"STRESS ANALYSIS OF JIB, COUNTRJIB AND HOOK OF TOWER CRANE: A REVIEW"

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Abstract

Cranes are transport machines, which generally used in heavy machinery industry, shipyards, seaports, warehouses and construction sector. There are several factors that have to be taken into consideration when a crane being designed. Most important factors are; own weight of the crane, the weight of the bulk which has to be transported and the dynamic loads which occur during the movements. Moreover, for the cranes which operate in open-air, the external loads caused by wind and the other climate conditions have to be considered. In order to prevent possible accidents which can cause enormous losses after manufacturing, all these factors have to be taken into account during the design process. That means crane design process requires repetitive strength calculations. During the design process, time can be saved by handling these calculations with the assistance of Finite Element Method. In this study; results of the analytical calculation and the results that were obtained by finite element method have been compared. In this way, it has been investigated the reliability of the finite element method for JIB crane design. As a result, it has been seen that, F.E.M is the most practical and reliable method which can be utilized during JIB crane design process.

Key Words: *Crane jib, Crane counter-jib, Crane Hook, Computer Aided Design (CAD), Cross Sectional Area, ANSYS, Von misses Stress.*

I. Introduction

Cranes and hoisting equipment in general, are almost always subjected to severe cyclic loading in service. The possibility of developing fatigue in many of their structural components is always present. It is thus very important that cranes and associated equipment be inspected regularly at least visually and preferably by nondestructive test methods for the presence of cracks.

Further, it often appears that inspection is restricted to initial erection, Crane collapse due to bolt fatigue and fatigue failure of a crane support column, crane tower, overhead yard crane, hoist rope, and overhead crane drive shaft and no surveillance of subsequent service is undertaken even though the crane may continue in service for months or even years after the initial inspection. This requires inspection of construction cranes every six months or at every re-erection

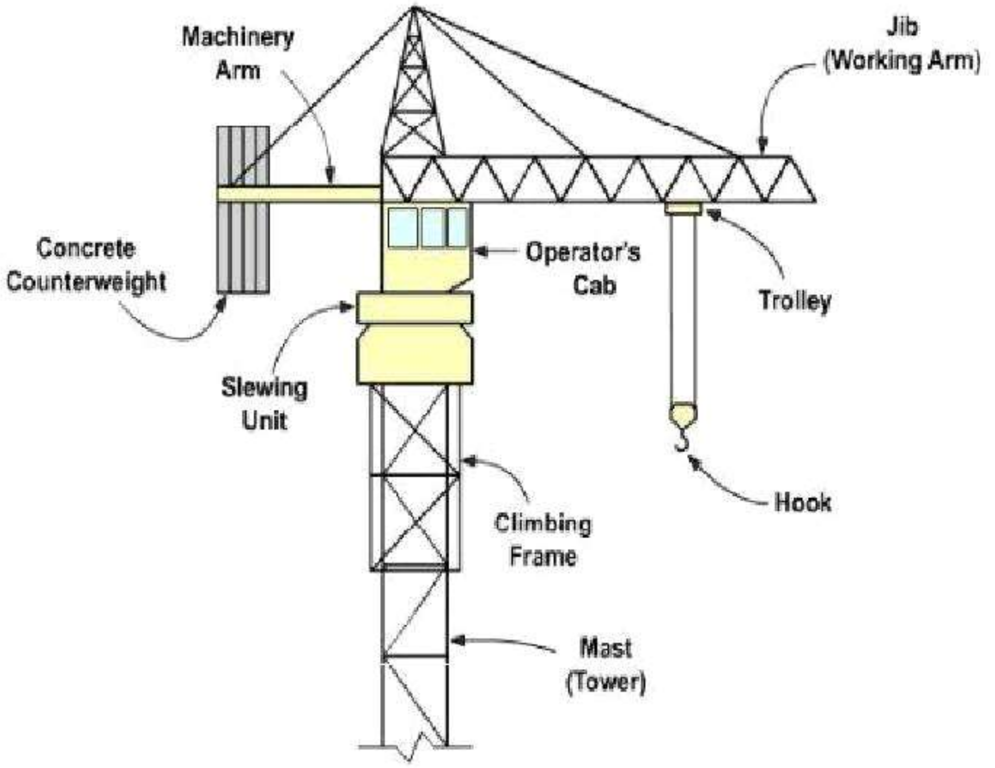
The following cases, which have been investigated, deal briefly with failures of cranes and their components. In all instances, the presence of fatigue at least contributed to the failure. In most instances, fatigue was the sole cause. Further, in each case, with regular inspection, fatigue cracks probably would have been detected well before final failure.

Cranes are widely used to transport heavy loads and hazardous materials in shipyards, factories, nuclear installations, and high-building construction and play an important role in production process and serve to transfer loads from one place to another. Cranes are the best way of providing a heavy lifting facility covering virtually the whole area of the industry. Their design features vary widely according to their major operational specifications such as the type of motion, dead weights and type of the load, location of the crane, geometric features and environmental conditions. Since the crane design procedure is highly standardized with critical components, main effort and time spent mostly for interpretation and implementation of available design standards.

