International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 1 Issue 10, December- 2012

Effect Of Temperature Distribution In 10c4/60c50 Gas Turbine Blade Model Using Finite Element Analysis

V.Veeraragavan
Lecturer in Mechanical Engineering
Eritrea Institute of Technology, Asmara, Eritrea, N.E.Africa

Abstract

In this research paper is mainly apprehensive with aircraft gas turbine engine. Turbine blade is an important part of aircraft gas turbine engine. The research focus of 10 C4 / 60 C 50 turbine blade model, because of its common use in all types of aircraft engines. Investigate used, Pro-e model and ANSYS tools. Present research was focused on using Finite element methods (FEM) to predict the location of possible temperature areas on turbine blades. The conventional alloys such as titanium, zirconium, molybdenum, super alloys are chosen for analysis. Initially the model is created with the help of Pro-e and then it is imported to Ansys.The static analysis of solid model is carried out by applying temperature from external circumference tip of turbine blade to root of the blade and the temperature distribution is plotted. At that time measured the maximum temperature withstood capacity in gas turbine blade. Finally the entire four alloy materials are compared with respect to temperature distribution to found out of the best one. Then suggested to which material is better performing in gas turbine engine applications.

Keywords: Gas turbine**,** Titanium, Temperature Distribution, Turbine blade, Rotor.

1. Introduction

Gas turbines play an important role in aviation and industrial applications. There is a growing tendency to use higher temperatures at the inlet of the turbine to improve the efficiency of the gas turbine engine. Consequently the heat load on the turbine components increases, especially in the high pressure turbine section. This heat load is caused by the exposure of an enormous heat flux of the burnt gas from the combustion chamber. Turbine blades are one of the most important components in a gas turbine application. There are components across which flow of high pressure gases takes place to produce work. A blade can be defined as the medium of transfer of energy from the gases to the turbine rotor. For turbine blades, however, stresses due to aerodynamic forces are typically much less important than stresses due to centrifugal loads. The same is not necessarily true to thermal stresses. If blade temperature is non- uniform (as it may well be, if exposed to a gas 400°C to 500°C better than the blade and subject to intense inner cooling through a distribution of air passages), it can suffer fairly large thermal stresses. A gas turbine is similar to the steam turbine but gas is used to run the turbine. It is mainly used in the aircraft engines, electric power generation, marine propulsion etc. Damage to turbine blades is of critical importance in aircraft engines. The irregular movements of throttle settings are a mandatory requirement for the pilots to perform various air combat maneuvers. This leads to excessive stresses on engine compressor and turbine blades in various flight regimes. The aircraft are also required to fly in varying atmospheric conditions ranging from negative temperature in icing conditions to over 50 degree Celsius in summers. These factors in addition to operations from deserts and tropical weathers also add to the variety of conditions that an aircraft engine is exposed.

ISSN: 2278-0181
Vol. 1 Issue 10, December- 2012

2. Materials

2.1 Titanium Alloys

Table-1: Composition

Composition	Weight Percentage
Aluminum (A1)	8
Molybdenum (M0)	1
Titanium (Ti)	90
Vanadium (VD)	1

Table-2: Properties

Density	4370 kg/m^3
Yield Strength	1070 Mpa
Ultimate Strength	1180 Mpa
Poisson Ratio	0.32
Young's Modules	120 Gpa
Melting Pont	1540^0 C
Thermal Expansion	0.000010/m^0 C
Thermal Conductivity	600 W/mk
Specific Heat	502 J/Kg k

2.2 Zirconium Alloys

Table-3: Composition

Composition	Weight Percentage
Iron + Chromium (F_e + C_r)	0.2
Hafinium (H_f)	Max 4.5
Niobium (N_b)	2.5
Oxygen (O)	0.18
Zirconium (Z_r)	Min 95.5

Table-4: Properties

Density	6640 Kg/m^3
Yield Strength	582 Mpa
Ultimate Strength	750 MPa
Poisson Ratio	0.33
Young's Modules	97.9 Gpa
Melting Pont	1740^0 C
Thermal Expansion	0.0000063 /m^0 C
Thermal Conductivity	17 W/ m –k
Specific Heat	285 J/Kg^0 C

