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DESIGN, ANALYSIS AND RE-MODIFICATION OF CHAIN BLOCK SYSTEM

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Keywords: Drum, Von-Mises and chain link.

ABSTRACT
Chain block system plays an important role in an industry to carry the load/materials from one place to another. Computer aided design and analysis of chain block system is one of the techniques used in manufacturing sectors to arrive for the best manufacturing condition, which is an essential need for industry manufacturing of Chain block at lower cost. The objective of my paper work is to study the design of various components which are used in chain block system. A sufficient amount of research work has been described by researchers on the modification of chain hoist system. In a vision of above, my paper work present design, analysis and re-modification of chain block system.

INTRODUCTION
A crane is hoisting device used for lifting or lowering load by means of a drum or lift wheel around which rope or chain wraps. EOT crane is a mechanical lifting device used for lifting or lowering the material and also used for moving the loads horizontally or vertically. It is useful when lifting or moving the loads is beyond the capacity of human. Crane is specially design structure equipped with mechanical means for a load by raising or lowering by electrical or manual operation. Cranes are commonly employed in the transport industry for loading and unloading of freight, in construction industry for the movement of materials; and in the manufacturing industry for the assembling of heavy equipment [3, 4, and 5].

Appropriate solution of shape and materials of hooks enables the increase of loading capacity of hoisting machines. Need of the present day, equipment to handle heavy loads with fast speed, reliability, safety, economy etc. So the crane is used. Crane is one of the most important equipment used in the industries. It works as a material handling equipment or device. Applications of material handling device is a prime consideration in the construction industry for the movement of material, in the manufacturing industry for the assembling of heavy equipment, in the transport industry for the loading and unloading and in shipping etc. This device increase output, improves quality, speed up the deliveries and therefore, decrease the cost of production. The utility of this device has further been increased due to increase in labour costs and problems related to labour management. Crane is a combination of separate hoisting mechanism with a frame for lifting or a combination of lifting and moving load. There is very much useful to pick up a load at one point and be able to transport the object from one place to another place to increase human comfort.

There are three major considerations in the design of cranes. First, the crane must be able to lift the weight of the load. Second, the crane must not topple. Third, the crane must not rupture. There are so many types of crane are available such as Tower crane, Truck mounted crane, EOT crane, Telescopic crane, Gantry crane, Aerial crane, stocker crane, etc. Here, discus about Electric Overhead Travelling (EOT) crane. EOT crane is also known as bridge crane. Electric Overhead cranes typically consist of either a single girder or a double girder construction. An overhead crane consists three types of motion:

- The bridge providing long travel motion of the hoist, trolley and the load.
- The trolley providing cross travel motion of the hoist and the load.
- The hoist providing up-down motion of the load

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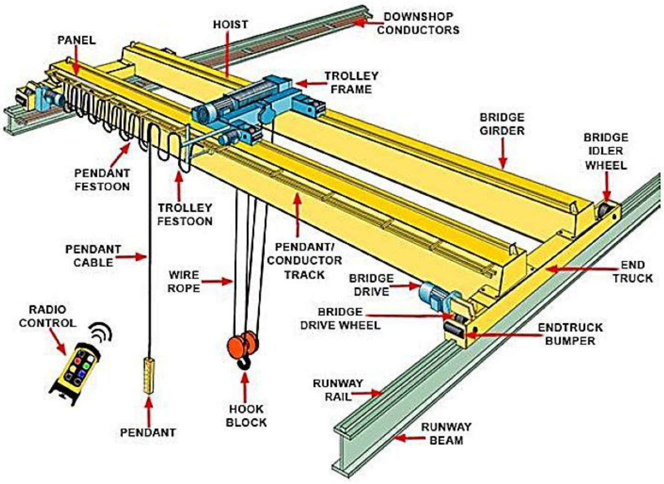

Fig. 1.1: Double Girder EOT Crane

Types Of Overhead Cranes
Various types of overhead cranes are used in industries with many being highly specialized. Various types of overhead cranes are single girder cranes, double girder cranes, gantry cranes and monorails.

a. Single Girder Cranes
The crane consists of a single bridge girder supported on two end trucks. It has a trolley hoist mechanism that runs on the bottom flange of the bridge girder.

b. Double Girder Cranes
The crane consists of two bridge girders supported on two end trucks (end carriages). The trolley runs on rails on the top of the bridge girders. Double girder electric overhead cranes are widely used in the industries because they can carry more loads with more span than any other type of crane. In this project we are concentrating mainly on double girder electric overhead cranes.

c. Gantry Cranes
These cranes are essentially the same as the regular overhead cranes except that the bridge for carrying the trolley or trolleys is rigidly supported on two or more legs.

