DESIGN AND ANALYSIS OF EOT CRANE HOOK FOR VARIOUS CROSS SECTIONS

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Abstract
Crane hooks are one of the important components which are used to transfer materials having heavy loads, mainly in industries. Crane hooks are liable components subjected to failure due to stress in accumulation of heavy loads. Failure of a crane hook mainly depends on three major factors i.e. dimension, material, overload. The design parameters for crane hook are area of cross section, material and radius of crane hook. In this project the design of EOT crane hook has been carried out. The dimensions of the hook have been determined for a load capacity between 9 to 12.5 Tones for Trapezoidal, Rectangular and Circular cross-sections. These dimensions are calculated on the basis of design criteria i.e. keeping area same for all cross-sections. After the analytical i.e. theoretical calculations, ANSYS 15 is used to calculate the deformation, stress and strain for all three cross-sections for different loads. The stresses obtained by theoretical method and by software are in good agreement. The model prepared is used for further studied with different loads and also for different materials.
Index Terms: Lifted load, Eye diameter of hook, Direct stress, Bending stress, Equivalent stress, Deformation, Strain.

I. INTRODUCTION

Cranes are industrial machines that are mainly used for materials movements in construction sites, production halls, assembly lines, storage areas, power stations and similar places. Their design features vary widely according to their major operational specifications such as: type of motion of the crane structure, weight and type of the load, location of the crane, geometric features, operating regimes and environmental conditions.

A hook is a tool consisting of a length of material that contains a portion that is curved or indented, so that this portion can be used to hold another object. In a number of uses, one end of the hook is pointed, so that this end can pierce another material, which is then held by the curved or indented portion.

In the industries crane hooks are one of the important components. They are used to transfer the materials having heavy loads. Crane hooks are liable components subjected to failure due to stress in accumulation of heavy loads. Area of cross section, material and radius of crane hook are the design parameters for crane hook. Failure of a crane hook mainly depends on three major factors i.e. dimension, material, overload.

The design of EOT crane hook has been carried out. The dimensions of the hook have been determined for different load capacities. Various dimensions for cross sections of various shapes for crane hook have been found. After the system was designed, the stress and deflection are calculated at critical points using ANSYS and optimized.

II. DESIGN AND CALCULATION

A. DESIGN OF HOOK

The hook is to be designed having load carrying capacity of 125kN. Hook is made up of high tensile steel. Three different cross sections i.e. trapezoidal, rectangular and circular are considered. By keeping area same for all cross sections as a design criteria, direct stress, bending stress, shear stress are found.

