TITLE: DESIGN AND ANALYSIS OF CRANE HOOK

Abstract:

Crane Hooks play an important role in lifting heavy objects and are subjected to load in inner curvy area where the stress concentration is higher. The failure in this component will lead to loss of productivity, and sometimes causes damage to environment. The previous journals and studies have concentrated more on the selection of material and design optimization. This paper discusses about static structural analysis and modal analysis. The individual part models are done in Creo parametric and assembled. Three critical parameters (Cross section, Material, Load acting) are selected at three different level. Design of experiments is conducted by using Taguchi L9 Orthogonal array. These experiments are conducted in ANSYS workbench and output parameters are deformation, shear stress. Finally, the best optimal parameters are selected for design. The optimal model is analyzed for fatigue life and safety factor.

Keywords: Crane Hook, Creo 6, Ansys 2021, Static structural analysis, optimization, ANOVA.

Introduction:

The Crane Hook is widely used for lifting heavy objects. They have more applications in Building construction, Ship building and so on. There are variety of crane hooks available based on the dimensions, cross sections, materials and applications. Recently, excavators having a crane-hook are widely used in construction works site. One reason is that such an excavator is convenient since they can perform the conventional digging tasks as well as the suspension works. Another reason is that there are work sites where the crane trucks for suspension work are not available because of the narrowness of the site. In general, an excavator has superior maneuverability than a crane truck. Fracture will occur in crane hooks due to stress concentration. strain aging embrittlement due to continuous loading and unloading changes the microstructure. 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. Each option offers particular benefits and downsides that must be kept in mind while deciding which is better suited for our specific conditions. The hook is the main connecting point between the crane and the cargo it needs to carry. When you need to move large or heavy particulars around your job point, you can trust the hook to hold them so the rest of the crane can do its work. The Trapezoidal sampling hooks are more common as it's suitable to absorb further perpendicular cargo and deviation.

1. 1. Literature Review

S. No.	Summary of the Research Paper
1.	G Bhagyarajet et al. Presented the Crane Hook design and analysis. They have modelled a 25tonne resistant block hook made up of lead alloy 1.2637 which have higher yield strength, compressive strength and tensile strength from the analysis the lead alloy has lesser Von Mises stress and have reduced mass
2.	Chetan N. Benkar et al. Presented the Design and Analysis of Crane Hook – Review. The study of the earlier publications enables us to conclude that among all the different methods, the Finite Element Method (FEM) is one of the most effective and powerful method for the stress analysis of the crane hook
3.	S. K. Lakshmana Moorthy et al. presented the Design and Analysis of Crane Hooks of Different Cross Sections Made of Hardened-Tempered Alloy Steel AISI 6150 and AISI. The obtained stresses are compared with different models to reduce the stress formed in hook by changing the shape of cross section of hook. From the analysis, it can be concluded that trapezoidal shape is better
4.	Mr Ravinarayan R et al. has presented the Estimation of Load acting on a Crane Hook by Inverse Finite Element Method. In this paper, inverse finite element technique is used. A crane hook having trapezoidal cross-sectional area is used for analysis. The magnitude of the load is within 2% of the actual load
5.	Kaushal Kishore et al. has presented the Failure analysis of a 24 T crane hook using multi-disciplinary approach. The parts were modelled using SOLIDWORKS. The assembled model is Analysed using SOLIDWORKS simulation. consisted of visual observations, fractography using SEM and stress analysis. Failure of the component is due to stress concentration and notch. Recommendations are given to prevent the failure.
6.	Apichit Manee-ngam et al. has presented the Hook Design Loading by The Optimization Method with Weighted Factors Rating Method. A lifting hook is created by ISO 7597:2013 and analyzed for axial load of 2 tonnes. Optimum design was also analyzed by weighted factor rating method.
7.	G. U. Rajurkar et al. has presented the Investigation of Stresses in Crane Hook by FEM. The individual part models are done using creo parametric. The analysis is done for stress, deformation and strain induced at loading For numerical analysis ANSYS is used. From the output of these analyses maximum stress concentration occurs at inner most surfaces.

