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Structural and Modal Analysis of Gas Turbine Rotor Blade

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ABSTRACT:

The gas turbine rotor is a critical components since it is subjected to high centrifugal loads and temperatu res.Before fabrication of the components,it has to be analysed for stresses due to loads. The gas turbine rot ating at 1,00,000 rpm is considered for the analysi s.The geometric model of the gas turbine rotor was design by using Catia software and analysis is done by ansys software.

Modal analysis is carried out to determine the dynamic behavior of the component.Stress stiffening and rotational effects are considered.

Project objectives:

1. ***Perform the structural analysis to determine the stresses and deformation***
2. ***Perform the modal analysis in order to determine the vibrational caracteristics of the components.***

LITERATURE REVIEW

Extensive work has been reported in the literature of gas turbine blade. S.Gowreeshetal studied on the first stage rotor blade of a two stage gas turbine has been analyzed for structural, thermal, modal analysis using ANSYS 15.0.which is powerful Finite Element Method software. The temperature distribution in the rotor blade has been evaluated using this software. The design features of the turbine segment of the gas turbine have been taken from the preliminary design of a power turbine for maximization of an existing The purpose of turbine technology is to extract the maximum quantity of energy from the working fluid to convert it into useful work with maximum efficiency by means of a plant having maximum turbo jet engine. it has been felt that a detail study can be carried out on the temperature effects to have a clear understanding of the combined mechanical and thermal stresses.

Kauthalkar the purpose of turbine technology is to extract, maximum quantity of energy from the working fluid to convert it into useful work with maximum efficiency. That means, the Gas turbine having maximum reliability, minimum cost, minimum supervision and minimum starting time. The gas turbine obtains its power by utilizing the energy of burnt gases and the air.

This is at high temperature and pressure by expanding through the several rings of fixed and moving blades. A high pressure of order 4 to 10 bar of working fluid which is essential for expansion, a compressor is required. The quantity of working fluid and speed required are more so generally a centrifugal or axial compressor is required. The turbine drives the compressor so it is coupled to the turbine shaft.John.v studied on the design and analysis of
Gas turbine blade, CATIA is used for design of solid model and ANSYS software for analysis for F.E.model generated, by applying boundary condition, this paper also includes specific post processing and life assessment of blade .HOW the program makes effective use of the ANSYS preprocessor to mesh complex turbine blade geometries and apply boundary conditions. Here under we presented how Designing of a turbine blade is done in CATIA with the help of coordinate generated on CMM. And to demonstrate the preprocessing capabilities, static and dynamic stress analysis results, generation of Campbell and Interference diagrams and life assessment. The principal aim of this paper is to get the natural frequencies and mode shape of the turbine blade.V.Raga Deepu Studied on a Gas turbine is a

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device designed to convert the heat energy of fuel in to useful work such as mechanical shaft power. Turbine Blades are most important components in a gas turbine power plant.

A blade can be defined as the medium of transfer of energy from the gases to the turbine rotor. The turbine blades are mainly affected due to static loads. Also the temperature has significant effect on the blades. Therefore the coupled (static and thermal) analysis of turbine blades is carried out using finite element analysis software ANSYS. A.K.Matta studied the stress analysis for N 155 & Inconel 718 material. On solid blades it is reported that Inconel 718 is better suited for high temperature operation.

I. INTRODUCTION

A turbine is a rotary mechanical device that extracts energy from a fluid flow and converts it into useful work. A turbine is a turbo machine with at least one moving part called a rotor assembly, which is a shaft or drum with blades attached. Moving fluid acts on the blades so that they move and impart rotational energy to the rotor. Early turbine examples are windmills and waterwheels.

The first turbines to be used were the steam turbines but now on the basis of the fluid from which energy is extracted there are four major types of turbines:

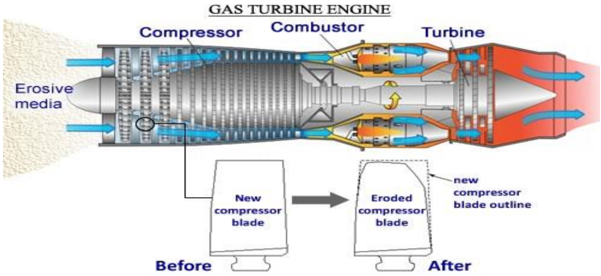
- Steam turbines
- Water turbines
- Wind turbines
- Gas turbines

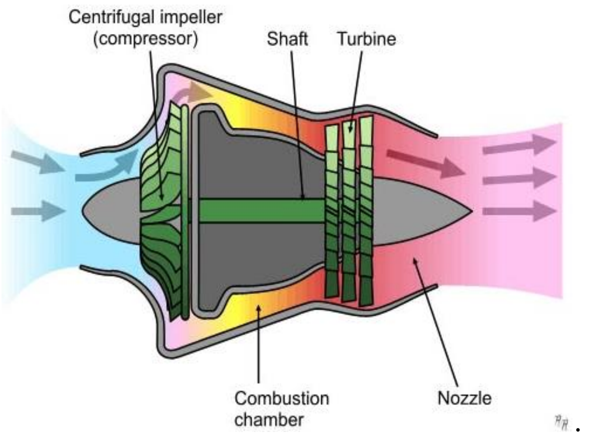
Gas Turbine

Gas turbines use up high pressure gas to produce energy. These turbines are not used for producing electricity but they are used to propel jet engines. Gas turbines are the latest types of turbines. Their structure is advanced but the principle is same.

