Abstract - The product Trolley (Product used to place load were the lifting of load is manual & Push /pull of vehicle with/without load is manual) is one of the top selling product in industry which was mainly due to its economy and its wide range of handling loads which is used in various industries for hauling purpose. The company’s major revenue comes from selling the product. In order to increase the sales, and to meet customer demands & satisfactions and cope up with the competitors, the management has decided to improvise existing product design with respect to various parameters like Commissioning, Failures, Costing & life of product.

To be more competitive in the market a survey with the existing customers of the company was done. The survey results showed that customers were looking for trolley with steerable mechanism, as the current trolley design requires lots of human skills / energy to push/pull load while turning, which makes the hauling process more difficult and consumes more time. Also during the process there will be wear and tear of wheels and failures of its sub parts like Pins, bearings, fasteners which leads to breakdown of trolley and need immediate maintenance else it would impact day to day manufacturing activities.

To satisfy this benchmark, we use Design for Assembly perspectives for the development of a manual steerable mechanism.

1. INTRODUCTION

Trolley is a product which is characterized under MHE which is used to haul and place miscellaneous loads; where the lift function is manual while translational movement is manual. It is very useful in assembly section where there will be frequent movement of component from one place to another. It is useful for working in all environments and ergonomically designed for enhanced productivity and safety. The pallets, containers, Rolls and many other conveyable loads are generally transported within shop floor and warehouse by Trolley.

1.1 LITERATURE SURVEY.

Most well-known manufacturers of Material Handling Equipment’s (MHE’s) have a product called “Trolley”; A Product used to pick and place miscellaneous loads; where the lifting of load is automatic and the Push /Pull of vehicle with/without loads is manual; this product is one of the top selling products in its line of industry. That was mainly due to its economic and wide range coverage for handling loads which are used for various industries/ stacking purpose. The Material Handling manufacturing company’s major revenue comes from selling this product. The management has decided to improvise the product design with respect to various parameters like commissioning, failures, costing, reliability, maintainability, assembly, manufacturing, and life of product.

The Canadian Standards Association (CSA) standard is B335-04 (R2012) “Safety standard for forklift trucks” includes the development and implementation of a lift truck safety program, operator training requirements, qualifications of the lift truck trainer (including medical and fitness requirements), maintenance and repair practices, etc.

2 DESIGN OF STEERING MECHANISM SYSTEM

2.1 Flow Chart of Methodology

In order to accomplish the set of objectives outlined above, a process flow chart shown in the figure 2.1 was formulated. This chart gives a broad view of the methods involved in modeling & simulation conducted to study the Tray design.
Chart 1.1: Project Methodology

The load condition and boundary conditions are applied in to the finite element model and finally validate the FEA model or structure.

2.2 Actual Design of steering system.

Fig.2.1 Actual Design of steering

Fig.2.2 Assembly view

Fig.2.3 Actual design detailed sectional view

2.3 Re Design of steering system.

Fig.2.4 Re Design of steering

Fig.2.5 Re design detailed sectional view
2.4 Costing details of Actual Design.

<table>
<thead>
<tr>
<th>Description</th>
<th>Weight Kg</th>
<th>Costing in Rs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Plate</td>
<td>10.3</td>
<td>631</td>
</tr>
<tr>
<td>Pivot pin assy.</td>
<td>5.26</td>
<td>590.6</td>
</tr>
<tr>
<td>RH Wheel assy.</td>
<td>7.76</td>
<td>508</td>
</tr>
<tr>
<td>LH Wheel assy.</td>
<td>8.16</td>
<td>651</td>
</tr>
<tr>
<td>Top plate assy.</td>
<td>0.74</td>
<td>91.08</td>
</tr>
<tr>
<td>Wheel set</td>
<td></td>
<td>291</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>32.22</strong></td>
<td><strong>2471</strong></td>
</tr>
</tbody>
</table>

18% factory overheads **2916**

Table.2.1 Costing details of Actual Design.

2.5 Costing details of Re Design.

<table>
<thead>
<tr>
<th>Description</th>
<th>Weight Kg</th>
<th>Costing in Rs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Plate</td>
<td>5.2</td>
<td>315.5</td>
</tr>
<tr>
<td>Pivot pin assy.</td>
<td>4.58</td>
<td>527.7</td>
</tr>
<tr>
<td>RH Wheel assy.</td>
<td>8.99</td>
<td>510.88</td>
</tr>
<tr>
<td>LH Wheel assy.</td>
<td>9.19</td>
<td>654</td>
</tr>
<tr>
<td>Top plate assy.</td>
<td>2.11</td>
<td>250.26</td>
</tr>
<tr>
<td>Wheel set</td>
<td></td>
<td>283</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30.07</strong></td>
<td><strong>2258</strong></td>
</tr>
</tbody>
</table>

18% factory overheads **2664**

Table.2.2 Costing details of Re Design.

2.6 Costing comparison

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Costing in Rs</th>
<th>% savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Actual Design</td>
<td>2664</td>
<td>9.5</td>
</tr>
<tr>
<td>2</td>
<td>Re Design</td>
<td>2916</td>
<td></td>
</tr>
</tbody>
</table>

Table.2.2 Cost comparison

2.7 Material properties.

2.8 Design for Assembly.

Design for Assembly is method of analyzing components and sub-assemblies in order to optimize the assembly process steps and estimate the assembly cost. It is a tool which helps designers in the design of products which intern reduces productions cost, focusing on number of parts handling and eases assembly process.

- Parts count minimized.
- Follow Modular design approach.
- Standard component/parts usage
- Multi-functional parts to be designed.
- Multi use parts to be designed.
- Design parts for ease of fabrication.
- Separate fasteners should be avoided.
- Assembly directions should be minimized.
- Maximize compliance.
- Minimize handling.