8.	Hanjun P U has presented the Analysis for Dynamic Characteristics in Load-lifting system of the Crane. A high precision direct precise integration method was proposed for calculating the dynamic loads. This method, with the advantages of high accuracy and taking less computing time, is simple and effective to analyze the dynamic characteristics of the crane system.
9.	Bezwada Mahesh Krishna et al. has presented optimization of design parameters for crane hook using Taguchi method. The design parameters for crane hook are area of cross section, material and radius of crane hook. The optimum input parameters for minimum Von Mises stresses are arrived
10.	Dr Suwarna Torgal et al. has presented the Optimization of Dynamics Parameters and the Effect of Sway Angles in Hydraulic Crane Hook, by studying the parameters like mass & length and by the use of mathematical models & equation like Lagrange's equation. The result of this mathematical model shows the effect of mass and length if changed then sway angle is optimized.
11.	Goran. V Pavlovic et al. has presented the optimization of crane hooks considered as curved beams with different cross-sections – a comparative study using MATLAB. The optimization procedure was conducted using some metaheuristic optimization. The goal of this research was to determine the optimum geometric parameters of mentioned cross-section types
12.	Vinod Kumar Rohilla et al. has presented about 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.
13.	Sushovan Ghosh et al. has presented the static analysis of crane hooks with different cross sections – a comparative study using ANSYS workbench. The hook of trapezoidal, T and I- section are modelled in CATIA V5R21 and are analyzed under similar conditions using ANSYS considering grey cast iron as the material of the model. The theoretical and ANSYS based results are found well in agreement.
14.	Yadav Bhola Chunkawan et al. has presented the Static Structural Analysis of Crane Hook. The chrome steel and Aluminum Alloy are used in this project for analyzing the hook. For reducing the failures of hooks the estimation of stresses, their magnitudes and possible locations are very important.
15.	Y.Torres et al. has presented the Brittle fracture of a crane hook. The objective of this work is to identify the causes that led to a failure of the crane hookAll the gathered evidences are in agreement with a strain-aging process triggering the embrittlement of the material, with the fracture starting from a crack generated at the heat affected zone of an uncontrolled welding of the hook.

1.2. Research Gaps Identified:

From the literature review, most of the papers were concentrated on the selection of geometrical cross section for the design of crane hook. They have also analyzed the different cross sections. Research gaps were identified in the field of predictive models to predict the output parameters of crane hook based upon input given. In this paper the output parameters were tensile strength, Shear stress. The input parameters were Load (kN), Material. Design of experiments is conducted by using Taguchi L16 method by using Minitab software. The output parameters were determined by using ANSYS. This paper aims to create predictive models that can be used in testing of Crane hooks and selection of optimum design parameters.

1.3. Solution proposed:

The material selected was Structural Steel and Aluminum alloy. The input parameters were Load (kN), force given, Type of material, type of cross section used. The output parameters are Bending stress, tensile strength. Design of experiments is conducted by using Taguchi L9 Array method by using Minitab software. The three input parameters were taken at three levels and design of experiments is carried out The output parameters were determined by using ANSYS workbench. The output parameters are Total deformation, Tensile shear stress, Finally the optimization is carried out to select better parameters.

2.Methodology:

The critical design parameters are the material used, cross section of hook, load applied. In static stage the component self-weight will be acting towards surface. In dynamic stage load applied will be acting. The weight of the component that the hook lifts will also be applied to the hook inner surface. The individual part models of Crane hook were created by using CREO Parametric software and also assembled using Creo. The assembled component is imported to ANSYS workbench and analysis is carried out. The design parameters are, Type of cross section, Radius of the cross section, Cross sectional area, Type of material. In crane hooks loads will be acting at the inner curved surface. The analysis can be considered as curved beam. Some of the cross sections used are Trapezoidal, I, T, Circular, Rectangular. But trapezoidal cross section is mostly used. In this work, the material used is structural steel and aluminum alloy. The load is given at the center of the inner surface and additional loads can also be given. The input parameters are material, cross section, load applied. These three parameters are selected at three levels and design of experiments is carried out using Taguchi L9 orthogonal array in Minitab software. The experiments are carried out in ANSYS workbench.

2.1 Design calculations:

In this paper the crane hook is modelled by using Trapezoidal cross section. The design calculations were done by using PSG Design data book(pg 6.3)

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

$$R = r_i + \frac{h(b_i + 2b_o)}{3(b_i + b_o)}$$

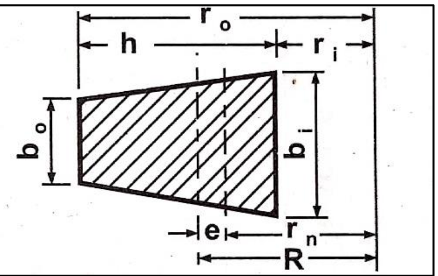


Figure 1 Curved beam with trapezoidal cross section

CALCULATIONS BASED ON DIMENSIONS:

