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Effective Design Optimizations for Strengthening the sheet metals used in tipper

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Abstract : The reliability and durability of the tipper trucks for heavy-duty and three-wheeler operations depend heavily on the strength of the sheet metal utilized in tipper trucks. The sheet metal in tipper trucks must withstand heavy mechanical strains like impact, bending, and load-bearing forces. The performance and strength of sheet metal are greatly influenced by the material selection, thickness, and fabrication methods. To assess the structural integrity of the sheet metal, engineering study, including finite element analysis (FEA) and stress simulations, is crucial. By doing so, it is possible to spot potential weak spots and improve the design's strength and load-bearing capabilities. With slight design modifications, sheet metal's strength can be increased. This work details numerous design modifications that can be employed for boosting.

***Keywords*- Stress distribution, deformation, reinforcement, Corrugation**

I. Introduction

Using the finite element approach, the stress and deformation of a three-axle tipper semitrailer structure. Low-alloy steel with improved strength is frequently used to create frames. The goal of the study was to determine how crossbar position affected stress and deformation under various load conditions. The first axle member's cushion-stringer region showed the highest level of stress. Since low-alloy steel with increased strength is frequently used to make frames, a compromise between lowering deformation and stress must be reached [1]. A tipper chassis strength is assessed under both static and dynamic load scenarios. Different loading scenarios were used for the analysis, including static loading and dynamic loading brought on by driving through uneven terrain. [2]. employing DEM-FEM coupling, load intensity estimates on a tipper body. The process involves fusing simulations of the structural reaction using the finite element method (FEM) and discrete element method (DEM) [3]. The coating of steel with polymer with the goal of providing good corrosion resistance is still being developed. Salt spray testing was done to measure the corrosion resistance of the material, and the results were satisfactory. This aspect can be used to coat the inner portion of tippers with polymer material to increase corrosion resistance [4]. It was discovered that by using LASER surface treatment to enhance the mechanical properties of the material, specifically CRCA Steel, the tensile strength of the material had increased by about 25–30% and by 20%, respectively. As a result, it is imperative to cover CRCA Steel with some sort of coating [5]. Using a typical tipper truck to unload loose material in mines or construction sites presents various difficulties. To increase efficiency and safety, material is loaded onto the tipper's three sides using a multi-side tilting mechanism. Three hydraulic cylinders and a unique EN8-material hinge joint are features of the design. the drawbacks of tipper truck unidirectional unloading [6] and suggests a design improvement [7] , Thus a very less amount of work is done for the strength enhancement of sheet metals. Hence this work presents the strength enhancing design optimizations methods.

2. OBJECTIVES OF THE WORK

The objectives of the present work are:

1. Enhancing the deformation resistance of the sheet metal by modifying the design.
2. Suggesting the best design optimization for better stress resistance by the simulation results of ANSYS.

3. METHODOLOGY

Steps followed to perform the work are as follows:

- Designing the Sheet metal in NX CAD
- Material selection
- Importing the design model in ANSYS

- Mesh quality checks
- Defining the boundary conditions
- Solving for the results

