Design and Analysis of Crane Hook with Different Materials

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Abstract - *Crane hook is significant component used for lifting the load with the help of chain or wire ropes. Crane hooks are highly liable components and are always subjected to bending stresses which leads to the failure of crane hook. Failure of a crane hook mainly depends on three major factors i.e. dimension, material, overload. To minimize the failure of crane hook, the stress occurred in it must be studied. Structural failure of the crane hook may happen as a crane hook is subjected to continuous loading and unloading. In this paper the design of the hook is done by analytical method for the different materials like high strength low alloy steel and Structural Steel. CATIA software is used for modelling the crane hook and ANSYS software used to find out the stresses induced in it. This result helps us for determining of stress in existing model. By predicting the stress concentration area, the hook working life increase and reduce the failure stress.*

Key word: - *Crane hook, CAD software, CAE software (ANSYS)*

1. INTRODUCTION

A Crane hooks are components which are always subjected to failure due to accumulation of large amount of stresses which can eventually lead to its failure. Crane hooks are generally used to lift 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. Cranes are mostly employed in transport, construction and manufacturing industry. Overhead crane, mobile crane, tower crane, telescopic crane, gantry crane, deck crane, loader crane, jib crane, are some of the commonly used cranes. A crane hook is a device used for lifting and grabbing up the loads by means of a crane. It is basically a hoisting fixture designed to engage a link of a lifting chain or the pin of a cable socket. Crane hooks with circular, trapezoidal, rectangular and triangular cross section are commonly used. So, crane hook must be designed and manufactured to deliver maximum performance without failure.

The crane hooks are vital components and are most of the time subjected to failure due to accumulation of large amount of stresses, which are ultimately leading to failure. Fatigue of the crane hook is happens due to continuous loading and unloading of crane. If the crack is detected in the crane hook, it can cause fracture of the hook. Due to this there are chances of serious accident. Bending stress, tensile stress, weakening of the hook due to wear, plastic deformation due to overloading, excessive thermal stresses are some of the other reasons of failure.

2. MATERIAL SELECTION

Structural Steel
High Strength Low Alloy Steel
ASTM Grade 60(Grey cast iron)

3. ANALYTICAL STRESS CALCULATION

Components having curved portions are frequently subjected to axial or bending loads or to a combination of bending and axial loads. The stress due to curvature become greater and the results of the equations of straight beams when used becomes less satisfactory, with the reduction in the radius of curved portion. For relatively small radii of curvature, the actual stresses may be several times greater than the value obtained for straight beams.
The various dimensions for crane hook are taken as follows:

1) Bed diameter

$C = x\sqrt{P}$, mm
$C = 3.12 \times 10^3$
Where, P=load, 49.82 KN

X=constant ranging between 12 to 24.For economic design, x should be as minimum as possible.

2) Throat of Hook (J): 2.34×10^3 mm

3) Depth of cross-section area:
$h = 70.89 \times 10^3$ mm

4) Width of cross-section (b):
$b_i = 46.08 \times 10^3$ mm

5) Parameter of cross-section:

The inner surface of the cross-section is called as intrados while the outer surface is called as extrados
The parameters of cross-section area are:

$R_i = 53.16 \times 10^3$ mm
$R_2 = 8.86 \times 10^3$ mm
$O_1O_2 = 8.86 \times 10^3$ mm

6) Radius of intrados and extrados:
$R_i = 1.56 \times 10^3$ mm
$R_0 = 110.58 \times 10^6$ mm

7) Stress in crane Hook:-
The crane hook is a curved bar subjected to:
- Direct stress(σ_d)
- Bending stress(σ_b)

8) Resultant stress at inner surface of crane hook(σ_i):
$A = 10.19.\times 10^3$ mm²
$M = 4.14 \times 10^9$ N-mm
$\sigma_d = 4.88$ N/mm2
$\sigma_b = 75.83$N/mm2

$$\boldsymbol{\sigma_i = \sigma_d + \sigma_b}$$
$$\boldsymbol{= 4.44 + 65.83}$$
$$\boldsymbol{\sigma_i = 80.71\ \ N/mm^2}$$

9) Resultant stress at outer surface of crane hook (σ_o):

$$\sigma_o = \sigma_d + \sigma_{bo}$$

$$\sigma_o = \frac{P}{A} + \frac{Mh_i}{AeR_i}$$

The resultant stress at inner surface is additional of tension stress due to direct load and tensile stress due to bending moment. Thus, net stress is additional of two stresses. The resultant stress at outer surface is tensile stress due to direct load and compressive stress due to bending moment. Thus, net stress is different of two stresses.

10) Neutral and centroid axes for Crane Hook
Distance for Trapezoidal Cross-section:-

$R_N = 6.66$
$R_G = 83.30 \times 10^3$
$e = R_g - R_N$
$e = 83.30 \times 10^3 - 6.66$
$e = 83.29 \times 10^3$

The above equations give the location of neutral axis and the distance between the two for various commonly used cross-sections.

