ISSN XXXX XXXX © 2018 IJESC

Research Article Volume 8 Issue No.4

Review on Thermal and Structural Analysis of Gas Turbine Blade by Computational Method

Kirti A Netam
Research Associate
Department of Automobile
Rustomjee Academy for Global Careers, India

Abstract:
The model is done in Solid Works as per the standards. Solid model is then imported to ANSYS workbench environment so as to perform thermal and static structural analysis. In thermal analysis, the model is given heat flux, convective heat transfer and ambient gas temperature and then is solved for temperature distribution over the blade. The obtained temperature distribution is taken as the thermal load into the static structural analysis. In static structural analysis, the model is given BCs and structural loads viz; centrifugal force, tangential force and pressure. The model is then solved for stresses and deflections. The von-Misses stress and Total deformation plots are taken for various operating conditions i.e., temperatures and speeds. The results are then compared for variable gas temperatures and turbine speeds..

Key words: Thermal analysis, static structural, von- Misses stress, deformation, speeds.

I. INTRODUCTION

The turbine is a rotary mechanical device that extracts energy from a fluid flow and converts into useful work and purpose of turbine technology are to extract the maximum quantity of energy from the working fluid to convert it into useful work with maximum reliability, minimum cost, minimum supervision and minimum starting time. Gas turbine are used extensively for aircraft propulsion, land based power generation and industrial application. Thermal efficiency and power output of gas turbine increases with increasing turbine rotor inlet temperature. The urrent rotor inlet temperature level in advanced gas turbine is far above the melting point of the blade material. Therefore, along with high temperature development, sophisticated cooling scheme must be developed for continuous safe operation of gas turbine with high performance. Losses on the turbine consist of mechanical losses due to the friction of rotating parts or bearings, tip clearance losses due to the flow leakage through tip gap, secondary flow losses due to curved passages, and profile

II.LITERATURE SURVEY

Heat transfer analysis of gas turbine blade is carried out with different models consisting of blade with without holes and blade with varying number of cooling holes. It is found that total heat transfer rate is maximum and the temperature of the blade leading edge is minimum for the blade consisting of 13 holes. The thermal and structural analysis is studied for two different materials constructions that is Chromium steel and Inconel718. By observing the graphs the thermal flux is maximum of Inconel718 blade with consisting of 13 number of holes, and the induced von misses stress and strain are within allowable limits. It is found that inconel718 is better than Chromium steel.[1]

Gas turbine blade cooling is studied for two different materials of constructions that is N 155 & Inconnel 718. It is found that Inconnel 718 has better thermal properties as the blade temperatures and thermal stresses induced are lesser. The provision of cooling passages in the blades is found to alleviate the problem of high temperatures and thermal stresses. On analyzing 4 different models with varying number of holes, it is inferred that the blade model with 13 holes is best suited.[2]

It is observed that as the no. of holes increases the temperature distribution increase. The structural analysis is carried out after the thermal analysis in SOLID WORKS SIMULATION TOOL. It is observed that blade with 10 holes has showing more stresses than the remaining blades. Finally the blade with 9 holes has giving optimum performance for prescribed loading conditions with average temperature of 514.1K at the trailing edge and von misses stresses as 17.7 Mpa. [3]

The finite element analysis for structural and thermal analysis of gas turbine rotor blade is carried out using. Solid 95 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 It is seen from above results both the materials are giving the considerable results; finally the conclusion can be one 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 Inconel 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. It is also seen Inconel 718 have good material properties at higher temperature has compare to that of the titanium T6. [4] It is observed that the temperature variations from leading edge to the trailing edge on the blade profile is varying from 839.5310C to 735.1620C at the tip of the blade and the variation is linear along the path from both inside and outside of the blade. Considerable changes are not observed from the first 6 mm length from the leading edge and from there to next 36 mm length of blade the temperature is gradually decreasing and reaching to a temperature of 781.5480C and for another 4 mm length it is almost constant.., it is observed that the maximum thermal stress is 1217.and the minimum thermal stress is. the maximum thermal stress is less than the yield strength value i.e, 1450.so, based on these values[5]

The temperature has a significant effect on the von Mises stress in the turbine blade. Maximum elongation and temperatures are observed at the blade tip section and minimum elongation and temperature variations at the root of the blade. The thermal stresses are predominant in the analysis when compared to the Pressure and Centrifugal forces. Deformations gradually increase along the blade length from root to the tip portion of the blade.[6]