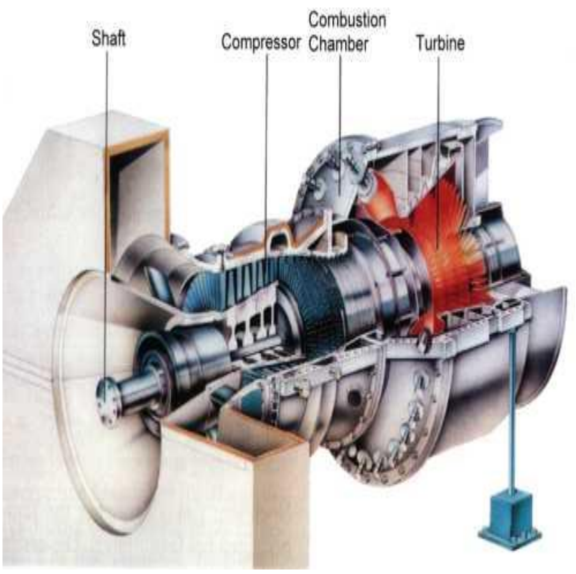
A gas turbine, also called a combustion turbine, is a type of internal combustion engine. It has an upstream rotating compressor coupled to a downstream turbine, and a combustion chamber in-between.

The basic operation of the gas turbine is similar to that of the steam power plant except that air is used instead of water. Fresh atmospheric air flows through a compressor that brings it to higher pressure. Energy is then added by spraying fuel into the air and igniting it so the combustion generates a high-temperature flow. This high-temperature high-pressure gas enters a turbine, where it expands down to the exhaust pressure, producing a shaft work output in the process. The turbine shaft work is used to drive the compressor and other devices such as an electric generator that may be coupled to the shaft. The energy that is not used for shaft work comes out in the exhaust gases, so these have either a high temperature or a high velocity. The purpose of the gas turbine determines the design so that the most desirable energy form is maximized. Gas turbines are used to power aircraft, trains, ships, electrical generators, or even tanks.





The compressed air is mixed with fuel injected through nozzles. The fuel and compressed air can be pre-mixed or the compressed air can be introduced directly into the combustor. The fuel-air mixture ignites under constant pressure conditions and the hot combustion products (gases) are directed through the turbine where it expands rapidly and imparts rotation to the shaft. The turbine is also comprised of stages, each with a row of stationary blades (or nozzles) to direct the expanding gases followed by a row of moving blades. The rotation of the shaft drives the compressor to draw in and compress more air to sustain continuous combustion.The remaining shaft power is used to drive a generator which produces electricity. Approximately 55 to 65 percent of the power produced by the turbine is used to drive the compressor. To optimize the transfer of kinetic energy from the combustion gases to shaft rotation, gas turbines can have multiple compressor and turbine stages



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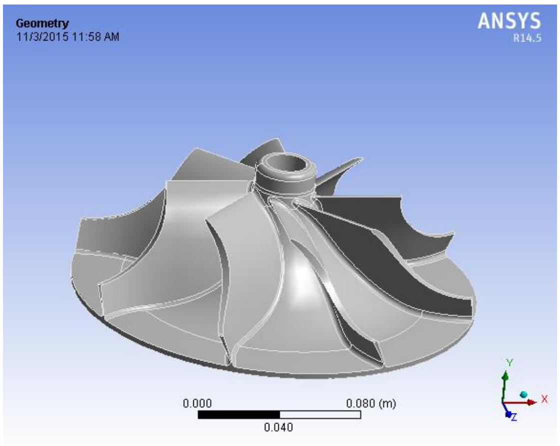
Because the compressor must reach a certain speed before the combustion process is continuous – or self-sustaining – initial momentum is imparted to the turbine rotor from an external motor, static frequency converter, or the generator itself. The compressor must be smoothly accelerated and reach firing speed before fuel can be introduced and ignition can occur. Turbine speeds vary widely by manufacturer and design, ranging from 2,000 revolutions per minute (rpm) to 10,000 rpm. Initial ignition occurs from one or more spark plugs (depending on combustor design). Once the turbine reaches self-sustaining speed – above 50% of full speed – the power output is enough to drive the compressor, combustion is continuous, and the starter system can be disengaged.

II.MODEL OF BASIC TURBINE ROTOR BLADE WITH AL 2024

MODEL OF TURBINE BLADE



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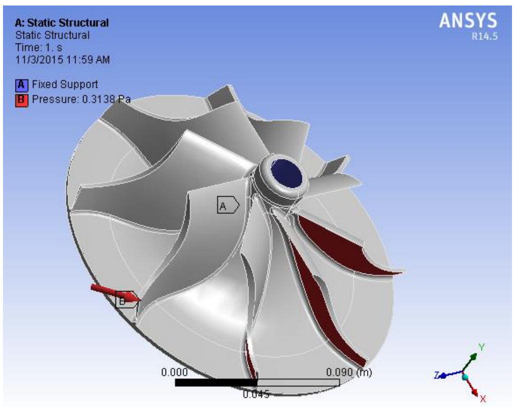

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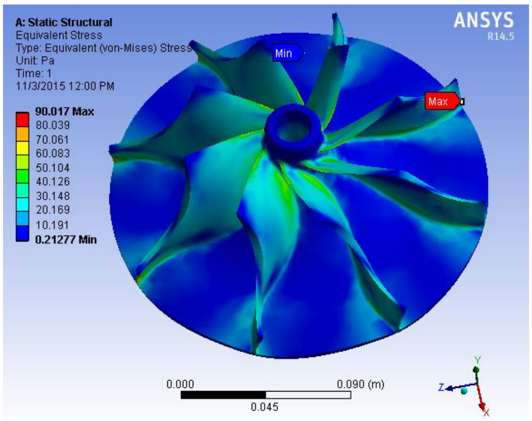
STRESS