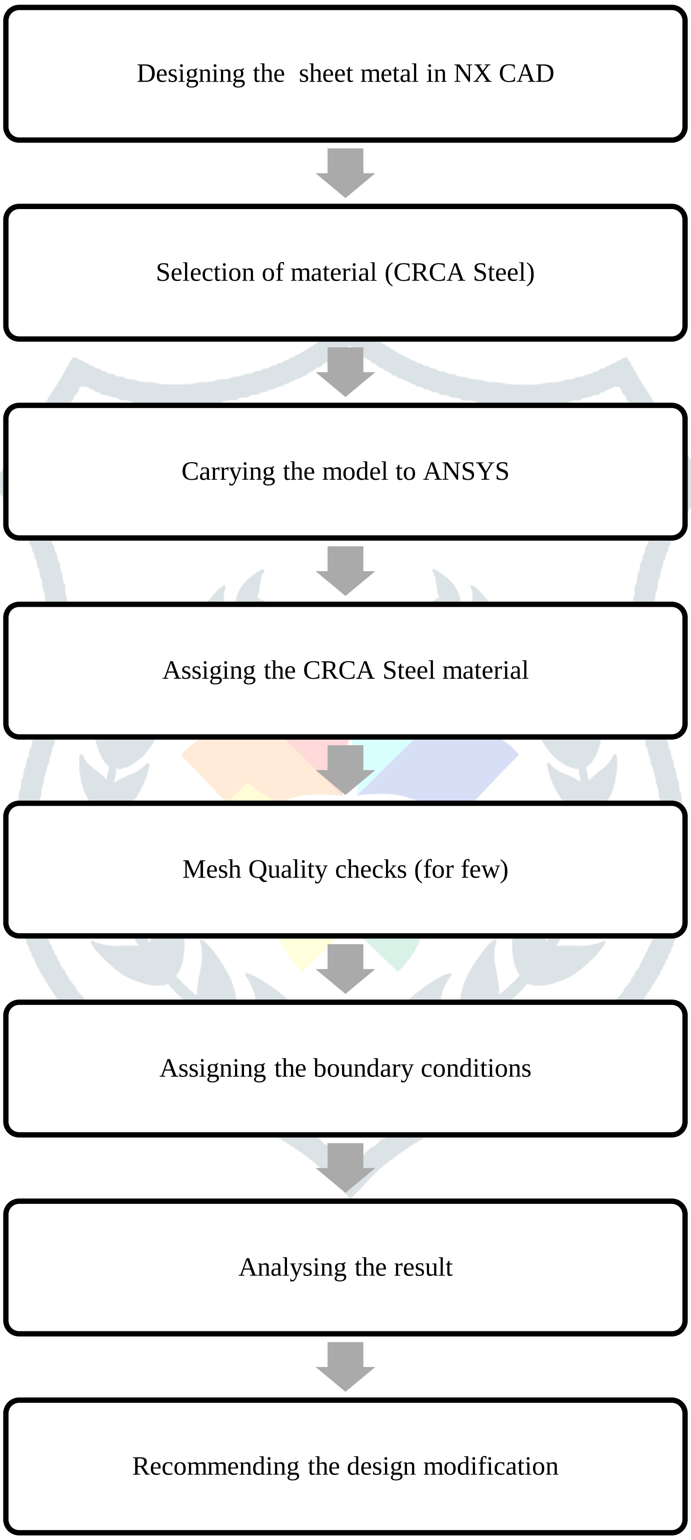
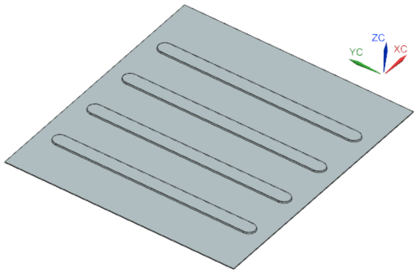
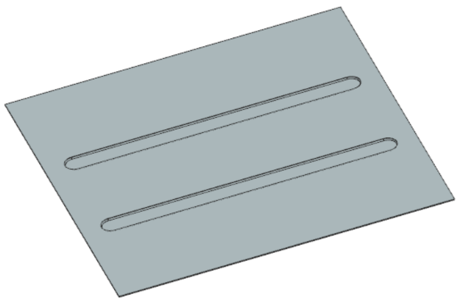
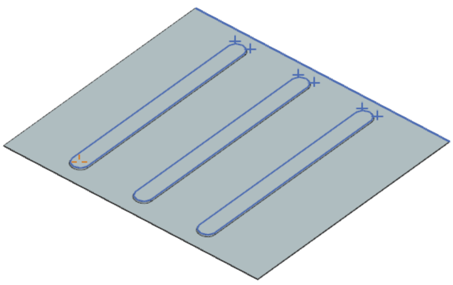
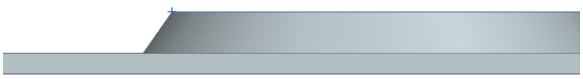


Fig 3.1 Flow chart of steps carried out to perform this work

3.1 MODELLING

Table 3.1 NX CAD models of different corrugated sheet

Parameter	*Dimension of corrugation*	*Number of corrugation*
 *fig 3.1 Corrugated sheet with 4 Corrugations*	Sheet dimension is common 500 X 500 X 1.5 30 mm corrugation 15 mm fillet	4
 *fig 3.2 Corrugated sheet with 3 Corrugations*	30 mm corrugation 15 mm fillet	2
 *fig 3.3 Corrugated sheet with 2 Corrugations*	30 mm wide corrugation 15 mm fillet	3
 *fig 3.4 Corrugated sheet with 21^0 Draft angle Corrugation*	30 mm wide corrugation 21 degrees the corrugation.	3
 *fig 3.5 Corrugated sheet with 35^0 Draft angle Corrugation*	30 mm wide corrugation 35^0 draft-angle for the corrugation.	3

