International Journal for Ignited Minds (IJIMIINDS)

# Alternative Design of C Clamp for Minimization of Counter Weight Using FEM

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**ABSTRACT**

*C-Clamps are the major equipment in the load lifting applications. In the competitive environment, the trial is always for the better products with less stress and higher durability along with optimum functioning. In the mechanical members, stress is the most important in deciding the safety of the structure.*

*In the present work, a C-Clamp of 15 tons capacity is checked for the structural safety by finite element analysis. The geometry is built and converted to finite element model by Solidedge, meshing using standard meshing software Hypermesh. The meshed geometry is imported to Ansys to check for 15 ton load capacity. Three dimensional brick mesh is carried out for accurate results. The results are captured for stress and deformation to check the structural safety. Due to ductile nature of the problem, von-Mises stress is captured. The result shows safety of the structure for stress conditions, but failing for deformation conditions. So stiffness of the structure needs to be increased to reduce the deflection of the structure. Alternative mechanisms are explored to make the structural component safe. Since bending moment directly depends on free length and force applications, the mechanisms are represented to balance this moment from the opposite side. The results shows if problem is converted to simply supported case, the shear force, bending moment and bending stress will reduce along with counter weight requirements. If the C-Clamp is arranged with an equal length arm to support the component, almost counter weight can be eliminated or else count weight can be minimized. The results for all configurations are shown with corresponding graphical representation.*

***Keywords*** *- C-Clamp, Structural Safety, Bending Moment, C-Clamp, von-Mises Stress.*

## 1. INTRODUCTION

C Clamps are the devices used to lift and carry heavy loads from one place to another place. These are mainly used in construction areas, industries and at harbors, used to lift the coils and the disc. A hook is a device with some length of material having curved portion, so that the curved portion is used to hold an object. One end of the hook is pointed so that it can pierce into another material.

Hooks shall not load beyond the capacity; however it is loaded beyond the limit during testing. Hooks having certain ductility are selected which undergoes certain amount of permanent deformation before fracture. Fig 1 shows the C Clamp.

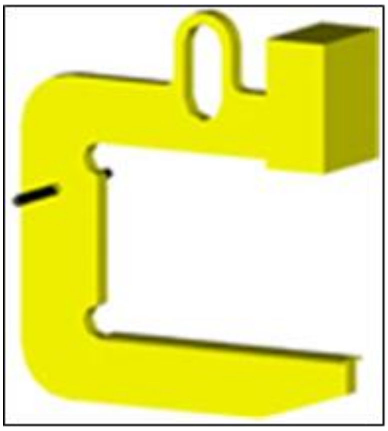

Fig 1: C-Clamp Model.

## 2. LITURATURE SURVEY

Rashmi Uddanwadiker[1] carried analysis on the crane hook. To study the stress pattern of the crane hook in loaded condition, solid model of it is created using CMM and CAD software and the real pattern of stress concentration in 3D model of crane hook is obtained by analyzing the model. The stress on crane hook is analyzed by Diffused light Polariscope setup. She concluded that hook manufactured by forging gives good model over the casting, residual stresses is created in casting the material due to non-uniform solidification, hence casted hooks cannot bear high tensile load.

The stress analysis shows that removal of material will increase the stress in material due to reduced resistance and stress concentration. If area of inner side of hook at the portion of maximum stress is widened then stress will get reduced. If the thickness is increased by 3mm stress is reduced by 17%. Hence hook design can be modified by increasing the inner thickness considerably.

## 3. MATERIAL PROPERTIES

In this work, SAILMA 550 material is used, named by steel authority of India limited manufactured

Shown the mechanical properties of SAILMA 550

Yield strength= 550MPa

Poisson's ratio = 0.3

Density = 7800 Kg/m$^3$

Allowable stress = 275MPa

Factor of safety = 2.

## 4. MODELLING OF C CLAMP

The geometry is built using SolidEdge software, a three dimensional modeling and drafting software. It also has similar modules of alternative CAD Software's like sketcher, part modeler, assembler and drafting. Drafting is very important module for representing the dimensioning and tolerances for production requirements. The ribs are provided to increase the strength of the structure. All the stress concentrations are ribbed to reduce the stress effect.

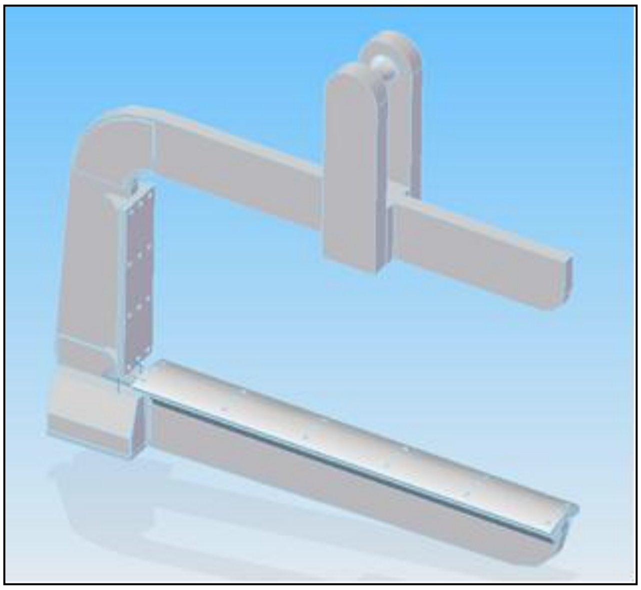

Fig 2: C-Clamp full Assembly.

