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FEA ANALYSIS METHOD OF STRESS CALCULATION OF VARIOUS CROSS SECTION OF CRANE HOOK

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Abstract - *The crane hook is very important component used in most industries. The design of crane hook contains such parameters like cross section of hook, material and radius of curvature. In this present work cross section of crane hook is considered for analysis purpose. The cross section is trapezoidal, rectangular, circular, triangular, I and T section. Here, first modeling of trapezoidal cross section is done by taking dimension from design data book. The area of cross section of trapezoidal is used to find out the cross-section dimension of other. Modeling is done on CATIA V5 R19 3d software. The FEA analysis is done on ANSYS Workbench 15.0 to find out the max equivalent stress, total deformation and location of max stress area. By comparing these stresses of all cross section find out the better cross section. Here trapezoidal, I and T cross section are better than all other cross sections. The triangular cross section is also suitable, but stress induced during loading is more as compare to other cross sections. Then these trapezoidal, I and T cross section are used for optimization. Then the cross-section parameters are changes by taking same cross section area and analysis is performed. The tabular result of this analysis is used to find out the best possible combination of cross-sectional parameter of all cross section of crane hook.*

Key Words: Crane Hook, Crane Hook Cross Section, FEA analysis, Direct and Bending Stress.

1. INTRODUCTION

The study had done on various cross section of crane hook. These cross sections are Trapezoidal, Rectangular, Circular, Triangular, I and T. The crane hooks are used to lift the heavy load which produces high stress on crane hook, which leads to failure of crane hook. Thus, it must be designed to deliver maximum performance without failure. Thus, the aims of this research are to find better cross section and their cross-sectional parameter and study the stress distribution pattern within a crane hook. This can be done by FEA analysis, analytical and experimental method. This analysis is used to find the location of max stress area. The optimization of crane hook is done by changing the cross-sectional parameters of suitable cross section of crane hook.

The crane hook is a curved bar subjected to:

- Direct stress (σ_t)
- Bending stress (σ_b)

The general expression for the bending stress (σ_b) in a curved beam at any fibre at a distance y from the neutral axis is given by,

$$\sigma_b = \frac{M}{A.e}\left(\frac{y}{(R_n - y)}\right)$$

Where,

M = Bending moment acting at the given section about the centroidal axis,
A = Area of cross-section,
e = Distance from the centroidal axis to the neutral axis = R – Rn,
R = Radius of curvature of the centroidal axis,
Rn = Radius of curvature of the neutral axis, and
y = Distance from the neutral axis to the fibre under consideration. It is positive for the distances towards the centre of curvature and negative for the distances away from the centre of curvature.

2. OBJECTIVE

The objective of this paper is to calculate the stresses produced in the crane hook due to loading and find out the location of max stress area in all different cross sections by FEA analysis method. Then by comparing this stress find out the best suitable cross sections for crane hook.

3. MODELING OF CRANE HOOK

All cross sections of crane hook are modeled in CATIA V5 R19 software. Dimensions are taken from design data book. The .igs files of these models are imported in ANSYS Workbench 15.0 for analysis purpose. The three-dimensional model of the crane hook for all cross sections are shown in the Fig. 1

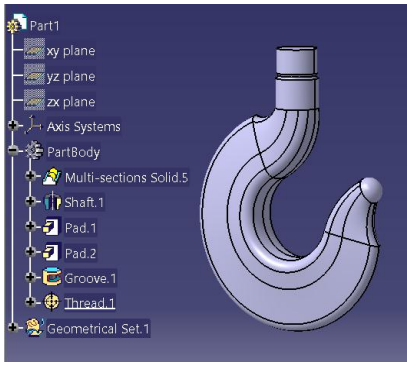

Fig.1: Modeling of Crane Hook

4. STATIC STRUCTURAL ANALYSIS OF CRANE HOOK

The structural analysis of all cross sections of crane hook is done on ANSYS Workbench 15.0

