International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 5 Issue 1, November-December 2020 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Design and Analysis of Crane Hook with Different Materials

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ABSTRACT

Cranes are industrial machines that are mainly used for materials movements in construction sites, production halls, assembly lines, storage areas, power stations and similar places. A hook is a tool consisting of a length of material that contains a portion that is curved or indented, so that this portion can be used to hold another object. In several uses, one end of the hook is pointed. They are used to transfer the materials having heavy loads. Crane hooks are liable components subjected to failure due to stress in accumulation of heavy loads. Area of cross section, material and radius of crane hook are the design parameters for crane hook. Failure of a crane hook mainly depends on three major factors i.e. dimension, material, overload. In this paper the design of the hook is done by analytical method and design is done for the different materials like forged steel and high tensile steel. After the analytical method design and modelling of hook is done in modelling software (SOLIDWORKS). The modelling is done using the design calculation from the modelling the analysis of hook is done in FEA software (ANSYS WORKBENCH). This result leads us to the determination of stress in existing model. By predicting the stress concentration area, the hook working life increase and reduce the failure stress.

KEYWORD: *Crane hook, Finite element analysis, SOLIDWORKS, ANSYS WORKBENCH*

How to cite this paper: T. Venkatesh | Sk. Mohammad Shareef | A. L. N. Arun Kumar "Design and Analysis of Crane Hook with Different Materials" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-1, December 2020, pp.802-807, URL: www.ijtsrd.com/papers/ijtsrd38099.pdf

IJTSRD38099

INTRODUCTION

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. Crane hooks are the components which are generally used to elevate the heavy load 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 material. Cranes are mostly employed in transport, construction, and manufacturing industry. Overhead crane, mobile crane, tower crane, telescopic crane, gantry crane, deck crane, jib crane, loader crane is some of the commonly used cranes. A crane hook is a device used for grabbing and lifting the loads by means of a crane. It is basically 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, circular, rectangular, and triangular cross section are commonly used. So, it must be designed and manufactured to deliver maximum performance without failure. Thus, the aim of this research is to study stress distribution pattern within a crane hook of various cross sections using analytical, numerical, and experimental method.

A. Types of Crane Hooks:

According to the different standards, crane hooks can be classified into different types. They are as follows.

- Single and double crane hook
- The forging and laminated crane hook
- Closed and semi-closed crane hook
- Electric rotary crane hook

According to different features, these types of crane hooks are widely used in different applications.

Crane hooks can be classified into single hook, C type hook, and double hook, etc

Fig .1Types of crane hooks based on shape

B. Failure of Crane Hooks:

Due to continuous working of crane hook nanostructure of crane hook are changes and some problems like weakening of hook due to wear, tensile stresses, plastic deformation due to overloading and excessive thermal stresses these are some other reason of failure. Hence continuous working of crane hook may increase the magnitude of these stresses and eventually result in failure of crane hook. 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.

Due to some design modification and changing the materials. All the above-mentioned failures may be prevented.

LITERATURE REVIEW

1. STRUCTURAL ANALYSIS OF CRANE HOOK by Joseph Leo, Arut Pranesh.K, Balasubramani.V, consider Crane catches are exceptionally committed parts that are conventionally used for mechanical purposes. Thusly such parts in an industry must be delivered and made in a way to deal with pass on most noteworthy execution without frustration. Disillusionment of a crane catch basically depends on upon three essential issue i.e. estimation, material, overload. The wander is stressed towards extending the ensured load by changing the cross-sectional estimations of the three ranges. The picked fragments are rectangular, triangular, and trapezoidal.

2. DETERMINATION OF STRESS DISTRIBUTION IN CRANE HOOK BY CAUSTIC by M. Shaban, Mohamed, E. Abuelezz, t. Khalifa study's crane snares are greatly, In peril portions what's more are continually subjected to dissatisfaction because of the measure of anxieties focus which might through the whole deal actuate its disappointment. Will imagine the strain body of evidence of crane snare previously, its stacked condition, a robust model of crane snare is set up with the help from claiming ABAQUS modifying. Relentless the event from claiming stress fixation previously, 3d model of crane snare may be acquired. The apprehension dispersal delineation may be checked to its rightness for an acrylic model for crane snare utilizing shadow optical methodology (Caustic method) set up.