2.9 Handle set assembly.

In the actual assembly the bearing bush is mounted to the load plate by 4 hexagonal bolts, washer & nuts.

This assembly is re designed by reducing 4 free holes in load plate to 3 tapped holes & Hexagonal

Material Grade: IS2062 Specification of Structural Steel for Fabrication

Chart 2.1: Cost comparison

Figure 2.6: Pivot pin assy.
a) Actual design b) Re design

2.7 Material properties.
bolt is replaced with Counter sunk bolt. Hence the washer & nut is avoided. Over all 20 components were reduced to components. The assembly time was reduced by 35.29%.

2.10 Comparison of number of assembly components

<table>
<thead>
<tr>
<th>SL. No.</th>
<th>Description</th>
<th>Actual Nos.</th>
<th>Re Design Nos.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Load plate</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>RH wheel assy.</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>LH wheel assy.</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>Pivot pin assy.</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Total assy.</strong></td>
<td><strong>62</strong></td>
<td><strong>45</strong></td>
</tr>
</tbody>
</table>

Table 2.3 Costing details of Re Design.

2.11 Assembly time comparison

<table>
<thead>
<tr>
<th>SL. No.</th>
<th>Description</th>
<th>Assembling time in sec.</th>
<th>Actual</th>
<th>Re design</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Load Plate</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Pivot pin assy.</td>
<td>68</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>RH Wheel assy.</td>
<td>53</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>LH Wheel assy.</td>
<td>53</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Total assy.</strong></td>
<td><strong>164</strong></td>
<td><strong>106</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 2.4 Assembly time comparison

3 TECHNICAL CALCULATIONS.

3.1 Load on wheels.

pay load capacity

\[ W = 3000 \text{ kg} \]

Self weight of equipment

\[ W = 600 \text{ kg} \]

Load distance center

\[ L = 1475 \text{ cm} \]

Distance from vehical COG of steering wheel

\[ L = 635 \text{ mm} \]

Distance from pay load to steering wheel

\[ L = 840 \text{ mm} \]

Factor of safety

\[ F = 2 \]

\[ RA = \frac{W \times a}{L} \]

\[ RB = \frac{W \times b}{L} \]

\[ W = RA + RB \]

i) Load on wheel due to self weight

\[ R_{A1} = 635 \text{ mm} \]

\[ R_{B1} = 840 \text{ mm} \]
Ra₁ = \frac{600 \times 840}{1475} = 341.69\, kg

ii) Load on wheel due to pay load.

Ra₂ = \frac{3000 \times 675}{1475} = 1372.88\, kg

2.9 Combined load acting on rear wheel.

iii) Combined load acting on rear wheel

RA = Ra₁ + Ra₂ = 341.69 + 1372.88

= 1714.58\, kg

iv) Load acting on steering wheel

W = \frac{RA}{2} = \frac{1714.58}{2}

= 857.29\, kg

Design load on steering wheel

= Load acting on steering wheel \times FOS

= 857.28 \times 2

= 1714.58\, kg = 17145.8\, N

3.2 Combined Center of Gravity.

\[ RA = \frac{w \times b}{L} \]

1714.6 = \frac{3600 \times b}{1475}

b = 702.5\, mm

a = 772.5\, mm

a = L – b; 1475 – 702.5

a = 772.5\, mm

3.3 Pulling force.

Pulling / Pushing Force
FH = Fv \times u
\mu = \text{Friction b/w wheel and road.}
\mu = 0.35
FH = 12600\text{N}

Shear stress [Single Shear]

Pin with diameter = \phi 30\text{mm}
Fv = \text{Vertical force}
The pin is under single shear
FH = \text{Horizontal force}

\tau = \frac{F}{A}
\tau = \frac{12600 \text{N}}{706.95 \text{mm}^2}
\tau = 17.82 \text{MPa}

4 FEA RESULTS

Fig.4.1. Vonmises stress for pulling force

Fig.4.2. Vonmises stress and Deflection plot of RH wheel

Fig.4.3. Vonmises stress and Deflection plot of LH wheel

5 CONCLUSION AND FUTURE SCOPE

The application of concept of DFA inserted in a Concurrent Engineering collaborative context for the development of a new steering system for the SES manufacturers focused in low-cost, high manufacturability, long-term reliability and resistance to severe working duty.

The development of Re design of steering system substantially improves working condition in an engineering environment, the development will be faster when teams work together and continuously. The results can be represented faster with increases in control level, rightfulness & investment application with Design for assembly as a methodology of work.

The concept of Re Design and the usage of concept of Design for assembly improved the communication between the operational, planning, quality & design become better which improvises the transfers of information from the Product engineering to the Industrial engineering which improved the manufacturing section. Overall this communication improved lead time.

The rework was avoided, good economy was achieved and the parts was designed more than one time and the final components was manufactured once which saved money in building the prototypes, testing and lead time.

The parts which were designed for production line had fewer parts and there were speeds up in assembly line with reduced fasteners, pre-assembled features, self-positioning parts. The casted parts in the place of weldment assembly made the design more robust and produced the productive teams.

REFERENCES


Prof. Rajan Suri University of Wisconsin 1995

Applied G. Lewis and H. Connelly

[6] Product Design for Manufacture and Assembly,
Geoffrey Boothroyd, Peter Dewhurst, Winston
Knight, 2nd Edition, Marcel Dekker, New York

Tien-Chien chang, Richard A Wysk, and Hsu-Pin

Design and Material Handling. 3rd. Ed. Upper Saddle:
Prentice Hall.

[9] Rehg, James A. & Kraebber, Henry W.

Computerized Automation in US Manufacturing, J