Table 1: Static structural analysis

Object Name	Static Structural (A5)	
State	Solved	
Definition		
Physics Type	Structural	
Analysis Type	Static Structural	
Solver Target	Mechanical APDL	
Options		
Object Name	Fixed Support	Force
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	7 Faces	2 Faces
Definition		
Geometry	7 Faces	2 Faces
Suppressed	No	
Define By		Components
Coordinate System		Global Coordinate System
X Component		0. N (ramped)
Y Component		0. N (ramped)
Z Component		-1.6e+005 N (ramped)

5. MESHING

The process of dividing the model into small pieces is called meshing. The behaviour of each element is well-known under all possible support and load scenarios. The finite element method uses elements with different shapes. Elements share common points called nodes.

Table 2: Netting

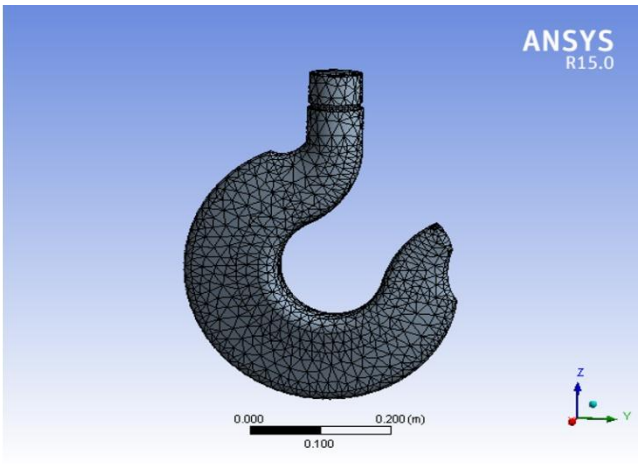

Fig. 2: Modeling of Crane Hook

6. LOADING AND BOUNDARY CONDITION

In this, shank of crane hook is fixed, and load is applied in vertical down word direction of crane hook. Here 16-ton load is applied.

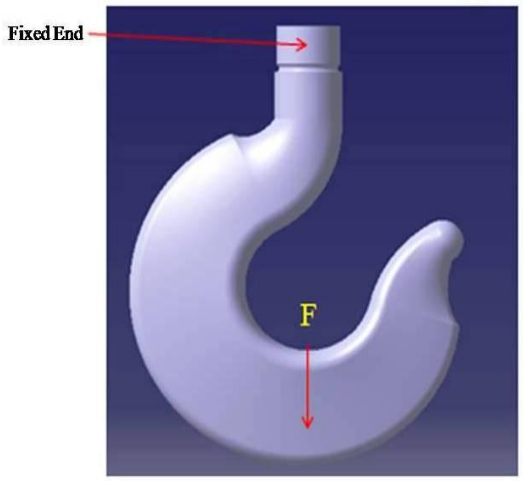

Fig.3: Loading and boundary condition

7. APPLICATION OF MATERIAL

The structural steel material is used for analysis. The properties are as follow,

Table 2: Material properties of structural steel.

	Structural Steel
Density (Kg/m3)	7850
Youngs modulus (GPa)	200
Tensile strength-Yield (MPa)	250
Tensile strength-Ultimate (MPa)	460
Thermal Expansion (Base 22^0 C)	12

8. SOLUTION

The analysis is performed, and max equivalent stress and deformation is considered for analysis. This analysis gives the location of max stress area. The equivalent stress and total deformation of trapezoidal cross section are shown in fig. 4 and fig. 5 respectively. Same analysis is carried out for all other cross sections.

