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Analysis of Crane Hook

Dr T. Nageswara Rao[1], K. Sivateja Reddy[2], S. Mushtaq Ahmed[3], A. Tulasinath Reddy[4], H. Anil kumar[5]
[1]*Head of department,* [2, 3, 4, 5]*U G student, Department of Mechanical Engineering, GITAM (Deemed to be University), Bengaluru, India*

Abstract: Crane hooks are the prominent components, mainly used for the industrial purposes to lift and transfer the loads. Crane hook is a liable component undergoes failure due to accumulation of large amount of stresses which can eventually lead to its failure. Hence study of stresses in crane hooks helps to better understand how to prevent them. The aim of the present work is to design the crane hook of different cross sections and find the failure due to accumulation of large amount of stresses which can eventually lead to its failure Von Moises stress distribution and total deformation of hook when the load is applied. The crane hook is designed in the CATIA and the analysed in the ANSYS. This work gives insight on deformation and on stresses under the working conditions.
Keywords: Crane hook, Stresses, Deformation, CATIA, ANSYS

I. INTRODUCTION

We come across many application of curved beam principles in engineering, the most common being the frames of machines such as punches, presses, planners, etc. Another common example of curved beam application is the crane hook. Curved beam subjected to bending moment alone are of rare occurrence, but examples of curved beam subjected to bending and direct stress are numerous. Hooks, rings are other links, frames of machines, C-clamps and machine tools of various sorts are common examples. The stress at any point on a cross-section of such a member is the algebraic sum of the direct stress and the stress due to bending moments as in straight beams; however the flexural stress should be calculated according to curved beam theory. In curved beams (crane hook), the neutral axis is shifted towards the centre of curvature of the section and is nearer to the centre of curvature than the centroidal axis. If the section of a curved beam of area A is subjected to a bending moment M, the general equation for the stress at any fibre at a distance y from the neutral axis is given as

$$F = \frac{M}{A.e} * \left(\frac{y}{r_n + y}\right) = \frac{M.y}{A.e.r}$$

Where e = the distance from the centroidal axis to the neutral axis.

r_n = The radius of curvature of the neutral axis.

r = Distance from the axis of curvature to the elemental area dA

Stress in curved beams

The stress distribution in a curved member differs distinctly from that of a straight member, when it is subjected to bending stresses. The stress distribution for a curved flexural member is found by using the following assumptions

1) The beam is subjected to pure bending.
2) The material of beam is isotropic and homogeneous.
3) The stresses induced in the beam do not exceed the elastic limit and they follow the hooks law
4) The cross-section has an axis of symmetry in a plane along the length of the beam.
5) The cross-section of the beam remains plane after bending.
6) The modulus of elasticity is same in tension as well as in compression. It is observed that the neutral axis for a curved member does not coincide with the centroidal axis (unlike a straight beam).

II. LITERATURE REVIEW

Abhijit Devaraj [4] Crane hook is designed in the manual drafting and Modelling of hook in NXCADD software and analysis done in the ANSYS 15.0 at the 1KN load conditions for different materials of the Trapezoidal cross-section of the crane hook. The Maximum Shear stress is 1.2207 N/mm2 and Von-Mises stress are 4.9574 N/mm2 for the stainless steel. Concluded that Forged Steel AISI 4140 and Stainless Steel 316(marine) are more suitable for making crane hooks as they have higher capacity to withstand loading.

M.Amareswari Reddy et.al [5] I and T sections of crane hook models are selected for the analyses in ANSYS 14.0 for 6KN load conditions. Modelling is done in the SOLIDWORKS. Different materials are selected for the crane hook, i.e., Grey cast iron, Stainless steel, Nickel alloy and Carbon steel. Concludes that T section of Nickel Alloy offers good results for optimization of the crane hook design.

Osman Ashraf Ansari [6] a solid model of crane hook is prepared with the help of Pro/Engineer wildfire 5.0 software and analysed in the ANSYS 12.1. Structural steel is used as crane hook material. The crane hook model can withstand the proposed loads with considering a factor of safety as 1.2.

