Review of Overhead Crane and Analysis of Components Depending on Span

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Abstract – *The main aim of this paper is to study various components of electric overhead crane, types of overhead cranes, difference between single girder and double girder cranes on various parameters and to find the effect of increase in span on crane components. Planned and unplanned requirements may necessitate changes in span. The distance between two gantries may get modified during the shed building of factory or the crane in one bay of factory needs to be shifted from one bay to other which have different span. In such condition we have to modify the existing crane to suit the required parameters.Electric overhead crane having 10T capacity and 20m span is to be modified for 22m span. We will study effect of increase in span for various components like long travel wheel, long travel motor and long travel brake.*

***Key Words*:**Overhead Crane, Long travel machinery, Double Girder Crane, Wheel, Motor, Brake, etc.

1. INTRODUCTION

Material handling is a vital component of any manufacturing system and the material handling industry is consequently active, dynamic, and competitive. A crane is a mechanical lifting device equipped with a rope drum, wire rope and sheaves that are used both to lift and lower materials and to move them horizontally. It uses simple machines to create mechanical advantage which helps to move loads beyond the normal capability of a human. Cranes are commonly used in the transport industry, in the construction industry and in the manufacturing industry. The overhead cranes handle and transfer heavy loads from one position to another.

Electric overhead travelling cranes are widely used in many industries for lifting the safe working load. The escalating price of structural material is a global problem. Many small scale industries purchase the existing electric overhead cranes from bigger industries and make the required modification to suit their requirement.

2. OBJECTIVES

- To study the overhead crane components, standards related to the crane and the research work on the crane.
- To find the components depending on the span of overhead crane.
- To check whether the increase in span from 20m to 22m in overhead crane will affect the long travel machinery components like crane wheels, long travel motor and long travel brake.
- To validate the results using SOLIDWORKS for long travel wheel.

3. TYPESOF OVERHEAD CRANES

Various types of overhead cranes are used in industries with many being highly specialized. Various types of overhead cranes are single girder cranes, double girder cranes, gantry cranes and monorails.

3.1 Single Girder Cranes

The crane consists of a single bridge girder supported on two end trucks. It has a trolley hoist mechanism that runs on the bottom flange of the bridge girder.

3.2 Double Girder Cranes

The crane consists of two bridge girders supported on two end trucks (end carriages). The trolley runs on rails on the top of the bridge girders. Double girder electric overhead cranes are widely used in the industries because they can carry more loads with more span than any other type of crane. In this project we are concentrating mainly on double girder electric overhead cranes.

3.3 Gantry Cranes

These cranes are essentially the same as the regular overhead cranes except that the bridge for carrying the trolley or trolleys is rigidly supported on two or more legs running on fixed rails or other runway. These “legs” eliminate the supporting runway and column system and connect to end trucks which run on a rail either embedded in, or laid on top of, the floor.

3.4 Monorail

For some applications such as production assembly line or service line, only a trolley hoist is required. The hoisting mechanism is similar to a single girder crane with a difference that the crane doesn’t have a movable bridge and the hoisting trolley runs on a fixed girder. Monorail beams are usually I-beams (tapered beam flanges). Monorail or repair trolley cranes are used for maintenance purpose. For maintenance of any single or double girder crane, the crane which is to be taken for maintenance is brought under the repair trolley (monorail) crane so that it can lift the components of the crane for repair or replacement.

4. BASIC COMPONENTS OF OVERHEAD CRANE

4.1 Girders

Besides the obvious variation of span and capacity, crane girders of various designs are in common use. The most frequently used designs are wide flange beams, capped structural beams, box girders and lattice girders. Box girder is the most popular girder design used in overhead travelling crane because of its design efficiency. Box type girders constructed from structural steel plate. Full depth stiffeners and additional partial depth stiffeners welded to webs and bearing on cover plates contribute to the internal strength of the girders. The trolley travels on the cross travel rails mounted on the girders.

These girders are designed so that they will take the vertical load and the deflection of these girders is within the permissible limit. These girders provide assess for mounting electric panels and platforms are welded to them. The girders are designed with positive pre-camber and the vertical deflection due to the working load and the trolley weight in the central position shall not exceed 1/900 of the span.

4.2 End Carriage

End carriages are located on both sides of the girder. They house the wheels on which the entire crane travels. It consists of structural members, wheels, bearings, axles, etc., which supports the bridge. Wheel base of the end carriage assembly shall be not less than 1/7 of the bridge span.

