Design & Analysis of Crane Hook with Ansys

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ABSTRACT:-

Crane hook is very significant component for lifting the load with the help of chain or links. Crane hooks are highly liable and are always subjected to failure due to the amount of stresses can ultimately lead to its failure. To minimize the failure of crane hook, the stress induced in it must be studied. A crane is subjected to continuous loading and unloading. This may causes fatigue failure of the crane hook. The review of previous enable to conclude that components with complex geometry as crane hooks require a more extensive investigation in view of the fact that a very few articles have been published so far regarding stress analysis of this curved beam (crane hook).

Keywords:- crane Hook, design

1. INTRODUCTION OF CRANE

Crane hooks are always subjected to loads due to accumulation of large amount of stresses which can eventually lead to its failure. These 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.

1.1 Used in Construction Field

A crane is a lifting machine principally works by the use of pulleys and cables. For the construction industry, these are valuable machines because they make working with heavy machinery and construction materials effectively.

The invention of cranes made things easy for humankind because without them, loading, unloading, and lifting had to be done by human hands, would consume more time, and the entire system was not efficient at all. The ancient Greeks invented the first construction crane hundreds of years ago. Modern day construction cranes are huge, taking up tons of material hundreds of meters in height. For high end infrastructure projects, tower cranes are used that have a reach as high as 800 meters.

Fig.1 Crane used in construction site

2. CRANE WORK

The reason for this research is, damage is one of the key points toward the safety improvement. If a crack is developed in the crane hook, mainly at stress concentration areas, it can cause fracture of the hook and lead to serious accidents. In ductile fracture, the crack propagates continuously and is more easily detectable and hence preferred over brittle fracture. In brittle fracture, there is sudden propagation of the crack and the hook fails eventually.

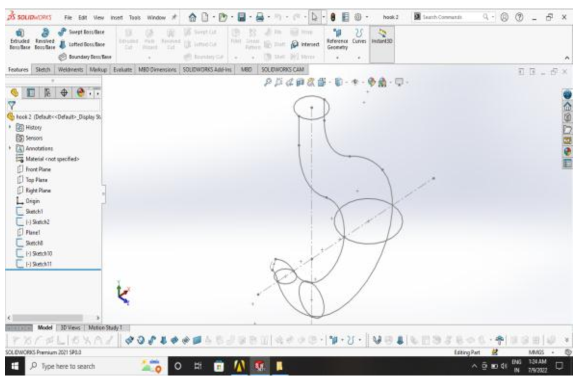

Fig.2Triangular cross-section Sketch

This type of fracture is very dangerous as it is very difficult to detect. Hence continuous use of crane hooks may increase the magnitude of these stresses and leads to the result in failure of the hook. All the above mentioned failures may be prevented if the stress concentration areas are well predicted and some design modification to reduce the stresses in those particular areas.

Failure of crane Hook:- Bending stresses combined with tensile stresses, weakening of hook due to wear, plastic deformation due to overloading, and excessive thermal stresses are some of the other reasons for failure. Hence continuous use of crane hooks may increase the magnitude of these stresses and eventually result in failure of the hook. due to continuous working structure of crane Hook are changes and some problems like weakness of crane hook due to tensile stresses,wear,plastic deformation due to overloading and excessive stresses these are other reason of failure.

2.1 Circumferential Stresses In A Curved Beam:

The circumferential stress distribution for the curved beam is obtained by the curved beam formula:

$$\sigma_{\theta\theta} = \frac{N}{A} + \frac{M(A - rA_m)}{Ar(RA_m - A)}$$

Where,

$\sigma_{\theta\theta}$ = hoop stress, $\frac{N}{A}$ = axial stress,remaining quantity is bending stress.

2.2 Radial Stresses In Curved Beams

The radial stresses stress distribution for the curved beam is obtained by formula:

$$\sigma_{rr} = \frac{AA'_m - A'A_m}{trA\ (RA_m - A)} M_x$$

2.3 Analytical Method For Stress Calculation

Curved beam flexure formula is used when the curvature of the member is pronounced as in case of hook for different cross-sections mathematical analysis of stress.

$$\sigma = \frac{F}{A} + \frac{M \times Y}{I}$$

Where,

M=maximum bending moment.

Y=Distance between centroid axis to neutral axis.

I=Moment of inertia for different cross sections.

Crane Hook safety:- Crane hooks used with safety latches used to provide an extra level of security when hoisting and rigging loads, safety latches can help ensure that a sling is securely attached to the load, to prevent it from sliding when the sling becomes slack. Proper lifting can move large objects efficiently and decrease manual handling operation improper design of crane hook lead to accident improper lifting case injuries lowest to work time and property manpower machinery loads methods and the environment are all important factor for proper lifting providers that enough safety measures are fully implemented accidents can be decreased.

