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Model Analysis of Gas Turbine Blade with Different Metals by Using Ansys 11.0

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Abstract

The gas turbine obtains its power through a hot fluid with high temperature and pressure moving at a high speed and expanding through the several rings of moving and fixed blades. The purpose of gas turbine is mainly to generate electricity and to propel different machinery and objects via the mechanical energy produced. Gas turbines use up high pressure burnt gas to produce electricity and industrial application and is also used to propel jet engines.The number of gas turbine stages have a more effect on the turbine blades and are designed for each stage. Most of the gas turbine engines are double spool designs, meaning that there is a low pressure spool and a high pressure spool and the turbines used three spools, intermediate pressure spool is added in between the low and high pressure spool.

Theincrease of turbine rotor inlet temperature,thermal efficiency and power output of gas turbine increases and rotor inlet temperature of gas turbine is far above the melting point of the blade material.CATIA is used for design of solid model for the analyses of gas turbine blade,furtheranalysis of this solid model in ANSYS software by generating finite element model, and then apply boundary condition; this includes the specific post-processing and life assessment of turbine blade. The program makes effective utilize of the ANSYS pre-processor to mesh complicated turbine blade geometries and apply boundary conditions. Designing of a turbine blade is in CATIA with the assist of co-ordinate generated and to demonstrate the pre-processing capabilities, static and dynamic stress analysis results and life assessmenton CMM. In these analysesto study the thermal stresses on turbine blade with titanium and graphite as material and obtain the natural frequenciesof the turbine blade.A structural analysis has been carried out to study the stresses, shear stress and displacements of the turbine blade which is been develop due to the combination effect of centrifugal andthermal loads. An attempt is also made to suggest best material through comparing the results obtained from the analyses of two different materials (Graphite and Titanium)of a turbine blade. Titaniumis the best material based on the analysis results and plots, as well as it has high-quality material properties at higher temperature as compare to that of graphite material.

Keywords:

Turbine blades,

Graphite,

Titanium,

Ansys

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1. INTRODUCTION

Turbine as a rotating machine for generating power from water is not moderately exact. Water in natural world is a practical source of energy. It comes straight in mechanical form, without the losses drawn in heat engines and fuel cells, and no fuels are needed. Solar heat evaporates water, generally from the oceans, where it is mixed into the lower atmosphere by turbulence, and moved by the winds.

In a realistic, gas turbine, gases are initial accelerated in either a centrifugal or axial flow compressor. These gases are then slowed by a diffuser; these processes increase the pressure and temperature of the gasses flow. In a model system this is an isentropic. However, in practice energy is lost to heat, due to turbulence and friction. Gases next pass from the diffuser to a combustion chamber, where heat is additional. In an ideal system this occurs at steady pressure (isobaric heat addition). As there is no change in pressure the specific of the gases increases. S.Gowreesh et.al [1] considered on the initial stage rotor blade of a two stage gas turbine has been analysis for structural, thermal and modal analyses using ANSYS 11.0 which is a influential Finite Element method software. The temperature sharing in the rotor blade has been evaluated using this software. The design features of the turbine section of the gas turbine have been taken from the beginning design of a power turbine for maximization of an existing turbo jet engine. It has been felt that a detail study can be conceded out on the temperature effects to have a clear understanding of the combined mechanical and thermal stresses. Narasa Raju. G et.al., [2] had completed research on dissimilar types of the cooling technique which maintain temperature of the blade to permissible limits, Finite element analyses is used to inspect steady state thermal & structural performance for Inconel 155 and Inconel 718 nickel-chromium alloys. Four different models consisting of solid blade and blades with varying number of holes (5, 9 and 13) were analyzed to find out the optimum number of cooling holes. They had used two materials Inconel 718 and Inconel 155 for their research work and found out Inconel 718 has the better thermal properties as the blade temperature and the stress induce is smaller. Kauthalkar.S et.al, [3] had investigated the stresses and deformations induced in blade geometry and establish the highest elongations and temperatures are observed at the blade tip segment and minimum elongation and temperature variations at the origin of the blade. Temperature allocation is almost unvarying at the maximum curvature region along blade shape. Temperature is linearly declining from the tip of the blade to the origin of the blade section. Maximum stress induced is within safe edge. Gas turbines are available in sizes range from 500 kilowatts to 250 Megawatts. Gas turbines can be used in power-generation or in combined heat and power (CHP) systems. The most proficient commercial technology for central station power generation is the gas turbine-steam turbine combined-cycle plant, with efficiencies approaching 60 percent lower heating value (LHV). For Power generation simple-cycle gas turbines are most accessible with efficiencies approaching 40 percent (LHV). Gas turbines have extensive been used for peaking capacity. However, by means of changes in the power industry and advancements in the technology, the gas turbine is now being progressively more used for base-load power.

