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Optimization of Material Handling Trolley

[1]Adinath B. Tikone, [2]Dr. Galhe D.S, [3]Prof Said K.M.

[1]Mech. Design Engineer, [2],Dept. Mech. JCOE Kuran [3] Dept. Mech. JCOE Kuran
[1]ME Mechanical (Design Engineering),
[1]Jaihind College of Engineering Kuran, Pune, India.

Abstract : Every company's fundamental requirement is the transportation of automobile components within the plant, between industries, and from the manufacturing sector to OEMS industries. Fast delivery and fewer defective parts during transportation are important factors in inventory control, which in turn affects the industry's profitability. The components that were carried must either be kept for later use or employed in an assembly line. A vehicle that travels down the street on tracks is called a tram. The tram finds extensive use in a variety of settings, including homes, offices, railroads, airports, hospitals, resorts and the manufacturing and construction sectors. So, the target of this project is design, analysis the existing trolley & find out scope of optimization; as per scope optimize the trolley using FEA method.

***IndexTerms* - Design, Analysis, CAD Model, Meshing, Optimization.**

I. Introduction

Material handling trolley is more important in industry to handling the different parts, automotive components as per industry base applications. Some industry regularly uses different types of trolley which is regularly uses. Also for transport different components, supply to customers. Hence, regularly required to face problems also handling issues, heavy weight, manufacturing costs, storing purpose and all. So, this project is mostly focus on design and analysis of existing trolley, study on it, find out different scope for optimization, different solutions on facing problems.

Once we get different scopes and their factors problems solutions the as per methodology redesign the trolley with considering that factors and all. In that firstly making CAD Model on Solid Work software, with changing material, structural arrangement, easy to manufacture, cost reduction, easy to handling purpose and all. Then analyze on analysis software as per our load conditions. Design at safe mode and optimize our existing factor which is meet to our objectives. Hence this project is mostly useful to industry for how to optimize trolley. Hence this project is most helpful for future also.

II. Literature Reviews

[1]Lauren M. Smith et al. (2015) explains Driving Mode, each mechanism has two of its three individual wheels in contact with the ground, allowing it to roll quickly and efficiently over smooth surfaces, much like a wheeled robot would. The main drive shaft, which is situated at each mechanism's centroid, allows the Tri-Wheel wheels to passively pivot around the robot body because their orientation is not fixed.

In that, in order to resume driving, the top wheel takes over as the leading ground wheel. This is the expected behaviour in the event of a positive or negative hindrance. The Tri-Wheel will rotate in the direction of the motor output without any individual wheels spinning if it is lifted completely off the ground while operating in this mode and all reaction forces from the surrounding environment are eliminated. This is because the frictional forces in the gears effectively lock up the gear set, preventing power transmission to the wheels.

[2] Kyle A. Johnson et.al (2015) outlined Tumbling Mode, which offers a powered way to keep a robot moving when it encounters more unstable obstacles (stairs, rubble, loose terrain, etc.). When the Tri-Wheel assembly is in Tumbling Mode, a braking mechanism is activated to apply force to the gearing system, causing the three wheels to revolve around the centre axle and walk‖ over obstacles like a Whigs robot. To help the robot move forward, the tri-spoke rotation purposefully rotates in the same direction as each individual wheel.

Even though this article has some limitations in terms of the structure's strength and design, it can still be seen as a modest advancement in the field of stair climbing vehicles. It was determined during the project's test run that taking this design into consideration for moving big items up stairs wouldn't be a bad idea. If this product can be made into a product that meets the needs, it will be highly praised. Even though the project's starting cost appeared larger, more precise production would reduce this. Regarding the product's commercial aspects, it will be unthinkable to accept it if it can be produced more cheaply and with complete automation.

III. Objectives

To find out optimization scope of existing trolley by the study of stress, deflection as per load conditions. Using that scope of factors redesign new model of trolley and minimize overall weight of trolley, easy to manufacture of trolley, and reduce the cost of trolley, verifying on simulation software with safe design mode.

IV. METHODOLOGY

For this project we use following methods to optimize or meet to the objective and find out conclude results. Firstly understand the problem statements, Objectives, Finite Element Discretization of existing trolley using Hyper mesh Analysis of existing trolley, study the analysis result & Theoretical result. To find results for optimization. Then new design their static analysis result and discussion, if design safe, final design, end to find out stresses and deflection theoretically & Analysis base as per load condition & conclude it.

