DESIGN AND ANALYSIS OF CENTRIFUGAL PUMP IMPELLER

MEB4441 - PROJECT & VIVA-VOCE REPORT

Submitted by

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BONAFIDE CERTIFICATE

Certified that this Project Report titled "DESIGN AND ANALYSIS OF CENTRIFUGAL PUMP IMPELLER" Is the bonafied work of P.MOHAN SRINIVASA GUPTA (18127005), J.HARSHA VARDHAN REDDY (18127012), P.YASWANTH SAI (18127035), T.SOURISH (18127052).Who carried out the project work under my supervision during the academic year 2021-2022.Certified further that to the best of my knowledge that the work reported here does not form part of any other project/research work on the basis of which a degree or award was conferred on an earlier occasion on this or any candidate.

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

ACKNOWLEDGEMENT

We are highly elated in expressing our sincere and abundant respect to the Vice Chancellor Prof. Dr.S.N.SRIDHARA for giving us this opportunity to bring out and implement our ideas in this project.

We wish to express our heartfelt gratitude to Dr.P.VIJAYABALAN, Head of the Department of Mechanical Engineering and Project Coordinator for much of his valuable support encouragement and guidance in carrying out this work.

We would like to thank our internal guide Dr.A.JOHN PRESIN KUMAR**,** Associate Professor for continually guiding and actively participating in our project, giving valuable suggestions to complete the project work.

It’s a matter of pride and privilege for us to express our deep gratitude to the management of HITS for providing us the necessary facilities and support.

We would like to thank all the technical and teaching staff of the Mechanical Engineering Department, who extended directly or indirectly all support.

Last, but not the least, we are deeply indebted to our parents who have been the greatest support while we worked day and night for the project to make it a success.

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ABSTRACT

Centrifugal pump is a device that used to transport fluid from one place to another. Centrifugal pump works by converting the rotational kinetic energy to hydro dynamic energy. Impeller is the rotating part in pump that increase fluid flow by accelerate fluid towards outlet using rotational energy provided by the engine or motor. Impeller blade and blade angle are main aspects to be considered when it comes to efficiency and the out flow. In this project we are going to research about the various designs of centrifugal pump impeller and their materials, applications in various domains, review the previous works done on centrifugal pump impeller.The Problem identified was the conventional materials used for impellers are high in density and poor in corrosion resistance. These may fail in high pressure applications like deep sea applications, So We are going to select a better material other than the conventional materials because of their heavy weight and failures, and design a 3d model of the impeller using 3d design software and analyze the model for its strength and vibrations produced using analysis software and compare the results obtained with the results of old material.we are also going to simulate the centrifugal pump with impeller in simulation software.

Keywords: Centrifugal Pump, Impeller, GFRP, Modal Analysis, Strength Analysis.

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Department of Mechanical Engineering

MEB4441 - Design Project 6 (8^{th}Mech)

Project Batch No	: 6
Title of the project	: Design and analysis of centrifugal Pump impeller
No of students in the batch	: 4

Student's Individual Contribution

Name of the student	: P.Mohan Srinivasa Gupta
Register No	: 18127005

I P.Mohan Srinivas Gupta contributed towards CFD simulation of centrifugal pump in 'SOLIDWORKS 2020' and also took active part in design calculation of the impellers finding the required parameters to design the impeller, literature review where I collected journal papers related to our project from standard journal papers ,also involved in preparing the project report.

P.Mohan Srinivasa Gupta

(Name of the student with Signature)

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Department of Mechanical Engineering

MEB4441 - Design Project 6 (8^{th}Mech)

Project Batch No : 6

Title of the project : Design and analysis of centrifugal Pump impeller

No of students in the batch : 4

Student's Individual Contribution

Name of the student : J.Harsha Vardhan Reddy

Register No : 18127012

I J.Harsha Vardhan Reddy contributed towards the 3d designing of impeller using ' Autodesk Fusion 360' Software With relevant dimensions of impeller. I collected all the relevant information of new materials used for centrifugal impeller and found out the new material GFRP, I Used standard journals for materials also took active part in literature review where I collected journal papers related to our project from standard journal papers ,also involved in preparing the project report.

J.Harsha vardhan reddy

(Name of the student with Signature)

Department of Mechanical Engineering

MEB4441 - Design Project 6 (8^{th}Mech)

Project Batch No : 6

Title of the project : Design And Analysis of Centrifugal Pump Impeller

No of students in the Batch : 4

Student's Individual Contribution

Name of the student : Pendota Yaswanth Sai

Register No : 18127035

I P.Yaswanth Sai contributed towards Structural Analysis part in the project where I worked on finding Total deformation, Equivalent Stress, Strain , modal analysis where I found the natural frequencies of the impellers and the methodology used to perform , I also took active part in literature review where I collected journal papers related to our project from standard journal papers ,also involved in preparing the project report.

P.Yaswanth Sai

(Name of the student with Signature)

Department of Mechanical Engineering

MEB4441 - Design Project 6 (8^{th}Mech)

Project Batch No : 6

Title of the project : Design and analysis of centrifugal Pump impeller.

No of students in the batch : 4

Student's Individual Contribution

Name of the student : T. Sourish

Register No : 18127052

I T.Sourish contributed towards Material selection of wind turbine in the project where I actively participated in searching about current materials used and their drawbacks. I worked out in simulation preparation. Used standard journals for material selection and also took active part in literature review where I collected journal papers related to our project from standard journal papers ,also involved in preparing the project report.

T.Sourish

(Name of the student with Signature)

CHAPTER 1

INTRODUCTION

1.1 IMPELLER

An impeller is a rotating component equipped with vanes or blades used in turbo machinery (e. g. centrifugal pumps). Flow deflection at the impeller vanes allows mechanical power (energy at the vanes) to be converted into pump power output.

Fig 1.1: Impeller

1.2 WORKING OF CENTRIFUGAL PUMP

Centrifugal pumps work to produce flow or raise a fluid from a lower level to a higher level. The working of these pumps is based on a straightforward mechanism. A centrifugal pump turns rotational energy coming from a motor into energy in a moving fluid.

The two main components responsible for this task are the impeller, and the casing, both of which belong to the portion of the pump called the wet end. The impeller is the rotating part, and the casing is the airtight path that surrounds the impeller.

The fluid in a centrifugal pump enters the casing, falls on the impeller vanes at the impeller eye, and rotates radially outward until it exits the impeller through the diffuser (volute) of the casing. As it passes through the impeller, the fluid gains both velocity and pressure.

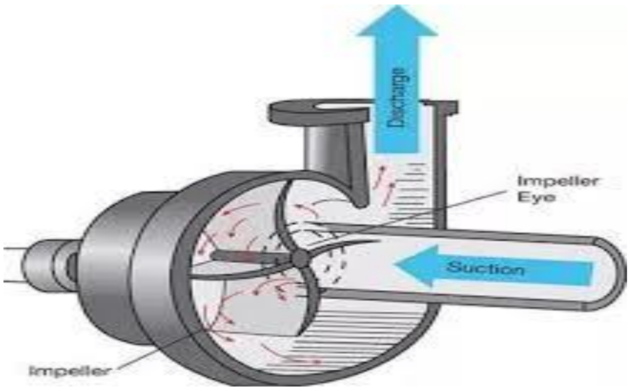

Fig 1.2 : Working principle

1.3 TYPES

1. Open Type impeller: Open impellers have the vanes free on both sides. Open impellers are structurally weak. They are typically used in small-diameter, inexpensive pumps and pumps handling suspended solids.
2. Semi-open type impeller: The vanes are free on one side and enclosed on the other. The shroud adds mechanical strength. They also offer higher efficiencies than open impellers. They can be used in medium-diameter pumps and with liquids containing small amounts of suspended solids. Because of the minimization of re-circulation and other losses, it is very important that a small clearance exists between the impeller vanes and the casing.
3. Closed type impeller: The vanes are located between the two discs, all in a single casting. They are used in large pumps with high efficiencies and low required Net Positive Suction Head. The centrifugal pumps with closed impellers are the most widely used pumps handling clear liquids. They rely

on close-clearance wear rings on the impeller and the pump casing. The closed impeller is a more complicated and expensive design because of the impeller, but additional wear rings are needed.

Fig 1.3 : Open, Semi Open, Closed type impellers.

In this Project Semi Open type of Impeller is selected and designed and analyzed further. The impeller type can be selected according to the application of use and requirements.

1.4 APPLICATIONS Centrifugal applications are found in various domestic and commercial purposes, some of the applications are following:

1.Water supply for residential areas

2. Fire protection systems

3. Sewage/slurry disposal

4. Food and beverage manufacturing

5. Chemical manufacturing

6. Oil and gas industrial operations

CHAPTER 2

LITERATURE REVIEW

[1] In this paper they had designed and analyzed centrifugal impeller with composite materials(CFRP, GFRP, AL 1060, INCONEL 625, 740) for static dynamic and modal analysis, found the vibration frequencies and determined the best material, the design software used is catia and analysis using the Ansys software.finally find out the stresses, strains, deformations in static analysis and Deformations are find out at different frequencies in modal analysis .

[2] Here, Materials such as Caprolone (Nylon) and ABS (Acrylonitrile Butadiene Styrene) have been considered which has chemical, thermal stability along with toughness and strength.The design and analysis of impeller is designed and analyzed using commercially available simulation tools.

[3] Here a comparison is made between 5, 7, 9 blades impeller to determine the effect of the impeller blade number on pumps performance, It is Found That the losses are minimum and efficiency is more for 7 blade impeller than compared to 5 and 9 blade Impeller.CFD tool is used to perform this work.

[4] In this paper they had designed impeller using CatiaVR5, found the total axial thrust produced by the impellers and developed a design procedure to nullify the axial thrust.CATIAV5R19 software is used to design and The boundary conditions applied to are referred from API610 (American petroleum industry).

[5] In this Paper the modeling and simulation of the impeller have been carried out Using Creo 4.0 and ANSYS Workbench software . The respective frequencies and corresponding mode shapes impeller were measured by using eigenvalues and eigenvectors respectively. The results showed that the varying

impeller blade exit angle had significant effect on natural frequency of the impeller.

[6] In this project we have designed an impeller for a domestic need using formulas formulated by Dr. K.M Srinivasan, in the book Rotodynamic Pumps. The impeller is modeled using CAD software and analyzed using Ansys package. The Ansys output is cross checked with desired requirements, so as to state the accuracy and need of Ansys analysis.

[7] In this paper they had analyzed the looseness failure between impeller and shaft. The torque capacity of interference connection was analyzed using FEM, It is found that the max torque transmitted by interference connection being lower than resultant resistance torque is the main reason of looseness failure between impeller and shaft.

[8] In this paper Design and simulation were conducted using ANSYS CFX, using the Navier-Stokes equation. Shear Stress Transport (SST) was chosen for turbulence model, it is observed that observed that as the rotation speed of the impeller increases, the pressure within the impeller increases, the efficiency of the impeller increases as the rotation speed increases.

[9] In this paper they had designed and did performance analysis of centrifugal pump impeller made of Polyphenylene Sulphide (PPS) polymer material.and found that the impeller with PPS material is best compared to Cast Iron . The maximum pressure that impeller could bear is found using computational fluid dynamics (CFD) analysis & found to be within limits.

[10] In this Paper it gives the static and Modal analysis of MS & SS Pump impeller in order to optimize strength of centrifugal pump. check Strength of Pump and vibrations produced by pump.The design Software used is CATIA V5R18 and Analysis software used is FEA package in Ansys.

[11] In this paper, the dynamic characteristics of an impeller of a centrifugal pump were studied.Modeling and simulation of the impeller have been carried out using ANSYS Bladegen and ANSYS Workbench software, respectively.The

results showed that the varying number of impeller blades and impeller blade thickness had minimal effect on frequencies.

[12] In this paper, the impeller design is based on Berman Method.The performance analysis of centrifugal pump is carried out after designing the dimensions of centrifugal pump. So, shock losses,impeller friction losses, volute friction losses, disk friction losses and re-circulation losses of centrifugal pump are also considered in performance analysis of centrifugal pump.

CHAPTER 3
MATEREIAL SELECTION

Generally, cast iron is the conventional material used to manufacture the centrifugal pump impeller. But we found some drawbacks when we use cast iron. Cast iron: An alloy of iron that contains 2 to 4 percent carbon, along with varying amounts of silicon and manganese and traces of impurities such as sulfur and phosphorus. It is made by reducing iron ore in a blast furnace**.**

3.1 Drawbacks of conventional material is listed below

- More likely to require post-fabrication finishing like DE-burring and painting which could add time and cost to the project.
- Has high Density and Mass.
- Cannot Resist High Pressures in under water Applications.
- More difficult to machine/fabricate.
- Custom applications can be costly and have a long production time.

3.2 Criteria for selection of impeller Material

1. Corrosion resistance
2. Abrasive-wear resistance
3. Cavitation resistance
4. Strength (primarily for the casings)
5. Casting and machining properties
6. Cost

Bellow Table shows the material properties of cast iron material:

	UNIT	CAST IRON
Compressive strength	MPa	100-600
Tensile strength	MPa	245
Flexural strength	MPa	150-400
Density	Kg/m^3	7150-7250
Young's Modulus	GPa	80-140
Thermal capacity	J/(kg-k)	0,5
Thermal conductivity	W/(m-k)	45-50
Thermal Expansion	$10^{-6}/k$	9-12

Table 3.1 : Properties of cast iron

3.3 SELECTED NEW MATERIAL

Based upon the above criteria we have selected Glass Fiber Reinforced Plastic (GFRP 'E') which has more corrosion resistance and ability to withstand high pressure under water without breaking, Reduces the Repair Costs, which is Ideal for pumping sea water applications.