2.4 Design Calculations

Design of crane hook using trapezoidal cross section area:

Allowable stress = 160 N/mm^2

h=70mm (diameter)

C=164 mm (bed diameter)

Parameter of crane hook:

Width of cross section:

$B_i = 0.65 \times h = 0.65 \times 70$

= 45.5 mm

Let us take; $B_0 = 0.5 \times B_i$

$\mathbf{B_0} = 0.5 \times 45.5$

$\mathbf{B_0}$ = 22.7 mm

(I)Cross section area (A):

$A = ((b_i+b_0)/2) \times h$

$= ((\frac{45.5+22.7}{2}) \times 70$

A = **2387 mm^2**

(II) Inner and outer radius:

$R_i = 0.5 \times c$	$R_o = (0.5 \times c) + h$
$= 0.5 \times 164$	$= (0.5 \times 164) + 70$
$\mathbf{R_i}$ **= 82 mm**	R_o = **152 mm**

(III) Radius of neutral axis (R_N)

$$\mathbf{R_N} = \frac{\left(\frac{b_i+b_o}{2}\right) \times h}{\left(\frac{b_i \times R_o - b_o \times R_i}{h}\right) \log\left(\frac{R_o}{R_i}\right) - (b_i - b_o)}$$

$$= \frac{\left(\frac{45.5+22.7}{2}\right) \times 70}{\left(\frac{45.5\times152-22.7\times 82}{70}\right)\log\left(\frac{152}{82}\right) - (45.5-22.7)}$$

R_n = 92.6mm

(IV) Radius of centroidal axis = $(\boldsymbol{R_g})$

$$R_g = R_i + \frac{h(b_i + 2b_o)}{3\,(b_i+b_o)}$$

$$= 82+ \frac{70(45.5+ 2\times22.7)}{3\,(45.5+22.7)}$$

$\boldsymbol{R_g}$ = 113 mm

(V) Distance between centroidal axis or neutral axis

E = $\boldsymbol{R_g}$ – R_n = 113 – 92.6

=20.4 mm

Resultant stresses at inner surface($\boldsymbol{\sigma_i}$)

M = p × R_n = p × 92.6

H_i=$\boldsymbol{R_N}$ – $\boldsymbol{R_i}$ = 92.6 – 82

=10.6 mm

H_0 =R_0 - R_n = 152 - 92.6 = 59.4

$$\sigma_i = \frac{p}{A} + \frac{Mh_i}{A_e R_i}$$

$$\sigma_i = \frac{p}{2387} + \frac{p\times 92.6 \times 10.6}{7408.1 \times 82}$$

130=5.65 × 10^{-3} P

P = 35.5x10^3 N

Resultant stresses at outer surface (σ_0)

$$\boldsymbol{\sigma_0 = \frac{p}{a} - \frac{Mh_0}{A_e R_0}}$$

$$\sigma_{0}= \frac{p}{2387} - \frac{p \times 92.6 \times 59.4}{7408.1 \times 152}$$

170 =1.4638 × 10^{-3} P

P = 63508 N

Load carrying capacity:

Taking lowest of two values given by equations the load carrying capacity of crane hook is

P = 35.5 ×10^3 N

ANSYS:-Ansys, Inc. is an American multinational company with its headquarters based in Canonsburg, Pennsylvania. It develops and markets CAE/metaphysics engineering simulation software for product design, testing and operation and offers its products and services to customers worldwide. Ansys develops and markets engineering simulation software for use across the product life cycle. Ansys Mechanical finite element analysis software is used to simulate computer models of structures, electronics, or machine components for analyzing the strength, toughness, elasticity, temperature distribution, electromagnetism, fluid flow, and other attributes. Ansys is used to determine how a product will function with different specifications, without building test products or conducting crash tests.[5] For example, Ansys software may simulate how a bridge will hold up after years of traffic, how to best process salmon in a cannery to reduce waste, or how to design a slide that uses less material without sacrificing safety.Most Ansys simulations are performed using the Ansys Workbench system,which is one of the company's main products. Typically Ansys users break down larger structures into small components that are each modeled and tested individually. A user may start by defining the dimensions of an object, and then adding weight, pressure, temperature and other physical properties. Finally, the Ansys software simulates and analyzes movement, fatigue, fractures, fluid flow, temperature distribution, electromagnetic efficiency and other effects over time. Ansys also develops software for data management and backup, academic research and teaching. Ansys software is sold on an annual subscription basis.