V. EXISTING CASE OF TROLLEY

Theoretical Consideration of trolley:

Material use for existing trolley IS4923, Structural Carbon Steel. There are different sizes are available in market with different thickness. For existing trolley used 3mm thickness having size 50 x 50 mm.
Design data:
55 parts in total are mounted to the trolley.
A 341 kg external mass load is applied to the trolley, calculated as 55 x 6.2.
The load of each component is divided into two locations, shown by round circular bars. Consequently, an external mass of 170.5 kg is applied to each bar. There are fifty-five pieces in all.

Fig. 1 Structure of Existing case of trolley

The trolley measures 2 M in length, 1.2 M in breadth, and 1.48 M in height. According to aspect ratio: When the height to length ratio is 0.74 and less than or equal to 1.5, it is considered appropriate. When the length is 1.5 to 2 times the width, a length to width ratio of 1.66 is appropriate. Therefore, the current tram structure is appropriate in terms of aspect ratio.
Take a look at a round, round hollow bar that has a 50 mm diameter and a 2.5 mm Thk.
Therefore, we must ascertain the load stress applied to the circular bar. Because there are two bars under load-carrying conditions, the load is divided between them.
Material is IS4923 Carbon Steel, with young's Modulus 2.1*e+5, Poisson's ratio 0.3 & yield strength 250.
To calculate the overall as each bar's 525mm length is specified.
Each component weighs 6.2 kg, with a total of 55 kg placed on the cart
. 55 x 6.2 = 341 kg of load, thus.
If we take FOS 1.5 into consideration,
341 x 9.81 = 3345.21 N;
on both bars, 3345.21 x 1.5 = 5017.8 N.
For single bar load is 2508.9 N.
Hence, total 2508.9N load separately for both bars.
Position A is fixed at one end by applying equilibrium criteria. UDL load is imposed, and other is free.

Σ Fy = 0
(↑+ve, ↓ -ve)
∴ RA =2508.9 = 0 ……….(a)
Calculation for Area, $A = \frac{\pi}{4}$ x $(D - d)^2$ …......(Using existing Diameter 50 mm for outer & 45 mm for inner).

∴ By calculating we get A = 19.63mm^2.
For calculate induced stress. Using force per unit area. F =2508.9 N & Area =19.63mm^2.
Hence, we get 127.8Mpa…….(b).
Using Maximum Distortion Energy theory.
When the component's cause of failure is investigated and the factor of safety is maintained within tight constraints, the distortion energy theory is applied.
Thus, this Acceptable stress value = Material yield stress (Syt).
for comparison with yield stress alone in the elastic zone.
Syt = 250 MPa
According to the conditions, the induced stress value must be smaller than the allowable stress value.

Hence,
127.8Mpa < 250 Mpa ……(c)
Hence from (c) we get design is safe mode, for maximum deflection

$$\delta = \frac{WL^3}{8EI}$$

First find out Moment of Inertia,

$$I = \frac{\pi}{64}(D^4 - d^4)$$

$$I = 105207.1mm^4$$

Using deflection formula we get 2.1mm deflection……(d).

Linear Static Analysis for existing case:

At present, the dimensions of the trolley are 2.0*1.2*1.48 M (LBH), which were established using standard dimensions and considerations that were directly acquired from the vendor.
Meshing is done using hyper mesh. Size 5 components are used in the meshing of this model. There are 242806 modes and 243243 elements in the current model. The quality of the elements is evaluated and kept within reasonable bounds.

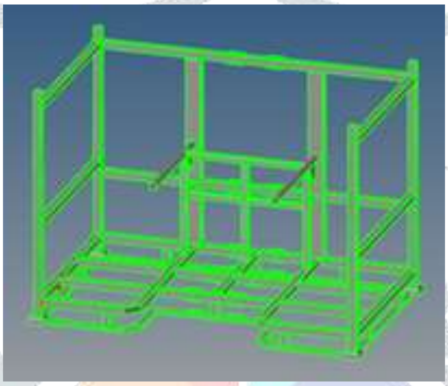

Fig.2 Existing trolley meshed

If some components can be accurately portrayed by 3D elements, then Tria or Hex mesh can also be used. Fig 2 Shows that meshed model of existing material handling trolley.
Since the load is distributed over the upper side, the load acting on the trolley is calculated to be 5017.8N acting downward on both circular hollow tubes. Stability is maintained in the structure.