MATERIAL PROPERTIES

Here in this project we were considered two materials for designing of crane hook. They are as follows:

1. High tensile steel
2. Forged alloy steel

A. High Tensile Steel-AISI 4340

AISI 4340 steel is a medium carbon, low alloy steel known for its toughness and strength in relatively large sections. AISI 4340 is also one kind of nickel chromium molybdenum steels. 4340 alloy steel is generally supplied hardened and tempered in the tensile range of 930 – 1080 Mpa. Pre hardened and tempered 4340 steels can be further surface hardened by flame or induction hardening and by nitriding. The 4340 steel has good shock and impact resistance as well as wear and abrasion resistance in the hardened condition. AISI 4340 steel properties offer good ductility in the annealed condition, allowing it to be bent or formed. Fusion and resistance welding is also possible with our 4340 alloy steel. ASTM 4340 material is often utilized where other alloy steels do not have the hardenability to give the strength required. For highly stressed parts it is excellent choice. AISI 4340 alloy steel can also be machined by all customary methods.

TABLE I. CHEMICAL COMPOSITION OF HIGH TENSILE STEEL

Element	Content (%)
Iron, (Fe)	95.195-96.33
Nickel, (Ni)	1.65-2.00
Chromium, (Cr)	0.700-0.900
Manganese, (Mn)	0.600-0.800
Carbon, (C)	0.370-0.430
Molybdenum, (Mo)	0.200-0.300
Silicon, (Si)	0.150-0.300
Sulphur, (S)	0.0400
Phosphorous, (P)	0.0350

TABLE II. MECHANICAL PROPERTIES OF HIGH TENSILE STEEL

Properties	Value	Units
Tensile strength	1110	N/mm^2
Elastic Modulus	205000	N/mm^2
Poisson's ratio	0.32	-
Shear Modulus	80000	N/mm^2
Mass density	7850	Kg/m^3
Yield Strength	710	N/mm^2
Thermal Conductivity	44.5	W/(m-k)
Specific Heat	475	J/(kg-k)
Thermal expansion coefficient	1.23e-005	/k

B. Forged Alloy Steel-AISI 4140(1.7225-42CrMo4)

AISI SAE 4140 alloy steel is a chromium molybdenum alloy steel specification widely used in general purpose high tensile steel for components, like axles, shafts, bolts, gears, and other applications. Like alloy grade AISI 4130 chrome moly alloy steel but with a slightly higher carbon content. The higher carbon content of AISI 4140 steel gives greater strength and heat treatment capabilities in comparison to AISI / ASTM 4130 alloy steels, however it does have inferior weldability characteristics.

TABLE III. CHEMICAL COMPOSITION OF FORGED ALLOY STEEL

Element	Content (%)
Iron, (Fe)	96.68-97.5
Nickel, (Ni)	-
Chromium, (Cr)	0.9-1.2
Manganese, (Mn)	0.6-0.9
Carbon, (C)	0.38-0.45
Molybdenum, (Mo)	0.15-0.30
Silicon, (Si)	0.4
Sulphur, (S)	0.035
Phosphorous, (P)	0.035

TABLE IV. MECHANICAL PROPERTIES OF FORGED ALLOY STEEL

Properties	Value	Units
Tensile strength	1000	N/mm^2
Elastic Modulus	210000	N/mm^2
Poisson's ratio	0.28	-
Shear Modulus	79000	N/mm^2
Mass density	7800	Kg/m^3
Yield Strength	750	N/mm^2
Thermal Conductivity	14	W/(m-k)
Specific Heat	440	J/(kg-k)
Thermal expansion coefficient	1.1e-005	/k

MODELLING OF CRANE HOOK

The hook is to be designed using SOLIDWORKS software. Hook is made up of high tensile steel and forged alloy steel. Two different cross sections i.e. trapezoidal and circular cross sections are considered. By keeping area same for all cross sections as a design criterion, direct stress, bending stress, shear stress and maximum deformation are found. The design of the crane hook is rather simple, and its use is restricted to the lifting of heavy loads performed in the thermal i.e. hot regions where the crane hook gets deformed because of heating conditions. This crane hook tries to improve the quality of the lifting heavy loads, make the load transformations from one place to another place much better, both in aesthetic as well as design standards. There has been lot of brain storming, and the both the designs are shown below. The description of entire crane hook design will be discussed in the later sections.