GFRP

Glass-Fiber reinforced plastic (GFRP) is a composite material consisting of plastic reinforced with fine glass fibers. These fibers may be arranged randomly, flattened as a sheet, or woven to make a fabric-like material. A plastic resin is then overlaid onto the glass fibers to create combined uniform material.

FIBER USED

E-GLASS

E-Glass / Epoxy Resin, or Borosilicate Glass Reinforced Epoxy Composites are extremely strong materials used in roofing, automobiles, and pipes. E-Glass or electrical grade glass was originally developed for standoff insulators for electrical wiring.

Properties of GFRP:

S.no	Particular	value	unit
1	Glass content (by weight)	75±5	%
2	Epoxy resin content (by weight)	25±5	%
3	Reinforcement, uni-directional	‘E’ glass roving	----
4	Water absorption	0.07	%
5	Density	1.95-2.1	gm/cc
6	Tensile strength	650	N/mm^2
7	Compression strength	600	N/mm^2
8	Shear strength	255	N/mm^2
9	Modulus of elasticity	320	N/mm^2
10	Thermal conductivity	0.30	N/mm^2
11	Electrical strength(radial)	3.5	KV/mm
12	Working temperature class	Class “F” (155^0)	Centigrade
13	Martens heat distortion temperature	210^0	Centigrade

Table 3.2: Properties of GFRP

CHAPTER 4
DESIGN CALCULATION

The Required Parameters for the design of impeller are found using bellow formula's and selected pump specifications:

4.1 Specifications of Centrifugal Pump

S.No	Parameter	Value
1.	Head (H)	24 mm
2.	Discharge (Q)	95 lpm = 1.583 lps
3.	Power Output (P)	746 w = 1hp
4.	Speed N	2880 rpm
5.	Pipe Size	25X25
6.	Total Pressure devoloped in the fluid (p)	141744.4773 Pa = 0.141744 MPa

Table 4.1 : Specifications of Pump.

4.2 Theoretical Calculations of Impeller

1.Specific Speed (N_s)**:**

The Specific speed for the pump is calculated as below:

$N_s = 3.65\frac{N\sqrt{Q}}{H^{3/4}}$

$= 3.65\frac{2880\sqrt{0.00158}}{24^{3/4}}$

N_s = 38.53 rev/min

where

N = Speed of impeller.

Q = Discharge.

H = Head of pump.

2.Power input to pump (P)**:** hp

The Power is given as:

$$P = \frac{\rho Q g H}{\eta_o}$$

$$= \frac{1000}{0.63}*1.583*9.81*24$$

P = 1.84 hp

where

ρ = Density of water.

Q = Discharge.

g = Acceleration due to gravity.

H = Head of pump.

η_o= Overall efficiency.

3.Shaft diameter (d_s): mm

Shaft diameter can be found using the following formula

$$d_s = \sqrt[3]{\frac{16T}{\pi\tau_t}}$$

$$= \sqrt[3]{\frac{16*4.6}{\pi*1.31*10^{-7}}}$$

d_s = 25mm

where

T = Torque applied on plate.

τ_t = Shear stress.

4.Outer diameter of impeller (D_2): mm

The outer diameter D_2 can be calculated using:

The head coefficient (ψ)

$$\Psi = \frac{gH}{\frac{U^2}{2}} = \frac{9.81*24}{\frac{21.71^2}{2}} = 2$$

$$U_2 = \frac{\pi D_2 N}{60} = \sqrt{\frac{2gH}{\Psi}}$$

$$= \sqrt{\frac{2*9.81*24}{2}}$$

U_2 = 21.71m/s

$$D_2 = \frac{60}{\pi N}\sqrt{\frac{2gH}{\Psi}}$$

$$= \frac{60U_2}{\pi N}$$

$$= \frac{60*21.71}{\pi*2880}$$

D_2 = 144mm

where

g = Acceleration due to gravity.

H = Head of pump.

U = Velocity.

Ψ = Head coefficient.

5. Selected No. of blades = 4

6.Angular Velocity (ω): rad/sec

$$\omega = \frac{2*\pi*N}{60}$$

$$\omega = \frac{2*\pi*2880}{60}$$

ω = 300 rad/sec

7. Mass (kg):

In Ansys software the Mass of the entire Geometry is obtained and are noted down bellow.

For Grey Cast Iron , mass = 0.71467 kg.

For GFRP, mass = 0.19356 kg.

All the calculated parameters of the impeller are tabulated bellow:

S.no	Dimension	value
1.	Diameter	144 mm
2.	Shaft diameter	25 mm
3.	Blade Inner diameter	42 mm
4.	Blade Outer Diameter	44 mm

5.	Impeller base thickness	5 mm
6.	Blade height	25 mm

Table 4.2 : Dimensions of Impeller

CHAPTER 5

3D-MODELLING

With the design parameters calculated for the design of the impeller, in this stage a 3d-model is designed using 3d modelling software which is Autodesk Fusion 360.

5.1 Steps followed during the design

1. Draw a circle of radius 144mm which is the whole base diameter of impeller and extrude it up to 5mm thickness.
2. After extruding the base diameter draw another circle of diameter 25mm on the base of the impeller which is the shaft diameter and extrude it in reverse direction to make a hole.

Draw two concentric circles of diameter 41.33(inner diameter) and 44.83 (outer diameter) which is used create impeller blades. And the thickness of blade is 2.5mm. and trim the rest of the sketches in the drawing and extrude the blades.

Here bellow are the images of the designed Impeller both in 3d view and 2d view:

5.2 2D-MODEL

The 3 views I.e Front view , Top View, Side view along with Isometric are shown bellow:

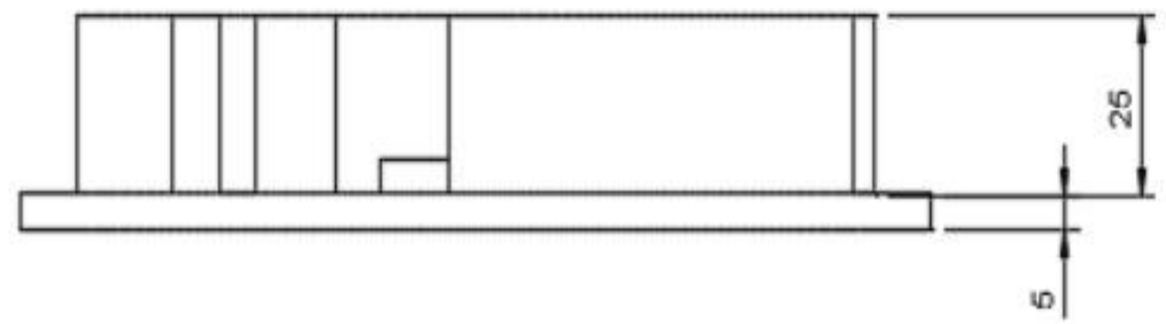

Fig 5.1 : Front view of the impeller.

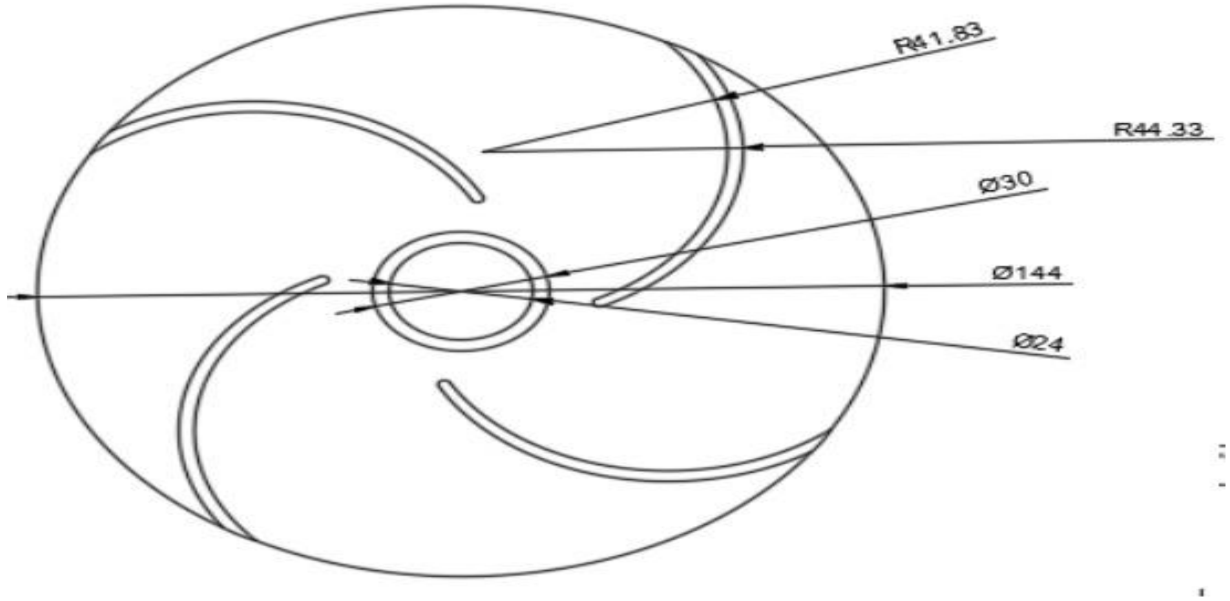

Fig 5.2 : Top view of the Impeller.

The Front view and side view of the impeller are same in this case:

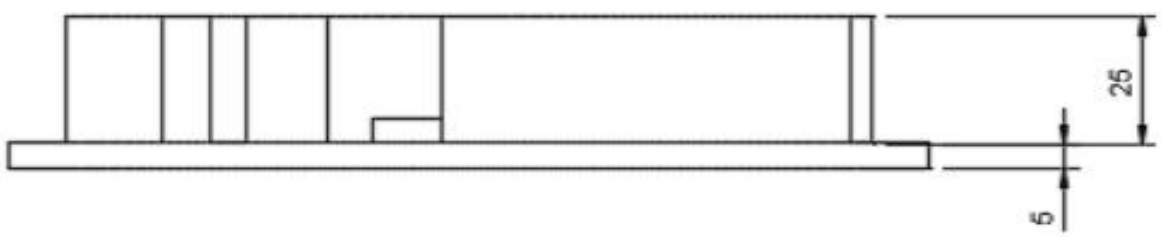

Fig 5.3 : side view of the Impeller.

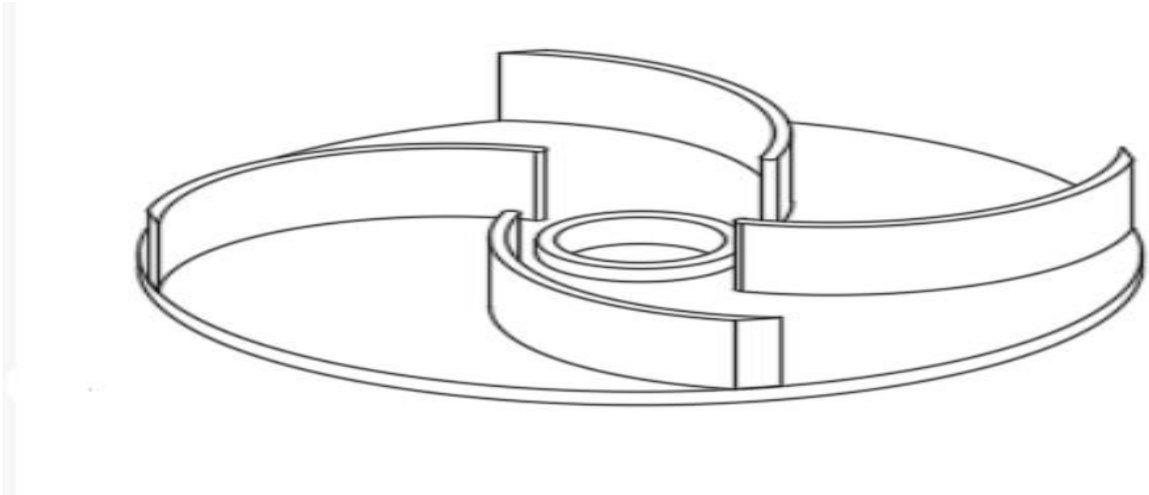

Fig 5.4 : isometric view of the Impeller.

5.3 3D-Model

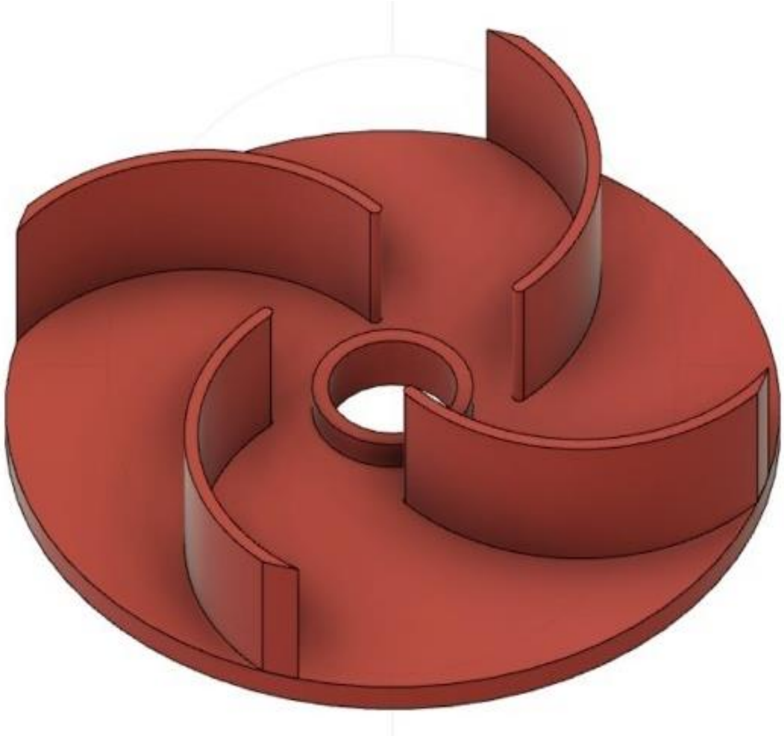

Fig 5.5 : 3d model of the Impeller.