2.3 Molybdenum Alloys

Table-5: Composition

Composition	Weight Percentage
Molybdenum (M_o)	52.5%
Rhenium (R_h)	47.5%

Table-6: Properties

Density	9320 Kg/m^3
Yield Strength	845 Mpa
Ultimate Strength	1180 Mpa
Young's Modules	365 Gpa
Poisson Ratio	0.285
Thermal Expansion (at 1000^{0}C)	6.45 m/m^{0}C
Thermal Conductivity	36.8 W/ m –k
Specific Heat	255 J/Kg^0 C
Melting Point	2450^{0}C

2.4 Super Alloys

Table-7: Composition

Composition	Weight Percentage
Nickel Base (Ni)	78%
Chromium (Cr)	20%
Titanium (Ti)	0.4%
Carbon (c)	0.12%

Table-8: Properties

Density	8526 Kg/m^3
Yield Strength	855 Mpa
Young's Modules	220 Gpa
Poisson Ratio	0.33
Melting Pont	870^0 C
Thermal Expansion	15.8 micron/m.k
Thermal Conductivity	24.9 W/ m –k
Specific Heat	525 J/Kg^0 k

3. Modeling and Analysis

Pro/Engineer is a solid modeling software and it develops models as solid, allowing to work in a three dimensional environment. These models have volume and surface area, so you can calculate the mass properties directly from the geometry that you can create and manipulate their display on the screen, the models remain as solids. To truly appreciate the power of Pro/ Engineer as a solid modeling tool, you must a quire an understanding of the following concepts: feature based, associative and parametric modeling. Then after creating a model, imported to ansys and mesh the model. After that applying all properties of materials in ansys and temperature graph plotted.

4. Results and Discussion

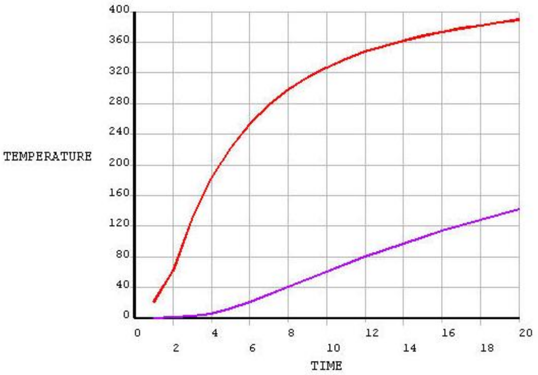

Fig-1. Temperature Propagation for Titanium Alloy.

Fig-1 shows show that, blue color curve to represent the temperature from root of the blade. The red color curve to represent the external circumference tip of turbine blade.Hence,during that time of 20 seconds corresponding to the temperature will reaches 140° C in root of the blade and 390 ° C in external circumference tip of turbine blade respectively.

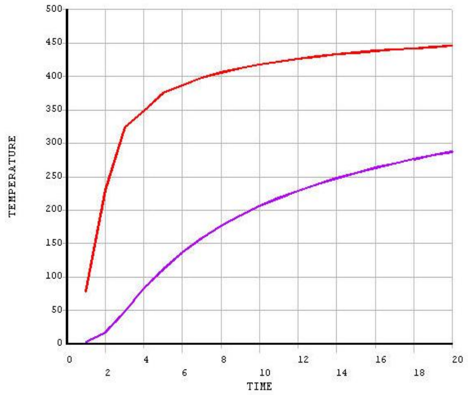

Fig-2. Temperature Propagation for Zirconium Alloy.

Fig-2 shows show that, blue color curve to represent the temperature from root of the blade. The red color curve to represent the external circumference tip of turbine blade.Hence,during that time of 20 seconds corresponding to the temperature will reaches 290° C in root of the blade and 450 ° C in external circumference tip of turbine blade respectively.

