iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL
FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 Issue: VI Month of publication: June 2019

DOI: http://doi.org/10.22214/ijraset.2019.6409

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VI, June 2019- Available at www.ijraset.com

Characterization of Inconel (SU-718) Super Alloy at Different Temperatures on Shaft LP Spool

Sethu madhavi Gaddam [1], Dr. J. Suresh Kumar [2],
[1]P.G. Student, [2]Professor, Department of Mechanical Engineering, JNTUH College of Engineering, Kukatpally, Hyderabad, India

***Abstract:** Nickel has been the material of choice for space structures of all types. Chosen for its light weight and its ability to withstand the stresses that occur during launch and operation in space, Nickel has been used on Apollo spacecraft, the Skylab, the space shuttles and the International Space Station. Inconel superalloys consistently exceed other metals in such areas as mechanical stability, dampening, thermal management and reduced weight. In the development of Ni alloys, proper temperatures and solution proportions are involved to vary the mechanical properties. The optimum heat treatment conditions are verified by determining various parameters of governing equations. Also the workability of Ni alloys is measured by strain hardening exponent which is determined by performing functional fitting of experimental data thus confirming the validation of heat treatment process.*

Moreover, different proportions of other additives into wrought Ni also varies the properties and their adaptability to higher temperatures. It is clear that a correlation as well as demarcation between monotonic and cyclic behavior with respect to various flow parameters in standard heat treatment condition is vital to optimize the properties. The present work focusses on heat treated Ni super alloy Inconel and comparison of their parameters at different temperatures.

***Keywords**: Fatigue life in terms of starin, Low cycle fatigue, coffin manson , Cyclic stress – strain hysteresis loop.*

I. INTRODUCTION

Aero Engines are the type of external combustion heat engines which take the ambient air, compresses it to high temperatures, and later on combusted with fuel and provides the required thrust or power to move. So in this regard there are different temperatures are involved and it is not possible to use only one type of alloys or materials in all the sections, as the temperature exceeds very much and it may reach almost near to melting point. In considering different materials for different components, weight becomes prime factor to control and it must be optimised. So in this regard we need compromise with the following:

A. Mechanical properties
B. Weight as well as life of component.
C. Retaining the properties at higher temperatures.
D. Corrosion and oxidation resistance
E. Creep resistance

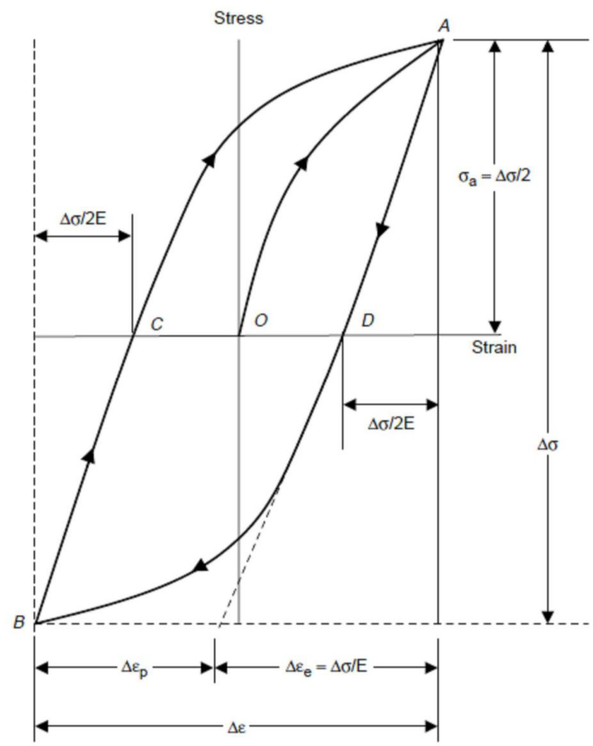
Nickel alloys are one of the toughest structural materials available. They also have a good electrical conductivity and magnetic properties. Nickel base Super alloys service at high temperatures, particularly in the hot zones of gas turbine engine. Turbine Inlet Temperature (TIT) depends on the temperature capability of first stage High-Pressure Turbine blade made of nickel base super alloys exclusively The most commonly used Nickle base super alloy is the two phase (gamma and gamma prime) alloy, INCONEL 718. This project deals with fatigue behavior of Inconel super alloy under low cycle fatigue environment when used for the purpose of compressor in aero engine and Aero engine Shaft

II. METHODOLOGY AND SAMPLE PREPARATION

The material is extruded in the form of bar and then solution treated .
Nickel super alloy Inconel is having chemical composition listed .

