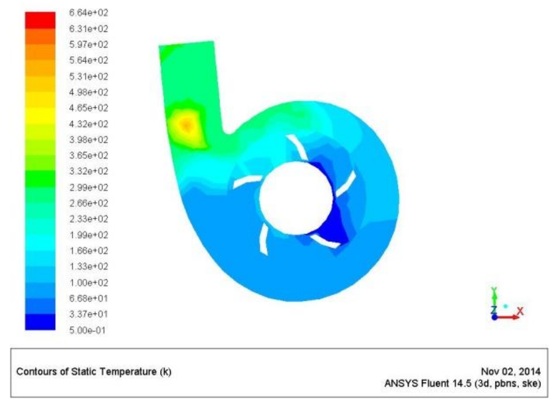
Boundary conditions → Inlet → Edit

Mass flow rate=0.0125m^3/sec

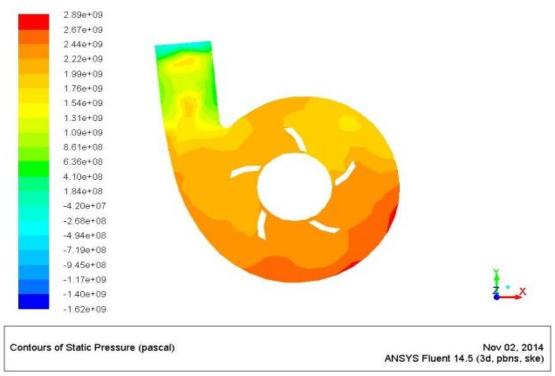
Velocity Magnitude



Temperature



Static pressure



IV. RESULTS TABLE STRUCTURAL ANALYSIS

Material	Angle	No of blades	Displacement (mm)	Stress (N/mm^2)	Strain
Steel	20°	5 blades	0.524409	3385.94	0.17092
		6 blades	0.572838	3593.8	0.017918
		7 blades	0.545191	3583.9	0.017864
	30°	5 blades	0.539388	3591.03	0.017899
		6 blades	0.617447	3591.97	0.017908
		7 blades	0.589036	3590.84	0.017897
	50°	5 blades	0.655216	4305.02	0.021111
		6 blades	0.669112	4033.16	0.019838
		7 blades	0.799257	4520.65	0.02211

Material	Angle	No of blades	Displacement (mm)	Stress (N/mm^2)	Strain
Aluminum	20°	5 blades	0.544646	1123.36	0.017162
		6 blades	0.59818	1224.57	0.018492
		7 blades	0.570149	1220.3	0.01843
	30°	5 blades	0.557783	1223.37	0.018474
		6 blades	0.640799	1223.24	0.018471
		7 blades	0.616168	1222.41	0.018462
	50°	5 blades	0.673687	1485.76	0.022014
		6 blades	0.689291	1361.32	0.020202
		7 blades	2.40952	4520.65	0.66655

MODAL ANALYSIS

FOR STEEL

Angle	No of blades	Frequency (Hz)			Deformation (mm)		
		Mode1	Mode2	Mode3	Mode1	Mode2	Mode3
20°	5	34.3856	45.2283	52.2075	0.461022	0.46477	0.463796
	6	36.2225	46.7288	36.0782	0.466547	0.47501	0.477452
	7	36.7201	46.6426	33.6969	0.467985	0.480106	0.488040
30°	5	36.2287	46.7422	55.6214	0.461059	0.47352	0.45923
	6	36.715	46.914	55.8645	0.477664	0.484229	0.476273
	7	26.2807	45.5266	54.2272	0.472289	0.49207	0.509789
50°	5	36.0676	45.6289	54.1309	0.497717	0.522524	0.497724
	6	36.4122	45.6092	52.4406	0.506727	0.505229	0.577268
	7	36.6712	45.0781	53.17	0.524207	0.528044	0.541272

FOR ALUMINUM

Angle	No of blades	Frequency (Hz)			Deformation (mm)		
		Mode1	Mode2	Mode3	Mode1	Mode2	Mode3
20°	5	34.4799	45.1982	32.9476	0.795655	0.784801	0.829001
	6	26.5116	46.65	55.7727	0.810369	0.827962	0.824637
	7	26.8096	46.4151	55.2448	0.808226	0.829647	0.826249
30°	5	36.5214	46.7098	33.3613	0.796201	0.827709	0.803937
	6	36.8721	46.5449	55.3549	0.829121	0.54444	0.82275
	7	26.4672	45.628	52.0277	0.821459	0.85566	0.876922
50°	5	26.1095	45.5225	52.702	0.802221	0.90177	0.856429
	6	26.418	45.2292	52.988	0.874635	0.577291	0.996426
	7	21.1204	26.4231	20.6228	0.524207	0.528049	0.541272

CFD ANALYSIS RESULTS

Angle	No of blades	Velocity (m/s)	Pressure (Pa)	Temperature (K)
20°	5	4.91e+04	2.87e+09	6.64e+02
	6	3.51e+04	9.73e+09	5.30e+12
	7	1.77e+15	2.00e+11	3.65e+02
30°	5	2.65e+04	2.87e+09	3.08e+02
	6	1.34e+04	1.62e+10	2.94e+02
	7	1.76e+15	4.60e+10	3.32e+02
50°	5	4.04e+04	3.10e+10	2.82e+02
	6	1.27e+04	1.64e+09	4.56e+02
	7	2.61e+04	4.41e+09	3.10e+02

V. CONCLUSION

In this paper an impeller of a centrifugal pump is designed and modeled in 3D modeling software Pro/Engineer. The present model has 5 blades and angle of blade is 20^0 in this thesis the number blades are chnaged to 6 and 7 and angle od blades is changed to 30^0 and 50^0. Materials used are steel and aluminum. Structural analysis frequency analysis and CFD analysis are performed. Analysis is done in Ansys. By observing the structural analysis results the stresses are increasing by increasing the number of blades and increasing the angle of blade. When Aluminum material is used the stresses are less than that of steel. By observing modal analysis results the frequencies are reducing by increasing the number of blades thereby the vibrations are reduced. But the frequencies are slightly increasing by increasing the angle of blade. But for aluminum material by increasing the number of blades the frequencies are increasing. By observing CFD analysis results the velocity is decreasing by increasing the number of blades and angle the pressure is increasing and the temperature is decreasing. But for 50^0 angle the results are reverses so using angle 50^0 is not proposed.So it can be concluded that using Aluminum for impeller is better since the stresses are less. By considering stresses using number of blades 5 and angle 20^0 is better but by considering frequencies using number of blades 6 and angle 20^0 is better.

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