Review of Computer Aided Analysis and Design of Crane Hook of a Chain Block System

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Abstract— In this review paper an overall design of the hoisting mechanism of a Chain Block System has been carried out. The dimensions of the main components have been determined for a load capacity of 50 ton crane having 8 rope falls. 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. Which cross section would be better keeping some parameters constant for all the case? Various dimensions and load per wire for wire ropes has been found. Using various formulae found the dimensions for pulley, Rope-drum. Also calculated the Power and ratings for the motor, brakes used in the hoist mechanism.

Key words: Crane hook, Wire rope, pulley and rope drum

I. INTRODUCTION

Hoisting is the process of lifting something or some load or person from lower position to higher position with the help of some device or mechanism.

A. *Hoisting Devices*

A hoisting device is used for lifting or lowering a load by means of a drum or lift-wheel around which rope or chain wraps. It may be manually operated, electrically or pneumatically driven and may use chain, fiber or wire rope as its lifting medium
Eg: Elevators ,crane.

The manual chain hoist for 250 to 10 000 kg is a new concept in which esthetics have been associated with reliability. It offers high security, with lower weight and less upkeep.

The hoist is composed of :

- a chain guide case which guides the chain, maintains it in the correct position and protects the chain wheel,
- treated steel mechanisms : shafts, cogs, sprockets,
- a lifting pulley
- lifting and suspension hooks in treated steel alloy with safety clips,
- an automatic self locking brake,
- a lifting chain,
- an galvanized maneuvering chain.

Parameters to consider when specifying hand chain operated hoists are:

- Speed of lifts
- Height of lifts
- Frequency of lifts
- Weight of load

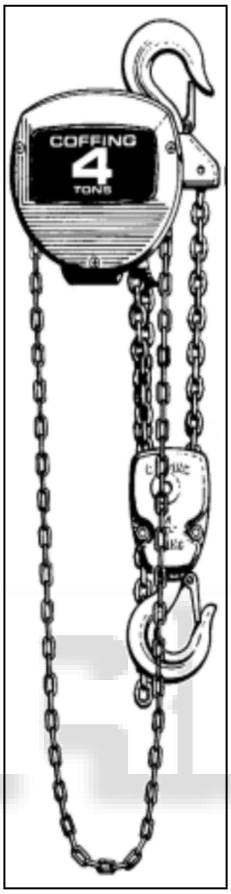


Fig. 1: Chain Block System

A hand hoist, being a force multiplier, gives you the ability to lift very large loads (up to 50 ton) with ease by using mechanical advantage. Most hand hoists are used for infrequent maintenance applications where speed is not a requirement. They are considerably less expensive than powered hoists, but they require physical effort (pulling on the hand chain) to lift the load. They are not fast and should not be specified for continuous lifting applications, especially when long lifts are required. In industry, hand chain hoists are most often used as an in-plant tool for periodic maintenance applications. A typical use might be for lifting pumps, generators, or other heavy equipment in water treatment facilities. Whether it be used in construction, machine shops, automotive garages, farms, or in the private home, hundreds of applications exist for a hand chain hoist and many thousands are sold every year.

II. LITERATURE REVIEW

A. *Sam T. Hutcheson*

This report covers the design of a portable gantry hoist with a custom frame design. The design was based off of the materials that were available and practical for this project to save money. The portable gantry hoist will be rated for a 2 ton capacity. The casters, trolley, and hoist were the only parts purchased.

B. Rajendra Parmanik

in a post "Design Of Hoisting Arrangement Of E.O.T. Crane(2008) he has discussed about history of crane, various types of crane ,application and a model design of the various parts of the EOT crane

C. R. Uddanwadiker

in the paper "Stress Analysis of Crane Hook and Validation by Photo-Elasticity" states that "Crane Hooks are highly liable components and are always subjected to failure due to accumulation of large amount of stresses which can eventually lead to its failure. By predicting the stress concentration area, the shape of the crane is modified to increase its working life and reduce the failure rates."

