STRUCTURAL AND MODAL ANALYSIS OF MICRO GAS TURBINE ROTOR BLADE USING CATIA V5 SOFTWARE & ANSIS 15

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ABSTRACT:

In gas turbines the rotor is a component subjected to high Tangential loads and extreme temperatures.The Present work is on the gas turbine blade is made up of al 2024, inconel 718, techtenium and titanium 6 alloyis considered for the analysis.The geometric model of the gas turbine rotor was designed using CATIA software and analysis was done by ANSYS software.

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

Project objectives:

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

The paper identifies various criteria in the development of micro gas turbine blade using several material compositions. The design and modeling is done with the help of CTIA V5 and accordingly the static model analys has been carriedout with limited boundary conditions.

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Structual Integrity of Gas Turbine Blade has been checked by using CATIA V5 Software and later interpolated to Hypermesh for better results.

KEYWORDS: Gas turbine, Rotor blade, Alloy materials, Structural analysis and Modal analysis.

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 on 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.

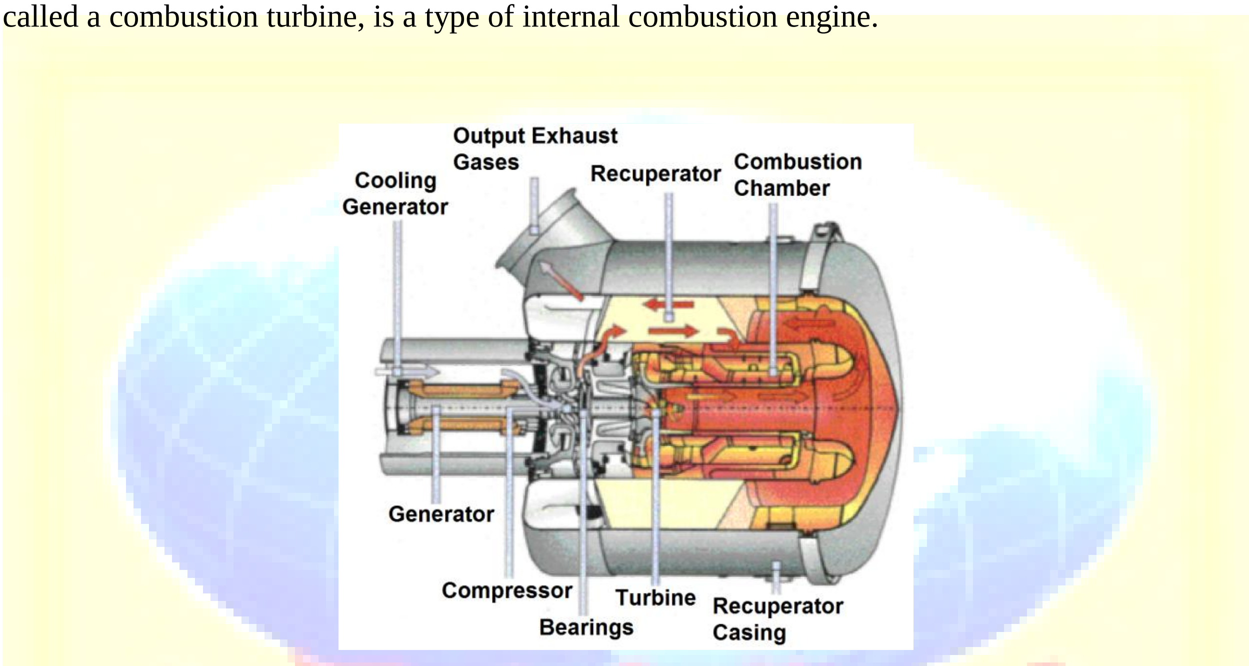
- Steam turbines
- Water turbines
- Wind turbines
- Gas turbines

MICRO GAS TURBINE

Micro turbines are energy generators whose capacity ranges from 15 to 300 kW. Their basic principle comes from open cycle gas turbines, although they present several typical features, such as: variable speed, high speed operation, compact size, simple operability, easy installation, low maintenance, air bearings, low NOX emissions.

Micro turbines came into the automotive market between 1950 and 1970. The first micro turbines were based on gas turbines designed to be used in generators of missile launching stations, aircraft and bus engines, among other commercial means of transport. The use of this equipment in the energy market increased between 1980 and 1990, when the demand for distributed generating technologies increased as well.

