International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 9
September 2017

Design and Analysis of centrifugal Pump Impeller by using FEA

1) Prof.Pranav RMane 2) Prof.Pankaj L Firake 3) Prof. Vijay L. Firake
[1, 2]JSPM'S Rajarshi Shahu College of Engineering Tathwade Pune
[3]J. T. Mahajan College of Engineering Faizpur

Abstract -*Centrifugal pump is a device mainly used for transporting liquid from lower level to higher level. Centrifugal pumps are widely used for irrigation, water supply plants, steam power plants, sewage, oil refineries, chemical plants, hydraulic power service, food processing factories and mines, because of their suitability in practically any service. In pumps the mechanical energy is converted into hydraulic energy. The two main components of centrifugal pump are impeller and casing therefore, they must be carefully designed for better performance of pump. Impellers impart a radial and rotary motion to the liquid, which results in increase in both the pressure and the kinetic energy and forcing it to the volute. The main function of pump casing is to guide the liquid from the suction nozzle to the center of the impeller. The centrifugal pump terms are firstly introduced by H. Addison.*

Key Words: Static and Modal Analysis of pump impeller, weight optimization of impeller.

Static analysis

Static analysis deals with the conditions of the equilibrium of the bodies acted upon by forces. A static analysis can either be linear or non-linear. All types of non-linearity are allowed such as large deformations, plasticity, creep, stress stiffening, contact elements etc.

A static analysis calculates the effects of steady loading conditions on the structure, while ignoring inertia and damping effects such as those carried by time varying loads. A static analysis is used to determine the displacements, stresses, strains and forces in structures and components caused by loads that do not induce significant inertia and damping effects. A static analysis can however include steady inertia loads such as gravity, spinning and time varying loads.

Modal analysis-Centrifugal pump impellers are high speed rotating components vulnerable to vibrations resulting in the failure of the system pump eventually. Vibration problems are most commonly associated with centrifugal pumps. The sources of vibration in centrifugal pumps can be categorized into three types such as mechanical causes, hydraulic causes and peripheral causes Modal analysis is used to determine the vibration characteristics of as structure or a machine component while it is being designed. The machine may be rotating or non-rotating. Use of modal analysis is to determine the natural frequencies and mode shape of the structures and both these factor are very important design parameters.

1. LITERATURE SURVEY :

[1]"Optimization of Centrifugal Pump Impeller Outlet Vane Angle by Using Modal Analysis"

Kotakar Sandeep Gulabrao1, D. S. Khedekar2

They have studied Design the pump impeller and pump systems as per requirement of company and changing the impeller outlet vane angle 200, 240, 300, 350; Theoretical result it is conclude that 240 pump impeller is most suitable for avoiding structural deformation of pump impeller. Experimentation result of 240 pump impeller shows efficiencygoes on increasing 1.2% and it considering comparatively efficiency increase 29.1%.

[2]"Optimization of Centrifugal Pump Impeller Outlet Vane Angle by using Modal Analysis."

Kotakar Sandeep Gulabrao†* and D.S. Khedekar

They conducted natural frequency is greater than critical frequency of vibration which is 260Hz for

2600 RPM and 6 vanes by calculation hence all vane angle are best to sustain for vibration state. They have check the performance pump impeller by mathematical form then we obtained as vane angle change 20 to 35 then overall efficiency is same for all vane angle but mechanical efficiency goes on decreasing and manomatric efficiency goes on increasing. But for vane outlet angle 23 to 25 mechanical as well as manomatric efficiency are in selection condition so they prefer vane outlet angle 24 for 5HP pump to give high performance.

[3]"Design Optimization of Monoblock Centrifugal Pump Impeller using Computational Fluid Dynamics" 1Dr . K. Ragu,2 V. M. Mohamed Ashif K.,3 Naveen Kumar

They studied selection of number of blades in impellers is very important. As the number of blades decreases, angle of divergence increases and secondary losses increases. For 4 blades, head reduces due to flow separation and circulatory increase of β2.For 18 outlet angle, the torque requirement increases. The head developed increases with increase of angle of attack upto 38.8 . They found that higher efficiency is attained when α1 is slightly lower than 90 i.e., 85 < α < 90 . For 38.8 inlet blade angle,absolute angle α1 is 85 . The optimum blade angle at inlet is 38.8 .