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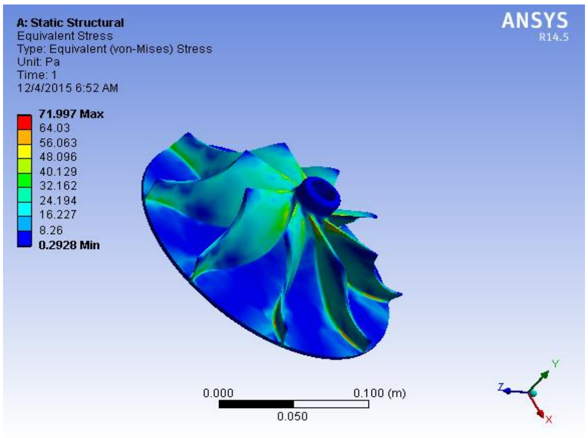

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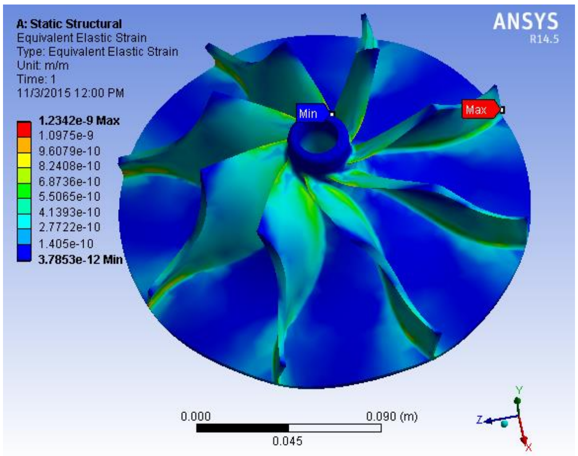

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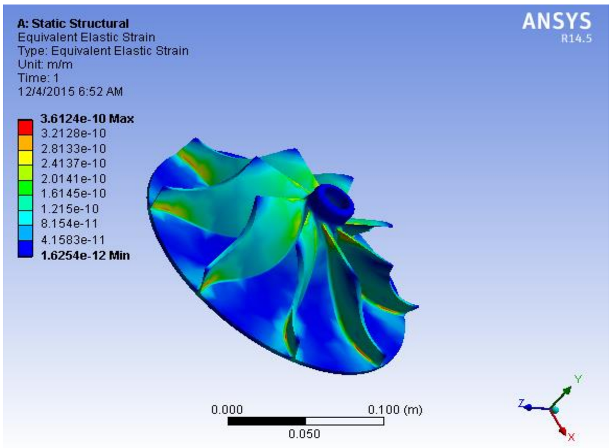

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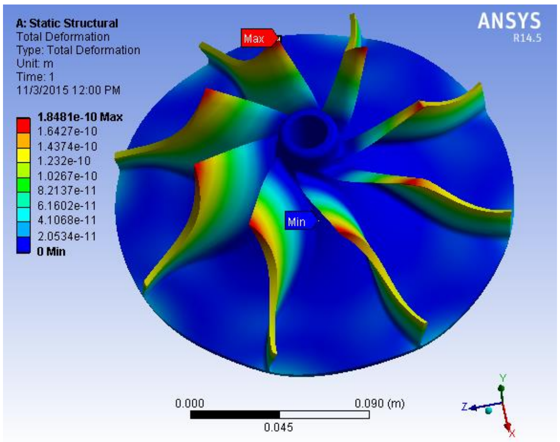

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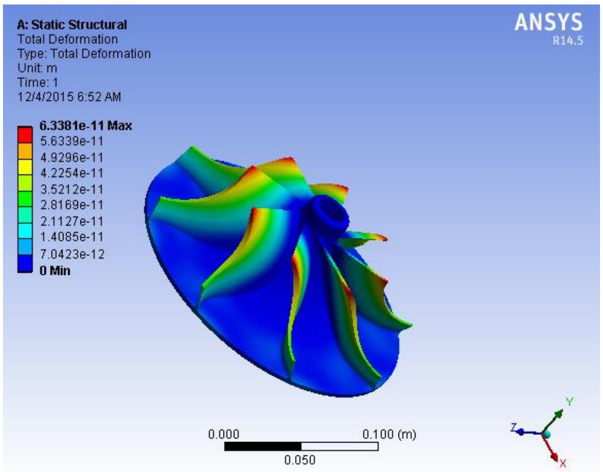

III.IMPORTED MODEL OF BASIC TURBINE ROTOR BLADE WITH INCOLE 718

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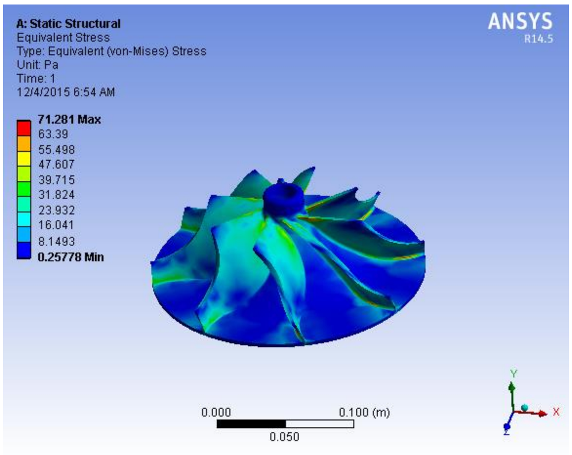
IV. MODEL OF BASIC TURBINE ROTOR BLADE WITH TECHNETIUM