B. CALCULATION FOR TRAPEZOIDAL CROSS SECTION

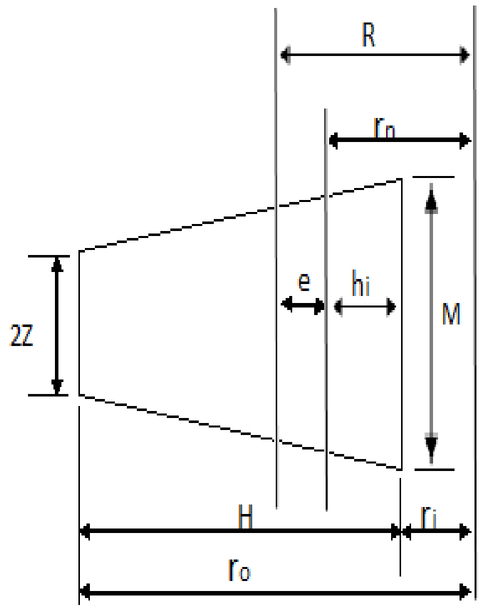


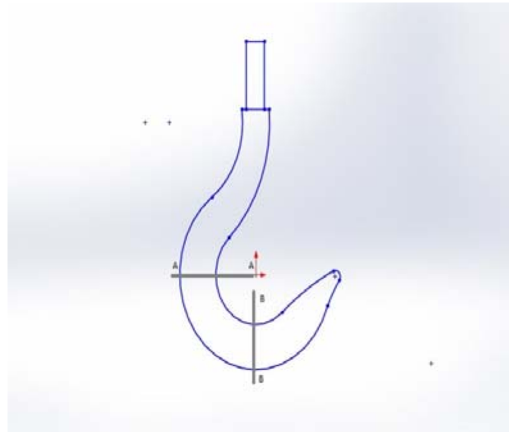
Fig. No.1 Standard Trapezoidal Hook

Eye diameter of hook, C=131mm and Dimensions corresponding to C are G=70mm, G_1=M68.

Table No.1 Notation for trapezoidal c/s area

Notation on PSG 9.11	**Dimension (mm)**	**Notation on PSG 6.3**	**Nomenclature**
H=0.93C	121.83	H	Height for trapezoidal c/s.
M=0.6C	78.6	b_i	Inner width of trapezoidal c/s.
2z=2(0.12C)	31.44	b_o	Outer width of trapezoidal c/s.
C/2	65.5	r_i	Inner radius for trapezoidal c/s.
H+C/2	187.33	r_o	Outer radius for trapezoidal c/s.

Stresses induced in hook (at section A-A & B-B)



A) Distance of neutral axis from axis of curvature (PSG 6.3)

$$r_n = \frac{1/2(b_i + b_o)h}{\frac{(b_i r_o - b_o r_i)}{h}\left(\ln\frac{r_o}{r_i}\right) - (b_i - b_o)} \qquad \text{(I)}$$

r_n = 107.98 mm

B) Distance of CG from axis of curvature.(PSG 6.3)

R = $r_i + \frac{h}{3}\left\{\frac{b_i + 2b_o}{b_i + b_o}\right\}$, R = 117.71mm (II)

Cross section area,
$a = \frac{1}{2}(b_i + b_o)h$, a = 6703.08 mm^2 (III)

Total stress induced at A-A

For innermost layer: - Total stress, $\sigma = \sigma_d + \sigma_b$
Where,
σ_d = direct stress = $\frac{W}{a}$ = 18.648N/mm^2 (IV)

σ_b = bending stress = $\frac{M_b \times h_i}{a \times e \times r_i}$ = 146.312 N/mm^2 (PSG 6.2) (V)
Hence σ = 164.96 N/mm^2, taking FOS=3.
$\sigma_{y\,reqd} = \sigma \,.FOS$= 494.88 N/$mm^2$

Selecting material 40cr1 (PSG 1.13)
σ_y = Yield stress = 600 N/mm (PSG 1.13)

Hence, design stress = $[\sigma]$ = σ_y / FOS = 200 N/mm^2 (VI)
$[\tau]$ = σ_y / 2. FOS = 100 N/mm^2

Checking for direct shear stress at B-B

$\tau = W/a =$ 18.648N/mm^2 < 100 N/mm^2 (safe) (VII)

C. CALCULATION FOR RECTANGULAR C/S

For same cross section by keeping area is same and assuming h/b = 1.5

Cross section area, a = 6703.08 = b * h = b * (1.5b) = 1.5 b^2

Hence, b = 67mm and h = 101mm (VIII)

$r_o = r_i + h = C/2 + h = 65.5 + 101 = 166.5$mm (IX)

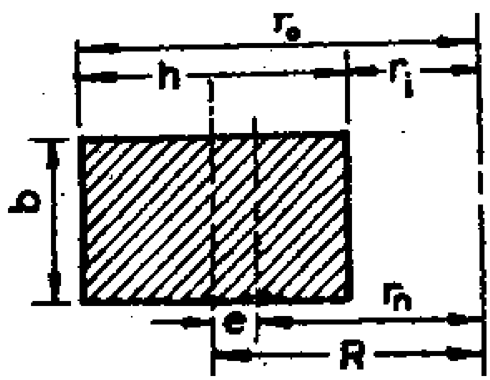


Fig. No. 2 Standard Rectangular Hook

A) Distance of neutral axis from axis of curvature (PSG 6.3)