Parts Of The Hoisting Devices
A hoisting device is used for lifting or lowering a load by means of a drum or lift-wheel around which rope or chain wraps. It may be manually operated, electrically or pneumatically driven and may use chain, fiber or wire rope as its lifting medium

Eg: Elevators, crane
Here the hoisting part of an EOT crane is discussed

The hoisting part of the EOT crane consists of the following parts
- Hoist motor
- Gear box
- Drum
- Pulleys
- Wire rope
- Hook

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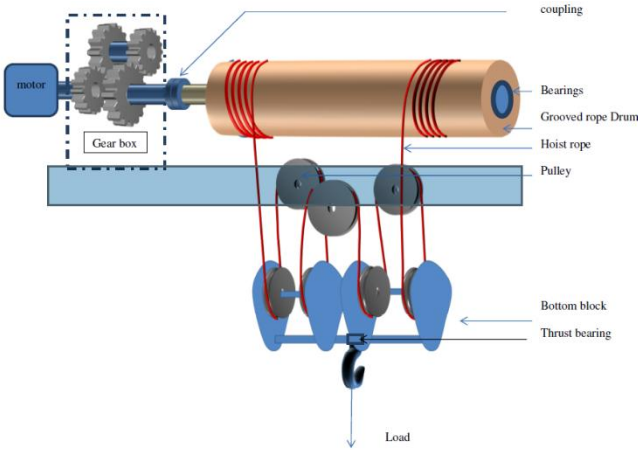

Fig. 1.2: Schematic view of the hoisting device

PROBLEM IDENTIFICATIONS & OBJECTIVES

Problem Identification

In this chapter discussion of the problem is elaborated and the objectives behind the thesis work are converted also in this chapter. Stresses in a pulley and chain link found maximum during the gradually impacting loading, a designer needs focused on different design parameters in order to make it suitable with the operation. The problem with used of existing material is tried to overcome by replacing the existing material.

Objectives

1. To developed, an analytical calculation for design of pulley and chain link for capacity of 0.5 ton.
2. Analysis of deformation at various loading conditions.
3. To modelled the model with PRO-E software
4. To apply the loading conditions using the ANSYS software on the both components design with different materials.
5. To compare results of the existing materials and new material used for design and validated the results of the study.

DESIGN CALCULATION OF CRANE COMPONENT

Selection Of Material

The selection of material is very important thing in order to design any mechanical components. The recents trends towards optimizing the mechanical components through continuous design modification needs lots of data to maintained, also during the design proper material selection is also needed. The presented design of drum and chain link for EOT crane described with used of two different material like SAE 1041 and glass fiber is used. The basic mechanical properties of the materials as shown in the following table 4.1 and 4.2

Basic Calculation Of EOT Crane

a. Total Lifting Capacity (W) = 0.5 ton
   = 0.5 X 10000 N
   = 5000 N
b. Lifting Height = 29.95 meter
   = 29.95 X 1000
   = 29950 mm
c. Breaking Strength of Chain Link

No. of rope parts (nt) = 1
Efficiency of pulley or drum (p) = 94%
From Design Data Book, for n =11,

$$P = \frac{5000}{\eta p x nos. of\ Chain\ link} = 5319N$$

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d. Selecting the Chain Link
Now,

$$A = \left[\frac{P}{\frac{\sigma u}{\eta f} - \frac{(dw - Er)}{Dmin}}\right]$$

Where,
σu = Tensile of the wire = 1600 N / $mm2$
ηf = Design factor = 4
$E\ r$ = Corrected modulus of elasticity
D = Diameter of drum
d = Diameter of Chain link
P = Breaking strength of Chain Link = 5319N
Now, all values are put in this equation,
$A = 30.39mm^2$
$A = 0.4d^2$
$d = 8mm$

e. Design of Pulley or Hoisting Drum

Hoisting drum with one coiling rope has only one helix, while the drums with two coiling ropes are provided with helices, right hand & left hand. A design procedure of hoisting drum is as under:
Minimum diameter of pulley = 16d = 128mm
It is advisable to take diameter of pulley = 27d = 216mm

Diameter of compensating pulleys
D_1= 0.6x 216 =129.6mm, D_1=130mm

a) Number of turns on a drum for one rope member

$n = \left(\frac{h_i}{\Pi D}\right) + 2 = \left(\frac{6000*2}{3.14*200}\right) + 2$=21.10 turns$\cong 22\ turns$

Where, h = height of load to which it is raised (Consider double of height)
i = ratio of pulley system = 2
D = drum diameter = 25d = 25(8) = 200 mm

b) Length of Drum

$$L = \left[\left(\frac{2h_i}{\Pi D}\right) + 7\right] * P_i$$

$$L = \left[\left(\frac{2*6000*2}{3.14*200}\right) + 7\right] * 9.5 = 430mm$$

p = pitch of grooves of two turn = 9.5mm

c) Thickness of Drum

$$t = 0.02D + 10 = 14mm$$

d) Outer diameter of drum

$$D_o = D + 6d = 248mm$$

e) Inner diameter of drum

$$D_i = D - 2t = 172mm$$

f) Checking for the stresses in the drum

I. Compressive stress in the drum

$$\sigma_c = \frac{W}{t(pi)}\ Mpa = \frac{5000}{14*9.5} 37N/mm^2$$

II. Maximum bending stress

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$$\sigma_c = \frac{8WLD}{(D^4 - D^4)} \Pi \ Mpa$$

$$\sigma_c = \frac{8 * 5000 * 430 * 200}{(200^4 - 172^4)} * 3.14 \ Mpa = 14.90 N/mm^2$$

