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DESIGN AND MODELLING OF RAIL TRANSFER TROLLEY

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***Abstract*—Material Handling plays very important role in production process. Hence using correct material handling tool is very important. In this article we have designed Rail Transfer Trolley for carrying castings. Components of trolley are designed using analytical formulation and then components of trolley are modeled and assembled in SolidWorks2016 software referring calculated dimensions. Analysis of designed components is carried out in ANSYS 16. Trolley Assembly is meshed for further analysis work using Hypermesh14.0 software.**

Keywords—Rail Trolley, Design, Analysis,Mesh.

I. INTRODUCTION

In every industry material handling is a very important aspect. Material Handling supports actual manufacturing process and hence effective as well as efficient material handling systems are very essential. Large number of alternative are available for material handling process but it is required to choose appropriate system as per the industry environment, shop floor conditions and production requirement. Automated Guided Vehicles are one of the promising solutions for material handling. The level of automation depends upon cost of AGV, path that must be followed by AGV and working conditions[1-3].

This article focuses on the designing of Semi-automatic Transfer Trolley. The existing designs of trolleys are enormous due to the reality that they require to carry loads of different sizes. In the global competition, it is very essential for the manufacturer to develop new product designs to market at a more rapidly rate and also at cheaper cost. Trolley is the large base which is used to transfer the heavy parts from one place to another place. Transfer Trolley is used to transfer castings form moulding line to fettling shop. The main intention of the trolley is to provide a hassle-free mode of transporting from one loading station to other loading station. Required capacity of trolley is considered to be 3000KG. Article includes the designing of main components of trolley and CAD model of trolley drawn based upon the results of design calculations.

II. DESIGN OF TROLLEY

The basic design concept of trollies is very simple, it includes base plate for carrying the material, driving unit, wheels for movement and control unit. Here the designed trolley is semi-automatic and wheels used for trolley movement are rail wheels, which have more strength and less wear than castor wheels. Trolley is considered to be operated with wired remote, which controls its movement.

A. *Designof base plate*

Base plate of trolley provides the main base for carrying objects. Mild steel plates are considered for this application due to its material properties. Size of plate decides the size of trolley, which depends upon the castings to be carried on the trolley. Generalized dimensions of casting are 950×450×430 mm and weight of each casting considered is 150KG. Dimensions of plate are selected as 2500×1250mm, so that total weight on trolley will be 2500kg if it is assumed that castings are resting on trolley with face of dimension 430mm.

Now, to calculate thickness of plate that will be able to carry applied load on trolley, plate is assumed as simply supported beam at both ends. Plate subjected to UDL and point load are shown in fig. 1 and fig. 2 respectively. Applying theory of beam to plate,

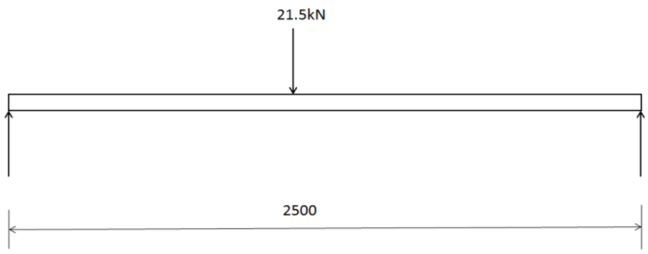


Fig 1: Load on plate considered as UDL

$$Y_c = \frac{5}{384}\frac{WL^3}{EI} \quad (1)$$

Where, Y_c = Permissible deflection in plate
W= Load on plate
L= length of beam
I= Moment of inertia

The permissible deflection in plate is considered 10mm. Depending uponequation (1) calculated thickness of plate is 7.30mm.

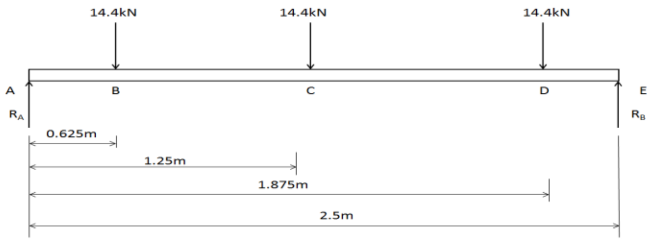


Fig 2: Considering load as point load

Applying theory of beam under point load to plate by assuming total load is acting on plate at 3 points; thickness obtained for plate is 9.3mm. Thus consider standard thickness of plate i.e. 10mm.

