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Modal Analysis on Turbocharger Turbine Blade by Varying Materials Using FEA

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ABSTRACT: In the present study case we have considered the Turbocharger Turbine blade which plays a major role in turbocharger Assembly whereas coming to the Functional and the fundamental point view of the Turbocharger. It acts like a Compressor that Compresses the air from the exhaust after the combustion and that reflect back to the compression blade resulting in the high input of air and thereby increases the performance of the system. The Design of the Turbine Blade was carried out in the CAD Design Software i.e CATIA (Computer Aided Three-Dimensional Interactive Application) And Simulation on turbine blade was performed using ANSYS Software (Analysis of Systems). In This project Strength of materials, Design of Machine Members, and various physical and material properties.

KEYWORDS: Turbine Blade, CATIA, ANSYS, FEA

I. INTRODUCTION

The turbocharger is a Device or an Assembly, which consists of a turbine wheel and turbine housing, converts the engine exhaust gas into mechanical energy to drive the compressor. The gas, which is restricted by the turbine, flow cross-sectional area, results in a pressure and temperature drop between the inlet and outlet. Blades of Turbine shaft or pillar are designed to operate in different conditions, which typically involve lower rotational speeds and temperatures. Turbine blades are subjected to high working conditions that they may face high temperatures and stresses and deformation. Thus the turbine blade is designed to resist these mechanical failures like crack, break, corrosion, Buckling etc.

The turbine blades of an turbocharger are responsible for extracting heat energy, high gas produced by the combustor. To protect the blades during this difficult environment from varying mechanical failures, turbine blades often use exotic and high strength materials like super alloys and lots of different methods of cooling which will be categorized as internal and external cooling and resistant coatings. The mechanical failure i.e. Fatigue in the turbine blade is a major source of failure in steam turbines. Fatigue is caused by the strain induced by vibration and resonance within the operating range of machinery. Friction dampers are the key source to prevent blades from these high dynamic stresses.

II. MATERIAL AND MANUFACTURING PROCESSES

Material selection of specified components plays a major role. Basically the material Selection for a component was selected based upon the various mechanical experienced forces and we need to distinguish all the mechanical failures. The turbine blade is a component of turbocharger assembly which has to revolve at an higher speeds by experiencing the tremendous amount of weighted exhaust air or gas with an higher temperature upto 1500 degree centigrade. The Selected material must possess good strength and Life and it should be resistance to damage when it experienced the loads

Secondly Cost Effective is the concern of choosing the material according the usage and it should be readily available in the market for various manufacturing sites

In this Present Project we have selected five different materials in that two are previous materials and the remaining materials are chosen with respect to the loading conditions.

Material	Young's Modulus Pa	Density Kg/m ³	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa
Titanium Alloy	9.6e+10	4260	0.36	1.1429e+11	3.529e+10
Aluminium Alloy	7.1e+10	2770	0.33	6.9608e+10	2.6692e+10
AA3103	8E+10	2870	0.33	7.8431e+10	3.0075e+10
Structural Steel	2e+11	7850	0.3	1.6667e+11	7.6923e+10
Austenitic Stainless steel	1.93e+11	7750	0.31	1.693e+11	7.3664e+10

Table 1: shows the material properties of the of Titanium,aluminium,AA3103,Structural steel, Austenitic Stainless steel

III. MODELLING AND ANALYSIS PROCEDURE

For the Modelling of Turbine blade we have chosen the CATIAV5 R21 which is really a good user interactive and friendly software has different modulus like part, Surface and Assembly Design. The procedure of creating the blades is as follows initially take plane and positioned sketch here we have created an 2D Sketch as a Geometrical element which need to constrained and then converted into a part by inserting a body. The Major Tool bars used are pad, revolve, pattern, slot etc and