The objective of the present study is to develop an integrated finite element method to analyse the deformation, displacement, stress and strain of the turbine blade with graphite and titanium material. From the FEM analyses titanium material has the less thermal stress when compared to the graphite material.

1. Mathematical Modeling

Fig.1 Gas Turbine blade with thermal barrier coating

The objective of the present investigation is to develop an integrated finite element method to analyze the deformation, displacement, stress and strain of the turbine blade with graphite and titanium material. From the FEM analysis titanium material has the less thermal stress when compared to the graphite other material.

Table 1 represents the dimensions of the gas turbine blade for the analysis.

Parameter	**Dimension**
Blade Span	120 mm
Blade axial Chord Length	110 mm
Cooling passage diameter	2 mm

Table 2 represents the properties of the turbine blade material of graphite and titanium

Property	**Graphite**	**Titanium**
Density	2250 x 10^6kg / m^3	4500 kg /m^3
Modulus of Elasticity	68 Gpa	116 Gpa
Poison's Ratio	0.19	0.32

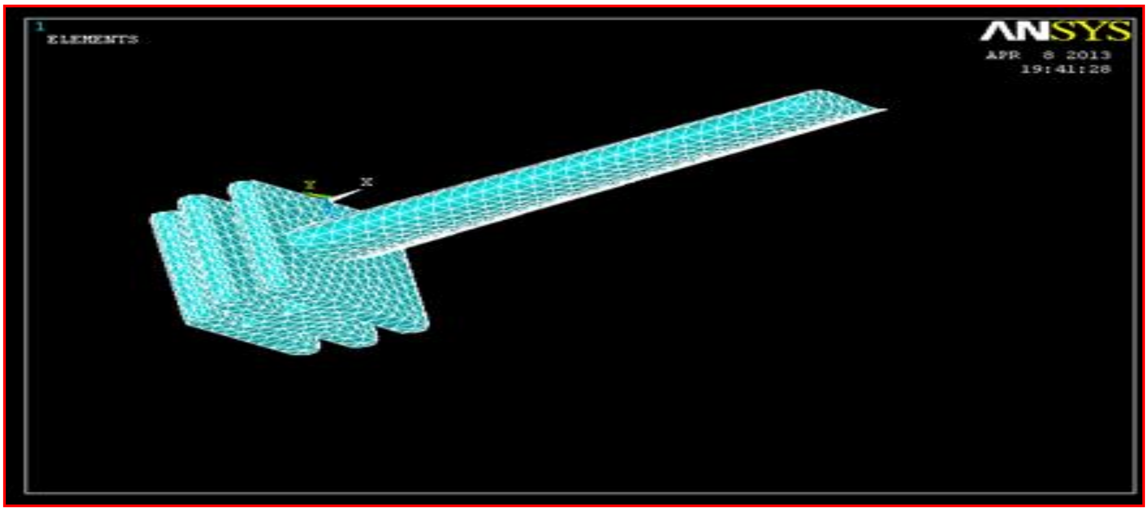

Fig. 2 Represents the meshed modal of gas turbine blade**.** Forstructural and thermal analysis boundary conditions are considered.