4.3 Hoist Machinery

The Hoist Mechanism is an assembly of motor, gearbox, brake, coupling, drum, wire rope and bottom block. The bottom block consists of sheave assembly which supports a swivelling hook. The hook block is suspended from drum through wire rope. Selection of wire rope size depends on load to be lifted and the number of rope falls. Depending upon rope reeving arrangement either rope balancer or equalizer sheave may be provided on the trolley frame.

4.4 Long Travel Machinery

The long travel mechanism is a unit consisting of a motor drive, coupling, brakes, gearing & wheels designed to travel the whole crane in either direction. Crane wheels are generally double flanged. However Flange-less wheels with guide rollers are also used. Long travel mechanism is mounted to the bridge assembly.

5. ELECTRIC OVERHEAD CRANE COMPARISON

5.1 Based on Safe Working Load

Double girder cranes can lift the loads up to 500T capacity. Single girder cranes are suitable for low safe working load. Because of extra girder in double girder cranes load distributed in two girders and hence double girder cranes can carry safer working load than single girder cranes.

5.2 Based on Span

For longer span the double girder cranes are used whereas single girder cranes are useful for smaller span.

5.3 Based on Application

Double girder cranes are efficient for the intensive use. Because of the rigidity of the structure, they are used in extreme conditions like lifting the molten metals. Single girder cranes are used for irregular and light use. They are used in small workshops, storage area, etc.

5.4 Based on Cost

In general the single girder cranes are less costly than the double girder cranes. Double girder cranes consist of more walkways, other accessories which add the cost. Single girder cranes cost less in many ways, only one cross girder is required, trolley is simpler and installation is quicker.

5.5 Based on Long Travel Speed

The single girder cranes are suitable for lower long travel speed whereas the double girder cranes can run with higher long travel speed.

6. LITERATURE REVIEW

YogiRaval, in "Design analysis and improvement of EOT crane", analyzed the crane wheel for optimum size. Using FE as a optimization tool, the optimization of the crane wheel size is carried out. [1]

AbhinaySuratkar and Vishal Shukla, "3D Modeling and finite element analysis of EOT crane" made a comparison between the analytical calculations and FE analysis. As a result of study they have proposed the design optimization method for overhead crane. [2]

Patil P. and Nirav K. in "Design and analysis of major components of 120T capacity of EOT crane" analyzed various components of crane like wheels, pulleys, rope drum and girder. They have done the manual calculations using Indian standards and on the basis of these calculations 3D modeling and analysis has been carried out. For modeling they have used Creo software and ANSYS as analysis software.[3]

Rudenko N, in the book of Material Handling Equipment briefed the structure of overhead travelling crane. The structure of an overhead travelling crane with a plate girder is composed of two main longitudinal girders assembled with the two end carriages which accommodate the travelling wheels. The main factors in the solution of plate girders are the safe unit bending stress and the permissible girder deflection. The vertical loads on the girders are dead weights and the force exerted by the wheel of the trolley carrying the maximum load.[5]

In IS: 4137-1985 various factors are mentioned which are helpful in the design of crane components. The preferred wheel diameters and the formula for obtaining the wheel sizes are also stated in this Indian standard.[6]

IS 13834 (Part 1) provides a general classification of cranes based on the number of operating cycles to be carried out and a load spectrum factor.[8]

In IS: 807 [2006] Design, erection and testing (structural portion) of crane and hoist- code of practice, various design parameters for structure of overhead cranes are mentioned.[10]

In IS: 3177-1999, various factors like drive efficiency, average acceleration, friction factors for anti-friction bearings etc. are mentioned which is very important in calculating the required mechanical power.[11]

7. COMPONENTS UNDER STUDY

The components which depend on span are long travel wheel, long travel machinery which includes motor brake gearbox rating. Also the structural members like girder and end carriage are depending on span of crane. In order to calculate the sizes of components and power required basic data are collected.

7.1 Data Collected for Crane Components

In order to get the idea about the crane, we got the following information from the one of the reputed company planning to increase the span of the crane. The crane is of class M8, 10T capacity and span of 20m is having the crane weight as 12T and trolley weight of 2.5T. The hook approach required is 1.5m. This crane runs on the CR80 rail at the speed of 40m/min. The same crane is planned for modification to suit 22m span. The increase in span will increase the crane weight which is assumed as 15T.

