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Analysis of Creep Life of Steam Turbine Blade by Using Different Material

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Abstract

Turbine Blades are the main component of any steam power plant and have to withstand in very high temperature. The main aim of this paper is to calculate the creep life of 210MW Reheat Reaction Turbine Blade by changing the different material and suggested the best material for the turbine blade, so the life of the turbine blade is increased to some extent. In this paper the modeling of blade is done in PRO-E and analysis of stress is done in ANSYS 14.5 FEA tool. After structural analysis of the turbine blade Modified Larson Miller Parameter is used to calculate the creep life of the turbine blade then the results are compared and finally some of the results are presented.

Keywords: Turbine Blade, Stress Analysis, Creep Life, ANSYS 14.5

Introduction

A turbine blade is the individual component which makes up the turbine section of a steam turbine. The blades are responsible for extracting energy from the high temperature, high pressure gas produced by the combustor. The turbine blades are often the limiting component of steam turbines. To survive in this difficult environment, turbine blades often use exotic materials like super alloys and many different methods of cooling, such as internal air channels, boundary layer cooling, and thermal barrier coatings. Cylindrical reaction blades are used for high pressure, low pressure and intermediate pressure turbines. Twisted blades with integral shroud, in the last stages of low pressure, intermediate pressure and initial stages of low pressure turbines, to reduce profile and tip leakage losses[1].

Modern turbine blades often use nickel-based super alloys that incorporate chromium, cobalt, and rhenium. Super alloys were developed since the second quarter of the 20th century as materials for elevated temperature applications and can be divided in three groups: nickel-base super alloys, cobalt-base super alloys and iron base super alloys. Gas turbine blades are principally made of nickel-base and cobalt-base super alloys. The main reason for the existence of super alloys is their outstanding strength at elevated temperatures, which make them suitable for the fabrication of gas turbine components. During the operation of power generation gas turbines, the blades and other elements of hot gas path undergo service-induced degradation, which may be natural or accelerated due to different causes. The degradation or damage may have a metallurgical or mechanical origin and results in reduction of equipment reliability and availability[2]. To identify the causes of the blade failures, a complete investigation has to be carried out, integrating both the mechanical analyses and metallurgical examination. Metallurgical examination can be very effective in determining whether the failure is related to material defects, mechanical marks, poor surface finish, initial flaws or heat treatment. There are different factors, which influence blade lifetime, as design and operation conditions but the latter are more critical.
Typical blade material is:-

- 11.5 to 13.5% Chromium
- 1% Nickel
- 1% Manganese
- 1% Silicon
- 0.12% Carbon
- Trace Sulphur & phosphorus [3]

Larson Miller Parameter

Larson Miller Parameter is useful for creep life prediction. The Larson Miller parameter can be used for designing in order to achieve maximum

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working condition as well as to attain favorable function lifetime. This method also presented the correlation between stress, Temperature and fracture time. In figure 4 the relationship between stress and Larson miller parameter is plotted.

Formulae:

The modified Larson Miller Parameter can be defined as:-

LMP=T [$\log_{10}$t + C] ×10^{-3}

T=Temperature in Kelvin

σ = Stress in Mpa

t = Creep life in hours

C= Constant for IN738LC considered 20 for 100000 hours.

Figure:

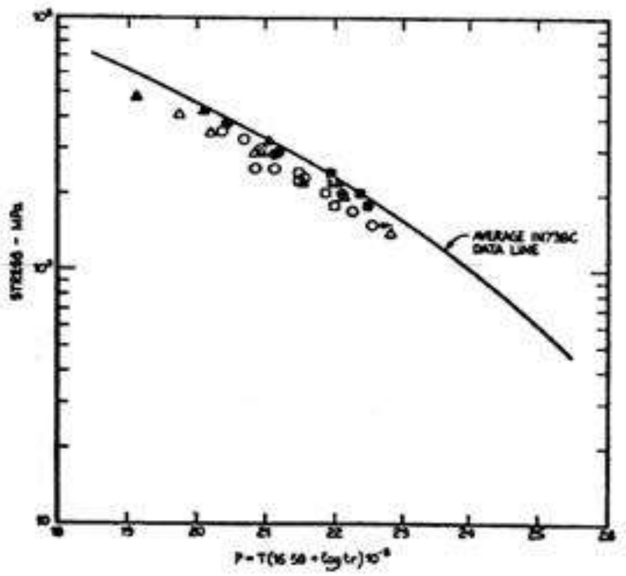

Figure 1.1 Relationship Between Stress and Larson Miller Parameter[4]

Mechanical Properties of Different Material

Mechanical properties of all the three materials Hastealooy-X, IN625, IN738LC is shown in tble below[5].

