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INTERNATIONAL JOURNAL OF RECENT TECHNOLOGY SCIENCE & MANAGEMENT

A REVIEW ON STUDY OF CRANE HOOK DESIGN

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ABSTRACT

Crane hook is very significant component used for lifting the load with the help of chain or links. Crane hooks are highly liable components and are always subjected to failure due to the amount of stresses concentration which can ultimately lead to its failure. To minimize the failure of crane hook, the stress induced in it must be studied. A crane is subjected to continuous loading and unloading. This may causes fatigue failure of the crane hook. The review of previous publications enable to conclude that components with complex geometry as crane hooks require a more extensive investigation in view of the fact that a very few articles have been published so far regarding stress analysis of this curved beam (crane hook).

KEYWORDS Crane hook, Curved beam, fatigue failure, FEM, Stress

I. Introduction

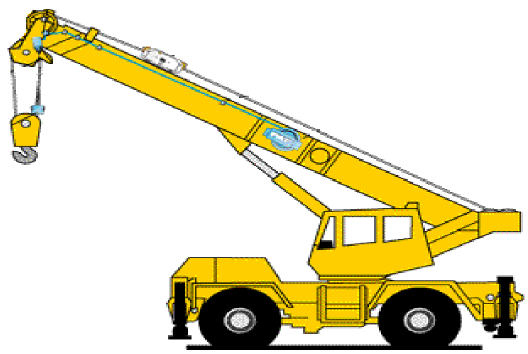
The structure strength is the important characteristic to respond the load bearing capability of the elevating equipment. Crane hook is a curved bar used to lift the loads in the cranes. In order to reduce the structure failure in the crane hook, induced stresses are analysed. Fatigue damage is the initiation of crack due to fluctuating loads. It is caused due to stress levels which are insufficient to cause damage in a single application. It is a highly responsible and important component used for industrial applications.

Crane hooks are highly liable components and are always subject to failure due to accumulation of large amount of stresses which can eventually lead to its failure. Crane hooks are the components which are generally used to elevate the heavy loads in industries and constructional sites.

A crane is a machine, equipped with a hoist, wire ropes or chains and sheaves used to lift and move heavy materials. Overhead crane, mobile crane, telescopic crane, gantry crane, jib crane, deck crane, loader crane are some of the commonly used cranes.

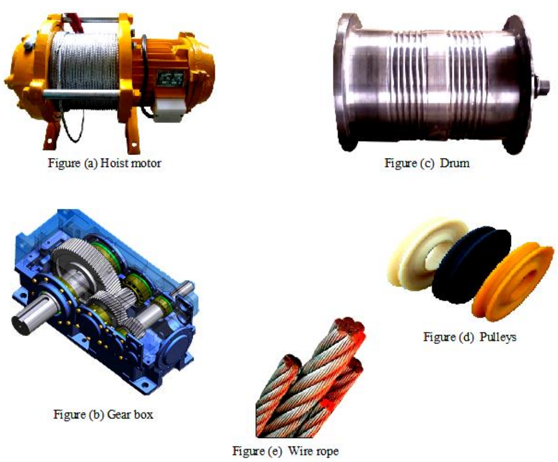
Hook is used to grab and lift the loads. It is a hoisting fixture designed to engage a ring or link of a lifting chain or the pin of a shackle or cable socket. Crane hooks with trapezoidal, rectangular, circular of triangular cross sections are commonly used. The hooks must be designed to deliver maximum performance without failure.

Hoisting is the process of lifting something or some load or person from lower position to higher position with the help of some device or mechanisms known as hoisting devices or mechanisms. A hoisting device is used for lifting or lowering a load by means of a drum or lift-wheel around which rope or chain wraps. It may be manually, pneumatically of electrically operated or driven and may use chain, fibre or wire ropes as its medium.



Hoisting part of a crane includes:

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



II. FAILURE OF CRANE HOOKS

Strain aging embrittlement due to continuous loading and unloading changes the microstructure. Bending stresses combined with tensile stresses, weakening of hook due to wear, plastic deformation due to overloading, and excessive thermal stresses are some of the other reasons for failure. Hence continuous use of crane hooks may increase the magnitude of these stresses and eventually result in failure of the hook. All the above mentioned failures may be prevented if the stress concentration areas are well predicted and some design modification to reduce the stresses in these areas.

III. LITERATURE SURVEY

In this section, contribution of different researchers is discussed. M. Shaban et. al (2013), studied the stress pattern of crane hook in its loaded condition, a solid model of crane hook is prepared with the help of ABAQUS 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 shadow optical method (Caustic method) set up.

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 triaxiality.

Ram Krishna Rathore et. al (2012), this paper involves A general approach for the multiple response cases optimization start with using the regression models to calculate the correlations between response functions and control factors. Then, a system for collecting various response functions together into a one quantity, such as an objective function, is engaged and at last, an optimization technique is used to calculate the best combinations for the control functions. A different method proposed in this paper is to use an artificial neural network (ANN) to calculate the parameter response functions. At the optimization stage, a multi objective genetic algorithm (MOGA) is used in combination with an objective functions to establish the optimum conditions for the control functions. A crane hook example has been taken to optimize multiple shape parameter responses to with stand a new loading condition. The results estimate the reduction in mass and sufficient factor of safety to show the proposed approach for the optimization of multi- disciplinary shape optimization problems. This paper proposes a method for the optimization of multi-response. The approach considers an artificial neural network for every response function to calculate its relation with control functions, unrestrained objective functions to combine diverse responses into single, and a multi objective genetic algorithm (MOGA) to perform the multi-disciplinary optimization. The projected method is novel because of three things. First, it utilizes design of experiment with central composite design method. Second, it usage artificial neural networks to calculate the responses for every parameter with respect to the output function. Finally, it utilizes the multi objective genetic algorithm for optimize the responses created with artificial neural networks. This has been shown with the help of the crane hook example through which the shape responses are estimated for the mass and the factor of safety. Especially, the projected optimization method only involves estimating outcome of the responses. Therefore, one can extend the proposed method to include the more number of parameters for the responses. In this condition, manufacturable constraints are needed to estimate the different responses at various settings of the control factors.

