IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

REPSE-17

Sri Venkateshwara College of Engineering, Bengaluru

Vol. 4, Special Issue 7, May 2017

Static Structural Analysis of Gas Turbine Blades Comparing the Materials

Nagesh R[1], Apoorva H R[2], R Mohan[3]

Assistant Professor, Mechanical Engineering, Sri Venkateshwara College of Engineering, Bangalore, India [1]

UG Student, Aeronautical Engineering, Achutha Institute of Technology, Bengaluru, India [2, 3]

Abstract: During the operation modern aircraft engines components are subjected to increasingly demanding operating conditions such as high temperature cycles, rotation speed and pressure, especially the high pressure turbine blades (HPT). This blades are identified there most likely component to be failed due to the operating conditions at elevated temperature. These condition make these blades undergo different type of time dependent degradation, one of which is creep, a failure mechanism that can significantly reduce parts life either by generating cracks, or by over elongation of blade tip that contact with the turbine's casing. In general blade failures can be grouped into two categories that are fatigue; including both high cycle fatigue (HCF) and low cycle fatigue (LCF) and second is creep rupture. Due to the thermal loads acting on the blades the extra cooling has to be provided. To sustain these high loads the high strength material has to be used. The material used are INCONEL-718 and Ceramics. This also increases the life assessment of the blade also. The performance of the blade increases. We use CATIA V5 R21 for modeling and ANSYS R15 for structural analysis.

Keywords: Gas turbine blades, materials, failure, structural analysis.

I INTRODUCTION

Turbine blade is a part of engine which extracts fluid flow and converts into useful mechanical and kinetic energy. The work produced by this can be used to produce electrical power and produce thrust. 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. Turbine blade is the individual component which makes up the turbine section of gas turbine. They are the limiting components of the gas turbine. The blades are responsible for extracting the energy from the high pressure gases produced in the combustion chamber. To protect the blade from this environment the super alloys and the barrier coatings on the blades are used. Impulse turbines change the direction of flow of a high velocity fluid or gas jet. The resulting impulse spins the turbine and leaves the fluid flow with diminished kinetic energy. There is no pressure change of the fluid or gas in the turbine blades (the moving blades), as in the case of a steam or gas turbine, all the pressure drop takes place in the stationary blades (the nozzles). Before reaching the turbine, the fluid's pressure head is changed to velocity head by accelerating the fluid with a nozzle. Newton second law describes the transfer of energy for impulse turbines. Impulse turbines are most efficient for use in cases where the flow is low and the inlet pressure is high. Reaction turbines develop torque by reacting to the gas or fluid's pressure or mass. The pressure of the gas or fluid changes as it passes through the turbine rotor blades. Newton third law describes the transfer of energy for reaction turbines. Reaction turbines are better suited to higher flow velocities or applications where the fluid head (upstream pressure) is low. The smaller the engine, the higher the rotation rate of the shaft(s) must be to attain the required blade tip speed. Blade-tip speed determines the maximum pressure ratios that can be obtained by the turbine and the compressor. This, in turn limits the maximum power and efficiency that can be obtained by the engine. In order for tip speed to remain constant, if the diameter of a rotor is reduced by half, the rotational speed must double. The high pressure turbine is exposed to the high pressure air and the low pressure turbine is exposed to the low pressure air. This difference in turbine blades leads to the different material used and the different methods of cooling have to be followed.

The length of the blades depends on the impulse or reaction style, weather it is an axial or radial flow turbine, and where the blade is located within turbine of an axial flow turbine. The length of the blade increases depending on the inlet weather it is steam or gas. The increase or decrease in profile depends on the inlet to discharge.

A. FAILURE MODES OF TURBINE BLADES

As the turbine blades acts the main role in the turbine part they are subjected to various kinds of failures. Mainly high temperature, high potential vibration and high stress plays main role in the failure of the turbine blade. A major challenge facing turbine design is reducing the creep that is induced by the high temperatures.

