COMPONENTS DESIGN OF HOISTING MECHANISM OF 5 TONNE EOT CRANE

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Abstract

In modern days Electric Overhead Travelling crane is very important material handling equipment in industry because of safety, reliability, economy, fast speed etc. Most of industries are using EOT cranes for handling of material, EOT cranes are available in many load carrying capacities, 5 tonne EOT crane is mostly used in industries. Following are components of hoisting mechanism in EOT crane such as crane hook, thrust ball bearing, pulley, wire rope, drum, gear box, electric motor brake etc. In this paper we have designed these components for 5 tonne crane. Same procedure can be used for heavy load cranes.

Keywords: Overhead Crane, Crane Hook, Thrust ball bearing, Pulley, Wire rope, Drum, Gear box, Electric motor, Brake.

I. INTRODUCTION

The crane is one of the most important equipment for handling of material in any industries with fast speed, reliability, safety, economy etc. so crane is used. EOT crane is a mechanical lifting device used for lifting or lowering the material and also used for moving the loads horizontally or vertically. It is useful when lifting or moving the loads is beyond the capacity of human.

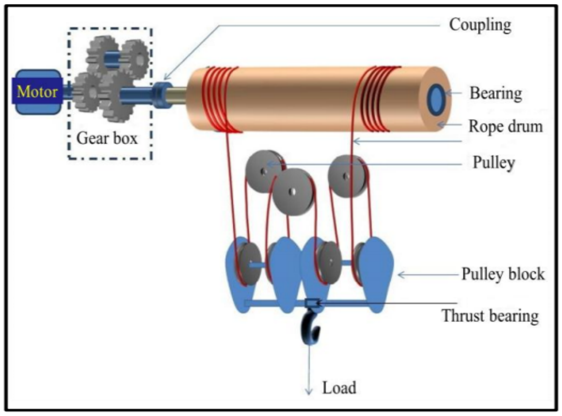
Applications of material handling device like crane is a prime consideration in the construction industry for the movement of material, in the manufacturing industry for the assembling of heavy equipment, in the transport industry for the loading and unloading and in shipping etc. This device increase output, improve quality, speed up the deliveries and therefore, decrease the cost of production. The utility of this device has further been increased due to increase in labour costs and problems related to labour management.

Crane is a combination of separate hoisting mechanism with a frame for lifting or a combination of lifting and moving load. There is very much useful to pick up a load at one point and be able to transport the object from one place to another place to increase human comfort. There are three major considerations in the design of cranes. First, the crane must be able to lift the weight of the load. Second, the crane must not topple. Third, the crane must not rupture.

The cranes are available in so many types of such as Jib crane, Tower crane, Truck mounted crane, EOT crane, Telescopic crane, Gantry crane, Aerial crane, stocker crane, etc. Here, discus about Electric Overhead Travelling (EOT) crane. EOT crane is also known as bridge crane. Electric Overhead cranes typically consist of either a single girder or a double girder construction.

Generally an Overhead crane show three motions-

1. Long travel
2. Cross Travel
3. Hoisting (up & down)



(Fig. hoisting Mechanism of EOT Crane)

II. LITERATURE REVIEW

A. Indian Standard (807-2006) [1]:

This standard describes design of structural portion for cranes, hoists, specifics permissible stresses and other details of design. In order to ensure economy in design in reliability in operation. To deal with the subject conventionally, cranes have been broadly classified into eight categories based on their nature of duty and number of hours in service per year. It is producers or manufactures responsibility to ensure the correct classification.

B. Indian Standard (3177-1999) [2]:

Indian standards are broader in concept and give a standard principle in a generalized from because of uniformity of a product or services.
This standard covers the mechanical and electrical drives of the cranes. The components of crane are made with dimensions or design in accordance with the help of Indian standard. IS-3177-1999 covers all selection criteria of components in EOT crane such as lifting hooks, shaft, wire rope, rope drum, flanges, sheaves, bearings, gear boxes, couplings, fasteners, motor, etc.

C. Rajendra Parmanik [3]:

Rajendra parmanik in a post "Design of hoist arrangement of EOT crane" (2008), he has discussed about the history of crane, various types of crane, application, the design of the hoist of EOT crane is done by algebraic calculation and a model design of the various parts of EOT crane.

D. Dr. Frank Jauch [4]:

Dr. Frank jauch in a post "care, use and maintenance of wire ropes on cranes", he has discussed about drum. There are two types of drum: single layer drum and multi layer drum, both are used based on lifting capacity of an object. He has also discussed about crane ropes.

E. Pradyumnakesharimaharana [5]:

Pradyumnakesharimaharana, in the thesis "Computer Aided Analysis and design of hoisting mechanism of an EOT crane"(2012), states that wire rope is liable component in crane and failure due to large amount of stresses. So increase the number of rope falls decrease the tension on rope falls and also used factor of safety.

