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Analysis of Gas Turbine Rotor Blade by Using F.E.M

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Abstract:
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 project 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 11.0 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.

The turbine escapes energy from the exhaust gas. Like the compressor, turbine can be centrifugal or axial. In each type the fast moving exhaust gas is sued to spin the turbine, since the turbine is attached to the same shaft as the compressor at the front of the engine, and the compressor will turn together, The turbine may extract just enough energy to turn the compressor. The rest of the exhaust gas is left to exit the rear of the engine to provide thrust as in a pure jet engine. Or extra turbine stages may be used to turn other shafts to power other machinery such as the rotor of a helicopter, the propellers of a ship or electrical generators in power stations.

1. INTRODUCTION:

The gas turbine obtains its power by utilizing the energy of burnt gases and the air which is at high temperature and pressure by expanding through the several rings of fixed and moving blades, to get a high pressure of order of 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 drive the compressor so it is coupled to the turbine shaft, If after compression the working fluid were to be The present paper deals with the first type is centrifugal stresses that act on the blade due to high angular speeds and second is thermal stresses that arise due to temperature gradient within the blade material. The analysis of turbine blade mainly consists of the following two parts: Structural and thermal analysis. The analysis is carried out under steady state conditions using Ansys software. The study has been conducted with three different materials N155, Hastealloy X & Inconel 625.

2. LITERATURE SURVEY

S.Gowreesh et.al(1) studied on The first stage rotor blade of a two stage gas turbine has been analysed for structural, thermal, modal analysis using ANSYS 11.0.which is a 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 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 et.al(2) 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.

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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 et.al(3) 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 pre-processor 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 co-ordinate generated on CMM.And to demonstrate the pre-processing 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 shafe of the turbine blade. V.Raga Deepu et.al(4) Studied on a Gas turbine is a 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. In this paper the first stage rotor blade of the gas turbine is created in CATIA V5 R15 Software. This model has been analysed using ANSYS11.0. The gas forces namely tangential, axial were determined by constructing velocity triangles at inlet and exist of rotor blades.

After containing the heat transfer coefficients and gas forces, the rotor blade was then analysed using ANSYS 11.0 for the couple field (static and thermal) stresses.

3. COMPUTER AIDED ANALYSIS OF GAS TURBINE ROTOR BLADE

The model is created and analyzed using CATIA and ANSYS. For automatic mesh generation and node selection is used. The structural, thermal modal modules of ANSYS 11.0 are used for the analysis of the rotor blade. The rotor blade was analyzed for mechanical stresses, temperature distribution, combined mechanical and thermal stresses and radial elongations, natural frequencies and mode shapes. The blade is then analyzed sequentially with thermal analysis preceding structural analysis. The model is discretised using 8 noded plane element (plane 82) & solid 95 3D 20-nodes structural solid element.

4.1 Details of Turbine blade

D=1308.5 mm, N=3426 Rpm, L=117mm, d=2mm

Table 1 Mechanical properties of N155, Inconel 625 & Hastealloy X

propertie s	Units	N15 5	Incone l 625	Haste alloy X
E	Pa	143 E09	150E0 9	144E09
ρ	Kg/cu m	824 9	8400	8300
K	W/m-K	20.0	10	25
μ	---	0.34 4	0.331	0.348
α	E-06/^{o}C	17.7	15	16
C_P	J/KgK	435	410	450

Melting point	OC	135 4	1350	1380
Yield stress	MPa	550	1030	360

5. RESULTS & DISCUSSIONS

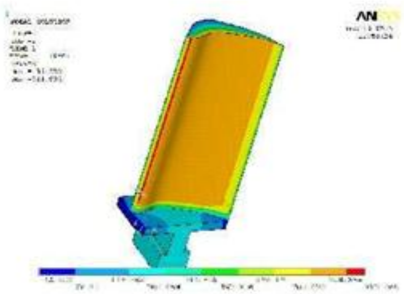
Thermal analysis:

From the post processing, the temperature variation obtained as shown in fig. From figure, it is observed that the temperature variations from leading edge to the trailing edge on the blade profile is varying from 913.886^{0}C to 944.489^{0}C throughout the blade and the variation is linear along the path from both inside and outside of the blade.

