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Finite Element Analysis of Laminated Crane Hook Used for Lifting Ladles

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***Abstract* – The paper imparts an idea about the design of laminated crane hook used for lifting ladles in steel melting shop. It is an attempt to optimize self weight of hook by taking care that the sudden or complete failure of hook should not occur as it may lead to human casualty. With respect to the design of laminated hook, FEA technique is used to optimized and reduce weight of hook. An improved redesign of hook is prepared in 3-D modeling and the results are compared with 3-D Basic model. The redesign results found satisfactory with less stress value and shows reduced weight of hook.**

Index Terms-Crane hook, FEA, Stress analysis.

I. Introduction

The hot metal Ladle lifting laminated crane hook is subjected for heavy loading. The conventionally designed hooks are more prone to sudden failure due to extensive loading of molten metal so that hooks made more heavy weighted. Conventional design calculations are made and that is compared by the results obtained by a Basic 3-D model with same specifications as of the conventional design. The stresses observed are quite close to approximation. In this paper a redesign idea is generated to minimize the weight of hook. A box structure is more reliable in reduction of stress as compared to a laminated structure. The hook with changed design has to undergo in a computer software using Autodesk Inventor 2012 and later the results have to be compared for accuracy and refinement with the Basic 3-D Model.

II. Design Calculation 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 . Standards Used 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
3. Standard Brief:
4. IPSS i.e. Inter Plant Steel Standard specifies the dimensions required to manufacture the laminated hook. IPSS also specifies the main manufacturing features, as follows:-
5. Material: Rolled steel plates of Fe 410W confirming to IS:2062-2011
6. Rivets: Confirming to IS:1929, diameter not less than 12mm & not greater than 48mm
7. Supporting Bush: Confirming to the steel 50C4 as per IS:1570
8. Trunion seat wearing plate: Fe 410W confirming to IS:2062
9. Thickness of plates: It should not be less than 16mm & not greater than 32mm.

The cutting of plates shall be in the direction of rolling/grain size. The gap between laminations shall not exceed 0.1mm for a distance of 2 times the rivet diameter from the edge of a rivet hole. In other area it shall not exceed 0.2mm.For calculation purpose, we are considering the 40 tons lifting capacity hook as per IPSS:1-08-009-83 prepared by SAIL & BIS.

Table I

Form & Dimensions Of The 40 Tons Lifting Hook

Capacity	40 Tons	R5	800	A	1750
D	250	R3	85	H	2400
D1	150	R2	365	h	440
A1	30	R4	180	b 1	345
R	450	R1	120	b 2	850
h3	125	h 1	80	Mass	950

Design stress calculation on the basis of AISE Technical Report No.7 i.e. specification for ladle hook.

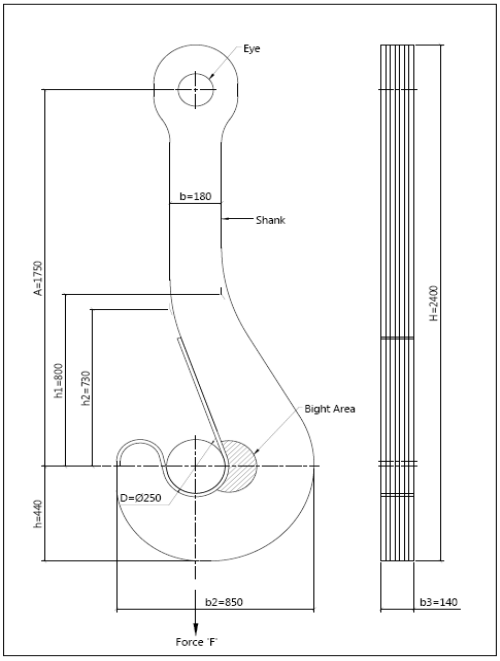

Fig. 1 Laminate Hook Drawing

A. Modified Laminated Hook

The following are the shapes of modified laminated hook which has to be replaced instead of the basic laminated hook. The technical specifications are kept as per the earlier standards.

The hook parts shown in fig. 1& 2 are modified in a b0x pattern and stress compared with conventionally designed hook. It prepares the complete 3-D model. The complete 3-D solid model with improved design is ready to for solid mesh with the help of FEA techniques in Autodesk Inventor. The simulation will be carried out in this improved 3-D solid meshed model as shown in fig. 3.

B. Finite Element Analysis

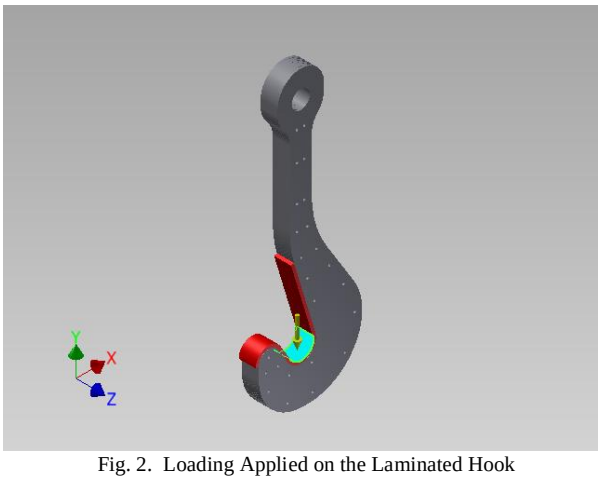

Fig. 2. Loading Applied on the Laminated Hook

These laminated models compared with redesign improve 3D model of hook.