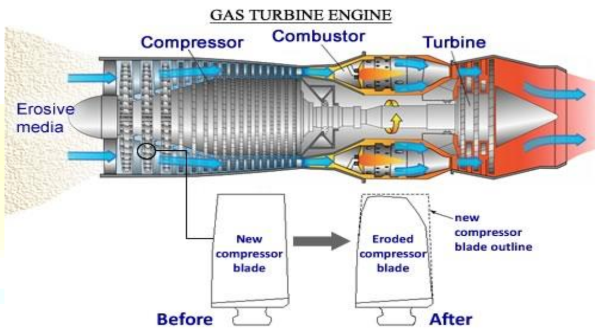
In fact, the technology of micro turbines is not new, as researches on this subject can be found since 1970, when the automotive industry viewed the possibility of using micro turbines to replace traditional reciprocating piston engines. However, for a variety of reasons, micro turbines did not achieve great success in the automotive segment. The first generation ofmicro turbines was based on turbines originally designed for commercial applications in generating electricity for airplanes, buses, and other means of commercial transportation. Micro gas turbine, also called a combustion turbine, is a type of internal combustion engine.



A micro 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 that 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. Gas turbines are used in power aircraft, trains, ships, electrical generators, or even tanks and many more application in present and future. These gas turbines plays wider role for major power generation for industrial and commercial applications.



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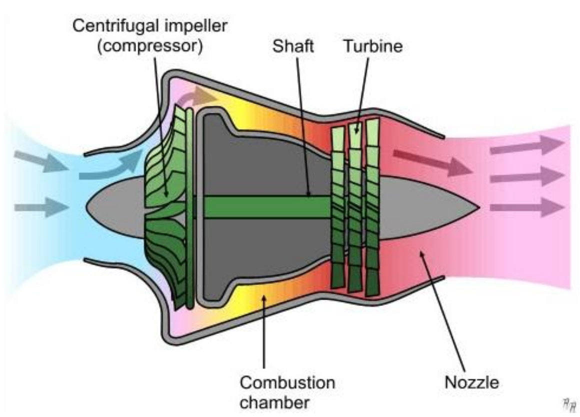
The compressed air is mixed with fuel injected through nozzles. The fuel and compressed air can be pre-mixed or the compressed air can be introduced directly into the combustor. The rotation of the shaft drives the compressor to draw in and compress more air to sustain continuous combustion. The remaining 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



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.

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. 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.

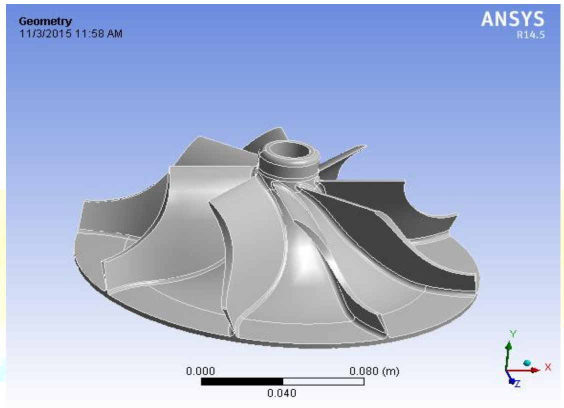
Altogether the purpose of turbine technology is to extract, maximum quantity of energy from the working fluid to convert it into useful work with maximum efficiency. That means, the Gas turbine is designed to have maximum reliability, minimum cost, minimum supervision and minimum starting time. The gas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

John. Y 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. The program makes effective use of the ANSYS preprocessor to mesh complex turbine blade geometries and apply boundary conditions. Here under we presented how the design of a turbine blade is done in CATIA with the help of coordinates generated on CMM, 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. Gas turbine is a device designed to convert the heat energy of fuel into 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.

II.MODEL OF BASIC TURBINE ROTOR BLADE WITH AL 2024

MODEL OF TURBINE BLADE



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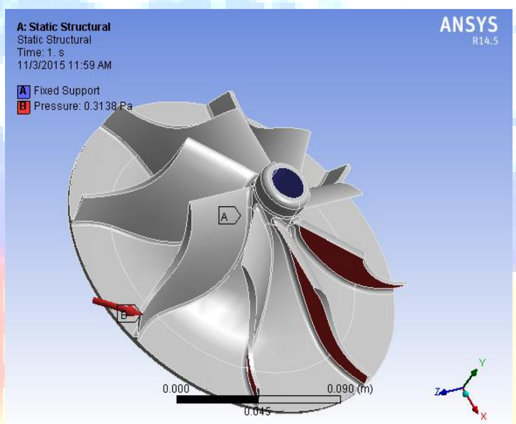