[4]"FATIGUE (FEA) AND MODAL ANALYSIS OF A CENTRIFUGAL FAN" Manish Dadhich1, Sheetal Kumar Jain2, Dhirendra Agarwal3

They examined In the fatigue analysis of the fan three fatigue contours are plotted. The three plotted contours are fatigue life, fatigue damage and fatigue factor of safety. The figure shows the results from life represents the number of life cycles with the structure can withstand until it will fail due to fatigue. In the fatigue analyses of fan the contours of fatigue life, fatigue damage and fatigue safety factor were plotted and from the contours it is observed that fan will not run safely for its designed life.lts

[5]."Design and Performance Analysis of Centrifugal Pump"Khin Cho Thin, Mya Mya Khaing, and Khin Maung Aye

They has conducted analysis of centrifugal pump by using a single stage end section of pump.They observed that the performance of centrifugal pump is described by a graph plotting the head generated by the pump over a range of flow rates. A typical pump performance curve are included its efficiency and brake horsepower, both of which are plotted with respect to flow rate. The output of a pump running at a given speed is the flow rate delivery by it and the head developed. The efficiency of a centrifugal pump depends upon the hydraulic losses, disk friction mechanical losses and leakage losses.

[6] "Parametric Study and Design Optimization of Centrifugal Pump Impeller-A Review"

Vijaypratap R Singha, M J Zinzuvadiaa, Saurin M. Shethb They have discussed pump performance parameters for the efficient operation of centrifugal pump, but Experimental studies to determine different performance parameters in different type of pumps are complex, time consuming and costly. By using CFD and DOF prediction model it is easy to predict the performance of different pump and speed up the production. Impeller outlet width (*b*2) Pump head decreases with increased blade width and the required pump brake horsepower decreases when the blade width rises.

[7]."Inverse Design of Impeller Blade of Centrifugal Pump with a Singularity Method" Wen-Guang LI

He has evaluate the hydraulic performance and suction characteristics of original impeller may be unsatisfactory, especially at partial flow rate. It is highly on demand to improve the impeller design. Two measures are taken hereby one is put more blades into impeller passages to lower the loading coefficient level and other move the peak loading coefficient away from the leading edge to somewhere close to the blade trailing edge.

Von Mises Stress

In materials science and engineering the Von Mises yield criterion can be also formulated in terms of the Von Mises stress or equivalent tensile stress, σ_v, a scalar stress value that can be computed from the stress tensor. In this case, a material is said to start yielding when its Von Mises stress reaches a critical value known as the yield strength, S_y. The von Mises stress is used to predict yielding of materials under any loading condition from results of simple uniaxial tensile tests. The Von Mises stress satisfies the property that two stress states with equal distortion energy have equal Von Mises stress.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 9
September 2017

