FINITE ELEMENT ANALYSIS AND FATIGUE ANALYSIS OF CRANE HOOK WITH DIFFERENT MATERIALS

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Abstract - *In the earlier stage of seminar the design of the hook is done by analytical method and analysis was done for the different Cross sections by applying same load on crane hook. like rectangular and trapozoidal . Out those two area Trapozoidal area is selected for further static structural analysis with different materials . Because it gives better results in comparision with other one as because stresses induced are less in trapozoidal cross section. After the analytical method design and modeling of hook is done in modeling soft-ware .The modeling is done using the design calculation from previous work the analysis of hook is done in FEA software (ANSYS).The aim is to select the best material from aluminium alloy , structural steel, wrough iron for crane hook from analysis result and fatigue analysis*

***Key Words*: Crane hook ,CatiaV5, Ansys14.5**

1. INTRODUCTION

Crane hooks are highly liable components and are always subjected to failure due to accumulation of large amount of stresses which can eventually lead to its failure. Crane hooks are the components which are generally used to elevate the heavy load in industries and constructional sites. A crane is a machine, equipped with a hoist, wire ropes or chains and sheaves used to lift and move heavy material. Crane hooks with trapezoidal, circular, rectangular and triangular cross section are commonly used. So, it must be designed and manufactured to deliver maximum performance without failure. In the earlier stage of seminar the design of the hook is done by analytical method and analysis was done for the different Cross sections by applying same load on crane hook out of these trapozoidal area was selected for the previous work. Now, in this stage of seminar the stress analysis are done on different materials and from that the material which has minimum deflection and stresses are selected for fatigue analysis to select best material for crane hook. Fatigue damage is the initiation of a crack due to fluctuating loading. It is caused due to stress levels which are insufficient to cause damage in a single application. The seminar work shows the stress ,deformation and fatigue life contour plots of crane hook using Ansys Workbench

2. LITRATURE SURVEY

Following litratures are studied ,

[1] Sayyedkasim Ali1, Harish Kumar2 described their work on Stress Analysis of Crane Hook with Different Cross Section Using Finite Element Method. In this analysis the material properties of hook kept constant throughout the analysis and stress is to be reduced by varying different geometric parameters. After optimizing the cross section of crane hook the approach turned towards the material saving during manufacturing of crane hook. For material saving the maximum stress region is to be identified by using FEM analysis and then material is removed by considering the maximum bending stress at failure point.

[2] Yogesh Tripathi1, U.K Joshi2 carried an" comparison of stress between winkler-bach theory and ansys finite element method for crane hook with a trapezoidal cross-section ". The induced stresses as obtained from Winkler-Bach theory for curved beams are compared with results obtained by ANSYS software.

[3] Patel Ravin B, Patel Bhakti K., Patel Priyesh M, described their work on "design and analysis of crane hook with different material". The results of stress analysis calculated from FEA analysis for various different material such as Forged Steel ,Wrougt iorn/MS, Aluminium Alloy. For the different Material, It is observed that keeping the tone are same with different Material topology we will get different results, but from that it is found that the Forged Steel material gives minimum stress.

[4] Amandeep Singh, Vinod Rohilla described their work on optimization and fatigue analysis of a crane hook using finite element method This is done to reduce weight and balance economy. Further, out of these candidates, best candidates are considered and fatigue analysis is performed on these candidates.

3. DESIGN OF CRANE HOOK

Machine frames having curved portions are frequently subjected to bending or axial loads or to a combination of bending and axial loads. With the reduction in the radius of curved portion, the stress due to curvature become greater and the results of the equations of straight beams when used becomes less satisfactory. For relatively small radii of curvature, the actual stresses may be several times greater than the value obtained for straight beams. It has been found from the results of Photo elastic experiments that in case of curved beams, the neutral surface does not coincide with centroidal axis but instead shifted towards the Centre of curvature. It has also been found that the stresses in the fibers of a curved beam are not proportional to the distances of the fibers from the neutral surfaces, as is assumed for a straight beam.The design of crane hook was done by taking the data pertaining to load(w), and curvatures which are used in industrial applications of crane hook

3.1 Theoretical Analysis

Winkler batch theory is used to calculate the theoretical stress. For the straight beams, the neutral axis of the cross section coincides with its censorial axis and the stress distribution in the beam is liner. But in case of curved beams, the neutral axis of the cross-section is shifted towards the centre of curvature of the beam causing a non-linear distribution of stress. The application of curved beam principle is used in crane hooks. This article uses Winkler-Bach theory to determine stresses in a curved beam.