The stresses of operation on the turbine tend the materials to become damaged through these mechanisms. Turbine blades are subjected to stress from centrifugal force (turbine stages can rotate at tens of thousands of revolutions per minute (RPM)) and fluid forces that can cause fracture, yielding, or creep failures. As temperatures are increased in an effort to improve turbine efficiency, creep becomes more significant. Modern turbine faces temperatures around 2,500°F (1,370 °C), up from temperatures around 1,500°F (820 °C) in early gas turbines. Due to this high temperature it also causes fatigue failure, thermal corrosion etc. on the blades. This reduces the blade performances by reducing its life cycle. In order to reduce this design of blades is made carefully.

II GAS TURBINE BLADE MATERIAL

Turbine Blades are subjected to significant rotational and gas bending stresses at extremely high temperature, as well as severe thermo mechanical loading cycles as a consequence of normal start-up and shutdown operation and unexpected trips. Inlet of the turbine consists of extreme temperature (1400C-1500C), high pressure, high rotational speed, vibration, small circulation area and so on. In order to overcome those barriers, gas turbine blades are made using advanced materials and super alloys that contains up to ten significant alloying elements, but its microstructure is very simple; consisted of rectangular blocks of stone stacked in a regular array with narrow bands of cement to hold them together. The replacement of material by the titanium gave improved high temperature strength and also improved oxidation resistance. However, the biggest change has occurred in the nickel, where high levels of tungsten and rhenium are present. An important recent contribution has come from the alignment of the alloy grain in the single crystal blade, which has allowed the elastic properties of the material to be controlled more closely. These properties in turn control the natural vibration frequencies of the blade. To achieve increased creep strength, successively higher levels of alloying additions (Al, Ti, Ta, Re, W) have been used to increase the levels of precipitate and substitution strengthening. However, as the level of alloying has increased the chromium additions have had to be significantly reduced to offset the increased tendency to reduce the limit ductility and reduced strength. Reduced chromium levels also significantly reduce the corrosion resistance of the alloys. This has necessitated the development of a series of protective coating systems. The coatings are applied to provide increased component lifetimes but they often demonstrate low strain to failure properties that can impact upon the thermo mechanical fatigue endurance. Now days the ceramics had been come to picture in the blade design. Ceramics are the old material used before using the steel nickel, super alloys etc.,but now by reducing the weight and by alloying the other material with the ceramics the ceramic materials are used. Here the blade material used is INCONEL718 and CERAMICS.

III ANALYSIS RESULTS

The structural analysis and thermal analysis of the turbine rotor disk is carried out. Sectorizing the 3D model of the full rotor, meshing the sector, thermal structural analysis of high pressure turbine BLISK (HPT) is done.

A. STEADY STATE RESULTS

Figure shows the distribution of static stresses throughout the blade. The static stresses are mostly the result of centrifugal load on the blade.

