Design Analysis And Weight Optimization Of Lifting Hook

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***Abstract*— Lifting hooks are the components which are generally used to elevate the heavy load in industries and constructional sites. It is the member used for lifting the heavy mass using wire ropes and crane. The main objective of this paper is to establish a methodology to design and stress analysis of a lifting hook using stress distribution and changing the cross sections where the stress is minimum. A survey of literature for this subject has shown that, various CAD and FEA software used for modeling and analysis of a hook. The lifting hook is given by company and prepared the model in in proe wildfire 5.0 and analysis done in ansys 14. Using FEM, weight optimization done in ansys and remove the material where the stress is minimum. For Weight Optimization Of Lifting Hook, MATLAB software is used for Genetic Algorithm and Prepare a new Model According to Optimization And Analysis done in Ansys 14.0 for 1.5 tonne load.**

***Index Terms* — Finite Element Method, Lifting hook, Curved Beam Theory.**

I. INTRODUCTION

Lifting hooks are the components which are generally used to elevate the heavy load in industries and constructional sites. It is the member used for lifting the heavy mass using wire ropes and crane. The objective of this work is to carry out computer aided design and analysis of hook. In analysis of hook the load applied is 1.5tonne. The material of the hook is High Tensile Steel. The CAD modeling done in PROE Wildfire 5 and finite element analysis is done in ANSYS 14.

II. LITERATURE REVIEW

CAD model of a trapezoidal section prepared in CATIAV5R20 and then 2 ton load equivalent to 19620 N applied. In MATLAB, Design of experiments are applied by varying the length of two parallel side of the Trapezoidal Hook and studies on the basis of Stress, Mass, Displacement and Energy stored within the hook.[1], The comparative study by Mr. A Gopichand has shown that taguchi method can be used for optimization of crane hook. In his work optimization of design parameters is carried out using Taguchi method. He considered total three parameters and made mixed levels a L16 orthogonal array. The optimum combination of input parameters for minimum Vonmises stresses Are determined.[2], Nishant soni has worked on the optimization of low carbon steel for its self-weight. The self-weight and component load coming on the crane–hook hence he worked with objective of the optimization of the mass for cane hook-under the effect of static load comprising the peak pressure load. He used finite element analysis for the shape optimization of crane hook as well as for validation of final geometry. He also considered geometry and manufacturing constrain during optimization process and results shows that optimized cane hook is 14% lighter then original crane hook.[3], The stress distribution pattern is verified for its correctness on model of crane hook using (Winkler Bach theory) for curved beams.[4], The hook was tested on the UTM machine in tension to located the area having maximum stress and located the yield point.[5].

III. MATERIAL ASSIGNMENT

Many industries manufacture Hook by high tensile steel (AISI4140) material. These materials are widely used for production of hook and beams of different cross sections. Other than the load carrying capacity of hook, it must also be able to absorb the vertical load and deflection.

Table 2.1 Chemical composition of material:

Element	C	Mn	P	S	Si	Cr	Mo
Weight %	0.38	0.75	0.035	0.04	0.15	0.80	0.15

Table 2.2 Mechanical properties of AISI4140

Mechanical property	**Values**	**Unit**
Elastic Modulus	190-210	GPa
Poisson's ratio	0.27-0.30	N/A
Density	7850	Kg/m^3
Tensile Strength	655	MPa
Yield Strength	417.1	MPa
Reduction in Area (%)	56.9	

IV. CROSS SECTION OF HOOK

There is a various cross section of hook available but trapezoidal section is most preferable because Trapezoidal section has thinner edge from inside and thicker edge from outside. Inner edge of hook acts as curved beam make it smoother to operate.