his project work deals with "stress analysis of gas turbine multi stage rotor assembly" for suggesting optimum material for the turbine rotor assembly. Initially literature survey and data collection was done to understand the methodology and also used for material selection. Three materials are selected, present material AISI-4130 super alloy steel, Hast alloy c-271(as per previous paper), and new material INCONEL alloy-718 for performing analysis. Parametric modelling was done in pro-engineer using parameters collected from the design department of BHEL. Using the above three materials static, thermal and couple field(combination of static and thermal) analysis was conducted on both turbine rotor assembly and single blade (for comparison with previous journal results). Results tables and graphs are prepared for the easy comparison and understanding. Couple field analysis provides fully developed analysis using thermal and structural loads as per the coupled field analysis Inconel alloy-718 is showing good characteristics Fatigue analysis was done to find life and damage percentage of turbine rotor assembly, each cycle refers to one year of running time, fatigue analysis is directly connected with S-N curve. As per results obtained from analysis 3rd material (INCONEL alloy-718) gives the maximum life to the turbine rotor assembly, due to its good structural properties, low deformation, stress, strain and thermal behaviours.[7] Maximum stresses and strains are observed near to the root of the turbine blade and upper surface along the blade roots. The maximum stress of 1.958 GPa occurs at the trailing edge nearer to the root of the blade exceeds the yield stress of the material and this might leads to the failure of the turbine blade. At all other parts of turbine blade, the stresses induced are within the same limits.[8]

Maximum temperatures are observed at the blade tip sections and minimu temperature at the root of the blade. Temperature distribution is linearly decreasing from the tip of the blade to the root of the blade section. The temperatures observed are below the melting temperature of blade material. The temperature has a significant effect on the overall turbine blade. This non uniform temperature at tip and root of the blade materal might induce the thermal stresses in the turbine blade. These thermal stresses along with the mechanical stresses set up in the turbine blade might reduce the life of blade material. The results obtained in the present work add the information for the design of high pressure and temperature (HPT) turbine blades of multistage gas turbine of higher outputs and efficiencies.[9]

The main objective of this work is to taken an account of previous work carried out on gas turbine blade. From the review it can be noted that there are various factors like blade angle, blade geometry, number of perforated holes and the material of the blade can affect structural as well as thermal stresses. The cast iron with partially stabilized zirconium coating is more beneficial due to low stress displacement, low cost and easy manufacture. The temperature has significant effect on the overall stresses induced in the turbine blades. The blade temperature attained and thermal stresses induced are lesser for Inconel 625 as it has better thermal properties. The blade with 8 holes has the best temperature distribution when compared other configurations of the blade when the coolant temperature was 300 ºC. The bending stresses are lower for the blade with 8 holes. Hence it can be conclude that gas turbine blade can be designed then performing FEM analysis by using ANSYS to check the failures and suggest the remedies for the same. [Four different materials such as ZiCr5, Titanium Alloy, Mullite, AlSi used for manufacture of turbine blades of a gas turbine. The turbine blade is analysed for its thermal as well as structural performance due to the loading condition and the temperature gradients for both type of geometries having 4 nos and 6 nos of perforated holes. Maximum temperatures are observed at the blade tip sections and minimum temperature at the root of the blade. Temperature distribution is almost uniform and is linearly decreasing from the tip of the blade to the root of the blade.[10]Using finite element analysis as a tool, the structural and thermal analyses were carried out sequentially. The blade with different no. of holes 7, 8, 9, 10, 11 and 12 were used for analysis. From the results obtained, it was found that the blade with 8 holes has the best temperature distribution when compared other configurations of the blade when the coolant temperature was 300ºC. The temperature distribution for the blade with eight holes, matches closely with prescribed temperature of 800°C for the better performance of the turbine. The bending stress, obtained from finite element analysis shows lower stress level for the blade with 8 holes. These results indicate that the blade with eight holes will have optimum performance for the prescribed loading conditions.[11]

The distribution of static stresses throughout the blade. The static stresses are mostly the result of centrifugal load on the blade. A neck stress of 25,000 psi (172 MPa) is calculated for the blade dovetail, which is quite acceptable for a typical blade material such as AISI 403 we have analyzed previous designs and generals of turbine blade to do further optimization, Finite element results for free standing blades give a complete picture of structural characteristics, which can utilized for the improvement in the design and optimization of the operating conditions. [15]

In the first step we have designed turbine blade using CMM data from existing model. In the second step we have done the study on different materials which are suitable for the improvement of turbine blade. In the third step we have validated our design using existing materials. In the next step we have applied different materials for turbine blade to suggest best material. From the above results we can conclude that using cast iron with partially stabilized zirconium coating is more beneficial than previous materials, due to low stress displacement, good thermal strength, low cost and easy to manufacture.[15] So from the total analysis results we can conclude that the modified rotor blade with titanium 6 alloy is the better product and has the better performance and better efficiency than the other materials and original rotor.[16]

The finite element analysis of turbine blade and rotor is carried out on brick and isoperimetric elements. The static, modal and thermal analysis is carried out. The temperature has a significant effect on the. Overall stresses in the turbine blade. Maximum elongation and temperatures are observed at the blade tip section and minimum elongations and temperature variations at the root of the blade. Temperature distribution is almost uniform at the maximum curvature region along the blade profile. Temperature is linearly decreasing from the tipof the root of the blade section. Maximum thermal stresses are stresses are setup when the temperature difference is maximum from outside to inside. The thermal stresses are predominant in the analysis. The order follows thermal, pressure and centrifugal forces. Maximum stresses and strain are observed only at blade region in the rotor along the blade length and elongations in Y-direction are gradually varying from the different sections along the rotor axis.[17]