Weight %	Ni	Fe	Al	Ti	Cr	Mo	Nb	C	Cu
Inconel	53	18.5	0.5	0.9	19	3.0	5.1	0.08	0.15

1) *Low Cycle Fatigue:* During cyclic loading within the elastic regime, stress and strain are directly related through the elastic modulus. However, for cyclic loading that produces plastic strains, the responses are more complex and form a hysteresis loop as below. From point O up to point A, the component is in tension. On unloading, the strain response of the specimen follows the curve from A to D. At D, the component is under no stress. As the component is subjected to compressive stress, the strain response follows the curve from D to B. Releasing the compressive stress from B and re applying tensile stress, the component stress-strain condition returns to point A along the curve defined by B, C, and A. Points A and B represent the cyclic stress and strain limits. The total strain, De, consists of both elastic and plastic components:



1. Cyclic stress – strain hysteresis loop

2) *High Cycle Fatigue Test:* High-cycle fatigue involves a large number of cycles ($N>10^5$ cycles) and an elastically applied stress. High-cycle fatigue tests are usually carried out for 10^7 cycles and sometimes $5 *10^8$ cycles for nonferrous metals. Although the applied stress is low enough to be elastic, plastic deformation can take place at the crack tip. High-cycle fatigue data are usually presented as a plot of stress, S, versus the number of cycles to failure, N. A log scale is used for the number of cycles. The value of stress, S, can be the maximum stress, σ_{max}, the minimum stress, σ_{min}, or the stress amplitude, σ_a. The S-N relationship is usually determined for a specified value of the mean stress, σ_m, or one of the two ratios, R or A. The fatigue life is the number of cycles to failure at a specified stress level, while the fatigue strength (also referred to as the endurance limit) is the stress below which failure does not occur. As the applied stress level is decreased, the number of cycles to failure increases. Normally, the fatigue strength increases as the static tensile strength increases. It should be noted that there is a considerable amount of scatter in fatigue test results. It is therefore important to test a sufficient number of specimens to obtain statistically meaningful results. Fatigue cracking can occur quite early in the service life of the component by the formation of a small crack, generally at some point on the external surface.

The stress range, σ_r, is the difference between the maximum and minimum stress in a cycle:

$$\text{Cyclic stress range: } \Delta\sigma = \sigma_{max} - \sigma_{min}$$

The alternating stress or cyclic stress amplitude is one-half the stress range

$$\text{Cyclic stress amplitude: } \sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2}$$

The mean stress is the algebraic average of the maximum and minimum stress in the cycle

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VI, June 2019- Available at www.ijraset.com

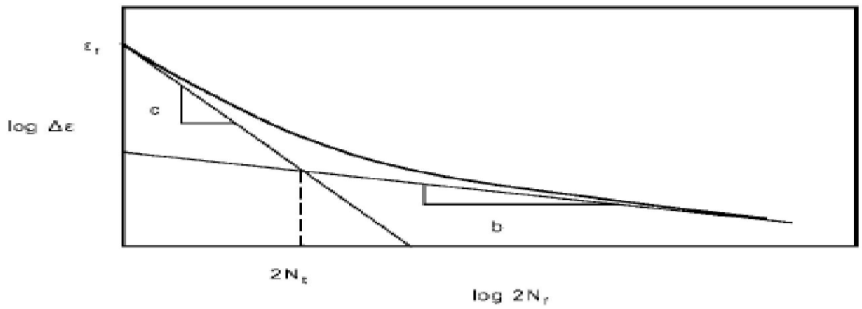
$$\text{Mean stress: } \sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2}$$

Two ratios frequently used in presenting fatigue data are

$$\text{Stress ratio: } R = \frac{\sigma_{min}}{\sigma_{max}}$$

$$\text{Amplitude ratio: } A = \frac{\sigma_a}{\sigma_m} = \frac{1 - R}{1 + R}$$

The fatigue strain-life curve tends toward the plastic curve at large strain amplitudes and toward the elastic curve at small strain amplitudes (Fig. 1.10). For high-cycle strain conditions, ductile metals have the longest lives while at low-cycle strain conditions, strong metals have the longest lives



