Design And Analysis of Hoisting Mechanism of An Electric Overhead Travelling Crane

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Abstract- *In today's modern era, the crane is very important material handling equipment in the industry because of safety, reliability, fast speed, economy, etc. There are several components used for hoisting mechanism in EOT crane. In this review paper, discussed about various parts of hoisting mechanism. Carried out design calculation of various parts and analyzed it for structural or functional aspect. The dimensions of the main components have been determined for a load capacity of 50 ton crane having 8 rope fall. Various dimensions of 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. In this project an overall design of the hoisting mechanism of an EOT crane has been carried out. The dimensions of the main components have been determined for a load capacity of 50 ton crane having 8 rope fall. Various dimensions of 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 cases. 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.*

Keywords- Drive efficiency, Fishing hooks, dynamic loads, failure analysis, equivalent stress)

I. INTRODUCTION

Electric overhead travelling crane or EOT crane is one of the most common types of overhead crane, or called bridge cranes, which consist of parallel runways with a travelling bridge spanning the gap. As obvious from the name, EOT crane is operated by electric, generally there is an operator cabin or a control pendant along with the EOT crane.

a) Single girder EOT crane

As the name shown, single girder EOT crane has one main girder, which is easy to install and requires less maintenance. The most common single girder EOT cranes are as follows:

- LD type single girder EOT crane
- LDP type single girder EOT crane and
- HD type single girder EOT crane

b) Double girder EOT crane

- QD type hooks, double bridge crane
- LH electric hoist, double girder bridge crane
- NLH type, doubles girder EOT crane

Hoisting is the process of lifting something or some load or person from a lower position to a higher position with the help of some device or mechanisms known as hoisting devices or mechanisms. The hoisting devices are used to lift or lower the load by the assistance of drum or lift-wheel. The cranes may be manually, pneumatically of electrically operated and may use chain, fibre or wire ropes as its medium as shown in figure 1.

Hoisting part of a crane includes:

- Hoist motor
- Gear box
- Drum
- Pulleys
- Wire rope
- Hook

Fig.1 Crane model

Crane hook is generally used to elevate the heavy loads, heavy machineries, man, material in industries and constructional sites. Recently, excavators having a crane-hook are widely used in construction work site. The excavator is used to perform the conventional digging tasks as well as the suspension works. There are many cases that the there are cases that the crane hook are damaged during the same kind of work. From a safety point of view, such damage must be prevented. First, identify the reason of the damage is one of the key points toward the safety improvement. Mainly in loading area due to friction heat are generated and crack is developed in the crane hook. It can cause fracture of the hook and lead to serious accidents. Crack propagates continuously. In ductile fracture, and is more easily detectable and hence preferred over brittle fracture. There is sudden propagated. In brittle fracture, and the hook fails suddenly. This type of fracture is very dangerous as it is difficult to detect.

II. LITERATURE REVIEW

The literature review is one of the earlier studies. This technique helps us to get the information about previous study of structural analysis of the overhead crane girder. A range of literature studies have been done an early phase of project such as scientific journals, textbooks, conference volume article where the main font in job guides. Development of a hook is a long process which requires a number of tests to validate the design and manufacturing variables. We have used CAE to shorten this development, thereby reducing the tests. A systematic procedure is obtained where CAE and tests are used together.

In fact, their use has enabled the automakers to reduce product development cost and time while improving the safety, comfort, and durability of the crane hook they produce. This paperwork is carried out on hook of any heavy cream. The objective of this work is to carry out computer aided design and analysis of hook. The material of the hook is Steel. The CAD modelling and finite element analysis is done in ANSYS ver 17.0. Hook and line fishing is a highly selective low energy fishing method and is well suited for the exploitation of sparingly distributed fishes. It is one of the most ancient fishing techniques, which is still in use all over the world. Fishing hooks form the indispensable part of any hook and line fishing system. Modern day fishing hooks are manufactured from high carbon steel wire.