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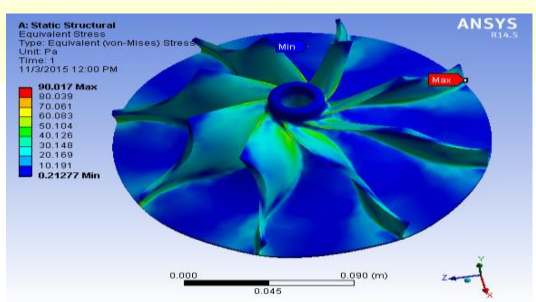

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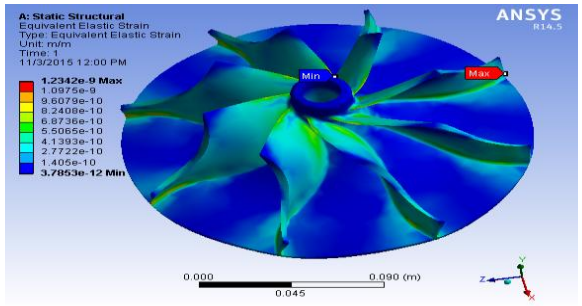

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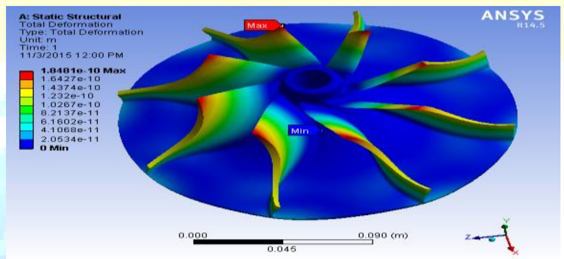
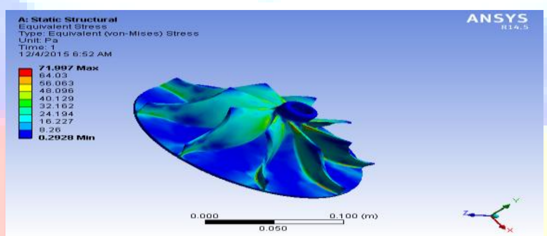


III.MODEL OF BASIC TURBINE ROTOR BLADE WITH INCONEL 718

STRESS



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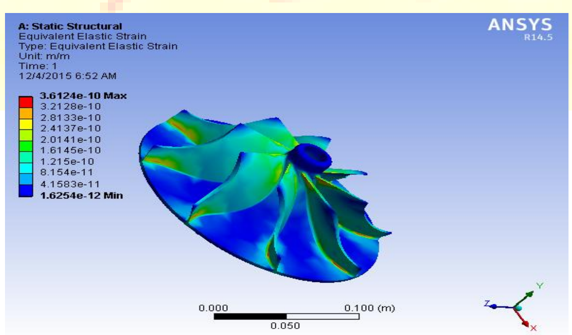

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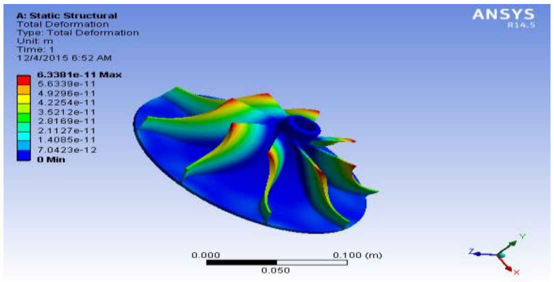
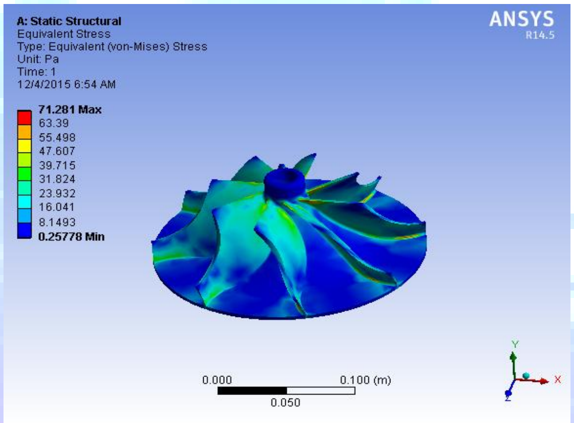