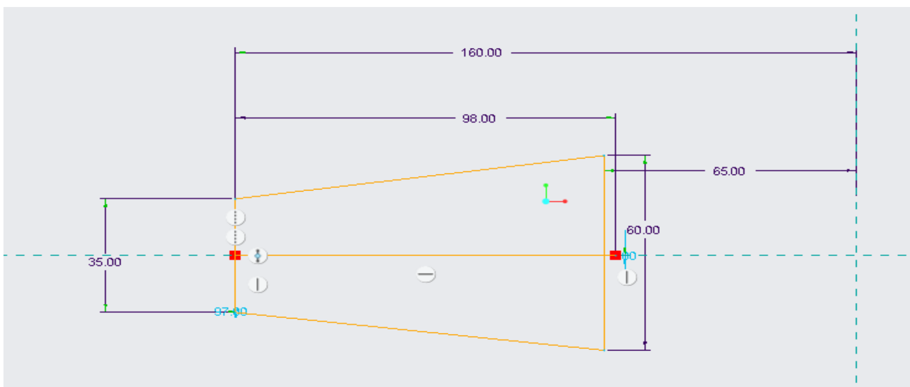


Figure 2 Dimensions of trapezoidal cross section hook

r_n = (½(60+35)*98) / 77.10(0.9007) – 25

r_n = 4655 / 44.44

r_n = 104.86mm

R = 65 + (98(60+70)) / 3(95)

R = 44.70 + 65

R = 109.7mm

e= R-r_n

e = 109.7 – 104.86

e = 4.84mm

INPUT PARAMETERS AND THEIR LEVELS:

Three critical input parameters (cross section, material, load) were selected at three levels by using Minitab software.

CROSS_SECTION	MATERIAL	LOAD(kN)
TRIANGLE	GRAY_CAST_IRON	10
CIRCULAR	STRUCTURAL_STEEL	30
TRAPEZOIDAL	HIGH_CARBON_STEEL	50

Figure 3 Input parameters and levels

DESIGN OF EXPERIMENTS USING TAGUCHI L9 ORTHOGONAL ARRAY

CROSS_SECTION	MATERIAL	LOAD(kN)
TRIANGLE	GRAY_CAST_IRON	10
TRIANGLE	STAINLESS_STEEL	30
TRIANGLE	HIGH_CARBON_STEEL	50
CIRCULAR	GRAY_CAST_IRON	30
CIRCULAR	STAINLESS_STEEL	50
CIRCULAR	HIGH_CARBON_STEEL	10
TRAPEZOIDAL	GRAY_CAST_IRON	50
TRAPEZOIDAL	STAINLESS_STEEL	10
TRAPEZOIDAL	HIGH_CARBON_STEEL	30