Finite element analysis results for first stage HPT blade give a complete picture of structural and thermal characteristics, which can be utilized for the improvement in the design and optimization of the operating conditions. The turbine blade model data under examination has been obtained using Coordinate Measuring Machine (CMM) from existing Turbine blade. Comparative study has been carried out on turbine blade made of different materials which are preferable for marine gas turbine rotor blade. From the obtained results, it is clear that the HPT turbine blade with existing material (Super alloy grade X) was not failed because of tangential, axial and centrifugal forces. The equivalent stresses obtained at max rpm (9000) are well below the safe values. The von-mises stresses for the blade are maximum at the joint portion where profile is attached to root. From the structural contours of ANSYS it can be observed that total deformations are maximum at tip portion of the blade profile. It is observed that the temperature distribution is uniform and maximum temperature obtained is within the melting point of turbine blade made of Nickel based Super alloy X. Among the three materials the Super alloy X is the best material for marine HPT rotor blade due to its less equivalent stress values at three different speeds and safe temperature distributions.[18]

A steady state gas flow analysis was carried out by means of Advanced CFD, which is a section of Workbench ANSYS 11.0 software. Then, by mapping these results on the simulation section of this software, the stress analysis was carried out. Temperature and pressure contours and the magnitude and direction of flow velocity showed consistency withreal conditions. It is found that the blade failure was not directly related to centrifugal and gas loading. Finally, it is thought that the cause of the rotor blade failure may be increased in blade length and contact between blade tip and casing as a consequence of creep after an extended period in service.[19]

The material selection and modeling of gas turbine blade using Pro-E has been performed and the Steady state thermal & structural performance of the blade made up of N 155, Haste alloy x & Inconel 625 materials has to be analyzed using ANSYS software. By conducting the analysis on existing material and different composite materials, the results will be compared with each other. By the obtained results it can be concluded that the stresses induced in all the materials that are within the allowable limits and the material which develops less deformation than the other material can be determined.[20]

Analysis of gas turbine blade is carried out with different models consisting of staggered varying number of cooling holes. In the overall stresses the temperature show the significant effect in the turbine blade. The blade leading edge is minimum for the blade consisting of 14 staggered holes and the total heat transfer rate is maximum. In the maximum curvature of the blade profile the temperature distribution is almost uniform. In the blade section the temperature is linearly decreasing from the tip to the root

[21] From the above study it can be observed that the bottom trailing edge of the blade is prone to failure. The top trailing edge of the blade exhibits large deformation as compared to overall blade. For the temperature range for 7500C-12500C, Alloy 685 is best suited and from temperature range of 12500C-22000C, Ti6242S is suited and can be used. It is also found that with the use of thermal barrier coatings the above materials will exhibit greater stability and longer life.

[22]Gas pressure on the blades, and stresses resulting from thermal gradients. Linear static analysis, as well as transient thermal analysis, were conducted, taking into consideration the material behavior at elevated temperatures. The results were compared with a simplified analytical solution that gives approximate values of the stresses at the blades[23]

Gas turbine blade assembly is analysed for various load cases to find the structural stability. The overall summary is as follows. Initially the loads and Convection heat transfer coefficients are calculated from the given input data by using velocity triangles and as per the standard thermal formulations. The theoretical estimates for centrifugal force, tangential and axial loads are calculated for the given load data by specifying heat flux and convection on the faces of the turbine rotor and the disc the analysis the thermal analysis is carried out carried out for rotational load alone. Later the analysis is carried out for rotation along with the gas forces.[24]