Above image shows the finished 3d model of centrifugal impeller designed in Fusion 360 Software.

CHAPTER 6

ANALYSIS

6.1 Structural Analysis

Definition

Structural analysis is the determination of the effects of loads on physical structures and their components.

Overview of Analysis

The Following are the steps followed in ansys:

1. Engineering data - Selecting the required Material for Analysis or inserting your own material with its properties for Analysis.
2. Geometry - Creating the Model using design modeler or can import design files with specified format.
3. Model - Reviewing the 3d model and meshing is done.
4. Setup - Here the pre analysis setup like applying loads…etc is made.
5. Solution - This is the Solving Phase, Creating the required parameters for which we need the analysis data.
6. Results - The final results can be viewed here.

Here In this Project The Strength of Blades of the Centrifugal Pump Impeller is Analyzed in Structural Analysis Using Analysis software ‘Ansys Student 2021 R1’.

The Resulting Total Deformation, Equivalent (Von-Mises) Stress, Equivalent Strain are Observed And the obtained results are Interpreted.

The Structural analysis is done using two materials i.e grey cast iron and glass fibre reinforced plastics (GFRP), at the end of analysis the best suitable material for designed impeller is concluded using the results obtained.

Analysis Setup Along with all the results are shown bellow in images and the final results are tabulated in table.

Setup

For Meshing Coarse Meshing (default) is used, The face of the blades are made as fixed supports and a Rotational velocity of 300 rad/sec is applied to the impeller.This Setup is shown bellow:

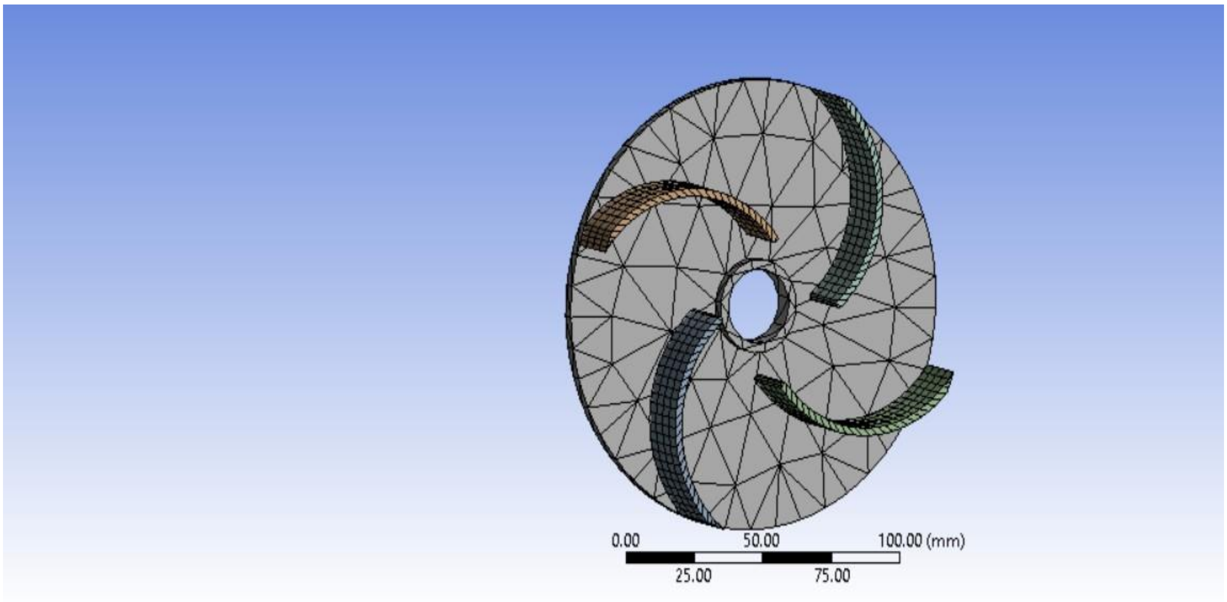

Fig 6.1: Meshing of impeller.

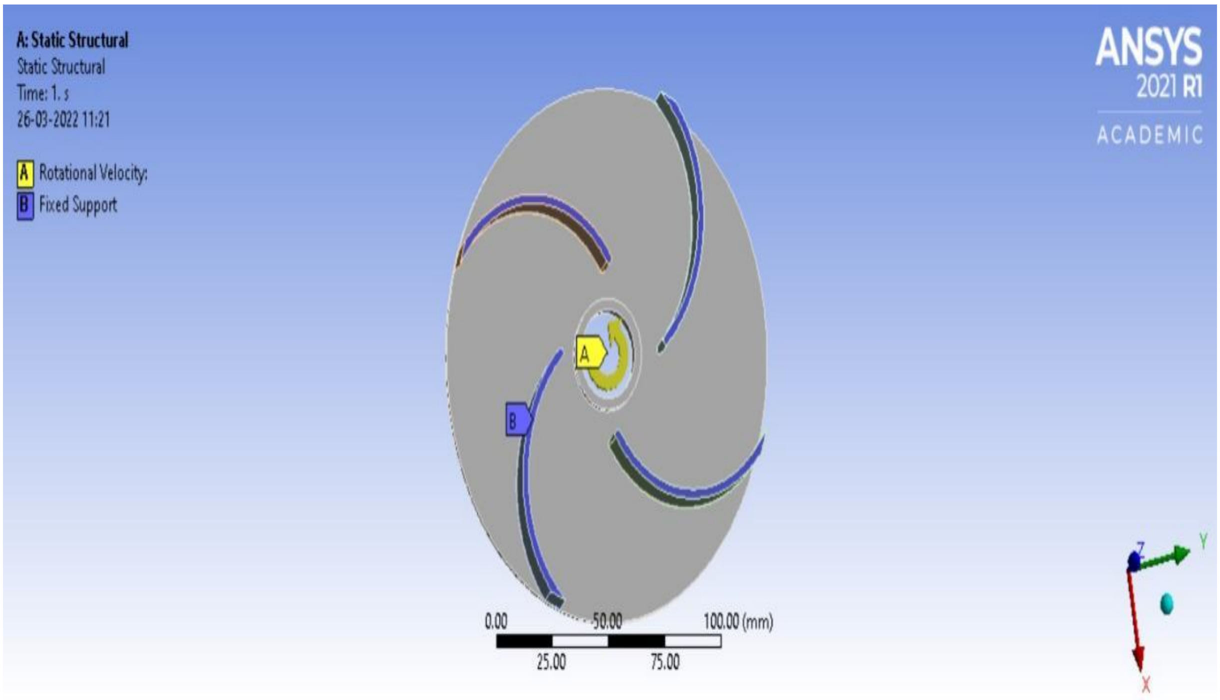

Fig 6.2: Structural Analysis Setup.

Equivalent (Von-mises) Stress The Resulting Equivalent (Von-Mises) stress Images are shown bellow for both the materials Cast iron and GFRP.

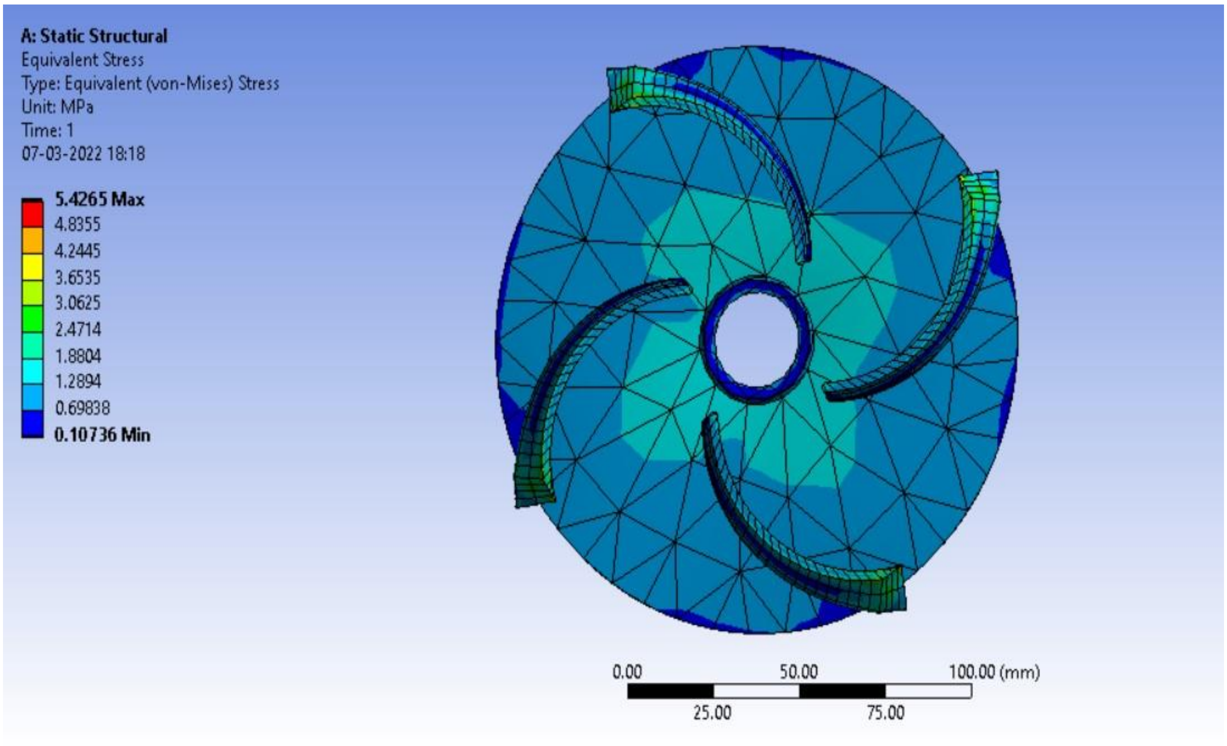

Fig 6.3: Resulting Equivalent Stress of Grey Cast Iron

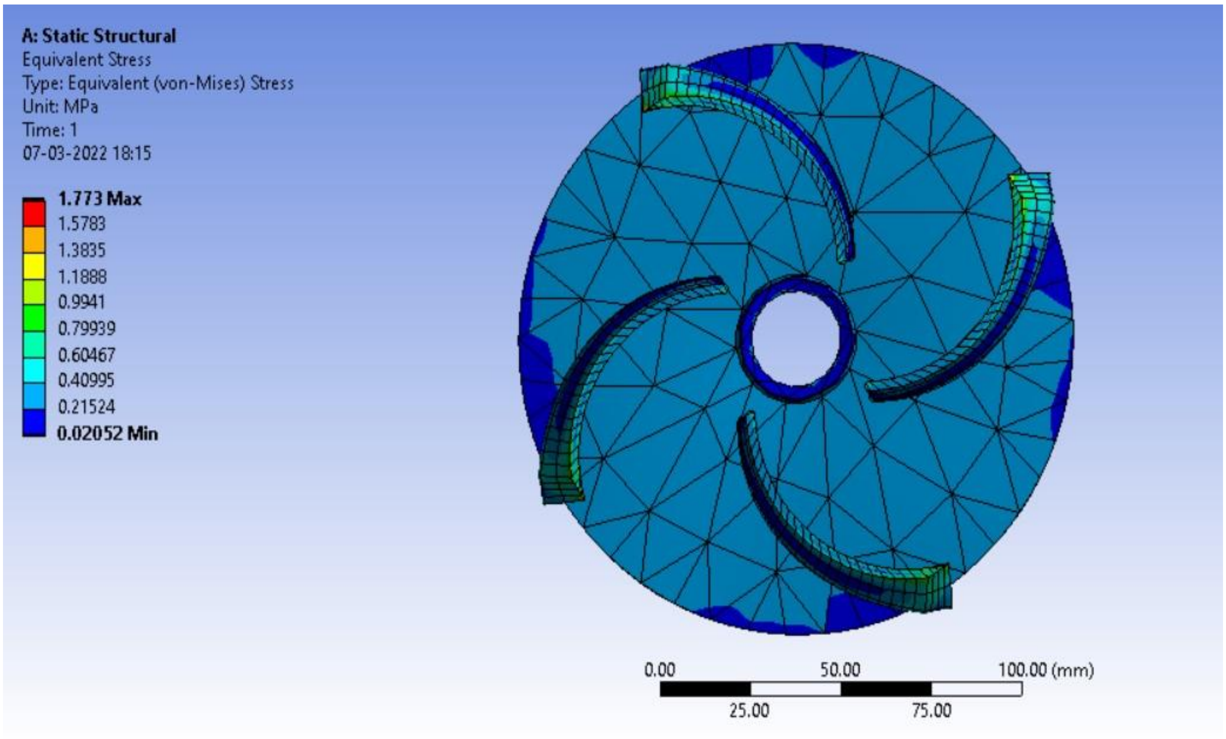

Fig 6.4: Resulting Equivalent Stress of GFRP.

Equivalent Strain The Resulting Equivalent strain Images are shown bellow for both the materials Cast iron and GFRP.