Ceramics

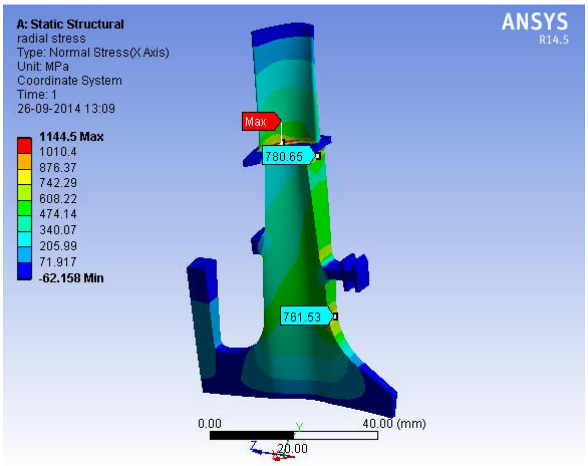

Figure.1: Normal stress on X-Axis

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

REPSE-17

Sri Venkateshwara College of Engineering, Bengaluru

Vol. 4, Special Issue 7, May 2017

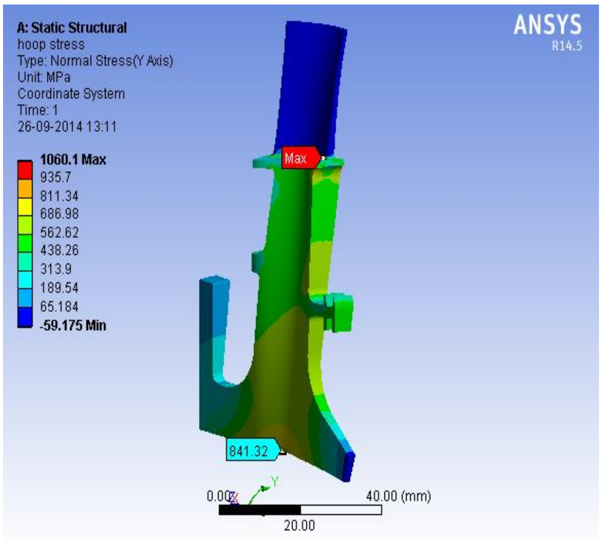

Figure 2: Normal stress on y-Axis

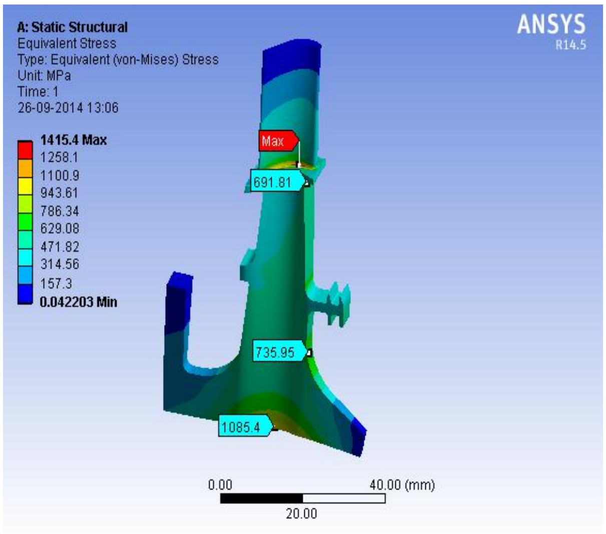

Figure 3: Equivalent stress (Von-Mises)

This output file have results as Von-mises (1415.4 MPa), radial (1144.5 MPa), hoop stresses (1060 MPa). The maximum Von-mises or radial stress occurs at the fillet radius.