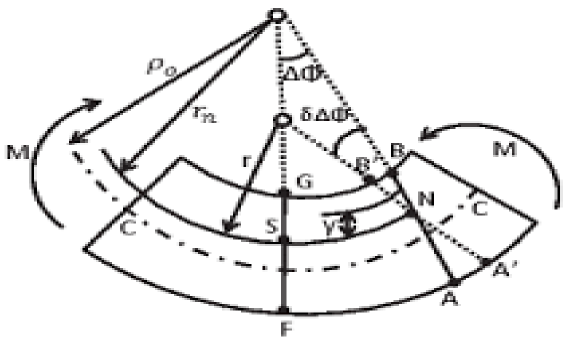


Figure 1: Curved Beam Nomenclature Reference [1]

d2 = Distance of center of gravity from the upper side. R = Radius of curvature

$\sigma = M/ AR\ [1 + R2/ H2 \times Y /R+Y]$ ..(Tensile)

$\sigma = M/ AR\ [1 - R2/ H2 \times Y /R-Y]$ ..(Compression)

Table 1: Dimensions For Reference [1]

Hook Cross Section	Dimension
Trapozoidal	B=51, b= 26 , D=75

3.2 Trapozoidal Section :

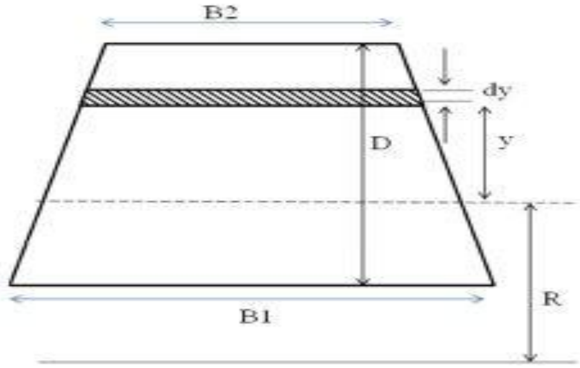


Fig.2 Trapozoidal Section[1]

$\sigma = M/ AR\ [1 + R2/ H2 \times Y /R+Y]$ ..(Tensile)

H= 0.93 × C =0.93×25 = 23.25 mm

M= W× R= 9806×888629=372628 Nmm

R= C+ D/2= 38

A=5700/2= 2850mm^2

(6_t) total= 194 N/mm^2 ≤ 250 N/mm^2

Geometry of Trapozoidal Section

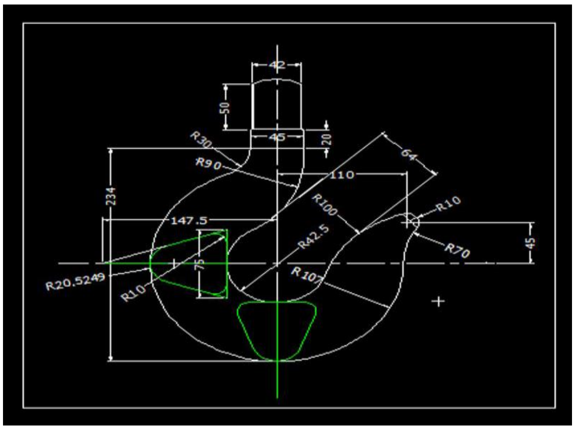


Fig.3 Geometry of Trapozoidal Section[3]

4. CAD MODELING

For generation of CAD model of crane hook in Catia various geometrical features and dimensions are selected from existing model and best one is selected for modelling .