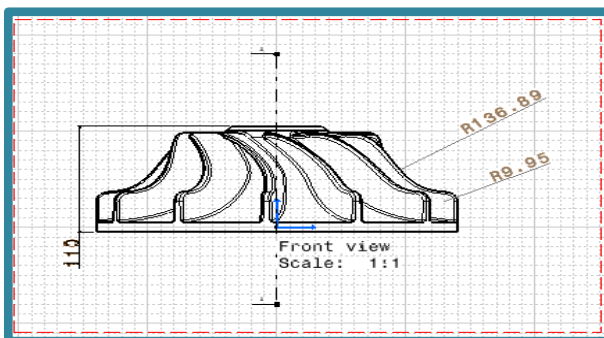


Fig.1 Front view of the Blade

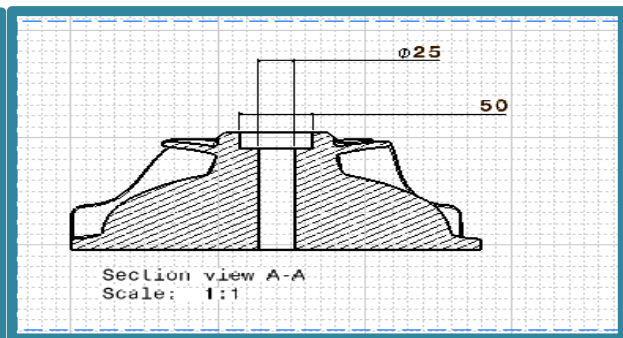


Fig.2 Sectional view of the Blade

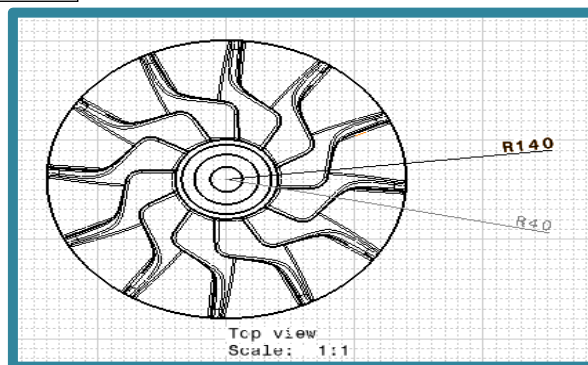


Fig.3 Top view of the Blade

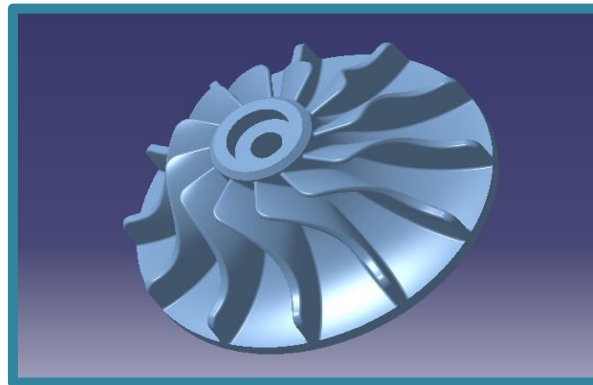


Fig4. Shows the turbine blade after Designing

After Designing the Turbine blade it was saved in an STP format (step File) which can be easily uploaded in ANSYS Workbench

ANSYS is a Finite element Analysis Software package. Different types of analysis can be carried out using Ansys like Structural, Model, and Thermal etc. Ansys is performed with an internal sequence of steps i.e Pre-processing, Meshing, Loading Boundary Conditions Post processing , solve and finally the results.