Fig.3 3-D Mesh Model of Laminated hook

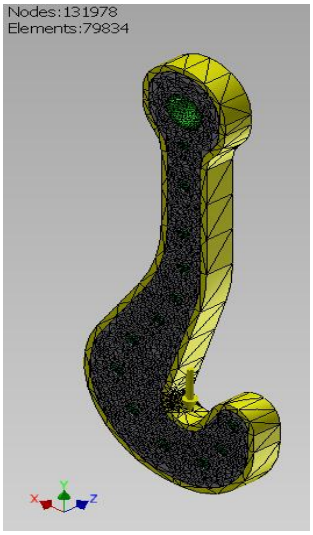

Fig.4 Redesigned Solid Meshed Model of Laminated

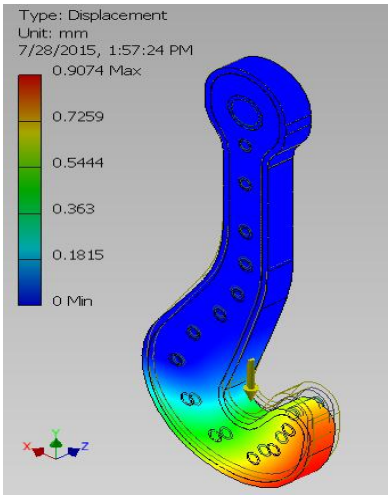

Fig. 5 Maximum and Minimum values of Displacement

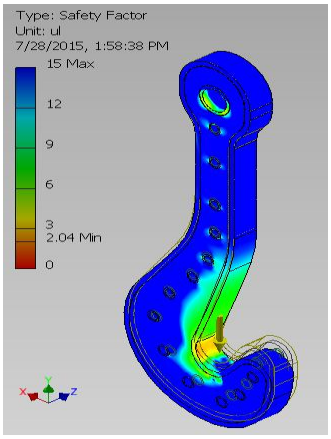

Fig. 6 Maximum and Minimum values of Safety Factor

After the 3-D basic model is solved and results acquired, it is necessary to compare these values with the ones from the Autodesk Inventor Stress model. The comparison between analytical calculations and finite element results is shown in Table2.

TABLE1I
COMPARISON OF ANALYTICAL CALCULATIONS & FINITE ELEMENT ANALYSIS

Values of Finite Element Analysis for Conventional Design Of Laminated Hook			
Sr. No	**Description**	**Analytical Calculations Results**	**Results From FEA**
1	Maximum Stress	119.047 Mpa	99.96 Mpa
2	Minimum Safety Factor	2.58	2.5
3	Maximum Displacement in Y-Direction	0.789mm	0.6648 mm
4	Self Mass of Laminated Hook	950 Kg.	

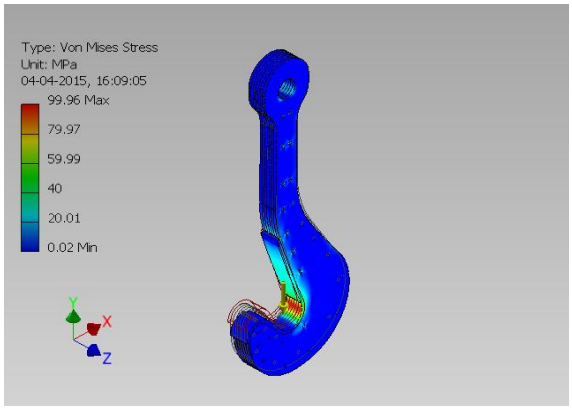

Fig.7 Maximum and Minimum values of Von Mises Stress

III. RESULTS

On the basis of the values of the FEA and simulation analysis a comparative result are drawn from the figures 4, 5 & 6. The results of redesign model 3-D model with Basic 3-D conventional model are charted as under:

TABLE I I I
COMPARATIVE FEA ANALYSIS OF 3-D MODELS

Values of Finite Element Analysis for Re-Designed Laminated Hook		
Sr. No	**Description**	**Results From FEA**
1	Maximum Stress	171.9 Mpa
2	Minimum Safety Factor	2.04
3	Maximum Displacement in Y-Direction	0.9074 mm
4	Self Mass of the Laminated Hook	588 Kg

IV. CONCLUSIONS

Thus from the above results, we can state that the design optimization of laminated hook has been done without compromising the strength & rigidity of the hook. This new design succeeds in reducing the overall mass of the hook by 38%

The results show that the redesign model is a success while keeping the intentions of the project intact and leaves behind a scope of studies for further more redesign in different conditions.

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