STRESS



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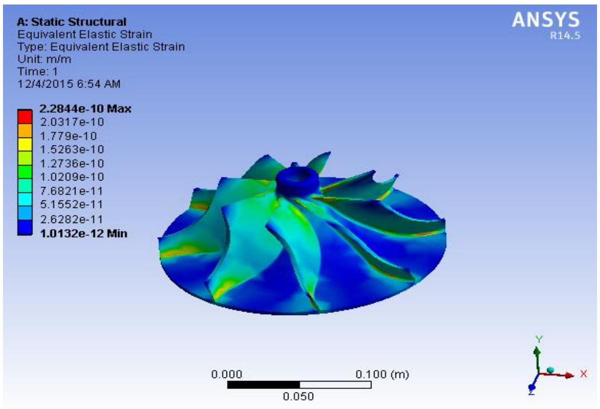

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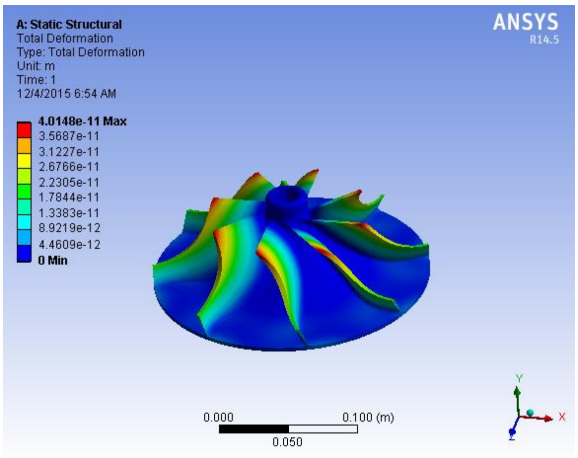
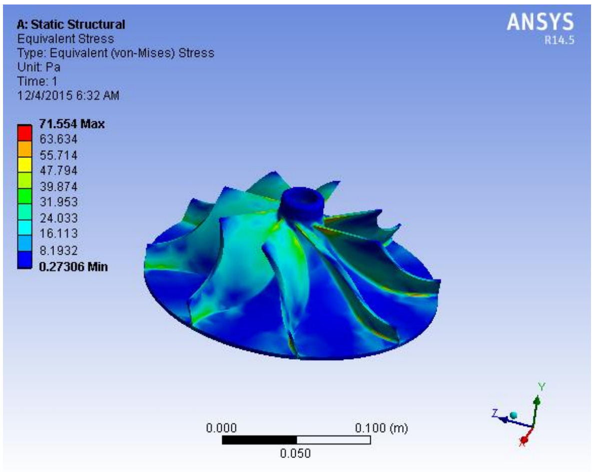


V. MODEL OF BASIC TURBINE ROTOR BLADE WITH T6

STRESS



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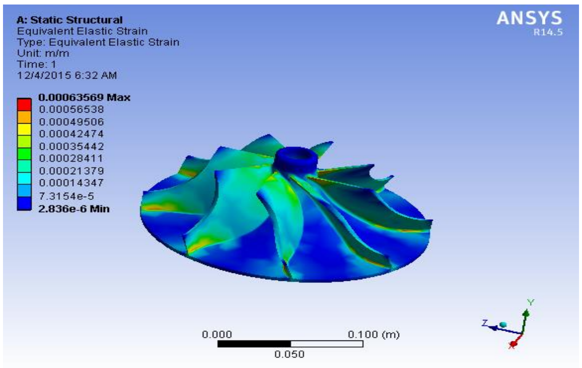

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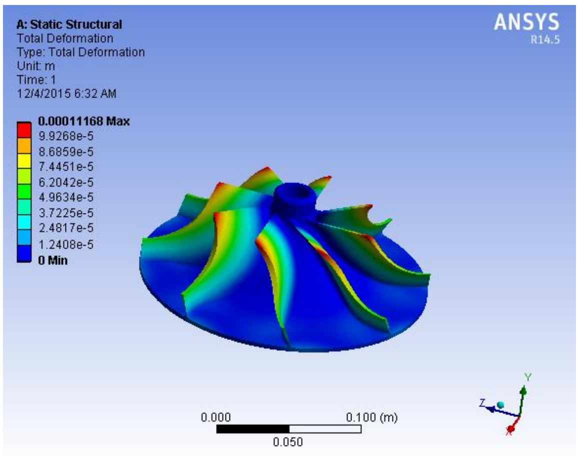

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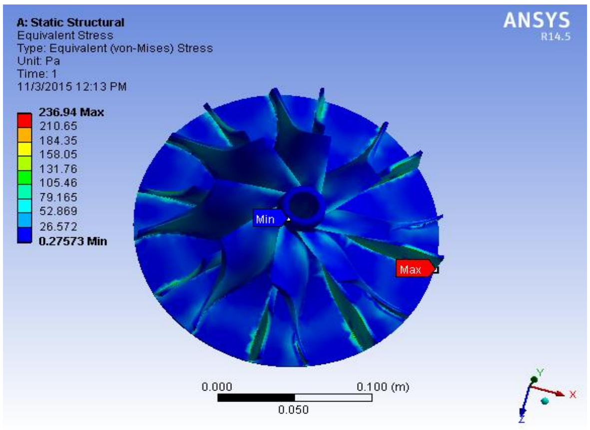
VI. MODEL OF MODIFIED TURBINE ROTOR BLADE WITH AL 2024