B. Rail Wheels

Design of rail wheel depends upon the dimensions of selected rail, load on wheel and required ground clearance. Width of wheel is determined by head width of rail. Selected rail is of designation 30KG/m for this application. For determining the diameter of steel rail wheels,

$$P_L \geq \frac{P_{smean}}{b \times D \times C_{1\,max} \times C_{2\,max}} \quad (2)$$

Where, P_L = Limiting pressure between wheel and rail
C_1 = Coefficient of RPM
C_2 = Coefficient of machine life
D = Diameter of wheel
$P_{s\,mean}$ = Maximum static load
b = usable width of rail

From above equation (2) by selecting proper material coefficients obtained diameter of wheel is 295mm.

C. Driving Shaft

Driving unit used to move the trolley is geared Servo motor of capacity 1.5kW with output speed of 22RPM. Chain and sprocket is used to transfer drive from motor shaft to trolley shaft. Approximate positions of components on the shaft are shown in fig. 3,

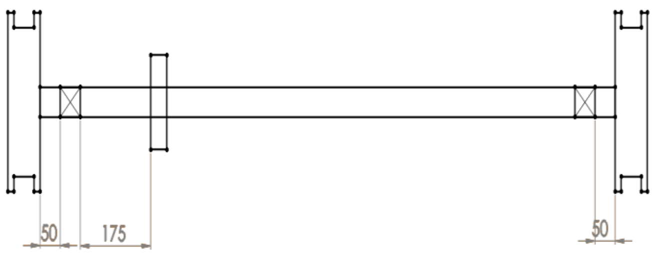
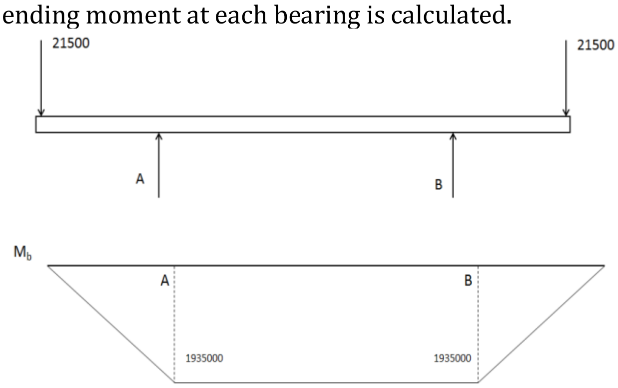


Fig 3: Shaft mounted with wheel, bearing and sprocket

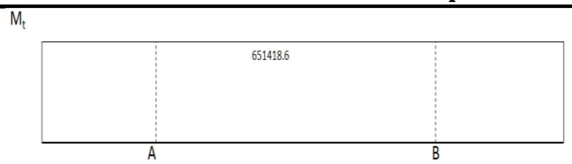
$$\text{Permissible Shear Stress, } \tau = \frac{S_{yt} \times 0.5}{F.O.S.} \quad (3)$$

$$\text{Torsional Moment, } M_t = \frac{60 \times 10^6\,(KW)}{2 \times \pi \times n} \quad (4)$$

Bending moment at each bearing is calculated.



(a)



(b)

Fig 4: (a) Bending moment diagram, (b) Torsional moment diagram

Design of shaft based on strength,

$$\tau_{max} = \frac{16}{\pi d^3}\sqrt{{M_b}^2 + {M_t}^2} \quad (5)$$

Depending upon equation (4) and (5) calculated diameter of shaft as 52.96mm. Selected shaft diameter is 60mm. Dimensions of key for shaft with diameter 58 and above are 16mm width and 10 mm height of key.

