International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 07 | July 2018 www.irjet.net p-ISSN: 2395-0072

Weight reduction of Standard Steel Pallet by using Corrugated sheet instead of CRCA sheet & Evaluating its Strength through Finite Element Analysis

Chinmay D Kodape[1], Prof. Kushal S. Wasankar[2]

[1]PG Student, Mechanical Engineering Department, Government College of Engineering, Aurangabad (M.S.), India.
[2]Assistant Professor, Mechanical Engineering Department, Government College of Engineering, Aurangabad (M.S.), India.

Abstract - *Steel Pallets are widely used for Material handling in high volume production industries. The main objective of this experiment is to optimize the design of a Standard Steel Pallet to predict the Alternate material. The study investigates the effect of design parameters influencing the strength of the pallet and their interactions. This helped in choosing the design parameters for two identical pallets manufactured from two different materials loaded with the same load. Finite Element Analysis (FEA) approach is used in order to achieve the intended objectives. This technique is proposed for reduction in the necessary experimental cost and effort in addition to getting a higher level of verification. It can be stated that the Finite Element Analysis approach provide a good contribution towards the optimization of Steel pallets.*

Key Words: Finite Element Analysis (FEA); Design optimization; Standard Steel Pallet; Material Handling

1.INTRODUCTION

What is Finite Element Analysis (FEA) concept?

FEA is an engineering computational analysis methodology that helps to determine the strength of a product (part or assembly) in response to loading that might typically be experienced in its operating environment. It can also help determine why parts have failed.

FEA simulates the behavior of a real component or assembly with an idealized mathematical model (or finite element model) representation including the physical conditions (loads and boundary conditions) in which it operates. The finite element model is then analyzed by a finite element analysis solver, which calculates results data that reflect the design behavior to the applied boundary conditions, and can help to identify weaknesses or potential failures in the design [1].

1.1 Why FEA

We perform analysis for:

• deformations and internal forces/stresses

• temperatures and heat transfer in solids fluid flows (or without heat transfer)

• conjugate heat transfer (between solids and fluids) etc...

Analysis means probing into, modeling, simulating nature. Therefore, analysis gives us insight into the world we live and this Enriches Our life. [2]

An effective design is one that:

• performs the required task efficiently

• is inexpensive in materials used is safe under extreme operatinis operating conditions [2]

The importance of Simulation in Design process is shown in the fig 1 [1].

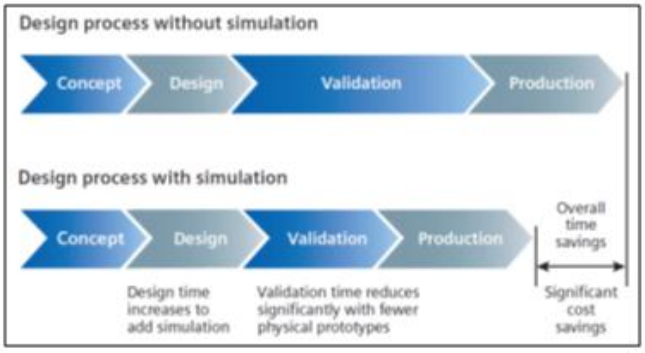


Fig 1: Speeding up time-to-market by using virtual testing instead of physical prototypes for design validation

Today, FEA fits in both the design engineer's and engineering analyst's process. Early in the design process, FEA plays an important role in promoting innovation through the ability to digitally experiment

with the design. In order to do this, the simulation functionality must be presented in an environment that is familiar to the design engineer, that of the CAD system itself which is possible with an embedded FEA solution.

Besides ease of use, other aspects help to bring FEA closer to CAD including model associativity that allows the design's analytical properties, such as geometry topology, material properties, loads and boundary conditions inherent in the CAD model, to also carry over to the finite element analysis model.

Therefore, any changes made to the CAD model will carry through and update the analysis model automatically. [1]

2. LITERATURE REVIEW

2.1 A Case Study of FEA in Packaging Industry

With reducing the dimension deformation occurred in finite element analysis result is very small that is within permissible results. Nilesh V. Kalyankar& Sachin G. Mahakalkar concludes that there are maximum stress found on the actual box with respect to product dimension by using FEM and found from compressor tester machine[3].