Joseph Leo. A, et.al [7] Triangular, Square and Trapezoidal cross-sections are analysed by using the ANSYS 14.5 software. The crane hook is modelled using PTC CREO software. Concluded that there is increase in the safe load in all the three sections while changing the cross sectional dimension.

Sarvesh A. Mehendale et.al [8] Crane hook is designed for the 125KN load conditions and analysed in ANSYS 15.0. The model was prepared using CREO software. The circular section has more stress induced than other two cross section. The trapezoidal cross section gives better results in comparison with other two cross sections as because stresses induced are less in trapezoidal cross section.

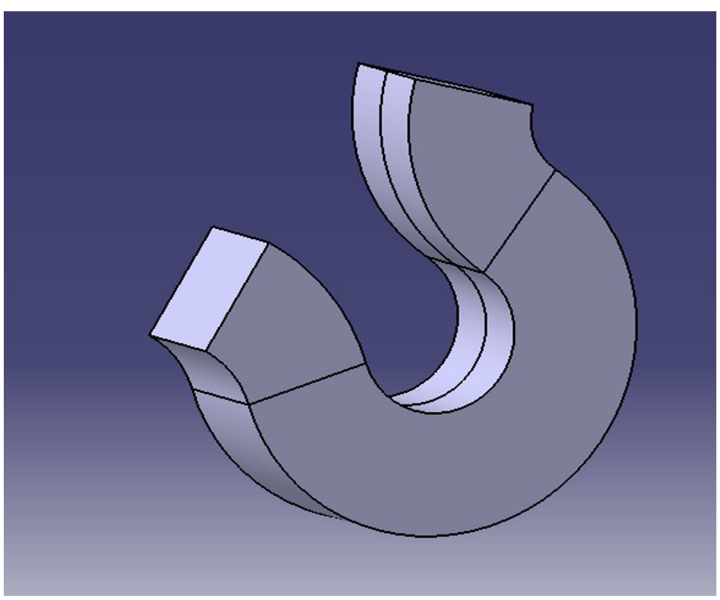
Patel Ravin B et.al [9] the results of stress analysis calculated from FEA analysis for various different material such as Forged Steel, Wrougt iron/MS, Aluminium Alloy. For the different Material, It is observed that keeping the tone are same with different Material.

III. MATERIAL PROPERTIES

In this work, High strength low alloy steel (HSLA) is considered. HSLA steels contain relatively low levels of carbon of about 0.05%. It also contains other elements such as chromium, nickel, molybdenum, vanadium, titanium, and niobium. HSLA steels are resistant to atmospheric corrosion and are better suited to welding than carbon steel.

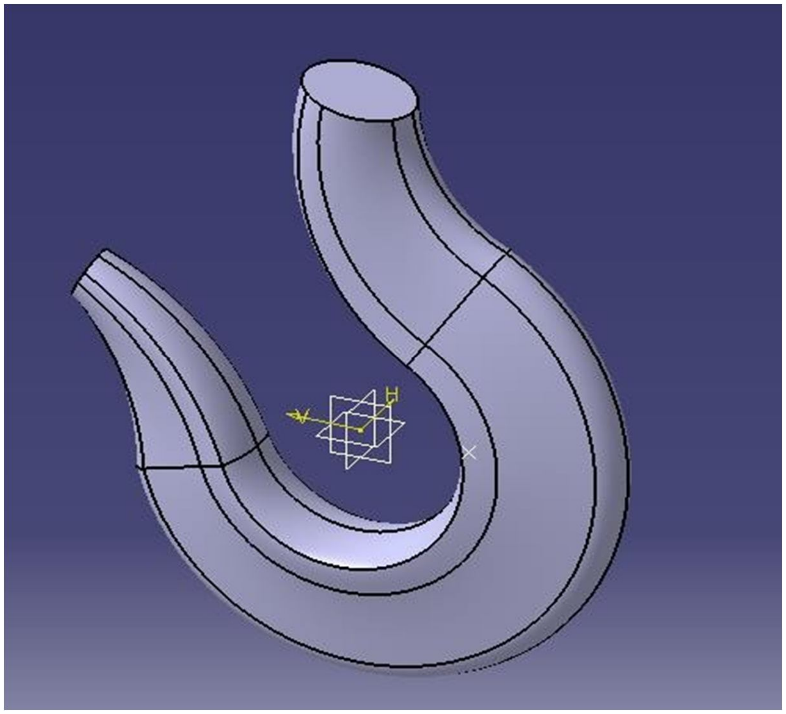
Table.1-Mechanical Properties of High Strength Low Alloy Steel