STRESS



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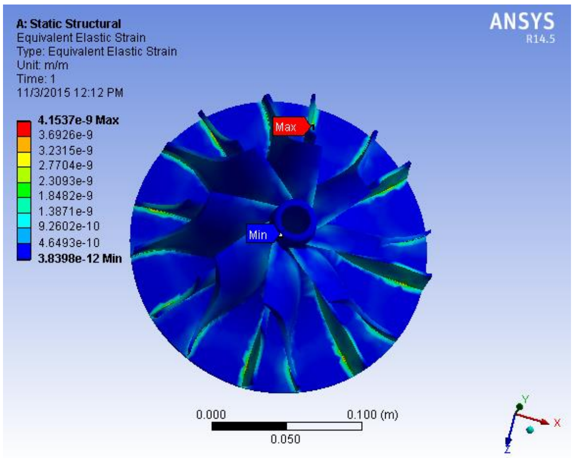

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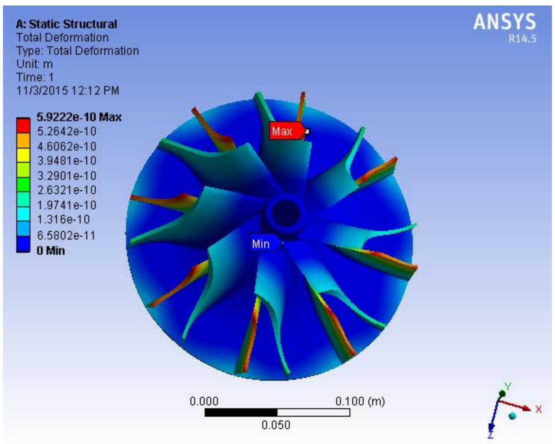
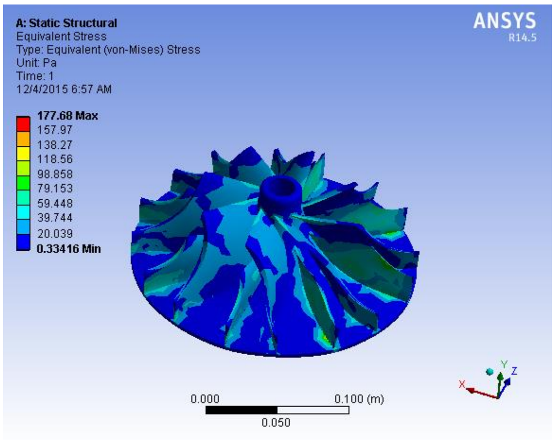


VII. MODEL OF MODIFIED TURBINE ROTOR BLADE WITH INCOLE 718

STRESS



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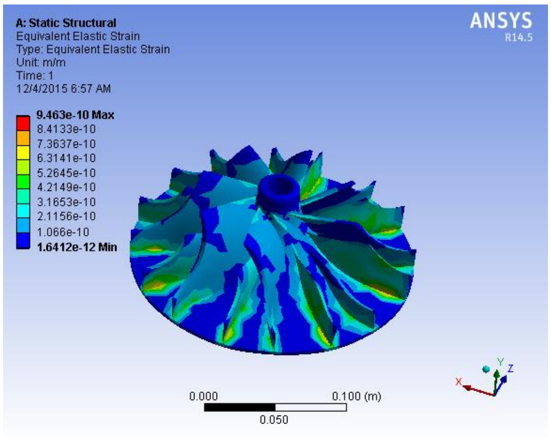

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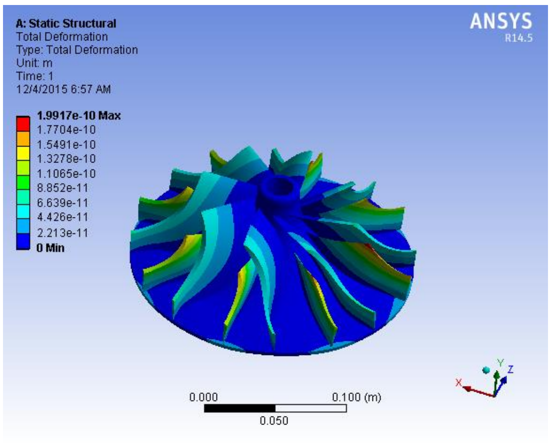

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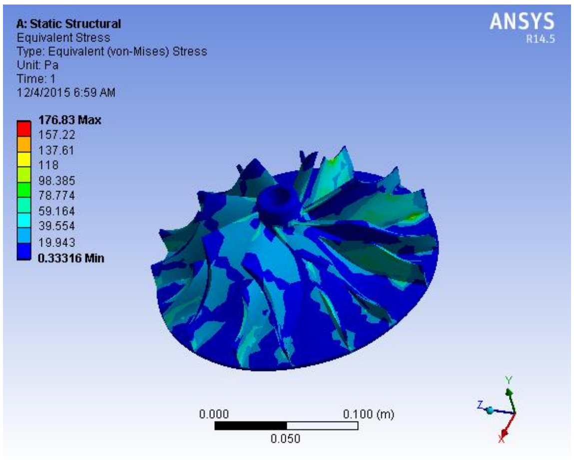
VIII. MODEL OF MODIFIED TURBINE ROTOR BLADE WITH TECHNETIUM

STRESS



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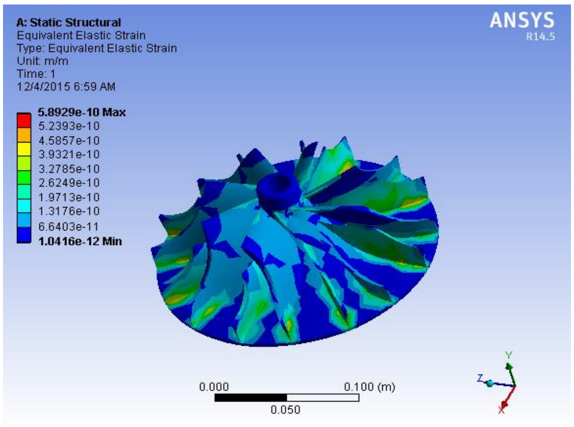