Ultimately reduce the risk of wire rope failure, increase number of rope falls so increase length of wire rope which is expensive. The arrangement of wire rope is also important and arrange in between upper pulley block and bottom pulley block.
(Fig.for 5 tonne)

He has been found various cross section of shape crane hook and calculated stress and deflection at critical points using ANSYS. So conclude that trapezoidal section show less stress. Also calculated rating of motor , brakes used in hoist mechanism. Motor power required depends on lifting speed and load applied.

III. DESIGN PROCEDURE

List of components used in Hoisting Mechanism of EOT Crane Design-

1. Crane Hook
2. Thrust ball bearing
3. Pulley
4. Wire rope
5. Drum
6. Gear box
7. Electric motor
8. Brake

1. DESIGN OF CRANE HOOK

In this phase basic dimensions for crane hook are calculated like bed diameter, throat diameter, depth of crane hook. In this study trapezoidal type cross-section are considered.
The hooks are tested to more than double the working load, and for this reason their strength need not be investigated ordinarily. Analysis of the stresses in the hook, which is a curved bar subjected to combined bending and tensile stresses is a matter of same complexity.
The most suitable practical section for the body of the shank hook approximates the triangular or trapezoidal from with the proportions.

Hook bed diameter is given by the formula, $C=\mu\sqrt{p}$

Where P is the load applied in tonne & μ is a constant varying from 3.75 to 7.5

For economy of material, the value of μ should be kept as low as possible, the lower limit being fixed by the size of slings, ring etc. to be accommodated. In shank hooks using metal fittings, μ has been fixed at 3.75.

For 5 Tonne Hook, $C = 3.75\sqrt{5}$

$= 8.385$ cm

This relation between C and d for the recommended standard section is

$d= 3.125 \sqrt{P} +0.1 C = 3.125 \sqrt{5} + 0.1\times8.385 =7.8275$ cm $=7.8$ cm

This value of d will be at the horizontal and vertical centre lines of the hook, whilst at a plane mid way between these (say at 45 to the horizontal), a section having a value of d some 8% greater is used. In this case, a value of 78×1.08=8.5 cm. is attained. As the body curves to join the shank, the section may be reduce provided that the reduction does not case the maximum stress to exceed a specified value.

The working tensile stress in the shank may be assumed at 400 kgf/cm² .as recommended by some authors.

Let d^1=Dia. Of shank at bottom of the threads.

Then, $0.785 (d^1)^2\times400= 500$

$(d^1)^2= 16$, $d^1= 4$ cm

The hook load will be carried bal thrust bearing through a round nut screwed on to the end of the shank.

Full dia. Of the shank = 40/0.84 = 48 mm say 50 mm

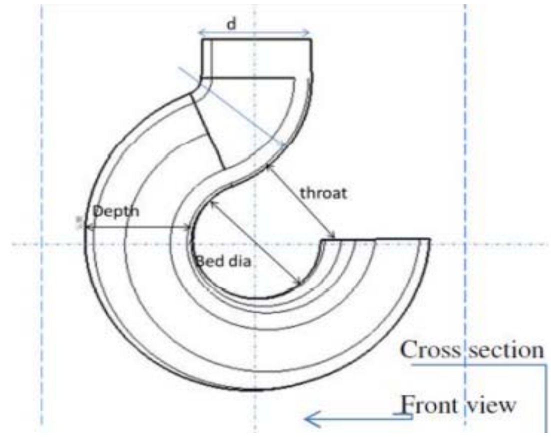
The other dimensions of triangular (or trapezoidal as it is called) section of the body of the hook can now be known.

Breadth at intrados =0.65 × 78 =50.8 say 51 mm

Radius of intrados curve = 0.75×78= 58 mm

Bed dia. = 84 mm

Corner radius = 78/8 =10 mm



2. SELECTION OF THRUST BALL BEARING

The swiveling motion of the hook will be very slow and intermittent rather the use of a ball bearing in such cases is only to prevent the spinning action of the load relative to the wire ropes. For this reason, the speed factor need not be taken into consideration.

It will show that a single thrust ball bearing type 51210 (50 mm bore) will be suitable here. The dimensions and load carrying capacity are as follows:-

Bore - 50 mm and 50.2 mm

Outside diameter – 78 mm

Thickness – 22 mm

Static carrying capacity – 9000 kg

Factor of Safety = 9000/5000 =1.8

3. DESIGN OF ROPE PULLEYS

For 6/37 construction of the wire ropes the minimum dia. Of rope pulley at the bottom of the v-groove as recommended by IS-2266-1963, should be 6 times the circumference of the rope. On this assumption, the P.C. dia. Of rope pulley should be 6×4.4 =26.4, say 27 cm or 270 mm at the bottom of the groove say 285 mm rope crs (min.) adopt 290 mm dia.

The general design of the rope pulleys may now proceed.

As the dia. Of the pulley is 290 mm (rope crs) only a solid web with cored holes (to lighten the weight) and with lateral ribs for stiffening will be preferable.