D. Bearing

Depending upon load type and magnitude of load acting, Deep groove ball bearing is most suitable for this purpose.

$$C = P \times (L_{10})^{0.33} \quad (6)$$

Where, P = Load on bearing
L_{10} = Revolutions of bearing in million

$$L_{10} = \frac{60 \times n \times L_{10\,h}}{10^6} \quad (7)$$

$L_{10\,h}$ = Expected hours life of bearing (30000 hours)
n= speed of rotation (RPM) = 22

$$L_{10} = \frac{60 \times 22 \times 30000}{10^6} = 39.6 \quad (8)$$

$$C = 15696 \times (39.6)^{0.33} = 53500N. \quad (9)$$

From the standard catalogue of bearing, best suitable bearing for 60mm diameter shaft and 53500N dynamic load capacity bearing with designation 6312.

E. Drive (Rear) Wheel Assembly

Drive wheels are mounted on shaft with help of keys. For holding the bearing in position bearing cap is designed and to restrict the movement of bearing in lateral direction projection on shaft are created. Projections on shaft must be of shorter height to reduce the stress concentration of shaft. This will reduce the probability of failure of shaft.

Bearing cap is used on rear side to hold bearing in position and it is connected to main frame using socket head bolts.

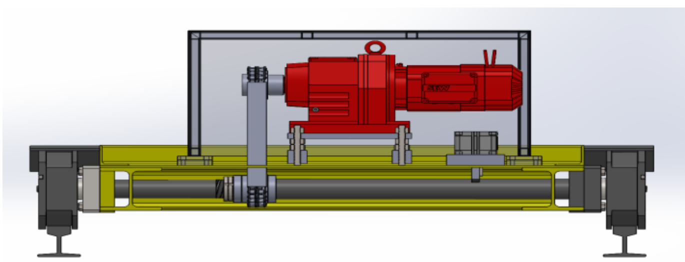


Fig 5: Drive wheel assembly

F. Driven Wheel Assembly

Front wheels are driven wheels, i.e. no independent drive provided. Hence, instead of single full length shaft, two short length shafts are provided for each wheel.

Rotation of wheel is kept independent about shaft. For this purpose bearing is place directly inside wheel.

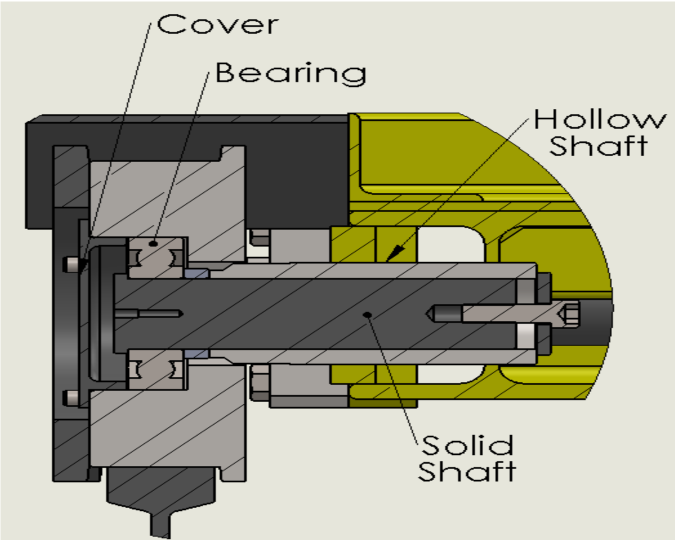


Fig 6: Section view of Driven Wheel assembly

Assembly of driven wheel is shown in fig 6. Solid shaft is fitted inside hollow shaft with interference fit. Projections on wheel and shaft are provided to restrict movement of bearing in linear direction.

To avoid entry of sand or metal dust between wheel and bearing, cover is provided to pack the wheel. This cover is attached to wheel using 3 socket head bolts. Bolt size is selected depending upon equation (10),

$$P_1 = P_2 = P_3 = \frac{P \times e \times r1}{(r1^2 + r2^2 + r3^2)} \qquad (10)$$

Where, P_1 = Forces on bolts
P = Total Load
e = Distance of load point from C.G.
r_n = Distance of n^{th} bolt from C.G.

Bolts selected for this application are M8×1.25. Size of Bolts which are subjected to high loads as well as used in critical position is determined using above equation.

G. Brakes for trolley and Electric Controls

Servo motor used for trolley is having in built braking mechanism. But for additional safety, pneumatic brakes are provided to trolley. Pneumatic valves have compact size and they eliminate requirement of power pack unlike hydraulic systems. Pneumatic cylinder is placed above shaft which is operated by 4×3 solenoid valve and 6 bar pressure.