IV. MODEL OF BASIC TURBINE ROTOR BLADE WITH TECHNETIUM

STRESS



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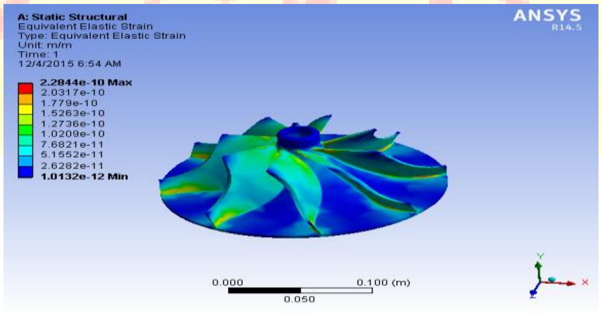

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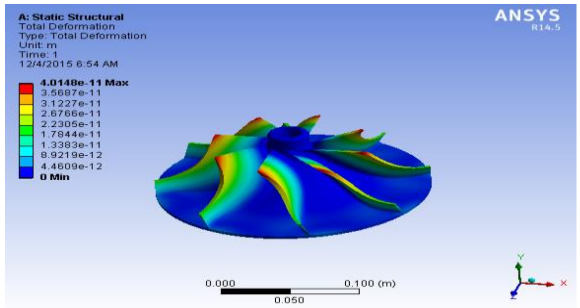
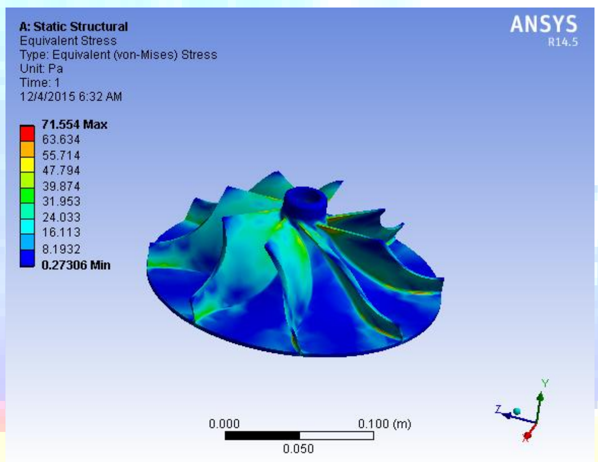


V. MODEL OF BASIC TURBINE ROTOR BLADE WITH T6

STRESS



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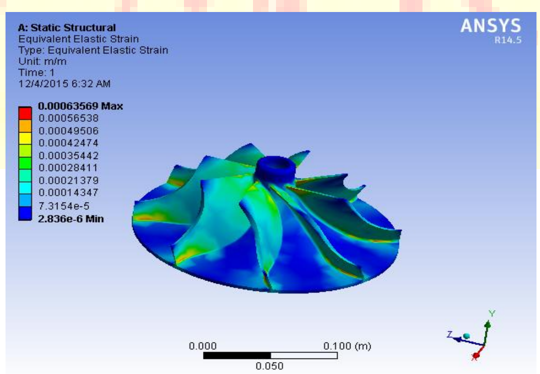

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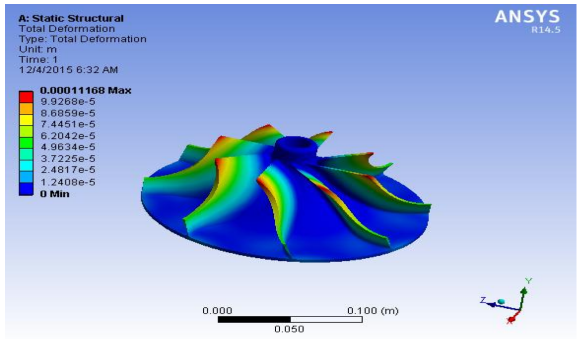
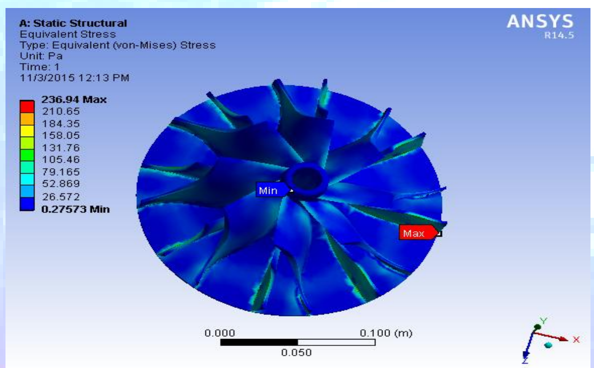