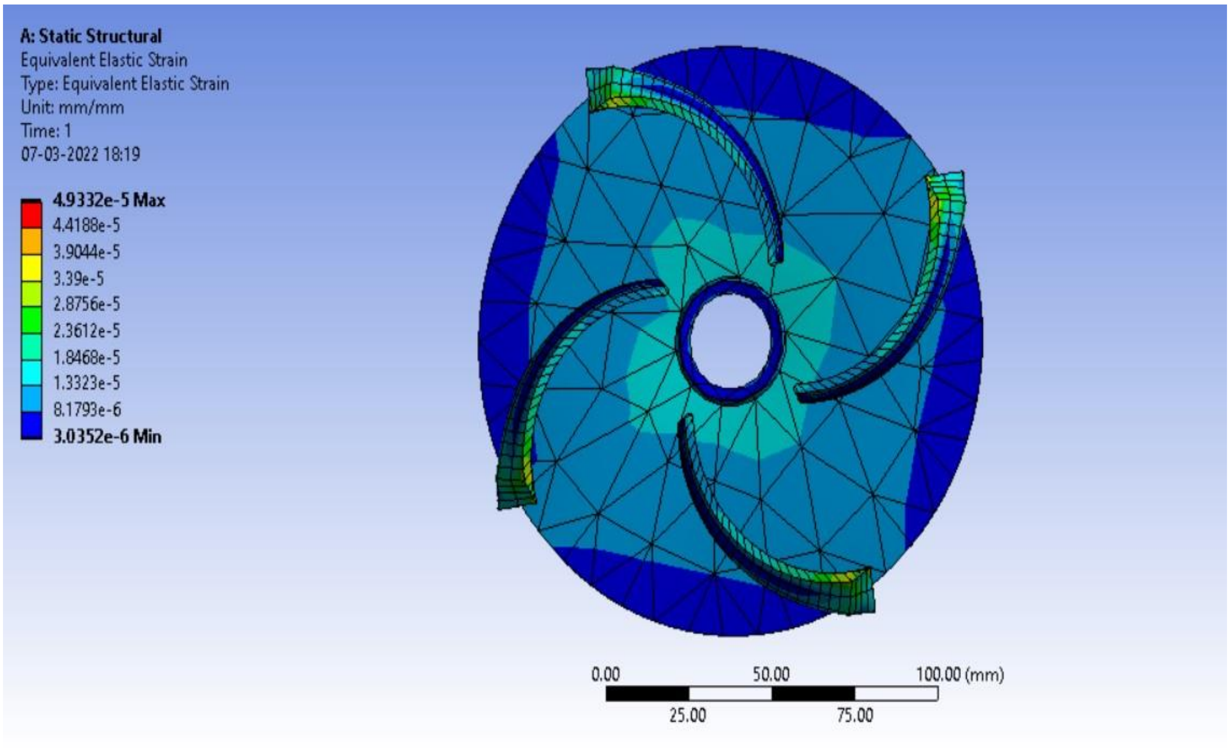

Fig 6.5: Resulting Equivalent Strain of Grey Cast Iron.

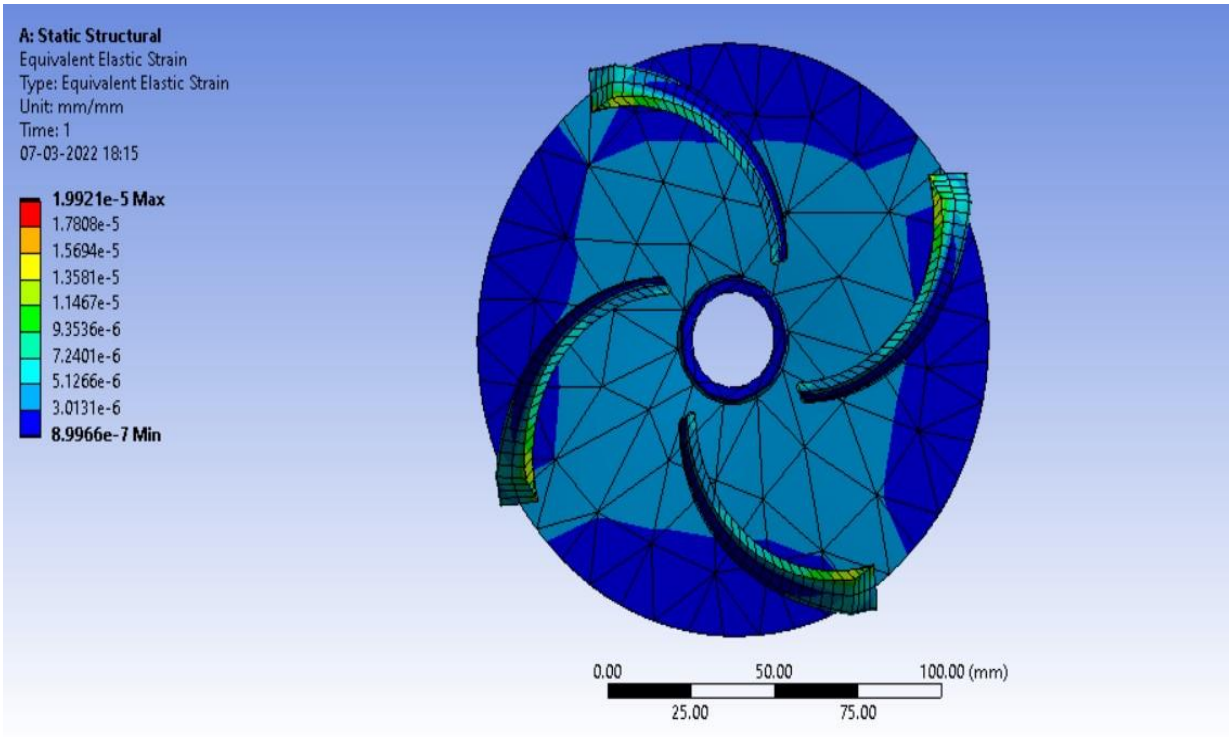

Fig 6.6 : Resulting Equivalent Strain of GFRP.

Total Deformation The Resulting Total Deformation Images are shown bellow for both the materials Cast iron and GFRP.

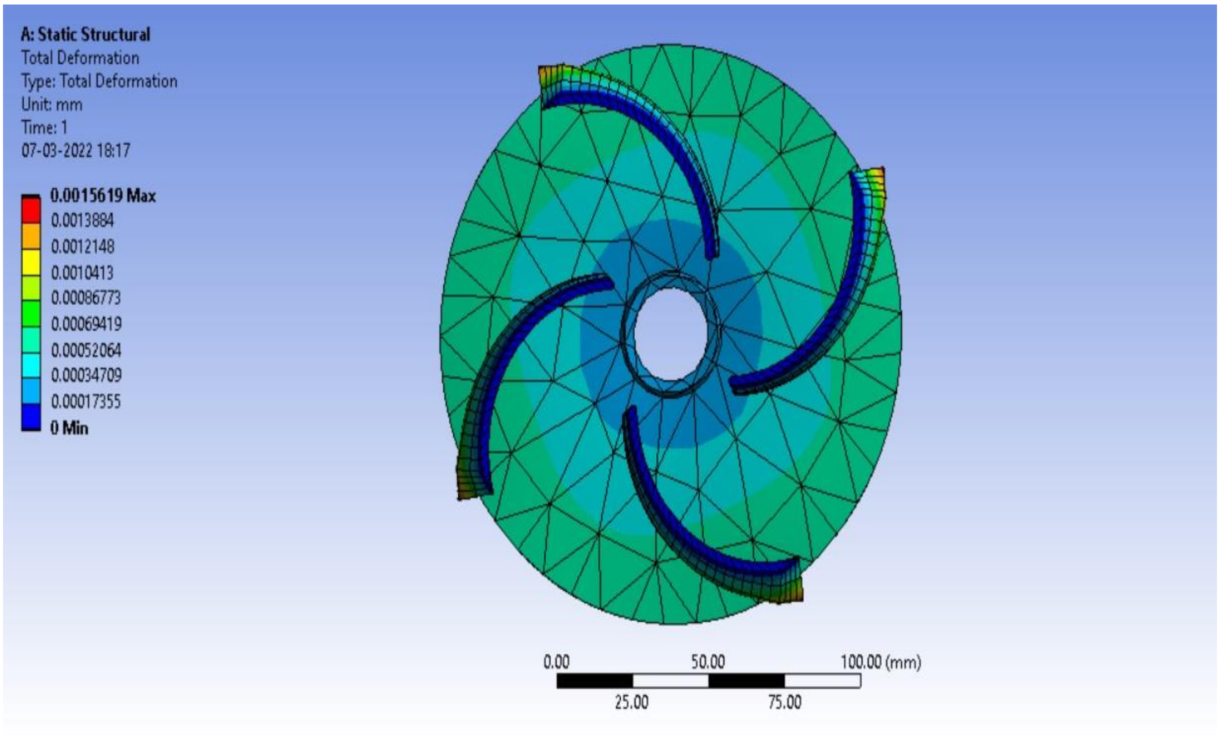

Fig 6.7: Total Deformation in Impeller for Grey Cast Iron.

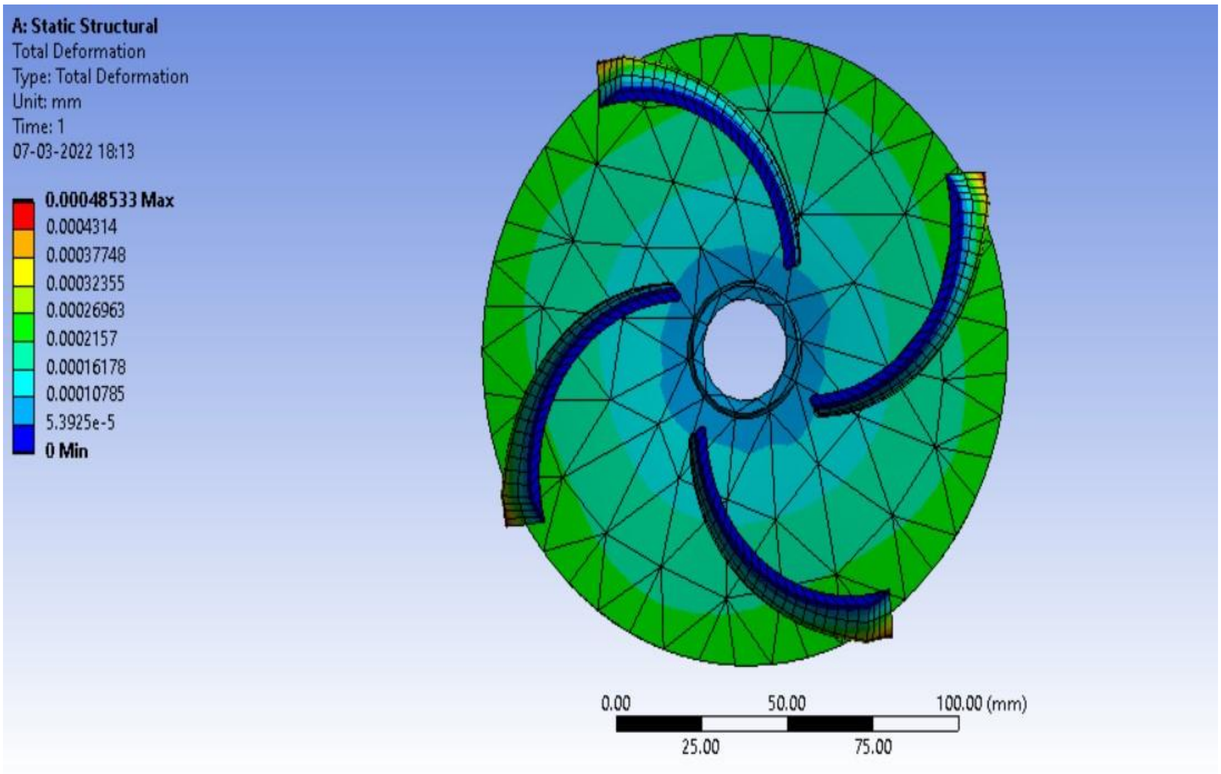

Fig 6.8 : Total Deformation in Impeller for GFRP.

All the Results obtained from structural analysis are tabulated in Bellow Table :

S.No	Material	Equivalent Stress (MPa)	Equivalent Strain	Total Deformation (mm)	Mass (kg)
1.	Grey Cast Iron	5.4265	4.9332 e-5	1.5619e-003	0.7146
2.	Glass Fiber Reinforced Plastic (GFRP)	1.8688	1.9921e-5	5.1156e-004	0.1935

Table 6.1 : Results Obtained from structural Analysis.

6.2 Modal Analysis

Definition

Modal analysis is the process of determining the inherent dynamic characteristics of a system in forms of natural frequencies, damping factors and mode shapes, and using them to formulate a mathematical model for its dynamic behaviour.

Overview of Analysis:

In Model Analysis The Natural Frequencies of Impeller for Both the materials are found out at 6 Modes and corresponding mode shapes and deformation are observed and results are interpreted.

Setup

Here in Model Analysis Only The faces of blades are made fixed support.