III. Maximum shear stress

$$\tau = \frac{16 T_{max} \ D}{(D^4 - D^4)} \Pi \ Mpa = \frac{16 * 553176 * 200}{(200^4 - 172^4)} * 3.14 = 7.66 \ N/mm^2$$

IV. Total normal stress on drum

$$\sigma_n = \sqrt{(\sigma_{b^2} - \sigma_{c^2})} = \sqrt{(14.90^2 - 37^2)} = 39.88 \ N/mm^2$$

(Permissible bending stress is 20 *MPa)*

MODELING & ANALYSIS

Tool For Modeling

a. Pro/ENGINEER

PTC Creo, formerly known as Pro/ENGINEER is a parametric, integrated 3D CAD /CAM/CAE solution created by Parametric Technology Corporation (PTC). It was the first to market with parametric, feature-based, associative solid modeling software. The application runs on Microsoft Windows platform, and provides solid modeling, assembly modeling and drafting, finite element analysis, direct and parametric modeling, sub-divisional and nurbs surfacing, and NC and tooling functionality for mechanical engineers. It features a suite of 10 applications which work within the same program.

Creo Elements/Pro provides a complete set of design, analysis and manufacturing capabilities on one, integral, scalable platform. These required capabilities include Solid Modeling, Surfacing, Rendering, Data Interoperability, Routed Systems Design, Simulation, Tolerance Analysis, and NC and Tooling Design. Creo Elements/Pro can be used to create a complete 3D digital model of manufactured goods. The models consist of 2D and 3D solid model data which can also be used downstream in finite element analysis, rapid prototyping, tooling design, and CNC manufacturing. All data are associative and interchangeable between the CAD, CAE and CAM modules without conversion. A product and its entire bill of materials (BOM) can be modeled accurately with fully associative engineering drawings, and revision control information. The associatively functionality in Creo Elements/Pro enables users to make changes in the design at any time during the product development process and automatically update downstream deliverables. This capability enables concurrent engineering – design, analysis and manufacturing engineers working in parallel – and streamlines product development processes. Creo Elements/Pro is a software application within the CAID/CAD/CAM/CAE category.

Approach For Modeling

- ***Modeling Of Drum And Chain Link***

The drum is model with the below rated parameter

Table:4.1 Summaries of Dimension

Diameter of Drum *(D)*	248 mm
Inner Diameter of Drum *(H)*	172 mm
Thickness	14 mm
Diameter of Chain Link	8mm

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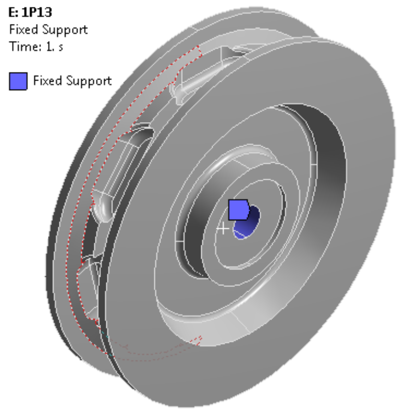

Figure 4.1 3D model of Drum or Pulley

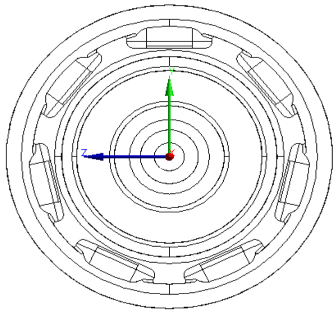

Figure 4.2 Wireframe model of Drum or Pulley

Table 4.2: Summaries of the material properties

SAE1045		SAE 1018	
Young's modulus	200 Gpa	Young's modulus	180-200 Gpa
Poisson's ratio	0.290	Poisson's ratio	0.20
Tensile strength	310 Mpa	Tensile strength	300 Mpa
Bulk Modulus	140 Mpa	Bulk Modulus	120 Mpa
Shear Modulus	80Mpa	Shear Modulus	75Mpa

Tool For Analysis

Ansys-14.0

The analysis of modeling design is carried out in ANSYS.It is engineering simulation software; it is used for finite element analysis. ANSYS offers engineering simulation solution sets in engineering simulation that a design process requires. Companies in a wide variety of industries use ANSYS software. The tools put a virtual product through a rigorous testing procedure (such as crashing a car into a brick wall, or running for several years on a tarmac road) before it becomes a physical object.

Finite Element Analysis

Finite element analysis (FEA) has become commonplace in recent years, and is now the basis of a multibillion dollar per year industry. Numerical solutions to even very complicated stress problems can now be obtained routinely using FEA, and the method is so important that even introductory treatments of Mechanics of Materials such as these modules should outline its principal features.

In spite of the great power of FEA, the disadvantages of computer solutions must be kept in mind when using this and similar methods. They do not necessarily reveal how the stresses are influenced by important problem variables such as materials properties and geometrical features, and errors in input data can produce wildly incorrect results that may be overlooked by the analyst. Perhaps the most important function of theoretical modeling is that of sharpening the designer's intuition, users of finite element codes should plan their strategy toward this end, supplementing the computer simulation with as much closed-form and experimental analysis as possible.