VI. MODEL OF MODIFIED TURBINE ROTOR BLADE WITH AL 2024

STRESS



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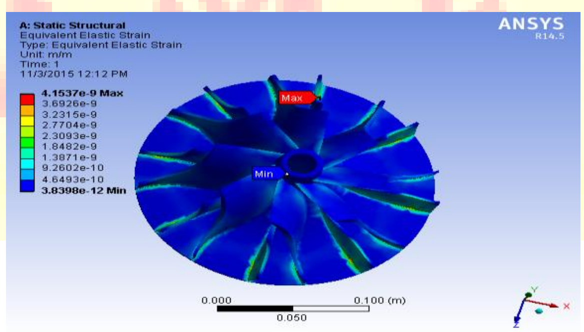

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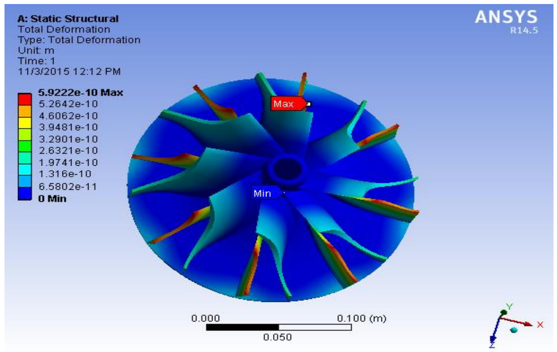
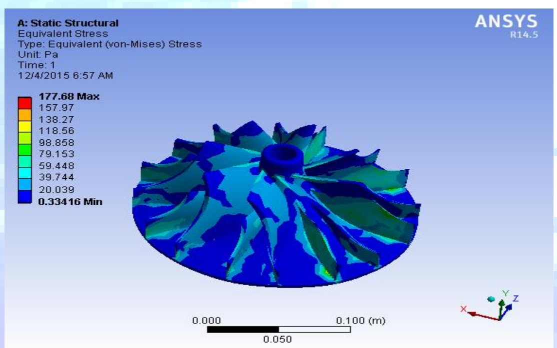


VII. MODEL OF MODIFIED TURBINE ROTOR BLADE WITH INCONEL 718

STRESS



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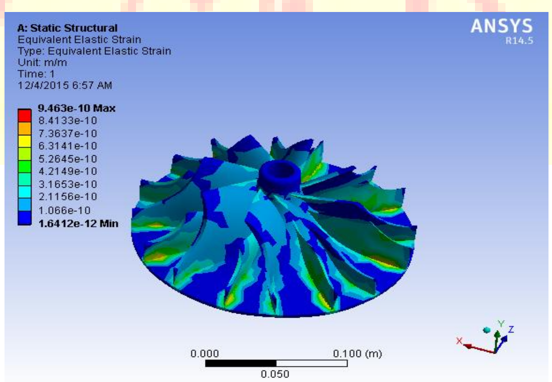

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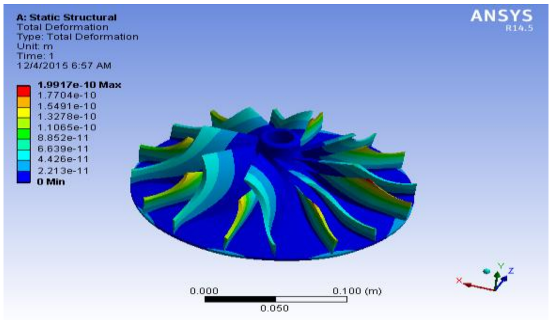
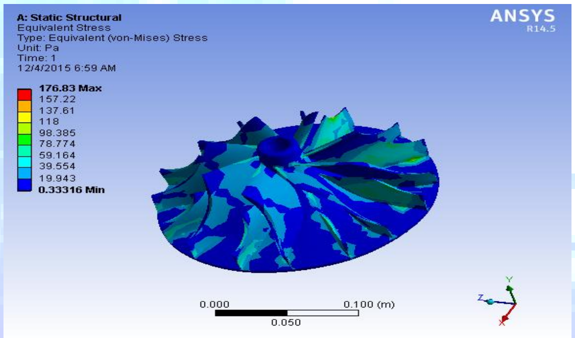


VIII. MODEL OF MODIFIED TURBINE ROTOR BLADE WITH TECHNETIUM

STRESS



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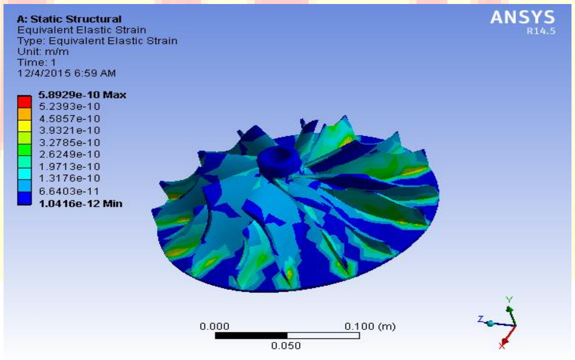