1.1 STATIC ANALYSIS OF PUMP IMPELLER: EQUIVALENT STRESS:

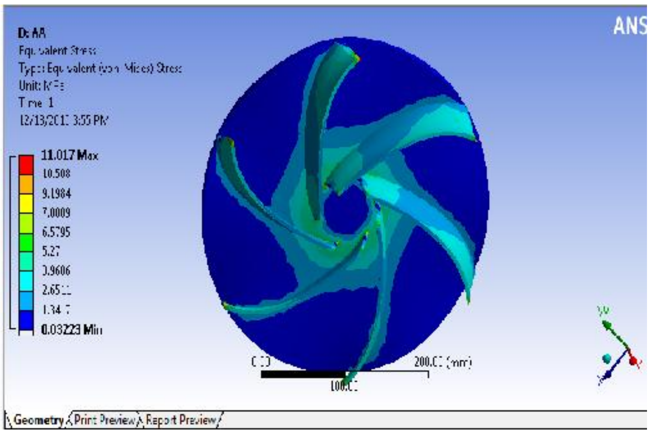

Fig. 1.1 Equivalent stress induced in aluminum alloy Pump impeller

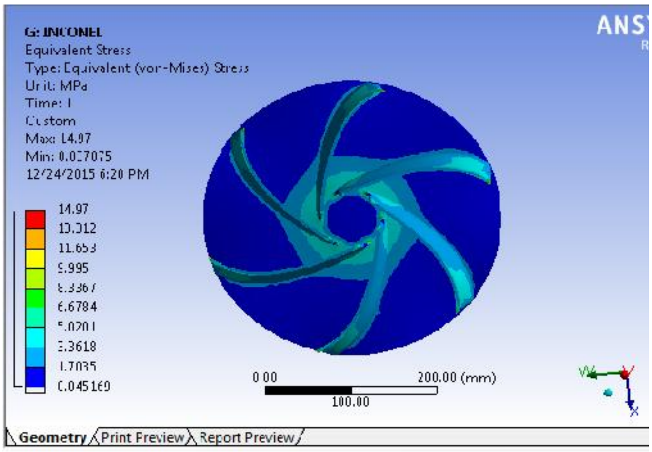

Fig. 1.2 Equivalent Stress induced in inconel Pump impeller

TOTAL DEFORMATION:

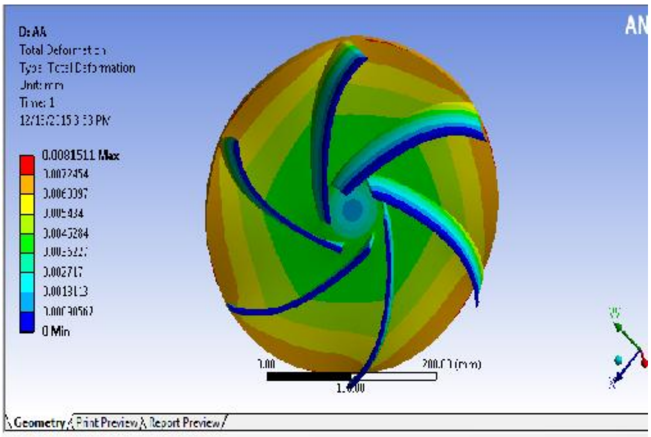

Fig.1.3 Total deformation of Aluminum alloy pump impeller

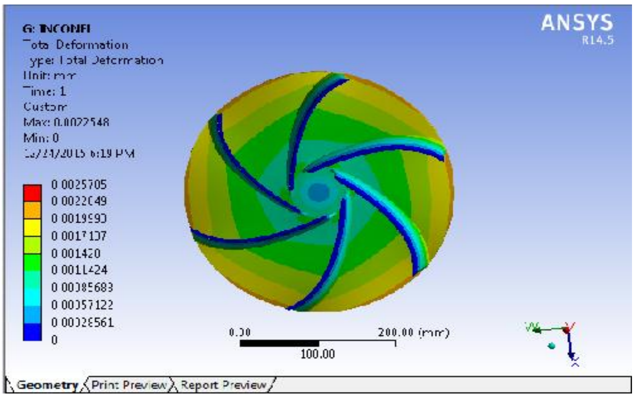

Fig.1.4 Total deformation of Aluminum alloy pump impeller

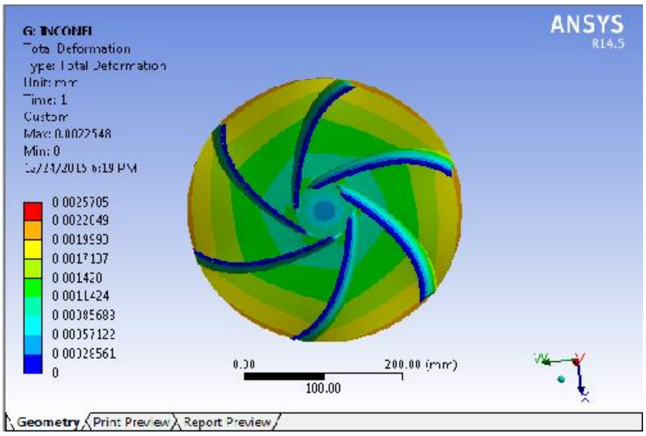

Fig.1.5 Total deformation of Aluminum alloy pump impeller

2. RESULTS & DISCUSSIONS:

Table : Result and Discussion

Sr. No.	Material	Stress (MPa)	Deformation (mm)	Weight (Kg)
1	AA (6061-T6)	11.81	0.0081511	10.044
2	Inconel 625	14.97	0.002570	28.89

The comparison of von mises stresses with respect to impeller materials .the maximum (equivalent) Von Mises stresses are induced in inconel 625, when compared to aluminum alloy (6016-T6). The maximum value of von mises stress 14.97MPa was noticed to inconel 625 which is very less as compared allowable stress (207Mpa). By doing

ISSN 2394 – 3386
Volume 4, Issue 9
September 2017

static structural analysis we realise that ,the maximum deflection induced in metallic pump impeller i.e . aluminum alloy (6016-T6) AA (6061) material is 0.0081511 mm, as the rigidity and strength of material is considered deformations are in limit. Hence based on rigidity the design is safe.