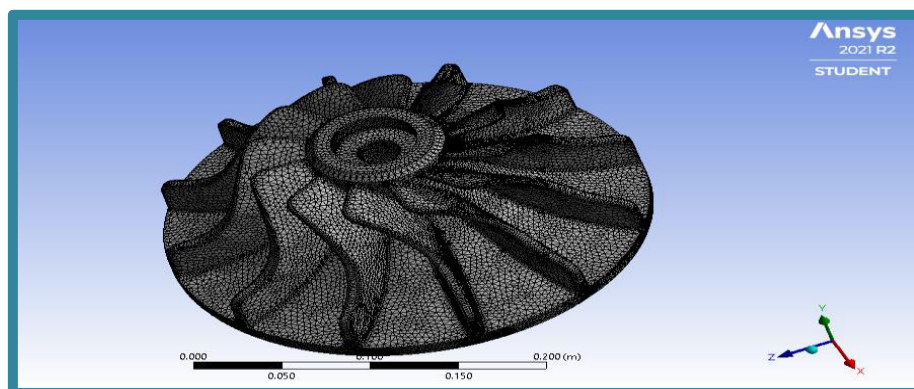


Fig.5 shows the mesh presentation

Meshing is an internal most important Simulation process in ANSYS. What happens is it divides or segregates the solid into tiny number of elements to make the speedup of solution and mostly high accuracy. Here we have created meshing with Tetrahedrons element shape with program controlled type and 1mm at the corner and 5mm normal size

IV. LOADING AND BOUNDARY CONDITIONS

As per the Functioning point view the turbine was fixed to the shaft and was connected to the compression blade to the other end of the shaft. Due to the Exhaust gases after the combustion process the turbine blade experiences tremendous amount of load and heat as well.



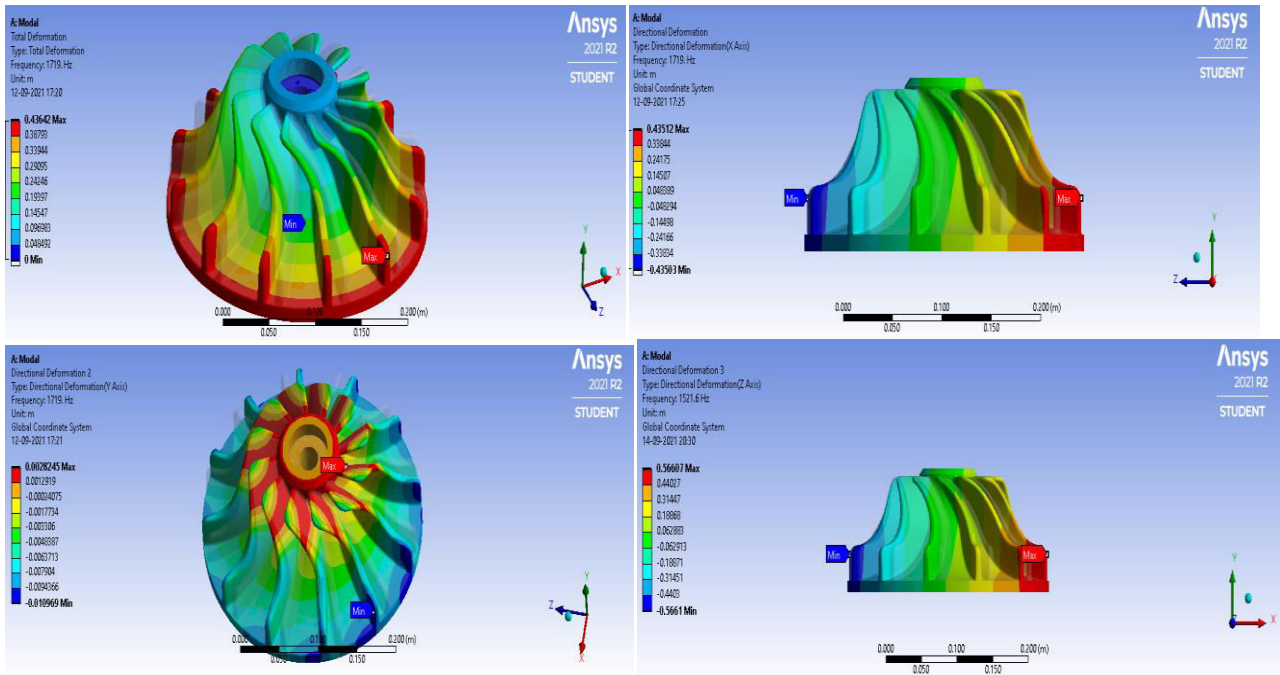
Fig6.Show the Turbine blade is fixed in all dof