The characteristic blend of fishing hook is formed by physically bending the wire to the desired shape and style. The most important step in hook manufacture is the tempering of the hook in which the hook is hardened to improve strength. This process hardens the metal and substantially increases its resistance to unbending, resulting in strong hooks with reduced brittleness. The resistance of fishing hooks towards unbending force is a very essential property as far as fishing hooks are concerned. But we have found that references of such studies are very limited. Most studies carried out were focused towards fishing efficiency of different fishing hooks

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[1] AbhinaySuratkar and Vishal Shukla, "3D Modelling 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 modelling and analysis has been carried out. For modelling 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.

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 [4].

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 [5].

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 [6].

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.[7]

[8] E.Narvydas et. *al* **(2012)**, investigated circumferential stress concentration factors with shallow notches of the lifting hooks of trapezoidal cross-section employing finite element analysis (FEA). The stress concentration factors were widely used in strength and durability evaluation of structures and machine elements. The FEA results were used and fitted with selected generic equation. This yields formulas for the fast engineering evaluation of stress concentration factors without the usage of finite element models. The design rules of the lifting hooks require using ductile materials to avoid brittle failure; in this respect they investigated the strain based criteria for failure, accounting the stress variations.

[9]Rashmi Uddanwadiker **(2011)**, studied stress analysis of crane hook using finite element method and validated results using Photo elasticity. Photo elasticity test is based on the property of birefringence. To study stress pattern in the hook in a loaded condition analysis was carried out in two steps firstly by FEM stress analysis of approximate model and results were validated against photo elastic experiment. Secondly, assuming hook as a curved beam and its verification using FEM of exact hook. The ANSYS results were compared with analytical calculations, the results were found in agreement with a small percentage error = 8.26%. Based on the stress concentration area, the shape modifications were introduced in order to increase strength of the hook.

[10]SpasojeTrifkovic' et. *al* **(2011)**, this paper analyzes the stress state in the hook using approximate and exact methods. They calculated stresses in various parts of the hook material firstly by assuming hook as a straight beam and then assuming it as a curved beam. Analytical methods were used with the help of computers, using FEM.

[11]Pu H. et al, Developed a dynamic model for load lifting system of the overhead crane. Direct precise integration method has been planned for calculating the dynamic loads of the system during lifting products. They have discussed the dynamic characteristics of the general crane and advanced crane which were used the traditional step speed regulation, variable frequency speed control technique respectively. The dynamic characteristics of the load-lifting system of the general crane and advance crane were calculated by the high precision time step PIM. The results showed that the advanced crane has much lesser dynamic loads as compared the general crane in the same case.

[12] Wu X. et al, Optimized the general structure and hoisting mechanism of large quenching crane for structure and technical requirements. They had designed and calculated for structural features of the quenching crane-related to technical documents, specific national standards, and main technical parameters. They have found that this development of large quenching crane to meet the development needs of venture production. It has provided the guideline and reference for the future design of similar cranes.

[13] Alicia et al analyzed of the total plate girder to determine their shear failure mechanism. It was observed that the shear-induced at plastic hinges only develop at the end of panels due to the shear deformation near about supports. It was shown that the simple shear panels, in the form of detecting plates do not accurately represent the failure mechanism of web plates. They concluded that the detached plate's simulation does not represent the true behaviour of plate girder web panels. It was found that the shear- induced plastic hinges occur only in the flanges on end panels after the deformation of partially inclined yield zones in webs. They do not occur in mid panels.

[14] Zambian et al, carried out failure analysis of a shaft used in a bridge crane. It has been different types of analysis such as chemical analysis, fractography, hardness measurements, micro structural characterization and finite element simulation. The analyzed the different factors which produced fatigue failure,such as oxides, microspores, manganese sulphide. It was found that the stereography examination revealed in the presence of beach and ratchet marks on the surface and the fractography examination shows striations, and shaft fractured by fatigue. The study found the length of MnS inclusions above the value of the critical inclusion size parameter that produced a drastic decrease in fatigue life.

[15] Chauhan N. & Bhatt P.M analyzed the stress condition in the power structure of overhead crane for increasing its toughness has been made by using the NX NASTRAN. The estimation of stresses state are pointed out at the critical areas and measures, which are imposed in order to increase the stiffness of the power of structure for the overhead equipment, were performed. They obtained EN-22 material is most excellent from another two materials and trapezoidal sections is finest than the round and rectangle section. They found that the stress and deflection are less in the EN-22 material than forged steel and Steel-20.