Table -1: Design summary

Material	Ultimate strength	Direct stress	Bending stress	Resultant stress	FOS
High Strength Low Alloy Steel	460	4.88	75.83	80.71	5.69
Structural Steel	440	4.88	75.83	80.71	5.46
ASTM Grade 60	420	4.88	75.83	80.71	5.20

4. ANALYSIS

4.1 SOLID MODEL

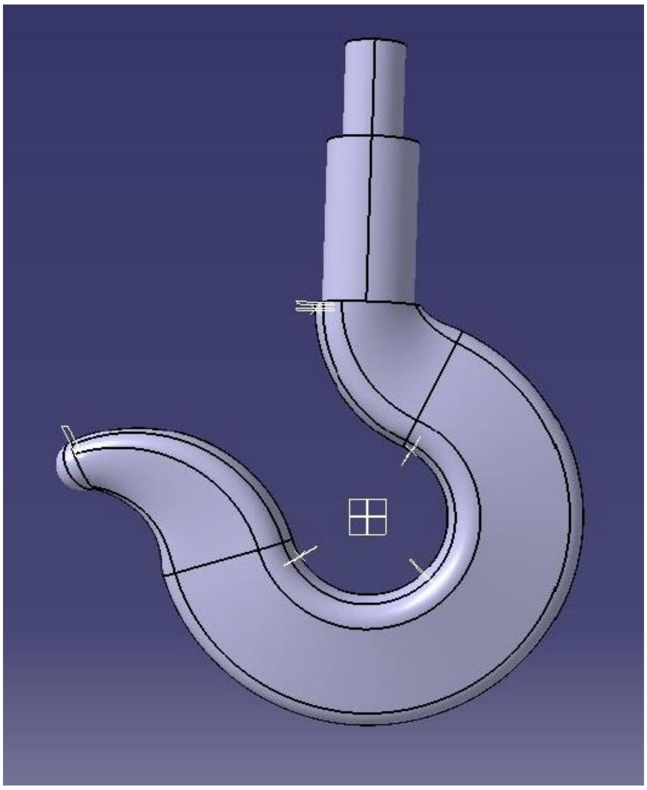

Fig 1.1 Solid Modelling of Crane Hook

4.2 MESHING

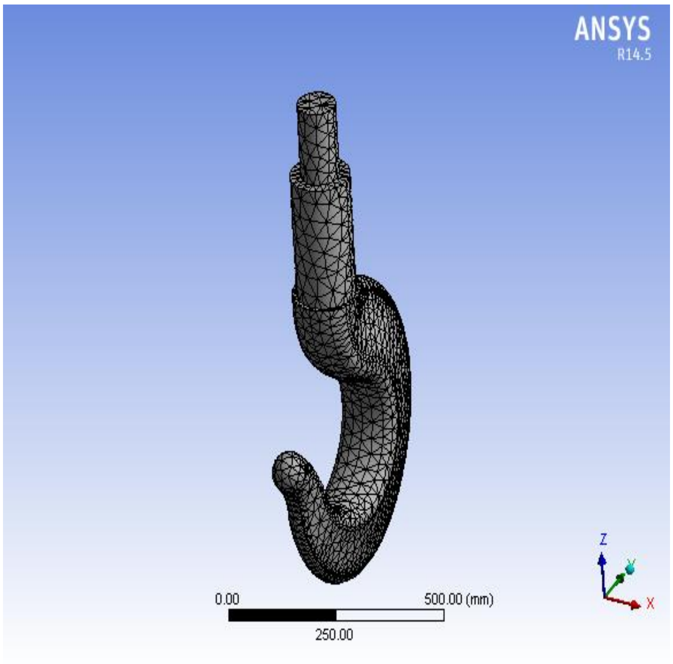

Fig 1.2 Meshing

4.3 LOADING & BOUNDARY CONDITIONS

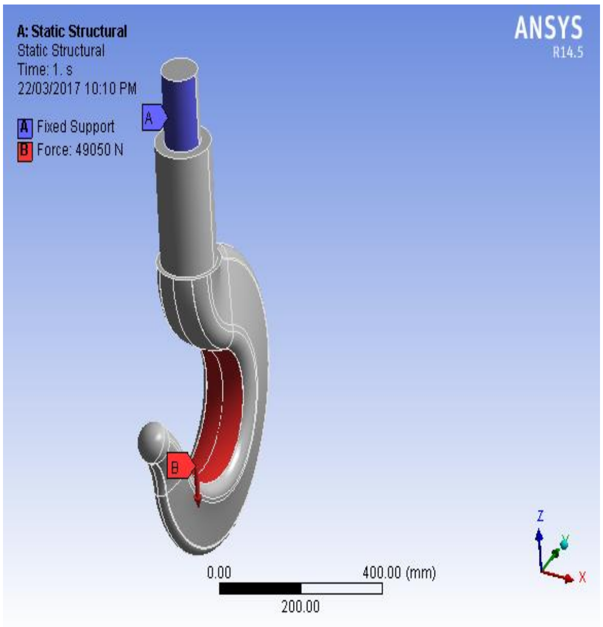

Fig 1.3 Loading & Boundary Condition

4.4 EQUIVALENT STRESS OF CRANE HOOK:

HIGH STRENGTH LOW ALLOY STEEL

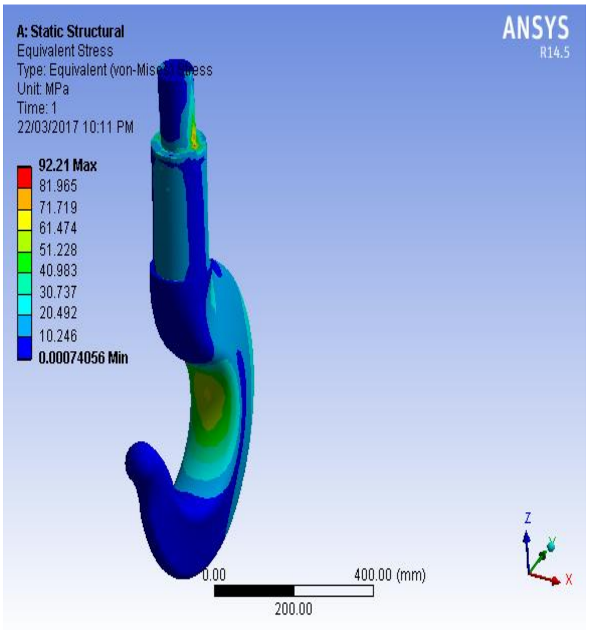

Fig 1.4 High Strength Low Alloy Steel

STRUCTURAL STEEL

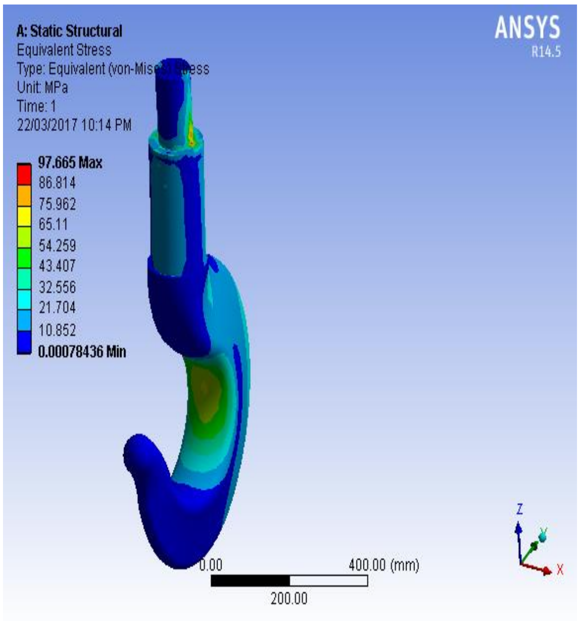

Fig 1.5 Structural Steel

ASTM Grade 60 (Grey cast iron)