2 Fatigue life in terms of total strain

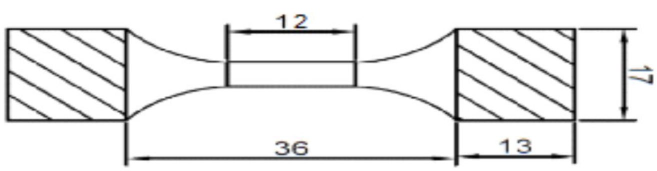
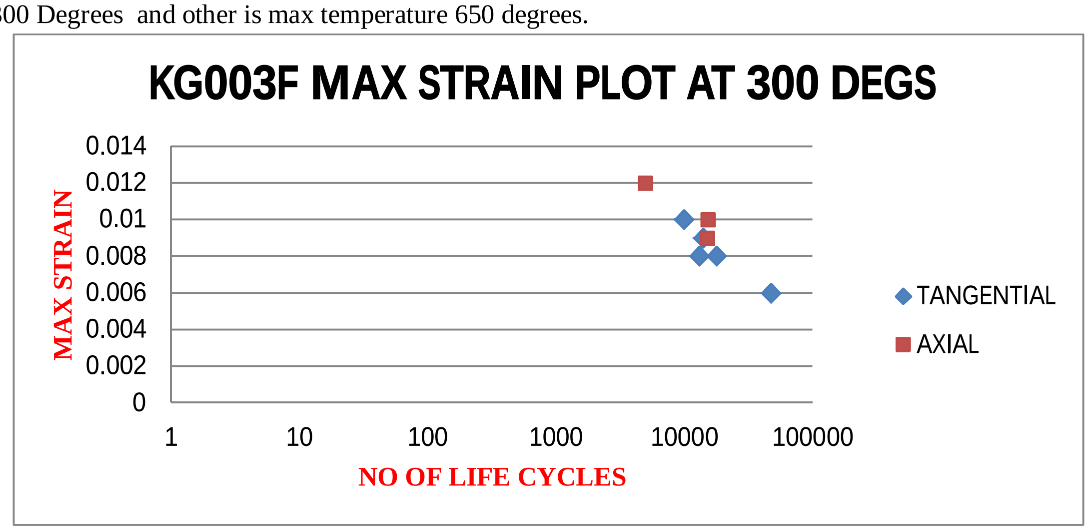


Figure.3: Fatigue specimen ASTM standard(mm

III.RESULTS AND ANALYSIS

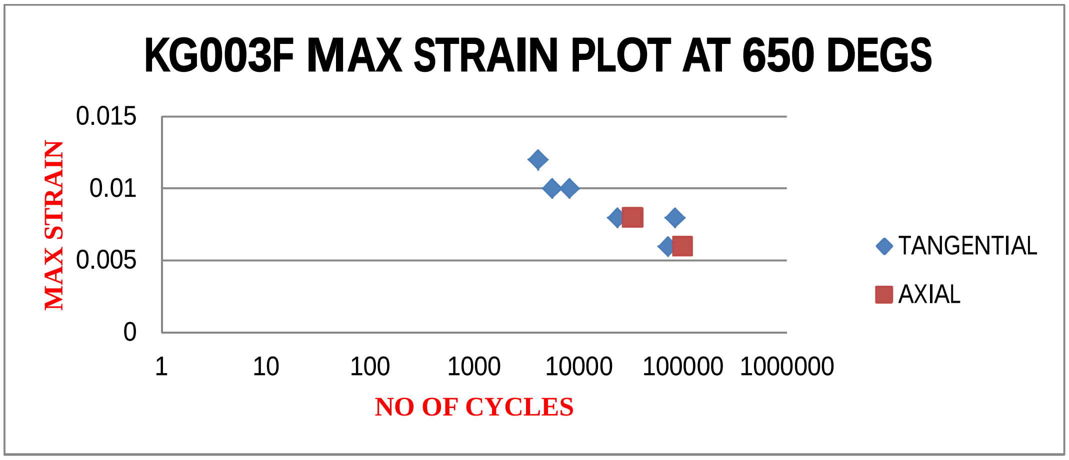
A. Study Of Stress & Strain Against Life

Life of the samples at the above mentioned strains has been studied The semi log graphical plot for maximum strain against life is shown in the figures.among five tempertures two of thee sample figures were taken for the observation.where one is minimum temperature of 300 Degrees and other is max temperature 650 degrees.