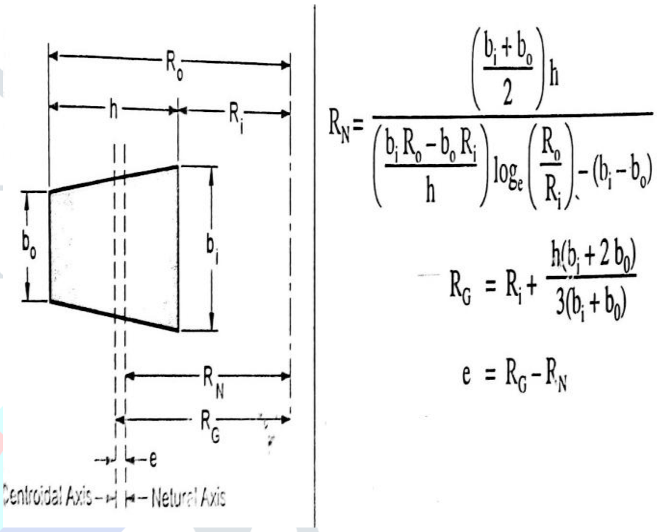
V. MODELING OF HOOK

PRO-E is used to project the trajectory with the required dimensions along with advanced feature of Swept Blend for the generation of hook .Generated model is saved in the format of Step file.

r_o =47.26mm
From the formula of r_n = 64.1869 mm
And r_g = 26.24mm
$e = r_g - r_n = 3.4935$mm
$c_i = r_n - r_i = 10.8865$ mm
Bending moment, $M = P * r_n$
$= 3.347 * 10^6$ N*mm
Resultant stress at inner surface, (σi) =

$$= \frac{P}{A} + \frac{Mci}{Aeri}$$

σi = 190.7919 N/mm²



VI. METHODOLOGY

ANALYTICAL METHOD:

For the straight beam, the neutral axis of the cross section coincides with its centroidal axis and stress distribution is linear, but in case of curved beam, the neutral axis of cross section is shifted towards the Centre of curvature so stress distribution is not linear.

Resultant stresses at inner surface of crane hook (σi):

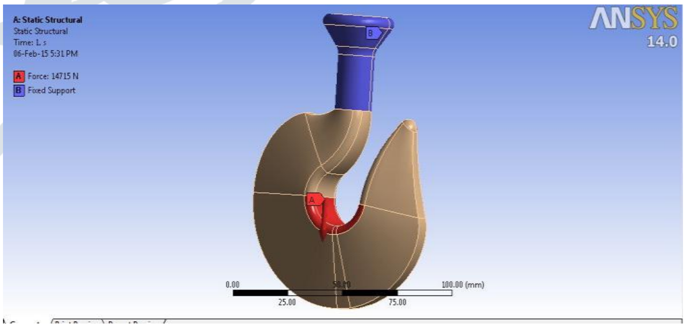
$$= \frac{P}{A} + \frac{Mci}{Aeri}$$

P= load applied in N
M=Bending moment
A= Cross sectional Area
e = Distance between centroidal axis and neutral axis,
r_i= radius of inner fiber
r_o = radius of outer fiber

For 1.5 tonne capacity Load
P = 14715N
C=23.72mm
h = 35.4mm
b_i = 24.3mm
r_i =11.86mm

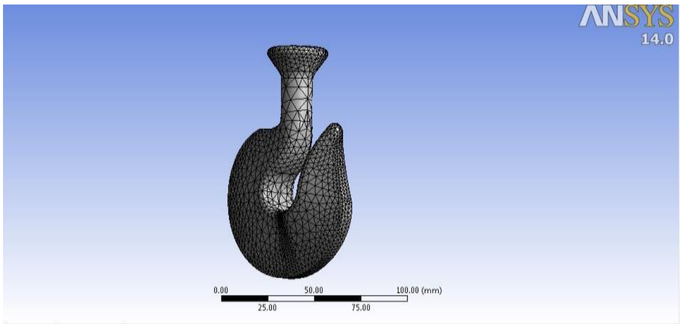
FINITE ELEMENT ANALYSIS:

3D Model made in Proe Wildfire 5.0 and step file import in ANSYS, then analysis done with 1.5 tonne load applied. Boundary condition as shown in fig.