III. METHODOLOGY

The complete study of change in design and analysis of Chain Block System is done through the CAD/CAM/CAE Software Auto-CAD and ANSYS.
<u>Research methodology to be employed: –</u>
<u>Software</u> - Auto-CAD, ANSYS.

A. Auto-CAD

Auto-CAD is a family or suite of design software supporting product design for discrete manufacturers and is developed by PTC. The suite consist of apps, each delivering a distinct set of capabilities for user role within product development. The change in design to resolve the failure of industry will be designed in Auto-CAD software v.14 which is developed PTC software company. The complete CAD model of Chain Block System is designed in Auto-CAD software. The new addition of material and the change in design of chain block system is designed in Auto-CAD software.

B. ANSYS

ANSYS Inc. is an engineering simulation software (computer-aided Engineering, or CAE) developer headquartered south of Pittsburg in the Southpointe business park in cecil in United States. One of the most significant products is ANSYS CFD, a proprietary computional fluid dynamics (CFD) program. ANSYS can import cad data and also enable to build a geometry with the preprocessing abilities.
The CAD model from CREO is imported in ANSYS software. The model is then meshing into number of user defined division. The boundary condition will be then applied on the model. The last step is called as post processing step is ANSYS in which result such as Stress, Displacement, Strain and various factors are calculated.

IV. DESIGN OF THE CRANE HOOK

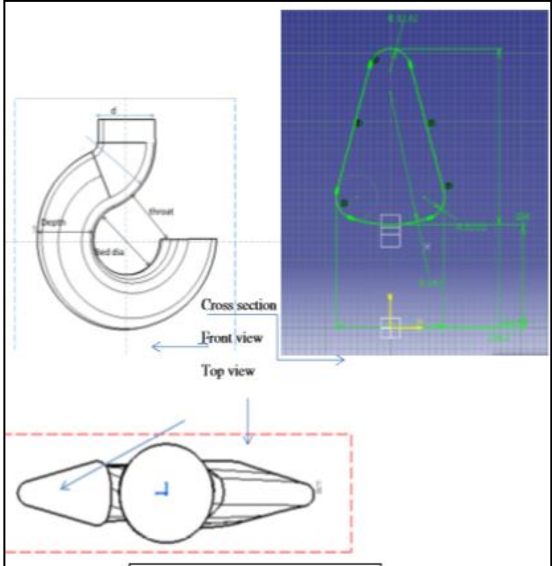


Fig 2 : different views of the crane hook

Fig. 2: Different Views of the Crenc Book

The inner side is called intrados and the outer side is called the extrados According to force diagram of the hook intrados experiences more tensile force than the extrados.
Hook bed diameter is given by the formula c=μ√P cm
Where P is the load applied in tonne c is the bed diameter μ is a constant varying from 3.8 to 7.6 Considering μ= 4.24 c = 30cm =300mm
Throat of the hook is taken 0.75c =225mm d= 3.2√P c/10 =256.2mm
Using safety factor 6
W=6x50000 =300,000 N

- A crane hook is treated as a curved beam
- Straight beam theory and shallow beam bending theory is not applied to the crane hook .Bending theory of beam with larger curvature is applied here In a beam with larger curvature neutral surface is displaced from the passing through the centroid towards the center of curvature.

Cross Section	Value of link radius
rectangular	$h^2 = 2.3\frac{R^3}{D}\log\left(\frac{2R+D}{2R-D}\right) - R^2$
circular	$h^2 = \frac{d^2}{16} + \frac{1}{8} \times \frac{d^4}{16R^2}$
trapezoidal	$h^2 = \frac{R^3}{A}\left[2.3\left(B_2 \frac{(B_1 - B_2)R_2}{D}\right)\log\frac{R_2}{R_1} - (B_1 - B_2)\right] - R^2$
triangular	$h^2 = \frac{R^3}{A} \times \frac{B}{D}\left[2.3R_2\log\frac{R_2}{R_1} - D\right] - R^2$