Tower cranes are a modern form of balance crane that consist of the same basic parts. Fixed to the ground on a concrete slab (and sometimes attached to the sides of structures as well), tower cranes often give the best combination of height and lifting capacity and are used in the construction of tall buildings. The base is then attached to the mast which gives the crane its height. Further the mast is attached to the slewing unit (gear and motor) that allows the crane to rotate. Top of the slewing unit there are three main parts which are: the long horizontal jib (working arm), shorter counter-jib, and the operator's cab. The long horizontal jib is the part of the crane that carries the load. The counter-jib carries a counterweight, usually of concrete blocks, while the jib suspends the load to and from the center of the crane. The crane operator either sits in a cab at the top of the tower or controls the crane by radio remote control from the ground. In the first case the operator's cab is most usually located at the top of the tower attached to the turntable, but can be mounted on the jib, or partway down the tower. The lifting hook is operated by the crane operator using electric motors to manipulate wire rope cables through a system of sheaves. The hook is located on the long horizontal arm to lift the load which also contains its motor.

In this study, a tower crane is modelled in 3D using NX8 computer software. Then, the generated components are meshed in ANSYS/HYPERMESH Software. The meshed components are mounted to each other and the meshed model of the tower crane is obtained. Finite element analysis is accomplished considering the load combinations in FEM norms. The obtained data is compared with the analytical calculations.

II. Tower Crane Layout



IV. Tower crane parts focused in this paper

Counter-jib: A crane drives, drums, gears, electronics and counterweights are found on the counter-jib platform. Counter-jib provides balancing force to the load on the horizontal jib.

Jib: The jib extends horizontally at various lengths depending on the model and configuration of the crane. Rotation of the jib is achieved by employing the slewing action. Jib is used to moves loads up and down using hook.

Hook: A hook or hoist attached to the hook block assembly. Hook is used for lifting and lowering the load.

VI. Work Methodology

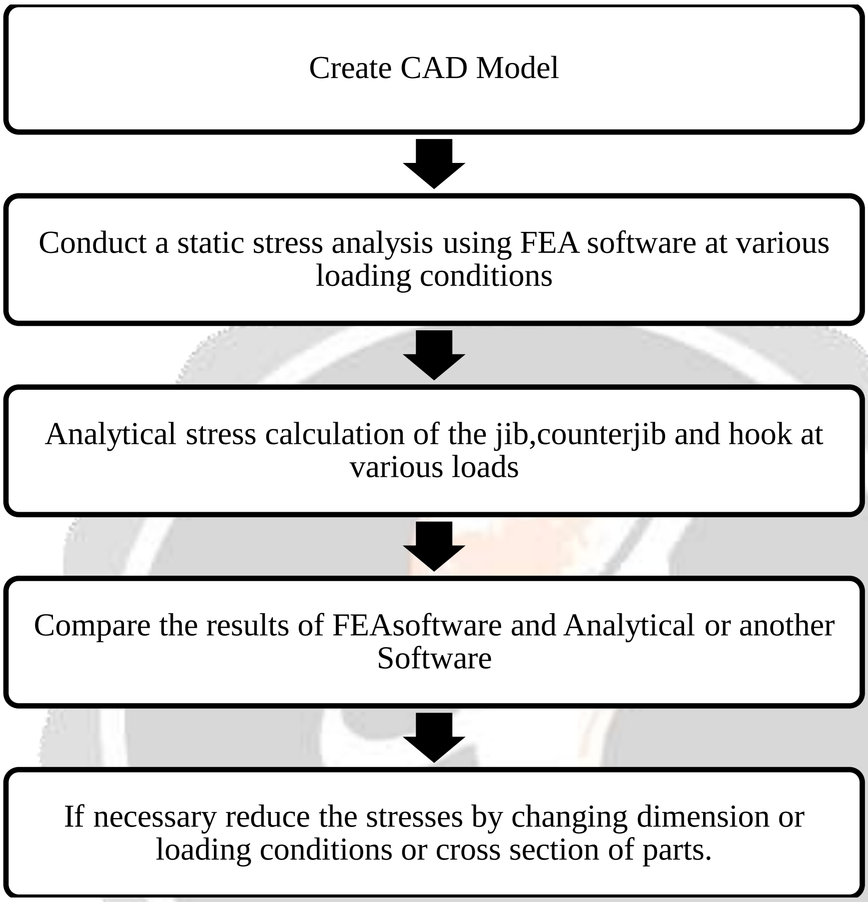


Table 1: Work methodology

VII. Literature Survey

Nenad D. Zrnic and et al [1] analyzed failure of tower crane Counter jib. They found counter jib collapse due to gusset plate failure. Due to parent metal hardening in fracture zone, weld seam perpendicular to the direction of force action and welded joint between profiles of the truss chord and plates fracture of counter jib occurred. Execution of welded joints and dynamic character of loads are the reasons behind gusset plate failure.

