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# Design and Static Stress Analysis of Returnable Pallet for Steel Wheel

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***Abstract*— This article discusses a detailed study of design & static stress analysis of pallet used in returnable packaging scheme. The primary application of pallet is in shipping and storing of various heavy and large sized products. It also helps in supplying the finished products from manufacturer to the customers without being damaged. While CAD modeling with hollow rectangular cross section tubes of pallet is done in CATIA software, pallet is analyzed statically using Hyperworks.**

**The analysis is carried out to determine the induced stresses and deflections at various locations on pallet.**

***Index Terms*— returnable pallet, static analysis.**

## I. INTRODUCTION

The pallet is used for transportation and storage system. Conventionally pallets are made of wood. however the Pallets can also be made of recyclable plastics, metals and composite materials. The pallet is available commercially in the various designs. From 1940s the pallet were used for material handling purpose in the industries, but pallet have relatively old background from last 100 years. Nearly 400 million pallets are made annually across the world. The pallets serve to provide greater protection to the finished products and try to reduce the damage of the product. So returnable pallet is replacing the conventional wood pallet, the ratio of usage of returnable pallets to that of wooden pallets is as high as 15 times. This is beneficial for the industry in reducing the transportation cost and helps in environment protection, as wood replaced by metals

## II. LITERATURE SURVEY

Qinhong Zhang, Anders Segerstedt,et al.[1] have studied on a returnable packaging management in automotive parts logistics in dedicated mode and shared mode. In their study, for dedicated mode- every parts supplier uses his own packaging; while in shared mode, packages can be shared among the suppliers. For each mode, the total cost consisting of transportation cost and inventory holding cost is calculated and is proved that the total cost, including the transportation cost and the inventory holding cost are smaller under the shared mode.

Anna Strutt, James A, Turneret al.[2] have studied the impacts of an international phytosanitary standard for wood packaging material Global and United States trade implications. . In his study the Wood packaging material (WPM) may be a vital pathway by that bark- and wood-boring insects move between countries. Recognizing this threat, a world commonplace for Phytosanitary Measures No. fifteen (ISPM 15) the treatment of rate is being enforced by several countries. They additionally estimate the economic impacts of 1 of the advantages of ISPM 15; averted us forest owner timber losses. ISPM fifteen is probably going to possess a tiny low, negative result on exports and economic welfare for many countries. These results should be tempered with the extra edges of ISPM fifteen in terms of potential averted family and environmental damages

E. Soury, A.H. Behravesh al. [3] has studied the application of an innovative method of optimization for the design of an I-shape profile used in a wood–plastic composite (WPC) pallet. The pallet was made via assembling three WPC extruded profiles manufactured in the extrusion process. The middle profile was considered to be I-shaped, a design which known to have a high load bearing capability.

Sumit Manohar Yadav, Dr. Lamal Bin Yusoh et al.[4] has studied Mechanical and Physical properties of wood-plastic composites made of polypropylene, wood flour And nanoclay. The focus of this study was to characterize mechanical and physical properties of experimental composition prepared from nanoclays (Cloisite 20A), wood flour and polypropylene.

## III. PROBLEM STATEMENT

There are various material handling systems. Transportation of finished products & storage of materials is one of them. Mostly wood, plastic and metals are used for manufacturing pallets. The wooden pallets are cheaper but they have less lifecycle than others. For the purpose of lifting these pallets forklift is used at certain loading condition. If the forklift lifts the overloaded wooden pallet then there is a possibility of finished products getting damaged. So the aim is to replace the wooden pallet design by a metallic pallet for steel wheel which can sustain the load. A company Kalyani Maxion Wheels Ltd. faced a problem of wheel damaging during transportation. From the study of statistical data, approximately 20- 25% of wheels are damaged from one container during transportation and company was paying the cost for repairing of wheels.