Mode	Frequency (Hz)	Deformation (mm)
1	1996.3	57.90
2	2137.4	82.03
3	2139.5	79.43
4	2447.7	82.13
5	2449.1	88.65
6	2559.9	33.30

MODAL ANALYSIS

Modal Analysis of AA (6061) Pump impeller:

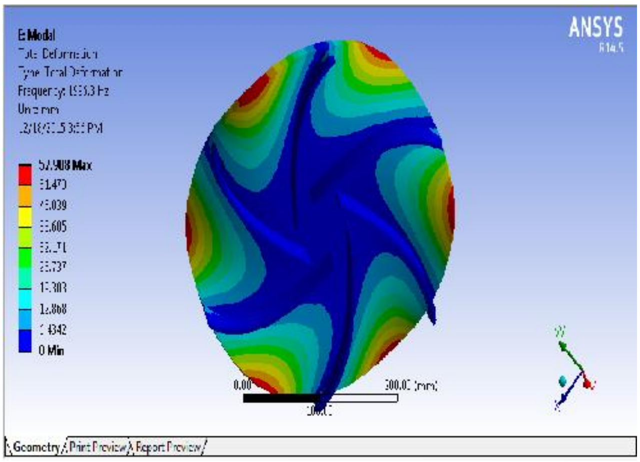

Fig. 2.1 First Mode Shape of AA Pump Impeller

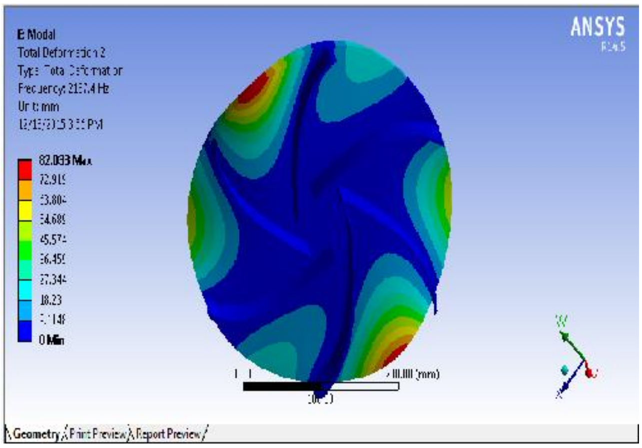

Fig. 2.2 Second Mode Shape of AA Pump Impeller

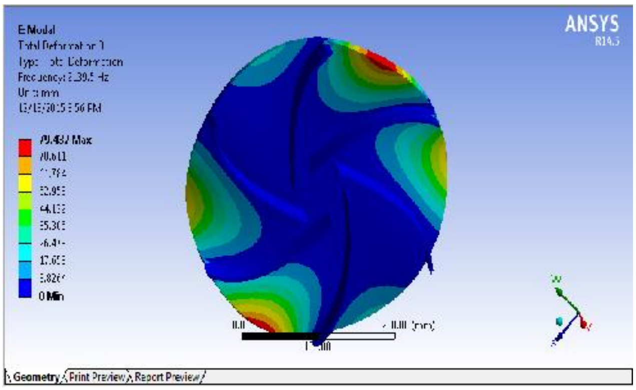

Fig. 2.3 Third Mode Shape of AA Pump Impeller

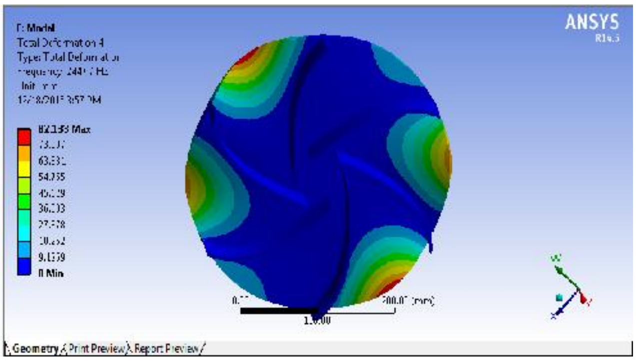

Fig. 2.4 Fourth Mode Shape of AA Pump Impeller

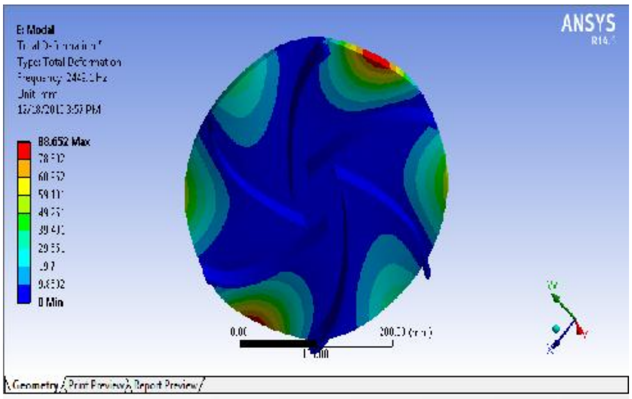

Fig. 2.5 Fifth Mode Shape of AA Pump Impeller

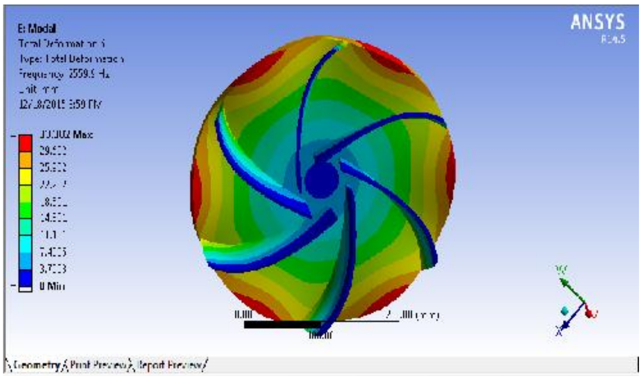

Fig. 2.6 Sixth Mode Shape of AA Pump Impeller

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 9
September 2017

➢ **Modal Analysis of inconel Pump Impeller:**

Mode	Frequency(Hz)	Deformation(mm)
1	2074.7	32.385
2	2224.5	46.278
3	2226.1	43.623
4	2555.5	48.881
5	2556.4	47.111
6	2706	22.135