[16] G.Martin L.M. et al reduced the ultimate strength of steel I-girders when the loads were applied at an eccentricity relative to the centre of the section. The effect of patch load length had investigated using a substantially larger data set that was available in the past. It was observed that the length of patch loading has an effect on ultimate strength for ratios tf /tw ≤ 1.5. Ultimate strength had obtained through the pondered least square method that resulted in the definition of a penetration coefficient k. It was found that the effect of the patch load has a significant influence on the strength reduction coefficient for small ratios of flange thickness to web thickness tf /tw.

[17] Sowa L. et al to evaluate of the stress state at the critical areas of gantry crane. Strength parameters of designed structures were analyzed using advanced software with high efficient possibilities of modeling. The mathematical model and numerical simulations of mechanical phenomena in the gantry crane beam are presented. The influence of changing the loading force position on generat the equivalent stress in the crane beam was evaluated. It was observed that the Huber-Misses equivalent stresses in the all crane beam about I-beam cross-section was less than the strength of beam material. It should be noted that results of numerical simulations are compatible with the results found in th literature of the subject. It was found that recommended reducing stresses near the end of the crane beam by improving structure gantry crane.

III. DESIGN OF THE CRANK HOOK

The inner side is called intrados and the outer side is called the extrado. According to force diagram of the hook intrado experiences a more tensile force than the extrado

Where P is the load applied in tonne c is the bed diameter
µis a constant, varying from 3.8 to 7.6
Considering _= 4.24 c = 30cm =300mm
The throat of the hook is taken 0.75c =225mm
Using safety factor 6
W=6x50000 =300,000 N

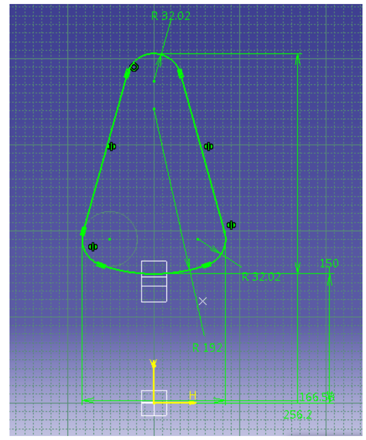

Fig 2. A crane hook is treated as a curved beam

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 as shown in figure 2.In a beam with larger curvature neutral surface is displaced from the passing through the centroid towards the center of curvature. The stress distribution in the curved beam due to moment is found by balancing the internal resisting moment to the externally applied moment.

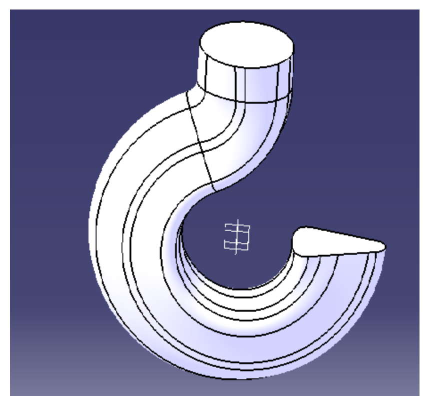

Fig 3. Modified cross section

The below figures show the ANSYS analysis of crane hooks of various cross sections. The stress distribution in the hook with modified cross section is shown in figure 4. The Stress distribution in the hook with another modified cross section is shown in figure 5`

