“Design of Jib Crane type rotating Derrick system”
In EOT CRANE
For easy lifting the spare parts during heavy maintenance in confined space

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ABSTRACT

EOT crane is the electric overhead traveling crane which is used to material handling and maintenance purpose, especially in steel plant. Which runs along the Rail track which is installed on girder in height about 20 to 30 mtr above from ground level. In some critical places where, there is no arrangements for lifting the EOT crane spare parts during maintenance job or break down job due to no arrangement of chain block fixing in height because of plane structure. We have only one way to use Liebherr crane (mobile crane) for that job like wheel changing, Gear box changing etc. And also availability of Liebherr crane is not easily possible & it required more space. Thus break down times increase due to lack of lifting arrangement.

Hence it can be developed by using Jib crane type rotating derrick system. We can install this system on end carriage of EOT crane in all four sides.

Keywords – EOT Crane, Metal Scrap cutting area (with electro magnet system).

I. INTRODUCTION

It is a device which is used to lift the load with the help of secondary arrangement such as chain block system or by wire rope pulling system etc. And it can shift the material by rotating arrangement.

This system is developed in crane for easy lifting the parts of crane during maintenance. In this system a chain block about 2 ton capacity is hanged then the parts are lifted during maintenance like motor changing, gear box changing and wheel changing etc.

Fig.1: Jib crane type rotating derrick system. [1]
II. CONSTRUCTION OF JIB CRANE TYPE DERRICK SYSTEM

It has very simple and comfort construction to carry the load because this is constructed to lift the spare parts of EOT crane. Like wheel, gear box, motor etc parts of crane in height work about 20 to 30 mtr above from the ground level. There for it is very important to keep safety of men and machines.

Main components of Jib crane type derrick system:
- Base.
- Thrust bearing.
- Bush.
- Mast.
- Boom & Supporting Rib.

- **Base:**
  Base is made from MS pipe 6 IN outer diameter which has 8 mm thickness. Which is permanently fixed by welding in end carriage of the EOT crane? To give more strength 03 pc MS plate 12 mm thick rib is welded on base in 120 degree with end carriage by fillet welding.

- **Thrust bearing:**
  The bearing works on the principle of hydrodynamic lubrication - the balls, squeeze the lubricant to a certain pressure at which point the fluid supports them. It is used to reduce friction when it’s rotate and to carry the axial load when force applied. Thrust bearing is the costly item therefore it can be self-made by making bearing cone from machining of MS plate and by using damage bearings ball for this application. Because it is rotate very less time.

- **Bush:**
  It is used to reducing friction between base pipe and mast. The bush works on the principle of fluid films, where the viscosity of the lubricant supports the mating surfaces. Bush requires very minimal amount of lubricants & In case of starvation, the bush does not self-destructed, and continue to function with reduced efficiency. Bush are usually made from the bronze alloy which has a self-lubricating effect.

- **Mast:**
  It is the vertical column which is made from the MS pipe 5IN outer dia which has 10 mm thickness. It is the member in which bending stress developed due to the load lifted. There is a rectangular key on bottom of mast pipe to self-engagement with bearing cone plate.

- **Boom & Supporting Rib:**
  Boom is the horizontal member (made from 4IN MS pipe which has 8 mm thickness) which is permanently welded on the top of vertical mast with a supporting rib.
III. DESIGN CONSIDERATION TO CARRY THE LOAD

Because jib crane type rotating derrick system is made for carry the load (by secondary arrangement such as chain block). Therefore it is very important to check the design for the particular dimension of model.

While designing a component, it is necessary to provide sufficient reserve strength in case of an accident. This is achieved by taking a suitable factor of safety ($fs$).

The factor of safety is defined as

\[ (fs) = \frac{\text{failure stress}}{\text{allowable stress}}. \]

Or,

\[ (fs) = \frac{\text{failure load}}{\text{working load}}. \]

The allowable stress is the stress value, which is used in design to determine the dimension of the component. It is considered as a stress, which the designer expects will not be exceed under normal operating condition.

For ductile materials, the allowable stress $\delta$ is obtained by the following relationship:

\[ \delta = \frac{\text{Syt}}{(fs)} \]

For brittle material, the relationship is:

\[ \delta = \frac{\text{Sut}}{(fs)} \]

Where Syt and Sut are the yield strength and the ultimate tensile strength of the material respectively.

There are a number of factor which are difficult to evaluate accurately in design analysis. Some of the factors are as follows:

- Uncertainty in the magnitude of external factor acting on the component.
- Variations in the properties of materials like yield strength or ultimate strength.
- Variations in the dimensions of the component due to imperfect workmanship.