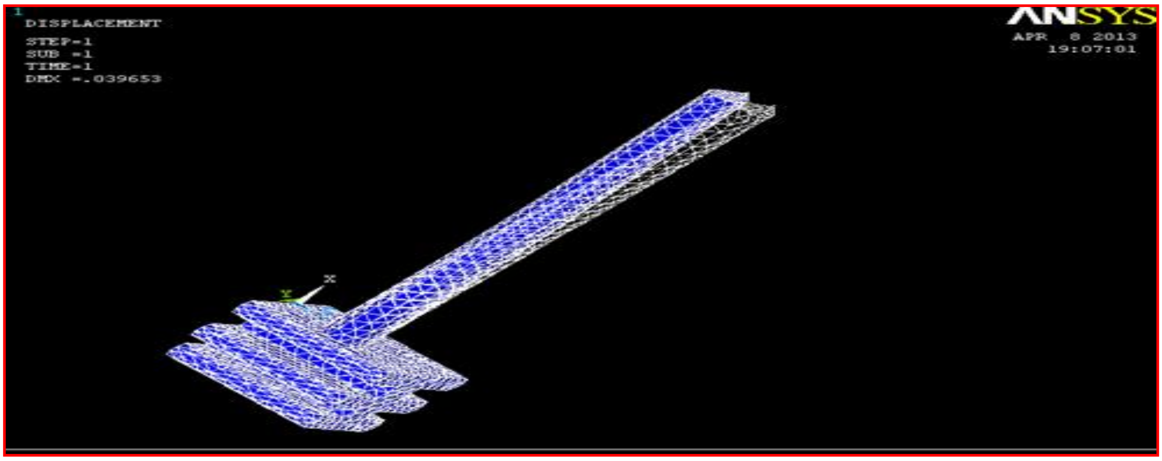

Fig. 3 Deformed Shape of Gas Turbine Blade with Titanium material

1. Results and Discussion

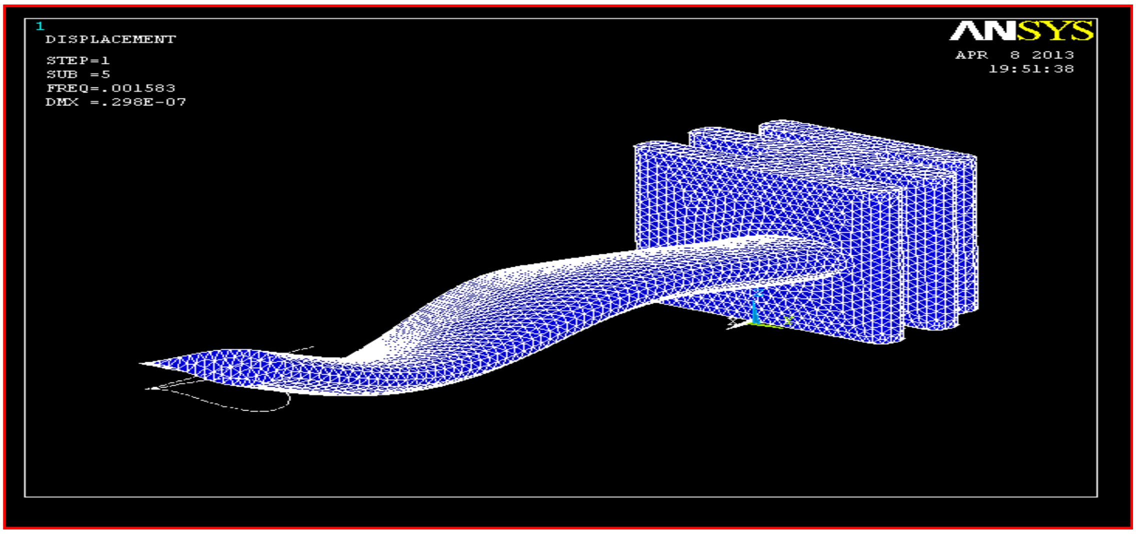

Fig. 4Deformed Shape in Modal Analysis for Graphite at last set

Figure 3 – 4 depicts the deformed shape of gas turbine blade with titanium and graphite material

