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DESIGN AND ANALYSIS OF GAS TURBINE BLADE BY USING FINITE ELEMENT METHOD

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ABSTRACT

In this paper we discussing the withstanding of gas turbine blades for the elongations is a major consideration in their design because they are subjected to high tangential, axial, centrifugal forces during their working conditions. Several methods have been suggested for the better enhancement of the mechanical properties of blades to withstand these extreme conditions. This paper summarizes the design and analysis of Gas turbine blade, on which CATIA V5 is used for deign of solid model of the turbine blade with the help of the spline and extrude options ANSYS 13.0 software is used analysis of F.E. model generated by meshing of the blade using the solid brick element present in the ANSYS software itself and thereby applying the boundary condition. This paper specifies how the program makes effective use of the ANSYS pre-processor to analyze the complex turbine blade geometries and apply boundary conditions to examine steady state thermal & structural performance of the blade for N 155, Haste alloy x & Inconel 625 materials. Finally stating the best suited material among the three from the report generated after analysis. From this the results are stated and reported.

KEYWORDS Gas turbine blade, CATIA V5 , ANSYS and F.E.Method.

INTRODUCTION

The finite element method is a numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. Because of its diversity and flexibility as an analysis tool, it is receiving much attention in engineering schools and in industries. In more and more engineering situations today, we find that it is necessary to obtain approximate numerical solutions to problems rather than exact closed form solution.

The finite element method has become a powerful tool for the numerical solution of a wide range of engineering problems. It has developed simultaneously with the increasing use of high-speed electronic digital computers and with the growing emphasis on numerical methods for engineering analysis.

ANSYS is a finite element software package. It is very extensively used and is recognized as the most powerful engineering design and analysis software. It is registered trademark of SAS IP Inc.

ANSYS is general purpose software, which can be used for almost any type of finite element analysis virtually in any industry automobiles, aerospace, railways, machinery, electronics, sporting goods, power generation, power transmission and biomechanics. "General purpose" also refers to the fact that the software can be used in all disciplines of engineering- structural, mechanical, electrical,

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electromagnetic, electronic, thermal, fluid and bio-medical.

ANSYS program can be run either in interactive mode or batch mode. Interactive mode, as its name implies, is where designer constantly interacts with the computer. When the command is issued the ANSYS program processes it and indicates what it did. Incase of a mistake, corrective action can right away be taken. Interactive, mode allows is the designer to use convenient features such as graphic displays, on line help, menu system and graphics picking.

RESULTS AND DISCUSSIONS

In the structural and thermal analysis of the model, after the modeling the part and after giving the required inputs, the solution part is executed. As there are no errors in the model developed therefore the solution is done successfully. Experimental results were shown in figures 1-6.

1.Rotational load:

Obtained result as the maximum and minimum radial stress i.e., along X direction is *Max315 N/mm^2 and Min -11.5 N/mm^2,where*as the maximum and minimum axial stress, along Y direction is *Max 72.4 N/mm^2 and Min -22.3 N/mm^2*.Obtained result as the maximum and minimum Hoop or tangential stress i.e., along Z direction is *Max 315 N/mm^2 and Min 72.1 N/mm^2*. Obtained result as the maximum and minimum Von Misses stress or equivalent stress is *Max 311 N/mm^2 and Min 71.2 N/mm^2*. And observed that minimum displacement is *0.047 mm* at hub side and maximum displacement *0.19 mm* is at rim side.

2.Rotational and Pressure loads:

The maximum and minimum radial stress were found to be along X direction is *Max 29.1 N/mm^2 and Min -306 N/mm^2*.Where as the maximum and minimum axial stress found to be along Y direction is *Max 55.2 N/mm^2 and Min -93.6 N/mm^2*.Maximum and minimum Hoop or tangential stress i.e., along Z direction is *Max 91.8 N/mm^2 and Min -144 N/mm^2*.And finallythe maximum and minimum Von Misses stress or equivalent stress is *Max 262 N/mm^2 and Min 86.1 N/mm^2*.