General procedure for Finite Element Analysis

Certain steps in formulating a finite element analysis of a physical problem are common to all such analyses, whether structural, heat transfer, fluid flow, or some other problem. These steps are embodied in commercial finite element software packages (some are mentioned in the following paragraphs) and are implicitly incorporated in this text, although we do not necessarily refer to the steps explicitly.

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Physics Of Problem

Modeling
In this section the brief process for modeling is describe. The basic steps in modeling can be divided as follows:

1. Set the Preferences
2. Pre-Processing
    - Define element types
    - Defining material properties
    - Creating a model
    - Mesh the give area
    - Apply displacement constrains
3. Solution
4. Post Processing

Pre-processor
Define the Element Type
During the actual working in ANSYS it's very important to choose the elements. Element type determines the degree of freedom, characteristic shape of the element,

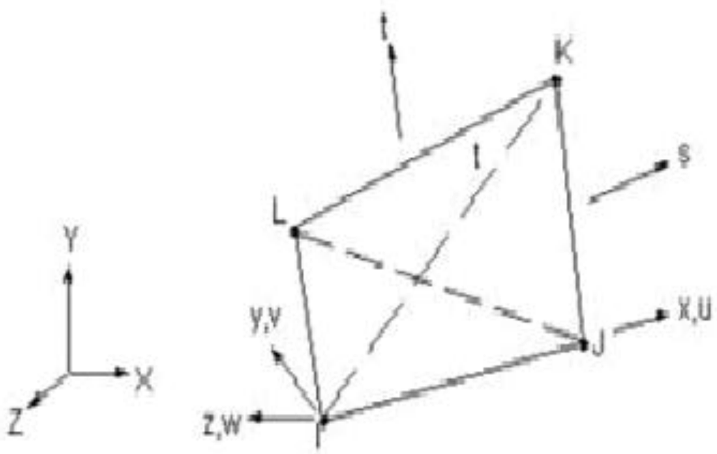

Figure 4.3 SHELL63 - Elastic Shell Element

(Line, Tetrahedrons, quadrilateral, brick etc.) And whether the element lies in 2D or 3D space. For analysis of blade we select the SHELL63 elements. SHELL63 can be adjusted for Non uniform materials.

- ***Defining Material Properties***

Material properties are constitutive properties of material such as modulus of elasticity or density, are independent of geometry. These material properties are obtained from experimental testing. Depending upon application, properties may be linear, non-linear, isotropic, anisotropic, etc. For this analysis the material properties are isotropic. The values of Young's modulus, density, Poisson's ratio are given as follows.

In this section the problem of physics such as stress and deflection are calculated when the drum and link undergoes loading.

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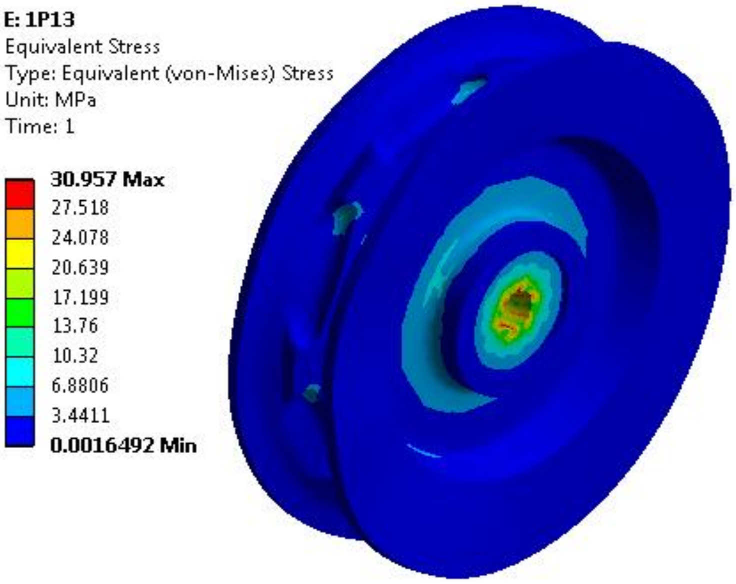

Figure 4.4 Equivalent Stress of drum in ANSYS

The model which has to be design having the thickness of 14 mm, diameter 248 mm.

- ***Generating The Mesh***

It involves dividing the component into large number of elements having a number of nodes. This method of dividing the component into large number of elements is called as discretisation. Greater is the number of elements, greater will be the accuracy. There are two main meshing methods: free and mapped.

Free Mesh: It has no element shape restrictions. The mesh does not follow any pattern. It is suitable for complex shape areas and volumes.

Mapped Mesh: It restricts element shapes to quadrilaterals for areas and hexahedra (bricks) for volumes. It typically has a regular pattern with obvious rows of elements. It is suitable only for "regular" areas and volumes such as rectangles and bricks.