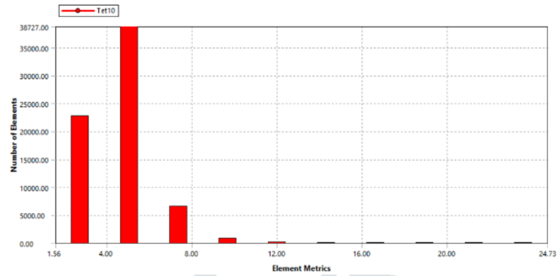
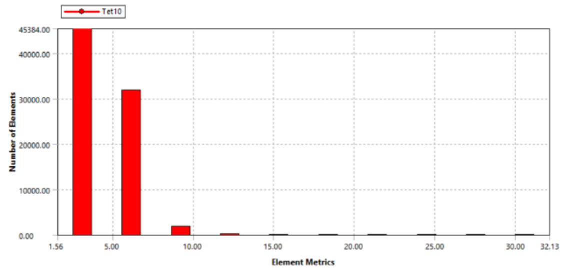
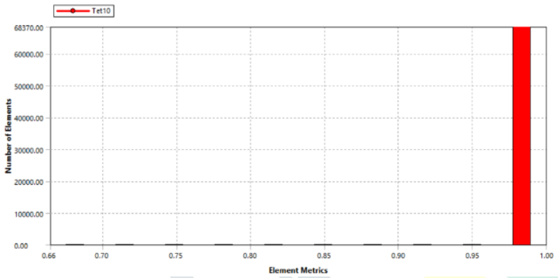
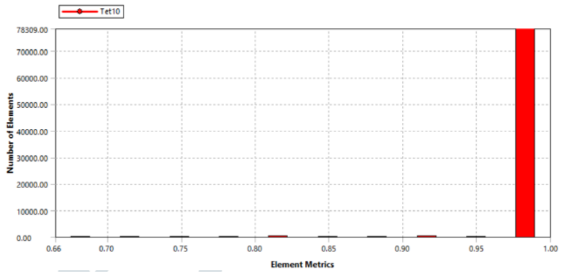
3.2 Material Selection

Table 3.2 Material Properties

Material Name	*CRCA Steel*
Youngs modulus	240 GPa
Yield stress	330 MPa
Ultimate tensile strength	450 MPa
Poisoons ratio	0.3
Density	7860 kgm^{-3}

3.3 Mesh Quality checks

Table 3.3 Mesh Quality checks for corrugated sheetswith 2 and 3 corrugations

Parameter	*Corrugated sheet with 2 corrugations*	*Corrugated sheet with 3 corrugations*
Number of elements		50260
Type of element	Tetrahedron	Tetrahedron
Aspect Ratio	 ***Fig 3.6 Aspect ratio for 2 corrugations sheet***	 ***Fig 3.7 Aspect ratio for 3 corrugations sheet***
Jacobian Ratio	 ***Fig 3.8 Jacobian ratio for 2 corrugations sheet***	 ***Fig 3.9 Jacobian ratio for 3 corrugations sheet***
Element Quality	0.72	0.66
Ideal Values	Ideal values of Element quality, aspect ratios and Jacobian's ratio are 1, 1 and 1 respectively Allowable values are as follows: Element quality: >= 0.6 Aspect Ratio: <5 Jacobian's Ratio >=0, close to 1	l values of Element quality, aspect ratios and Jacobian's ratio are 1, 1 and 1 respectively Allowable values are as follows: Element quality: >= 0.6 Aspect Ratio: <5 Jacobian's Ratio >=0, close to 1
Status	Element Quality: 0.72 Aspect Ratio: 4.27 Jacobian's Ratio: 0.993	Element Quality: 0.66 Aspect Ratio:4.49 Jacobian's Ratio: 0.992

3.4 Boundary Conditions

For all the corrugated surfaces, the boundary condition is as shown in fig 3.10
The load of 500 N acts on the surface of the sheet metal
The faces perpendicular to the face on which load is acting are fixed.
This type of boundary conditions is carried for the corrugated sheet with 3 and 4 corrugations, corrugated sheet with 3 corrugation with 30 mm and 40 mm width of corrugations.