Electric control panel is nothing but wired remote that operates trolley. It consists of forward backward trolley movement, braking controls and emergency stop switches.

III. Assembly of Trolley

Modeling of all components of trolley and assembly of trolley is done in SolidWorks 2016 software. Assembly of trolley is shown in Fig. 7,

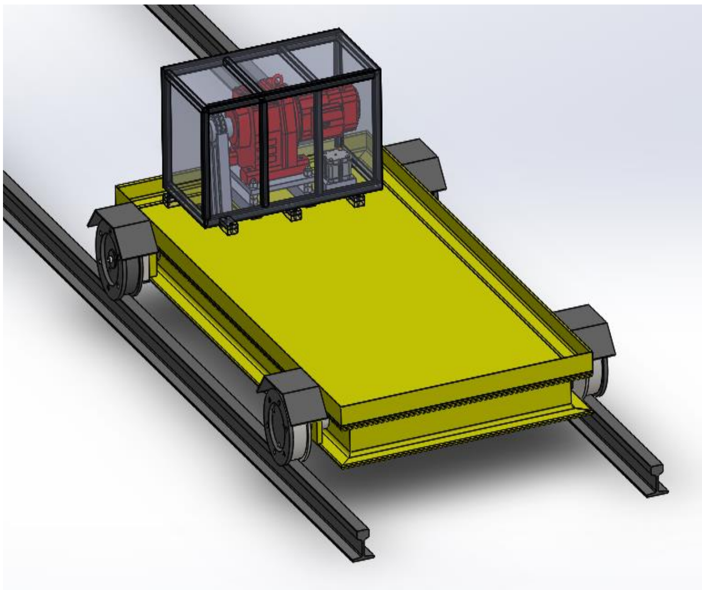


Fig 7: Trolley Assembly

IV. Analysis of Plate and Shaft

For carrying out analysis of designed components, geometrical models of components were imported in ANSYS software. And corresponding boundary conditions were applied[7].

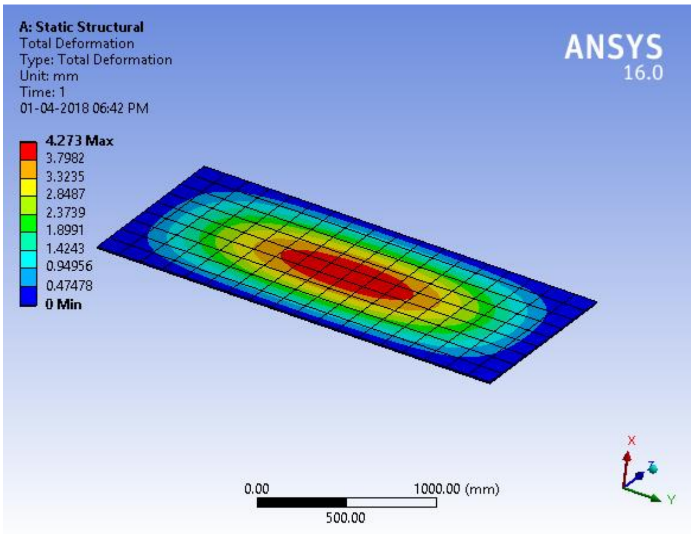


Fig 8: Analysis of Base Plate

Maximum and minimum deflection in steel plate is shown in Fig. 8, when plate is fixed form bottom at four edges and upper face of plate is subjected to force having magnitude equal to trolley capacity.