Figure 4 Design of experiments

2.2. Modeling of the Component:

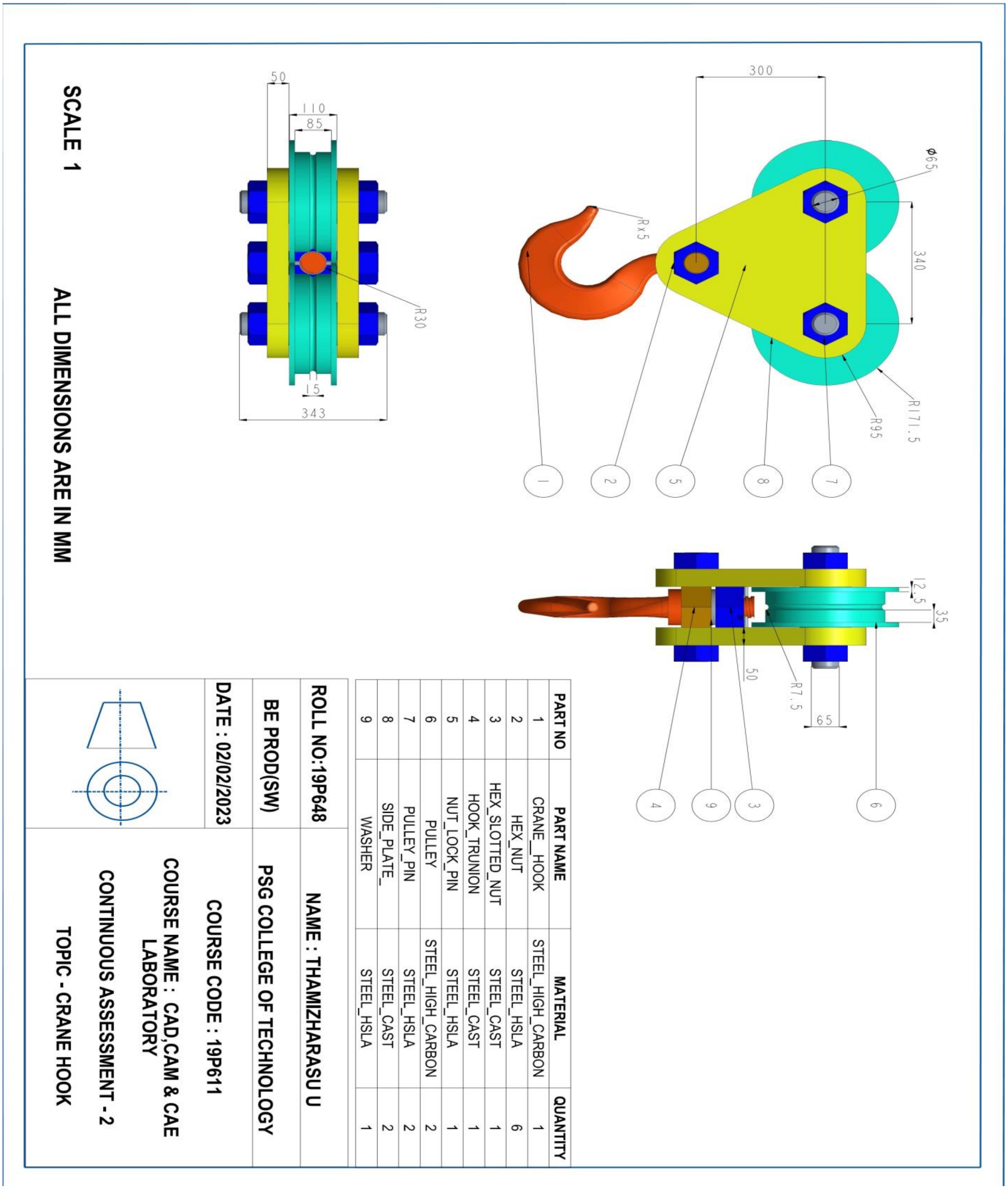
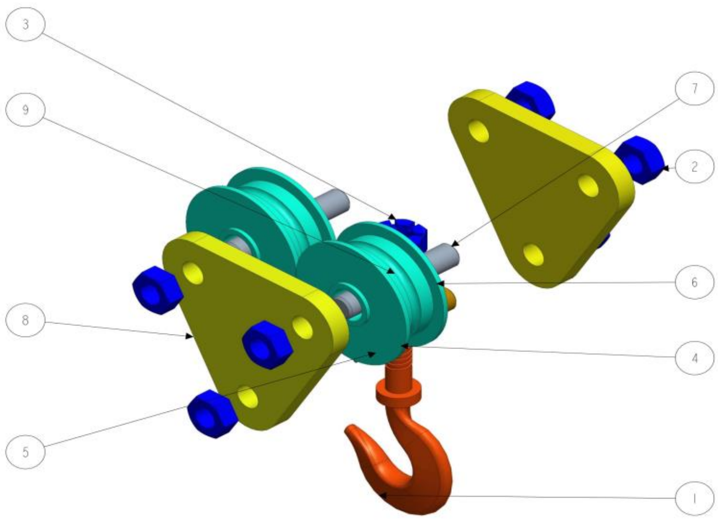


Figure 5 Orthographic view of component

ISOMETRIC VIEW AND EXPLODED VIEW



PART NO	PART NAME	MATERIAL	QUANTITY
1	CRANE__HOOK	STEEL_HIGH_CARBON	1
2	HEX_NUT	STEEL_HSLA	6
3	HEX_SLOTTED_NUT	STEEL_CAST	1
4	HOOK_TRUNION	STEEL_CAST	1
5	NUT_LOCK_PIN	STEEL_HSLA	1
6	PULLEY	STEEL_HIGH_CARBON	2
7	PULLEY_PIN	STEEL_HSLA	2
8	SIDE_PLATE_	STEEL_CAST	2
9	WASHER	STEEL_HSLA	1

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	COURSE NAME : CAD,CAM & CAE LABORATORY
	CONTINUOUS ASSESSMENT - 1
	CRANE HOOK - EXPLODED VIEW

SCALE 1

ALL DIMENSIONS ARE IN MM

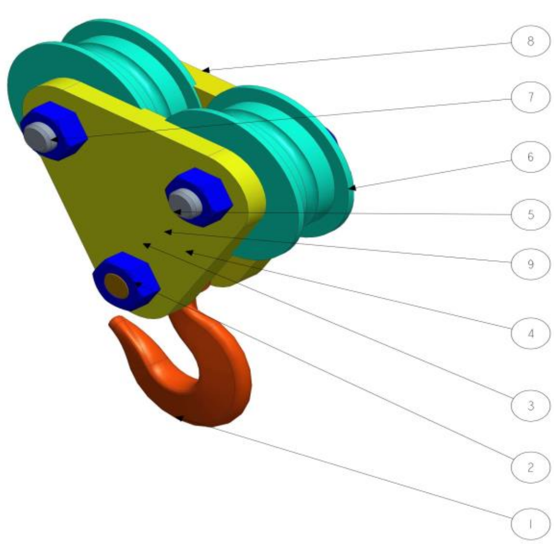

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Figure 6 isometric View and exploded view of the component