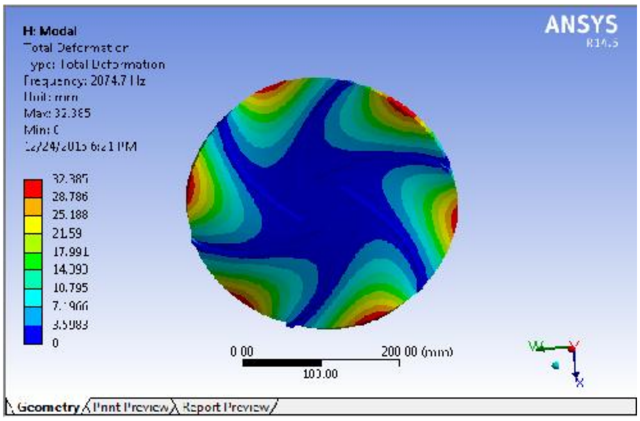

Fig. 2.7 First Mode Shape of Inconel625 Pump Impeller

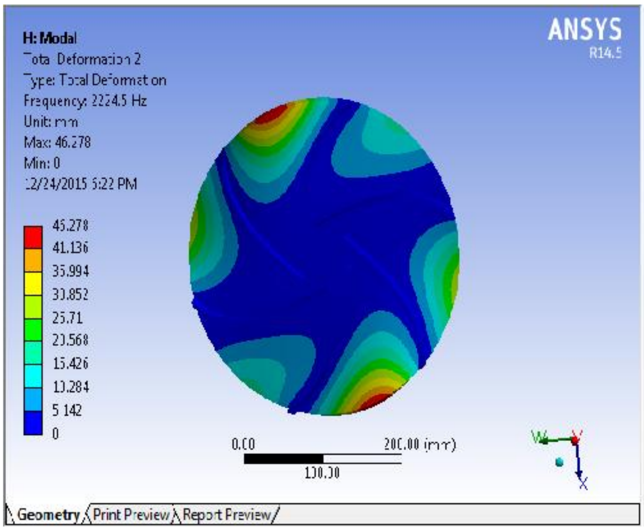

Fig. 2.8 Second Mode Shape of Inconel625 Pump Impeller

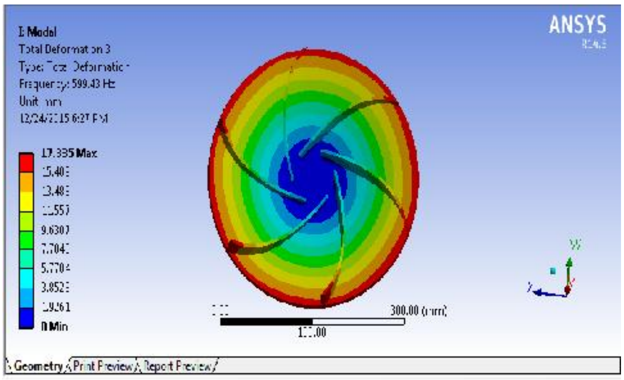

Fig. 2.9 Third Mode Shape of Inconel625 Pump Impeller

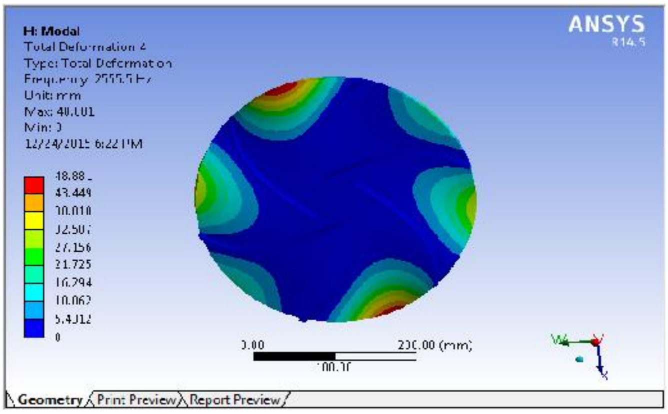