Properties	Value
Density	7850 kg/m3
Tensile yield strength	250MPa
Poisson’s ratio	0.3
Tensile ultimate strength	460 Mpa

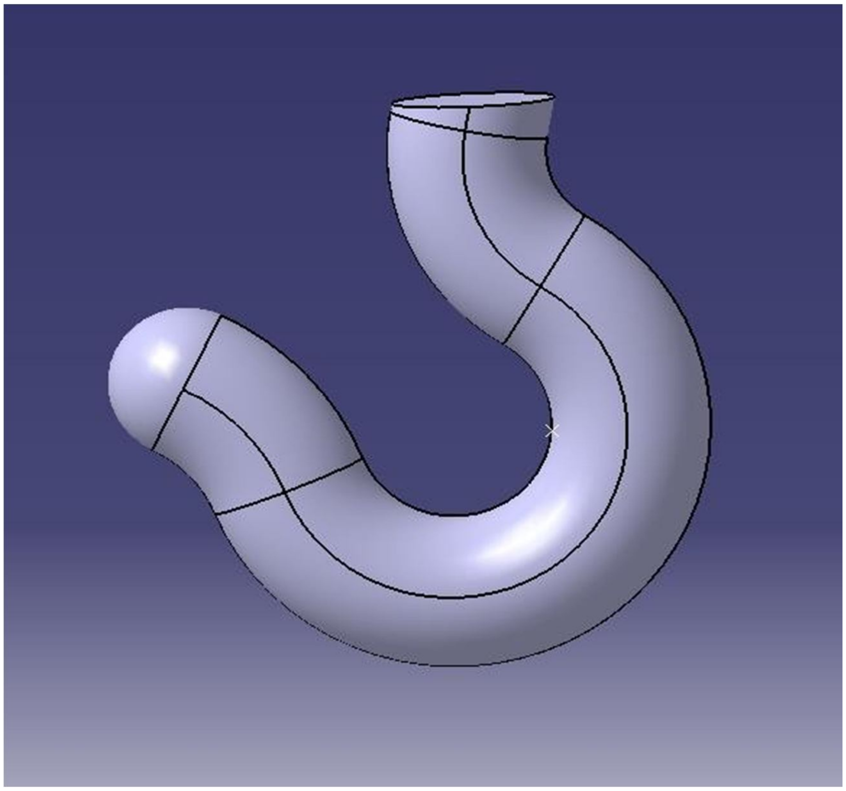


IV. MODELING OF CRANE HOOK

The crane hook is modelled using CATIA using the dimensions given in the design data book. The created solid model is imported in ANSYS for stress analysis. The three dimensional model of the crane hook for five cross sections is shown.