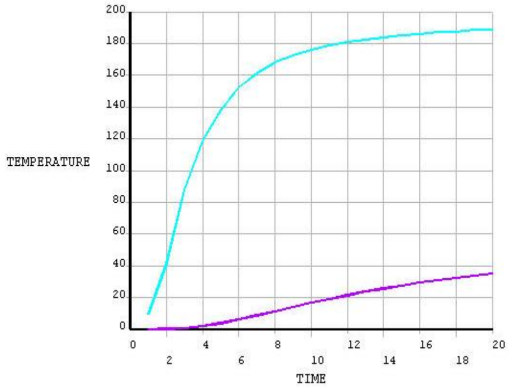

Fig-3. Temperature Propagation for Molybdenum Alloy

Fig-3 shows show that, blue color curve to represent the temperature from root of the blade. The red color curve to represent the external circumference tip of turbine blade.Hence,during that time of 20 seconds corresponding to the temperature will reaches 35° C in root of the blade and 190 ° C in external circumference tip of turbine blade respectively.

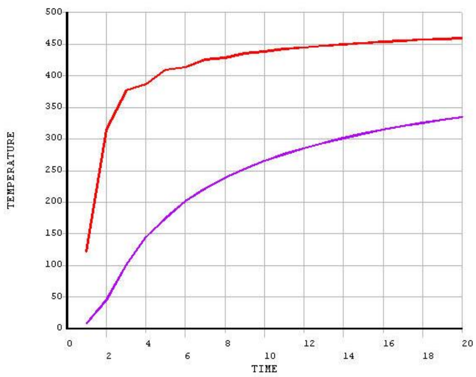

Fig-4.Temperature Propagation for Super Alloy.

Fig-4 shows show that, blue color curve to represent the temperature from root of the blade. The red color curve to represent the external circumference tip of turbine blade.Hence,during that time of 20 seconds corresponding to the temperature will reaches 345° C in root of the blade and 460 ° C in external circumference tip of turbine blade respectively.

5. Conclusion

The comparisons of temperature distribution of four alloys graphs are shows that, a first one titanium alloy temperature at 20 sec to reached temperature at 390°C.Second one zirconium alloy temperature at 20 sec to reached temperature at 450°C.Third one molybdenum alloy temperature at 20 sec to reached temperature at 190°C.Fourth one super alloys temperature at 20 sec to reached temperature reached at 460°C. Hence, these four alloys temperature comparatives are state that molybdenum alloys are a good temperature withstand. A second one-titanium alloy is a best one. Finally concluded by molybdenum alloy is a best suited for design and manufacture in aircraft engines.

References:

[1]. Mohanty A.K, Raghavachar T.S and NandaR.S (1977),*'Heat Transfer from Rotating Short Radial Blades'*, International Journal of Heat and Mass Transfer, Volume.20, 1977, P.1417.

[2]. Allen J.M (1982), *'Effect of Temperature Dependent Mechanical Properties on Thermal Stress in cooled Turbine Blades'*, Journal of Engineering Power, ASME Volume.104, P.349.

[3]. Bahree R. Sharan A.M. and Rao J.S. (1989),*'The Design of Rotor Blades due to the Combined Effects of Vibratory and Thermal Loads'*, Journal of Engineering Power and Gas Turbines, ASME Volume.111,P.610.

[4]. V.J.Parks, R.J Sanford and J.Cernosek, "*Analyis of Blades using a rapid three dimensional photo elastic method,*" Journal of Aircraft, AIAA 81-4078, Vol 10, No.3, pp 213 -219, March 1981.

[5]. L. He, V. Menshikova and B.R. Haller, "*Effect of hot streak counts on turbine blade heat load and forcing*" Journal of propulsion and power, Vol. 23, No.6, pp 1235 -1241, November-December 2007.

[6]. E. Couch, J. Christophel, E. Holfeld, K. A. Thole and F. J. Cunha, "*Comparison of measurements and predictions for blowing from a turbine blade tip*" Journal of propulsion and power, Vol. 21, No. 2,. pp 335- 343, March- April 2005.