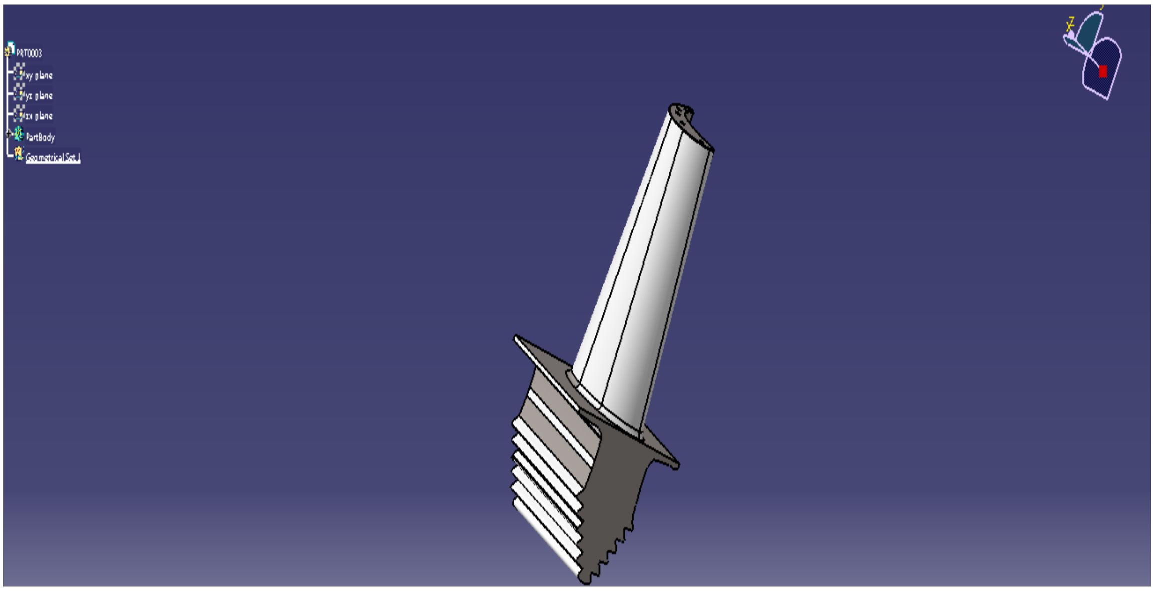
A three-dimensional finite element model of a gas turbine blade has been established by ANSYS software, and then its thermal fatigue behavior has been investigated. The following important conclusions have been obtained: Due to the non-uniform distribution of displacement, strain and stress in gas turbine blade, the regions located at the top, bottom of suction or pressure sides tend to produce a maximum of displacement, with the occurrence of a bigger strain or stress, where sub-critical cracks preferentially form. According to the maximum tensile stress criterion, dangerous regions of a turbine blade with Disc can be predicted. These dangerous regions mainly locate at of the lower fir-tree slot[25]

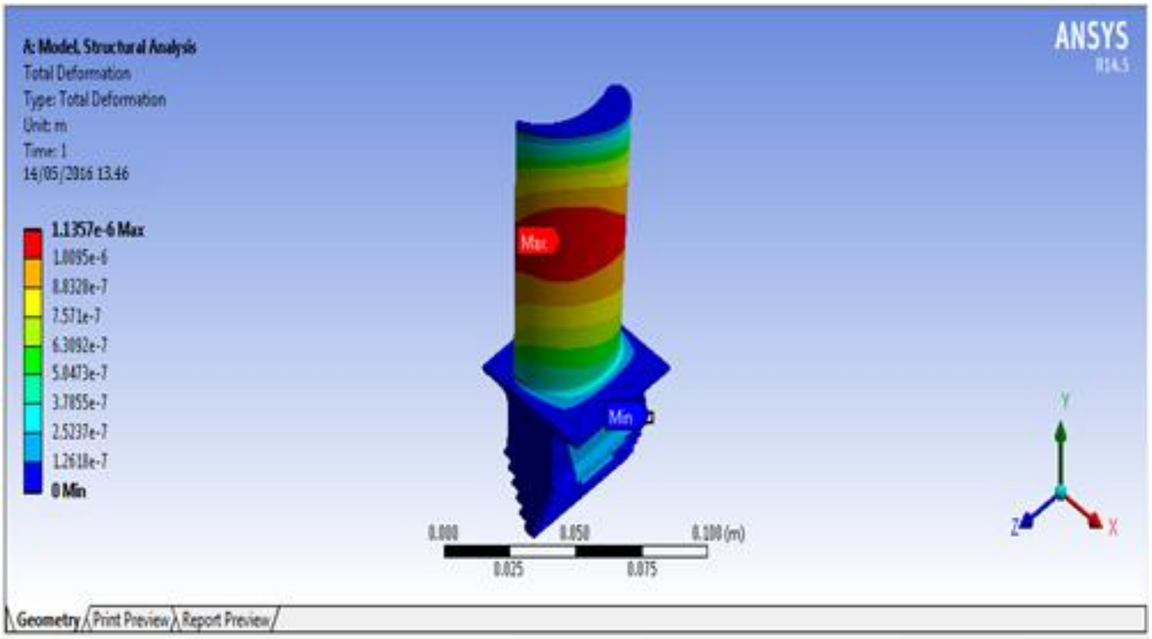
III. UNITS

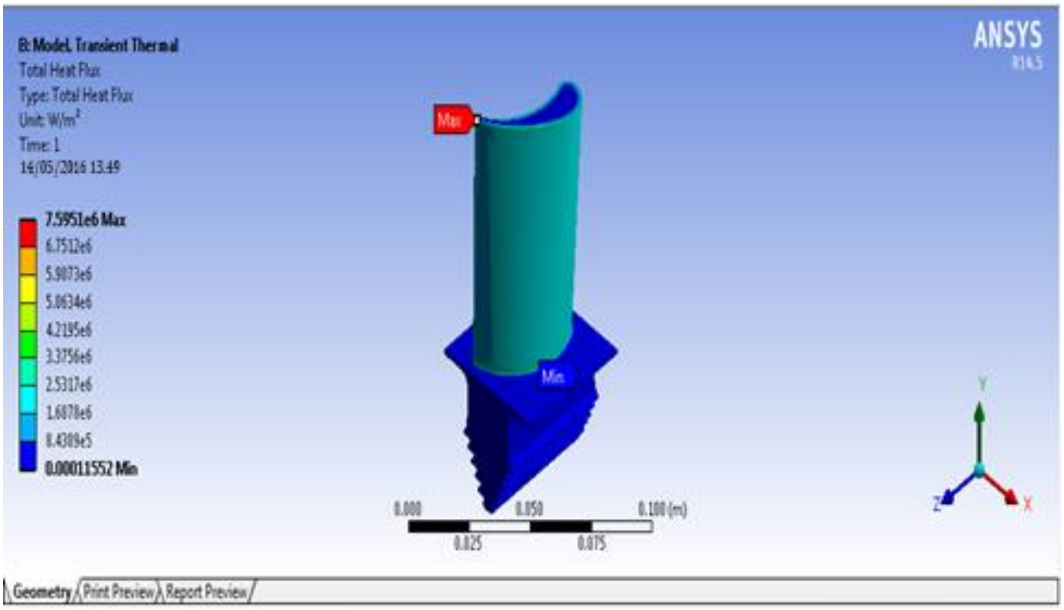
SI (MKS)