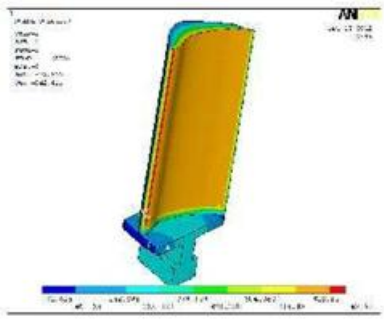
RESULTS OBTAINED:

Material Type	Stress (N/mm^2)	Deformation (mm)	Temperature (^{0}c)
N155	412.759	0.881842	913.886
HASTE ALLOY X	937.208	1.808	942.411
INCONEL625 ALLOY	910.375	1.742	944.489

Thermal Analysis Results:



Thermal Analysis Resul

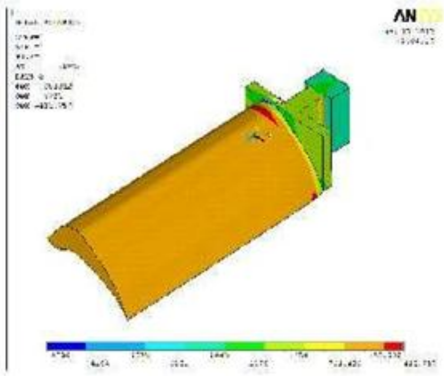


Thermal Analysis Results

Structural analysis:

The von misses stresses are obtained as shown in the figure; it is observed that the maximum von misses stress is 412.759 N/mm^2 for N155,937.208 N/mm^2 for Haste alloy X and 910.375 N/mm^2 for Inconel 625 alloy. The deformations are obtained as shown in the figure; it is observed that the maximum deformation is 0.881842 mm, 1.808 mm and 1.742 mm for N155, Haste alloy X and Inconel 625 alloy respectively. From the above results it is observed that the stress and deformation are low for N155

Structural Analysis Results



Stress induced in the blade, N/mm^2

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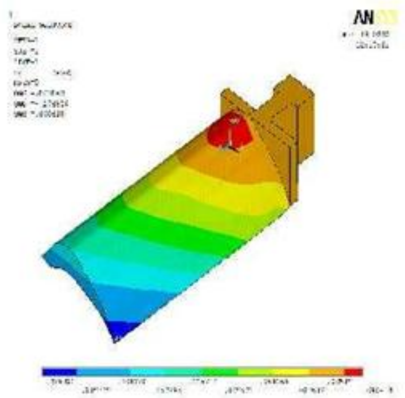
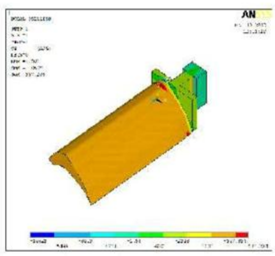
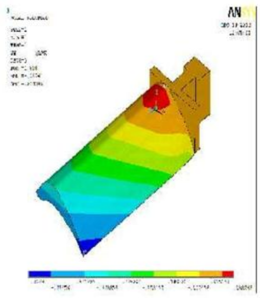


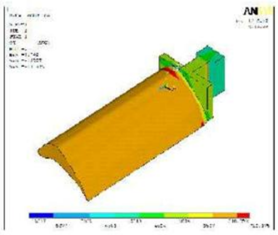
Deformation in Z-direction (Uz) in the blade, mm

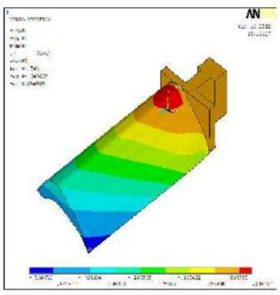
Static Analysis Results





Static Analysis Results





Stress induced in the blade, N/mm2

Stress induced in the blade, N/mm2

6. CONCLUSION:

It is seen from above results both the materials are giving the considerable results; finally the conclusion can be done on the basis of the cost and the availability of the materials. If cost of the materials is not a primary issue we can select the titanium T6 which have lesser density, lesser value• of deformation at a same time it will have lower value of yield strength and young modulus at higher temperature, which will have a lower strength.

On the other hand if cost of the material is a primary issue then we can select In conel 718, it will have little higher• deformation at high temperature as compare to titanium T6. But at the same time it will have higher value of elastic strength, higher values of yield strength which will induce lesser value of the stress on the blade. The finite element analysis for structural and thermal anaysis of gas turbine rotor blade is carried out using solid95 element. The temperature has a significant effect on the overall turbine blades. Maximum elongations and temperatures are observed at the blade tip section and minimum elongation and temperature variations at the root of the blade. Maximum stresses and strains are observed at the root of the turbine blade and upper surface along the blade roots three different materials of construction i.e., N-155,Inconel 625 & HASTEALLOY X materials. It is found that the temperature has a significant effect on the overall stresses induced in the turbine blades. The blade temperatures attained and thermal stresses induced are lesser for Inconel 625 as it has better thermal properties.

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