The Setup is shown bellow:

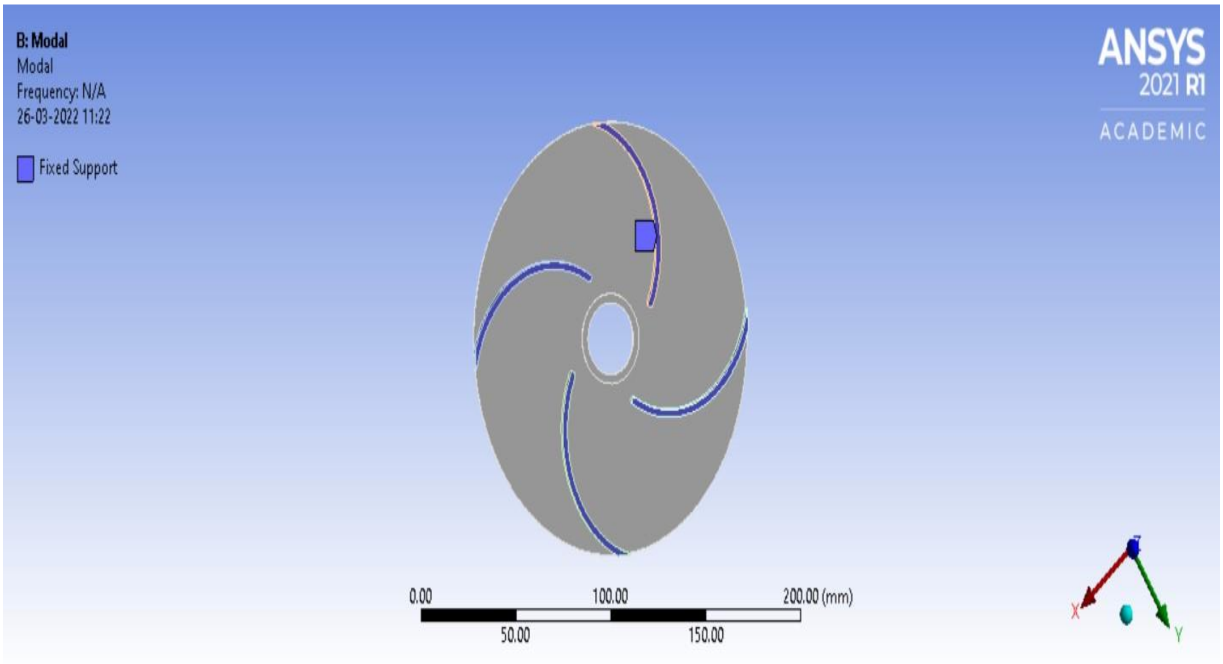

Fig 6.9 : Modal Analysis Setup.

The Natural Frequencies at 6 Modes along with their deformation and mode shapes for 2 different materials Grey Cast Iron and GFRP are shown bellow:

Grey Cast Iron

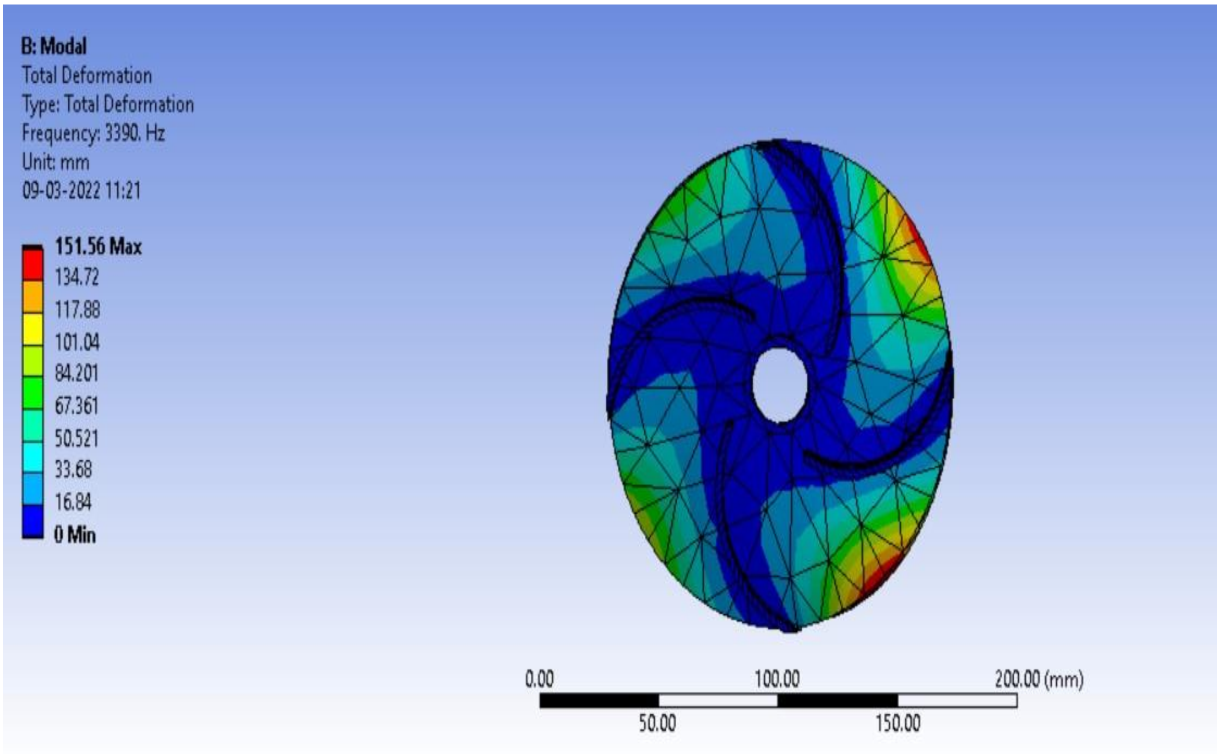

Fig 6.10: Mode 1, Natural Frequency of Grey Cast Iron.

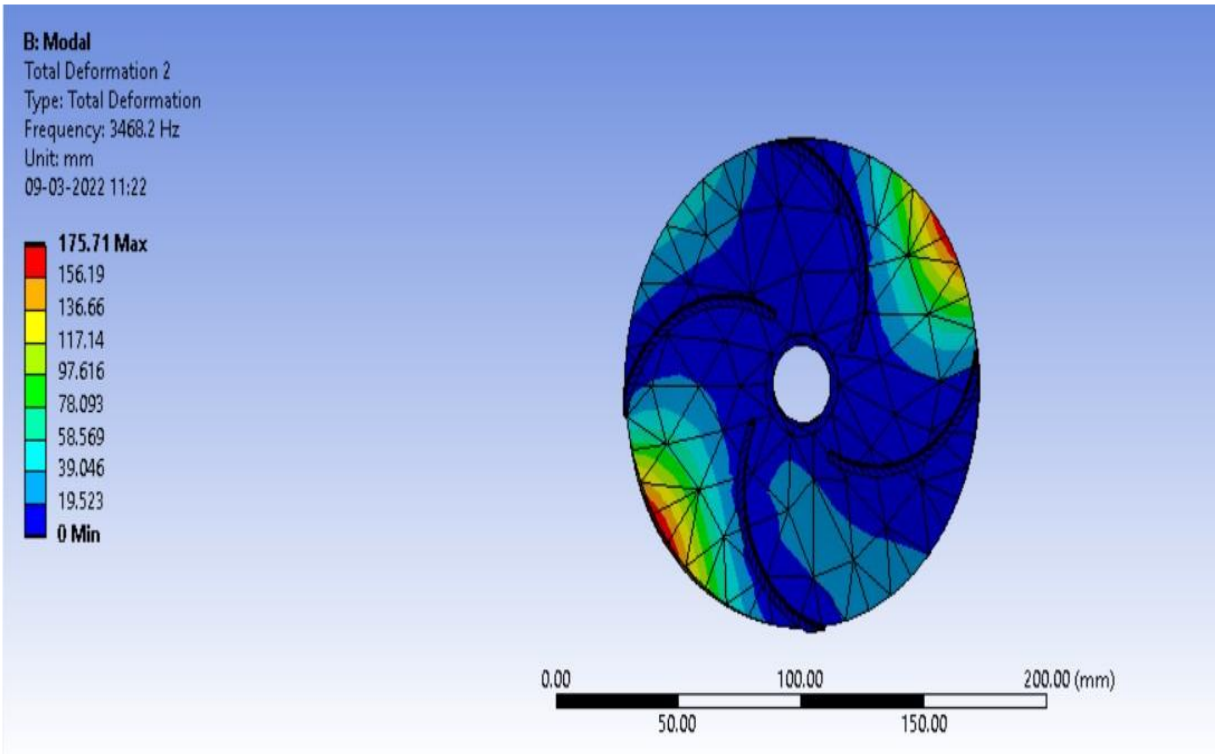

Fig 6.11: Mode 2, Natural Frequency of Grey Cast Iron.

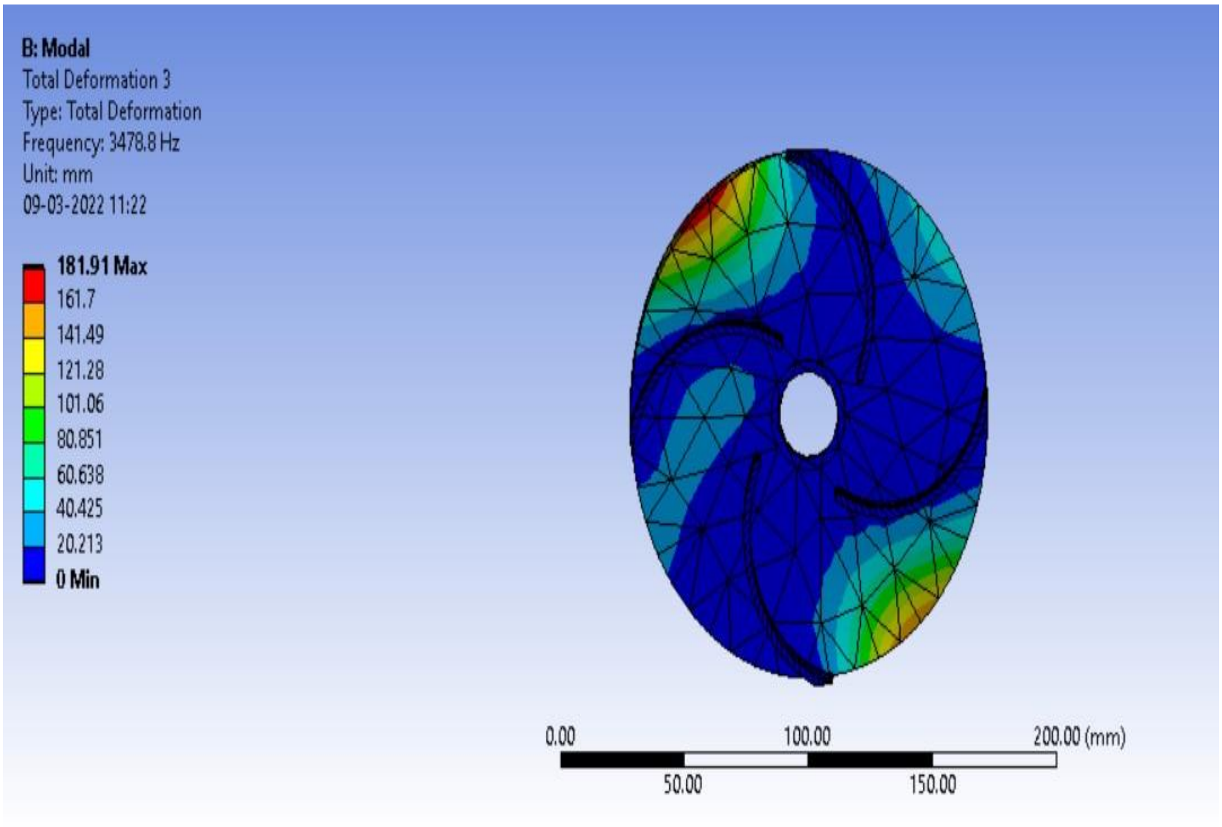

Fig 6.13: Mode 3, Natural Frequency of Grey Cast Iron.

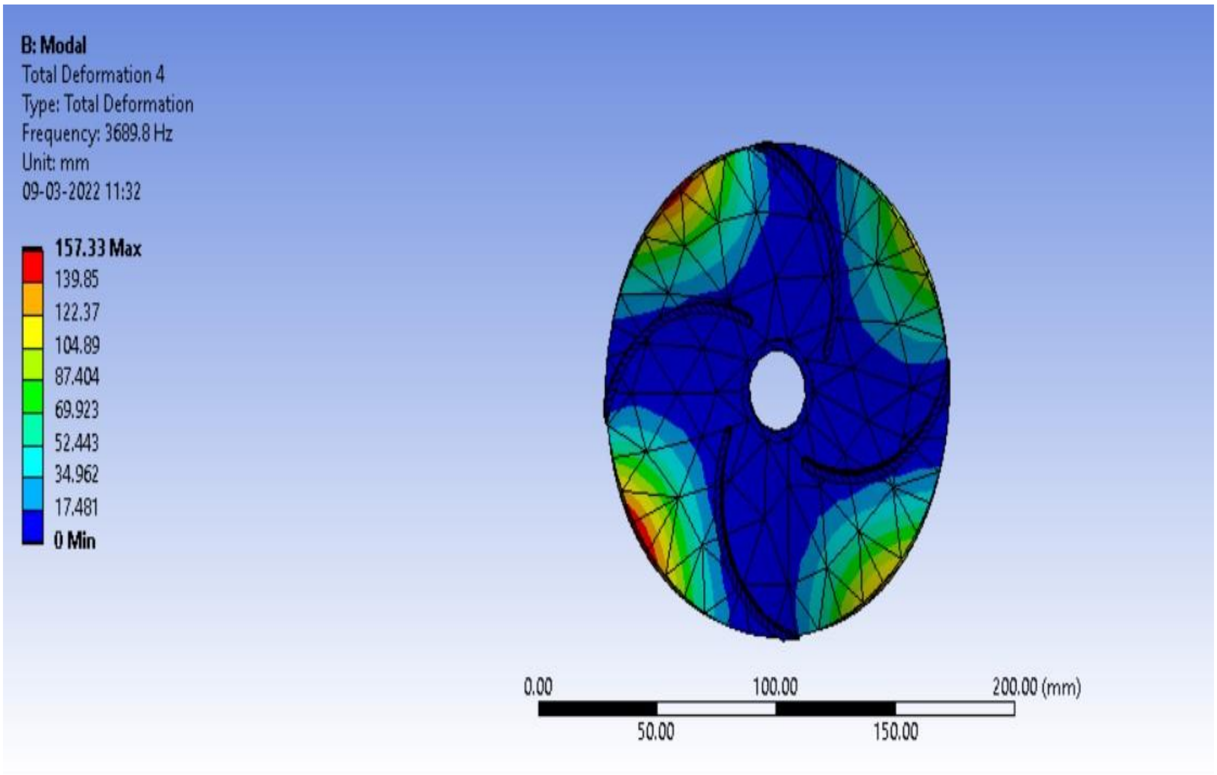

Fig 6.14 : Mode 4, Natural Frequency of Grey Cast Iron.

