

Experimental Investigation of Stress Concentration in Cross Section of Crane Hook

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ABSTRACT

Crane Hooks are highly liable components and are always subjected to failure due to the amount of stresses concentration which can eventually lead to its failure. To study the stress pattern of crane hook in its loaded condition, a solid model of crane hook is prepared with the help of solid works or Pro-E software. Real time pattern of stress concentration in 3D model of crane hook is obtained. By predicting the stress concentration area, the shape of the crane is modified to increase its working life and reduce the failure rates. Hooks are employed in heavy industries to carry tonnes of loads safely. These hooks have a big role to play as far as the safety of the crane loaded is concerned. With more and more industrialization the rate at which these hooks are forged are increasing. This work has been carried out on one of the major crane hook carrying a larger load comparatively. The cad model of the crane hook is initially prepared with the help of existing drawings. It is then followed by implementation of modified cross section of hook in the static structural analysis workbench of ANSYS. The selection was based on the satisfaction of several factors in the form of load carrying capacity, stress induced and deflection. Stress analysis plays a significant role in the design of parts and structures that must carry load. In this study, Crane hook which is one of lifting equipment, frequently used in material handling is investigated. Analytical (Straight beam, curved beam & Winkler-Bach approximation), (FEM) methods were used by various researchers to study stress pattern of crane hook in its loaded condition. The fatigue of the crane which leads to failure of propagation of cracks by stress concentration.

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I. INTRODUCTION

This chapter shows the overview of the work done by various authors in national and international conferences and taken relevant details for the project.

Govind Narayan Sahu (2013), hooks are employed in heavy industries to carry tonnes of loads safely. These hooks have a big role to play as far as the safety of the crane loaded is concerned. With more and more industrialization the rate at which these hooks are forged are increasing. This work has been carried out on one of the major crane hook carrying a larger load comparatively. The cad model of the crane hook is initially prepared with the help of existing drawings. It is then followed by implementation of modified cross section of hook in the static structural analysis workbench of catia v5. These results lead us to the determination of stress and deflections in the existing model. In order to reach the most optimum dimensions several models in the form of different dimensions of hook were tested and the most optimum dimension was selected. The selection was based on the satisfaction of several factors in the form of load carrying capacity, stress induced and deflection.

M. Shaban (2013), Crane Hooks are highly liable components and are always subjected to failure due to the amount of stresses concentration which can eventually lead to its failure. To study 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. By predicting the stress concentration area, the shape of the crane is modified to increase its working life and reduce the failure rates

A. Gopichand (2013), Crane hooks are liable components subjected to failure due to stress in accumulation of heavy loads. The design parameters for crane hook are area of cross section, material and radius of crane hook. In the present work optimization of design parameters is carried out using Taguchi method, total three parameters are considered with mixed levels and L16 orthogonal array is generated. The optimum combination of input parameters for minimum Vonmises stresses are determined.

E. Narvydaset 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.

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

DaryoushSafarzadehet al(2011), this publication analyzes the effect of crane hook parameters (mass & length) on the sway of payload. An approach was proposed based on the Lagrange equation to obtain equation of motion accounting the entire crane motions together. Equations of motion thus formed were easily solved by MATLAB. Both laboratory and theoretical study was performed to validate the results. Their major finding depicts that length of the hook has smaller effect on the sway angles than mass.

Yogesh Tripathi Stress analysis plays a significant role in the design of parts and structures that must carry load. In this study, Crane hook which is one of lifting equipment, frequently used in material handling is investigated. Analytical (Straight beam, curved beam & Winkler-Bach approximation), experimental (Photo-Elasticity) and numerical (FEM) methods were used by various researchers to study stress pattern of crane hook in its loaded condition. The review of earlier publications allow to conclude that components with complex geometry as crane hooks need a more extensive investigation since a very few articles in the field have been published so far.