Modified Section

Fig 4.1

d= $3.2\sqrt{P} + c/10$
=256.2mm
R=0.75 d =192.1
r =1/8d =32.05

Fig 4.2

Fig. 3: Modify Cross Section

The below figures show the ANSYS analysis of crane hooks of various cross sections

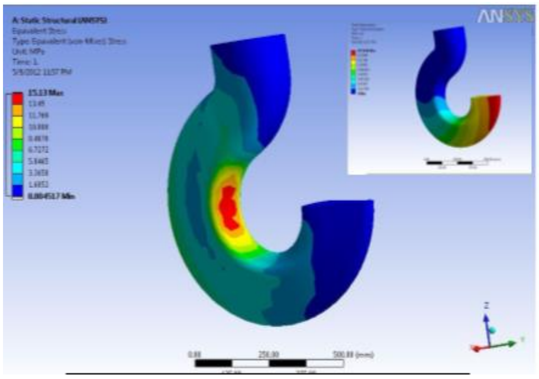


Fig. 4: Stress distribution in the hook with modified cross section

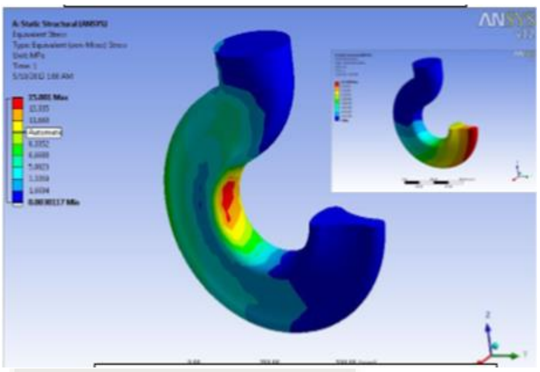


Fig. 5: Stress distribution in the hook with another modified cross section.

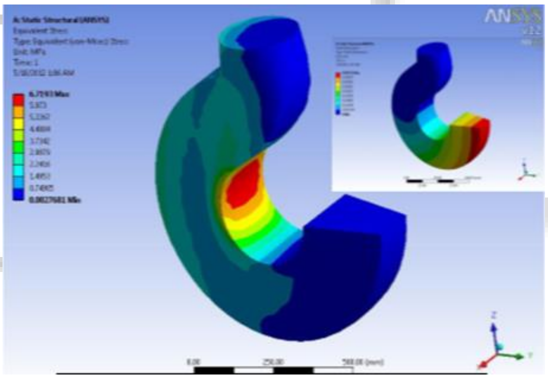


Fig. 6: Stress distribution in the hook with Trapezoidal cross section.

V. Hand Chain Hoists

A. Features

- Overload clutch standard feature on lever hoists and chain hoists
- Modern small body, compact, stamped steel construction
- Fully machined steel load sheaves
- Cast steel hook latches instead of stamped steel
- Fully enclosed gear train & caged internal bearings
- All exposed parts are plated or powder coated for corrosion protection
- Bottom hooks of chain hoists equipped with roller thrust bearings
- Double pawl Weston style load brake
- Conforms to ANSI B30.16 – Chain Hoists and Standard B30.21 – Lever Hoists

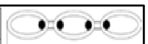
B. Dimensions and Specifications

MODEL	LCF-05	LCF-10	LCF-1.5	LCF-20	LCF-30	LCF-50	LCF7.5	LCF-100	LCF-150
Working Load Limit	.25t, .5t	1t	1.5t	2t	3t	5t	7.5t	10t	15t
Standard Lift	10ft	10ft	10ft	10ft	10ft	10ft	10ft	10ft	10ft
Falls of Chain	1	1	1	1	2	2	3	4	8
Effort to Lift Rated Load (lbs)	51	66	70	77	60	90	90	90	90 x 2
Net Weight with 10ft Lift (lbs)	22	26	30	49	71	102	140	183	374
	Clearance Dimensions (inches)								
A (Headroom)	10.64	12.49	15.7	16.31	18.32	25.06	30.24	31.42	35
B (Width)	5.00	6.23	7.36	7.37	8.27	9.97	14.84	14.1	25.6
C (Depth)	5.16	5.52	6.34	6.34	6.34	6.34	7.24	8.15	8.46
Hook Openings	.99	.99	1.42	1.32	1.58	1.97	1.97	2.52	3.35