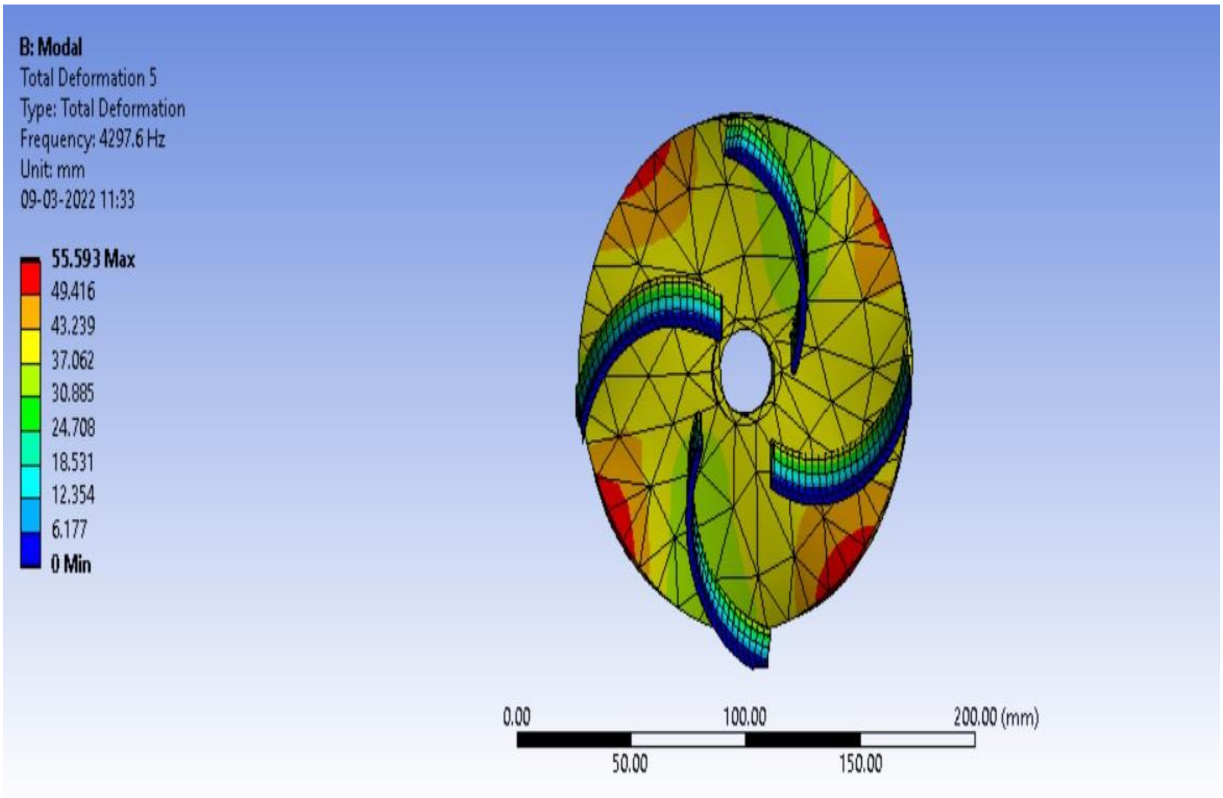

Fig 6.15: Mode 5, Natural Frequency of Grey Cast Iron.

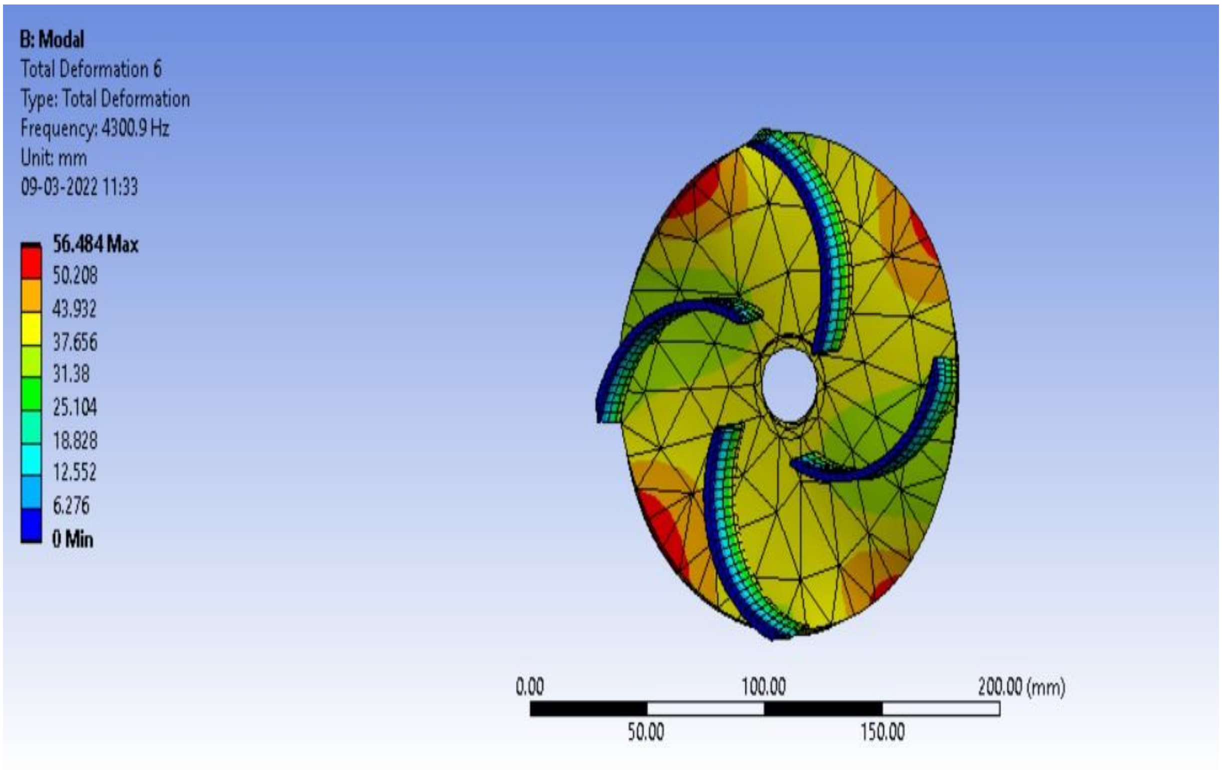

Fig 6.16: Mode 6, Natural Frequency of Grey Cast Iron.

Glass Fibre Reinforced Plastics (GFRP)

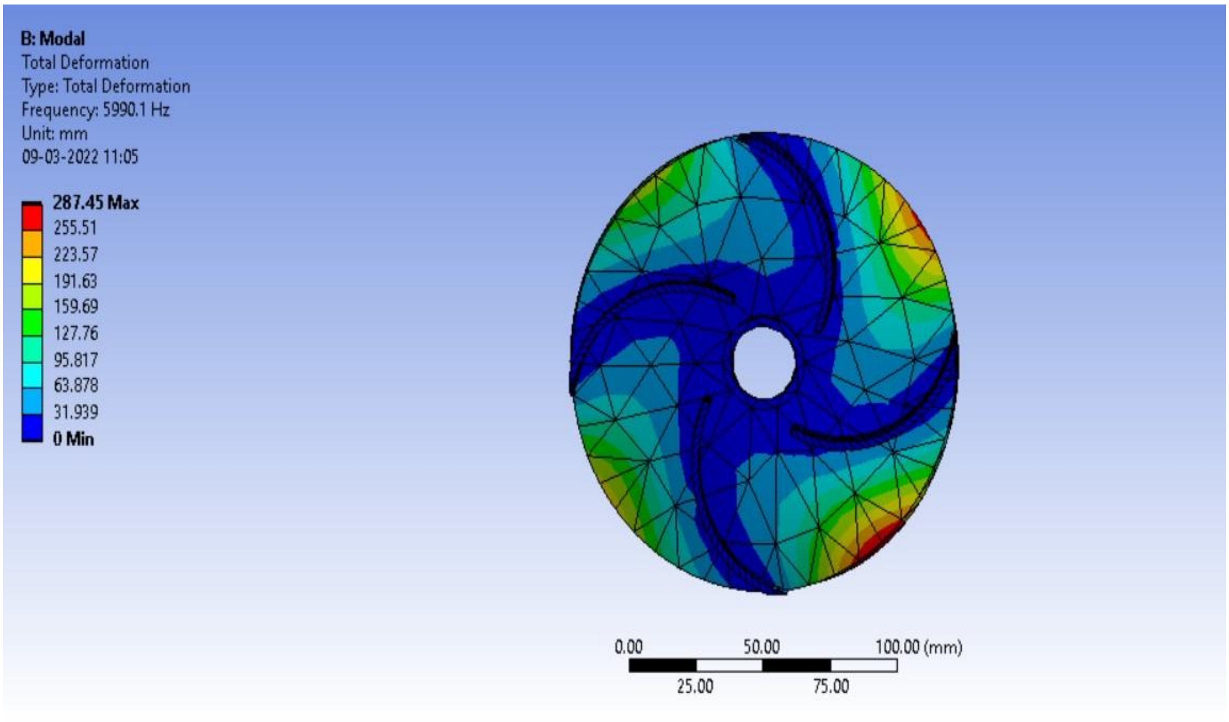

Fig 6.17: Mode 1, Natural Frequency of GFRP.

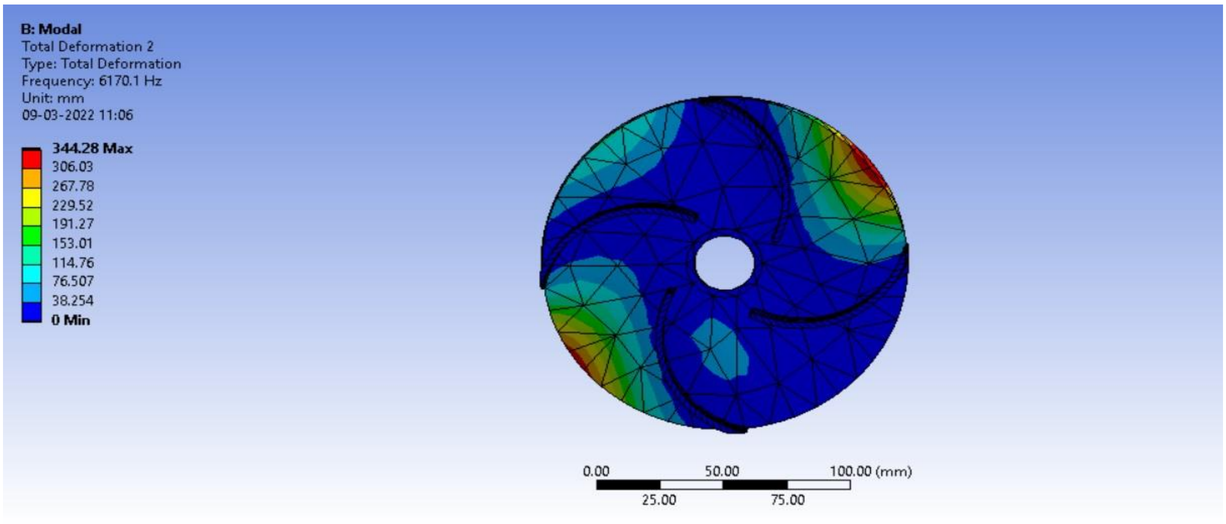

Fig 6.18: Mode 2, Natural Frequency of GFRP.