3.Thermal loads:

In thermal load analysis the maximum and minimum radial stress i.e., along X direction is *Max 471 N/mm^2 and Min -21.3 N/mm^2*. Obtained result as the maximum and minimum axial stress i.e., along Y direction is *Max 111 N/mm^2 and Min -36.3 N/mm^2*.The maximum and minimum Hoop or tangential stress i.e., along Z direction is *Max 625 N/mm^2 and Min -59.1 N/mm^2*.And maximum and minimum Von Misses stress or equivalent stress is *Max 599 N/mm^2 and Min 71.3 N/mm^2*.

4.Thermal, pressure and rotational loads:

The maximum and minimum radial stress i.e., along X direction is *Max 326 N/mm^2 and Min -23.7 N/mm^2*.Obtained result as the maximum and minimum axial stress i.e., along Y direction is *Max 99.9 N/mm^2 and Min -95.3 N/mm^2*.Where as the maximum and minimum Hoop or tangential stress i.e., along Z direction is *Max 695 N/mm^2 and Min -720 N/mm^2*.And the

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maximum and minimum Von Misses stress or equivalent stress is *Max 658 N/mm^2 and Min 73.2 N/mm^2*.

DISCUSSIONS

The stresses calculated under thermal and structural analysis with steady state inertia force acting on the wheel is found to be well within the permissible limits. The stresses for the disk obtained from analytical method are found to be well in agreement with that obtained from ANSYS.

We notably observed the thermal analysis and structural analysis were studied by using ANSYS software. The von mises stresses calculated *570 N/m^2*at centre and *570 N/mm^2*at rim. The tangential stresses calculated *322 N/mm^2*at centre and *-159 N/mm^2*at rim. The tangential stresses calculated *614 N/mm^2*at centre and *155 N/mm^2*at rim. The von mises stresses calculated *635 N/mm^2*at centre and -1.31*N/mm^2*at rim. Hence we can say that the design is safe and disk is ready for manufacturing process.

CONCLUSIONS

The stresses calculated under static analysis with steady state inertia force acting on the wheel are found to be well within the permissible limits. The stresses calculated under static analysis with pressure force acting on the wheel are found to be well within the permissible limits. The tangential and radial stress do not intersected, hence satisfying the design condition of the disk and also the dimensions of the disk are in co-ordinance to suit the operating conditions to which the disk will be subjected. Temperature is linearly decreasing from the rim side to centre of the rotor.Maximum elongations and temperatures are observed at the rim side and minimum elongation and temperature variations at the center of the rotor.

Maximum thermal stresses are setup when the temperature difference is varies from rim side to shaft side.Bending stresses on the rotor due to gas pressure load are significantly lower than those due to rotation load.Thermal stresses on the disc are quite high owing to the sharp temperature gradient that exists in the turbine disc. For the present design, stresses at the disc center are shown to be higher than those on the rim side of rotor wheel.The stresses for the disk obtained from analytical method are found to be well in agreement with that obtained from ANSYS. (Table-1)

Table -1 ANSYS results are tabulated below:

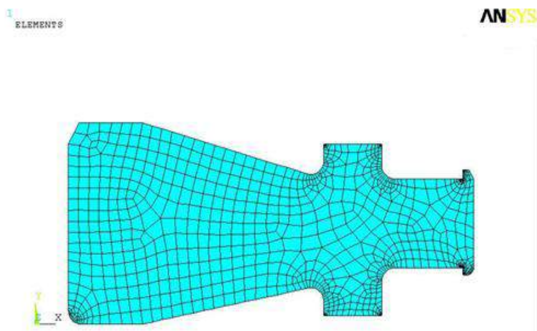

Fig 1: Mesh model of gas turbine rotor wheel cross-section

Fig 2: Mesh model of gas turbine rotor wheel

Stresses in N/mm^2	X-dir (radial)		Y-dir (axial)		Z-dir (tangential)		Von Mises	
Loads	Shaft side	Rim side	Shaft side	Rim side	Shaft side	Rim side	Shaft side	Rim side
Rotational	0	-1.15	0	-11.8	315	72.1	311	71.2
Rotational +Pressure	29.1	-232	-11.0	-11.0	91.8	-117	65.0	178
Thermal	-21.3	-21.3	29.0	-20.0	625	-591	599	599
Rotational +Pressure +Thermal	13.4	-237	34.8	-51.7	695	-720	658	658

Fig 3: 3-D model of gas turbine rotor wheel

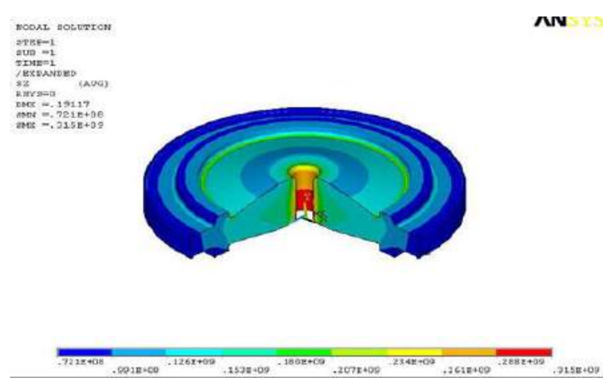

Fig 4: Stress distribution along z-direction for rotational load

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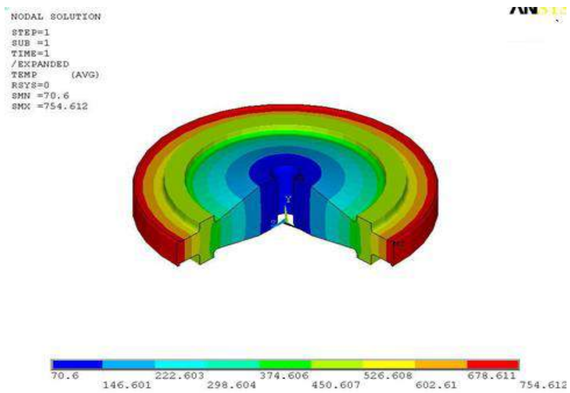

Fig 5: Stress distribution along x-direction for rotational and pressure loads

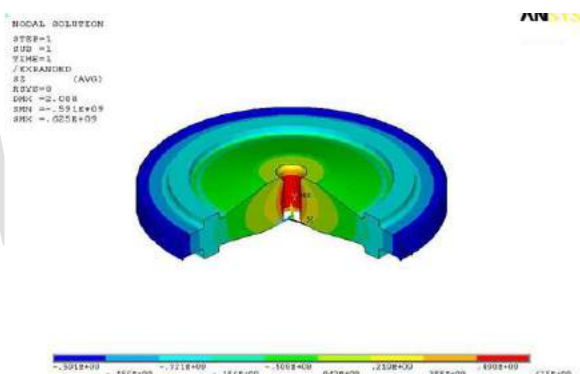

Fig 6: Thermal gradients of gas turbine rotor wheel

FUTURE SCOPE

The Gas Turbine Rotor wheel was analyzed for thermal and structural loads and stresses are found to be well within the permissible limits. The rotor wheel was analyzed but in future there is a need of analyzing rotor with blade. The work can be extended for designing the rotor with blade for accommodating different simulation operations. The present work represents thermal and structural analysis but in future modal analysis can be done to determine the mode shapes under variable frequencies. It would be helpful in carrying out the non-linear analysis as well as transient, creep analysis of rotor wheel. However, chrome-nickel steel alloy is found to be a good material for manufacturing of gas turbine rotor. It is suggested that for further any Aluminum alloys can be tried for optimizing the cost and reducing the weight of rotor wheel.

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