V. EXPERIMENTAL RESULTS

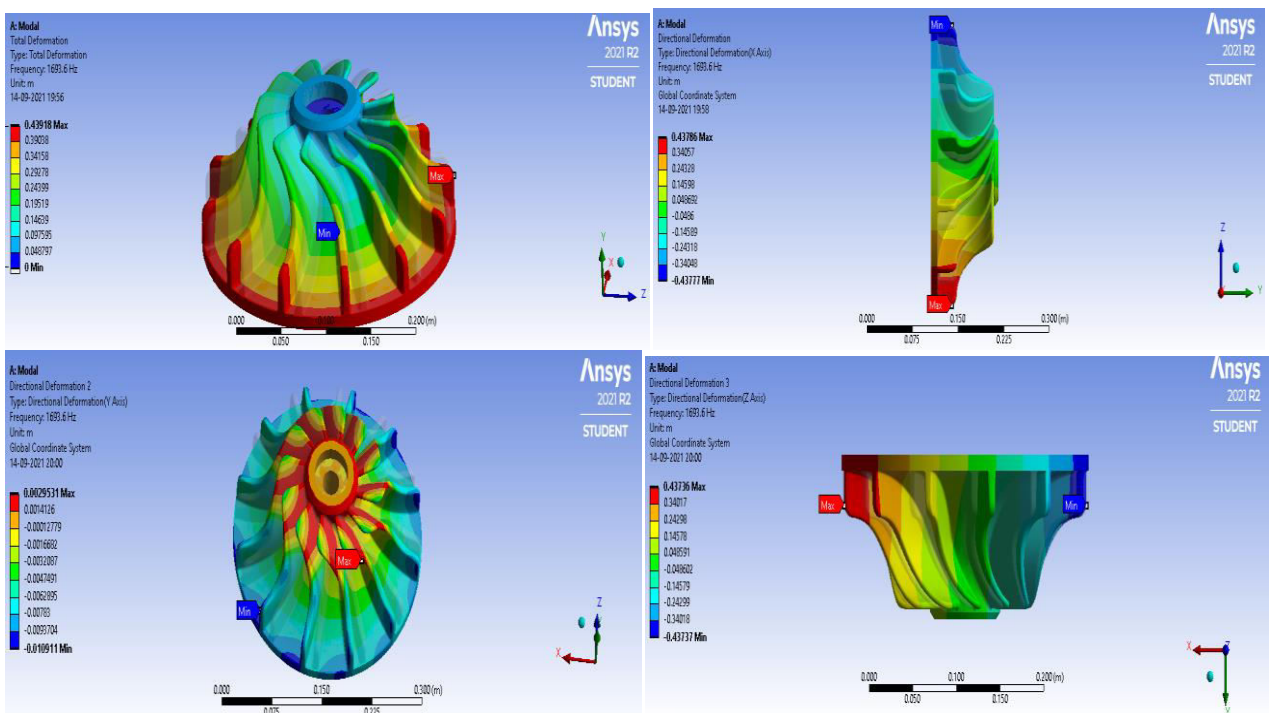
The Modal Analysis is been carried out up to 10 Natural Frequencies.