I. Different Cross-Sections of Crane Hook

A. Trapezoidal Cross Section

The dimensions used are:

bi = 60 mm
bo=36 mm
h = 88 mm
Ri = 62 mm
Ro= 150 mm

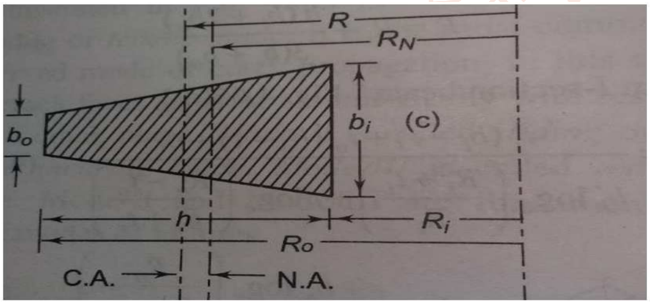

Fig 2. Trapezoidal cross-section

B. Circular Cross-Section

The dimensions used are
d= 88 mm,
Ri= 62 mm,
Ro= 150 mm

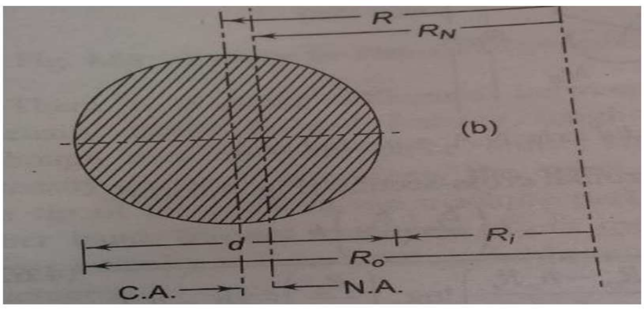

Fig 3. Circular cross-section

C. Design Based on Circular Cross Section

Here initially different circular cross sections are made in solid works software with different diameters according to the required fit. Then those circular cross sections are joined by using curves.