INCONEL718

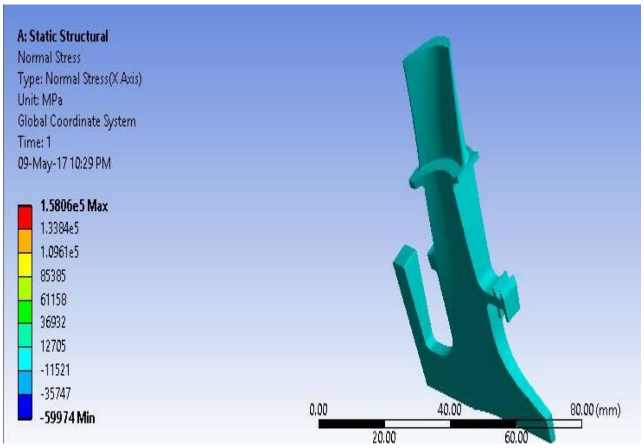

Figure 4: Normal stress on X-Axis

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

REPSE-17

Sri Venkateshwara College of Engineering, Bengaluru

Vol. 4, Special Issue 7, May 2017

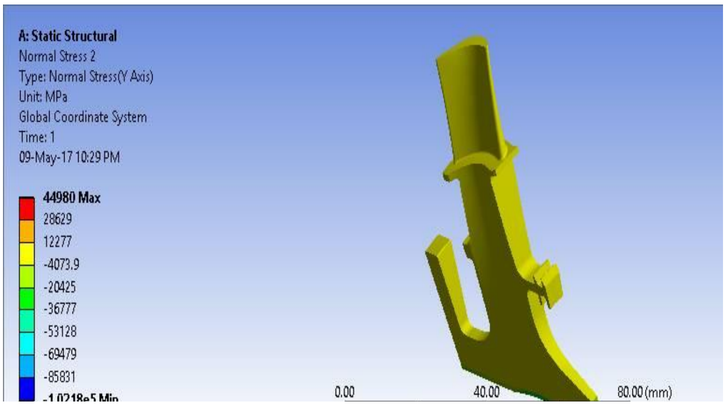

Figure 5: Normal stress on Y-Axis

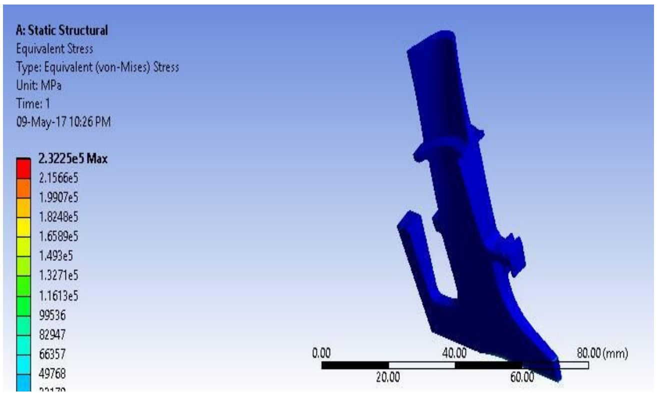

Figure 6: Equivalent stress (Von-Mises)

This output file have results as Von-mises (23225MPa), radial (1.5806 MPa), hoop stresses (44980MPa).

IV CONCLUSION

- From above results it can be observe that minor deviations in the curves used for sectorizing will not affect the solution significantly (solution= stresses at chosen locations of interest, likewise the bore, periphery of the disc)
- The solution (stresses) changes considerably at extremes of the disk (Bore and periphery), with the number of elements. But the stresses around the center (0.3-0.7R) will not vary.
- In both the studies (sector geometry dependence and grid dependence) though the stresses in bulk of the disc remain constant, the maximum stresses that are found in the blade root fillet region are varies only 5%.
- Structurally INCONEL718 has more capacity to resist the structural loads when compared with ceramics.
- Hence the it had been concluded that INCONEL is stronger than Ceramics
- Parametric study with different fillet radius can be carried out for different thermal loads.

REFERENCES

[1] Theju V,Uday P S,PLVGopinath Reddy,C.J. Manjunath, ―Design And Analysis Of Gas Turbine Blade,‖ International Journal ofInnovative Research in Science, Engineering and Technology, ISSN:2319-8753.

[2] V.NagaBushana Rao,N. NiranjanKumar,N. Madhulata,A.Abhijeet, ―Mechanical Analysis Of 1st Stage Marine GasTurbineBlade‖,International Journal Of Advanced ScienceAnd Technology vol.68(2014).pp.57-64.

[3] R D V Prasad,GNarasaRaju,M S SrinivasaRao,N Vasudeva Rao, ―Steady State Thermal And StructuralAnalysis Of Gas Turbine Blade CoolingSystem, International journal Of Engineering Research AndTechnology, ISSN:2278-0181.

[4] K HariBrahmaiah, M lava Kumar, ‖Heat Transfer Analysis of Gas Turbine Blade through Cooling holes, International Journal of Computational EngineeringResearch, ISSN: 2250-3005.

[5] AqeelJommaAthab,Dr, Naga Sarada,‖CFD Analysis Of A Gas Turbine Blade Cooling In The Presence OfHoles‖,International Journal And Magazine OfEngineering,Technology,Management And Research, ISSN:2348-4845.

[6] Amjed Ahmed Jassim,A L Luhaibi,MohammadTariq―Thermal Analysis Of Cooling Effect On Gas TurbineBlade, International Journal Of Research in EngineeringAnd Technology, ISSN:2319-1163.4.