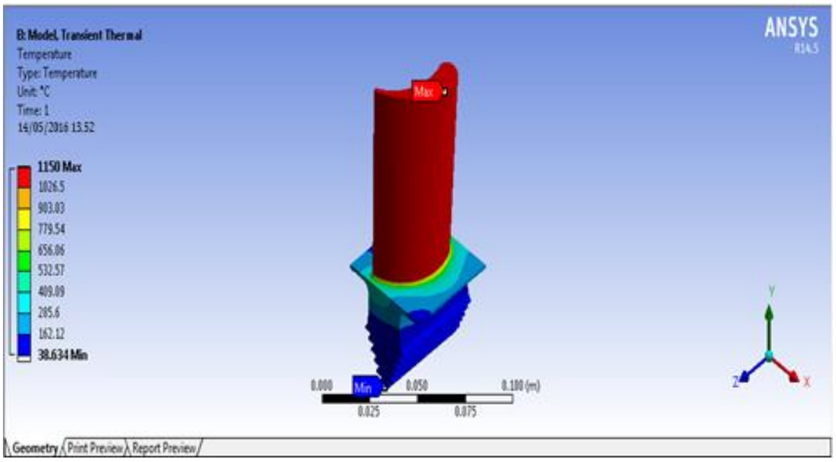
DESIGN AND ANALYSIS

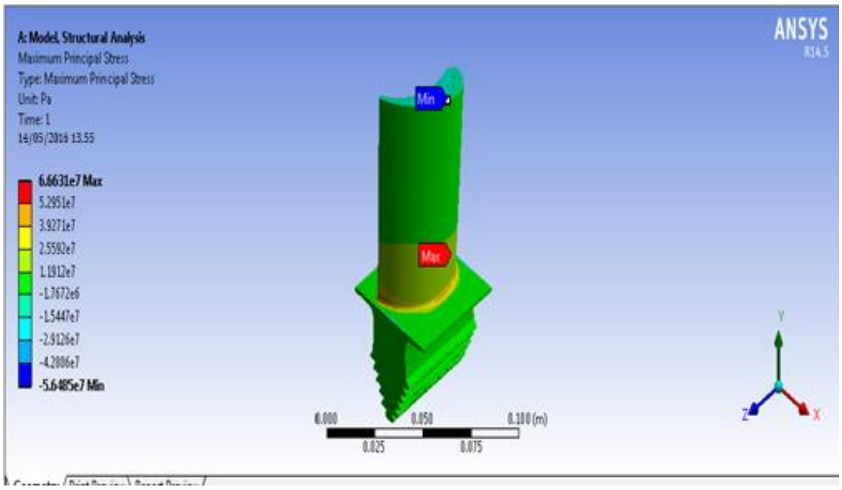
The gas turbine blade model profile is generated by using SOLIIDWORK software. 3D model of a gas turbine blade with root was done in two stages. First for creating the 3D model of the turbine blade, key points were created along the profile in the working plane. The points were joined by drawing B Spline curves to obtain a smooth contour. This contour was then converted into area and then into volume. Then working plane was rotated by 90º to generate the root part in the same way as the blade. These two volumes were then combined to make a single volume using union Boolean operation.











IV. METHODOLOGY

Methodology is the process used to collect information and data for the purpose of making business decisions. The methodology may include publication research, interviews, surveys and other research techniques and could include both present and historical information. Methodology is the systematic, theoretical analysis of the body of methods and principals associated with a branch of knowledge. It, typically, encompasses concepts such as paradigm, theoretical model, phases and quantitative or qualitative techniques. A methodology does not set out to provide solutions but offers the theoretical underpinning for understanding which method. It has been defined also as follows.

i) The analysis of the principles of methods, rules, and postulates employed by a discipline.

ii) The systematic study of methods that are, can be, or have been applied within a discipline

iii) The study or description of methods

The mechanical properties of the metals are those which are associated with the ability of the material to resist mechanical forces and load. These mechanical properties of the metal include strength, stiffness, elasticity, plasticity, ductility, brittleness, malleability, toughness, resilience, creep and hardness. The physical properties of the metals include luster, colour, size and shape, density, electric and thermal conductivity, and melting point. The following table shows the important physical and mechanical properties of metals.