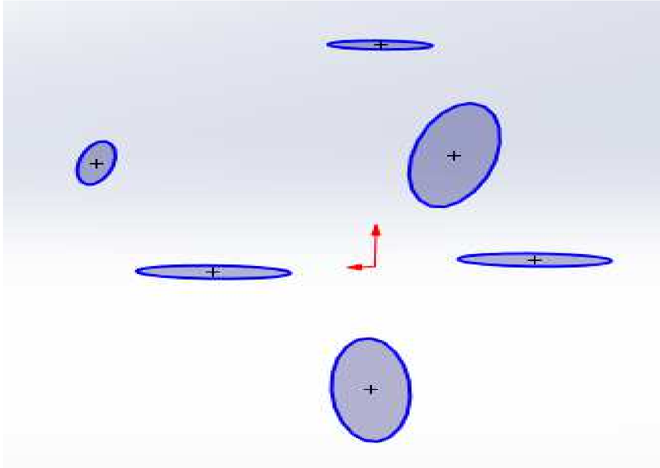

Fig 4. Circular cross-sections of crane hook

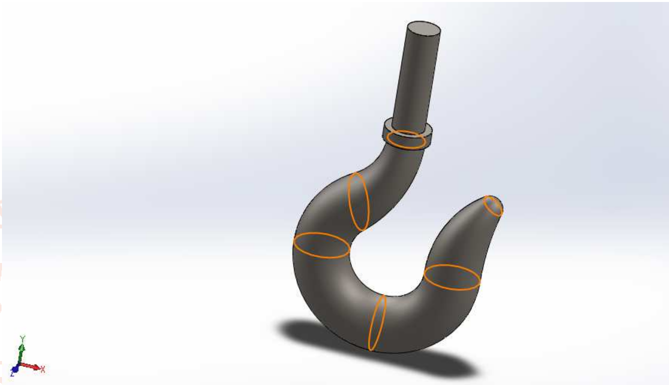

Fig 5. Design based on Circular cross-sections of crane hook

D. Design Based on Trapezoidal Cross-Section

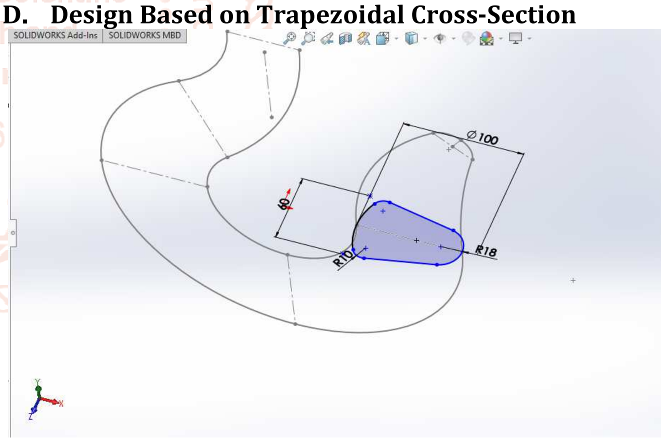

Fig 6. Trapezoidal cross-sections of crane hook

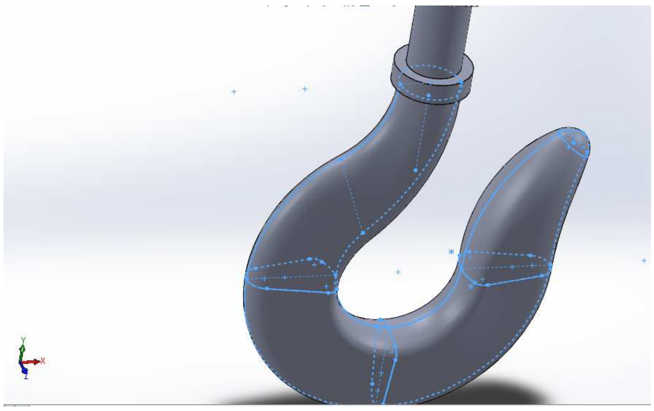

Fig 7. Design based on Trapezoidal cross-sections of crane hook

E. Crane Hook with Forged Alloy Steel

Fig 8. Circular with forged alloy steel

Fig 9. Trapezoidal with forged alloy steel

F. Crane Hook with High Tensile Steel

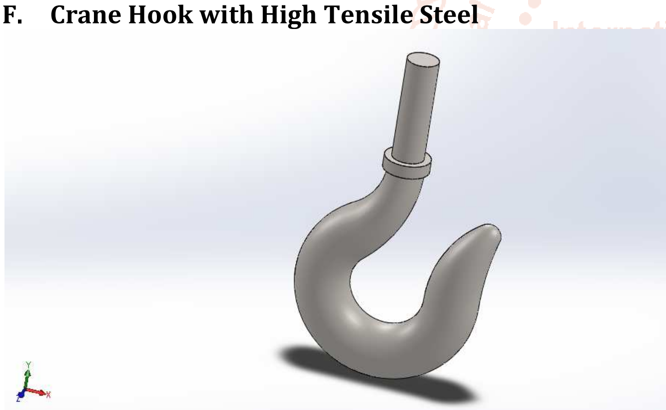

Fig 10. Circular with high tensile steel

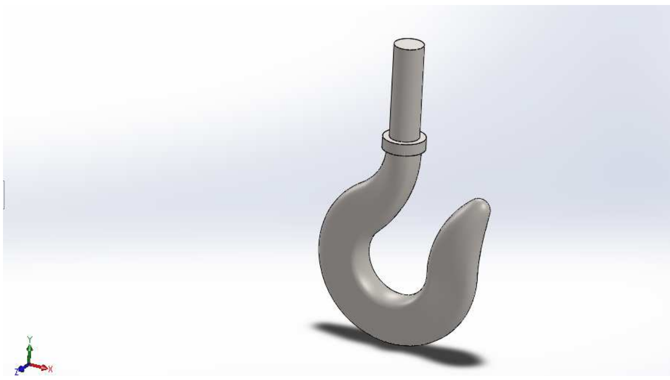

Fig 11. Trapezoidal with high tensile steel

ANALYSIS

A. Static Analysis of Circular cross-section with Forged Alloy Steel

The following analysis have to be performed, in order to know the performance of the crane hook in the real time, identify and correct the flaws, which have occurred during the design and manufacturing, so that we can achieve good results. The software used for performing the analysis is ANSYS WORKBENCH 18.2 version. Initially the design was done in solid works software and files are saved in IGES form. Later it was imported into the ANSYS WORKBENCH 18.2 for analysis purpose where we are going to take observations. Further analysis involves meshing, loading, material assignment. After assigning the taken problem (crane hook) is solved and results are obtained. The results involve stress distribution, load bearing capacity and deformation is observed. And these observations are going to be compared with numerical analysis observations. Each analysis we will come to know in later sections.