The Total Deformation and Directional Deformation In X,Y,Z Axis

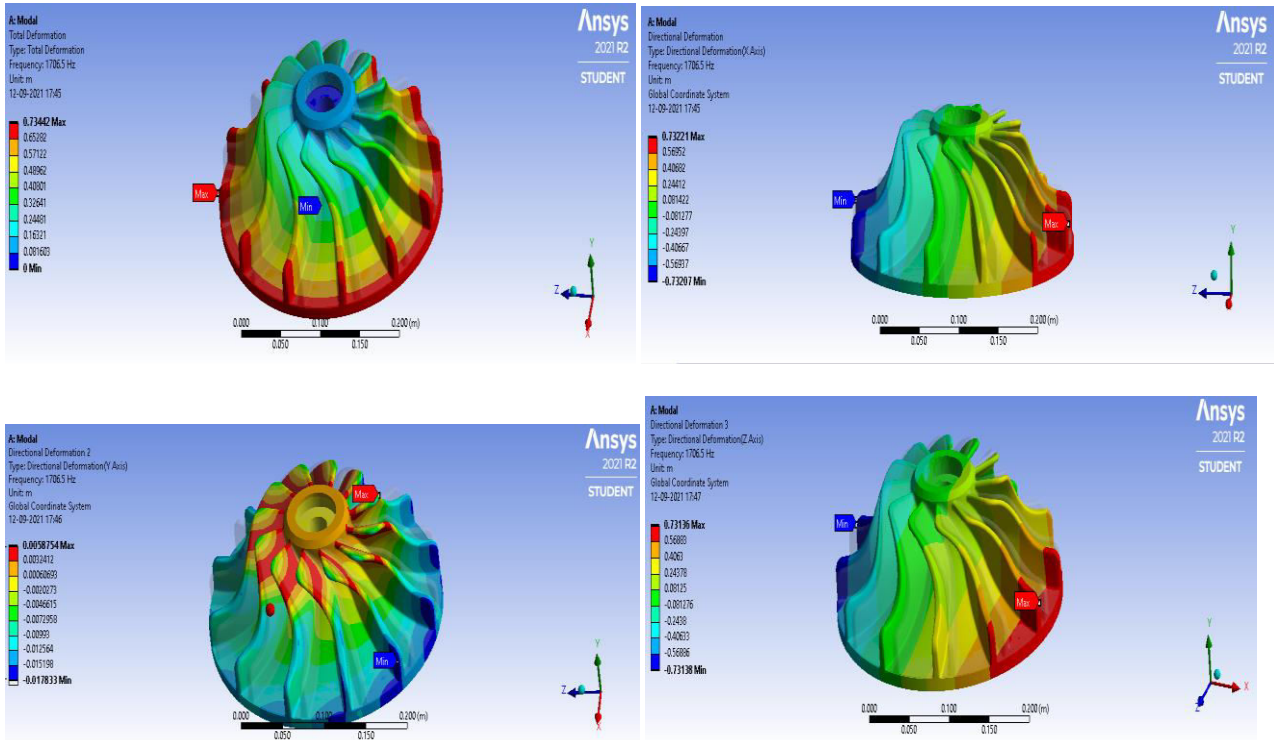
For Structural steel



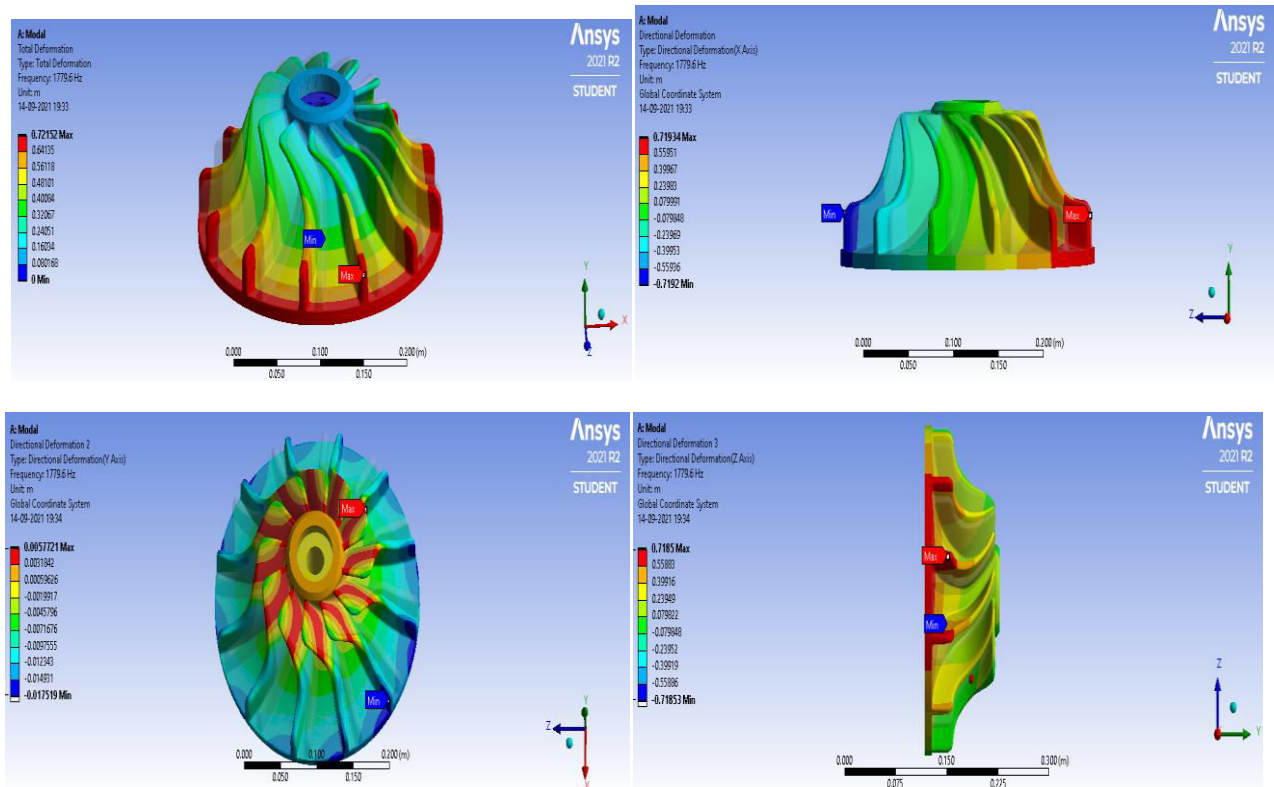
For Austenitic Stainless steel



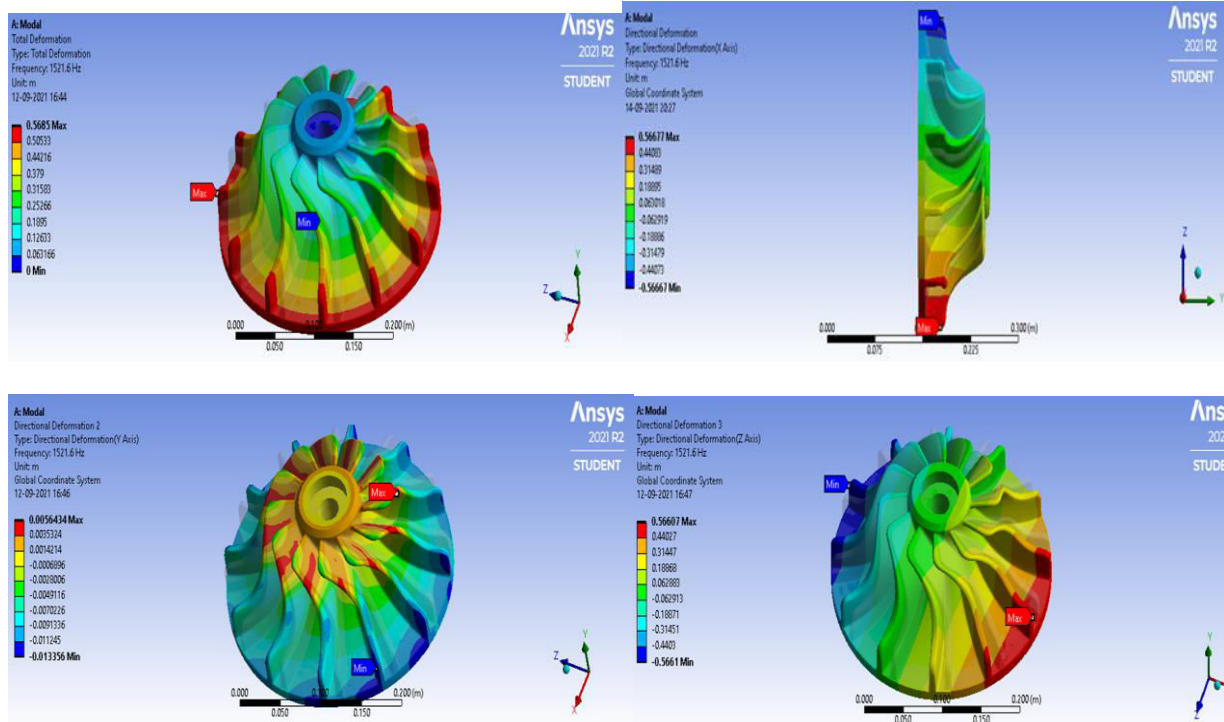
For Aluminum Alloy



For AA3103



For Titanium Alloy



Material	X-Direction	Y-Direction	Z-Direction	Rotation X	Rotation Y	Rotation Z
Structural steel	8.5814e-002	0.56125	8.7495e-002	0.56872	0.99513	0.58407
Austenitic Stainless steel	8.656e-002	0.56153	8.188e-002	0.56894	0.99513	0.58446
Aluminium Alloy	8.8025e-002	0.56195	8.91512e-002	0.56941	0.99512	0.58515
AA3103	8.8025e-002	0.56195	8.91512e-002	0.56941	0.99512	0.58517
Titanium Alloy	9.0175e-002	0.56482	9.1435e-002	0.57018	0.99512	0.5861

Table.2 shows the sum ratio of effective Mass to total Mass