Table 1:

C. Lifting Chain Certificate

Type of chain selected					
Chain Ø x pitch	4x12	5x15	6x18	8x24	9x27
Class	T	T	T	T	T
Minimum breaking strain (N/mm2)	900	900	900	900	900
Standard	DIN 5684-8	DIN 5684-8	DIN 5684-8	DIN 5684-8	DIN 5684-8
Safe load limit on 1 trace (kg)	250	500	1000	1500	2500
Breaking load (kN)	20	31,36	49	73,5	105
Min. total elongation over 7 links	10%	10%	10%	10%	10%
Dimension over 5 links + 2 diameters	68(+0.25,-0.15)	85(+0.33,-0.16)	102(0,-0.6)	136(+0.12,-0.66)	153(+0,45,-0,25)
Weight per meter (kg)	0,35	0,55	0,78	1,39	1,72



Dimensions over 5 links

Table 2:

D. Lifting Hook Certificate

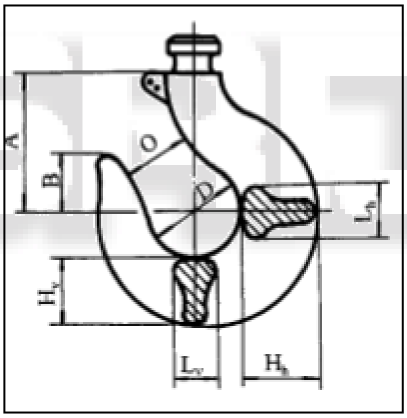


Fig. 7: Hook

Load Kg	Testing Load Kg	Nb. of falls	Breaking Load Kg	Marking	D	O	B	Hh	Lh	Hv	Lv	A
250	500	1	1000	13S	26.5	21.2	17	20	12.1	17	10.9	40
500	1000	1	2000	16S	31.5	25	20	25.7	16	21.8	14	47.5
1000	2000	1	4000	19S	37.5	30	23.6	33.5	20.6	28	18.5	58
1500	3000	1	6000	21S	42.5	33.5	26.5	40	24.3	33.5	21.8	64
2000	4000	2	8000	22S	45	35.5	28	43.7	26.5	36.5	23.6	67
3000	6000	2	12000	24S	50	40	31.5	51.5	31.5	43.7	28	75
5000	10000	2	20000	26S	59	47	45	61	36	54	31	90
6300	12600	3	25200	27T	-	-	65	68	47	59	44	110
7500	15000	3	30000	27T	-	-	65	68	47	59	44	110
10000	20000	4	40000	28T	-	-	-	77	47	64	49	-

Table 3:

VI. Hand Chain

A. Grade

The material, welding and finish shall beat least equal to that of grade 30 chain as per IS 2429. Hand chain shall be untested, pitched and polished condition. It should have proper seating in hand chain wheel and should not over ride.

B. Link Dimensions

The following dimensions are recommended:

Nominal Size mm	Pitch Outside mm	Width mm
5	22.5 * 0.5	17 +0.5
6	22.5 * 0.5	20 * 0.5

C. Length of Chain

The length of the hand chain shall be such that the lowest point of the suspended loop shall hang at least 400 mm above the operating level.

D. The hand chain

shall be joined without twist. The method of joining shall ensure that there are no sharp or projecting edges, causing any harm during its used.

E. Hand Chain Wheel

Hand chain wheels shall be provided with flanges and designed to ensure effective operation with the hand chain.