Trapezoidal Cross-section



Circular Cross-section

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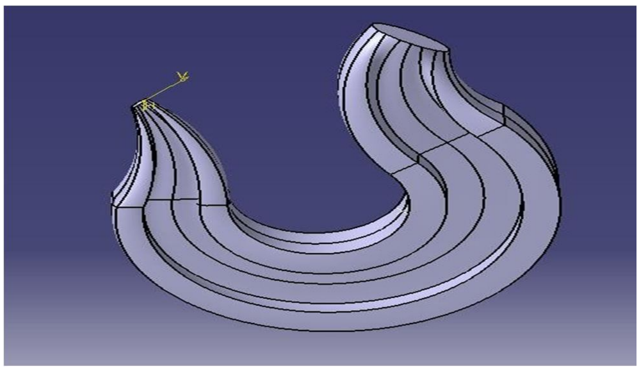
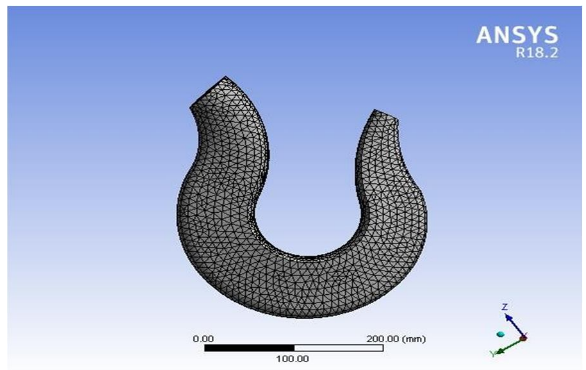
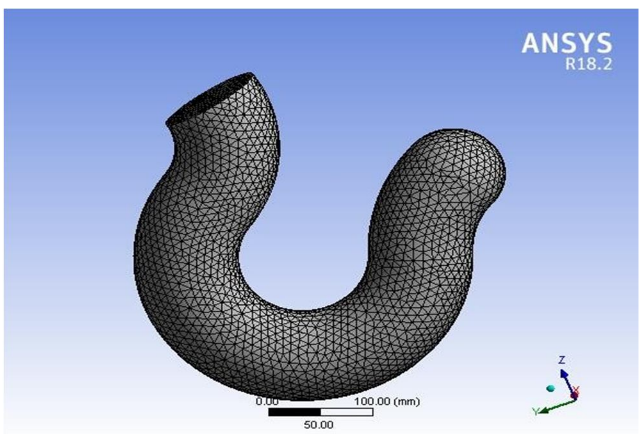
Square Cross-section
T-Cross-section
I-Cross-section

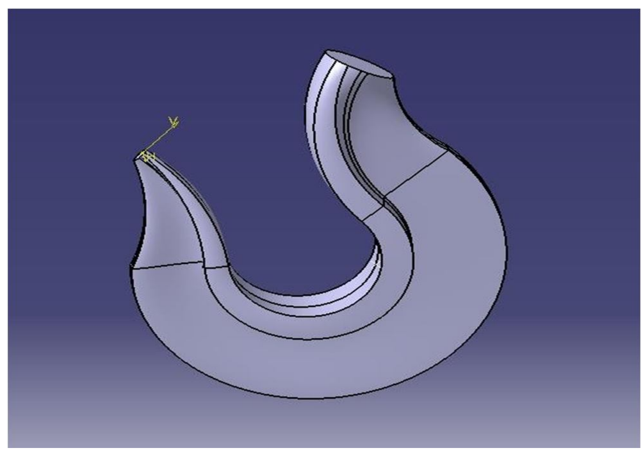
V. STRUCTURAL ANALYSIS OF CRANE HOOK

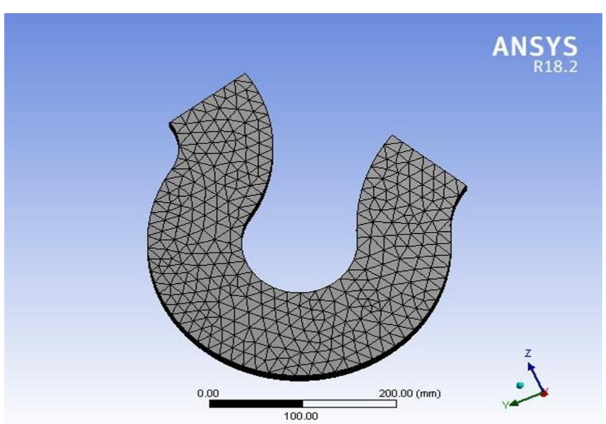
The solid model of the crane hook imported to the ANSYS workbench. The material properties of the crane hook given.
Mesh is generated of fine size. Element is used for meshing is SOLID187-3D 10 NODE TETRAHEDRAL STRUCTURAL SOLID. The element is defined by 10 nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions. The element has plasticity, hyper elasticity, creep, stress stiffening, large deflection, and large strain capabilities. It also has mixed formulation capability for simulating deformations of nearly incompressible elastoplastic materials, and fully incompressible hyper elastic materials.