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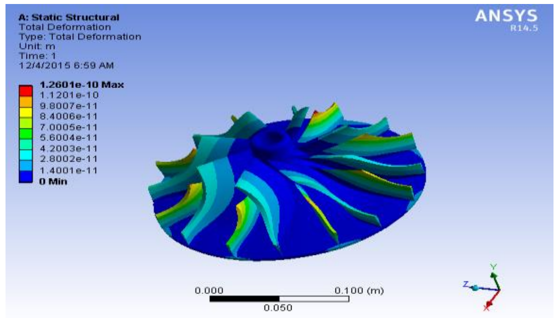
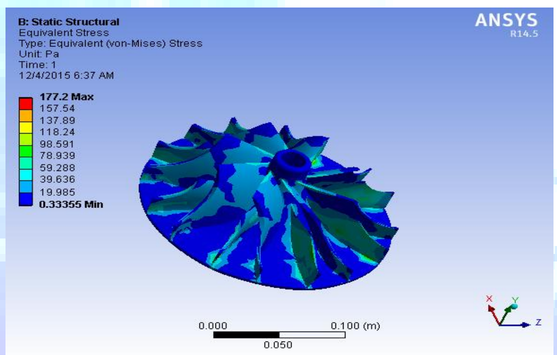


IX. MODEL OF MODIFIED TURBINE ROTOR BLADE WITH T6

STRESS



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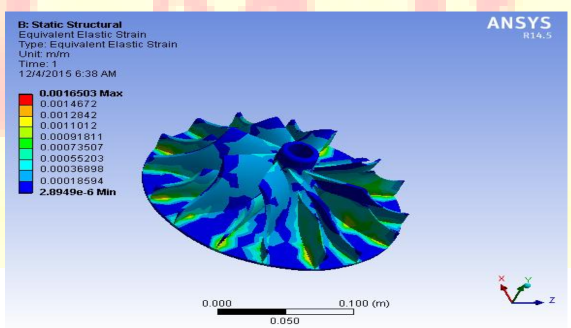

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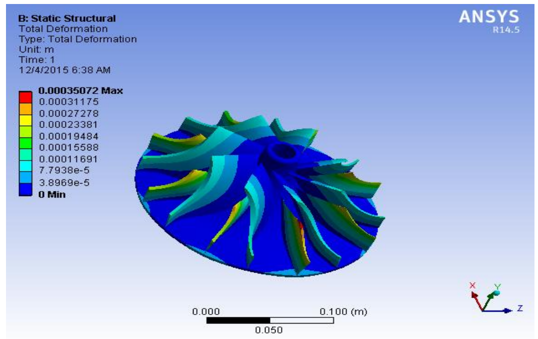

MODAL ANALYSIS

X. MODEL OF BASIC TURBINE ROTOR BLADE WITH T6

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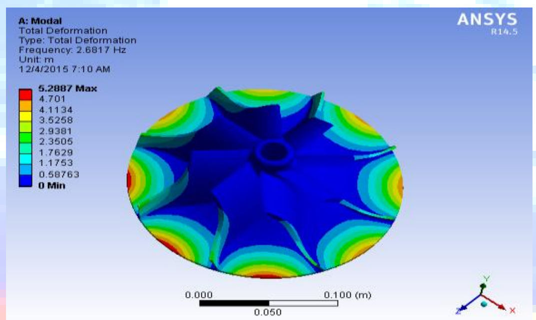

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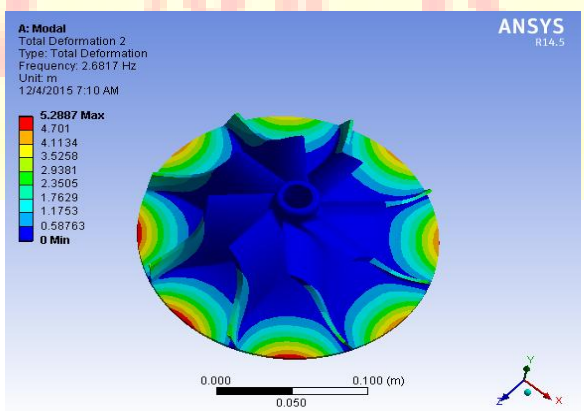