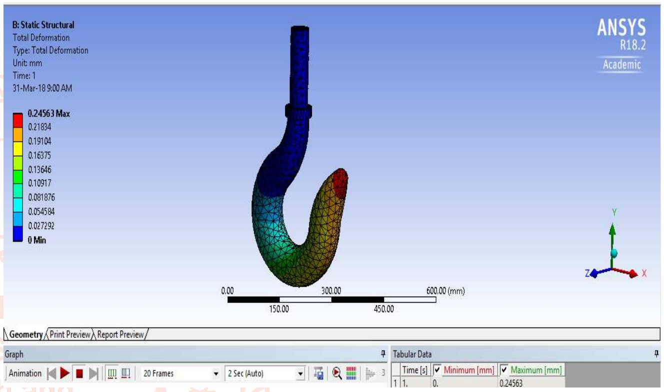

Fig 12. Total Deformation of circular with forged alloy steel

The results obtained from ANSYS WORKBENCH 18.2 shows that the global value for maximum deformation is about 0.24563 mm. The occurrence of the maximum deflection at the end of the hook shows that our design is in good agreement with the design principles.

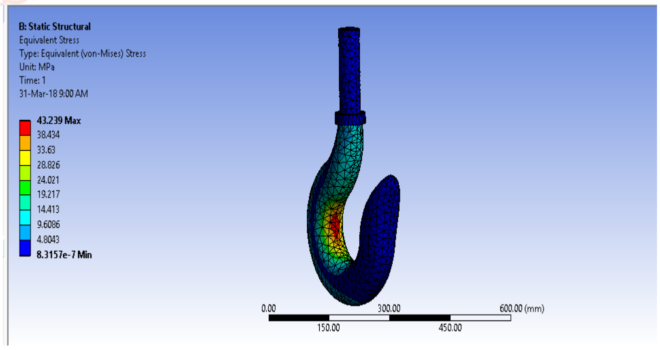

Fig 13 Von mises stress of circular with forged alloy steel

The results obtained from ANSYS WORKBENCH 18.2 show that the global value of maximum stress is 43.239 MPa, which is in range as per our design calculations. The occurrence of the maximum stress along the hook justifies that our design criteria is correct according to the design principles used.

Static Analysis of Circular cross-section with High Tensile steel

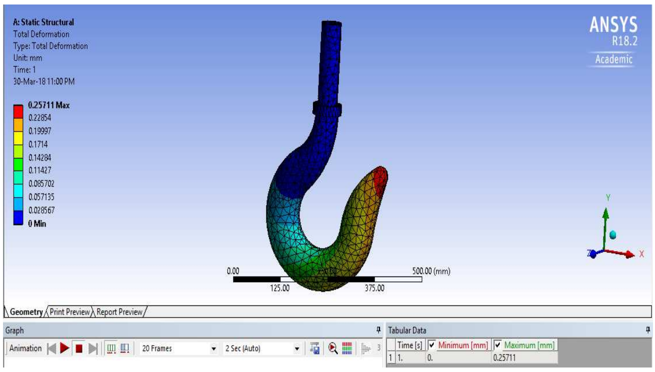

Fig 14. Total Deformation of circular with high tensile steel

The results obtained from ANSYS WORKBENCH 18.2 shows that the global value for maximum deformation is about 0.25711 mm. The occurrence of the maximum deflection at the end of the hook shows that our design is in good agreement with the design principles.