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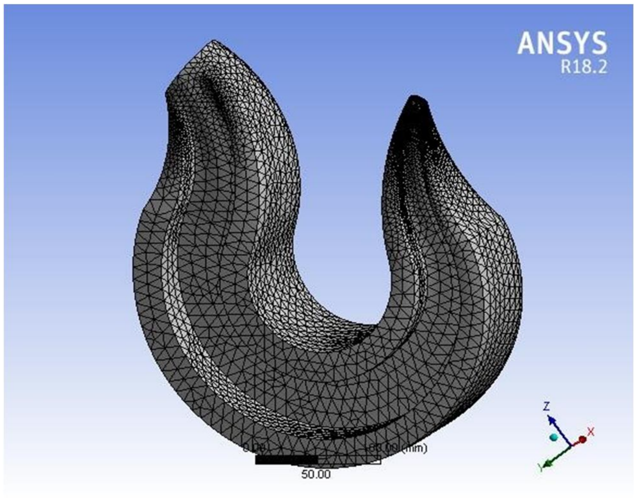
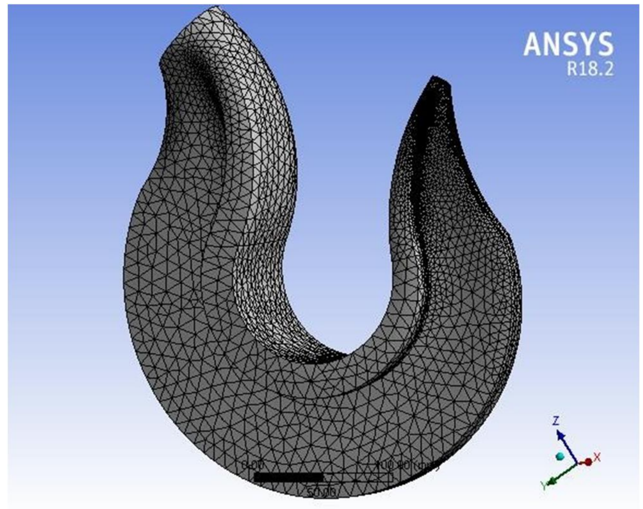
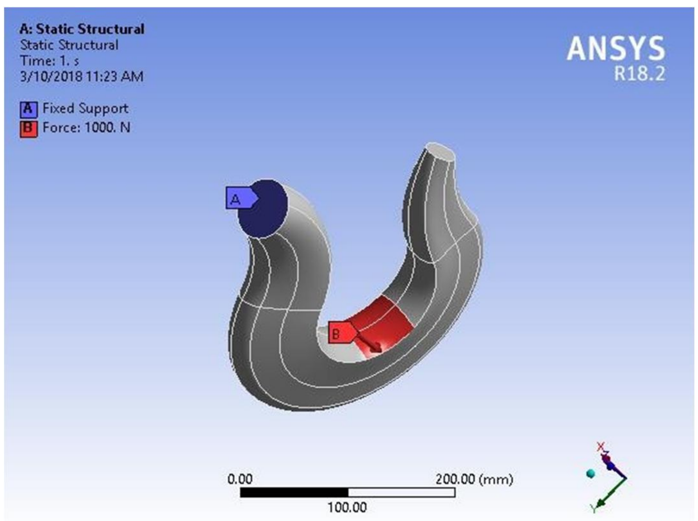
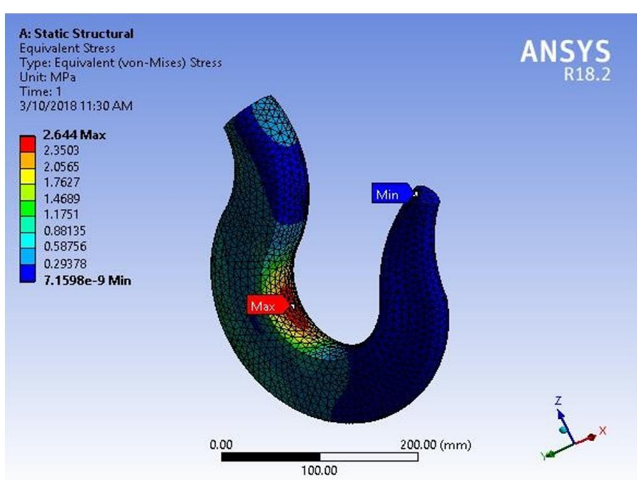