4.1 CAD Model of Trapozoidal Section (a)

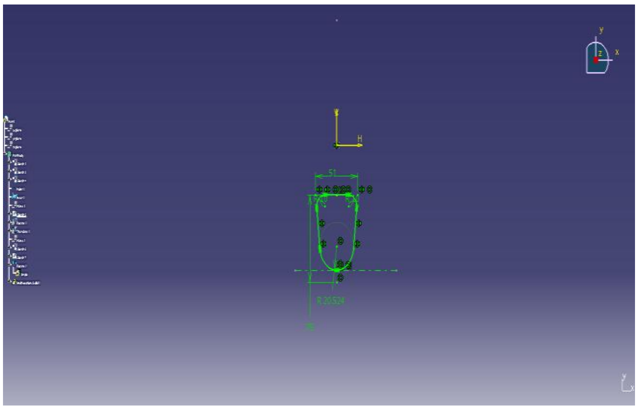


Fig.4 2D Model of Trapozoidal Section

4.2 3D Model of Trapozoidal Section

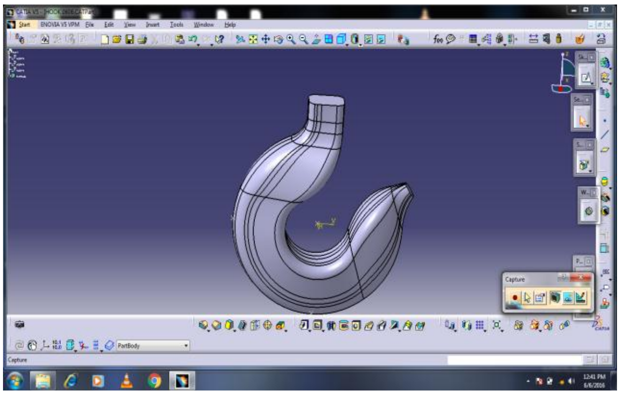


Fig. 5 3D Model of Trapozoidal Section

5. MESHING

A model prepared in CATIA is used for static analysis. Hook element is selected for creating FE model of the crane hook and a fine meshing is carried out. The meshed model created is shown in fig.6.

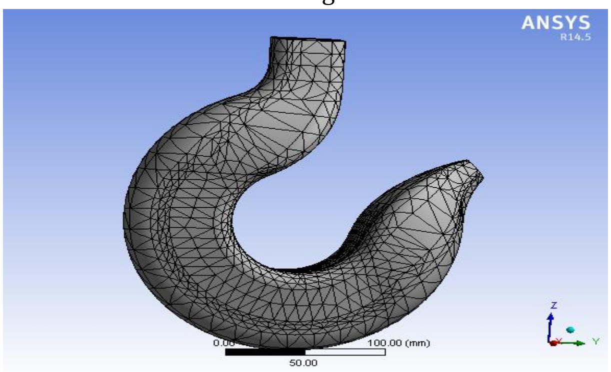


Fig. 6 Meshing of Trapozoidal section

6. FEA OF CRANE HOOK WITH DIFFERENT MATERIALS

Analysis has been done for static structural, single step loading loads of 9806 N (1 Tonn)is applied at principal cross-section of the hook. Eye section at top of the shank, kept fixed.

6.1 Material Properties Of Structural Steel

A shank end of crane hook is fixed and a loads are applied on bunch of nodes at lower centre of hook in downward direction. A load of 1ton (9806N) is taken for analysis. First material selected for crane hook is Structural Steel and the properties of material are given below:

Structural Steel > Constants

Density	7850kgm^-3
Coefficient of Thermal Expansion	1.2e-005C^-1
Specific Heat	434Jkg^-1C^-1
Thermal Conductivity	60.5Wm^-1C^-1
Modulus of elasticity	2.5e05Mpa
Poissons Ratio	0.3

Structural Steel > Compressive Yield Strength

Compressive Yield Strength	2.5e+008Pa

Structural Steel>Tensile Yield Strength

Tensile Yield Strength Pa
2.5e+008

Structural Steel > Tensile Ultimate Strength

Tensile Ultimate StrengthPa
4.6e+008

Reference Temperature C
22

Chemical Composition of Structural Steel

Element	Content (%)
Vanadium,V	0.03-0.08
Carbon, C	0.15-0.30
Phosphorus,P	0.04-0.05
Silicon, S	0.02-0.4
Nickel,N	0.25-1.25
Mangnese, Mn	0.50-1.70