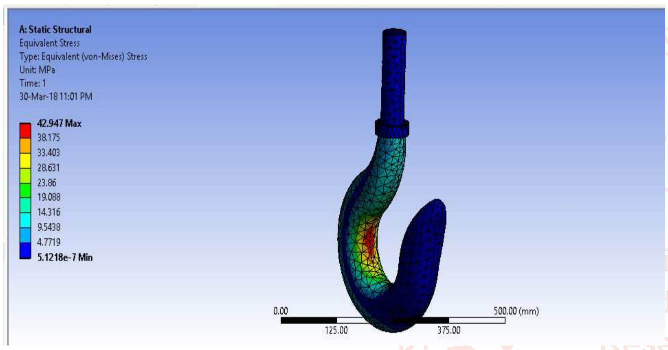

Fig 15 Von mises stress of circular with high tensile steel

The results obtained from ANSYS WORKBENCH 18.2 show that the global value of maximum stress is 42.947 MPa, which is in range as per our design calculations. The occurrence of the maximum stress along the hook justifies that our design criteria is correct according to the design principles used.

B. Static Analysis of Trapezoidal cross-section with Forged Alloy Steel

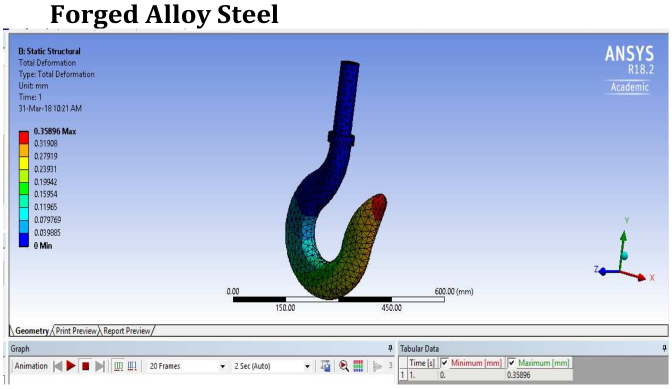

Fig 16 Total Deformation of trapezoidal with forged alloy steel

The results obtained from ANSYS WORKBENCH 18.2 shows that the global value for maximum deformation is about 0.35896 mm. The occurrence of the maximum deflection at the end of the hook shows that our design is in good agreement with the design principles.

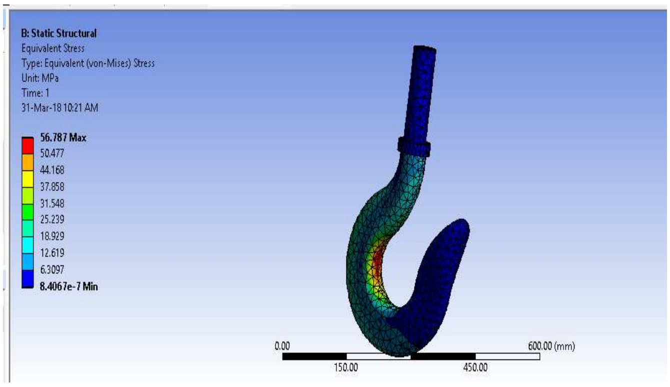

Fig 17 Von Mises stress of trapezoidal with forged alloy steel

The results obtained from ANSYS WORKBENCH 18.2 show that the global value of maximum stress is 56.787 MPa, which is in range as per our design calculations. The occurrence of the maximum stress along the hook justifies that our design criteria is correct according to the design principles used.

C. Static Analysis of Trapezoidal cross-section with High Tensile Steel

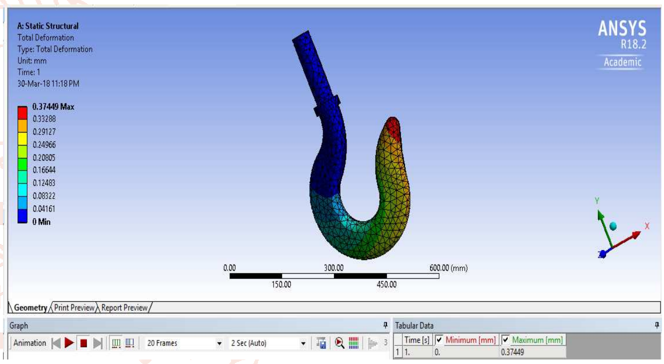

Fig 18 Total Deformation of trapezoidal with high tensile steel

The results obtained from ANSYS WORKBENCH 18.2 shows that the global value for maximum deformation is about 0.37449 mm. The occurrence of the maximum deflection at the end of the hook shows that our design is in good agreement with the design principles.