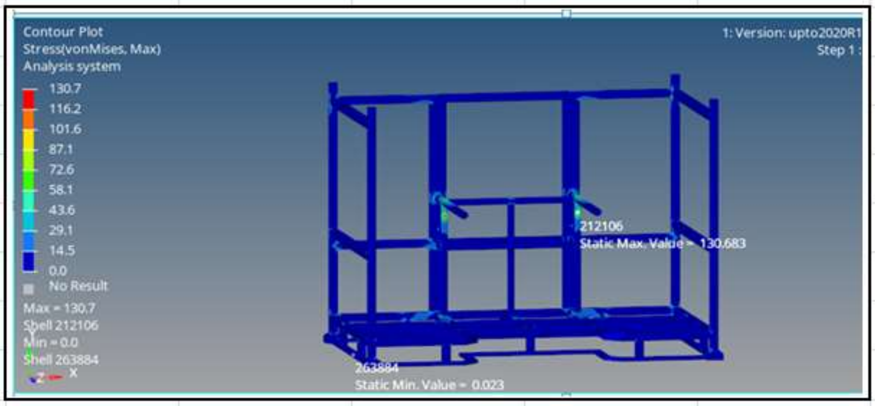

Fig. 3 Existing trolley Stress Distribution

The stress distribution on the current trolley is displayed in Fig. 3 using Ansys software. Static maximum stress readings here reach 130.7 MPa at the hollow tube connections that are round.

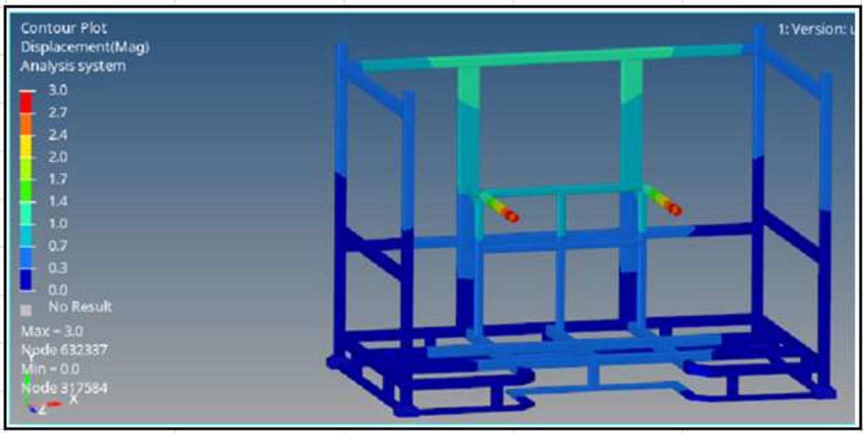

Fig. 3 Existing trolley Displacement

It has been noted that the hollow tube on the current trolley deforms when the imposed loading criteria is met, as illustrated in Figure 3. There is a 3mm maximum displacement.

To compare the trolley's current analysis and theoretical findings. Based on our findings, the following can be said about our primary goal: Determine which elements or aspects of the new redesign trolley we need to take into account in order to satisfy our optimisation criteria based on the outcomes of previous research. Because of the safer design, there is greater scope. In order to accomplish our goal and adjust the Thk, material, and Design Structure for the new design model.

VI. New Case of Trolley

Theoretical Consideration of new trolley:

Material uses for new trolley IS4923, Structural Carbon Steel same as per existing case. For new trolley used 2 mm thickness having size 50 x 50 mm.

The trolley's structure can be changed so that the thickness is reduced from 3 mm to 2 mm while maintaining a 250 Mpa yield strength and a 0.3 Poisson's ratio.

Design data:

55 parts in total are mounted to the trolley.

A 341 kg external mass load is applied to the trolley, calculated as 55 x 6.2.

Consequently, an external mass of 170.5 kg is applied to each bar. There are fifty-five pieces in all.

Fig. 4 New Structure of trolley

To calculate the overall as each bar's 525mm length is specified. Each component weighs 6.2 kg, with a total of 55 kg placed on the cart

55 x 6.2 = 341 kg of load, thus.

If we take FOS 1.5 into consideration, 341 x 9.81 = 3345.21 N;

on both bars, 3345.21 x 1.5 = 5017.8 N.

For single bar load is 2508.9 N.

Hence, total 2508.9N load separately for both bars.

Position A is fixed at one end by applying equilibrium criteria. UDL load is imposed, and other is free.

Σ Fy = 0

(↑+ve, ↓ -ve)

∴ RA =2508.9 = 0 ……….(e)

Calculation for Area, $A = \frac{\pi}{4} \times (D - d)^2$ ……..(Using existing Diameter 50 mm for outer & 46 mm for inner).