7.2Effect of Span on Long Travel Wheel Size

Wheel size of the crane depends on various parameters like crane weight, trolley weight, safe working load, span, hook approach and number of long travel wheels.

$$\text{Max. LT Wheel Load (Pmax)} = \frac{(\text{crane wt} - \text{trolley wt})}{\text{No. of Lt Wheels}} + \frac{2 \text{ x } (\text{Trolley wt} + \ldots}{\text{No. of LT whee}\ldots}$$

Using formula from equation (1), we can calculate the maximum wheel load for 20m span and for 22m span.

$$\text{Max. LT Wheel Load for 20m span (Pmax)} = \frac{(12 - 2.5)}{4} + \frac{2 \text{ x } (2.5 + 10)}{4} \ldots$$

$$\text{Max. LT Wheel Load for 22m span (Pmax)} = \frac{(15 - 2.5)}{4} + \frac{2 \text{ x } (2.5 + 10)}{4} \ldots$$

We have,

$$\text{Wheel diameter} = \frac{2 \text{ x Pmax}}{\text{Trade width of rail}} \quad (4)[6]$$

Using equation (4), we can select the diameter of long travel wheel for 20m span and for 22m span.

$$\text{Wheel diameter for 20m} = \frac{2 \text{ x } 9.55}{80} = 0.23875 \quad (5)$$

$$\text{Wheel diameter for 22m} = \frac{2 \text{ x } 10.31}{80} = 0.25775\text{m} \quad (6)$$

As per IS 4137- Code of practice for Cranes, preferred wheel sizes are mentioned like 315, 400, 450, 500, 630, 710, 800, 900, 1000 and 1200mm.[6] From the above calculations we can conclude that as the crane span increases wheel load increases which intern causes increase in wheel size. For increase in span from 20m to 22m the wheel size remains same as 315mm.

We will validate the results obtained by manual calculations using SOLIDWORKS.

Design Considerations,

Wheel Material: C55Mn75

Ultimate Strength: 720 N/mm^2 [12]

Duty Factor, C_{df}: 1.5 [11]

Basic Stress Factor, C_{bf}: 3.15 [11]

Safety Factor, C_{sf}: 1.12 [11]

$$\text{Permissible stress} = \frac{(\text{Ultimate Strength})}{\text{Cdf x Cbf x Csf}} = 136.05 N/mm^2 \quad (7)$$

Fig -1: Meshing of 320 diameter wheel

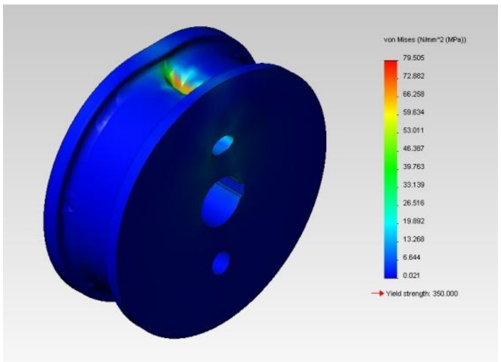

Fig -2: Stresses in 320 diameter wheel for 22m span

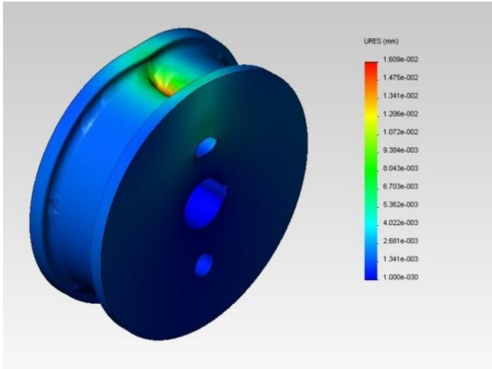

Fig -3: Deflection in 320 diameter wheel for 22m span

Using SOLIDWORKS, the stresses obtained are less than the permissible stress. Hence the same wheel is safe for 22m span.