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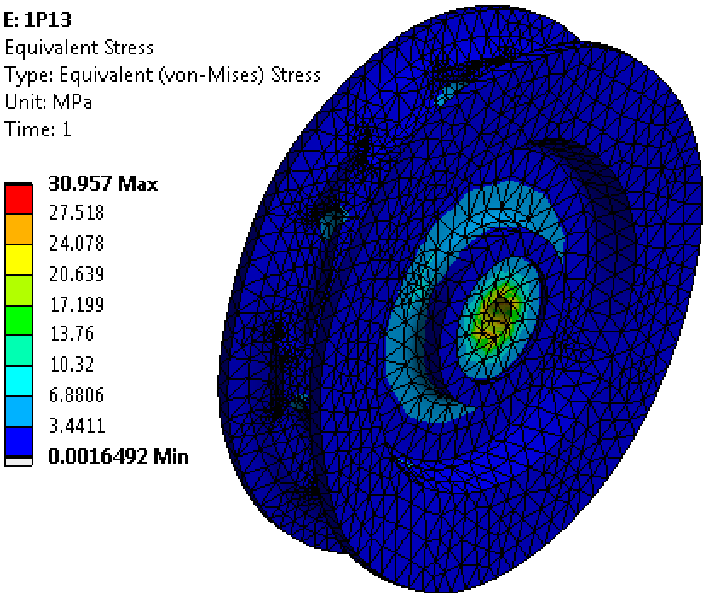

Figure 4.5 Meshing of Drum

The design of drum is analyzed, the analysis is performed on drum, the fixed constraints fixtures are applied on the top, bottom and center of the shaft, the fixtures constrained all translational and all rotational degrees of freedom. Therefore, the drum is stay in a static and fixed position. The load for this analysis is force with 5000 *N* obtained from the loading conditions analysis and equally distributed on the inner gap of drum.

Solution

The stresses, strain developed and the total deformation due to force applied on blade are shown below:

a. For Material Sae1045 Material

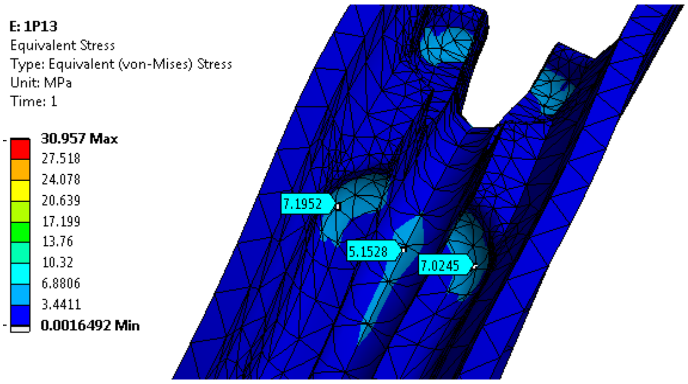

Figure 4.6 Equivalent stress distributions for Drum

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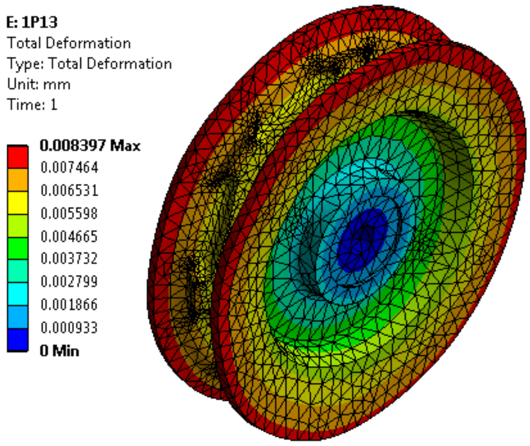

Figure 4.7 Maximum Deformation

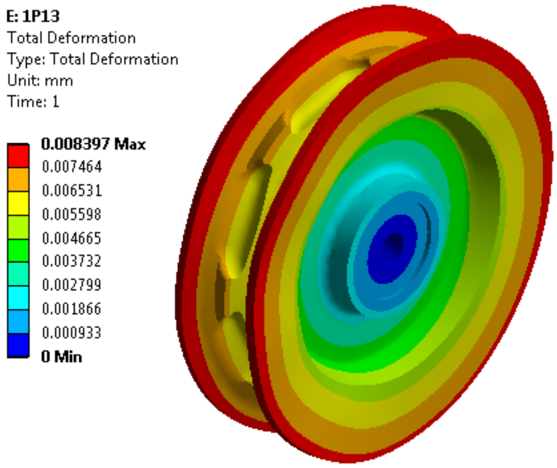

Figure 4.8 Maximum Deformation

The maximum and minimum Von Misses stress for the drum is obtained about 30.957 MPa respectively. Figure (5.6) shows the deformation of the model under the given load, the maximum displacement is 0.008397 mm at the edge of the drum. The deformation is acceptable because it is small in relation to the overall size of the blade structure.