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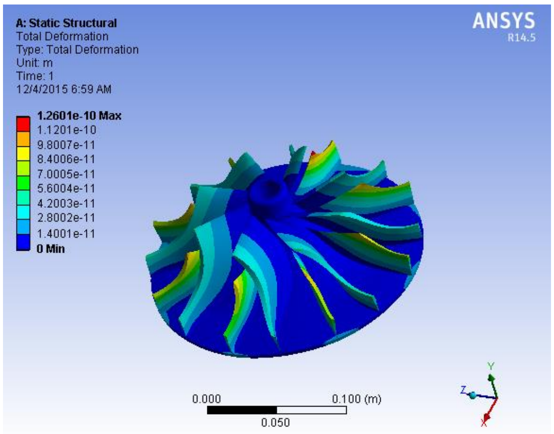
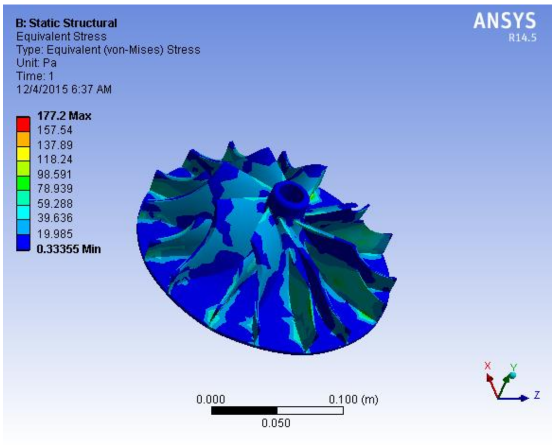


IX. MODEL OF MODIFIED TURBINE ROTOR BLADE WITH T6

STRESS



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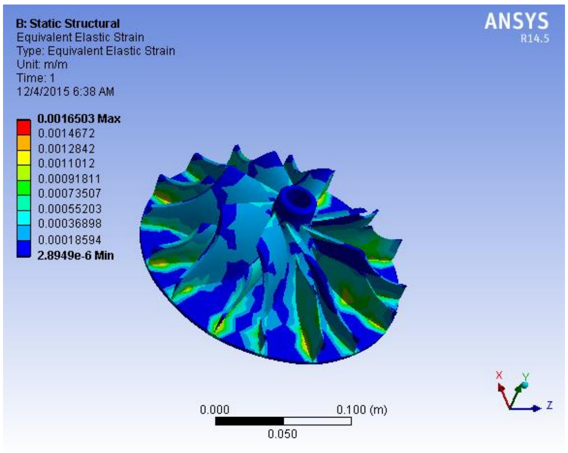

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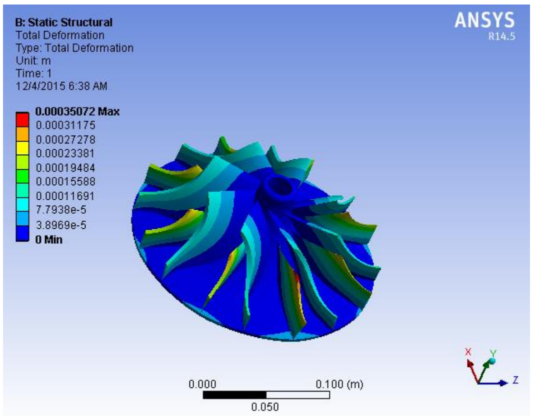

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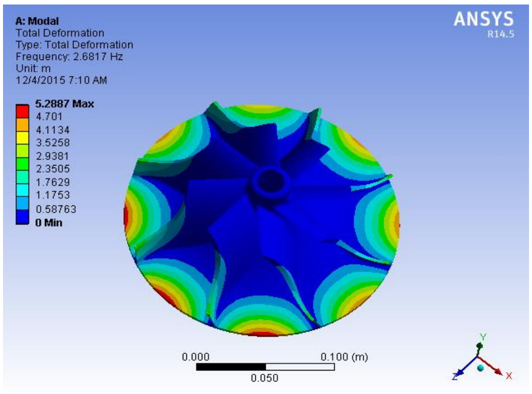
MODAL ANALYSIS

X. MODEL OF BASIC TURBINE ROTOR BLADE WITH T6

TOTAL DEFORMATION 1



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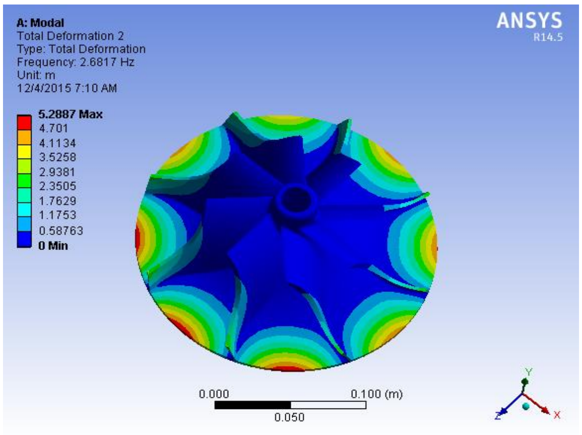