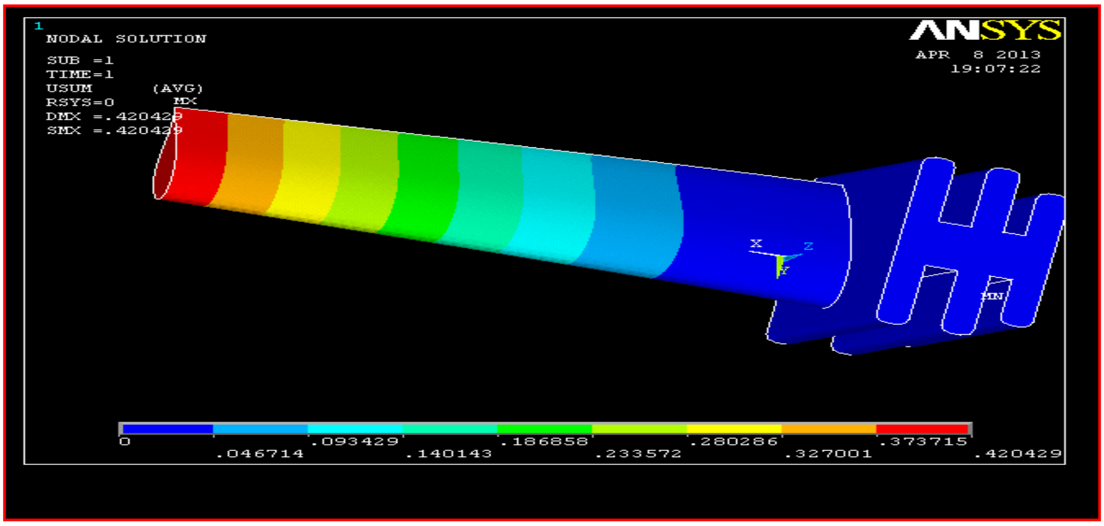

Fig. 5 Displacement Vector Sum turbine blade with Graphite material

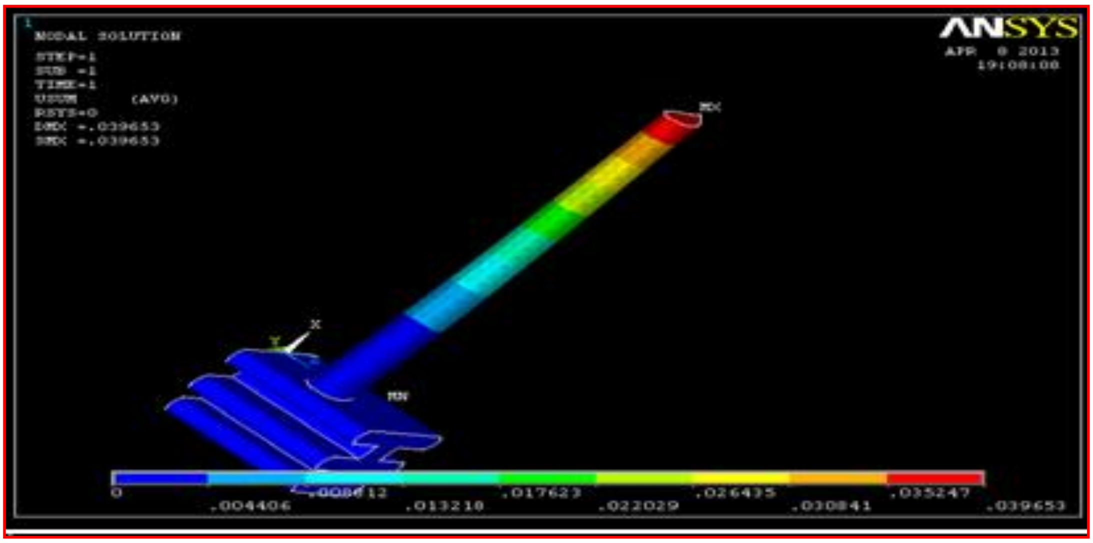

Fig. 6 Displacement Vector Sum turbine blade with Titanium material

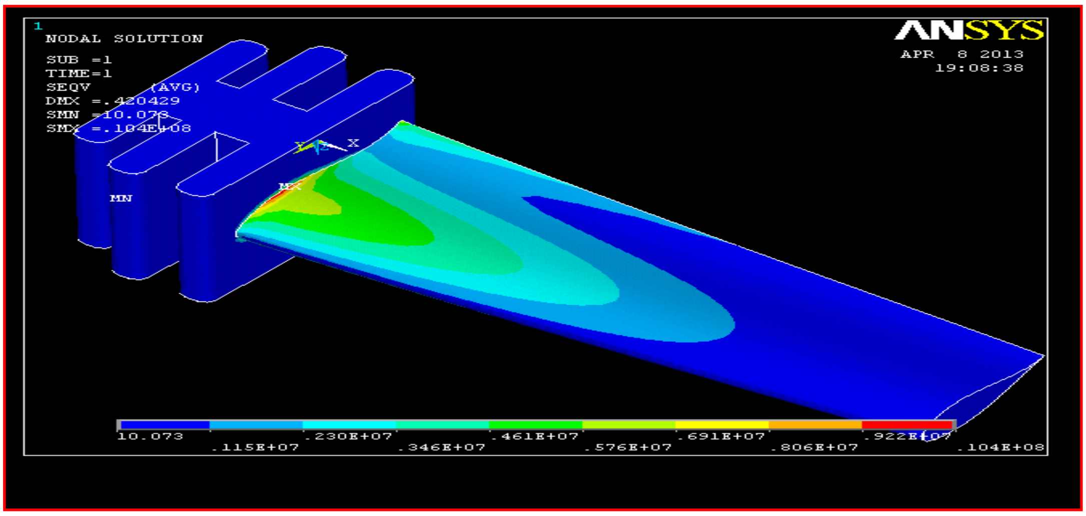

Fig. 7 Von Misses Stress in Gas Turbine Blade with Graphite material