Mode	Frequency [Hz]	Mode	Frequency [Hz]	Mode	Frequency [Hz]
1.	1521.6	1.	1779.6	1.	1706.5
2.	3014.9	2.	3489.5	2.	3346.1
3.	3017.4	3.	3492.1	3.	3348.6
4.	3723.3	4.	4291.3	4.	4115.1
5.	3730.2	5.	4335.9	5.	4157.8
6.	3732.6	6.	4338.7	6.	4160.5
7.	4074.5	7.	4701.5	7.	4508.4
8.	4080.1	8.	4707.1	8.	4513.8
9.	4095.4	9.	4726.3	9.	4532.1
10.	4101.6	10.	4731.	10.	4536.6

Titanium Alloy

AA3103

Aluminium Alloy



Mode	Frequency [Hz]
1.	1719.
2.	3336.2
3.	3338.5
4.	4085.2
5.	4161.2
6.	4164.1
7.	4483.
8.	4487.7
9.	4507.1
10.	4509.7

Structural Steel

Mode	Frequency [Hz]
1.	1693.6
2.	3298.1
3.	3300.4
4.	4044.4
5.	4108.7
6.	4111.4
7.	4435.6
8.	4440.4
9.	4459.3
10.	4462.4

Austenitic stainless steel

VI. CONCLUSION

The Modal Analysis has been carried out on Turbine blade with Five different materials i.e Titanium alloy, Austenitic stainless steel, Aluminum Alloy, Structural Steel, AA3103. The Total Deformation was found less comparatively with structural steel and Austenitic Stainless steel because of its high density value than the other materials. The Modal Analysis was carried out on Turbine Blade upto 10 natural Frequencies Found Titanium Alloy with the less Frequency Min value of 1521.6HZ For the 1st mode Structural Steel and Austenitic stainless steel are heavy in weight because of their High Density value Since Turbine Blade is a component which experiences load from the Exhaust gases and also Temperature is also an effect. According to the strength to weight ratio Titanium alloy is best suited material for the turbine Blade.

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