2.2 A Case Study of FEA in Transportation of Goods

Manoj P. Talele and Ashok J. Keche has selected the welded joints concept, since it has more advantage in terms of structural stability, load carrying capacity and very reliable in export shipment. They also shown good stability in road and sea transportation. On the other hand, Bolted joint concept is not been selected mainly due to higher stress level and it is more prone for fastener loosening at the time of actual shipment[4].

2.3 A Case Study of FEA in Structural Engineering

By using four examples of steel cladding systems, innovative hollow flange beams, plaster board lined cold-formed steel stud walls and an innovative cold-formed steel building system, M. Mahendran has demonstrated the significant benefits of using finite element tools and advanced computing facilities in obtaining safe and optimum building solutions without the need for expensive and time consuming laboratory testing. It has demonstrated how the use of finite element tools has not only allowed the introduction of innovative and efficient building products, but also the development of accurate design methods for use by engineers, manufacturers and designers in the building[5].

2.4 A Case Study of FEA in Medical Industry

Ashish B. Deoghare & P.M.Padole showed that a physical model enables correct identification of the abnormalities, accurate understanding of the anatomical structure, it also helps in implant design of body organs. A precise model facilitates the pre-operative planning of an optimal surgical approach and enables selection of correct and appropriate implants. The developed software facilitates to evaluate the stress analysis by implementing FEM technique for the developed 3D solid model[6].

2.5 LITERATURE GAP ANALYSIS

By studying all the above case studies, In the Case Study (2.2) for Transportation of Goods, the focus is only on type of joints used for manufacturing the pallet. Further research can be done in this area on type of material, type of design.

These different options can be evaluated virtually with help of Finite Element Analysis. Therefore, the research topic is decided as "Weight Reduction of Standard Steel Pallet by using Corrugated sheet instead of CR sheet & Evaluating through Finite Element Analysis".

2.6 OBJECTIVES

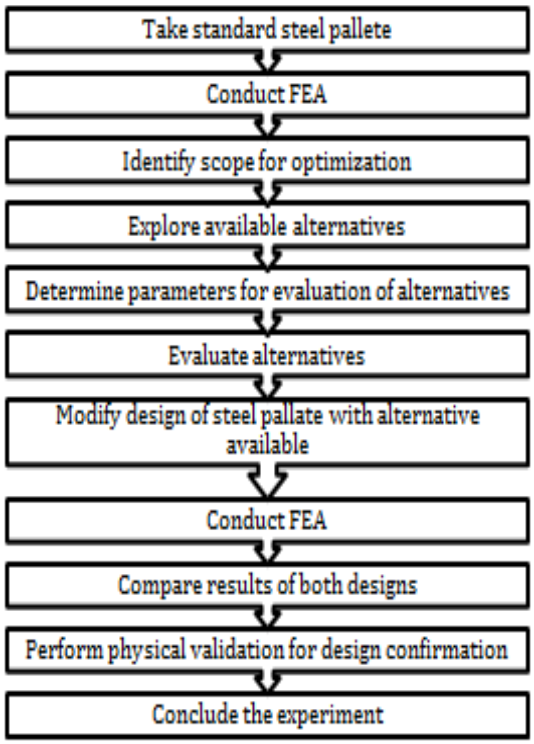
With reference to the above Literature Gap Analysis, the firm Objectives of the experiment are as per below:-

1. To reduce the weight of Standard Steel Pallet using Corrugated sheet instead of CR sheet.

2. To Evaluate the Strength of this pallet through Finite Element Analysis.

3. EXPERIMENTAL SET UP

For conducting experiment following methodology is adopted:-



Flowchart 1: Experiment Methodology

2.1 Existing Standard Steel Pallet:

Standard Steel (HSLA) pallet of dimension 1140 (L) X 1140 (W) X 100 (H) (mm) with CRCA sheet 1140 (L) X 1140 (W) X 1.6 mm thick is considered for optimization. The same is shown in the fig 2.