Table.1.Mechanical Material Properties

Specification	MATERIAL			
	ZiCr5	**Mullite**	**Al-Si**	**Titanium Alloy**
Youngs Modulus (Pa)	2.70×10^{10}	3.00×10^{11}	9.00×10^{10}	9.61×10^{10}
Poissons Ratio	0.289	0.25	0.34	0.48
Density (Kg/m^3)	3787	2800	6870	4620
Ultimate Tensile strength (Pa)	1.80×10^{10}	2.4×10^{8}	1.31×10^{9}	1.07×10^{9}
Mass of single blade (Kg)	0.28336	0.20951	0.51405	0.34569
Thermal Conductivity (W/m°C)	301	3.3	165	21.9
Specific Heat (J/Kg°C)	764	950	960	522
Thermal Expansion (1/°C)	1.60×10^{-5}	5.30×10^{-6}	2.10×10^{-5}	9.40×10^{-6}

Analytical Calculations

For material of the blade Titanium Alloy

Blade Mass (m_b) : 0.34569 Kg

Power Turbine : 14298 rpm

Angular velocity of rotar (w) : $2\pi nT/60$

$= 2\pi \times 14298/6$

$= 1496.52$ rad / sec

Tip Radius (R_{tip}) : 0.09778 m

Hub Radius (R_{hub}) : 0.020 m

Bending Thickness (δ) : 42.66mm

Mass Density (ρ) : 4620 Kg/ m^3

Utilizing fourth exponential equation, the function of airfoil cross section area is

$S_{(\zeta)} = -459.7 X^3 + 941 X^2 - 643.3 X + 146.12$

Analytical calculation for centrifugal forces

Basic Equation

$\sigma_{(r)} = F_{(r)} / S_{(r)}$ ………….... equation I

Where,

$\sigma_{(r)}$: Tensile Stress (N/m^2)

$F_{(r)}$: Centrifugal Force (N)

$S_{(r)}$: Airfoil Cross Section Area (m^2)

Determine the centrifugal force

$(F_r) = F_b + F_{bl}(r)$ ……………. equation II

Centrifugal force due to bending :

$F_b = m_b \omega^2 (R_{tip} + \delta/2)$

$= 0.34569 \times (1496.52)^2 \times (0.09778 + 0.04266/2)$

$= 774197.68 \times 0.11911$

$= 92214.68$ N

Centrifugal Force due to portion of the blade confined between *r-Rh* and *Rt* :

$F_{bl(r)} = \int_{r-Rhub}^{l} \rho\omega^2 S_{(\zeta)}(R_{hub+}\zeta)d\zeta$ …………….equation III

Where,

l = Rtip - Rhub = (0.09778-0.020) m = 0.07778 m

S(ξ) : Function of airfoil cross-section area

$\mathbf{S(\xi) = (-459.7\,\zeta^3 + 941\,\zeta^2 - 643.3\,\zeta + 146.12)}$

$F_{bl(r)} = 4620 \times (1496.52)^2 \int_{r-0.020}^{0.07778}(-459.7\,\zeta^3 + 941\,\zeta^2 - 643.3\,\zeta + 146.12)\ (0.020 + \zeta)\, d\zeta$

$= 1.04 \times 10^{10} \int_{r-0.020}^{0.07778}(-459.7\,\zeta^4 + 931.81\,\zeta^3 - 624.48\,\zeta^2 + 158.99\,\zeta + 2.92)\, d\zeta$

$= 1.04 \times 10^{10}\{-459.7 \int_{r-0.020}^{0.07778} \zeta^4 d\zeta + 931.817 \int_{r-0.020}^{0.07778} \zeta^3 d\zeta - 624.48\ 7 \int_{r-0.020}^{0.07778} \zeta^2 d\zeta + 158.997 \int_{r-0.020}^{0.07778} \zeta\, d\zeta + 2.927 \int_{r-0.020}^{0.07778} d\zeta\}$

$\mathbf{(F_r)} = 92214.68 + \{(9.56 \times 10^{11})\, r^5 - (1.98 \times 10^{11})\, r^4 + (2.36 \times 10^{12})\, r^3 - (9.60 \times 10^{11})\, r^2 + (5.36 \times 10^9)\, r + (7.35 \times 10^9)\}$

$S_{(r)} = -459.7\ (r-0.020)^3 + 941\ (r-0.020)^2 - 643.3\ (r-0.020) + 146.12$

Finally by substituting the calculated function in equation I the function of tensile stress will be result as follows :

$$\boldsymbol{\sigma_r} = \frac{92214.68+\{(9.56\times10^{11})r^5-(1.98\times10^{11})r^4+(2.36\times10^{12})r^3-(9.60\times10^{11})r^2+(5.36\times10^9)r+(7.35\times10^9)\}}{-459.7 + (r-0.020)^3 + 941\ (r-0.020)^2 - 643.3\ (r-0.020) + 146.12}$$

Hence,

by considering the different value of rotating radius (m) along the blade the tensile stresses for titanium alloy and other material like AlSi, Mullite, ZiCr5 by using the same functions.