$r_n = h / \ln (r_o / r_i) = 108.25$mm (X)

B) Distance of CG from axis of curvature (PSG 6.3)

$R = r_i + h/2 = 116$mm (XI)

D. CALCULATION OF CIRCULAR C/S

Cross section area, a = 6703.08 = π/4 * d^2
hence, d = 93mm

$r_o = r_i + d = 65.5 + 93 = 158.5$mm (XII)

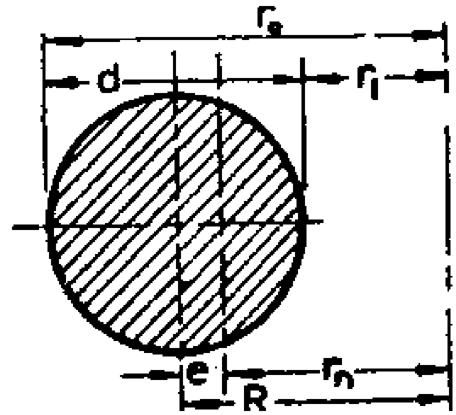


Fig. No. 3 Standard Circular Hook

A) Distance of neutral axis from axis of curvature (PSG 6.3)

$r_n = [\sqrt{r_o} + \sqrt{r_i}]^2 / 4 = 106.95$mm (XIII)

B) Distance of CG from axis of curvature (PSG 6.3)

$R = r_i + d/2 = 112$mm (XIV)

Table No. 2 Different Stresses (MPa) for Trapezoidal, Rectangular and Circular cross-sections.

Stress	Trapezoidal	Rectangular	Circular
Section A-A at curvature			
σ_d	18.648N/mm^2	18.648N/mm^2	18.648N/mm^2
σ_b	146.312 N/mm^2	182.174N/mm^2	216.725N/mm^2
σ	164.96 N/mm^2	200.822N/mm^2	280.373N/mm^2
Section B-B at curvature			
τ	18.648N/mm^2	18.648N/mm^2	18.648N/mm^2

Table No. 2 gives the values of direct stress, bending stress and shear stress for all cross sections. However above calculations are only for 125 kN load. By following same design procedure respective values for all stresses is been calculated for remaining loads i.e. 110 kN, 90 kN.

III. SIMULATION

Finite element analysis is done in following four steps namely, 1. Geometry 2. Meshing 3. Boundary Condition & 4.Solver. Geometry i.e.

solid modeling is done using solid works. Fig. No. 4 shows the solid model of hook.

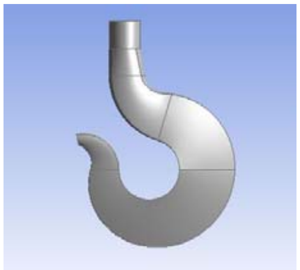
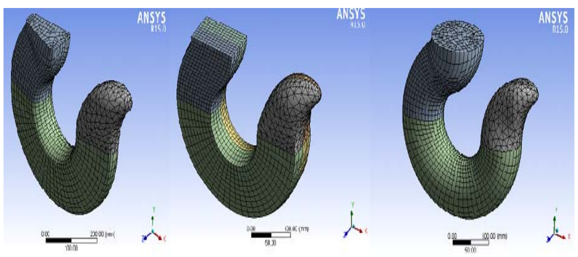


Fig. No. 4 3D model of Hook

This solid model is then imported in ANSYS 15.0 for further analysis. Meshing of the hook is done in ANSYS mesher keeping proximity and curvature option on. Fine mesh is done for good quality mesh. Meshing of the hook of different cross sections is shown in Fig. No. 5.