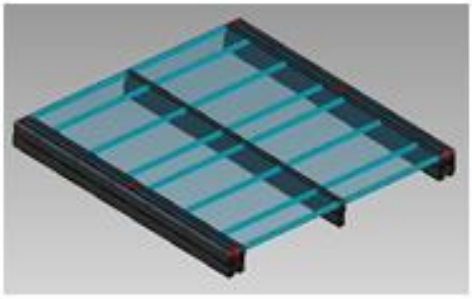
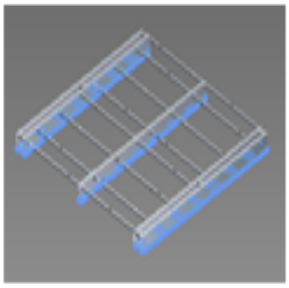


Fig 2: Standard Steel Pallet

2.2 FEA report of Standard Steel Pallet:

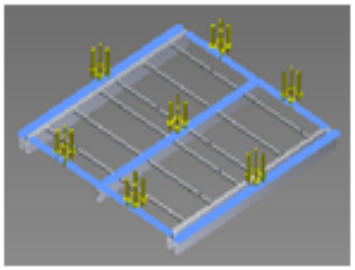
2.2.1 Drawing & BOM of pallet:



DET NO	DESCRIPTION	MATERIAL	SIZE	LENGTH	QTY
4	RECT TUBE	HSLA 340	25X25X1X25 MM	25	8
3	SHEET CRCA	CRCA	1142X1142X1.6 MM THK	-	1
2	SQUARE TUBE	HSLA 340	12.7X12.7X0.8X402.5	402.5	16
1	RECT TUBE	HSLA 340	40 x 25 x 1.00 THK	1140	8

Fig 3: Drawing with BOM of Standard Steel Pallet

2.2.2 Static Analysis:



Parameter	Value
Load	0.008 MPa
Yield Strength	207 MPa
Material	Steel (HSLA) & CRCA sheet

Fig 4: Loading condition & Input parameters

The load applied during FEA is a Uniformly Distributed load. The loading constraints & input parameters are shown in fig 4.

2.2.3 Result

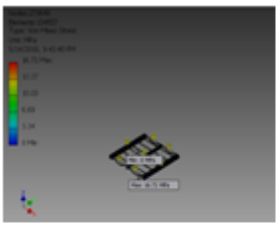


Fig 5: Von Mises Stress

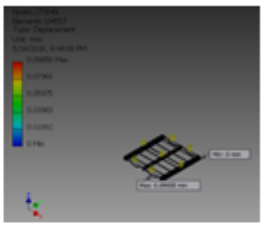


Fig 6: Z Displacement

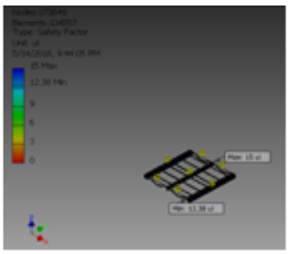


Fig 7: Safety factor

SN	Parameter	Value
1	Load applied for FEA (MPa)	0.008
2	Von Mises Stresses Induced (MPa)	16.72
3	Allowable Value - Yield Strength of Steel (MPa)	207
4	Displmnt in "z" direction	0.090
5	Allowable limit	0 -5 mm
6	Safety factor (ul)	12.38
7	Result	Design is Safe

The result of the FEA of Standard steel pallet is tabulated in Table 1. As the displacement (0.09 mm) is within the allowable limit (0 to 5 mm), the design is safe wrt the average loading conditions (1000 to 1200 Kg) (e.g., For handling of Cargo load, load for Automobiles for exports, for different kinds of loads for storage in shopping malls, etc.)

2.3 Scope for Optimization

From Table 1: Result of FEA of Std. Steel pallet red Std. Steel pallet is made of HSLA steel tubes & CRCA sheet. The steel tubes are acting as a load carrying members in the pallet design, hence they have to be maintained as it is for retaining the strength of the pallet . However, there is a scope for optimization in CRCA sheet, as they are only distributing the load to the tubes.

2.4 Explore & Evaluate available Alternatives

SN	Design Criteria	Wood	Corrugated	PP	Thermocol
					
1	Recyclable	√	√	√	X
2	Biodegradable	√	√	X	X
3	Depletion of Natural Resources	√	10%	√	√
4	Sustain different weather conditions	√	√	√	√
5	Feasible for multiple handling	√	√	X	X

Table 2: Evaluation of Alternatives

Based on the scope for optimization, we have identified the available alternatives & decided the parameters for evaluation of the same. The study is tabulated in table 2. It can be seen that after evaluating the available alternatives against the decided parameters; the "Corrugated sheet" meets all the requirements & hence it is selected as an alternative to CRCA sheet in the design of Steel pallet.