## IV. MATERIAL SURVEY

In an industry the pallets are manufactured by the wood, plastic and metal materials. The wooden material is used for pallet design from many years due to few desirable properties of wood, this includes strength, durability, functionality and market cost also it will be easily prototype. Another material used is Polyvinyl chloride (PVC) due to reasons of cleanliness, durable, germ free, weather resistance. PVC pallet is manufacturing by structural foam molding. Its cost is

3-6 times the cost of wood[5]. Metals can also be used in pallet manufacturing, the metal pallets are manufactured at less than 1% from other material. The advantages offered by metal material are strength, stiffness, durability, bug free, clean, and recyclable. From the parameters of metals are mostly used for designing & manufacturing purpose are as follows:-

Table 1. Material Properties at various factors

| Properties | Wood | Polymer | Metal |
|---|---|---|---|
| Load Carrying Capacity | Poor | Good | Excellent |
| Design Flexibility | Good | Poor | Excellent |
| Fire | Poor | Good | Excellent |
| Climate | Good | Good | Excellent |
| Cost | Excellent | Good | Good |

Materials for metal pallet manufacturing consist of stainless steel, carbon steel and aluminum. Steel has various characteristics, among them Mild Steel is better for pallet manufacturing. Because,

- The cost is less than other steels.
- Easily available.
- High durability.
- Tubes of any cross section are readily available.
- Easy to weld.

Considering above factors, mild steel having grade C40 is preferred for pallet design. The properties of the same are listed in table 2.

Table 2. Material Properties of M.S. C40

| Sr. No. | Material Properties | Values |
|---|---|---|
| 1. | Density | 7.8e-9Tonne/ mm3 |
| 2. | Young's Modulus (E) | 2.1e-5 MPa |
| 3. | Ultimate Tensile Strength | 441 MPa |
| 4. | Yield Tensile Strength | 320 MPa |
| 5. | Poisson's Ratio | 0.29 |

## V. DESIGN OF PALLET FOR STEEL WHEEL

The Pallet frame required to support various components has been designed by predictable design procedure. The weights of the components mounted on the frame were considered as loads for designing. According to the wheel specification concept model is generated for designing the pallet for wheel.

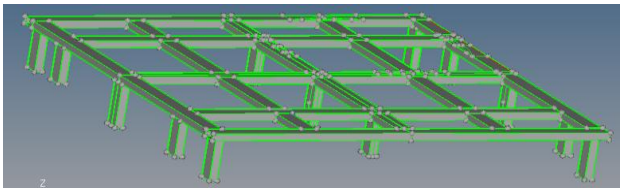

Fig.1 Concept Model

Design Considerations for pallet for Twelve wheels.

Length of the Pallet = 1215mm
Width of the Pallet = 1215 mm
Height of Pallet = 170 mm

Pallet frame is made by structural assembly. It contains various dimensions and cross sections of beams. By considering the weight, availability in market, ease of manufacturing and also for welding process the selection of hallow rectangular cross section is carried done.

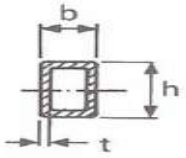


Fig.2 Hollow Rectangular Cross section

By using various dimensions of cross section, the method of trial error and formula using from strength of material the following hollow rectangular cross section is selected for a pallet. [6]

$$\frac{M}{I} = \frac{\sigma}{y}$$

Factor of safety = 3

$$\sigma = (M*y)/I$$

$$\sigma_{all} = (\sigma*3)$$

Selection of plastic clips:-

By the using of plastic clips metal to metal contact of wheel is prevented. It will be placed between two wheels. Each wheel is supported by 4 clips.

Selection Of The Pallet Legs:-

The legs of the pallet will be subjected to the buckling load. We will consider a rectangular hollow cross-section of the beam.

The formula for calculating critical buckling load is,[7]

$$P_{cr} = \frac{n\pi^2 EI}{L^2}$$

cross section of tube= 50x25x2 mm

critical buckling load is, $P_{cr}$ = 1428.22 KN

Total load on one leg = 0.86 KN

## VI. MODELING

As per standard hollow rectangular cross section selection of it depends on critical and actual buckling load for stability of pallet structure. Using all these inputs the modeling of structural pallet is done.