Fig. 2.10 Fourth Mode Shape of Inconel625 Pump Impeller

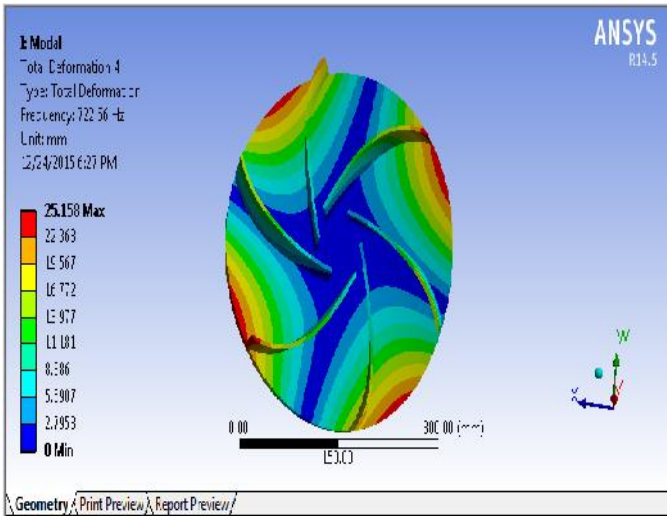

Fig. 2.11 Fifth Mode Shape of Inconel625 Pump Impeller

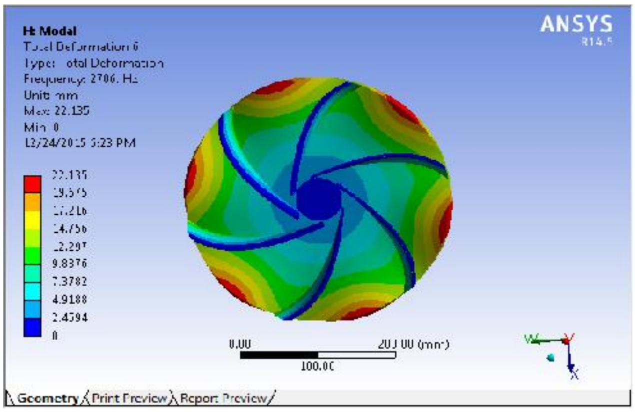

Fig. 2.12 Sixth Mode Shape of Inconel Pump Impeller

Table-: Comparison of first six natural frequencies Of AA,Inconel625 Pump Impeller