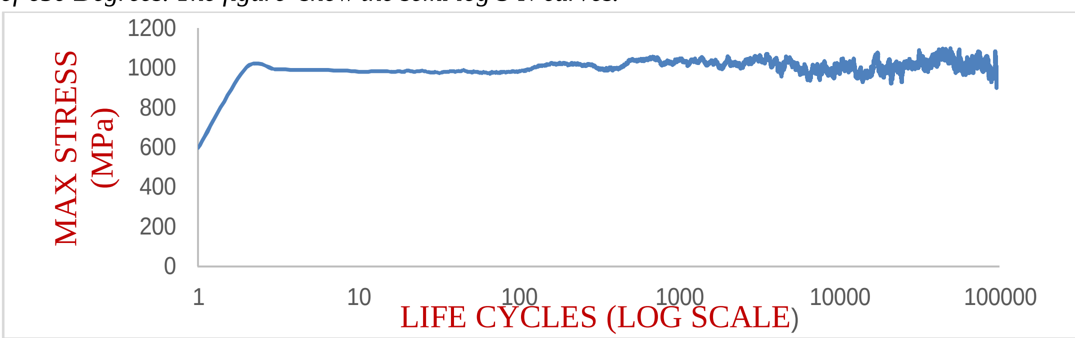
.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VI, June 2019- Available at www.ijraset.com



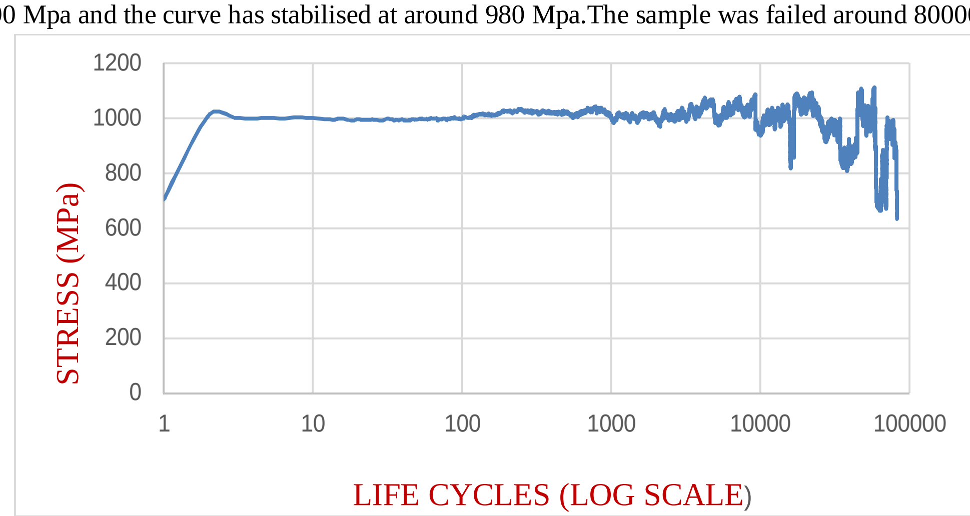
From the above Two sample temperatures semi-log graphs, it is observed that the life of the material is decreasing with increase in strain. The life of the material is effected by the change in temperature

B. Stress vs life curve (S-N curve) comparision is studied for few samples at Minimum Temperature 300 Degrees and maximum temperature of 650 Degrees. The figure show the semi log S-N curves.



S-N curve for Axial loaded specimen at 300□C temperature at Max.strain 0.006

Semi log S-N curves for axial loaded specimen plotted at maximum strain of 0.006. A continuous decrease in stress is observed from 1000 Mpa to 990 Mpa and the curve has stabilised at around 980 Mpa.The sample was failed around 80000 cycles.