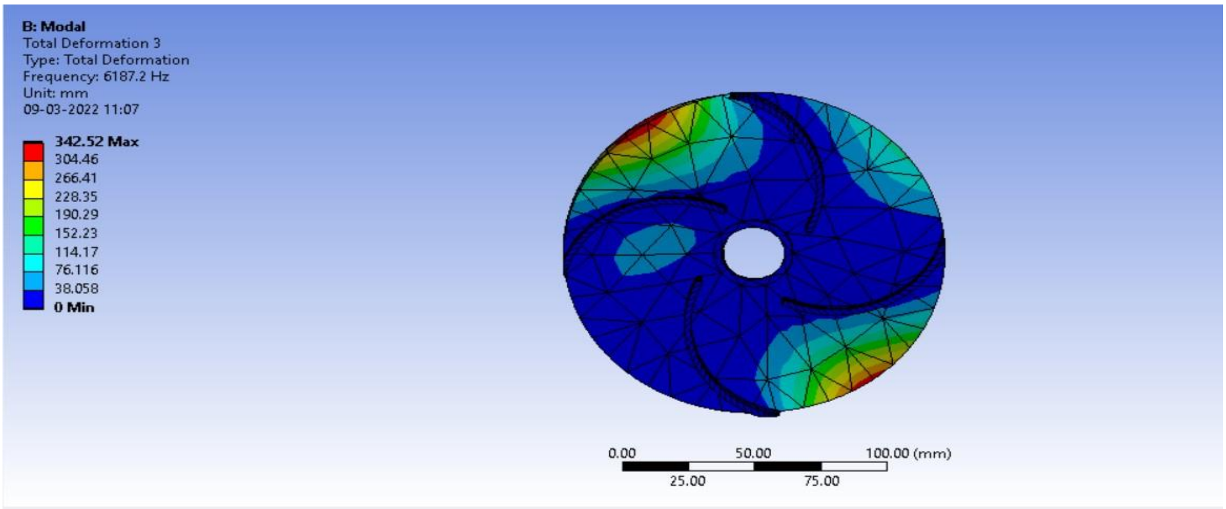

Fig 6.19: Mode 3, Natural Frequency of GFRP.

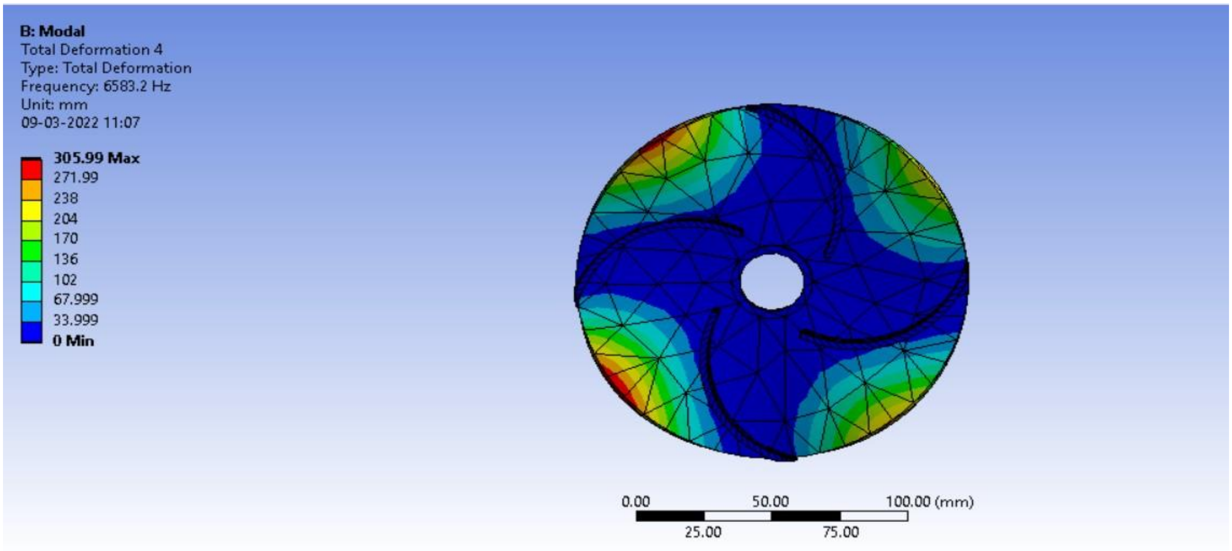

Fig 6.20: Mode 4, Natural Frequency of GFRP.

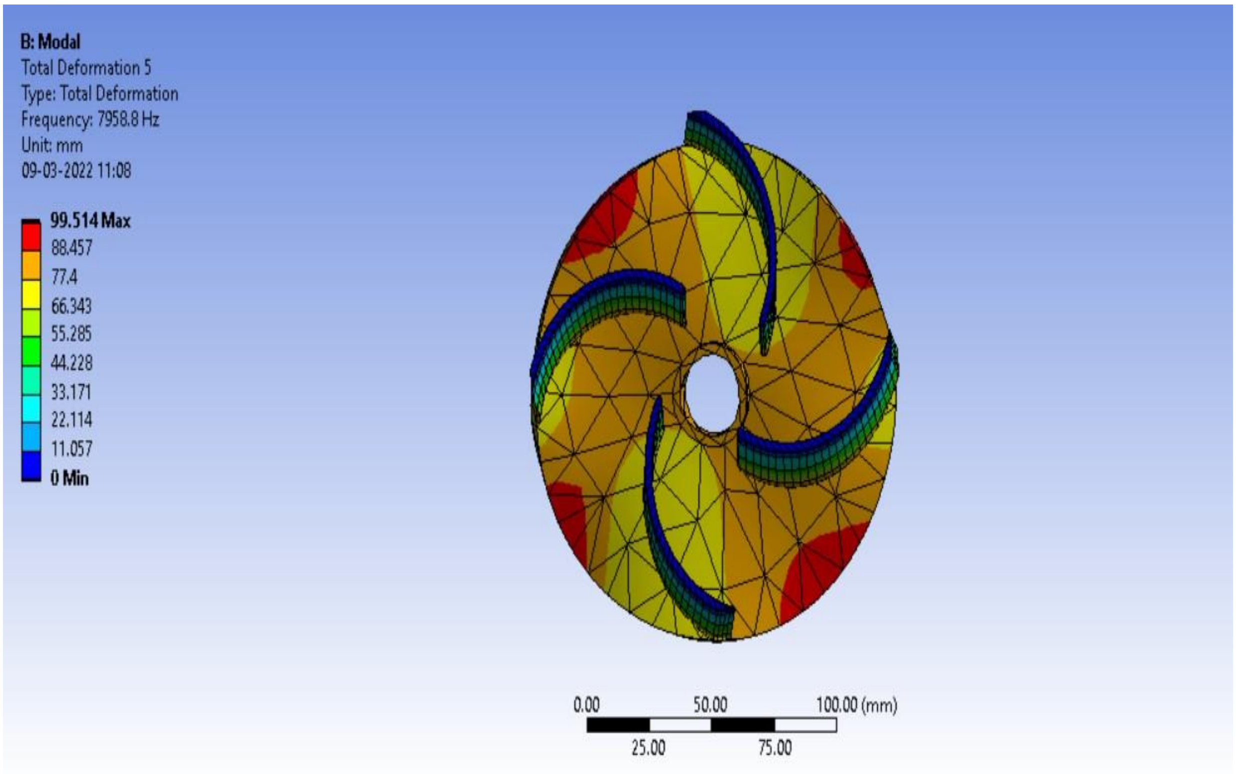

Fig 6.21: Mode 5, Natural Frequency of GFRP.

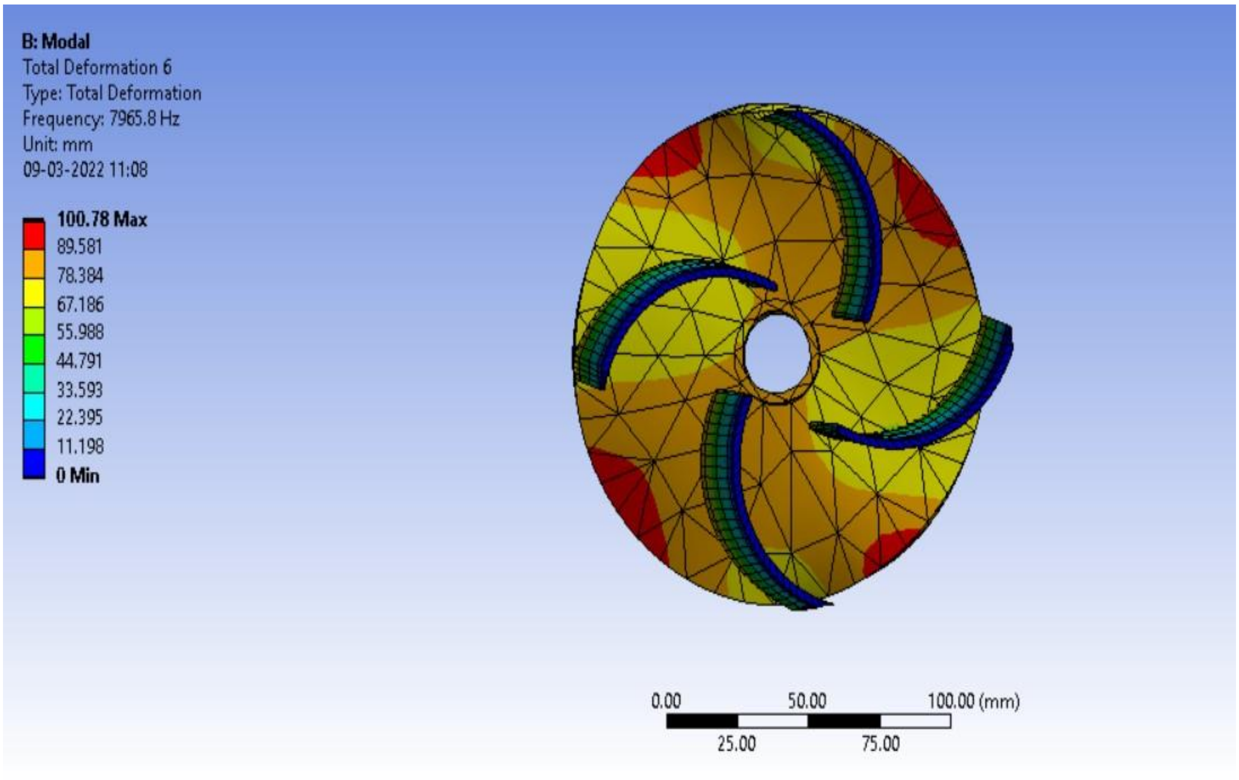

Fig 6.22: Mode 6, Natural Frequency of GFRP.

Result

The Natural Frequencies at all modes are tabulated in bellow table 2:

S.NO	Mode No	Natural Frequency(GFRP) Hz	Natural Frequency (Grey cast iron) Hz
1.	1	5834.5	3390
2.	2	6009.8	3468.2
3.	3	6026.4	3478.2
4.	4	6412.2	3689.8
5.	5	7752	4297.6
6.	6	7758.8	4300.9

Table 6.2 : Natural Frequencies at 6 Nodes from Modal Analysis

6.3 Simulation

A simulation of Centrifugal pump along with the Impeller designed is made using Solidworks 2020 software and the result is shown bellow in image:

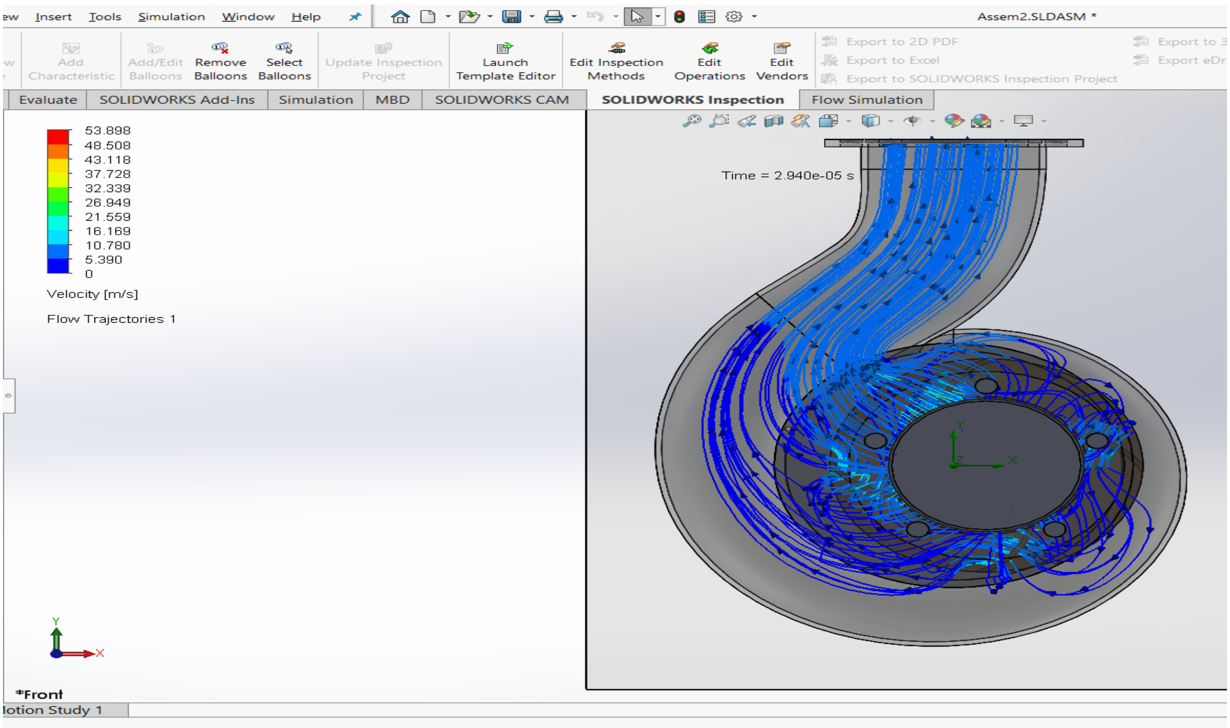

Fig 6.23 : Simulation of centrifugal pump.