Maximum Nodes = 12180
Maximum Nodes = 7499

6.2 Boundary Conditions Applied on Trapozoidal Hook for Structural Steel

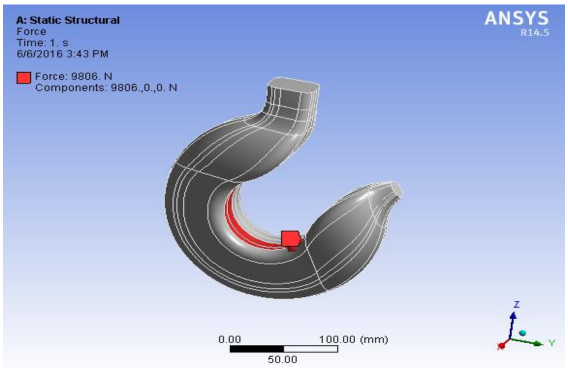


Fig. 7 Boundry Conditions Applied on Trapozoidal Hook

6.3 Stress Plot of Hook for Structural Steel

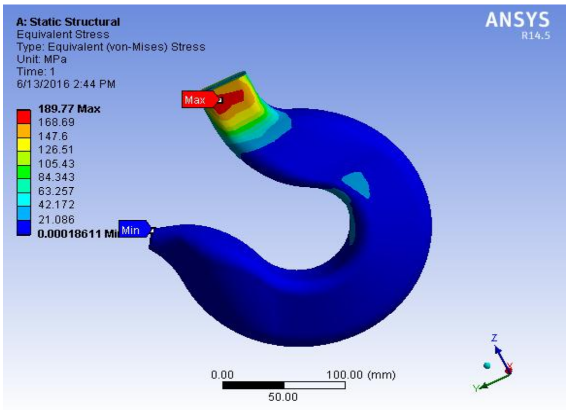


Fig. 8 Stress Plot for Structural Steel

6.4 Deformation Plot for Structural Steel

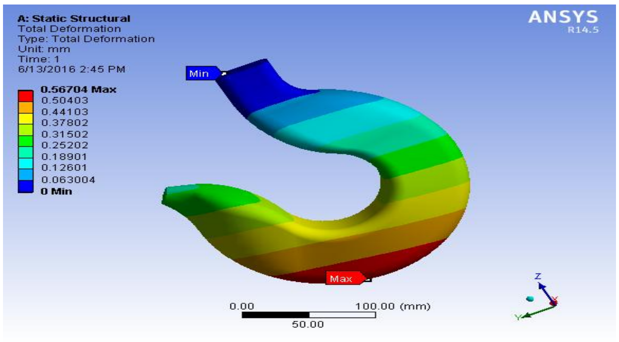


Fig. 9 Deformation Plot For Structural Steel

7. STRESS ANALYSIS OF HOOK WITH ALUMINIUM ALLOY

7.1 Material Properties of Aluminium Alloy

A shank end of crane hook is fixed and a various loads are applied on bunch of nodes at lower centre of hook in downward direction. A load of 1ton (9806N) is taken for analysis. Material selected for crane hook is aluminium alloy and the properties of material are given below:

Aluminium Alloy > Constants

Density	2770kgm^-3
CoefficientofThermalExpansion	2.3e-005C^-1
SpecificHeat	534Jkg^-1C^-1
ThermalConductivity	69.5Wm^-1C^-1
Resistivity	1.8e-007ohm

Aluminium Alloy > Compressive Yield Strength,E,m

CompressiveYield Strength	2.8e+008Pa
Modulus of elsticity	7.1e+10Pa
Poisson's Ratio	0.32