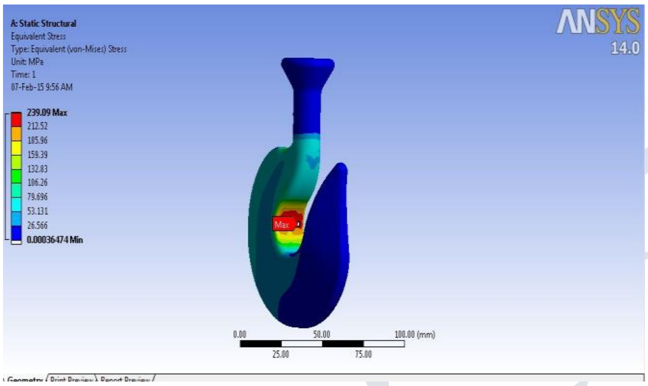


Meshing:

Nodes:	35387
Elements:	22374

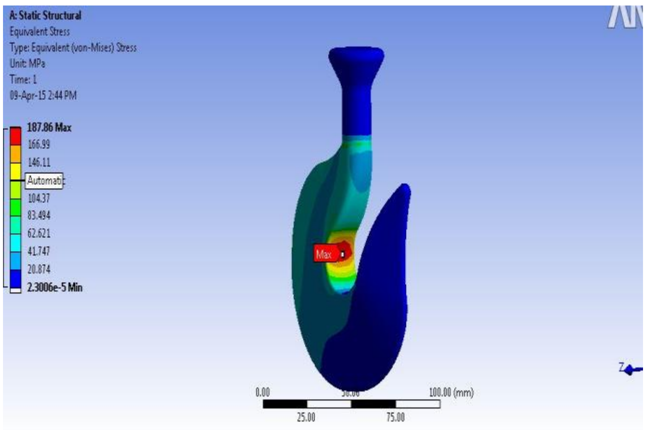


Von mises stress:



Remove the material where the stress concentration is higher so weight is reduced and prepare a new model according to new dimensions below:

By using FEM the stress value near about allowable stress and weight is also reduced. Analysis of lifting hook shown in fig and 1.5tonne load applied upper shank portion of hook is kept fixed and evaluated the results.



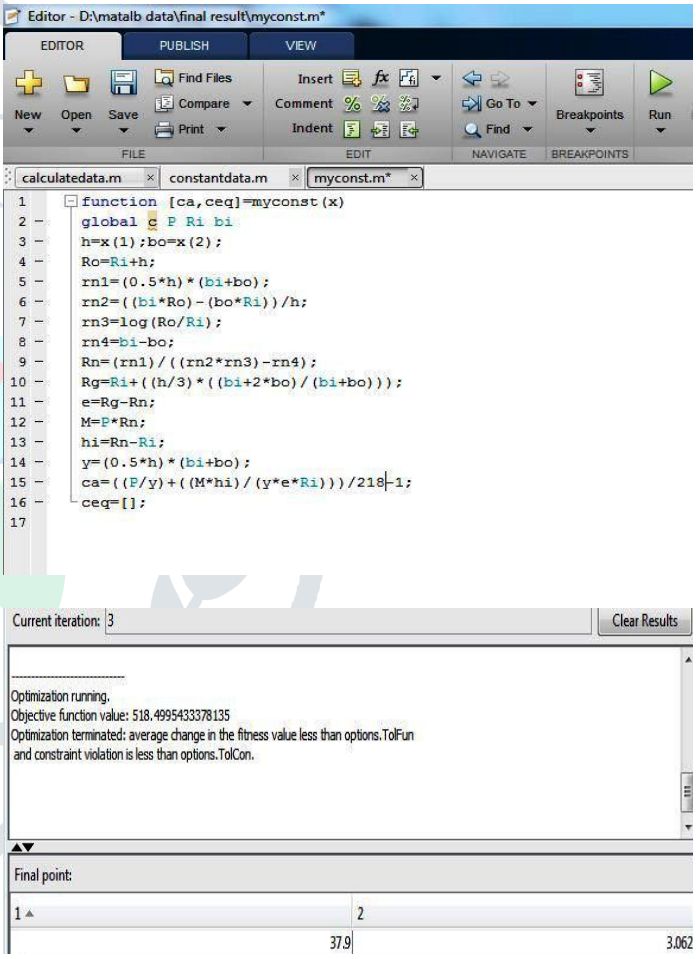
VII. OPTIMIZATION

For the Weight optimization of hook we can decrease the cross section of area so objective function is as below:

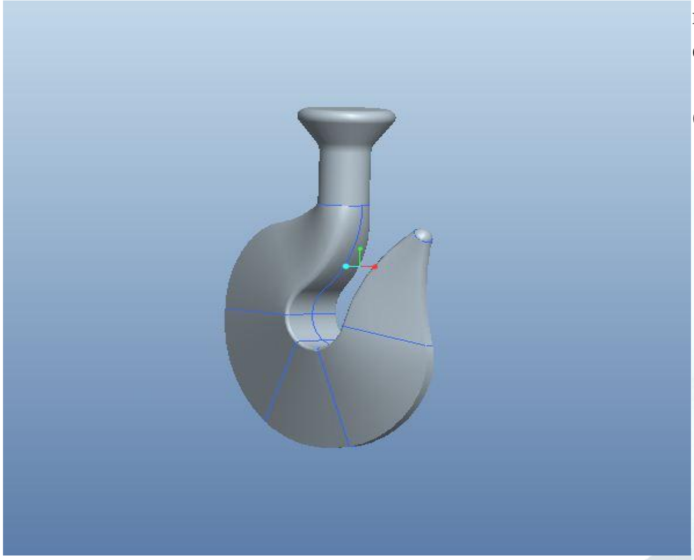
Minimize cross section area, **A**= $\frac{(bi+bo)}{2} * h$

Variable is height of cross section= h,
And outer width of c/s =bo
Constraints,
bi= 24.3mm
Hook radius C= 23.72mm,
Stress, $\sigma i \leq 218.33$ Allowable stress

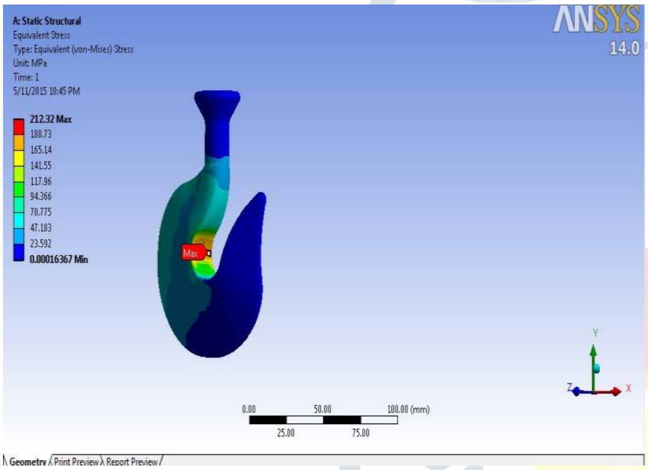
Programme for optim tool:



After the results of optim tool box, prepare the new model of lifting hook in pro e and analysis carried out in Ansys 14.0



VM stress= 212.32 MPa which is near about allowable.



VIII. RESULTS AND CONCLUSION

Results:

	Stress (Mpa)	Weight (gm)	% change
Existing model	214.79	759	16.97↓
Optimized model	212.32	630	

Cross section detail:

CROSS SECTION	EXISTING	OPTIMIZED
Height(mm)	35.4	37.9
Outer width(mm)	24.3	24.3
Inner width	6.8	3.06
Area(mm^2)	550.47	518.47

Stress induced and displacement in "Modified Lifting Hook" is least and stress concentration are distributed uniformly. It have less mass due to this we are able to save the material and balance economy.

Optimized model:

IX. FUTURE SCOPE

Further it is advisable to conduct photo elasticity test for the crane hook under investigation in order to get better insight for stress concentration. Also use optimization techniques for the reducing stress and weight of hook.

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