CHAPTER 7

RESULTS & CONCLUSION

7.1 Results &Conclusion

From the Results obtained from both Structural and Modal Analysis we conclude that from table 1 the equivalent stress generated for both the Materials are within the limits of maximum allowable stress of the materials, therefore the Impeller design is safe for both the materials.

And from table 1 it is clear that the maximum Equivalent Stress, Equivalent Strain, Total Deformation is High For Grey Cast Iron and Less for GFRP, With High Stress, strain, deformation the chances of failure is more compared to less stress, strain, deformation.So we conclude that the GFRP is better compared to Grey cast iron and the chances for failure are less.

From table 1 it is also clear that the mass of Grey cast iron impeller is more compared to GFRP impeller which effects performance and efficiency, so we conclude that the mass of impeller with GFRP is less compared to Grey cast iron , and less mass indicates lighter impeller and better performance.

From table 2 it is observed that the Natural Frequencies of GFRP are high compared to Grey Cast Iron, High Natural Frequencies indicate High Stiffness, With increase in stiffness of a component the natural frequencies of the component also increases.In order of Resonance to occur the pump casing surrounding the impeller need to meet the natural frequency of impeller so chances of occurring resonance in GFRP is less Compared to Grey cast iron.Finally we conclude that GFRP impeller has better stiffness and chance of occurring resonance is low.

As per the comparisons of the results obtained both from Structural, Modal analysis it is clear that GFRP offers better resistance to stress, deformation, strain, less mass and also high stiffness compared to Grey cast iron, So we conclude that GFRP suites best for the designed impeller.

All the results are tabulated in bellow table 1 :

	Material	Equivalent Stress (MPa)	Equivalent Strain (MPa)	Total Deformation (mm)	Mass (Kg)	Mode	Natural Frequency (Hz)
1.	Grey Cast Iron	5.4265	4.9332 e-5	1.5619e-003	0.7146	1	3390
						2	3468.2
						3	3478.2
						4	3689.8
						5	4297.6
						6	4300.9
2.	Glass Fibre Reinforced Plastics (GFRP)	1.8688	1.9921e-5	5.1156e-004	0.1935	1	5834.5
						2	6009.8
						3	6026.4
						4	6412.2
						5	7752
						6	7758.8

Table 7.1 : Structural and Modal Analysis Results.

Graphs Plotted between Total Deformation and time , Stress and Strain are shown bellow:

It is clearly seen that in case of Total deformation vs Time graph as load increases the deformation of the impeller also increases in both the materials.This is seen in form of a curve in graph.

In case of stress vs strain graphs as the stress increases the strain also increases in both the materials, it is seen in form of straight line.

Total Deformation vs Time

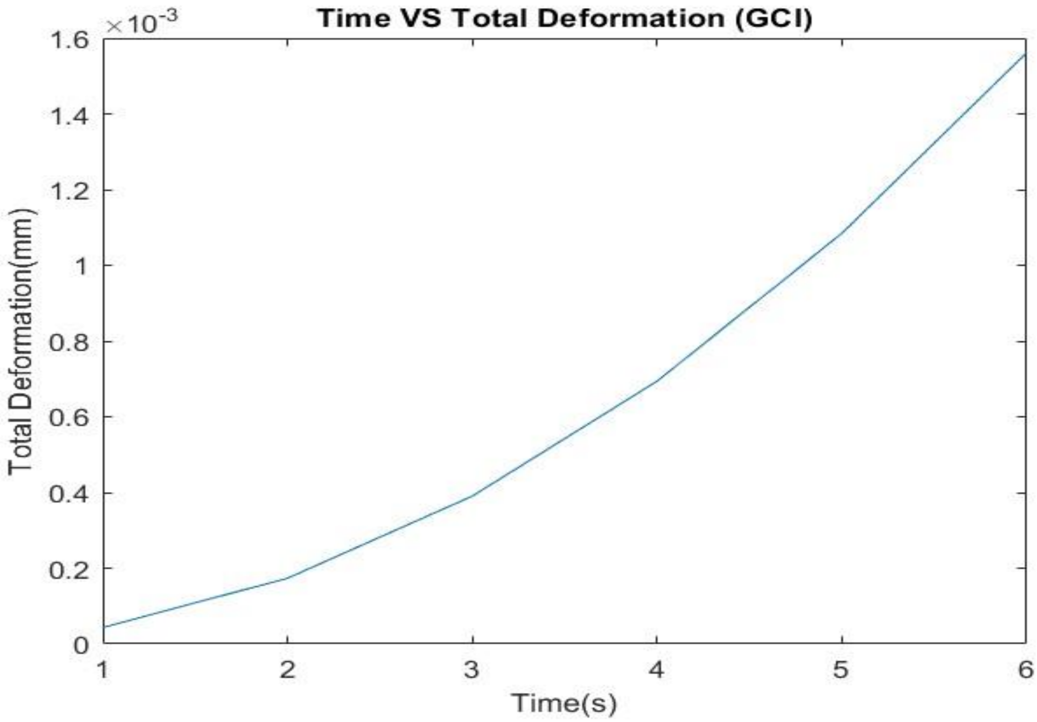

Fig 7.1 : Total Deformation vs time graph of grey cast iron impeller.

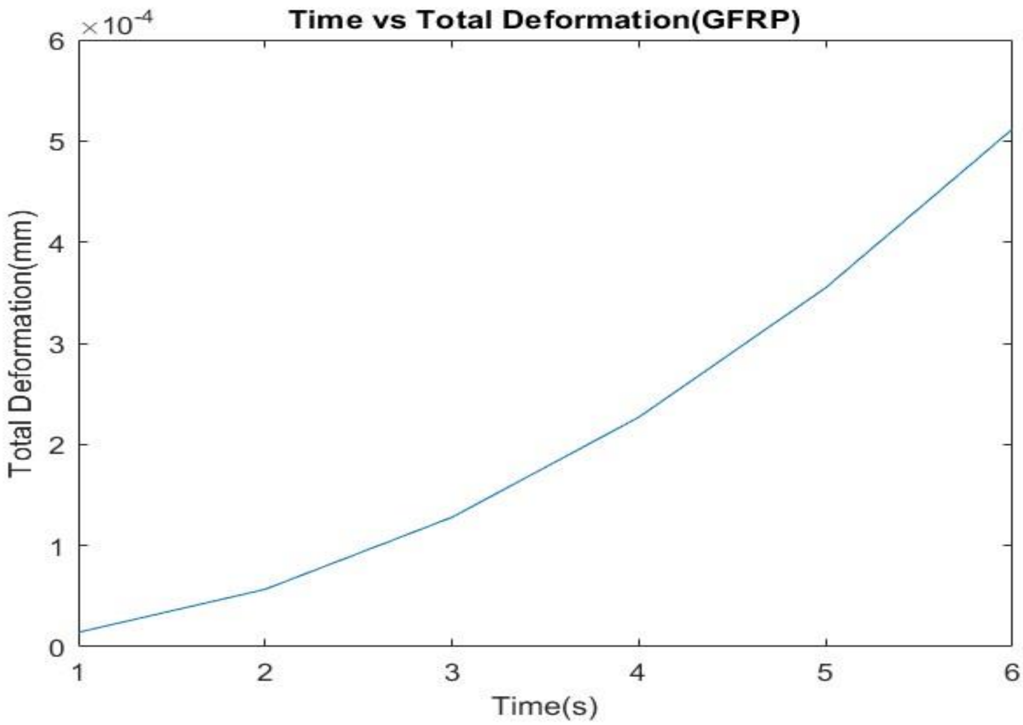

Fig 7.2 : Total Deformation vs time graph of GFRP impeller.

Stress vs Strain

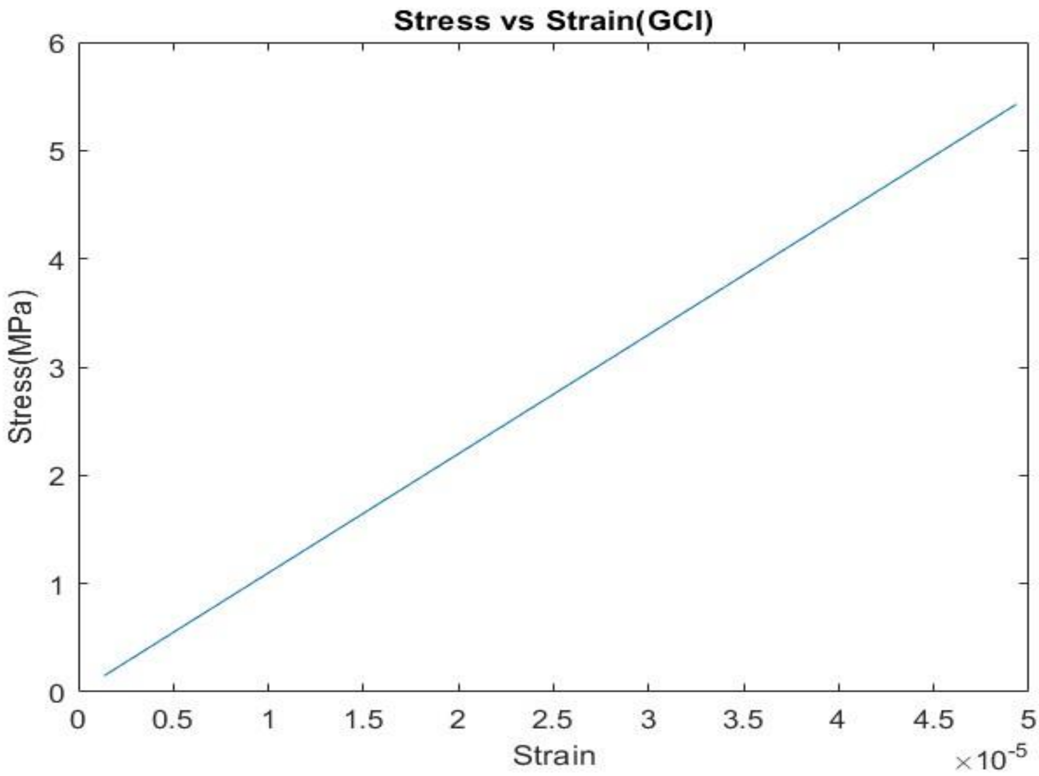

Fig 7.3 :Stress vs Strain graph of Grey cast iron impeller.

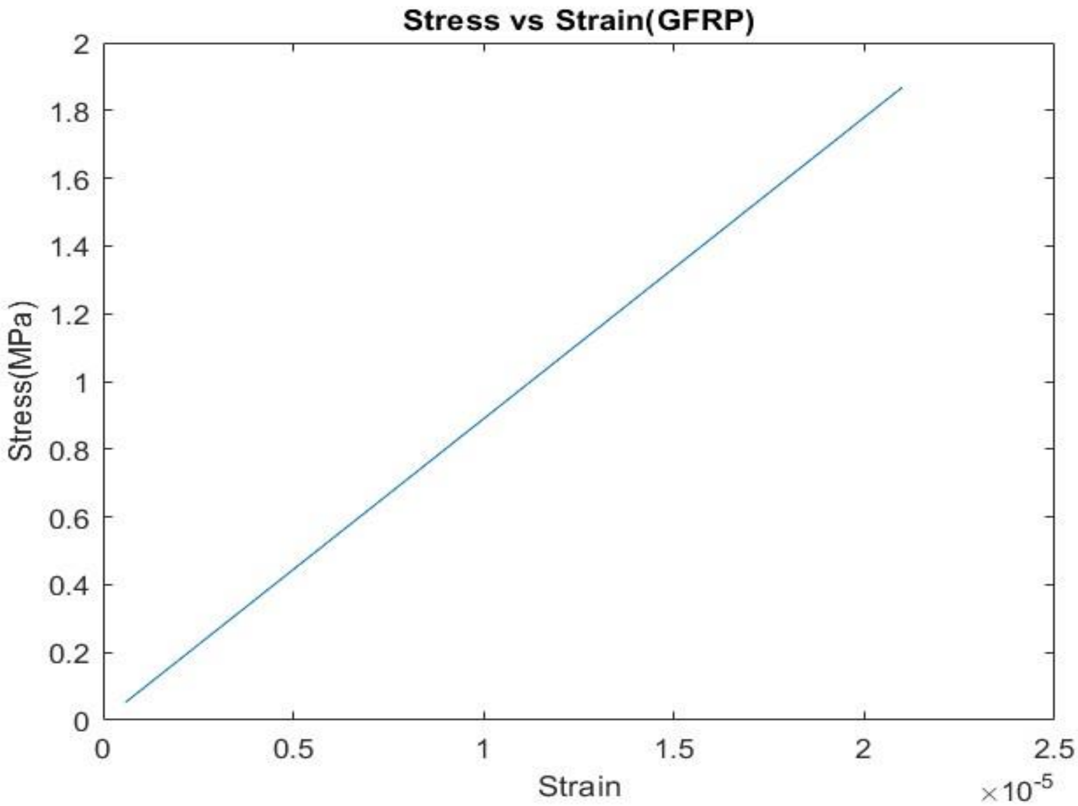

Fig 7.4 :Stress vs Strain graph of GFRP impeller.

CHAPTER 8

FUTURE SCOPE

In Future this work can be carried out by selecting different no of blades along with different impeller type like Semi closed and closed type impeller and evaluate the results with comparison to old results. A CFD analysis can be carried out on the pump by finding discharge and efficiency of the pump. Different specification of centrifugal pump can be selected and analyze the impeller.For larger industry application an impeller with much large dimensions can be analyzed and check the strength and deformation of the impeller.The entire impeller setup along with shaft for different applications can be designed in 3d modelling software and the setup can be analyzed in ansys.

CHAPTER 9

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