F. Hand Chain Guide

The hand chain guide shall be so designed that the chain will not come out of the hand chain wheel during use nor get caught between guide and hand chain wheel. When the chain pulley block is mounted on a troiley with the travel movement, the trolley frame shall be provided with adequately designed anti-tilt anti-drop plates which will prevent falling of the load in the event of bending of side plates or breakage of wheel or pin, etc.

VII. Crane Hoist Braking Torque

Sizing of crane hoist brakes is typically based upon full load hoisting torque. The following is a brief summary of guidelines for hoist brakes. Each hoist on a crane should be equipped with at least one spring-set magnetic brake; hoists handling hot metal should be equipped with more than one brake. Brake rating expressed as a percent of hoisting torque at the point of brake application should be no less than the following:

1) 1.5 times when only one brake is used.
2) 1.5 times when multiple brakes are used and the hoist is not used to handle hot metal. Failure of any one brake should not reduce braking torque below normal .
3) 1.75 times for hoists handling hot metal .
4) Failure of any one brake shall not reduce brake torque below 1.5 times.

VIII. Results

First the hook dimension was calculated and taken various cross section keeping bed diameter , area of the cross section and depth constant and analyzed the stress

Result: stress in the rectangular section was minimum followed by trapezoidal section a bit more circular cross section was found to exert maximum stress From the ANSYS analysis result was trapezoidal section was least stressed But stress in the modified section was more because the cross sectional area was less in the modified section

Bed dia for hook =300mm

Depth=256mm

IX. Conclusion

In the designed hoist model trapezoidal section show less stress .The modified section should show less stress but due to reduction in area it shows more stress Using more no. of Chain falls divide the load and make the tension less. Also it makes the work faster .E.g if we use Chain falls then using the same force 4 times work is done But increase in Chain fall increase the Chain length by that times ,which is expensive Also the Chain length determine the drum length. Increase in drum length increase the volume of setup to reduce the volume we can double winding of Chain on the drum can be adopted Motor power required depends on lifting speed and load applied The angular speed of drum and the motor are different so a gear box is used for power transmission.

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References

[1] ANSI/ASMEHST-1M-1982,Performance Standard for Electric Chain Hoists.
[2] NSI/ASME HST-2M-1983, Performance Standard for Hand Chain Manually Operated Chain Hoist.
[3] ANSI/ASME HST-3M-1985, Performance Standard for Manually Lever Operated Chain Hoist.
[4] ANSI/ASME HST-4M-1985, Performance Standard for Overhead Electric Wire Rope Hoists.
[5] ANSI/ASME HST-6M-1986, Performance Standard for Air Wire Rope Hoists.
[6] CMAA Specification No. 70, Specifications for Electric Overhead Traveling Cranes.
[7] CMAA Specification No. 74, Specification for Top Running and Under Running Single Girder Electric Overhead Traveling Cranes.
[8] PCSA - Power Crane and Shovel Association, Standards No. 1, No. 2, No. 4, and No. 5.
[9] Rajendra Parmanik "Design Of Hoisting Arrangement Of E.O.T. Crane" Posted on July 26,2008 by http://rparmanik.wordpress.com/about-me-rajendra-parmanik/
[10] R. Uddanwadiker, "Stress Analysis of Crane Hook and Validation by Photo-Elasticity," *Engineering*, Vol. 3 No. 9, 2011, pp. 935-941
[11] http://www.codecogs.com/reference/engineering/materials/curved_beams.php(updated last on 2011-10-17 08:12:34
[12] [R.S. Khurmi, "Strength of materials" 23rd Edition (2009) ,Chapter 33
[13] Shariff Abdulla, "Hand Book of Properties of engineering materials and design data for machine elements" (2009)
[14] High strength fiber coated steel wire rope deep hoisting application, technology ltd.
[15] http://www.diytrade.com/china/pd/9098053/trianfular_strand_wire_rope.html.

