# Design and Study of a Turn over Device to Tilt the Locomotive Engine from Vertical Position to Horizontal Position by Considering Ergonomics and Safety

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*Abstract*— The modern manufacturing system demands for increase in productivity, safe operations with fewer efforts in less cost of operation. In industrial sectors, in India, placement of component is a major factor specially in Locomotives. Transportation affects the production rate, cost and hence the profit of the company. Placement/mounting of products requires time. Hence, to make the process of mounting more easier, we design a Turn Over Device which will work in less available space and thus reduce the time required to Tilt the loads from one machine to another. The project discusses the mechanisms used to tilt engine of locomotive from vertical to horizontal position. This project gives an idea about designing of this turn over device by considering ergonomics and safety.

***Key words:*** Tilting Engine Components, Locomotive Engine

## I. PROBLEM STATEMENT

Earlier for lifting and tilting any heavy engine components was done by chain and weight lifting chain arrangement. Due to this it was very risky for the workers to do any process related to tilting of engine. Various other problems like Time loss, Ergonomic considerations etc were present. So overcome this shortcomings a new concept of "TURN OVER DEVICE" was initiated. Turn over device is used to tilt any object through a specific angle. TOD we are using is to tilt a 6 cylinder engine from vertical position to horizontal position. TOD provides various benefits like safety for user, easy handling, customer satisfaction, time saving etc. So the main problem of tilting a heavy engine is overcomed using Turn over device.

## II. OBJECTIVES OF THE PROJECT

### A. *Ergonomic Risk Reduction*

Earlier for tilting the engine we used chain and hoist mechanism. This method was not considered as ergonomic as it had various disadvantages. Worker movement was restricted, as the engine was lifted at particular height problems like strain on Neck, shoulder etc were observed. Also as the process done was above eye level so worker could not perform the task efficiently. Turn over device would essentially negate all these disadvantages and we can achieve a better working conditions.

### B. *Easy Handling*

Hoist and chain mechanism required both hands to be used simultaneously which caused lot of problems for the worker. Turn over device ensures that the process becomes easy as there are no complications at the workers end.

### C. *Operators Safety*

Earlier process involved lot of risky operations which were harmful for the worker. Whenever the engine was lifted and tilted by chain and hoist the motion of engine could not be controlled so wayward motion of engine caused lot of problems for the workers. Chances of engine colliding with the worker or any object were present which would definitely have an adverse impact on the working environment. Turn over device remove all these effects and ensure safe working.

### D. *Time Saving*

As lifting and tilting of engine required lot of time, patience as well as concentration the process took certain time. Turn over device will reduce the process time as well as no skilled labour will we required for the process.

## III. DESIGN AND SELECTION OF COMPONENTS

Following general components of Turn Over Device are to be designed and selected.

1. Rings
2. Stopper
3. Base frame
4. Brackets
5. Chain

## IV. CALCULATIONS AND COMPONENTS

### A. *To find out the weight of the system*

Mass of two rings = Density * Volume
= 467 Kg
Mass of Structure = 112Kg
Mass of Fixture provided for engine to rest = 221Kg
Total mass of Turnover device = 800Kg
Moment of Inertia
$800*x_1 = (467*0)+(112*0)+(221*470)$
$x_1$ =129.8mm
$800*y_1 = (467*0)+(112*800)$
$y_1$=112mm
Moment of inertia of turn over device and engine
Engine mass considered=3000kg

$3800*x_2=800*129.80$
$x_2$= 27.30 mm
$3800*y_2=800*112$
$y_2$= 23.58mm

Resultant = $\sqrt{(x_1*x_1 + y_1*y_1)}$
= $\sqrt{}$ (27.3*27.3+23.58*23.58)
=36.073mm

Torque = Force * *r*
= 3800* 9.81*36.073

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=1345 N-m

Power = $2\prod NT/60$ (N=7rpm)

=2*3.14*7*1345/ 60

= 985.44 W

= 1.32 HP

[746Watt=1Horse power]

Therefore, 985.44W =1.32HP

*B. To find the diameter of Shaft*

$$d = \sqrt{\frac{W}{cos\emptyset \times 2\pi \times 4 \times \tau}}$$

$$cos\emptyset = \frac{W}{x}$$

$$cos\emptyset = \frac{3800}{x}$$

$$x = 1478\ kg$$

$$F = \frac{w}{4cos\emptyset} \times \frac{4}{2 \times \frac{\pi}{4} \times d^2}$$

$$\tau = \frac{f}{Area} = \frac{f}{2 * \frac{\pi}{4} * d^2}$$

$$d^2 = \frac{f}{2 \times \frac{\pi}{4} \times \tau}$$

$$d^2 = \frac{1478}{2 \times 0.7854 \times 6}$$

$$d^2 = 156.81$$

$$d = 12.52mm\ (dsa\ for\ Roller\ pin)$$

## V. ANALYSIS

*A. Analysis of Stopper*

The stopper is a critical part considering the safe operation of the turn over device. We analyzed stopper for failure by applying loads which will actually act on it. We got a Factor of safety within safe limits that ensures that our part won't undergo failure. Minimum and Maximum FOS is shown in the figure. We got minimum factor of safety as 2.3354 which is considerably good. Only a small portion of the stopper is under considerably more stress, while the other major portion of the stopper is with a very high factor of safety.