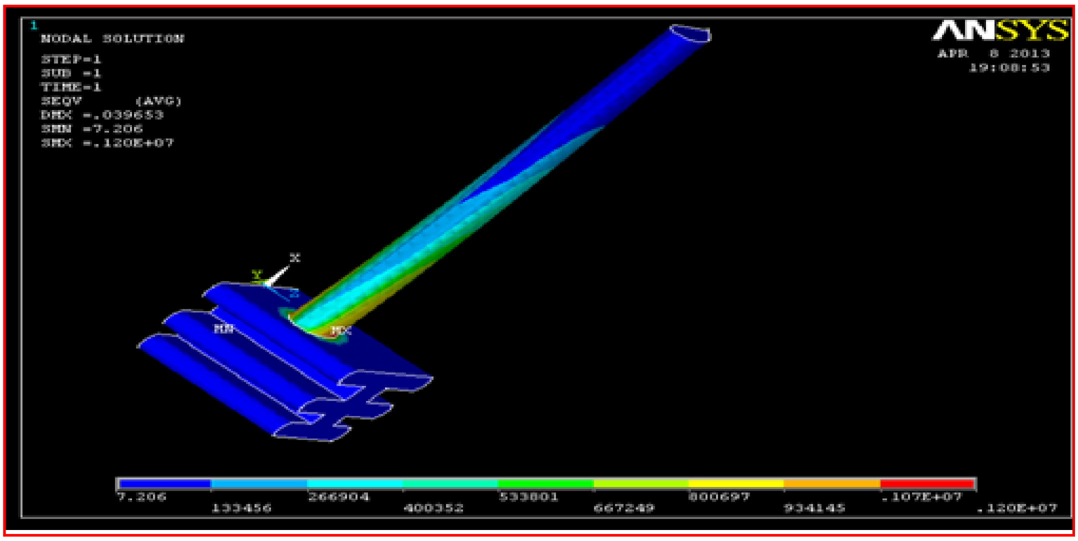

Fig. 8 Von Misses Stress in Gas Turbine Blade with Titanium material

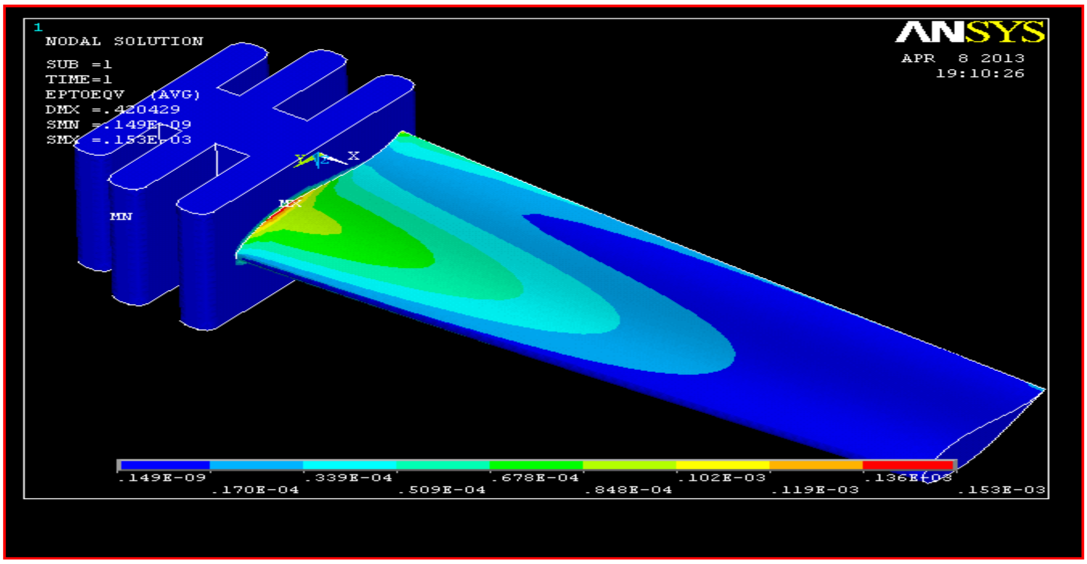

Fig. 9 Von Misses Strain of Gas Turbine Blade with Graphite material

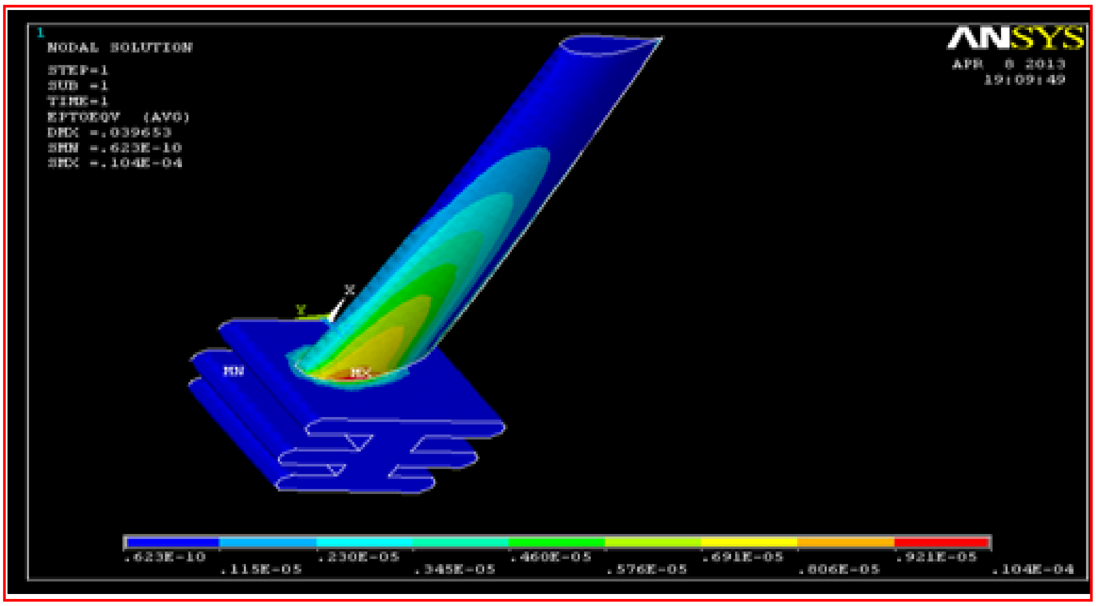

Fig. 10 Von Misses Strain of Gas Turbine Blade with Titanium material

Table 3 Static Analysis Comparison of turbine blade

Parameter	Graphite	Titanium
Force	24,000 N	24,000 N
Displacement of Vector Sum	0.420429	0.039653
Max Von Misses Stress	0.104E+08	0.120E+07
Min Von Misses Stress	10.073	7.206
Max Von Misses Strain	0.153E-03	0.104E-04
Min Von Misses Strain	0.149E-09	0.623E-10