∴ By calculating we get A = $12.5mm^2$.
For calculate induced stress. Using force per unit area. F =2508.9 N & Area =$12.5mm^2$.
Hence, we get 200.8Mpa…….(f).
Using Maximum Distortion Energy theory.
When the component's cause of failure is investigated and the factor of safety is maintained within tight constraints, the distortion energy theory is applied.
Thus, this Acceptable stress value = Material yield stress (Syt).
for comparison with yield stress alone in the elastic zone.
Syt = 250 MPa
According to the conditions, the induced stress value must be smaller than the allowable stress value.
Hence,
200.8Mpa < 250 Mpa ……(g)
Hence from (c) we get design is safe mode, for maximum deflection

$$\delta = \frac{WL^3}{8EI}$$

First find out Moment of Inertia,

$$I = \frac{\pi}{64}(D^4 - d^4)$$

$$I = 81008.55mm^4$$

Using deflection formula we get 2.9mm deflection……(h).

Linear Static Analysis for new case:

The model's meshing is done using hyper mesh as a preprocessor. This model is meshed with elements of size 5. The current model has 221397 total elements and 219203 modes. Elements are inspected and maintained within tolerance.

Fig 5 New case of trolley Stress distribution

The Ansys software's Fig.5 depicts the stress distribution on the new trolley. Static maximum stress readings here reach 205.8 MPa at the joints of the round hollow tubes.

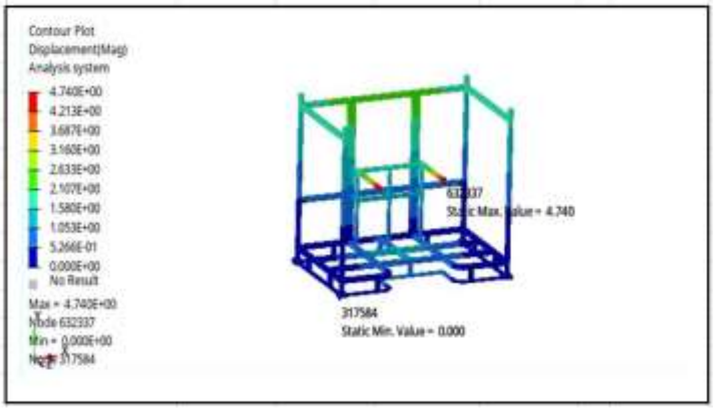

Fig. 6 New trolley Displacement.

Deformation is evident under the applied loading situation, as Figure 6 illustrates. On an existing trolley, the hollow tube can move up to 4.7 mm.

VII. RESULTS AND DISCUSSION

Following our methodology, we looked into the performance of the current material handling trolley first. Next, ascertain the new trolley's theoretical stress and deflection in relation to the load we want. Subsequently, research was done on the new trolley's meshing utilising hyper mesh software. examined the boundary conditions, useable material, and loading conditions. the new model's static structural study using Ansys software.

Table 6.1: Result of Existing & New Case

	Existing case		**New Case**	
	Theoretical	**Analytical**	**Theoretical**	**Analytical**
Stress (MPa)	**127.8**	**130.7**	**200.8**	**205.8**
Deflection (mm)	**2.1**	**3**	**2.9**	**4.7**
Weight (kg)	**175.4**		**128**	
Weight reduction (Kg)	**Existing**		**47.6**	

As a result, form table II displays the both results for the new trolley. The analytical result is a maximum stress of 205.8 Mpa, whereas the theoretical result is 201 Mpa. As a result, the outcomes of both methods roughly match. The design is in safe mode as well.

The new trolley's theoretical maximum deflection is 3 mm, while the analytical deflection is 4.7 mm. These are the maximum deflections for observation purposes. Therefore, we conclude that it also roughly corresponds. Additionally, a weight decrease of 47.6 kg is displayed in comparison to the current trolley.

In terms of price assessment, one trolley cost INR 18,000 since the current design from the vendor. Now that the factory team has approved this design, it will be produced internally, which will reduce the trolley's cost. Therefore, we only need to bring the material; the company has all other necessary supplies, like welders, welding equipment, and welding material.

As a result, square hollow pipe 125 kg having cost 8125 INR, MS electrodes 1000 & Labor cost 800 with other cost 1000 INR we get total near about 11000 INR. the price is lower than that of the current trolley, which costs close to INR 11000. The cost of a single trolley quantity is lowered by up to 40%. & The organisation needs 4 to 5 quantity every month, or close to 50 quantity annually. The current use will profit from this design, and it also offers an extra benefit based on the needs of multiple trollies.

References

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[2] Kyle A. Johnson, and D. J. Tidke, Parts Handling Systems for Machine Shops of Small and Medium Enterprises, International Journal of Engineering Research and General Science, 1(2), 2013, ISSN 2091-2730.

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