[7]. Ronald S. Bunker, "*Axial turbine blade tips: Funtion, Design and Durability" Journal of propulsion and power*, Vol. 22, No. 2, pp 271- 285, March-April 2006.

[8]. R. G Alderson, M.A. Tani, D.J. Tree and R.J. Hill "*Three dimensional optimization of a gas turbine disk and blade attachment*" Journal of Aircraft, Vol. 13, No. 12, pp 994- 999, December 1976.

[9]. M. J. Holland and T. F. Thake, "*Rotor blade cooling in high pressure turbines"* Journal of Aircraft, Vol. 17, No. 6, pp 412 – 561, June 1980

[10]. Philip H. Snyder and Richard J. Roelke, "*Design of an air cooled matellic high temperature radial turbine"* Journal of propulsion and power,, Vol. 6, No. 3. pp 283- 288, May- June 1990.

[11]. R. H. Mao, S.A. Meguid and T. Y. Ng, "*Finite element modeling of a bird striking an engine fan blade*" Journal of Aircraft, Vol. 44, No. 2, pp 583- 596, March- April 2007.

[12]. A. Hamed, Y. Sheoran and W. Tabakoff, "*Stress analysis study in cooled radial inflow turbine"* Journal of Aircraft, Vol. 15, No. 12,. pp 803- 804, December 1978.

[13]. D. N. Duhl and E. R. Thompson,"*Directional structures for advanced aircraft turbine blades"*, Journal of Aircraft, Vol. 14, No. 6, pp 521- 526, June 1977.

[14]. Kasra Daneshkah and Wahid Ghaly, "*Aerodynamic inverse design for viscous flow in turbo machinery blading*" Journal of propulsion and power, Vol. 23, No. 4, pp 814 – 820, July- August 2007.

[15]. M. L. Roberts "*Engine life, usage, and cycle selection"* Journal of Aircraft, Vol. 15, No. 4, pp 240 – 245, April 1978.

[16]. Zhijiang He, Bogdan I. Epueanu and Christophe Pierre, "*Fluid structural coupling effects on the dynamics of mistuned bladed disks*", AIAA Journal, Vol. 45, No. 3, pp 552 – 418, March 2007

[17]. Goldstein R.J,Eckert E.R.G, Wang H.P and Olson S.J (1996), '*Effects of Blade profile on Turbine Blade Heat (Mass) Transfer,* A symposium Paper in November 16.

[18]. Yahya S.M (1996),' Turbines, Compressors and Fans',Tata McGraw-Hill Publishing Company Limited.

[19]. Ganesan.V (1999),' *Gas Turbines'*,Tata McGraw-Hill Publishing Company Limited.

[20]. Sarvanamuttoo HIH, Rogers GFC and Cohen H,(2001),' *Gas Turbine Theory', Low Price Edition*.

[21]. BATHIE W.William, (1995),' *Fundamentals of Gasturbines*', John Wiley & Sons, Inc.

[22]. Jack D. Mattingly, (1996),' *Elements of Gas Turbine Propulsion'*, McGraw-Hill International Editions.

[23]. George F. Titterton,(1941),' *Aircraft Materials and Process'*, Pitman
.

[24]. Kenneth G. Budinski, (1992),' *Engineering Materials,Properties and Selection'*,Prrentice Hall.

[25]. Singiresu S.Rao, (2001), '*The Finite Element Method in Engineering'*, Butterworth Heinemann.

[26]. Segerlind L.J (1976),*'Applied Finite Element Analysis*', John Wiley and Sons.

[27]. ANSYS *Verification Manual*, Version 6.0.

[28]. ANSYS *Command and Theory Manual*, Version 6.0.

AUTHOR PROFILE

Mr.V.Veeraragavan has received the Master of Engineering from Anna University in 2004. Currently he is working as a Lecturer in Mechanical Engineering, Eritrea Institute of Technology, Ministry of Education, Eritrea. He has blended his wide experience of 12 years in teaching and research in the field of Mechanical Engineering. He has published a number of international journal papers. His areas of research interest include Heat and Mass Transfer, I.C.Engines and Power Plant Engineering.