The magnitude of factor of safety depends upon the following factors:

I. Effect of failure.
II. Types of load.
III. Degree of accuracy in force analysis.
IV. Material of component.
V. Reliability of component.
VI. Cost of component.
VII. Testing of machine elements.
VIII. Service condition.
IX. Quality of Manufacture.

A. STRESS-STRAIN RELATIONSHIP:

When a material component is subjected to an external static force, a resisting force setup within the component. The internal resisting force per unit area of the component is called stress.

The stress is called tensile when the fibers of the components tend to elongate due to the external force. On the other hand, when the fiber tends to shorten due to external force, the stress is called compressive stresses. A tension rod is in external force $P$ is shown in fig 4.

![Fig.4 Tensile and Compressive Stress](image)

The tensile stress is given by,

\[ \delta t = \frac{P}{A} \]

Where,

- $\delta t$ = tensile stress (N/mm²)
- $P$ = external force (N)
- $A$ = cross sectional area (mm²)

The strain is the deformation per unit length. It given by

\[ e = \frac{\delta}{l} \]

Where,

- $e$ = strain
- $\delta$ = change in dimension (mm)
- $l$ = original length (mm)

B. STRESS DUE TO BENDING MOMENT:

When a beam is subjected to a bending moment $M$. The beam is subjected to a combination of tensile stress on one side of the neutral axis and compressive stress on the other. Such a stress distribution can be visualized by bending a thick leather belt. Crack will appear on the outside, while folds will appear inside. Therefore, the outside fiber are in tension while the inside fiber are in compression. The bending stress at any fiber is given by,
Where, 

\[ \sigma_b = M_y / I \]

\( \sigma_b \) = bending stress at a distance of \( y \) from the neutral axis (N/mm²)  
\( M_b \) = applied bending moment (N-mm)  
\( I \) = moment of inertia of cross section about the neutral axis (mm⁴)

The bending moment is maximum in a fiber, which is farthest from the neutral axis. The distribution of stresses is linear and the stress is proportional to the distance from the neutral axis.

**C. CALCULATION OF LOAD BY CONSIDERING BENDING STRESS:**[2]

We have hollow circular column made from MS pipe, which has 120 mm outer diameter and 100 mm inner diameter. Which supports the projected bracket, load is carried on point A and B, which are in distance from columns center of axis 1000mm and 700mm respectively. We take the factor of safety 2.

We have distance between columns axis and load \( P_1 \) at point A,

\[ e_1 = 1000 \text{mm} \]

Distance between columns axis and load \( P_2 \) at point B,

\[ e_2 = 700 \text{mm} \]

Factor of safety (Fs) = 2  
Yield tensile strength for mild steel  
\( (Sy_t) = 248 \text{ N/mm²} \).

**Step-I: Calculation of permissible tensile stress.**

\[ \sigma_t = Sy_t / (Fs) = 248 / 2 = 124 \text{ N/mm²}. \]

**Step-II: Calculation of direct compressive and bending stress.**

The direct compressive stress for load \( P_1 \) is given by,

\[ P/A = P_1 / \left( \frac{\pi}{4} \times (D^2 - d^2) \right) \]

\[ = P_1 / \left( \frac{\pi}{4} \times (120^2 - 100^2) \right) \]

\[ = P_1 / (3455.75) \text{ N/mm²}. \] ------- (I)

The direct compressive stress for load \( P_2 \) is given by,

\[ P/A = P_2 / \left( \frac{\pi}{4} \times (D^2 - d^2) \right) \]

\[ = P_2 / \left( \frac{\pi}{4} \times (120^2 - 100^2) \right) \]

\[ = P_2 / (3455.75) \text{ N/mm²}. \] ------- (II)

The bending stresses are tensile on the left side and compressive on the right side of the cross-section. The tensile stress due to bending moment is given by:

For load \( P_1 \) which has 1000mm distance from columns axis, Moment due to load \( P_1 \),

\[ M_1 = P_1 \times 1000 \text{mm}. \]

Radius of curvature,

\[ y = 0.5 \times \text{Outer diameter of column}, \]

\[ y = 0.5 \times 120 \]

\[ y = 60 \text{ mm}. \]

Moment of inertia for hollow circular section,

\[ I = \frac{\pi}{64} \times (D^4 - d^4) \]

\[ I = \frac{\pi}{64} \times (120^4 - 100^4) \]

\[ I = 5270021.67 \text{ mm}^4 \]

We know that from bending equation,

\[ \sigma_b = M_1 / (I) \]

\[ = (P_1 \times 1000 \times 60) / (5270021.67) \]

\[ = P_1 \times 0.113 \text{ N/mm²}. \] ------- (III)