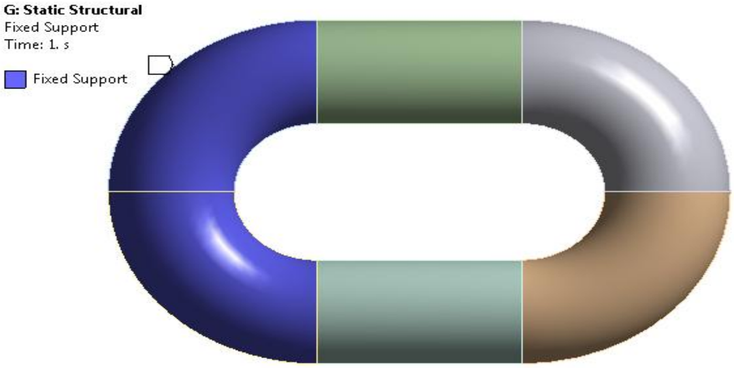

Figure 4.9 Chain Link

The chain link having the diameter of the 15mm and it is acted by the load off the 5000N.

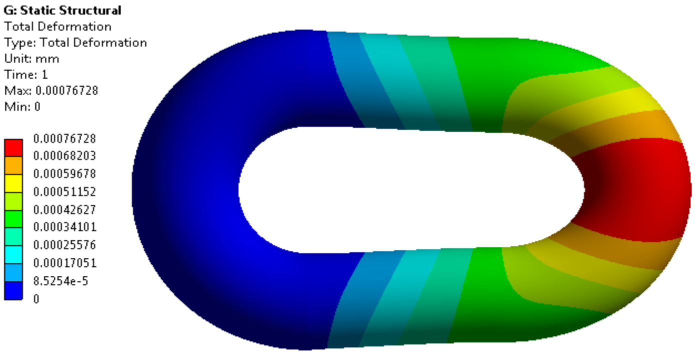

Fig.4.10 Static Structural Analysis of Chain Link

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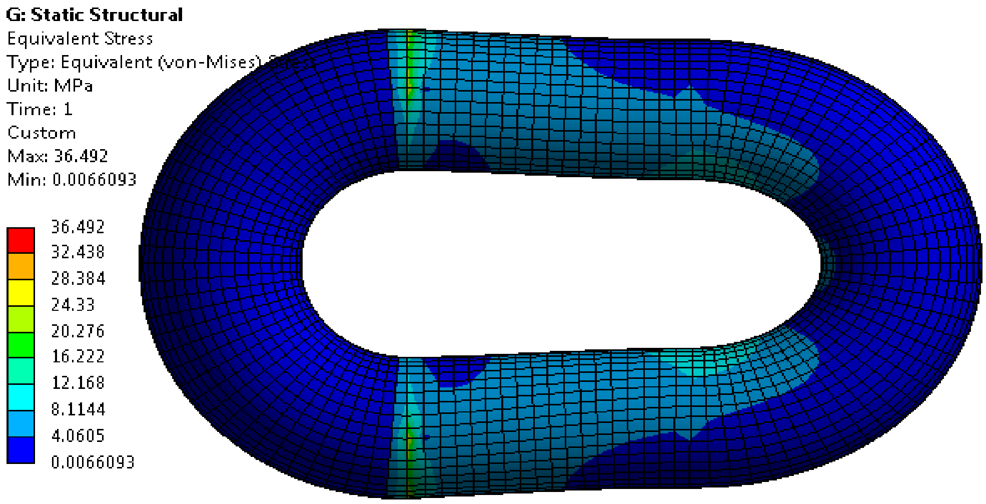
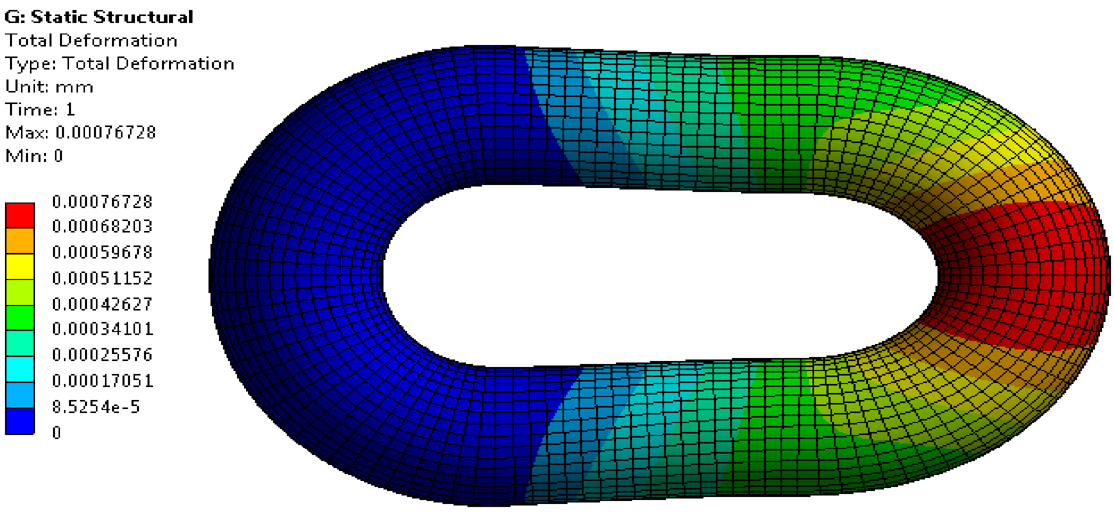
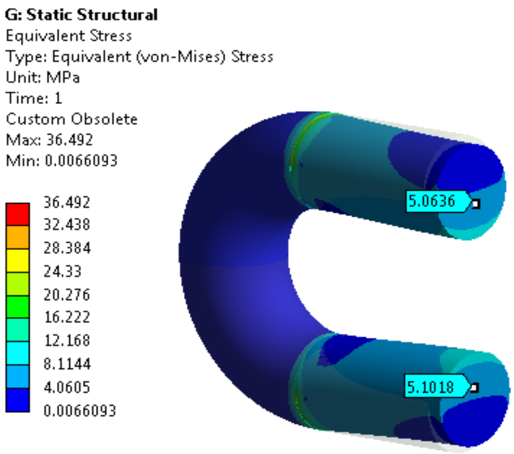