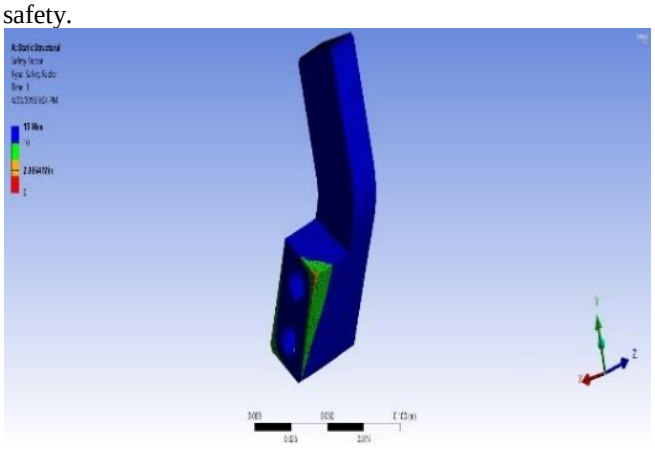

Fig.1: Analysis of stopper

*B. Analysis of mounting bracket*

Whole weight of engine will act on this bracket so analysis of this bracket becomes important. The engine weighs approximately 3000kg and the entire load is acting on the mounting bracket. The engine is bolted to the mounting plate using 5 bolts. The analysis is carried out to check whether the structure can sustain the weight and the forces exerted by the engine while tilting. As per the calculations a total force of 37,278 N was acting on the mounting plate. The red portion in the results indicate low factor of safety but is in safe zone and it can be seen that the minimum factor of safety is 1.4663 which is sufficient to prevent the failure of the structure.

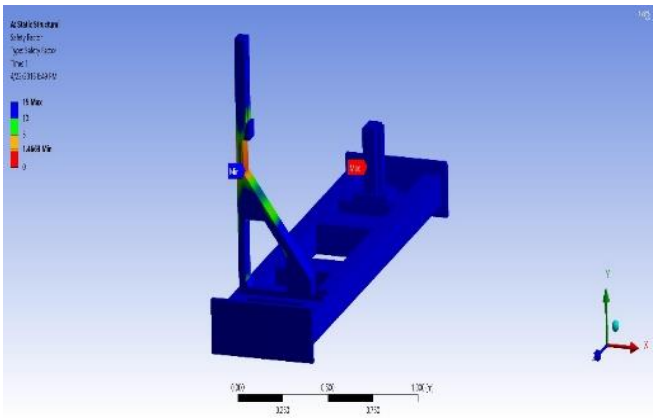

Fig. 2: Analysis of mounting bracket

*C. Analysis of base frame*

This is the structure on which the rings and the engine rests. The base frame is fixed on the shop floor. The rotation of the structure will induce some forces on the base frame, hence the analysis of the base frame is carried out. The factor of safety achieved is 8.4929 which is high and ensures safe working.

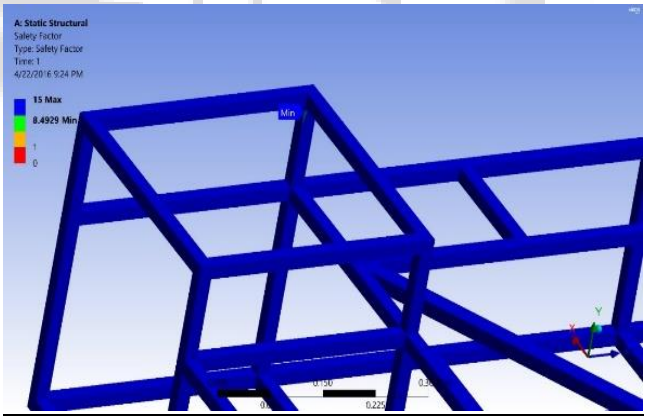


Fig. 3: Analysis of base frame

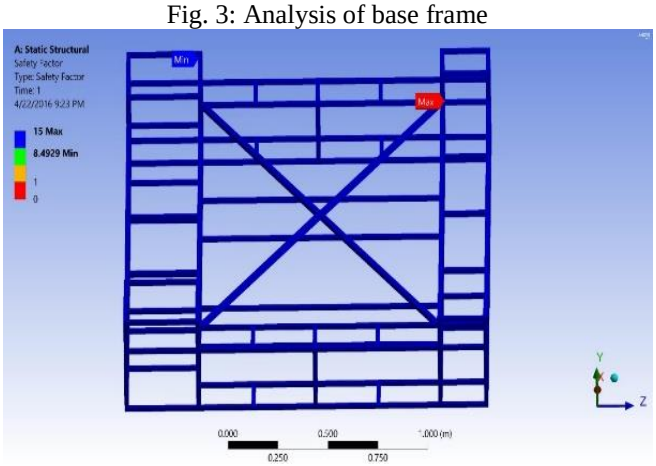


Fig. 4: Analysis of base frame

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## VI. CONCLUSION

Based on the new calculations done, it can be seen that the main aim of the project was accurately achieved by replacing the old method of turning the engine by new method considering ergonomics and safety. The workers had to work in unsafe conditions due to the old method. By replacing the old method by the turn over device almost all the risk factor has been removed. The risk of engine falling down due to the failure of the hoist and pulley mechanism while rotating the engine has been reduced to some extent. Injuries due to the same has also been tried to be avoided. Thus making safe working conditions for the workers. Considering ergonomics in the earlier process the workers had to work in unsuitable positions. The process was not taking place in their eye level making the worker look up, thus straining his neck. Assemblies which were earlier carried out in uncomfortable positions were now easily possible. This problem has also been solved by developing the turn over device. The time required for the entire operation has also been considerably reduced. Thus increasing the overall productivity.

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