Huang and et al [2] use SAP2000 and ANSYS for free vibration and modal analysis of tower crane. They found that designed & analyzed frame of a 63 tonne power press machine using Finite Element method. Due to the impact loading at the end of the bolster plate there was development of a crack at the corner and stress generated was more due to continuous loading and stress concentration. Modifications were done by introducing the fillets of proper size. Also plate thickness was reduced which saved material.

Joseph Leo. A. and et al [3] Studied different cross sections for hook, failure of a crane hook mainly depends on three major factors i.e. dimension , material , overload .Their project is concerned towards increasing the safe load by varying the cross sectional dimensions of the three different sections .The selected sections are rectangular ,triangular, and trapezoidal . The area remains constant while changing the dimensions of the three different sections. The crane hook is modeled using PTC CREO software. The stress analysis is done using ANSYS 14.5 workbench. The normal stress along y direction, deformation along y direction and strain is considered. It is found that trapezoidal cross section yields maximum load of 700 kg for constant cross section area among three cross sections.

Ajinkya Karpe and et al [4] selected jib for analysis since we wanted to validate the use of ANSYS (FEM method) for structural design of Tower Crane Jib. Jib model was generated in ANSYS 14.5 workbench and further analyzed in the same. Two models of Tower Crane jib were compared initially for axial force and deformation developed in members of the jib and the better model was selected for further analysis. Throughout the analysis, the load has been applied at the end of the jib of the tower crane to generate maximum moment and stresses in the jib. Initially the results of ANSYS 14.5 were validated using analytical method for the jib (Method of sections for trusses). Later, the results for static as well as dynamic analysis are obtained. In static analysis, crane's self weight, payload, hook weight, trolley weight and wind loading are considered whereas acceleration, braking, and angular velocity are considered in dynamic analysis.

Vivian W. Y. Tam and et al [5] investigates tower crane safety in related to the understanding and degree of executing statutory requirements and non-statutory guidelines for the use of tower cranes in the Hong Kong construction industry. They found Inadequate training and fatigue of practitioners are one of the main reasons.

C Klinger [6] studied wind effect on crane failure. Systems with elements that are highly tensile loaded and undamped, like hangers of bridges or tension bars of cranes are sensitive to wind induced vibrations. This paper describes exemplary the collapses of two modern cranes of different design and manufacturers.

Patel Ravin B and et al [7] studied the design of the hook is done by analytical method and design is done for the different materials like forged steel and high tensile steel. After the analytical method design and modeling of hook is done in modeling soft-ware (solid edge) .The modeling is done using the design calculation from the modeling the analysis of hook is done in FEA software (ANSYS). It is observed that keeping the tones are same with different Material topology we will get different results, they found that the Forged Steel Material gives minimum stress.

A.A. Marquez and et al [8] discussed failure of two cranes in their study. Both cranes have different designs, but common root causes have been identified, related to deficiencies in the design and construction of their bases. Striking similarities in failure circumstances are discussed in this study. The effects and implications of variable loads are often not completely understood or valued by builders and operators, which are used to deal with static loads their fore most of the cranes failure occurs.

VIII. Assumption considered

Following are the assumptions had been made for frame structure.

1. The load is considered as a perfectly vertical.
2. Structural steel material is considered for all parts.
3. Self weight of the parts, tension by tie rod and weight to be loaded 5 ton is considered.
4. Jib is of 12 meters considered for this study.

IX. Analysis Procedure of Jib, Counter jib and Hook of tower crane

The analysis of jib, counter jib and hook is done by the following steps.

1. Modeling

By taking the reference of different research papers and manuals published in journals modeling of jib, counter jib and hook of tower crane.

2. Finite Element Analysis

FEA analysis of a jib, counter jib, and hook of tower crane using ANSYS software by applying various loading conditions.

3. **Material Specifications**

Specification of Material
Designation: St 63.
Yield Tensile strength: 235 to 280 MPa.
Ultimate Tensile strength: 340 to 470 MPa.
Density: 7850 kg/m^3.
Poisons Ratio: 0.3.
Young's Modulus: 2×10^5 N/mm^2.

4. Specification of tower crane

Type	Hammerhead tower crane
Radius of tower crane	12 m
Max. capacity at the end of jib	1.3 tons
Capacity	5 tons
Material	ST 63

XI. Conclusions

In this paper an attempt is made to reduce crane accidents by studying the previous investigations that have been made on the analysis of various tower cranes. The literature review revealed about most of the work has been conducted to find reasons behind failure of tower crane and gives remedies on that. Majority of researchers have carried out work to reduce the unwanted stresses in the tower crane using material structural steel St63. Researchers are talking about fatigue failure, human errors, Vibrations in crane, self balancing, and environmental conditions in previous research papers. The Stress analysis by software and analytical techniques are going to be used for the current project of "Stress analysis of jib, counter jib, and hook of tower crane.

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