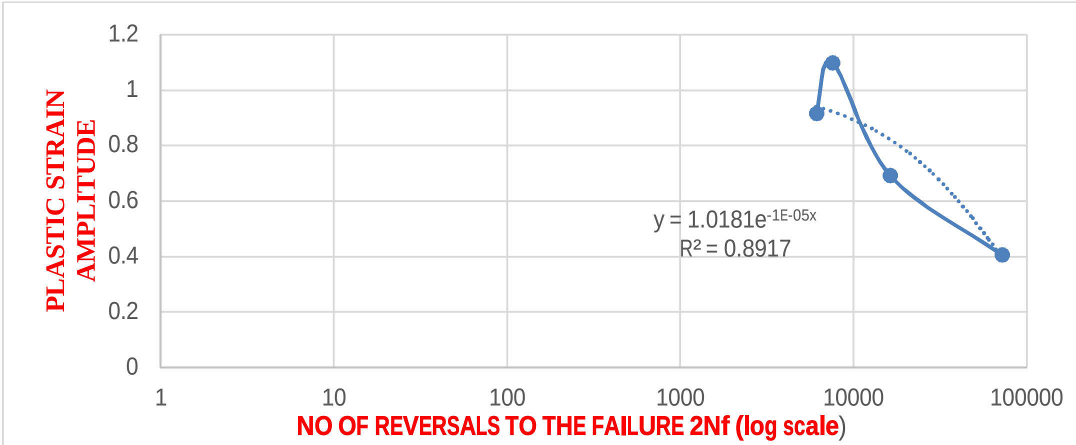


S-N Curve for TANGENTIAL loaded specimen at 650□C temperature at Max.strain 0.008

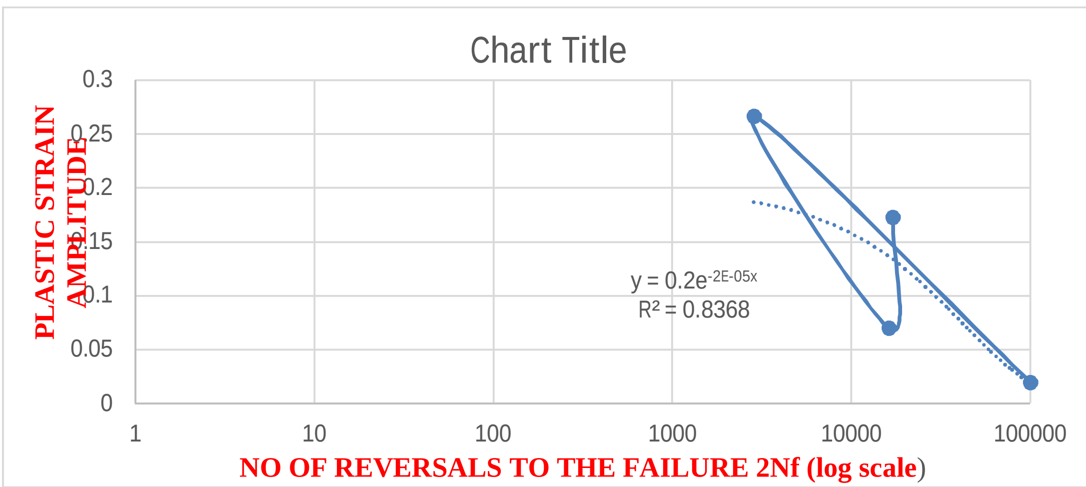
Above semi log S-N curves for Tangential loaded specimen plotted at maximum strain of 0.008. A continuous decrease in stress is observed from 1048Mpa to1000 Mpa .The sample was failed around 98000 cycl

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VI, June 2019- Available at www.ijraset.com

C. Coffin Manson Plots



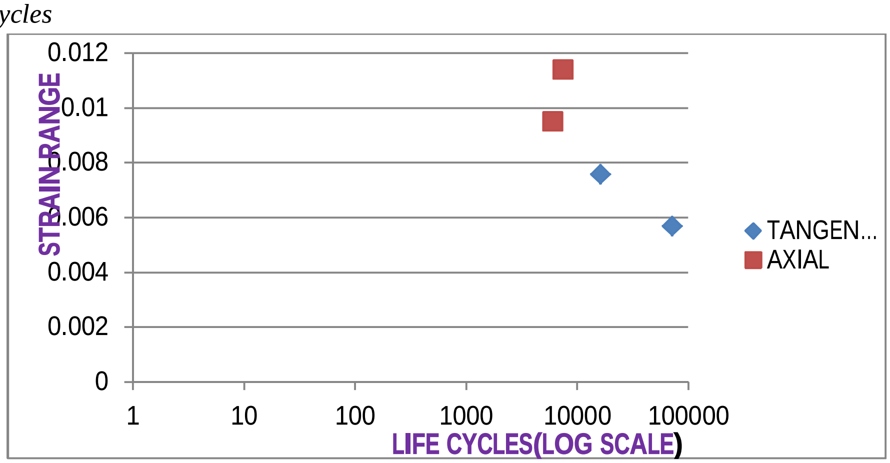
Coffin-manson plot at tangential and axial at 300□C