II. DESIGN CALCULATION

Curved beam theory

The flexural formula is accurate for symmetrically loaded straight beams subjected to pure bending. It also generally used to obtain approximate results for the design of straight beams subjected to shear loads, when the plane of loads contains the shear centre and is parallel to a principal axis of the beam; the resulting errors in the computed stresses are small enough to be negligible as long as the beam length is at least five times the maximum cross-sectional dimension. In addition, the flexure formula is reasonably accurate I the analysis of curved beams for which the radius of curvature is more than five times the beam depth. However, for curved beams the error in computed stress predicted by the flexure formula increases as the ratio of the radius of curvature of the beam to the depth of the beam decreases in magnitude. Hence, as ratio decreases, one needs a more accurate solution for curved beams. Timoshenko and Goodier (1970) have presented a solution based on the theory of elasticity for the linear elastic behavior of curved beams of rectangular cross sections for the loading. They used polar coordinates and obtained relations for the radial stress circumferential stress and the shear stress. However, most curved beams do

not have rectangular cross sections. Therefore, in the following we present an approximate curved beam solution that is generally applicable to all symmetrical cross sections.

CIRCUMFERENTIAL STRESSES IN A CURVED BEAM

The circumferential stresses distribution for the curved beam is obtained by substituting to obtain the curved beam formula.

RADIAL STRESSES IN CURVED BEAMS

The radial stresses stress distribution for the curved beam is obtained by substituting to obtain the curved beam formula.

III. Theory of Simple Bending

Due to bending moment, tensile stress develops in one portion of section and compressive stress in the other portion across the depth. In between these two portions, there is a layer where stresses are zero. Such a layer is called neutral layer. Its trace on the cross section is called neutral axis.

Assumption

- The material of the beam is perfectly homogeneous and isotropic.
- The cross section has an axis of symmetry in a plane along the length of the beam.
- The material of the beam obeys Hooke's law.
- The transverse sections which are plane before bending remain plane after bending also.
- Each layer of the beam is free to expand or contract, independent of the layer above or below it.
- Young's modulus is same in tension & compression.

Consider a portion of beam between sections AB and CD as shown in the figure.

Let e_1f_1 be the neutral axis and g_1h_1 an element at a distance y from neutral axis. Figure shows the same portion after bending. Let r be the radius of curvature and θ is the angle subtended by a_1b_1 and c_1d_1 at centre of radius of curvature. Since it is a neutral axis, there is no change in its length (at neutral axis stresses are zero.)

$$EF = E_1F_1 = R\theta$$

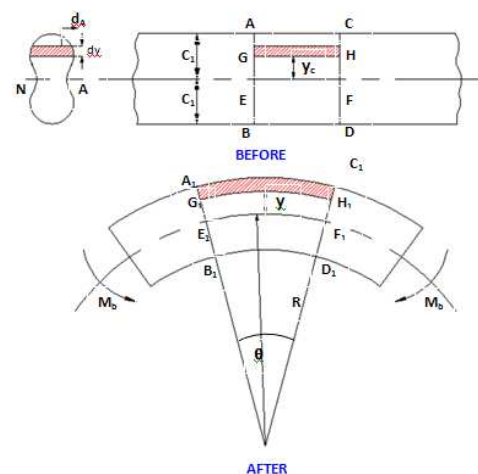


Fig 1 Bending stress diagram

Curved beams are the parts of machine members found in C Clamps, crane hooks, frames of presses, riveters, punches, shears, boring machines, planers etc. In straight beams the

neutral axis of the section coincides with its centroidal axis and the stress distribution in the beam is linear. But in the case of curved beams the neutral axis of is shifted towards the centre of curvature of the beam causing a non linear [hyperbolic] distribution of stress. The neutral axis lies between the centroidal axis and the centre of curvature and will always be present within the curved beams.