Aluminium Alloy >TensileYieldStrength

TensileYieldStrengthPa
2.8e+008

Aluminium Alloy > Tensile Ultimate Strength

Tensile Ultimate StrengthPa
3.1e+008

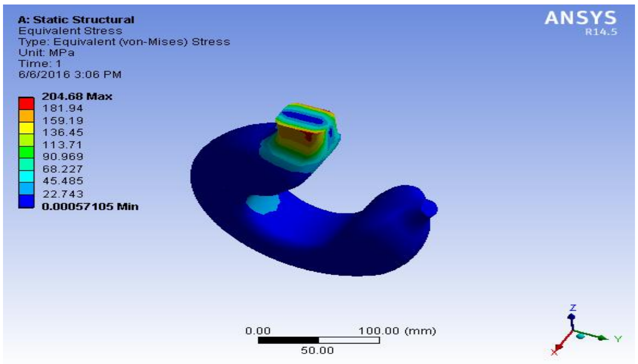


Fig.9 Max. Equivalent (Von -Mises) Stress For Trapozoidal Hook

7.2 Boundry Conditions Applied with Aluminium Alloy

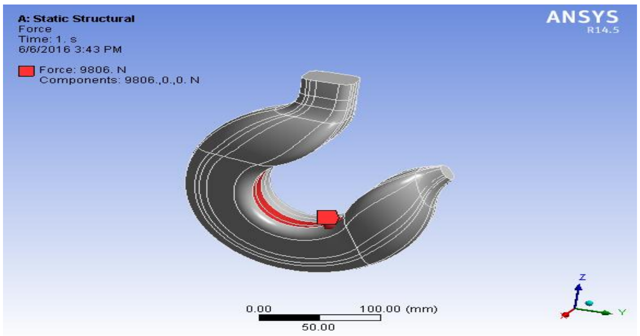


Fig. 10 Boundry Conditions Applied On Trapozoidal Hook

7.3 Stress Plot for Aluminium Alloy Of Hook

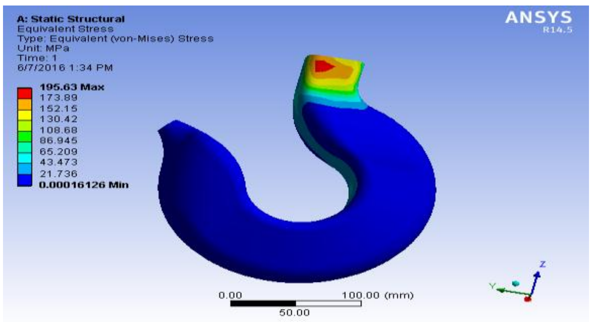


Fig.11 Max. Equivalent (Von -Mises) Stress For Aluminium Alloy

7.4 Deformation Plot For Aluminium Alloy

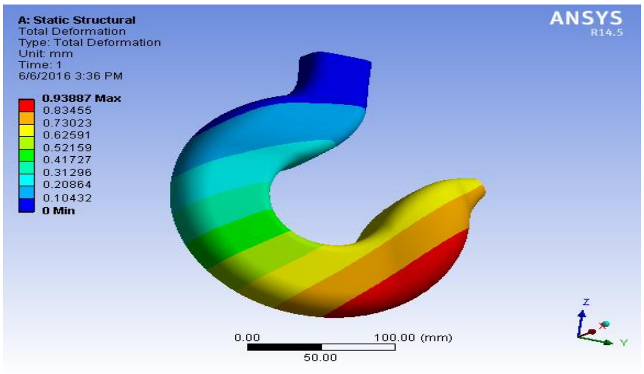


Fig. 12 Deformation For Aluminium Alloy

8. STRESS ANALYSIS OF HOOK WITH WROUGH IRON

8.1 Material Properties of wrough iron

A shank end of crane hook is fixed and a various loads are applied on bunch of nodes at lower centre of hook in downward direction. A load of 1ton (9806N) is taken for analysis. Material selected for crane hook is wrough iron and the properties of material are given below:

Chemical Composition of wrough iron

Element	Content (%)
Iron, Fe	99-99.8
Carbon, C	0.05-0.25
Phosphorus,P	0.05-0.2
Silicon, S	0.02-0.2
Sulfur, S	0.02-0.2
Mangnese, Mn	0.01-0.1

wrough iron > Density, MP

Density	7750kgm^-3
Coefficient of ThermalExpansion	1.3e-005C^-1
Melting Point	1540^{0}C
ThermalConductivity	69.5Wm^-1C^-1
Resistivity	2.3e-007ohmm