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.

Bhupender Singh et al (2011), Work presented involves the solid modeling and finite element analysis of crane boom has been done using PRO/E WILDFIRE 2.0 and ALTAIR HYPER MESH with OPTISTRUCT 8.0 SOLVER Software to get the variation of stress and displacement in the various parts of the crane boom and possible actions are taken to avoid the high stress level and displacement.By using Finite Element Analysis the following objectives have been achieved.

- Weight Reduction (4.86 kg, approx.5kg).
- Stresses are within limits (at higher load points).
- Cost cutting (Rs-180/- for a single component).

The analysis also concluded that maximum stress is coming near the fixing position.

Y. Torres et. al (2010), initially studied the probable causes which led to a failure of the crane hook in service. The study of accident includes: details of the standards governing the manufacturing and use of lifting hooks, experimental analysis, mechanical behaviour of steel of reported hook and simulation of the thermal history of the hook. It was concluded that the accident was caused by the strain-aging embrittlement of the used steel. The brittle fracture was originated from a crack in the material, generated during the welding performed on the lifting hook.

Takuma Nishimura et. al (2010), studied the damage estimation of crane-hooks. They estimated the load conditions which were assumed to be crucial to the crane-hook damages. FEM model of the crane-hook referring to one of its actual designs was constructed. A database was prepared based on the FEM model; it was constructed as a collection of a number of various possible load conditions and the corresponding deformation values, obtained as the results of the FEM analysis. The database was used to identify the load conditions that were fatal to those damaged crane-hooks. Some of the feature points were selected on the crane-hook design; the deformation of a damaged crane-hook can be then obtained based on the feature points detected by means of the image processing. The critical load condition of the damaged crane-hook was calculated by comparing the obtained actual deformation and the simulated deformation values in the database. On the basis of these calculated load conditions, the critical load condition for the crane-hook was estimated as a statistical distribution based on the Bayesian approach.

C. Oktay AZELOGLU et. al (2009), this paper presents the different methods of stress calculation for lifting hooks based on different assumptions. They applied curved beam theory, Finite Element Method and photo elasticity experiments to obtain the stress field on the hook. As a result, different methods used to obtain the stress field on the hook are compared. Some recommendations were suggested for lifting hook calculations on the field applications.

Yu Huali et. al (2009), the structure-strength is the key index to response the load-bearing ability of the elevating equipment. Researching and analyzing the static characteristic of the hook that functions at the limited load has an important meaning to design larger tonnage hook correctly. In this study, hook of drill well DG450 were analyzed. Firstly, based on the characteristic modeling technology, the 3-D entity model of the hook was built using Pro/E. Secondly; the static analysis on three dangerous work conditions at ultimate load of the hook was preceded by FEM software ANSYS. This work illuminates the instructional meaning and engineering application value to the design and development of the larger tonnage drill well hook.

Bernard Ross et. al (2007), this paper describes the comprehensive engineering analysis of the crane accident, undertaken to disprove the Mitsubishi theories of failure as confirmed by jury verdict. Among the topics discussed were: wind tunnel testing, structural analyses of the boom, metallurgy of failed parts from a critical king-pin assembly, and soils engineering work related to ground loads and displacements during the lift. Crucial role of the SAE J1093, 2% design side load criterion and Lampson's justification for an 85% crawler crane stability criterion were presented.

IV. ANALYTICAL METHOD FOR STRESS CALCULATION

Curved beam flexure formula is used when the curvature of the member is pronounced as in case of hook for different cross sections mathematical analysis of stress

$$\sigma = \frac{F}{A} + \frac{M \times y}{I}$$

Where, *M*=maximum bending moment.

Y=Distance between centroidal axis to neutral axis.

I=Moment of inertia for different cross sections.

Table: 1 Values of Radius of neutral surface for various cross sections

S.NO	GEOMETRY	VALUES
1.	RECTANGLE	$R = h / In(r_2 /r_1)$
2.	CIRCLE	$R = 1/2 (\overline{r} + / \{ \overline{r}^2 \}^{1/2} - \{c^2\}^{1/2})$
3.	TRIANGLE	$R = h^2 /2 / \{ r_2 In (r_2/r_1) - h \}$
4.	TRAPEZOID	$R = h^2/2 \times (b_1 +b_2) / (b_1r_1 – b_2r_2) In (r_2/r_1) – h (b_1 – b_2)$

V. CONCLUSION

The stress concentration factors are broadly used in strength and durability evaluation of machine elements. In order to minimize the failure of the crane hook, the stress induced in crane hook must be studied. The review of previous publications permit to conclude that the curved beam such as crane hook needs more broad investigation since a very few articles in this field have been published yet. The study of the earlier publications enables us to conclude that among all the different methods, the Finite Element Method (FEM) is one of the most effective and powerful method for the stress analysis of the crane hook.

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