(A) (B) (C)

Fig. No. 5 Meshing of hook (A) Trapezoidal c/s (B) Rectangular c/s (C) Circular c/s

After meshing, boundary condition i.e. load of 90 kN, 110 kN and 125kN is applied to generate real time condition. Application of boundary condition is shown in Fig. No. 6

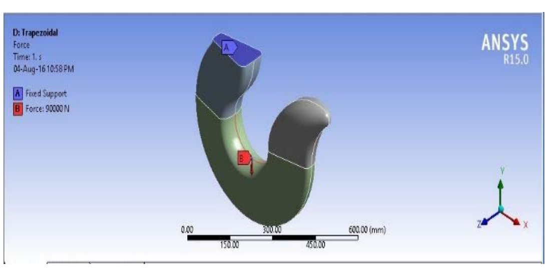
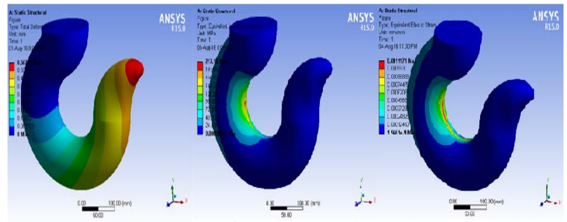


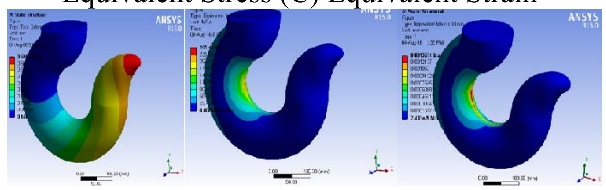
Fig. No.6 Application of Boundary Condition.

In solver, all the data is processed to give solution for different combinations of cross sections and loads.



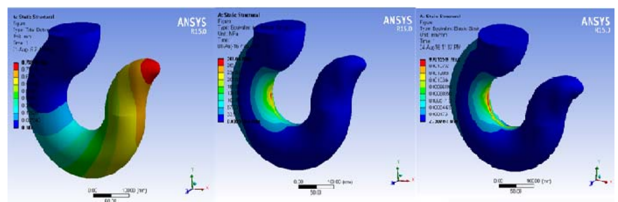
(A) (B) (C)

Fig. No. 7 ANSYS Result for 90kN and circular cross section (A) Total deformation (B) Equivalent Stress (C) Equivalent Strain



(A) (B) (C)

Fig. No. 8 ANSYS Result for 110kN and circular cross section (A) Total deformation (B) Equivalent Stress (C) Equivalent Strain



(A) (B) (C)

Fig. No. 9 ANSYS Result for 125kN and circular cross section (A) Total deformation (B) Equivalent Stress (C) Equivalent Strain

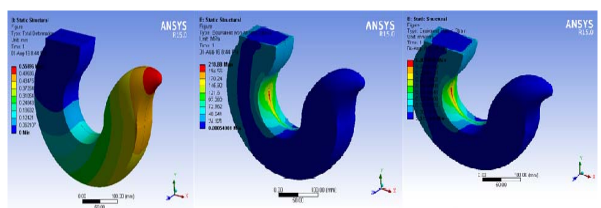


Fig. No. 10 ANSYS Result for 90kN and rectangular cross section (A) Total deformation (B) Equivalent Stress (C) Equivalent Strain

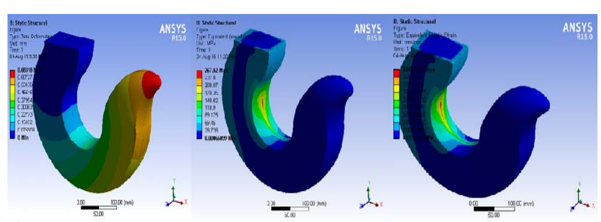


Fig. No. 11 ANSYS Result for 110kN and rectangular cross section (A) Total deformation (B) Equivalent Stress (C) Equivalent Strain