Fig.4.11 Static Structural Analysis of Chain Link (Von-Mises)





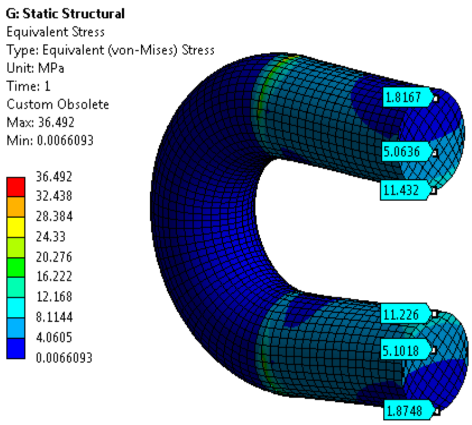


Fig.4.12 Total Deformation Chain Link (Von-Mises)

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b. ***For Sae 1018***

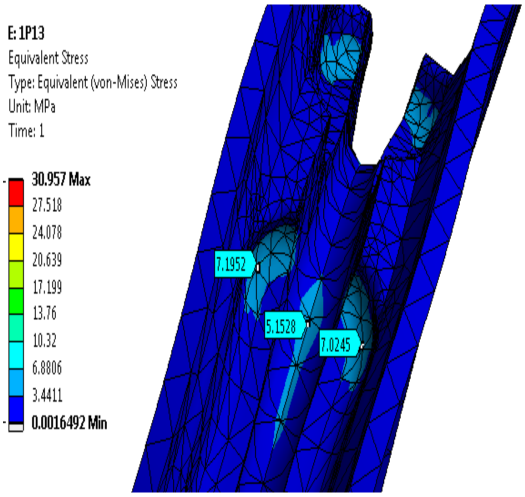

Fig.4.13 Equivalent Stress Von-Mises)

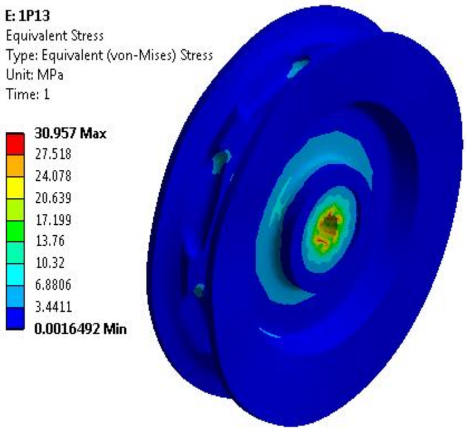

Fig.4.14 Equivalent Stress Von-Mises)