2.5 Design modification with Alternate material:

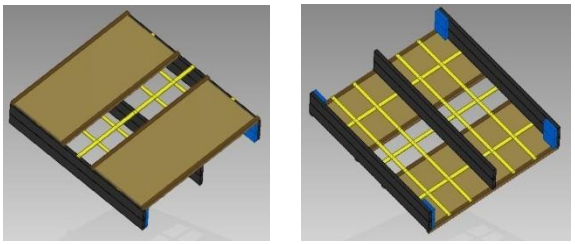


Fig 8: Modified Steel Pallet

As shown in the fig 8, the steel sheet is replaced by Corrugated sheet in the pallet. The "U" shaped bracket is made with the help of Press Brake tool for holding the corrugated sheet to the pallet. This bracket is welded to the pallet, as shown in the image. The MS strips provided from the bottom of the pallet for support & load distribution purpose, as shown in the fig 8.

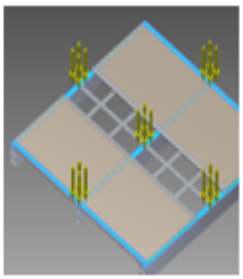
2.6 FEA report for Modified Steel Pallet:

2.6.1 Drawing & BOM of pallet:

5	SHEET 2	CORRUGATED SHEET WATER REPELANT	440 X 1140 X 5 PLY	440	2
4	STRIP HR	HRPO	25 X 1140 X 1.6 MM THK	1140	7
3	BOX HR	HRPO	62 X 1130 X 1.6 MM THK	1130	4
2	RECT TUBE	HSLA 340	40 x 25 x 1.00 THK	100	8
1	RECT TUBE	HSLA 340	40 x 25 x 1.00 THK	1140	8
DET NO	DESCRIPTION	MATERIAL	SIZE	LENGTH	QTY

Fig 9: Drawing with BOM of Modified Steel Pallet

2.6.2 Static Analysis:



Parameter	Value
Load	0.008 MPa
Yield Strength	207 MPa
Material	Steel (HSLA) & Corrugated sheet

Fig 10: Loading condition & Input parameters

2.6.3 Result

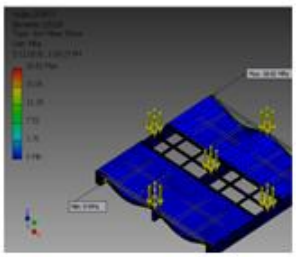


Fig 11: Von Mises Stress

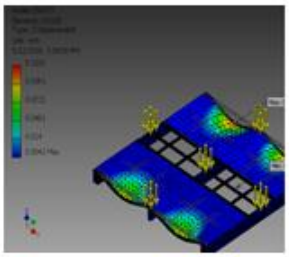


Fig 12: Z Displacement

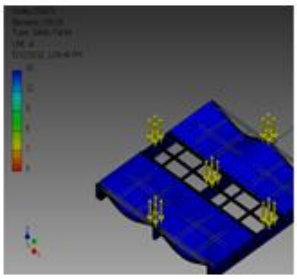


Fig 13: Safety factor

SN	Parameter	Value
1	Load applied for FEA (MPa)	0.008
2	Von Mises Stresses Induced (MPa)	18.82
3	Allowable Value - Yield Strength of Steel (MPa)	207
4	Displmnt in "z" direction	0.120
5	Allowable limit	0 -5 mm
6	Safety factor (ul)	15
7	Result	Design is Safe

Table 3: Result of FEA of Modified Steel pallet

The result of the FEA of Modified steel pallet is tabulated in Table 3. As the displacement (0.12 mm) is within the allowable limit (0 to 5 mm), the design is safe wrt the average loading conditions (1000 to 1200 Kg).

2.7 Physical Confirmation

To confirm the FEA done for both the pallets, we have kept the load on both the pallets & measured the displacement with dial gauge. The readings of the diaTable 3: Result of FEA of Modified Steel palletment values obtained in FEA. The result of the Physical confirmation test are tabulated in table 4.

The actual samples made are shown in fig 14 & 15.