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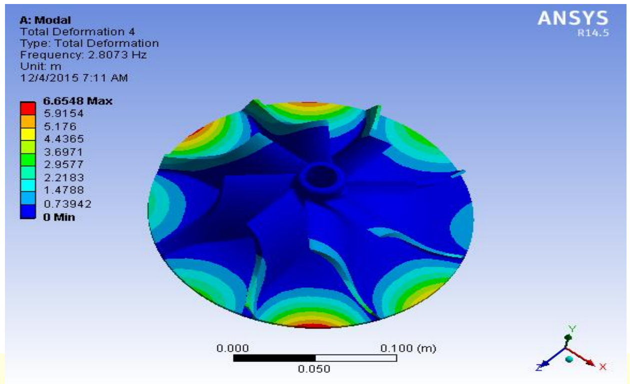

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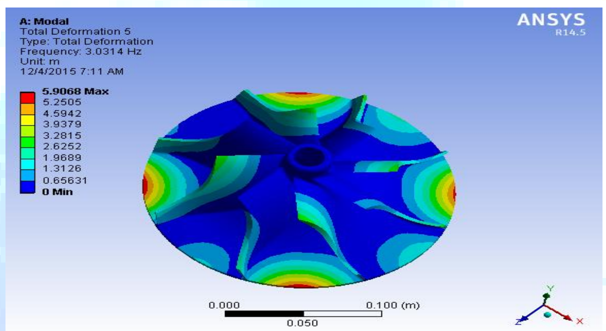

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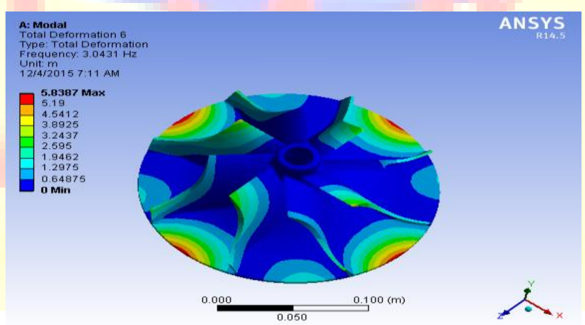

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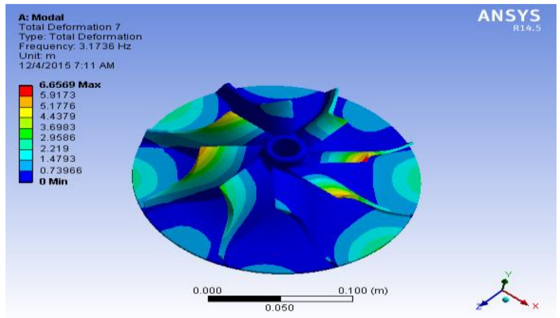

XI. MODEL OF MODIFIED TURBINE ROTOR BLADE T6

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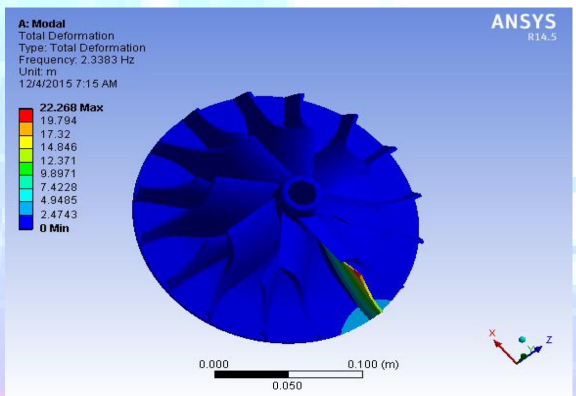

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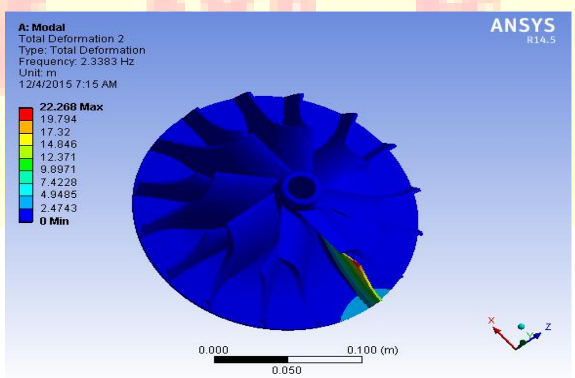

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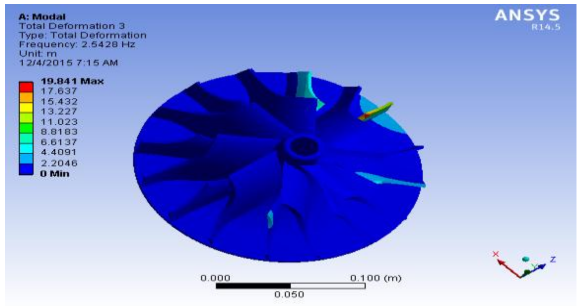