IV. Modal calculation

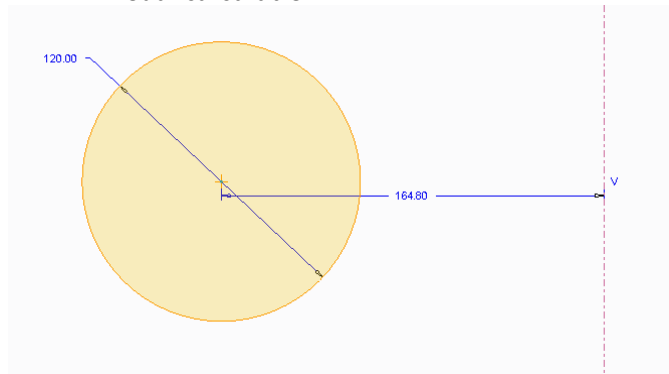


Fig 2 Modal calculation

Known data:
 P= 19620N
 B= 120mm
 b= 50mm
 d= 150mm

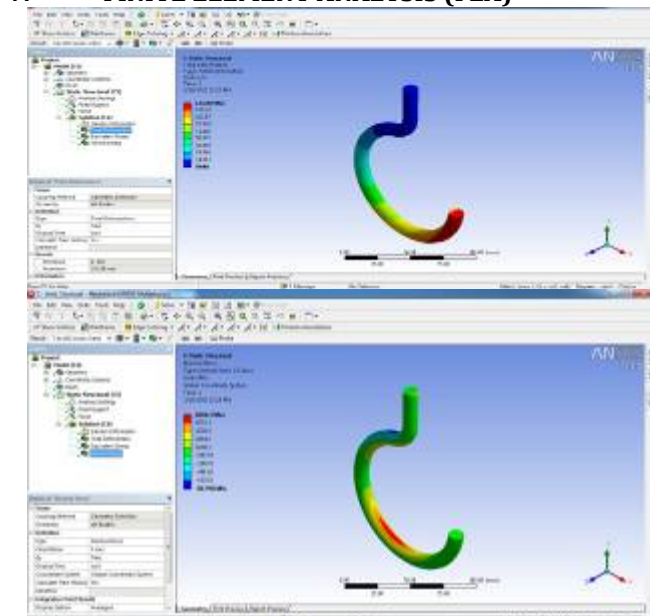
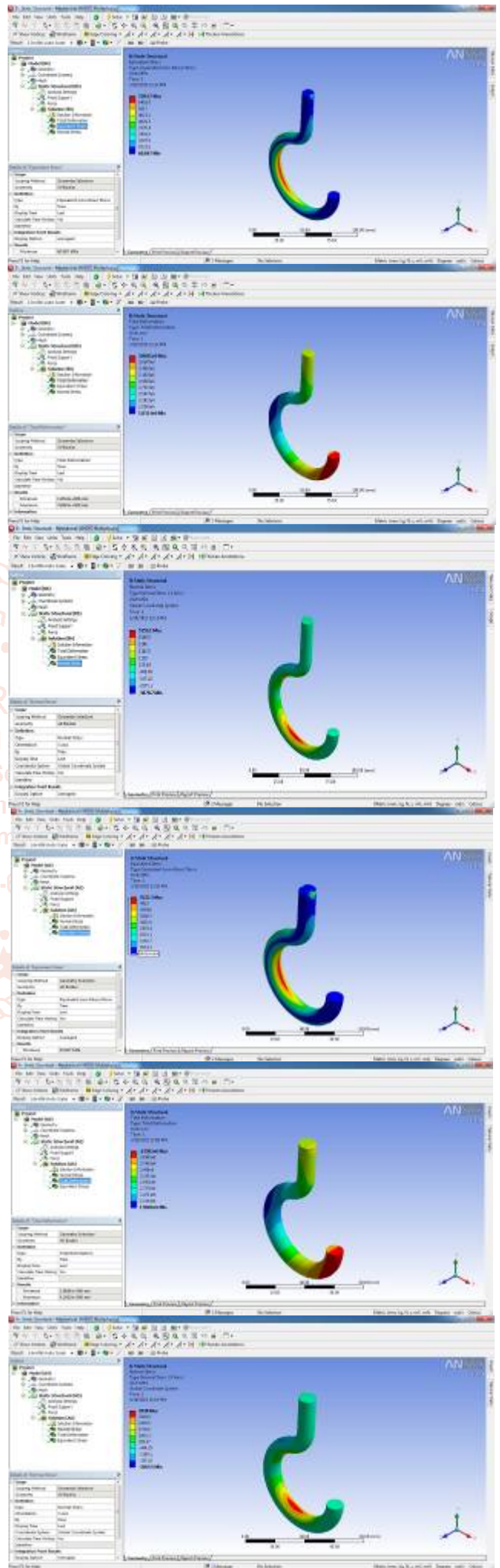
The calculated values are mentioned below from the known data