Parameter	Standard Pallet	Modified Pallet
Load (Kg)	1000	1000
"Z" displacement in FEA(mm)	0.090	0.120
Actual displacement on dial gauge (mm)	0.095	0.150

Table 4: Result of Physical Confirmation test

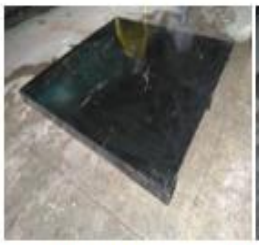


Fig 1 Std. Steel Pallet (Actual sample)

Fig 15: Modified Steel Pallet (Actual sample)

Fig 16: Dial gauge set to "0" before loading the Std. Steel pallet

Fig 17: Dial gauge reading after loading the Std. Steel pallet

Fig 18: Dial gauge set to "0" before loading the

Fig 19: Dial gauge reading after loading the

The images of dial gauge readings for Physical confirmation of Std. Steel Pallet are shown in fig 16 & 17 & of Mod. Steel pallet are shown in fig 18 & 19 respectively.

From table 4, it can be observed that there is a difference in the Z displacement value for Standard & Modified Steel pallet. For Std. pallet it is 0.090 mm; whereas for Mod. pallet it is 0.120 mm. This shows that though the Z displacement value is in the allowable limit, still the Mod. pallet will be deflect more by 0.03mm than the Std. pallet; which is very negligible difference.

Also there is difference in the Z displacement values obtained in FEA report & in actual on dial gauge. This difference is due to the exact application of loading while performing the confirmation test. The type of UDL applied while performing FEA will not be exactly similar while performing the Physical confirmation test; hence there will the difference in both the readings.

2.8 Costing & Weight Saving details

The costing & weight details of the Standard & Modified steel pallet are tabulated in table 5;

Type of Design	Estimated Cost (Rs.)	Weight of Pallet (Kg)
Std. Steel Pallet	1620	30
Modified Steel Pallet	1446	17
Saving	174 / pallet	13
	11%	43 %

Table 5: Costing & Weight saving details of Std. & Modified pallets

The difference in the cost & the weight are linked to the Bill of material required for fabricating both the pallets. The CRCA sheet is replaced by Corrugated sheet & there is change in the dimensions & Qty of Rectangular & Square tubes of Steel in the bottom structure, which are mentioned in detail in BOM in fig 3 & fig 9 for Std. & Mod. Steel pallets respectively.

3. Conclusions

The present work has successfully demonstrated the Optimization of Standard steel pallet by replacing CRCA sheet by Corrugated sheet & the retaining of its strength as confirmed by FEA report & physical confirmation tests.

The important conclusions drawn from the present work are summarized as follows:

1. From table 5, it can be observed that the cost of the pallet is reduced by Rs. 174 / pallet & weight of the pallet is reduced by 13 Kg / pallet.

2. This concept of optimization can be horizontally deployed in all other areas where these kinds of pallets are used for Material Handling.

3. Further, as a future scope, more Eco Friendly material can be identified as an alternative of Corrugated sheets & the desired strength can be checked with FEA.

4. Finite Element Analysis has contributed to a great extent in predicting the strength of the pallet with use of alternate material without taking the actual trials of the same.

5. The objective of Optimization of this experiment is achieved with 11% saving in cost / pallet & 43% saving in weight / pallet.

4. References

[1] 9487_tcm1023-57321_FEA for all Engineers_A white paper issued by: Siemens PLM Software.

[2] http://ocw.mit.edu/terms_ 2.092 / 2.093 Finite Element Analysis of Solids and Fluids I Fall 2009

[3] www.ijraset.com Volume 3 Issue IV, April 2015 IC Value: 13.98 ISSN: 2321-9653

[4] International Journal of u- and e- Service, Science and Technology Vol.8, No.5 (2015), pp.219 230http://dx.doi.org/10.14257/ijunesst.2015.8.5.20

[5]http://eprints.qut.edu.auMahendran,Mahen(2007)Applications of finite element analysis in structural engineering. In Siva Prasad, N. and Sekar, A.S. and Krishnapillai ,S., Eds. Proceedings International Conference on Computer Aided Engineering, pages pp. 38 -46, Chennai, India.

[6] 13th National Conference on Mechanism and Machines (NaCoMM 07), IISc, Bangalore ,India, December 12-13, 2007