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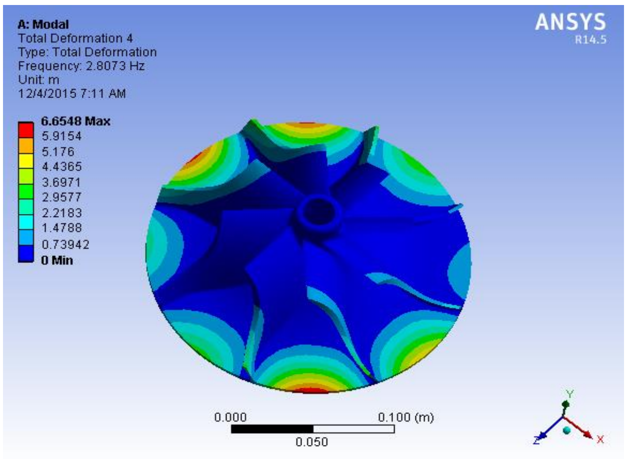

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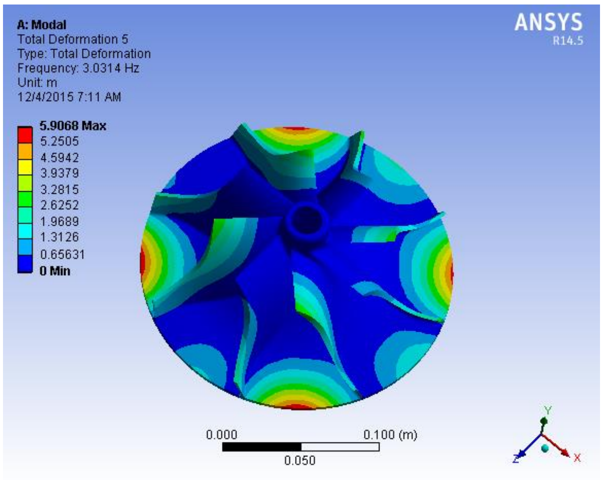

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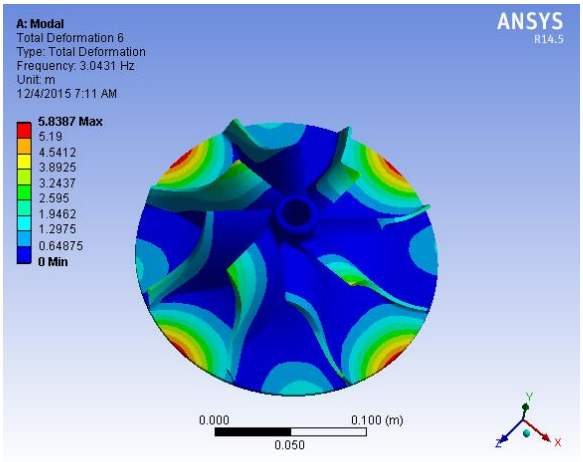

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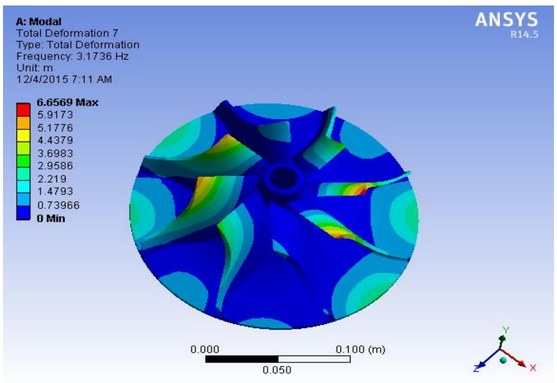
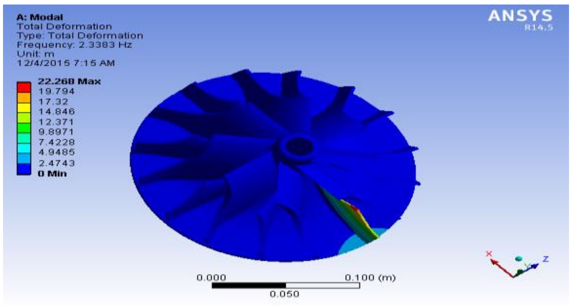


TOTAL DEFORMATION 7

XI. MODEL OF MODIFIED TURBINE ROTOR BLADE T6

TOTAL DEFORMATION 1



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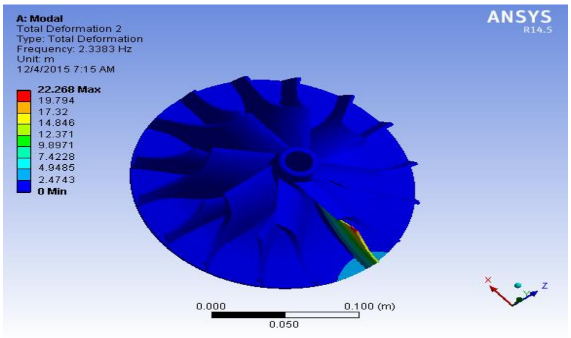

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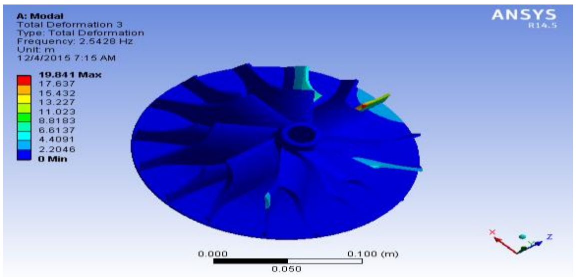