No. of Modes	Natural frequencies of AA impeller in Hz	Natural frequencies of Inconel625 impeller in Hz
1	1996.3	2074.7
2	2137.4	2224.5
3	2139.5	2226.1
4	2447.7	2555.5
5	2449.1	2556.4
6	2559.9	2706

For sake of convince and to get optimum result we have taken six mode,each mode wise natural frequency are shown in above table. From the mode shapes diagrams the mode shapes represent the bending mode in the blade of impeller and deformation of impeller. It is clear that the blade of impeller stiffness needs to be increase. On the other hand, to avoid the resonance at the operating speed, the difference between first natural frequency and operating frequency must be high.

Due to lower strength of pump impeller the deformations induced in pump impeller are also high. Due to lower strength there may be possibility to fail the material.

3. CONCLUSION:

In the FEA analysis certain contours of equivalent stress, equivalent strain and total deformation acting on pump impeller. It is observe maximum deformation takes place at the periphery of the pump impeller. The deformation in present case is very less. It is seen that maximum equivalent stress is acting at edges of curved vane. Von Mises stress, natural frequency and equivalent strain for inconel alloy 625 is optimum as compared to other material. From the ANSYS result, all the three designs are safe from mechanical point of view as the stresses acting are very less. Stresses are very less as there are a hardly few regions with maximum stress acting on localized point. Also the stress acting is very lower, in the entire four different material.By observing modal analysis results the frequencies are reducing by changing the material thereby the vibrations are reduced.Total analysis results compares and found that inconel 625 are having less deformation and stresses. The modal analysis of the semi-open impeller was done by the finite element analysis. The natural frequencies and the mode shapes of the impeller were extracted. It was found that the vector displacement of the impeller increased by increasing natural frequencies.

4. Future Scope of the Work

- Dynamic analysis can be performed for pump impeller using incnel 625.
- We can check the lifetime of the impeller with changing various material.
- Further development of this designed impeller can be done by CFD analysis of the impeller.
- Another way of development is by increasing the number of vanes. In this design as the numbers of vanes on diffuser were 4, impeller with three vanes could be used.

5. REFERENCES:

[1] Modal Analysis of a Semi-Closed Impeller of Centrifugal Water Pump 1Saeid Farokhzad, 2Asade Modarres Motlagh, 3Payam farhadi

[2] "Design, Modeling & Analysis of a Submersible Pump and to improve the Pump Efficiency" Shyam Karanth, V. K. Havanur

[3] "Optimization of Centrifugal Pump Impeller Outlet Vane Angle by Using Modal Analysis" Kotakar Sandeep Gulabrao1, D. S. Khedekar2

[4] Optimization of Centrifugal Pump Impeller Outlet Vane Angle by using Modal Analysis.Kotakar Sandeep Gulabrao and D.S. Khedekar

[5] Design Optimization of Monoblock Centrifugal Pump Impeller using Computational Fluid Dynamics 1 Dr .

K. Ragu,2 V. M. Mohamed Ashif K.,3 Naveen Kumar
[6] Design and Performance Analysis of Centrifugal Pump 1 Khin Cho Thin, 2 Mya Mya Khaing, 3 Khin Maung Aye
[7] Inverse Design of Impeller Blade of Centrifugal Pump with a Singularity MethodWen-Guang LI
[8] Modal analysis of a centrifugal pump1A.A. Nasser,2 M.A.Nasser, 3 E.H.T. El-Shirbeeny, 4 S.M.Abdel-Rahman
[9] FATIGUE (FEA) AND MODAL ANALYSIS OF A CENTRIFUGAL FAN Manish Dadhich1, Sheetal Kumar Jain2, Dhirendra Agarwal3