3. RESULT AND DISCUSSION:

A single point load (6 tons/ 63508N) is applied which is equally distributed throughout the selected surfaces and required results such as equivalent stress, strain and total deformation is analyzed. The simulations process is carried out by assigning four different materials having different characteristics.

Table 1 Material properties

Material Name	Grade	Density	Tensile Strength (MPa)	Yield strength (MPa)	Hardness (HB)	Modulus of Elasticity(GPA)	Passion ratio
Forged steel	AISI1020	7750	430	230	120	200	0.3
Structural steel	S355	7850	460	250	187	210	0.3
Cast iron	ASTM A48	7060	450	200	200	140	0.5
Wrought iron	ASTM A159	7750	410	220	180	98.2	0.278

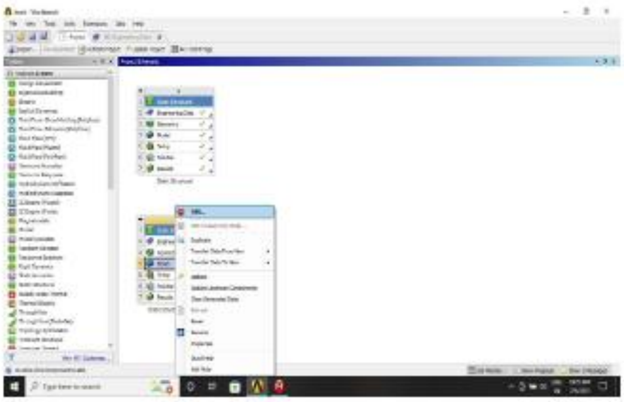

Fig.3 Material properties

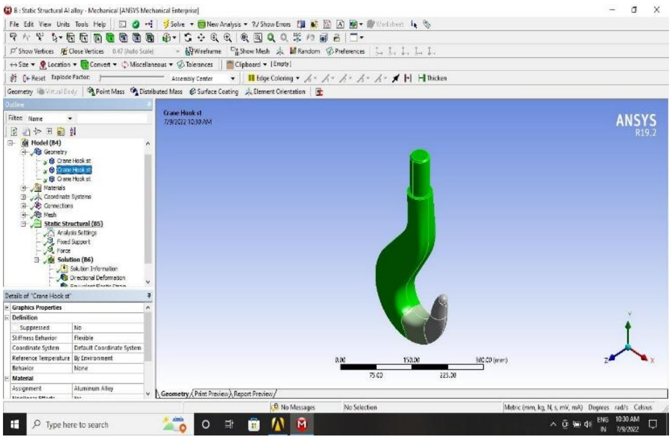

Fig4- Crane Hook modelling

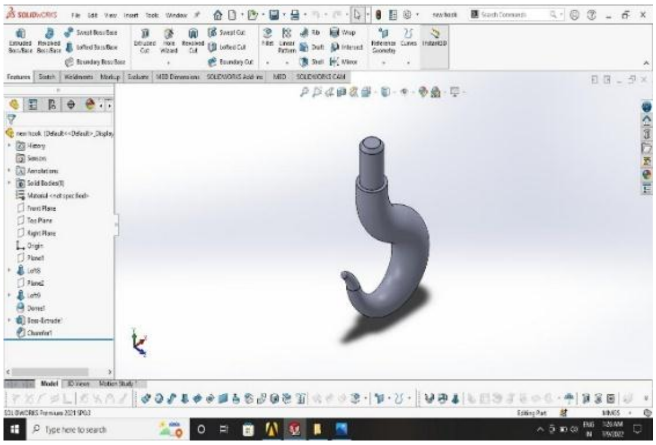

Fig5- Crane Hook design

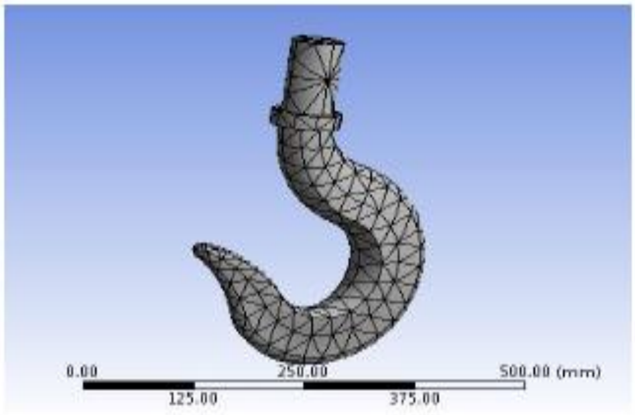

Fig.6 Crane hook meshing

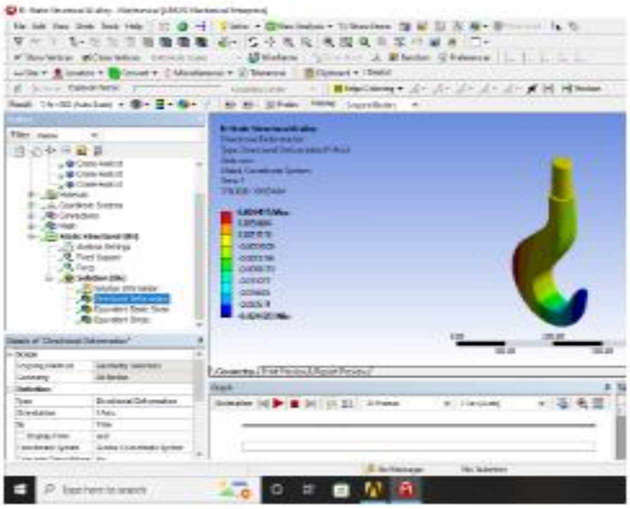

Fig.7 Crane hook stress analysis

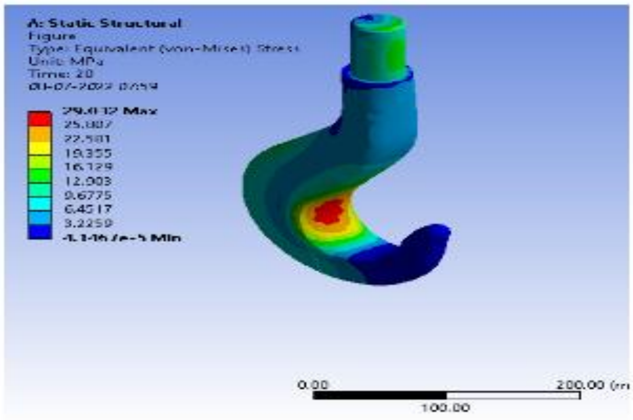

Fig.8 Crane hook deformation analysis

Structural steel is a category of steel used for making construction materials in a variety of shapes. Many structural steel shapes take the form of an elongated beam having a profile of a specific cross section. Most steels used throughout Europe are specified to comply with the European standard EN 10025. However, many national standards also remain in force.