Tables:

Table 1. Mechanical Properties of Different Material

S. NO	PROPERTIES	UNIT	HASTE ALLOY-X	IN625	IN738LC
1	E	Gpa	144	150	175
2	Α	$10^{-6}/K^{-1}$	16	15	11.6
3	Μ	--	0.348	0.331	0.3
4	Ρ	Kg/cum	8300	8400	8110
5	K	w/(mK)	25	10	18

Analysis Of Steam Turbine Blade

The purpose of finite element analysis is to recreate mathematically the behavior of an actual engineering system. In other words, Analysis must be an accurate mathematical model of a physical prototype .In order to 3-D Analysis stress in gas turbine blade we are required information such as geometric model, boundary conditions, loading and material properties[6].

Creep life of the turbine blade can be affected by the various operating parameters such as speed, temperature, force on the blade etc. In this study three nickel based alloy are choosen i.e Hasteallo-X, IN625, IN738LC, for the structural analysis of the turbine blade at the operating temperature of 535ºC. After structural analysis of the turbine blade Modified Larson Miller Parameter is used to calculate the creep life of the turbine blade then the results are compared and finally some of the results are presented.

Stress Analysis for Haste alloy-X

By applying boundary condition and mechanical properties of Hastealloy-X, stress analysis will be performed at 535ºC (Operating Temperature) in ANSYS 14.5 and the results are shown below.

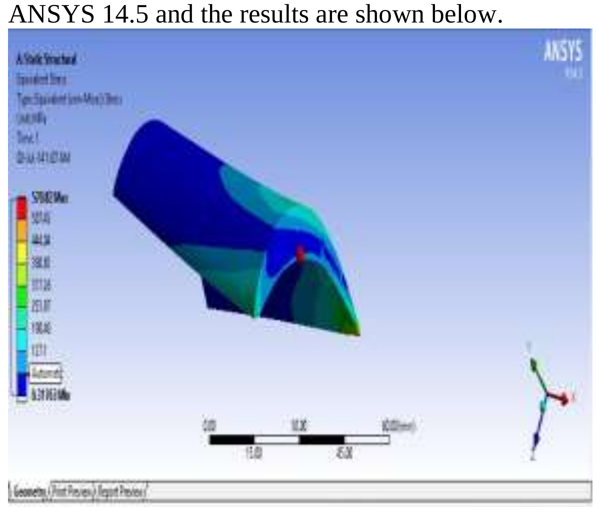

Figure 1.2 Von Misses Stress Distribution for Haste Alloy-X

The figure shown above shows the stress distribution on the surface of the turbine blade which is determined in the ANSYS 14.5 and the maximum stress is 570.82 Mpa.Now putting the values in LMP equation.

$$LMP=T [\log t + C] X 10^{-3}$$

Maximum Stress = 570.82 Mpa

$$LMP=18.97$$

$$18.97\times10^{3} = 808 [\log_{10} t+ 20]$$

$$\log_{10} t = 3.477$$

t = 3004.005 Hrs.

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Stress Analysis for IN625

By applying boundary condition and mechanical properties of IN625, stress analysis will be performed at 535ºC (Operating Temperature) in ANSYS 14.5 and the results are shown below.

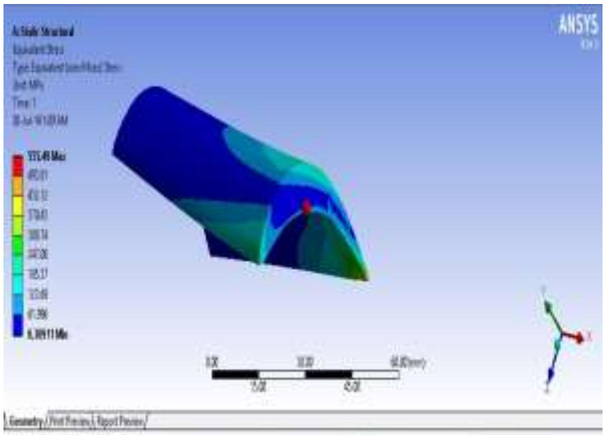

Figure 1.3Von Misses Stress Distribution for IN625

The figure shown above shows the stress distribution on the surface of the turbine blade which is determined in the ANSYS 14.5 and the maximum stress is 555.49 Mpa. Now putting the values in LMP equation.

$$LMP=T\ [\log t + C]\ X\ 10^{-3}$$

Maximum Stress = 555.49 Mpa

LMP=19.1

$$19.1\times10^{3} = 808\ [\mathrm{Log}_{10}\, t+ 20]$$

$$\mathrm{Log}_{10}\, t = 3.349$$

t = 4345.10 Hrs.