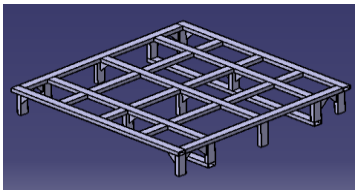

Fig.3. Pallet Assembly CAD Model

## VII. STATIC STRESS ANALYSIS

After completing the modeling of the pallet for packaging of wheels the static analysis is done. The overall packaging scheme analysis is carried out on HYPERWORK 13.0. For static analysis[8] input static load is 7800 N. The material used for pallet is M.S. So the properties are used for the static analysis are as follows:-

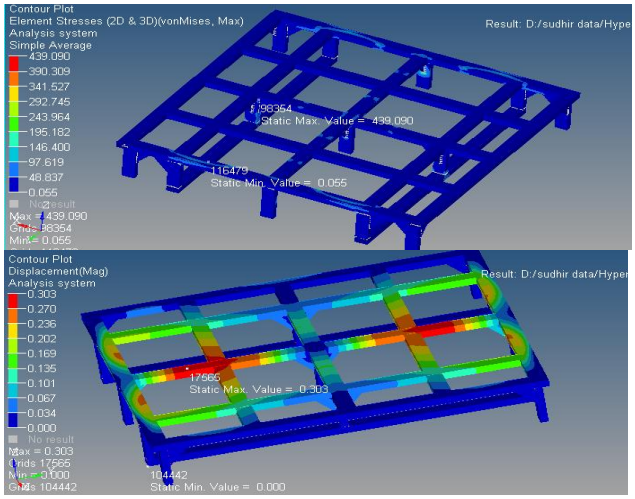


Fig.4. Stress Distribution on Pallet Assembly

Table 4. Equivalent Stresses in Pallet

| Stress | Part Name | Value |
|---|---|---|
| Maximum Stress | Resting tube | 339 MPa |
| Minimum Stress | Ground tube | 0.055 MPa |

Yield stress is 441 MPa of a material used for the pallet and maximum stress is less than yield stress so it implies that design of pallet is safe. Maximum total deformation at the resting rectangular tube is 0.055 mm which is negligible.

## VII. RESULTS

above results pallet is safe under buckling load because the critical load is greater than the actual load on one pallet. That means the model is under the safe condition.

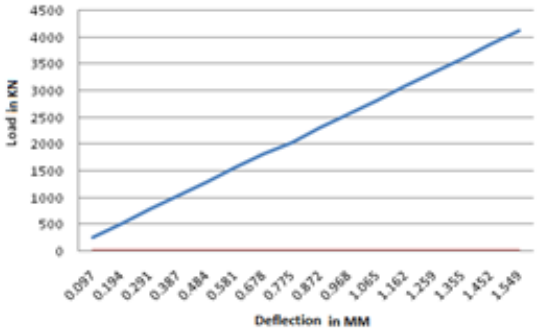


Fig.5 Deflection at various loading condition

## VIII. CONCLUSION

The work developed an illustration of pallet for twelve wheels in this design, modeling, analysis for giving operating condition. The stress, factor of safety and deflection lie within permissible limits of yield for the given loading conditions. By performing Finite Element Analysis and it is detected that Mild Steel have minimum deflection than others. So conclusion is that this type of pallet is safer for the transportation and storage of wheels.

## IX. REFERENCES

[1] Qinhong Zhang, Anders Segerstedt,et al., "Returnable packaging management in automotive parts logistics: Dedicated mode and shared mode ", Int. J.Production Economics168(2015)234–244.

[2] Anna Strutt, James A. Turner,et al., " Evaluating the impacts of an international phytosanitary standard for wood packaging material: Global and United States trade implications", Journal of Forest Policy and Economics 27 (2013) 54–64.

[3] E. Soury, A.H. Behravesh al., " Design, optimization and manufacturing of wood–plastic composite pallet " Materials and Design 30 (2009) 4183–4191

[4] Sumit Manohar Yadav, Dr Kamal Bin Yusohet al., " Mechanical And Physical Properties Of Wood-plastic Composites Made Of Polypropylene, Wood Flour And Nanoclay",Journal of Proceeding - Kuala Lumpur International Agriculture, Forestry and Plantation 12-13 (2015), ISBN 978-967-11350-7-5 .

[5] A. Emblem, London College of Fashion, UK," Plastics properties for packaging materials", Chapter 13 287-309(2012).

[6] Ramamrutham S. (2004), Strength of Materials, 14th edition, Dhanpat Rai Publishing Company.

[7] Shigley E.(2006), Mechanical Engineering Design, Tenth Edition,MC Graw Hill.

[8] http://www.ista.org/forms/Pallet testing guide lines_101-Clarke_2004.pdf

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