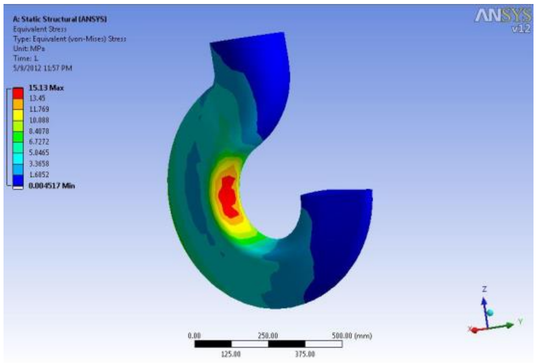

Fig 4 Stress distribution in the hook with Modified cross section

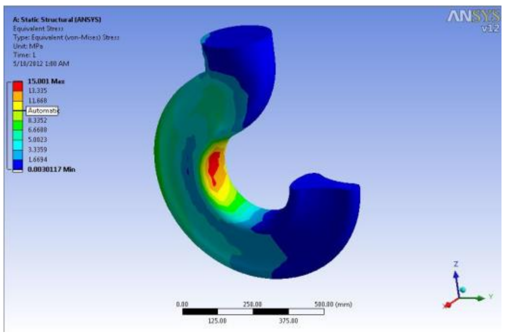

Fig 5 Stress distribution in the hook with another modified cross section

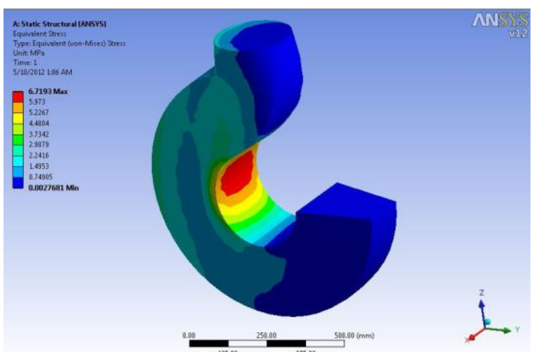

Fig 6. Stress distribution in the hook with Trapezoidal cross section

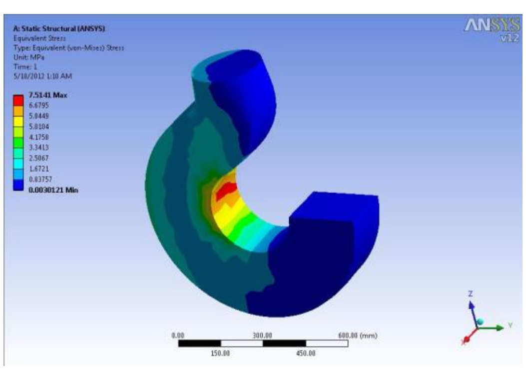

Fig 7. Stress distribution in the hook with Rectangular cross section

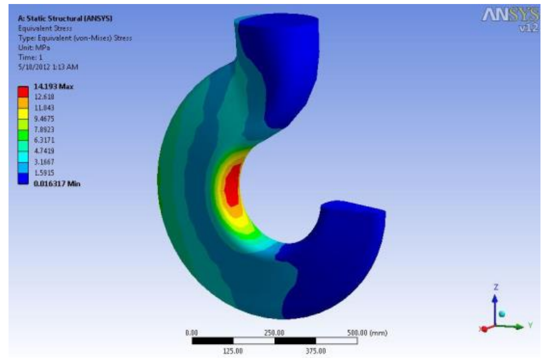

Fig 8. Stress distribution in the hook with a modified section

IV. HOIST BRAKE

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, and 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 braking 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.

Sizing of crane hoist brakes is typically based upon full load hoisting torque. The following is a brief summary the 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:

a. 1.5 times when only one brake is used.
b. 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
c. 1.75 times for hoists handling hot metal
d. Failure of any one brake shall not reduce brake torque below 1.5 times

V. 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
- Wire rope diameter chosen 6x19 as it show less stress on the wires
- Rope diameter=29mm
- Increase in no of rope falls increase drum length, work done,
- Drum length =4.5 m
- Drum dia =0.676m
- Pulley dia=0.725m
- Motor power=158.4 KWatt
- Braking torque=23 Nm

VI. CONCLUSION

In the designed hoist model trapezoidal section shows less stress. The modified section should show less stress, but due to a reduction in the area it shows more stress Using more no. of rope falls divide the load and make the tension less. Also, it makes the work faster .E.g. if we use 4 rope falls, then using the same force 4 the work is done But increase in rope fall increase the rope length by that time ,which is expensive Also the rope length determine the drum length. Increase in drum length increase the volume of setup to reduce the volume we can double winding of rope 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 gearbox is used for power transmission. According to the application, structural features of the electric overhead material handling crane girder were calculated correlative between the technical documentation, design standards, and main technical input/output parameters of EOT crane girder. At current, the crane has been in the perfect solution in all of industries related to material handling process such as steel industries, automobile industries, heavy industry and various types of workshop or station which are transformed material from one place to another.

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