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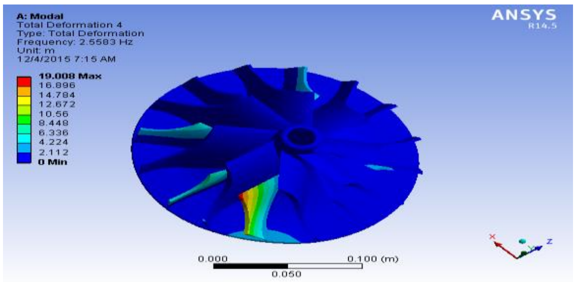

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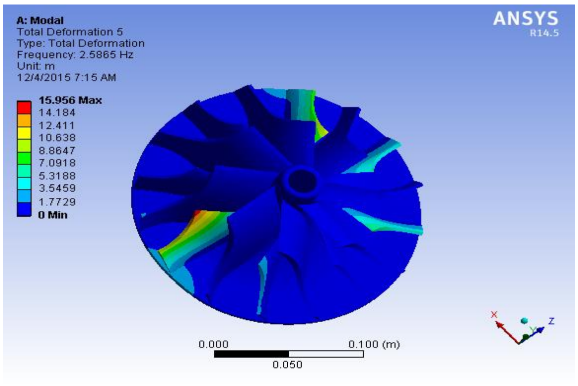

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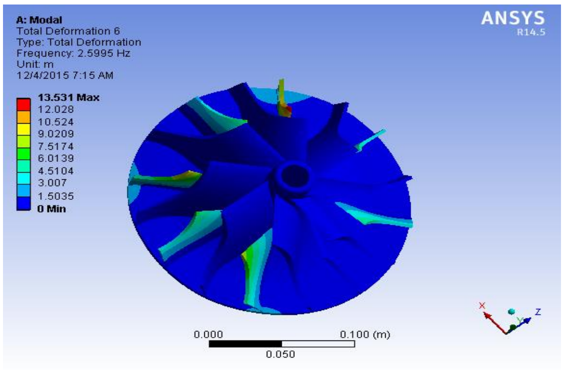

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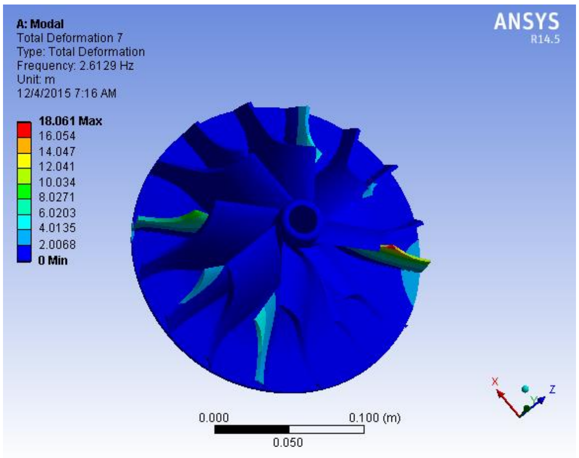

TURBINE ROTOR BLADE

TABLEBASIC TURBINE

	STRESS		STRAIN		TOTAL DEFORMATION	
	MIN	MAX	MIN	MAX	MIN	MAX
AL 2024	0.21277	90.017	3.79E-12	1.23E-09	0	1.85E-10
INCOLE 718	0.2928	71.997	1.63E-12	3.61E-10	0	6.34E-11
TECHNETIUM	0.25778	71.281	1.01E-12	2.28E-10	0	4.01E-11
T6	0.27306	71.554	2.84E-06	6.36E-04	0	1.12E-04

MODIFIED TURBINE

	STRESS		STRAIN		TOTAL DEFORMATION	
	MIN	MAX	MIN	MAX	MIN	MAX
AL 2024	0.27573	236.94	3.84E-12	4.15E-09	0	5.92E-10
INCOLE 718	0.33416	177.68	1.64E-12	9.46E-10	0	1.99E-10
TECHNETIUM	0.33316	176.83	1.04E-12	5.89E-10	0	1.26E-10
T6	0.33355	177.2	2.89E-06	1.65E-03	0	3.51E-04

MODEL ANALYSIS

	DEFORMATION 1	DEFORMATION 2	DEFORMATION 3	DEFORMATION 4	DEFORMATION 5	DEFORMATION 6	DEFORMATION 7
BASIC TURBINE (T6)	5.2887	5.2887	6.8953	6.6548	5.9068	5.8387	6.6569
MODIFIED TURBINE (T6)	22.268	22.268	19.841	19.008	15.956	13.531	18.061

VII. CONCLUSION

Here in this project we have designed the original blade and even modified the design according to the original design, and design work is carried through Catia software and analysis is carried out in Ansys software and here in this thesis we have considered 4 materials i.e. AL 2024, INCOLE 718, TECHTE NIUM AND TITANIUM 6 ALLOY.

Here as we verify in the first original of analysis we can observe that the titanium – 6 alloys has the better performance than the other product. As if we compare the results of stress (177.2) and strain (1.65E-03) and total deformation (3.51e-04) has the better results than any other materials. So here we can conclude that the titanium 6 alloy has the better life output for the original turbine rotor.

Here as we verify in the modified model of analysis we can observe that the titanium – 6 alloys has the better performance than the other product. As if we compare the results of stress (71.554) and strain (6.36E-04) and total deformation (1.12e-04) has the better results than any other materials. So here we can conclude that the titanium 6 alloy has the better life output for the original turbine rotor.

Here as we verify the original and modified in the modal analysis we can observe that the modified model has the better performance than the other product. As if we compare the results of total deformation, here we can conclude that the modified model has the better life output for the original turbine rotor.

So from the total analysis results we can conclude that the modified rotor blade with titanium 6 alloy is the better product and has the better performance and better efficiency than the other materials and original rotor.

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