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Design, Analysis and Material Optimization of Laminated Crane Hook: A Review

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***Abstract*— Ladle hooks attached to spreader / ladle beam are used primarily to lift liquid metal ladles & transport molten metal safely in the steel industry. The laminated hooks are also used to handle Tundish, Overflow boxes, Launder etc. The objective of this project is to design the laminated ladle hook and optimization of the same using Finite Element Analysis tool without compromising on the strength & keeping the safety within the specified limits as per the standard codes.**

***Index terms* –** Crane hook, FEM, stress analysis.

I. INTRODUCTION

A lifting hook is a device for grabbing and lifting loads by means of a device such as a hoist or crane. A lifting hook is usually equipped with a safety latch to prevent the disengagement of the lifting wire rope sling, chain or rope to which the load is attached. The basic hoist has two important characteristics to define it: Lifting medium and power type. The lifting medium is either wire rope, wrapped around a drum, or load-chain, raised by a pulley with a special profile to engage the chain. The power can be provided by different means. Common means are hydraulics, electrical and air driven motors. Both the wire rope hoist and chain hoist have been in common use since the 1800s, however mass production of an electric hoist did not start until the early 1900s and was first adapted by Germany. A hoist can be built as one integral-package unit, designed for cost-effective purchasing and moderate use, or it can be built as a built-up custom unit, designed for durability and performance. The built-up hoist will be much more expensive, but will also be easier to repair and more durable. Package units were once regarded as being designed for light to moderate usage, but since the 60s this has changed. Built-up units are designed for heavy to severe service, but over the years that market has decreased in size since the advent of the more durable packaged hoist. A machine shop or fabricating shop will use an integral-package hoist, while a Steel Mill would use a built-up unit to meet durability, performance, and reparability requirements.

To minimize the failure of crane hook, the stress induced in it must be studied. Crane is subjected to continuous loading and unloading. This causes fatigue of the crane hook but the fatigue cycle is very low.

This causes fatigue of the crane hook but the fatigue cycle is very low. If a crack is developed in the crane hook, it can cause fracture of the hook and lead to serious accident & human casualty. In ductile fracture, the crack propagates continuously and is more easily detectible and hence preferred over brittle fracture. In brittle fracture, there is sudden propagation of the crack and hook fails suddenly. This type of fracture is very dangerous as it is difficult to detect.

Figure1.Laminated hook

II. LITERATURE REVIEW

Structural optimization design is a new technique developed in twenty recent years, its development has been significant effect on the traditional structural design, and makes people enter from the passive analysis and verifying intensity period to the initiative designing stage

In May 1976, Association of Iron and Steel Engineers (AISI) [1], USA published “AISI Technical Report No.7”. This technical report covers the general design & construction features for laminated ladle hooks which are

rectangular in cross section and are used primarily for lifting hot metal ladles.

In August 2011, Rashmi Uddanwadiker[2] in her paper, "Stress Analysis of Crane Hook and validation by Photo-Elasticity", studied the stress pattern of crane hook in its loaded condition, a solid model of crane hook is prepared with the help of CMM and CAD software. Real time pattern of stress concentration in 3D model of crane hook is obtained. The stress distribution pattern is verified for its correctness on an acrylic model of crane hook using Diffused light Polariscope set up.

In January 2013, Yogesh Tripathi & U.K. Joshi[3], in their paper, "Investigation Stress of A Lifting Hook with Different Methods: A Review", they reviewed the various papers and concluded that very few articles have been published so far regarding stress analysis of this curved member (crane hook). Thus, need a more extensive investigation. In this regard it has been observed that the Finite Element Method has been evolved as important tool for designing and analyzing the structures.

In September 2013, Ajeet Bergaley & Anshuman Purohit[4] in their paper "Structural Analysis of Crane Hook Using Finite Element Method", tested the hook on the UTM machine in tension to locate the area having maximum stress and to locate the yield point. The model of hook is prepared in CAE software having dimension and material similar to the crane hook which was purchased from the market. The results obtained were compared with theoretical analysis. Then cross section in which minimum stress induced for given load was modified through FEM.

In May 2014, Chetan N. Benkar & Dr. N. A. Wankhade[5] "Finite Element Stress Analysis of crane hook with different cross sections", studied the the stress pattern of crane hook in its loaded condition, a solid model of crane hook is prepared with the help of ANSYS 14 workbench. Real time pattern of stress concentration in 3D model of crane hook is obtained. Finite Element Analysis have been performed on various models of crane hook having triangular, rectangular, circular and trapezoidal cross sections.

III. Proposed Methodology

The primary concern in the design of a laminated ladle hook is that a sudden, complete failure should not occur as it may lead to the human casualty in the industries. Use of laminated construction, where the hook is made up of a number of separate plates, is the most important factor in insuring that such a mode of failure does not occur. Crane Hooks are highly liable components and are always subjected to failure due to accumulation of large amount of stresses which can eventually lead to its failure.

The Laminated Crane hooks have been designed using AISI Technical Report No.7 published by Association of Iron and Steel Engineers, USA. Crane is a prime material handling equipment in modern industry where hook is the main stress bearing component. The hook manufacturing industry uses the conventional design procedures to design the hook. As a result, hook becomes bulky with heavy self mass. This project work, therefore, is a technical attempt to optimize the design quality of Laminated Crane Hook and reduce its cost comparing with the traditional design methods.

A. Objectives

Ladle hooks attached to spreader / ladle beam are used primarily to lift hot metal ladles & transport molten metal safely in the steel industry. The laminated hooks are also used to handle Overflow boxes, Launder etc. The objective of this project is to design the laminated ladle hook and material optimization of the same using Finite Element Analysis tool without compromising on the strength & keeping the safety within the specified limits as per the standard codes.

B. Definition of Laminated Hook

Laminated hook is a steel structural fabricated item made up of combination of 3 to 10 plates and joined together by means of rivets.

Purpose of laminated hook is to lift the ladles in the steel making shops, lifting & tilting of the ladle for deslagging and pouring steel respectively. It is the most critical item of the material handling system used in the steel

manufacturing system. The preventive maintenance & periodic inspection of the laminated hook should be done with the utmost care.

C. Standard using for design

1. IPSS i.e. Inter Plant Steel Standard prepared by SAIL & BIS.
2. AISE Technical Report No.7 for Design & Use of Laminated Hook published by Association of Iron and Steel Engineers, USA.

D. Finite Element Method

The advantage of high speed digital computer Has enabled engineers to employ various numerical discretization techniques for approximations solution of the complex problems. The Finite Element Method(FEM) is one such technique. It was originally developed as a tool for static analysis of structures ,its applications , now days range from linear deformation and stress analysis to nonlinear and dynamic analysis, heat transfer, fluid mechanisms, rock mechanisms flux, and various other areas of engineering.

The basic concept of finite of finite element method is that a body or a structure, under study ,is divided into smaller elements of finite length width called finite elements. These elements are assumed to be interconnected at joints called nodes.

a) Discretization of Domain
b) Selection of an interpolation model
c) Formulation of characteristics matrix
d) Assembly of the characteristic matrices
e) Application of boundary conditions
f) Solution of equations

IV. Conclusion

Laminated crane hooks are widely used handling industry for lifting liquid metal kept much ladles. For view point of safety the factor of safety kept much higher side hence hook becomes bulky. The literature review allows concluding very few article have been published so far regarding stress analysis and design optimization of laminated crane hook. Thus need a more extensive investigation. In this regards it has been observed that the finite element method has been evolved as important tool for design a optimization of the structure.

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