wrough iron > Modulus of Elasticity, Poisson's Ratio

Modulus of elsticity	1.93e+008Pa
Poisson's Ratio	0.278

wrough iron > Yield Strength

Yield Strength	2.29e+008Pa

wrough iron > Tensile Yield Strength

Tensile Yield Strength	2.34e+008Pa
CompressiveYield Strength	2.8e+008Pa

8.2 Boundary Conditions Applied On Wrough Iron Hook

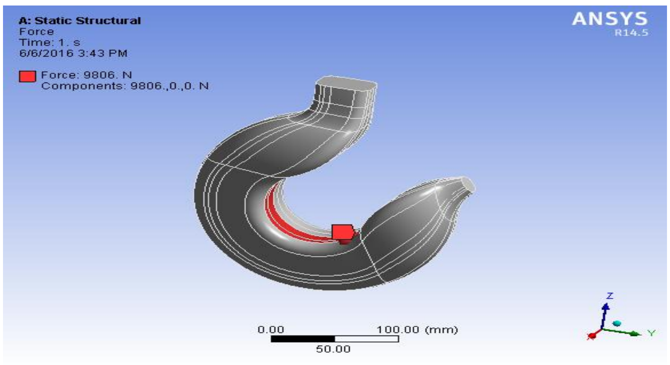


Fig.13 Boundary Conditions Applied On Wrough Iron Hook

8.3 Stress Plot for Wrough Iron hook

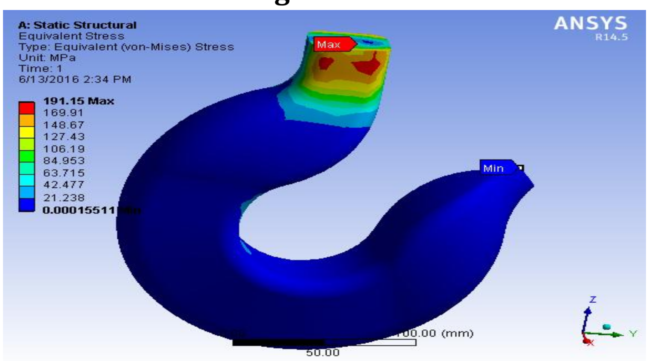


Fig.14 Max. Equivalent (Von -Mises) Stress For Wrough Iron

8.4 Deformation Plot For Wrough Iron

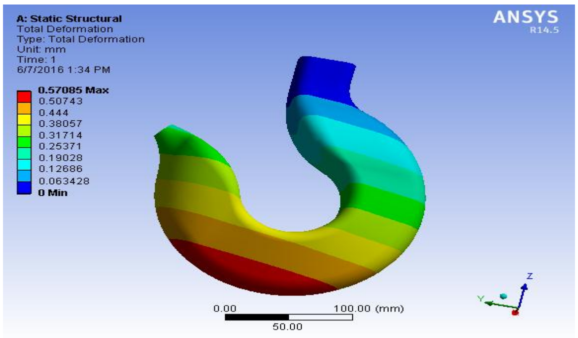


Fig.15 Deformation Plot for Wrough Iron hook

9. COMPARISON OF STRESSES

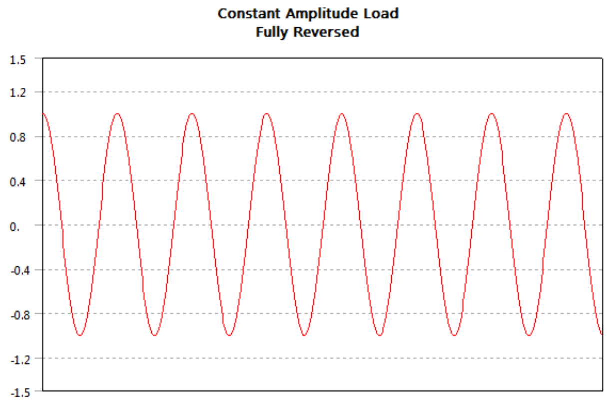
Table 2: Stresses for the various materials of Hook by ANSYS

Material	Load (N)	Max. Equivalent Stress (N/mm2)	Deformation in mm
Structural Steel	9806	189.77	0.56
Wrough Iron	9806	191.15	0.57
Aluminium Alloy	9806	195.63	0.93

It was observed that maximum total deformation occurred in Aluminium alloy and minimum total deformation occurred in structural steel and wrough iron. Thus among the three materials used, Structural steel is least prone to plastic deformation and stress which leads to failure of the material. It can be seen from the analysis that maximum stress concentration occurred in the upper region of the hook. From the Von Mises stress distribution it was observed that maximum stress concentration occurred in aluminium alloy and least stress concentration occurred in structural sreel and wrough iron. Thus, among the variable materials used for making hooks which were analyzed in this work, it is conclude that structural steel and wrough iron more suitable for making crane hooks as they have higher capacity to withstand loading.

10.FATIGUE ANALYSIS

Fatigue analysis is carried out for the model and the best 2 materials obtained and twofatigue contours are plotted. The two contour plots are fatigue life and fatigue damage. In the present study, the type of load mapping used for fatigue analysis is constant amplitude load mapping. Constant amplitude load mapping assumes FE stress/strain results to cycle between minimum and maximum values. The nCode Design Life SN constant amplitude load mapping engine is drag onto the solution cell of the mechanical system to generate file.rst file which reads node & element information and FE stress/strain results generated