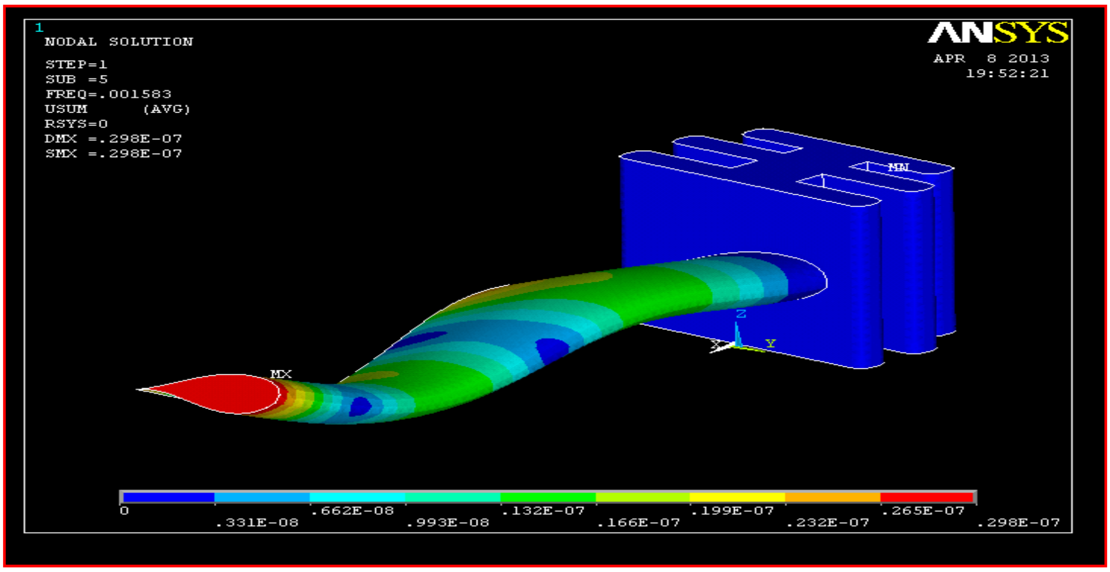

Fig. 11 Displacement Vector Sum in Modal Analysis Graphite material at last Set

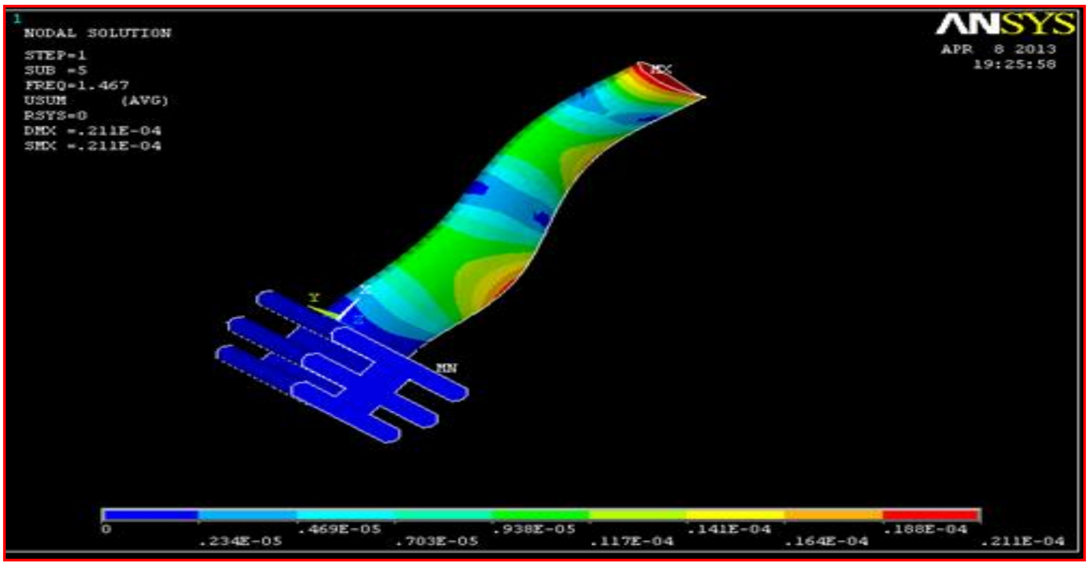

Fig. 12 Displacement Vector Sum in Modal Analysis with Titanium material at last set

Table 4 Modal Analysis Comparison of Von misses stress, strain and frequency range distribution for Titanium and Graphite materials.

S.No	Material	Frequency Range	Strain distribution	Von misses stress distribution (Pa)	Displacement of Vector Sum
1	Titanium	0-4000HZ	0.008541	0.131e-10	0.211E-04
2	Graphite	0-4000HZ	0.007235	0.120e-10	0.2988E-07

4. Conclusion

A comprehensive numerical investigation was conducted for different materials and thermally induced stresses of the gas turbine blade. A model of the gas turbine blade was developed to compute the Von Misses Stresses and strain of the blade and also study the effect of displacement with Graphite and Titanium materials. From the FEM analysis, it is observed that Titanium material has the less displacement, strain and thermal stress distributions. Thermal stresses purely depend on the thermal conductivity of the material. When compare the thermal conductivity of all the materials Titanium material has the less thermal conductivity. So the induced thermal stresses of the Titanium material is very less when compared to other material.

5. References

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