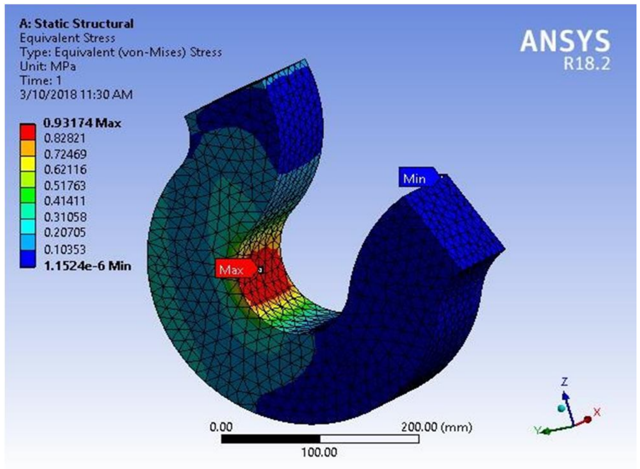


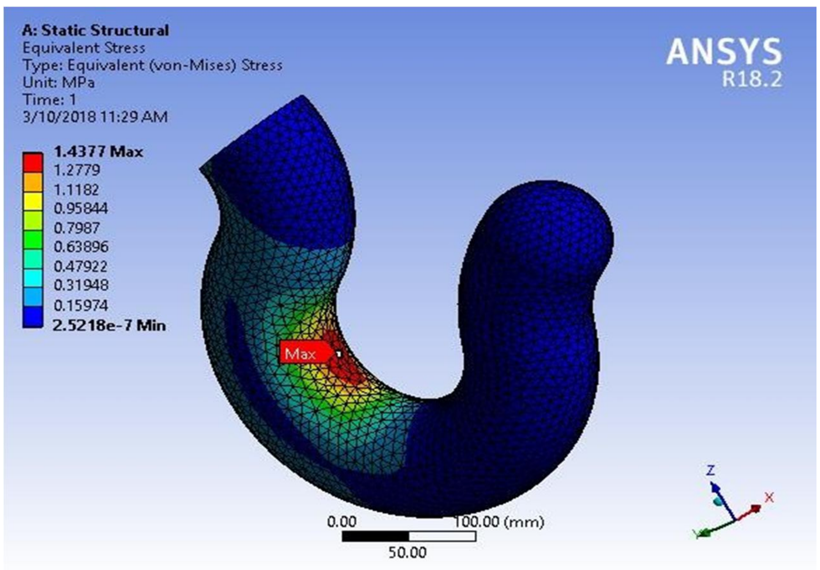
After the meshing fixed support and load of 1KN is applies in Static Structural for all type of cross- sectional crane hooks.