Table.2. Different value of rotating radius (m) along the blade the tensile stress for Titanium Alloy.

r (m)	$\mathbf{F_{(r)}=f_{(b)}+f_{bl(r)}}$ **(N)**	$\boldsymbol{\sigma_{(r)}}$ **(MPa)**
0.034	6.52×10^9	47.49
0.044	5.92×10^9	45.16
0.054	5.21×10^9	41.58
0.064	4.37×10^9	36.60
0.074	3.44×10^9	30.18
0.084	2.41×10^9	22.17
0.094	1.32×10^9	12.76
0.096	1.09×10^9	8.14

Table.3. Different value of rotating radius (m) along the blade the tensile stress for AlSi

r (m)	$\mathbf{F_{(r)}=f_{(b)}+f_{bl(r)}}$ **(N)**	$\boldsymbol{\sigma_{(r)}}$ **(MPa)**
0.034	9×10^9	63.13
0.044	8×10^9	59.35
0.054	7×10^9	53.52
0.064	5×10^9	45.50
0.074	4×10^9	35.14
0.084	2×10^9	22.27
0.094	7×10^8	6.71
0.096	3×10^8	3.26

Table.4. Different value of rotating radius (m) along the blade the tensile stress for Mullite.

r (m)	$F_{(r)}=f_{(b)}+f_{bl(r)}$ (N)	$\sigma_{(r)}$ (MPa)
0.034	4×10^9	25.67
0.044	3×10^9	24.13
0.054	3×10^9	21.75
0.064	2×10^9	18.49
0.074	2×10^9	14.27
0.084	1×10^9	9.03
0.094	3×10^8	2.68
0.096	1×10^8	1.28

Table.5. Different value of rotating radius (m) along the blade the tensile stress for ZiCr5.

r (m)	$F_{(r)}=f_{(b)}+f_{bl(r)}$ (N)	$\sigma_{(r)}$ (MPa)
0.034	4.78×10^9	34.79
0.044	4.29×10^9	32.71
0.054	3.7×10^9	29.50
0.064	3×10^9	25.08
0.074	2.21×10^9	19.37
0.084	1.34×10^9	12.29
0.094	3.85×10^8	3.73
0.096	1.87×10^8	1.83

V. RESULT

The research work deals with the modeling and analysis of gas turbine blade. The thermal-structural finite element analysis was performed for the turbine blade using ANSYS 14.5 software. Four materials such as Titanium alloy, ZiCr5, mullite and AlSi the material which is used in the manufacturing of gas turbine blade have been considered for the analysis under the operating conditions from gas turbine handbook and previous research. Analytically the centrifugal forces and stresses are calculated and validate with ANSYS result. The results are tabulated as

Table.6. Comparative values of stresses, deformation of both blade geometries for 4 materials.

Specifications	Materials							
	Titanium Alloy		Mullet		ZiCr5		AlSi	
	4 Holes	6 Holes	4 Holes	6 Holes	4 Holes	6 Holes	4 Holes	6 Holes
Total deformation (m)	5.51×10^{-6}	6.25×10^{-6}	1.14×10^{-6}	3.79×10^{-6}	1.70×10^{-6}	5.12×10^{-6}	3.08×10^{-5}	9.30×10^{-6}
Equivalent Stress (N/m^2)	1.57×10^{8}	9.60×10^{7}	5.98×10^{7}	5.81×10^{7}	8.31×10^{7}	7.87×10^{7}	1.52×10^{8}	1.42×10^{8}
Shear Stress(Nm^2)	3.70×10^{7}	1.93×10^{7}	1.02×10^{7}	1.17×10^{7}	1.37×10^{7}	1.59×10^{7}	2.48×10^{7}	2.88×10^{7}
Maximum Principal Stress (N/mm^2)	5.81×10^{7}	5.25×10^{7}	2.69×10^{7}	3.18×10^{7}	3.67×10^{7}	4.30×10^{7}	6.67×10^{7}	7.81×10^{7}

Table.7. Comparative values of temperature distribution, total heat flux, thermal error of both blade geometries for 4 materials.

Ambient Temperature (°C)	35							
Applied Temperature (°C)	1150							
Specifications	Materials							
	Titanium Alloy		Mullite		ZiCr5		AlSi	
	4 Holes	6 Holes	4 Holes	6 Holes	4 Holes	6 Holes	4 Holes	6 Holes
Temperature Distribution Min. (°C)	33.133	34.99	31.209	17.87	38.634	13.19	35.01	34.99
Total Heat Flux (W/m^2)	1.95×10^{7}	1.8×10^{7}	7.59×10^{6}	5.55×10^{6}	1.39×10^{8}	5.53×10^{6}	1.57×10^{8}	1.12×10^{8}
Thermal Error (J)	4745.1	1031.7	1795.2	1031.7	14962	1021.8	23800	16007

VI. CONCLUSION

It is observed that the stress distribution, deformation and temperature distribution patterns are same for all four materials. Maximum deformation is and temperatures are observed at the blade tip section and minimum elongation and temperature s at the root of the blade. Maximum stresses are observed at the root of the turbine blade and upper surface along the blade roots four different materials of construction.