Stress Analysis for IN738LC

By applying boundary condition and mechanical properties of IN738LC, stress analysis will be performed at 535ºC (Operating Temperature) in ANSYS 14.5 and the results are shown below.

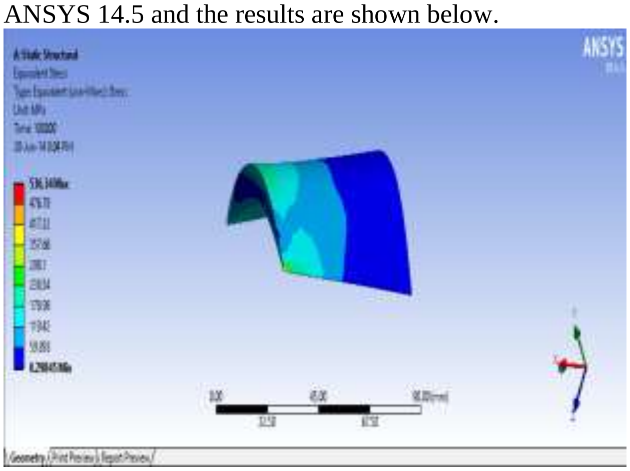

Figure 1.4Von Misses Stress Distribution for IN738LC

The figure shown above shows the stress distribution on the surface of the turbine blade which is determined in the ANSYS 14.5 and the maximum stress is 536.34 Mpa. Now putting the values in LMP equation.

$$LMP=T\ [\log_{10} t + C]\ X\ 10^{-3}$$

Maximum Stress = 536.34 Mpa

LMP=19.25

$$19.25\times10^{3} = 808\ [\log_{10} t+ 20]$$

$$\mathrm{Log}_{10}\, t = 3.824$$

t = 6668.04 Hrs.

Deformation of different Material

For Hastealloy-X

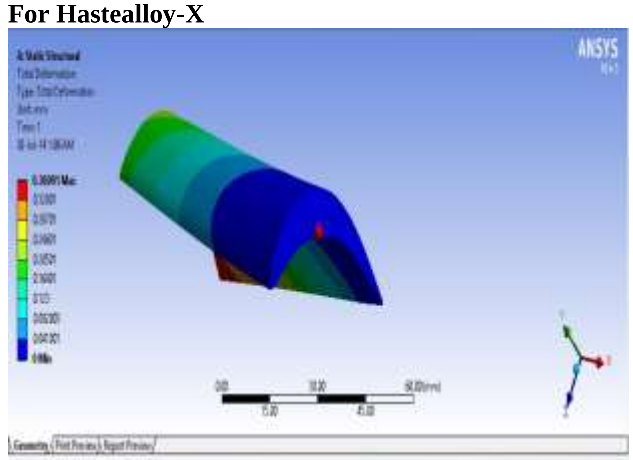

Figure 1.5 Deformation of Turbine Blade for Haste Alloy-X

The figure 6.5 shown above shows the maximum deformation on the surface of the turbine blade which is determined in the ANSYS and the maximum deformation is 0.36901 mm.

For IN625

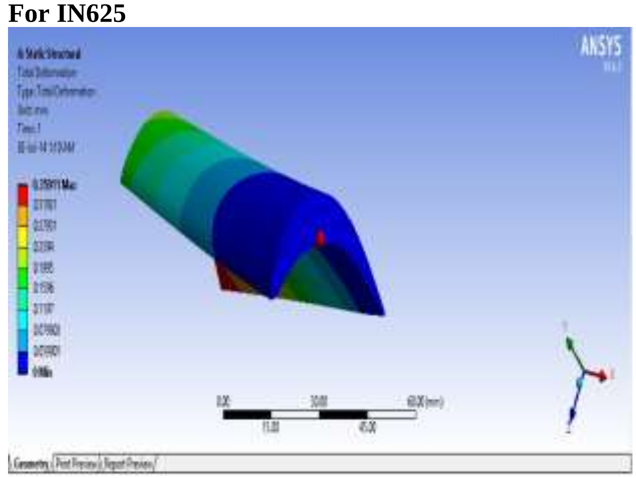

Figure 1.6 Deformation of Turbine Blade for IN625

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The above figure shows the maximum deformation on the surface of the turbine blade which is determined in the ANSYS and the maximum deformation is 0.35911 mm.