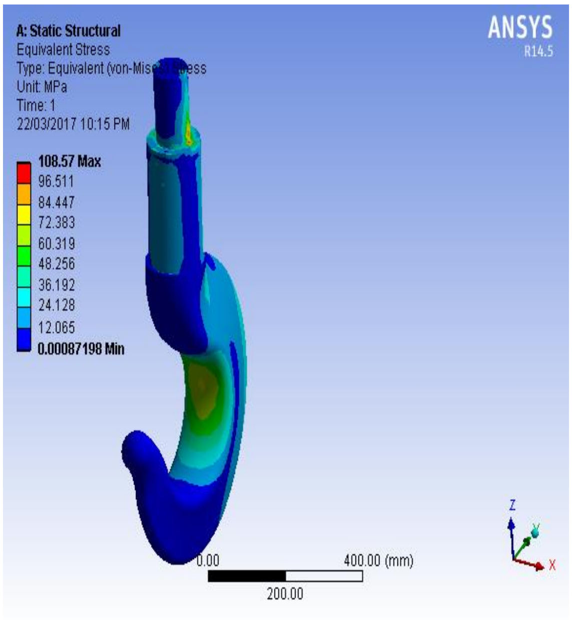

Fig 1.6 ASTM Grade 60(Grey cast iron)

RESULT AND CONCLUSIONS

The stress analysis results are calculated from FEA analysis for various different materials such as Structural Steel, ASTM Grade 60 (Grey cast iron) and High Strength Low Alloy Steel. For all different materials, we will get different results, by keeping the tone are same with different Material topology. But from the table, it is found that the High Strength Low alloy Steel Material gives minimum stress which describe in below table:

Table -2: Results

Material	Maximum Elastic Strain	Equivalent Stress	Total Deformation
High Strength Low Alloy Steel	0.00081354	92.21	0.67
ASTM Grade 60(Grey cast iron)	0.00095792	108.57	0.78889
Structural Steel	0.00086167	97.665	0.70963

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