One point that requires special investigation is the intensity of bearing pressure on the pulley pin. In this case the pulley boss acts as a bearing and is not fixed to the pin.

The bearing pressure on pulley pin should not exceed 18 kgf/cm².

Minimum projected area required for each pulley = 5250/(2×78) = 33.65 cm^2

Both the pulley will have to be accommodated within a space of 118 mm (distance between the side plates), so that the boss length of each pulley should not exceed (118-2)/2 = 58 mm.

4. SELECTION OF WIRE ROPE

The load will be on 4 falls; i.e. on two rope pulleys through the medium of an equalizing pulley or sheave fixed to the crab (trolley) frame.

Load per fall = 5000/4 =1250 kg plus 5% due to D.T. of Hook block =1313 kg

A factor of safety of 8 (minimum) is usual in the design of electric overhead travelling cranes and hoists etc.

Breaking load of the wire rope should be 1313×8 = 10500 kg (approx.)

Three construction of wire rope are in most common use for the design of hoists etc. 6/19, 6/24 (with fiber), and 6/37 out of these three, 6/37 is preferable, being more flexible than the other two. Also to reduce the dia. Of rope pulleys to a minimum possible a superior grade of wire rope having a tensile breaking stress of 1725 to 1885 kgf/cm^2 will be adopted.

From IS: 2266 – 1963 a wire rope having a circumference of 44 mm (14 mm ra.) and having a tensile breaking stress of 1725 to 1825 kgf/cm^2 will have a guaranteed breaking load of 10900 kg.

Rope type	Brakeing load	Rope diameter In cm	Available dimension(in mm)	Weight of rope/10 m in kg	Effective area	Stress in a wire
6x7	$4800d^2$	2.71	29		51%	1.68tonne/14.39mm^2 =116.74N/ mm^2
6x19	$5100d^2$	2.63	29	29.210	50%	0.61tonne/6.39mm^2 =95 N/ mm^2
6x37	$4800d^2$	2.71	29	29.332	43%	0.37tonne/2.84 mm^2 =130 N/ mm^2
8x19	$4400d^2$	2.83	29	30.212		

5. DESIGN OF ROPE DRUM

The rope drum should be made of seamless pipe machined & grooved accurately, to -ensure proper seating of wire rope in a proper layer. The drum should be fitted with two heavy duty Ball / Roller bearings of reputed make for smooth operation & longer life.

Drum length =pitch x ground height x no of rope fall/drum dia =35x10000x8/667 =4197mm

[let ground height be 10m]

Average drum thickness = h+h/2 = 31.9+7.1/2 =35

6. SELECTION OF GEAR BOX

Totally enclosed oil splash lubricated & dust free gear box should be provided for smooth, trouble free & longer life. All gears are helical type and cut from alloy steel/ low carbon steel on hobbing machines for achieving higher precision & a special process of gear toughening ensures smooth, silent, trouble free running of drive system. The pinions and gears are supported on anti-friction bearings on both ends.

For drum rotating angular speed,

=w x lifting speed/diameter of the drum

=0.184 radian/s

For motor let, w= 62.31 radian/s

Reduction in speed =342 times

7. SELECTION OF ELECTRIC MOTOR

Hoist & crane duty hour rated squirrel cage induction motors, confirming to IS 325 with comparatively higher H.P. and higher starting torque to reduce handling time. It is flange mounted to suit the design and provided with suitable insulation

Lifting speed varies from =10 to 26 f or 50.79 to 132.08 mm/sec.

Speed of drum =4×0.132/R = 2N

For drum rotating angular speed = w lifting speed/dia. Of the drum=0.184 radian

Power transmitted by shaft = 2NT/60

Power = 4×0.132×50000×6 = 158400 Watt=158.4 kW [7]

8. SELECTION OF BRAKES

When selecting the proper brake for a specific application, there are several factors are consider; a few that need to be reviewed-

Brake torque, stopping time, deceleration rates, brake mounting, brake location, thermal rating, environment, brake style.

The brake systems manufactured external friction brakes.

Applications for which these brakes are suited can be classified into two general categories:- non-overhauling , overhauling.

A) Non-overhauling loads are typically horizontally moving masses such as crane bridges, crane trolleys, horizontal conveyors.

B) Overhauling loads tend to accelerate in speed if a brake is not present, examples of which are crane hoists, winches, lifts, and downhill conveyors.

Non-overhauling loads require brake torque only to stop the load and will remain at rest due to friction. Overhauling loads have two torque requirements; the first is braking torque required to stop the load, and the second is the torque required to hold the load at rest.

IV. CONCLUSION

Over 5 Tonne EOT crane provide more reliability, safety & speed comparison to other available crane because different components used to perform function. Generally, there is one rope drum, motor and gearbox used in hoisting mechanism. It means that only single drive mechanism is used for lifting purpose & displacement of over objects. In this paper I am also discuss all designing factor and factor of safety according to Indian Standard.

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