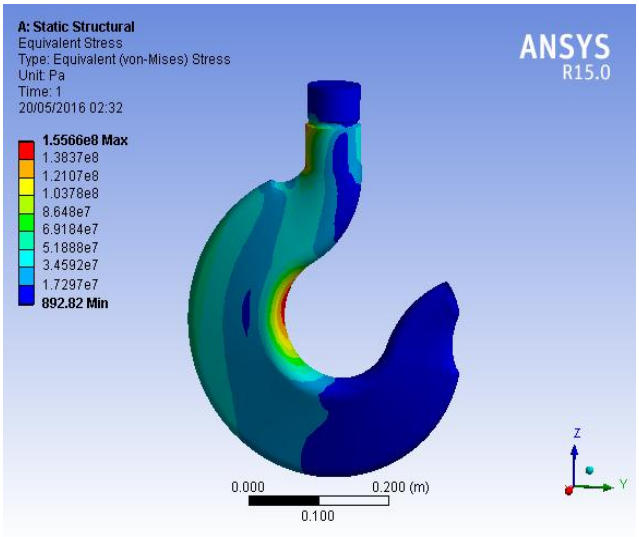

Fig. 4: Equivalent stress in trapezoidal cross section.

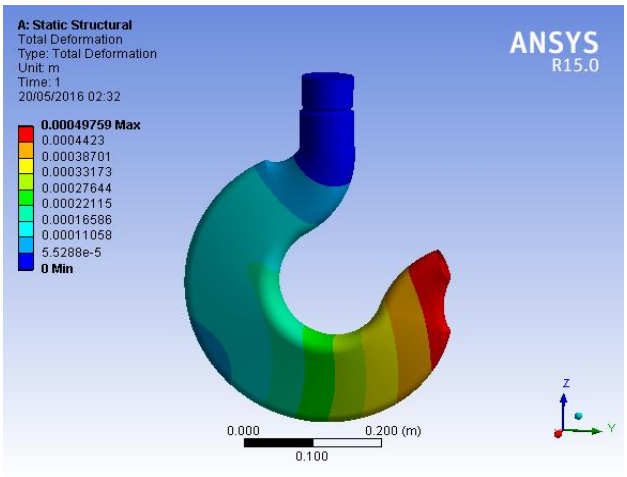

Fig. 5: Total deformation in trapezoidal cross section

9. DATA ANALYSIS BY FEA RESULT

Table 3: Max equivalent stress and Total deformation of all cross sections of crane hook by FEA analysis.

Cross section of crane hook.	Max equivalent stress (MPa)	Total deformation (mm)
Trapezoidal	155.66	0.495
Rectangular	194.72	0.531
Circular	284.42	0.562
Triangular	160.32	0.865
I Section	132.39	0.490
T Section	140.32	0.520

10. RESULTS AND DISCUSSION

This study tabulated the direct stress, bending stress and resultant stress of all cross section of crane hook obtained by analytical and fea method. Here this tabulated result are compared and find out the best possible cross section of crane hook. These cross sections are further used for optimization purpose and find out the best suitable cross-sectional parameter for crane hook.

The result obtained by analytical design calculation and FEA analysis are compared and find out the percentage error. This comparison gives the best possible cross sections of crane hook.

Table 4: Comparison between Analytical stress and FEA stress

Cross section of crane hook.	Analytical stress (MPa)	FEA(Max equivalent stress (MPa)	% Error
Trapezoidal	161.22	155.66	3.57
Rectangular	186	194.72	4.68
Circular	272.27	284.42	4.46
Triangular	165.52	160.32	3.24
I Section	138.21	132.39	4.39
T Section	146.17	140.32	4.17

11. SAFE LOAD CALCULATION

From table 5.1 best possible cross sections for crane hook are,

1. Trapezoidal Section
2. Triangular Section
3. I Section
4. T Section

The safe load carrying capacity for above cross sections are calculated by taking factor of safety 1.5

Table 5: Safe load carrying capacity of all cross sections by taking F.S = 1.5

Cross section of crane hook	Safe load by taking F.S = 1.5 (N)	Increased load carrying capacity (N)
Trapezoidal	165735.5	8765.5
Triangular	171447.6	14487.6
I Section	193334.1	36374.1
T Section	182906.1	25946.1

The stress induced during loading in triangular cross section is high as compare to other cross section.

So, from Table 5.1 and Table 5.2, the best possible cross sections for crane hook are

1. Trapezoidal Section
2. I Section
3. T Section

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