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Design and Strength Analysis of a Tilting Mechanism for Steel Structures

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Abstract - *The main of this project is to design a mechanism which can support the high weight of the steel beams and also to remove maximum amount of pickle liquor from it. The structural steel beams like I-beams, C-channels etc. are manufactured by extrusion process. Each beam will of total length twelve to thirteen meter long. After the extrusion process the beams are subjected to pickling by pouring pickle liquor on them. The pickling process is used to remove surface impurities and also to improve surface quality of the structures. But this pickle liquor is actually made up of acids which causes oxidation of the beams. As working temperature of the beam will be high it is impossible to drain off those beams manually. Also parameters like length of the beam, process continuation comes into picture to clean these beams manually. So this mechanism has been designed to carry the weight of the beams and to take off the maximum amount of liquid from the beams by tilting one part of itself by 90°. Also the analysis of the mechanism has been carried out to check the maximum amount of load it can carry without failing.*

Key Words: **Steel beams, Extrusion Process, Pickling Process, Pickle Liquor, Tilting Mechanism.**

1. INTRODUCTION

The main process used for steel beams is the extrusion process. When the steel ingot is extruded there will be surface roughness, chemical impurities, etc. deposited on the steel. To take care of these impurities, "pickle liquor" is poured on the metal. But because of chemical reaction metal starts rusting as it comes in contact with the pickle liquor. So maximum amount of liquid should be removed from the structures as soon as possible. But after extrusion the steel will be moved on a roller conveyor belt until it gets stored in one place. So it is very much difficult to remove the liquid from the structures. The main aim of this project is to design and manufacture a tilting mechanism which can be installed in the conveyor system and which can lift and tilt the beams to remove liquid from them.

1.1 System Design

The figure shows the top view of the tilting mechanism assembly. The length of the steel beams is in the range of 12mtrs to 13mtrs. And at one time there will be around 12 to 13 beams will be extruded and passed on a single conveyor belt. Weight of one single structure will be around 52kg to 53kg per meter. That means total weight of one beam will be 650 kg to 700 kg. So total weight of 12 beams will be around 8 ton. One single mechanism cannot lift so long and heavy beams. To support such heavy load I have designed 4 tilting mechanisms. The material used for tilting mechanism is mild steel (MS).

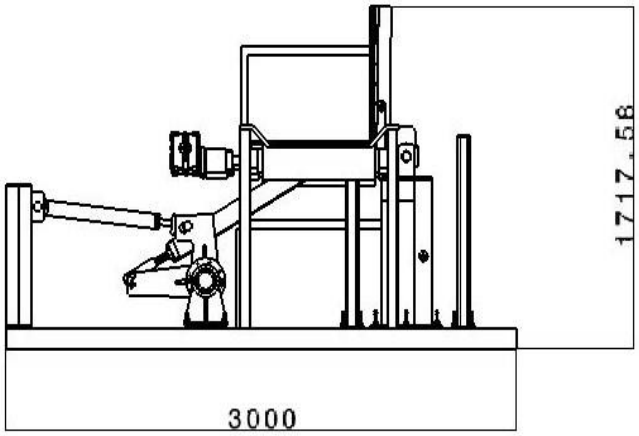

Figure 1 Diagram of the Tilting Mechanism

1.2 Design Calculations of various links

Maximum load carried by the individual mechanism is 2 ton.
The design is carried out considering the maximum load.
Area of the link 1, $A_1 = 32 \times 70$ mm^2
Diameter of the shaft (Link 2), D = 197 mm
Length of the individual shaft, L = 3000 mm
Area of the Link 3, $A_3 = 32 \times 90$ mm^2
Area of link 4, $A_4 = 50 \times 100$ mm^2

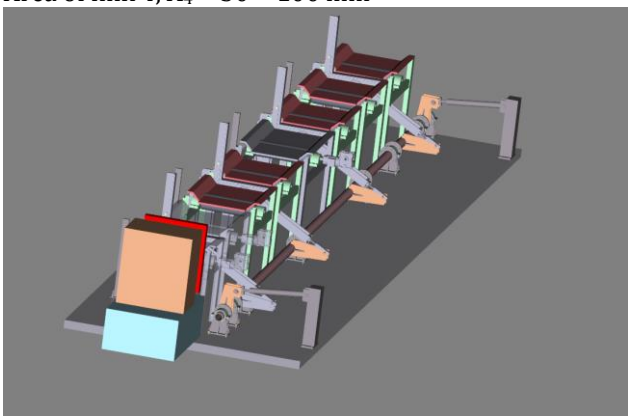

Figure 2 isometric view of the Tilting Mechanism Assembly

1.3 Meshing of the Geometry

To determine the amount of stress induced in each link it is necessary to perform FEM analysis. For FEM analysis the model is meshed very carefully, loading conditions are applied and finally the strength analysis is carried out for 2 ton load.
Initially the components are meshed with 2D elements (triangular or quadrilateral). The quality of the mesh is improved and the elements are converted to 3D elements to fill the volume of the geometry.
The meshing of the geometry is done in HYPERMESH V.14 software. For meshing the user profile is NASTRAN. The figure below shows the meshed model with boundary conditions and loading.