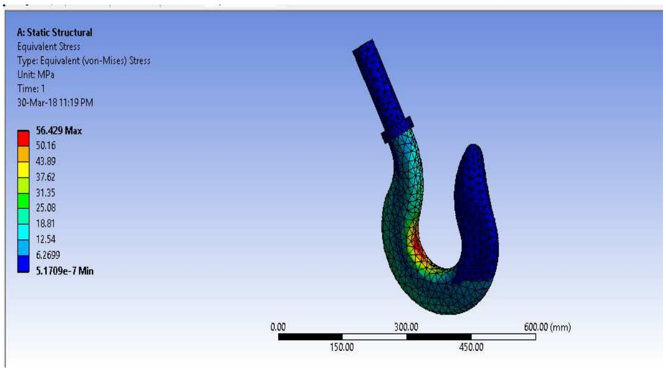

Fig 19 Von mises stress of trapezoidal with high tensile steel

The results obtained from ANSYS WORKBENCH 18.2 show that the global value of maximum stress is 56.429 MPa, which is in range as per our design calculations. The occurrence of the maximum stress along the hook justifies that our design criteria is correct according to the design principles used.

RESULTS AND DISCUSSIONS

From the analysis performed in ANSYS WORKBENCH 18.2 and visual inspection we obtain the following results.

A. Stress comparison between calculated values and FEM values along internal fibres

TABLE V. COMPARISON OF STRESSES AT INTERNAL FIBRE

Cross-section	Trapezoidal		Circular	
Material	Forged alloy steel	High tensile steel	Forge alloy steel	High tensile steel
Load	19620 N	19620 N	19620 N	19620 N
Calculated	51.45 N/mm2	51.45 N/mm2	48.47 N/mm2	48.47 N/mm2
FEM(ANSYS)	56.787 N/mm2	56.429 N/mm2	42.239 N/mm2	42.947 N/mm2
%error	10.37	9.67	14.75	12.86

B. Stress comparison between calculated values and FEM values along External fibers

TABLE VI. COMPARISON OF STRESSES AT OUTER FIBRE

Cross-section	Trapezoidal		Circular	
Material	Forged alloy steel	High tensile steel	Forge alloy steel	High tensile steel
Load	19620 N	19620 N	19620 N	19620 N
Calculated	22.796 N/mm2	22.796 N/mm2	26.059 N/mm2	26.059 N/mm2
FEM(ANSYS)	25.239 N/mm2	25.08 N/mm2	24.021 N/mm2	23.86 N/mm2
%error	10.71	10.01	8.48	9.21

DISCUSSIONS FROM THE ANALYSIS

1. The analytical and numerical analysis are made on two different cross-sections of a crane hook. The results indicate that the FEM results approximately match with the analytical calculations.
2. Linear static structural analysis has been carried out to estimate the maximum stress and deformation of crane hook.
3. It is state that maximum stress induced is 56.787 MPa and the deformation induced is 0.35896 mm for material AISI 4340 which is having percentage error of 10.37 comparing with the analytical results
4. Among two cross-sections trapezoidal cross-section is giving better results compared to circular cross-sections.
5. From the results obtained in this work, It is conclude that compression takes place at outer fibers and tensile takes place at inner fibers. So, more stress occurs at internal fibers than at external fibers. Material should be added more on the inner side than on outer side.

References

[1] Joseph Leo. A, Arut Pranesh .K., Balasubramani .V "Structural Analysis Of Crane Hook", International Journal of Emerging Technology in Computer Science & Electronics (IJETCSE) ISSN: 0976-1353 Volume 12.

[2] M. Shaban, M. I. Mohamed, A. E. Abuelezz , T. Khalifa "Determination of Stress Distribution in Crane Hook by Caustic", ,International Journal of Innovative Research in Science, Engineering and Technology Vol. 2

[3] Chetan N. Benkar, Dr. N. A. Wankhade "Finite Element Stress Analysis of Crane Hook with Different Cross Sections." May-2014, International Journal for Technological Research in Engineering Volume 1.

[4] Osman Ashraf Ansari, "Design and Analysis of Crane Hook for Load Conditions", International Journal of Mechanical Engineering and Technology (IJMET) Volume 7.

[5] Tushar Hire, V.N bartaria "Optimum Stress Analysis of Crane hook with help of finite element", April/2014, IJEET.