For load \( P_2 \) which has 700mm distance from columns axis,Moment due to load \( P_2 \),

\[ M_2 = P_2 \times 700 \text{mm}. \]

\[ \sigma_b = M_2 / (I) \]

\[ = (P_2 \times 700 \times 60) / (5270021.67) \]

\[ = (7.96 \times 10^{-3}) \times P_2 \text{ N/mm²}. \] ------- (IV)

**Step-III: Calculation of load.**

The resultant tensile stress is obtained by subtracting (III) from (I):

Equating the resultant stress to permissible tensile stress,

\[ (P_1 \times 0.113) - (P_1/3455.75) = 124 \]

\[ P_1 = 11276.6 \text{ N (or 1ton)} \]

Also the resultant tensile stress is obtained by subtracting (IV) from (II):
Equating the resultant stress to permissible tensile stress, 
\[(7.96 \times 10^{-3}) \times P_2 - \frac{P_2}{3455.75}\] \[= 124\]
\[P_2 = 16170.3\text{N (or 1.6 ton)}\]

Hence it has minimum capacity to lift the load is 1 ton. It can lift more load by shorting the distance between load and the axis of column (Mast).

**IV. INSTALLATION & WORKING**

It works to lift the load by small effort. Jib crane type derrick system is installed on end carriage of EOT crane by which all type of maintenance of long travel drive system could be completed.

Firstly Derrick Base is permanently welded on all the four sides of end carriage of the EOT crane. Base is made from MS pipe 6 IN outer dia which has 8 mm thickness. Which is permanently fixed by welding in end carriage of the EOT crane? To give more strength 03 pc MS plate 12 mm thick rib is welded on base in 120 degree with end carriage by fillet welding from Electrode E7018, 4mm supratherm.

A thrust bearing is used inside the base. The bearing works on the principle of hydrodynamic lubrication- the balls, squeeze the lubricant to a certain pressure at which point the fluid supports them. It is used to reduce friction when it’s rotate and to carry the axial load when force applied. Thrust bearing is the costly item therefore it can be self-made by making bearing cone from machining of MS plate and by using damage bearings ball for this application. Because it is rotate very less time.

A bush is used in the top side of the base pipe. It is used to reducing friction between base pipe and mast. The bush works on the principle of fluid films, where the viscosity of the lubricant supports the mating surfaces. Bush requires very minimal amount of lubricants & In case of starvation, the bush does not self-destructed, and continue to function with reduced efficiency. Bush are usually made from the bronze alloy which has a self-lubricating effect.

Then after the second arrangement Mast is introduced inside the Base. It is the vertical column which is made from the MS pipe 5IN outer diameter which has 10 mm thickness. It is the member in which bending stress developed due to the load lifted. There is a rectangular key on bottom of mast pipe to self-engagement with bearing cone plate. Then it gets ready to use.

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**Fig.5**: EOT Cranes Long travel parts.

**Fig.6**: Installation of Derrick base by welding [1]

**Fig.7**: Introducing the mast inside the base pipe.
Now 1 or 2 ton capacity chain block is hanged which operates mechanically by pulling the chain with man power.

All types of maintenance activity such as wheel changing, motor changing, gear box changing, material shifting from ground level to crane could be completed easily with safe condition. Below fig.8 & fig.9 shows the motor shifting during motor changing activity.

**Fig.8: Initial position of motor on platform**

**Fig.9: Motor shifted to crane after rotation.**

V. PROBLEM IN MAINTENANCE OF EOT CRANE WITHOUT LIFTING ARRANGEMENT

In some critical places where, there is no arrangements for lifting the EOT crane spare parts during maintenance job or break down job due to no arrangement of chain block fixing. We have only one way to use Liebherr crane for that job like wheel changing, Gear box changing etc. And also availability of Liebherr crane is not easily possible & it required more space.

Problem analysis:

PROBLEM DURING MAINTENANCE IN EOT CRANES

- Difficult to reach Liebherr crane at maximum work places due to small space.
- There is no space for using Liebherr crane

Thus break down times increase due to lack of lifting arrangement.

VI. CONCLUSION

The design and fabrication of a jib crane type derrick system is a difficult and great task because it is a lifting arrangement which is directly related to safety. The application of jib crane type derrick system in EOT crane is easy because it can be solved by crane maintenance...
department members with assistance of user departments it can be made by scrap and end cuts of MS plates and MS pipe which is easy available in steel plant.

By developing this arrangement in EOT crane maintenance becomes safe and easy.

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