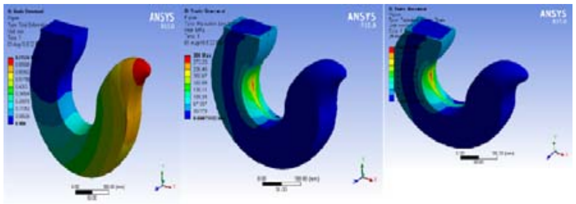


Fig. No. 12 ANSYS Result for 125 kN and rectangular cross section (A) Total deformation (B) Equivalent Stress (C) Equivalent Strain

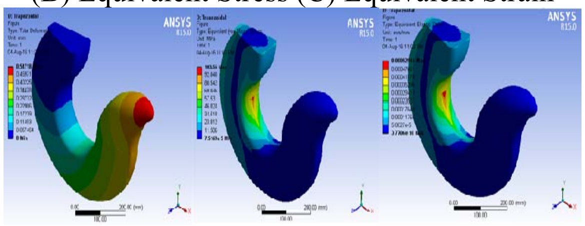


Fig. No. 13 ANSYS Result for 90 kN and trapezoidal cross section (A) Total deformation (B) Equivalent Stress (C) Equivalent Strain

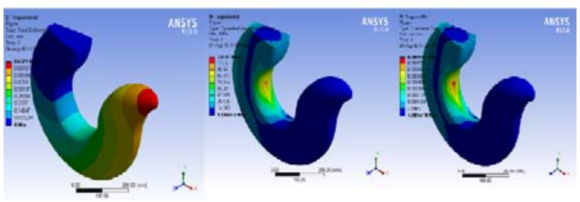


Fig. No. 14 ANSYS Result for 110 kN and trapezoidal cross section (A) Total deformation (B) Equivalent Stress (C) Equivalent Strain

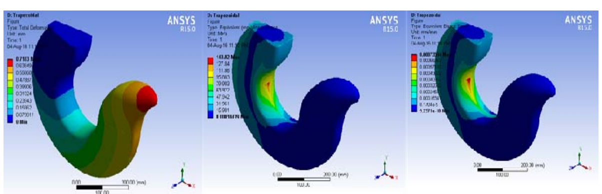


Fig. No. 15 ANSYS Result for 125 kN and trapezoidal cross section (A) Total deformation (B) Equivalent Stress (C) Equivalent Strain

IV. RESULT AND DISCUSSION

Table No. 3 Total Deformation in mm

Loads	Trapezoidal	Rectangle	Circular
90 KN	0.51718	0.55896	0.56792
110 KN	0.6321	0.68318	0.69413
125 KN	0.7183	0.77634	0.78878

Table No. 4 Stress in MPa

Loads	Trapezoidal	Rectangle	Circular
90 KN	103.55	218.88	217.18
110 KN	126.57	267.52	265.44
125 KN	143.82	304	301.64

Table No. 5 Strain

Loads	Trapezoidal	Rectangle	Circular
90 KN	0.00052944	0.0010944	0.0011171
110 KN	0.0006471	0.0013376	0.0013654
125 KN	0.00073534	0.00152	0.0015516

V. CONCLUSION

- By using curved beam concept crane hooks are successfully designed for three different cross sections.
- The model was prepared using CREO software and analysis has been carried out using ANSYS 15.
- All sections are safe in all loading conditions.
- Sample calculation is shown below for a load of 125KN

Table No. 6 Stress in MPa at section A-A (sample calculation)

	Trapezoidal c/s	Rectangular c/s	Circular c/s
Analytical result	164.96	182.174	216.725
ANSYS result	143.82	304	301.64

- The circular section has more stress induced than other two cross section.
- The trapezoidal cross section gives better results in comparison with other two cross sections as because stresses induced are less in trapezoidal cross section.

- The stresses obtained in theoretical and analytical methods are in good agreement. The model prepared is used for further studied with different loads and also for different materials.

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