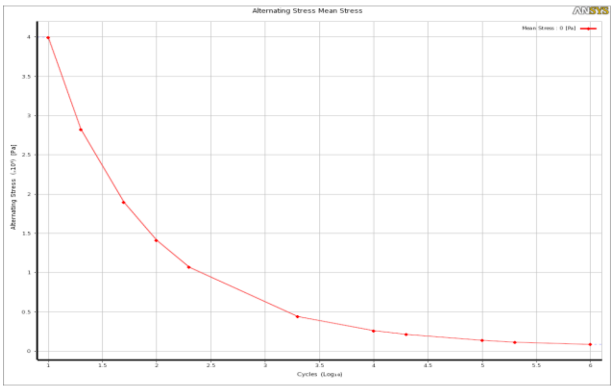


Fig. 16 S-N Curve

10.1. Fatigue Analysis Results

The available life for a specified fatigue analysis is given by the fatigue life contour plot. The contour plots of fatigue life of the actual model and the best

Materials	Minimum Fatigue Life(repeats)	Maximum Fatigue Damage
Structural Steel	$8.79E^{7}$	$1.138E^{-8}$
Wrough Iron	$8.805E^{7}$	$1.136E^{-8}$

Table 3. Comparison of fatigue results

two materials obtained are shown below. It shows the number of cycles the crane hook can withstand before fatigue failure. The minimum fatigue life of the actual crane hook model is repeats as shown in fig. The comparison of the fatigue life of each material is shown in table 3. Figures given below show contour plots of the fatigue damage of the actual hook and the best two materials obtained. It is noticed that the maximum fatigue damage occurs at the inner section of the crane hooks. The variation in fatigue damage of the crane hook is shown by the colour scale. The comparison of fatigue damage of each crane hook is shown in table 3.

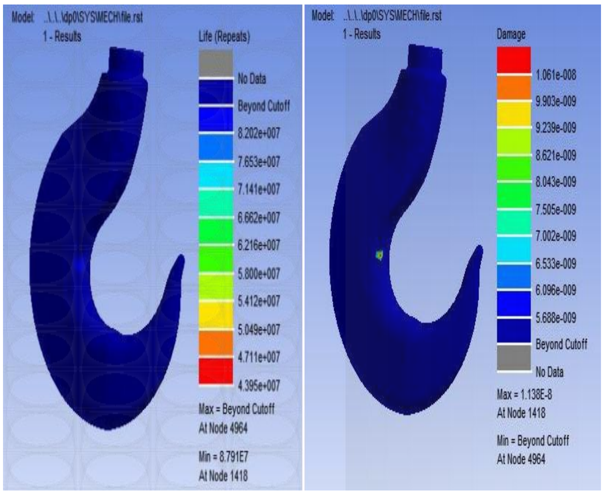


Fig.17 Fatigue life and damage contour plots of structural steel

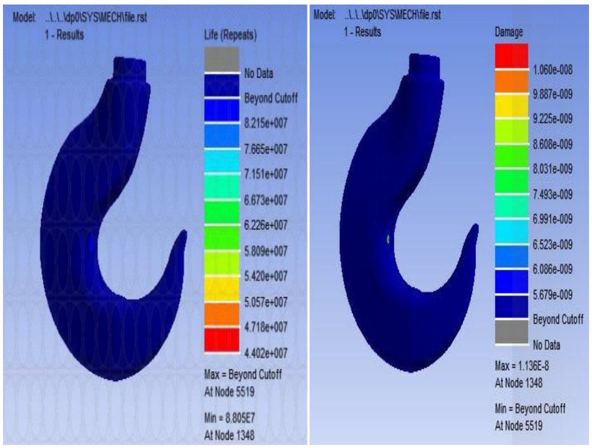


Fig.18 Fatigue life and damage contour plots of wrough iron

On the basis of fatigue analysis results obtained, wrough iron can withstand the maximum number of fatigue cycles before failure i.e., the minimum fatigue life obtained is 8.805E7 repeats which is nearer to structural steel values .Hence we can use wrough iron materials for crane hook.

CONCLUSION

The results of stress analysis calculated from FEA analysis for various different material such as Structural Steel ,Wrougt iron, Aluminium Alloy. For the different Material, It is observed that keeping the tone are same with different Material topology we will get different results, but from the above table it is found that the Structural Steel and Wrough Iron gives minimum stress .Further Fatigue analysis was done on the materials from that it is found that wrough iron can withstand the maximum number of fatigue cycles before failure. Hence we can use wrough iron materials for crane hook.

FUTURE SCOPE

Further it is advisable to conduct photo elasticity test for the crane hook under investigation in order to get better insight for stress concentration. Material saving approach by optimization of cross section area with consideration of stress concentration can be also done to put away manufacturing cost.

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BIBLOGRAPHY

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