For IN738LC

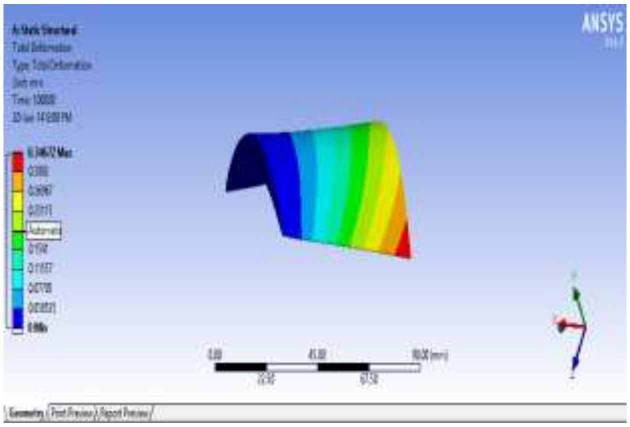

Figure 1.7 Deformation of Turbine Blade for IN625

The above figure shows the maximum deformation on the surface of the turbine blade which is determined in the ANSYS and the maximum deformation is 0.34672 mm.

Results Obtained

Most of the time turbine blade used in the thermal power plant is manufactured by N155, A-286, IN625, Haste alloy-X because they can work under the very high temperature and stress but in this project material IN738LC is taken for the blade material which has better properties and composition over these materials.

It is clearly shown in the table 7.2 below that at the same operating condition (535ºC) materials has different creep life.

Table 2. Result Obtained for Different Material

S.NO.	MATERIAL	STRESS (In Mpa)	DEFORMATION(In mm)	TIME (Hrs.)
1	IN625	555.82	0.35911	**4345.10**
2	Haste alloy-X	570.82	0.36901	**3004.1**
3	IN738LC	536.72	0.34672	**6668.4**

Conclusion

1) IN625 has the creep life of **4345.10 Hrs**. at the same operating condition.
2) Haste Alloy-X also has the different creep life of **3004.1 Hrs.** at the same operating parameters.
3) IN738LC is having the maximum life of **6668.2 Hrs.** on the same operating condition and the deformation is also minimum in case of IN738LC.

So from the above analysis it can be concluded that material IN738LC has better creep life as compared to the other three materials and has the capability to withstand in high temperature and stress as it is faced in thermal power plants. By using IN738LC for material for turbine blade the life of the blade can be increased to some extent

References

1. *S. M. Sanjay kumar, Manju, Raghavendra."Creep life prediction of steam turbine blade using finite element method". International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974. IJAERS/Vol. I/ Issue II/January-March, 2012/95-98.*
2. *Patil A.A., Shirsat U.M."Study of Failure Analysis of Gas Turbine Blade", IOSR Journal of Engineering (IOSRJEN) ISSN: 2250-3021 ISBN: 2878-8719 PP 37-43.*
3. *R.K. Rajput ,"A Text Book of Thermal Engineering" Laxmi publication.*
4. *Abbas Rahi, Mohsen Papari," Investigation of the Effect of Changing Operating Temperature on the Creep Life and natural Frequencies of Gas Turbine Blade" Recent Advances in Manufacturing Engineering ISBN: 978-1-61804-031-2.*
5. *P.V.Krishnakanth, G.Narasa Raju,R D V. Prasad, R. Saisrinu "Structural & Thermal Analysis of Gas Turbine Blade by Using F.E.M" International Journal of Scientific Research Engineering & Technology (IJSRET), ISSN 2278 – 0882 , Volume 2 Issue2 pp 060-065 May 2013.*
6. *Amit Kumar Gupta, Mohd. Rehan Haider." Creep Life Estimation of Low Pressure Reaction Turbine Blade" International Journal of Technological Exploration And Learning (IJTEL), ISSN: 2319-2135, VOL.3, NO.2, APRIL 2014*

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