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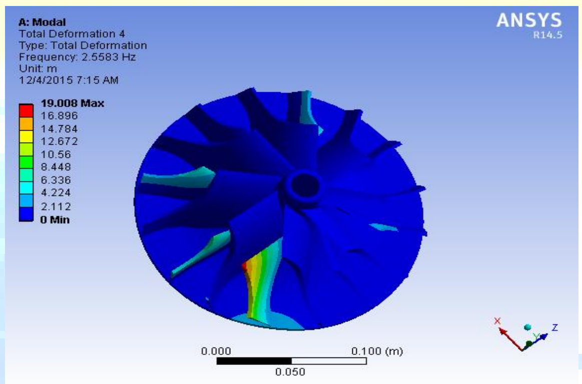

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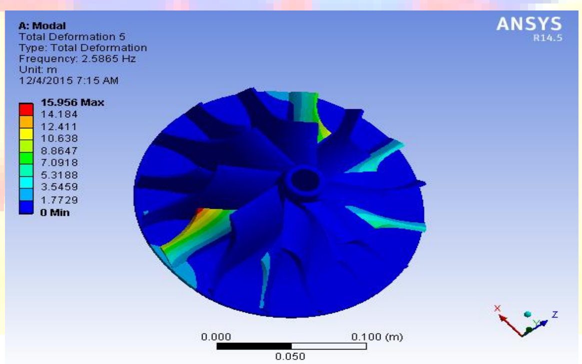

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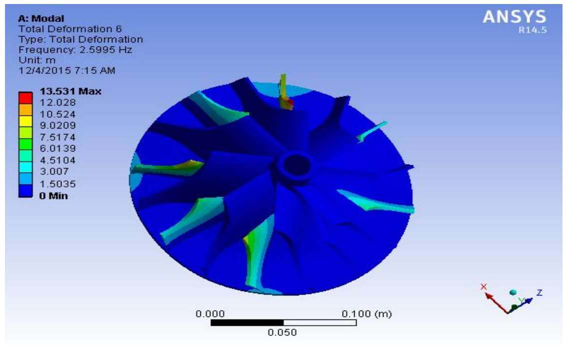

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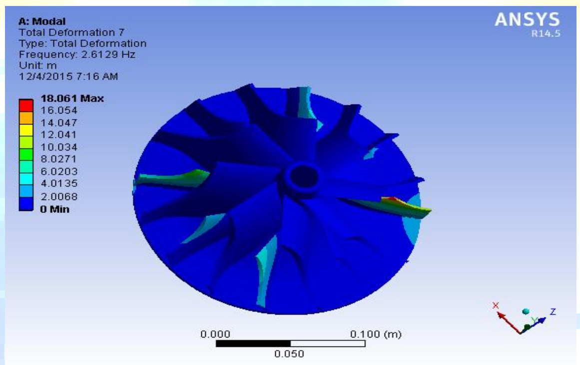
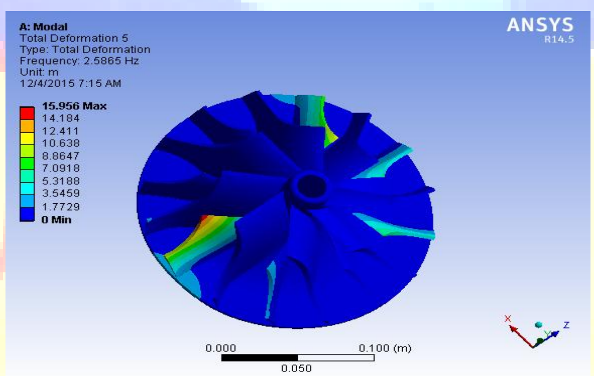


Total Deformation 8



RESULTS:

TABLE FOR BASIC 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
INCONEL 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
INCONEL 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 a blade for a Micro Gas Turbine engine and have also implemented necessary modification according to the original design. This has been achieved through CATIA software and analysis is carried out in ANSYS software. In the thesis we have considered 4 materials i.e. AL 2024, INCONEL 718, TECHTENIUM AND TITANIUM 6 ALLOY.

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

We can also observe that the titanium – 6 alloy has the better performance when 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 material.

So from the comprehensive analysis of the results, we can conclude that the modified rotor blade with titanium 6 alloy is the better with good performance and better efficiency than the other materials and original rotor.

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