## 5. ANALYSIS OF C CLAMP

The analysis is carried out for the given C-Clamp structure for the given loads. The results are checked for critical structural safety parameters of stress and deformation. Here von-Mises stress is checked as the material of the C-clamp is ductile. Generally von-Mises theory is applied to find the failure of the ductile components as the von-Mises theory forms upper bound for yielding.

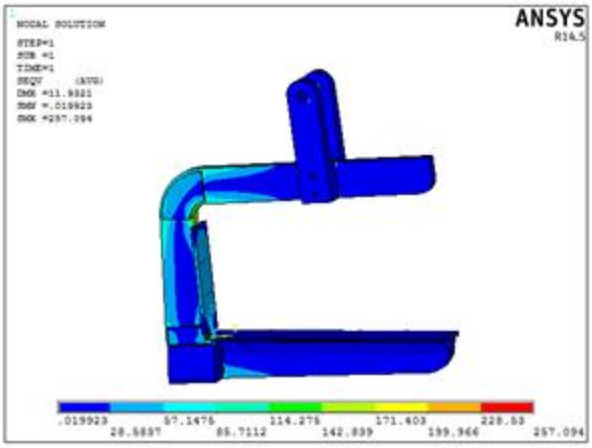


Fig 3: Maximum von-Mises Stress in C-Clamp Assembly.

Fig 3 shows von-Mises stress development in the problem. Maximum stress is 257.094MPa. This stress is less than the allowable stress of 275MPa. So structure is safe for the given load.

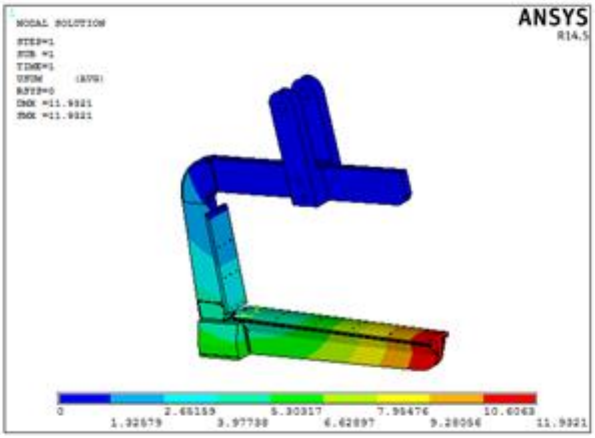


Fig 4: Maximum Displacement in C-Clamp Assembly

Fig 4 shows the displacements in the structure, from the FE analysis we can observe maximum displacement of 11.9321mm. The deflection is at the end region due to cantilever type of load arrangement. This deflection is more when compared to the allowable limits of the beam length. For the given 1971mm, allowable deflection is around 1971/350=5.63mm. So the structure is failing for stiffness stability even though it is satisfying the stress requirements.

## 6. DISCUSSION

During the analysis following configurations are considered. Configurations 1 solved with counter weight and without counter weight and the obtained bending moment is tabulated in table 4.1. For the configuration 3, 4 and 5 minor geometrical changes are made to minimize the counter weight.

In configuration 2 the length of the loading beam is increased, to reduce the bending moment due to increased length on the counter weight side.

In the configuration 3 both sides of members are linked to loading region which has given a reduction in bending moment due to generation of opposite bending moment at the hinged location.

In the configuration 4 boundary conditions are changed and analysis is carried out. This design is not so good due to increase in the bending moment

In the configuration 5 instead of C Clamp, Tong is used to lift the components. This configuration is not preferred due to increase in bending moment.

Table I shows the comparison of shear force and bending moment in each configuration.

| Configuration Sl No. | Shear Force | Maximum Bending Moment (For the Same Length of Loading Arm) |
|---|---|---|
| Configuration 1 | 150000 | $9x10^6$ with counter weight of 50000N |
| Configuration 1 | 150000 | $28x10^6$ without counter weight |
| Configuration 2 | 150000 | $9x10^6$ |
| Configuration 3 | 150000 | $4.8x10^6$ |
| Configuration 4 | 75000 | $28.87x10^6$ (Due to unequal lengths of the loading arms). If the loading lengths are equal bending moment value can be reduced. |
| Configuration 5 | 225000 | $492x10^6$ |

Table 1: Comparison of Shear Force and Bending Moment for each Configuration.

| Configuration Sl No. | Weight of the Configuration (Without Counter Weight) |
|---|---|
| Configuration 1 | 601.5kg |
| Configuration 2 | 780kg |
| Configuration 3 | 935kg |
| Configuration 4 | 741kg |
| Configuration 5 | 922kg |

Table 2: Weight of each Configuration.

## 7. CONCLUSION

Further analysis is carried out to find the actual counter weight required in the problem. The results shows, 5 ton counter weight is not sufficient to balance the system. So calculations are carried out to find the minimum counter weight for distributed load case and for point load case. The calculations shows limited area distribution of load at the end region or point loads will reduce the counter weight requirements.

Further analysis is carried out to find the effect of different arrangements for unbalance moment at the hinge region to find the counter weight requirements. The results are presented for stress generation, moment generation and shear forces. Stress wise, configuration 4 gives better results as it has lesser stress development as the maximum bending moment development is smaller compared to cantilever case subjected to uniformly distributed load.

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