7.3Effect of Span on Long Travel Motor Power

As span of the crane increases, weight of the crane will increase. To carry this increased weight the motor power rating will increase accordingly.

$$\text{Required mech. power in Kw} = \frac{(\text{M x V})}{(6117 \text{ x T})} \text{x} \left(\text{F} + \frac{1100 \text{ x a}}{981 \text{ x E}}\right) \text{(8)} \text{ [11}$$

Where,

M: Safe working load + crane weight

V: Long Travel Velocity of crane = 40m/min

T: Motor Torque factor = 1.7[11]

F: Friction factor for antifriction bearings = 8kgf/T[11]

a: Average acceleration = 12cm/sec2[11]

E: Drive efficiency = 0.9[11]

For 20m span, M= 10+12= 22T

$$\text{Required mechanical power in Kw} = \frac{(22 \text{ x } 40)}{(6117 \text{ x } 1.7)} \text{x} \left(8 + \frac{1100\text{x}12}{981\text{X}0.9}\right.$$

For 22m span, M= 10+15= 25T

$$\text{Required mechanical power in Kw} = \frac{(25 \text{ x } 40)}{(6117 \text{ x } 1.7)} \text{x} \left(8 + \frac{1100\text{x}12}{981\text{X}0.9}\right.$$

Motor used is of 132M frame size and 4.6Kw as rated power. 4.6Kw is much more than the required mechanical power. If the amount of increase in span is more, the long travel motor will change.

7.3Effect of Span on Long Travel Brake Size

Required braking torque depends on the mechanical power required to drive the system. More the mechanical power required more will be the braking torque and thus more the size of brake drum.

$$\text{Braking Torque} = \frac{(\text{Mech. Kw x } 716.2)}{(\text{Motor RPM x } 0.736)} \quad (11)$$

$$\text{Braking Torque for 20m span} = \frac{(1.94 \times 716.2)}{(983 \times 0.736)} = 1.92\text{Kgm} \quad (12)$$

$$\text{Braking Torque for 22m span} = \frac{(2.2 \times 716.2)}{(983 \times 0.736)} = 2.18\text{Kgm} \quad (13)$$

From the brake manufacturers catalogue used brake is having brake drum of 100mm diameter and braking torque of 5Kgm. Hence brake size will be same for the long travel of 20m and 22m span.

7. FUTURE SCOPE

In this work we have point out the components like wheel, motor, brake which will depend on the span of the crane. The logic needs to be made for which the components will remain unchanged for percentage increase in span. Similarly like mechanical components, structural members will also get affected by the increase in the span. Components like girder, end carriage and the gantry girders need to be analyzed for the finding effect of span on these components. For structural members, the experimental analysis needs to be done on small scale model to validate the analytical results.

8. CONCLUSIONS

In this work we have reviewed the work done on overhead cranes, types of overhead cranes and basic components of cranes. We have pointed out the components like wheel, motor, brake which will depend on the span of the crane. Using Indian standards, the components used for 20m span crane are safe for 22m span. The future work is to find the effect of increase in span on structural members like girder, end carriage and the gantry girders.

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REFERENCES

[1] Yogi Raval, "Design analysis and improvement of EOT crane wheel", International Journal of science technology & engineering, ISSN: 2349-784X, Volume 1, Issue 11, May 2015.

[2] Abhinay Suratkar and Vishal Shukla, "3D Modelling and finite element analysis of EOT crane", International Journal of mechanical and production engineering, ISSN:2320-2092, Volume-1, Issue 2, Aug2013.

[3] Patel P. and Nirav K, "Design and analysis of major components of 120 Tones capacity of EOT crane", IJEDR 2014, ISSN: 2321-9939, volume-2, issue 2.

[4] Prof. V.K.Jani and Apeksha Patel, "Design and Dynamic analysis of 70T double girder electric overhead crane", ISSN: 0975-668X, Nov-12 to Oct-13, Volume-2, and Issue 2.

[5] N. Rudenko, Material Handling Equipment, 2nd edition, Envee Publishers, New Delhi.

[6] Code of Practice for Heavy Duty Electric Overhead Travelling Crane Including Special Service Machines for Use in Steel Works, 1st revision, IS: 4137-1985.

[7] Crane Classification, Part-1, IS: 13834-1994.

[8] Crane Classification, Part-2, IS: 13834-1994.

[9] Code of Practice for General Construction in Steel, IS: 800-1984.

[10] Design, Erection and Testing of Cranes and Hoists- Code of Practice, IS: 807-2006.

[11] Code of Practice for Electric Overhead Travelling Crane and Gantry Cranes Other Than Steel Work Crane, 2nd revision, IS: 3177-1999.

[12] Design data of engineers, compiled by PSG College of technology, 1st edition, Kalaikathir Achchagam Publisher, Coimbatore.