Structural steel material is the most feasible material as compare to the other [wrought iron, Structural steel & Grey cast iron] because of its lowest Max.

Stress 250 MPa (as shown in graph).

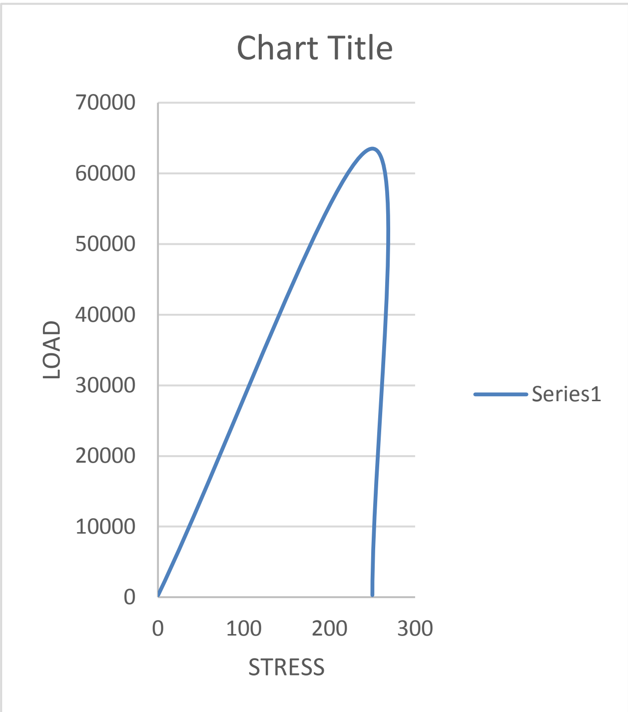

Fig.9 Graph of stress and deformation

The simulation studies conducted on the crane hook using the Alloy S355 for its sustainability against loading gives the results such as Von Mises stress, Factor of Safety (FOS), Strain and Displacements.

CONCLUSIONS:-

Structural steel material is the most feasible material compared to wrought iron, & grey cast iron as it has lowest maximum stress 250 MPa. The basic of structural steel compair to other yield strength, toughness is higher.We have successfully optimized the material of the crane hook We have study the structural stresses of hook by ANSYS R19.2 &o concluded that the material which is having less deformation will have more stability if less failure of crane hook. Final we got the material Structural Steel with less deformation. So it is the material suitable for crane hook.

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