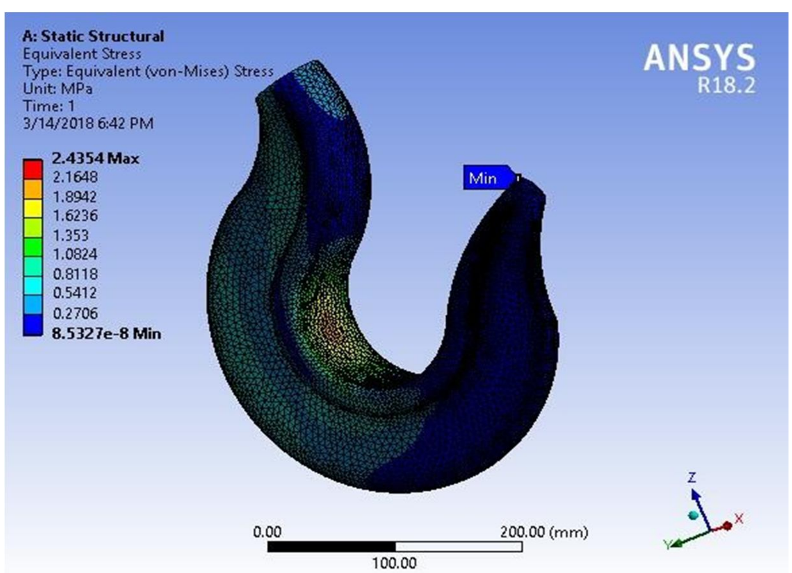


Von Moises stresses of all five cross-sections of the crane hook.