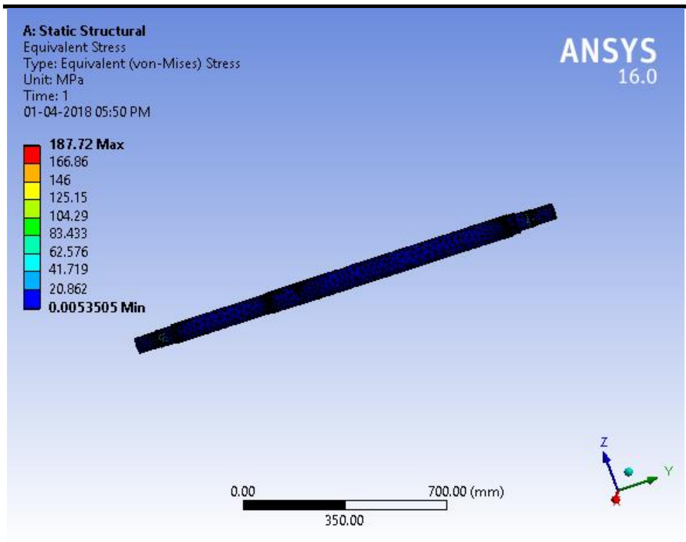


Fig 9: Analysis of Shaft

Fig 9 shows EN8 material shaft subjected to Max and Min stresses. Total load acting on shaft is divided into two components and they are considered to be acting at bearing locations. Also torsional moment is applied at sprocket location.

From analysis results of plate, it shows that max deflection in plate 4mm. As considered deflection in plate is 10mm for design purpose thus designed plate dimensions can sustain applied load. Similarly, there is no significant stress development in shaft; this shows shaft also can sustain the applied load.

V. Meshing of Trolley Assembly

To determine effect of load on trolley it is necessary to mesh the trolley assembly and analyze the results in analysis software. In this article we will focus on only meshing of trolley assembly.

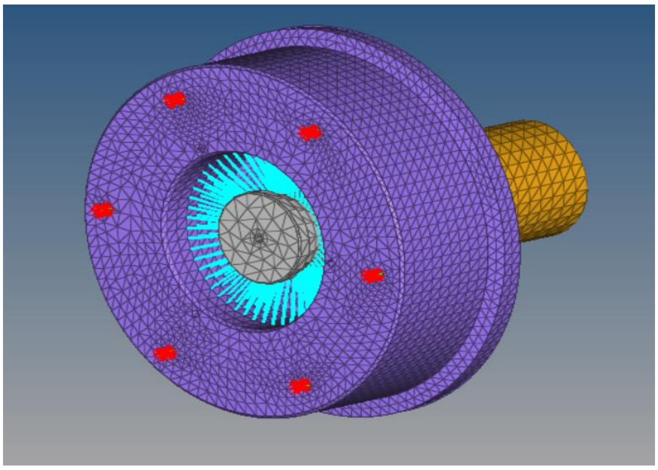


Fig 10: Meshed wheel

Trolley is meshed using 3D hex mesh. Fig 10 shows meshed driven wheel. Bearing inside the wheel is represented using 1D rigid element spider. Rotation of this element in corresponding direction is kept free and other degrees of freedom are restricted. Same technique is used for representing bolts but degrees of freedom for bolt elements are completely restricted[6].

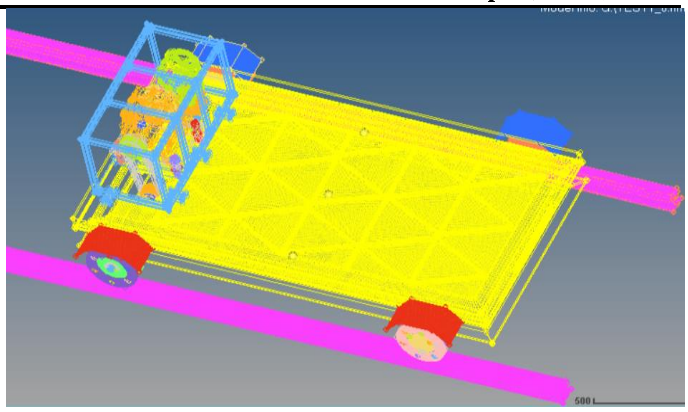


Fig 11: Meshed trolley assembly

Fig 11 shows meshed trolley assembly. For uniform load transfer between the trolley elements, node to node contact is created between the contacting faces of trolley. As finer the mesh more will be the accuracy of results but it will increase the computation time of results. Boundary conditions for trolley assembly re applied as per actual working conditions and separate material properties were applied to different materials.

VI. Conclusion

In this study, we calculated the dimensions of every important component of transfer trolley using analytical formulation. Fromanalysis results we can conclude that designed components are safe and can sustain the desired loading conditions.

Acknowledgment

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