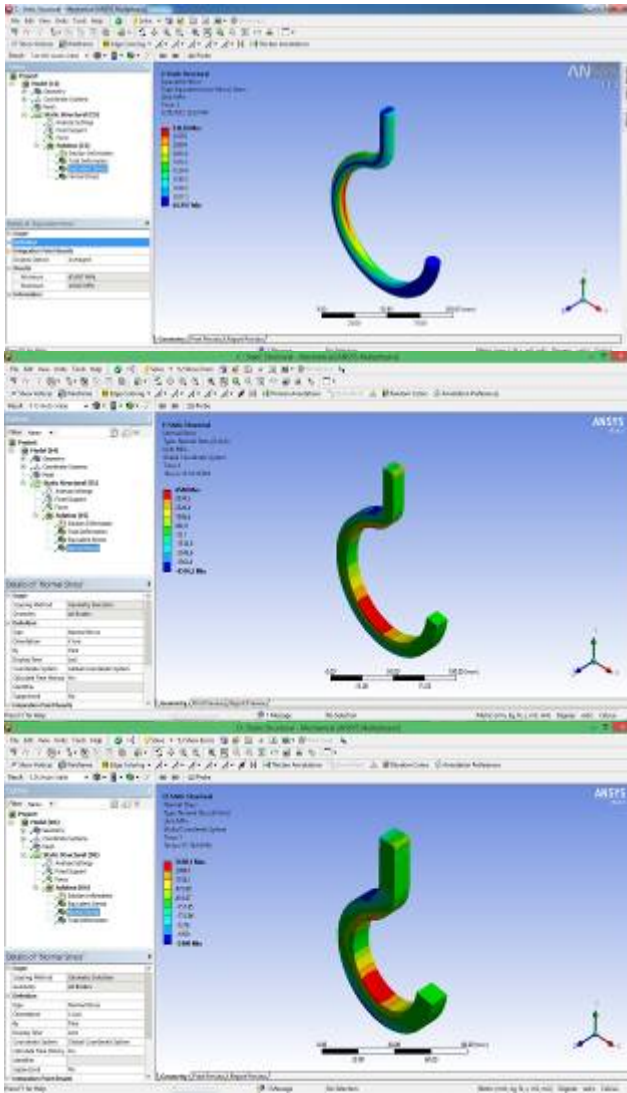
d1= 64.70
 d2= 85.30
 R= 164.70mm
 h²= 0.00825 m²
 M= -5886 N-m

Bending Moment A
 $\sigma_{bA} = 7.05 \text{ MN/m}^2$
 $\sigma_d = -3.48 \text{ N/m}^2$

Bending Moment B
 $\sigma_{bB} = -0.791 \text{ MN/m}^2$
 $\sigma_B = 4.271 \text{ N/m}^2$