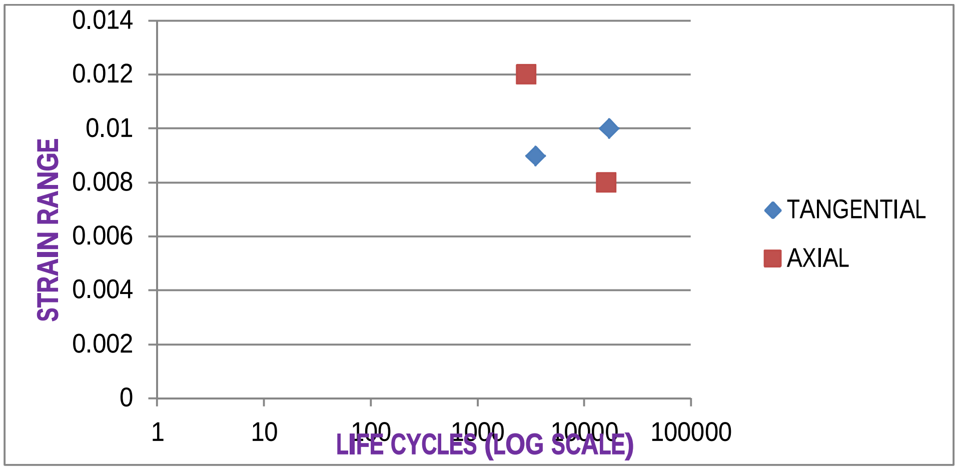
Coffin-manson plot of tangential and axial at 650□C

Amongst all the coffin Manson plots, more convergence is observed for the graphs plotted at a position with respect to orientation as shown in the figures. More convergence implies more idealness in the linearity of the power curve in semi-log plot. More the linearity, higher is the validation of Coffin-Manson rule.

D. Max Strain vs Life Cycles



Strain Range vs Life Cycles For Tangential And Axial At 300□C



Strain Range vs Life Cycles For Tangential And Axial At 650□C

The graphs plotted for both tangential and axial at each temperature shows that as strain range continuously increases Life cycles decreases.

The life of the material is less affected by the change in temperature and more affected by the strain. The reduction of fatigue life is due to the effect of the total strain range and microstructure evolution during high temperatures.

IV. CONCLUSION

.Testing has been done at different loading conditions on samples taken from different positions of the as-manufactured shaft LP spool. The isotropic nature of the material under isothermal forged conditions is studied and the results have shown considerable isotropic nature in the material.

A. As the analysis is done on five different straining conditions, the behavior of the shaft LP spool under variable loading in a real time scenario can be estimated from the documented results.

B. The higher convergence at the condition of both position and orientation taken together shows that fatigue properties are more ideal at a particular position and orientation.

C. Serrations were observed in the S-N curves at high temperatures, hence, it can be said that there is localized solute particle stress concentration or dynamic strain aging occurring at high temperatures.

D. All the testing has been done under uni-axial loading condition for axial and tangential loadings and it could be generalized in estimating the results inmulti axial loading conditions.

E. A considerable decrease in the fatigue properties is observed with increase I the temperature and large variation in stresses is observed from room temperature (24□C) to 650□C.

REFERENCES

[1] ‘’The development of gas turbine materials’’, Applied science publishers LTD, Essex, England, 1981
[2] Materials Properties Handbook: Nickle alloys, R. Boyer, G.Welsch, and E.W. Collings, eds.ASM International, Materials Park, OH, 1994.
[3] Materials Science and Engineering A263 (1999) 187–192
[4] “Fracture Appearance and Mechanics of Deformation and Fracture”, W.T.Becker, University of Tennessee, Emeritus; S.Lampman, ASM Internationa
[5] International Journal of fatigue 44(2012) 292-302
[6] An-investigation-on-fatigue-failure-of-turbine-blades pdf
[7] SK_ Bhaumik. fatigue failure in aeroengines pdf
[8] Nickle_Base_Superalloys in aeroengines.pdf
[9] Fundamentals-of-Aerodynamics by anderson.pdf
[10] ASM HandBook Volume 19 - Fatigue And Fracture.
[11] Mechanical9 Metallurgy book by George.E.Dieter.

.