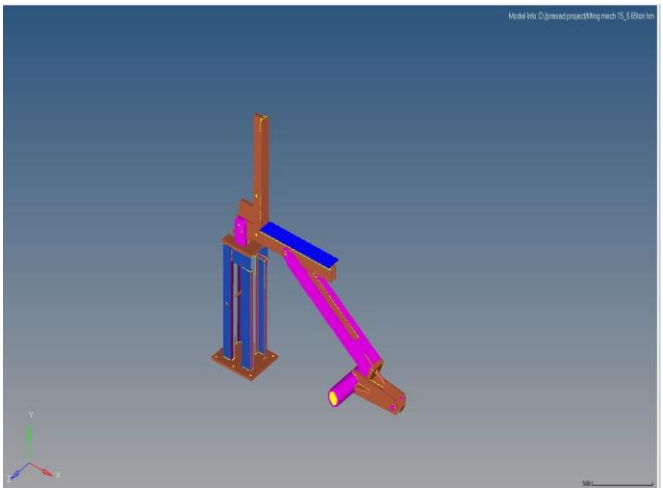

Figure 3 Meshed Model with Boundary Conditions and Loading

Tetra mesh is used for shaft and other circular sections, quad mesh is used for sections like plate, columns etc.
Rigid body connections (shown in yellow color) are given to connect two parts with each other. All the degrees of freedom are zero in this case.

2. STRENGTH ANALYSIS OF THE MECHANISM

The uniformly distributed load (shown in blue color) of 2 ton is applied on the mechanism and analysis is carried out.
For 2 ton load the value of stress induced is 211.7 MPa.
As the yield strength of the MS is 250 MPa, the induced stress (211.7 MPa) is less than the yield strength and hence the design is safe.

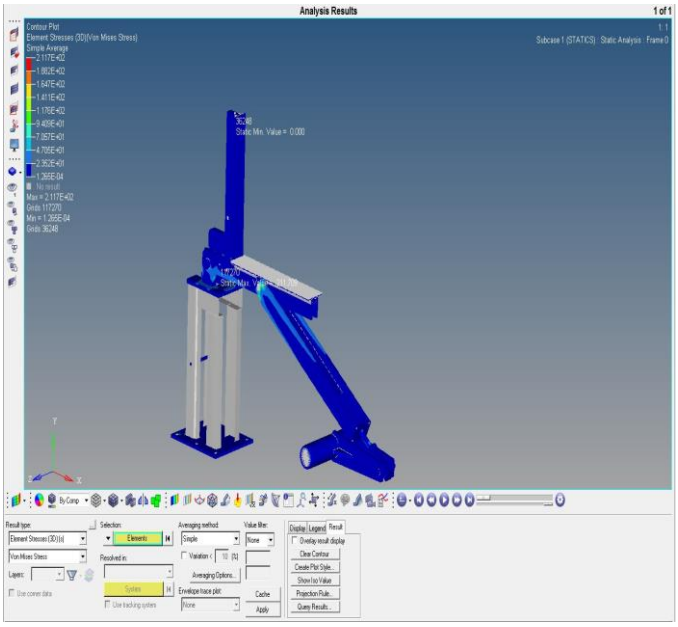

Figure 4 Maximum Stress Induced in the Mechanism for 2 ton Load

Now, iterations are performed to findout the maximum load carrying capacity of the mechanism. By iterations we found that maximum load it can carry without failure is 2.35 ton load.

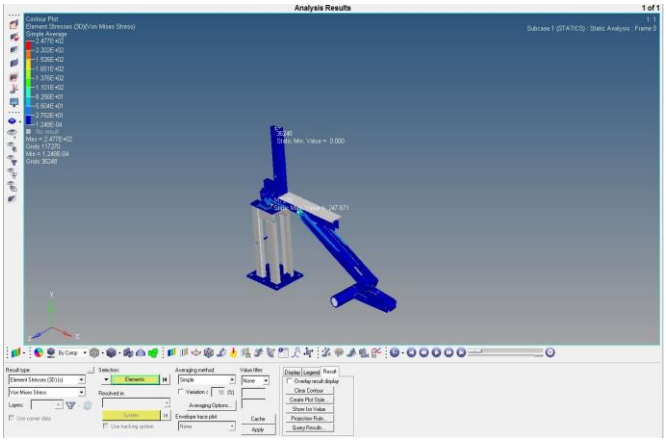

Figure 5 Maximum Stress Induced in the Mechanism for 2.35 ton Load

From above figure we can see that for the load of 2.35 ton the maximum stress induced is 247.7 MPa, which is almost near to the yield strength of the material but still the mechanism is safe.

3. RESULTS

After performing the analysis in HYPERMESH following are the results obtained.

Table -1: Comparison of stresses

SI No.	Cases	Von-Mises stress, MPa	Yield strength, MPa	Remarks
1	Mechanism under 2 ton load	211.7	250	SAFE
2	Mechanism under 2.35 ton load	247.7	250	SAFE

4. CONCLUSIONS

The tilting mechanism satisfies the assigned work of lifting the steel structures and tilting them to 90° so that maximum amount of pickle liquor can be removed. Also the mechanism does not fail under the given load of 2 ton. The maximum load it can lift is 2.35 ton.

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