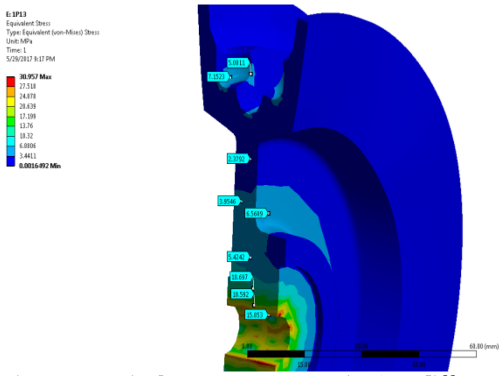

Fig.4.15 Equivalent Stress (Von-Mises) at different point

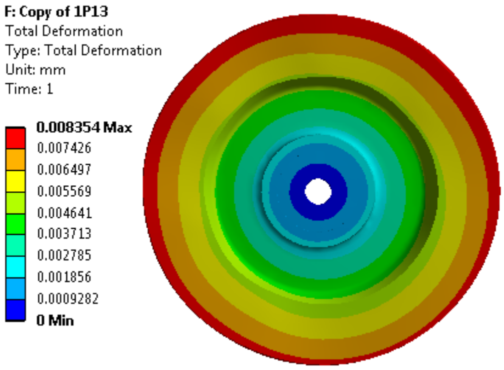

Fig.4.16 Total Deformation

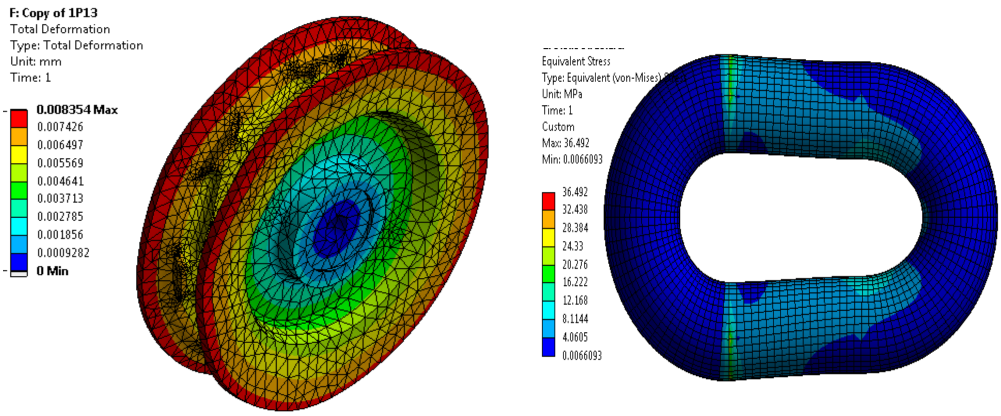

Fig.4.17Total Deformation

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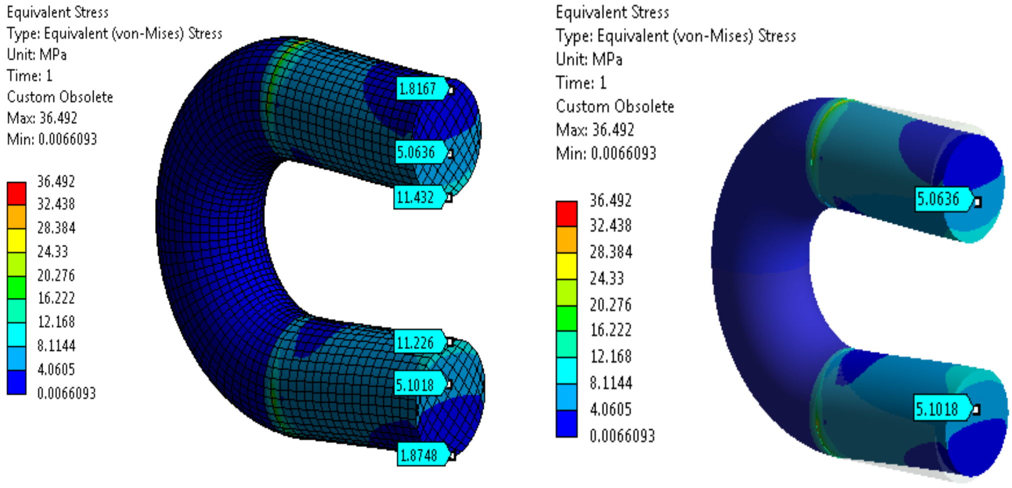

Fig.4.18 Equivalent stress on chain link

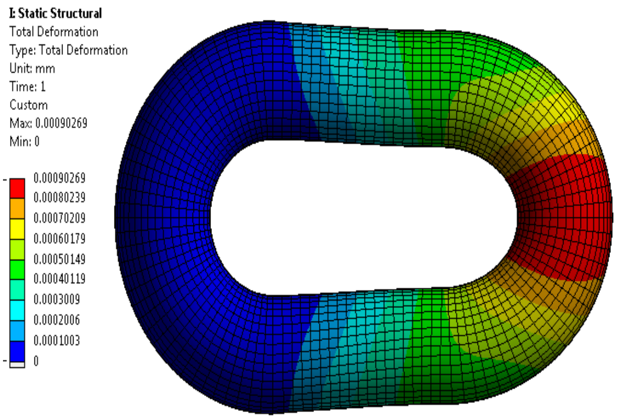

Fig.4.19 Total Deformation stress on chain link

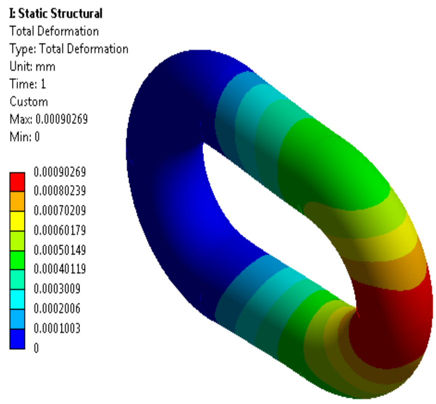

Fig.4.20 Total Deformation stress on chain link

Table: 4.4 Summaries of results obtained from Computational and Analytical Calculations

For Drum			
Properties	**SAE 1045**	**SAE 1018**	**Analytical Treat**
Equivalent Stress (Mpa)	30.957	30.95	37.28
Total Deformation (mm)	0.008397	0.008354	0.0072
For Chain Link			
Equivalent Stress (Mpa)	36.492	35.89	---
Total Deformation (mm)	0.0007628	0.0009026	---

CONCLUSION

This study investigated the elements that contribute to design and analysis of drum and chain link of EOT Crain. In this research work the analytical and computational analysis of is carried out for load of 5000N. The drum and chain link of EOT is designed by using Pro-E software. The structural feasibility is analyzed by Finite Element Analysis method. Finite Element Analysis is used in this project. Finite Element Analysis method is used to obtain the maximum deformation and stress experienced by the drum and chain link with loading of 5000N.

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