Trapezoidal, Circular, Square, I and T crane hooks

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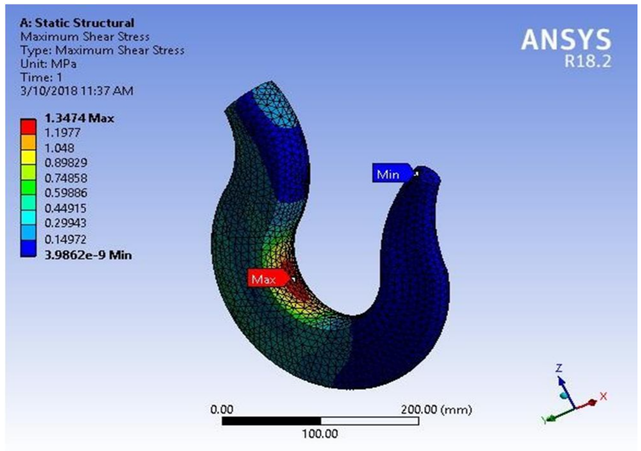
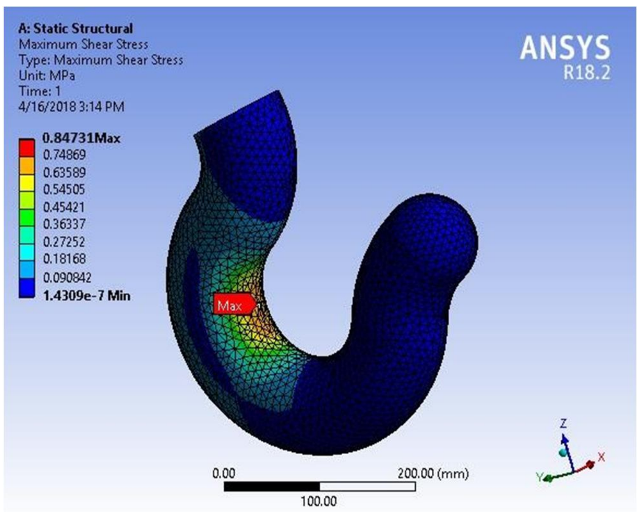
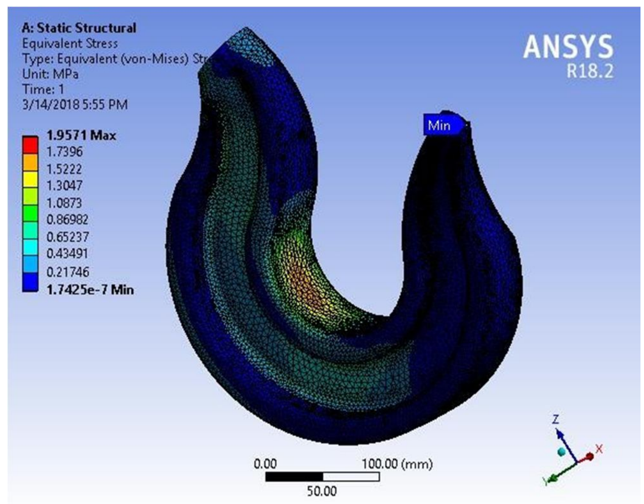
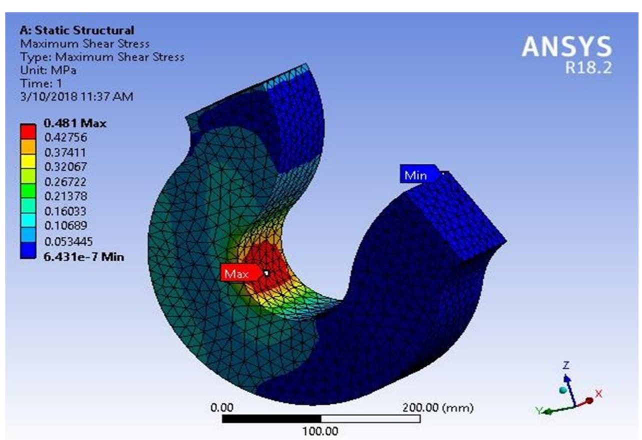
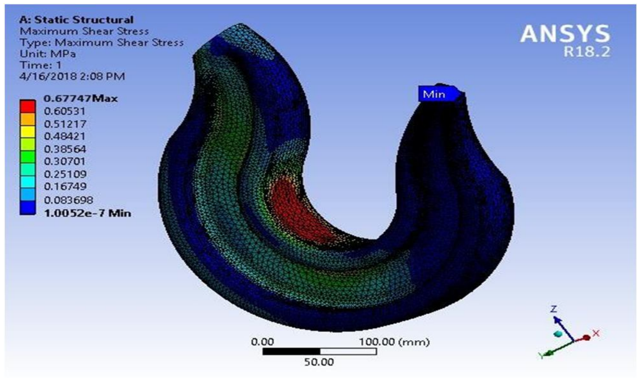
Maximum Shear Stress of different crane hooks

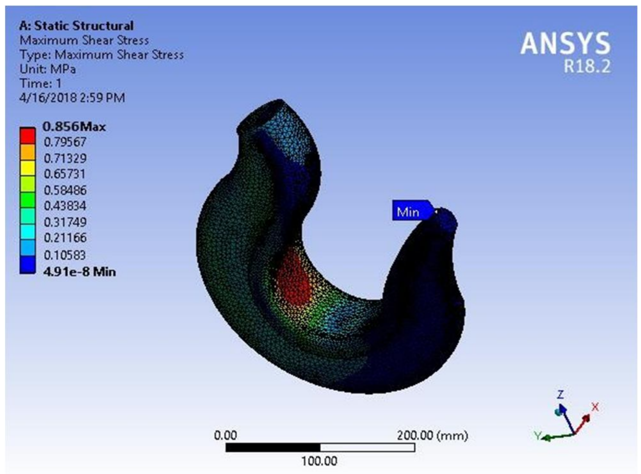












Trapezoidal, Circular, Square, I and T crane hooks.

VI. CONCLUSION

The model that is created in CATIA V5R20 and analysed in ANSYS V18.2. The model created in CATA is transferred to ANSYS through IGES (Initial Graphics Exchange Specification) format. The structural analysis has been performed on the model by applying the material properties, boundary conditions and loads.

By observing the stress in the different cross-sectional crane hooks trapezoidal hook gives a better performance compared to other under 1KN load condition.

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