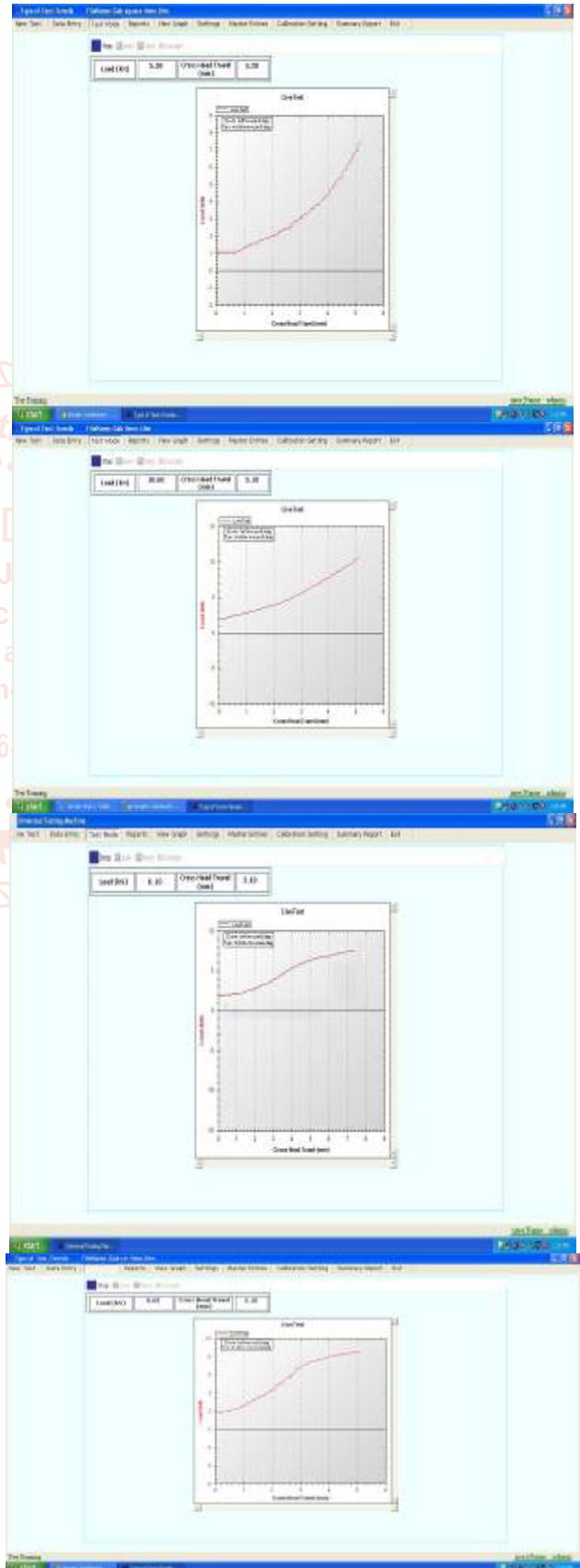
V. FINITE ELEMENT ANALYSIS (FEA)





- The cross section has an axis of symmetry in a plane along the length of the beam.
- The material of the beam obeys Hooke's law.
- The transverse sections which are plane before bending remain plane after bending also.

The whole study is an initiative to find an ANSYS created Finite Element technique, by confirming the results, for the Measurement of stress with Winkler-Bach theory for hooked Beams.



VI. EXPERIMENTAL EVIDENCE

The experimental Evidence is shown below Fig 2.

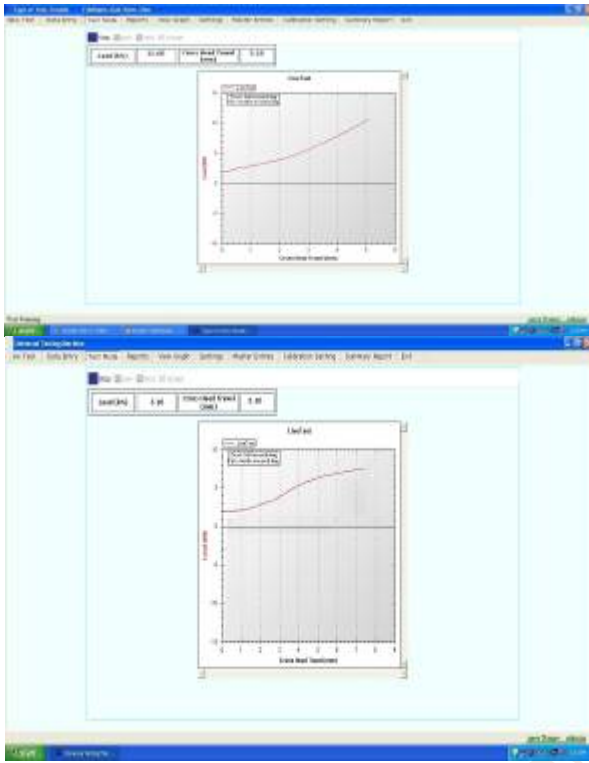


Fig 2 CRANE HOOK

VII. RESULTS

The induced stresses as found from the Winkler-Bach theory for curved beams are measured with results with simulated analysis by ANSYS software. The small percentage inaccuracy of 12%.

Possible reasons for variant influence be due to resulting



VIII. CONCLUSIONS

The complete study is an initiative to establish a FEA procedure, by validating the results, for the measurement of stresses. For reducing the failures of hooks the estimation of stresses, their magnitudes and possible locations are very

important. From the stress analysis we have observed the cross section of maximum stress area. If the area on the inner side of the hook at the portion of max stress is widened then the stresses will get reduced

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