VII. REFERANCE

[1]. Soo-Yong Cho "A Study on an Axial-Type 2-D Turbine Blade Shape for Reducing the Blade Profile Loss" KSME International Journal, Vol. 16, No. 8, pp 1154-1164, 2002.

[2]. John.V, T.Ramakrishna. "THE DESIGN AND ANALYSIS OF GAS TURBINE BLADE", International Journal of Advanced Research and Studies, Vol 2, No.1, pp 53-55, Dec 2012

[3]. B. Deepanraj "THEORETICAL ANALYSIS OF GAS TURBINE BLADE BY FINITE ELEMENT METHOD" Scientific World, Vol. 9, No. 9, pp 29-33, July 2011.

[4]. P.V.Krishnakanth Structural & Thermal Analysis of Gas Turbine Blade by Using F.E.M International Journal of Scientific Research Engineering & Technology (IJSRET) Volume 2, Issue2, pp 060-065, May 2013.

[5]. Michel Arnal "Fluid Structure Interaction Makesfor Cool Gas Turbine Blades" ANSYS Advantage • Volume I, Issue 1, Pp 6-8, 2007.

[6]. Sagar P.Kauthalkar "Analysis of Thermal Stresses Distribution Pattern on Gas Turbine" International Journal Of Engineering, Education And Technology (ARDIJEET) ISSN 2320-8.

[7]. Avinash V. Sarlashkar "BladeProTM: An ANSYS-Based Turbine Blade Analysis System"Impact Technologies, LLC, Rochester, NY 14623, U.S.A.

[8]. Jorgen M. Anders "A Parametric Blade Design System (Part I + II)" Hans Heukenkamp atech GmbH engineering software technology, Germany.

[9]. Patil A.A "Study of Failure Analysis of Gas Turbine Blade" IOSR Journal of Engineering (IOSRJEN) ISSN: 2250-3021 ISBN: 2878-8719 PP 37-43.

[10]. Ganta Nagaraju "DESIGN OPTIMIZATION AND STATIC & THERMAL ANALYSIS OF GAS TURBINE BLADE" International Journal of Engineering, Business and Enterprise Applications (IJEBEA) Volume I, Issue 2, pp 65-68.

[11]. Daniel K. Van Ness II "Turbine Tip Clearance Flow Control using Plasma Actuators" Center for Flow Physics and Control (FlowPAC), University of Notre Dame, Notre Dame, IN, 46556.

[12]. V.NagaBhushana Rao "ANALYTICAL COMPARATIVE STUDY OF GAS TURBINE BLADE MATERIALS USED IN MARINE APPLICATIONS USING FEA TECHNIQUES" International Journal of Engineering Sciences & Management Research, ISSN: 2349-6193.

[13]. Arif Sugianto "Failure Analysis of a First Stage High Pressure Turbine Blade in an Aero Engine Turbine" on PK-GSG Boeing B747-400.

[14]. V. NagaBhushana Rao "Mechanical Analysis of 1st Stage Marine Gas Turbine Blade" International Journal of Advanced Science and Technology Vol.68, pp.57-64, 2014.

[15]. Naresh Gurajarapu " Selection of a Suitable Material and Failure Investigation on a Turbine Blade of Marine Gas Turbine Engine using Reverse Engineering and FEA Techniques" International Journal of u- and e- Service, Science and Technology Vol. 7, No. 6, pp. 297-308, 2014.

[16]. Mehdi Tofighi Naeem "Failure Analysis of Gas Turbine Blades" Paper 120, ENG 108Proceedings of The 2008 IAJC-IJME International Conference ISBN 978-1-606 43-379-9.

[17]. Handbook of "SIEMENS Industrial Power Industrial Gas Turbines The compressive range from 5 to 50 MW".

[18]. Józef Błachnio and Wojciech Izydor Pawlak (2011). Damageability of Gas Turbine Blades – Evaluation of Exhaust Gas Temperature in Front of the Turbine Using a Non-Linear Observer, Advances in Gas Turbine Technology, Dr. Ernesto Benini (Ed.), ISBN: 978-953-307-611-9.

[19]. Xijia Wu (2010). Life Prediction of Gas Turbine Materials, Gas Turbines, Gurrappa Injeti (Ed.), ISBN: 978-953-307-146-6.

[20]. P.Satyanarayana "PARAMETRIC MODELING AND DYNAMIC CHARACTERIZATION FOR STATIC STRENGTH OF STEAM TURBINE MOVING BLADES" International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 7, July 2013.

[21]. A textbook on "Gas Turbine second edition by V Ganesan"published by TataMcGraw-Hill publishing company limited. ISBN 0-07-053-466-7.