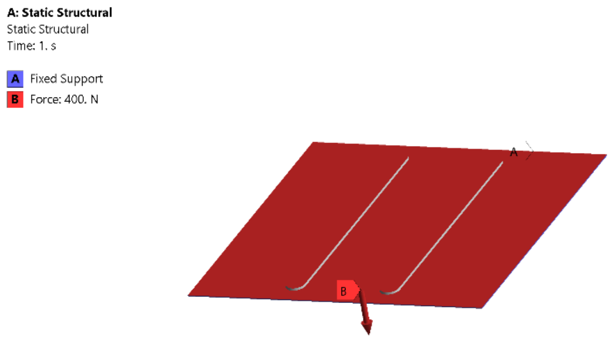


Fig 3.10 Boundary conditions for corrugated sheet with 2 corrugations

4. SIMULATION RESULTS AND DISCUSSION

4.1 Effect of number of corrugations on the strength of the steel

It can be seen in fig 4.1, the deformation that is experienced by the sheet with two corrugations with 400 N vertical load acting on it, the maximum deformation experienced by the sheet is 0.976 mm.

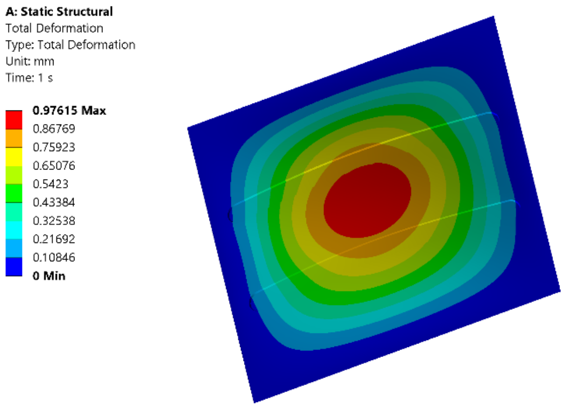


Fig 4.1 Deformation of corrugated sheet with two corrugations

Figure 4.2 represents the stress distribution on the sheet with two corrugations, the width of the corrugation is 30 mm, the maximum stress distribution in the sheet is 42.2 MPa. The yield stress of CRCA Steel is 330 MPa, it can be seen that the safety factor os beyond 7, which is safe for any design. To reduce the magnitude of the stress generation more corrugations are added.

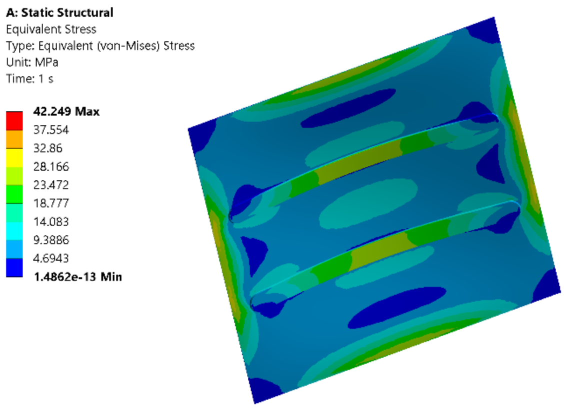
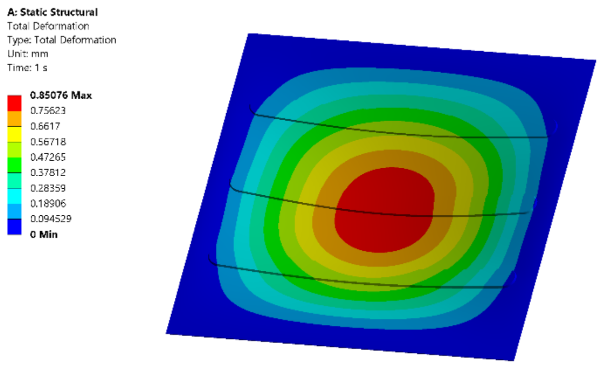
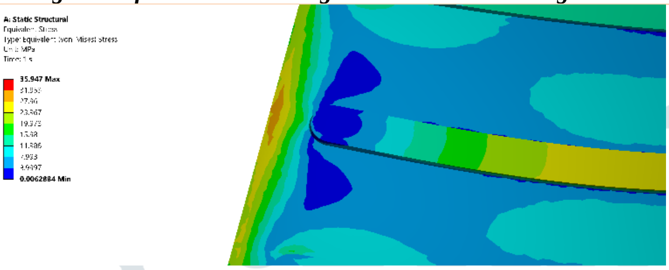
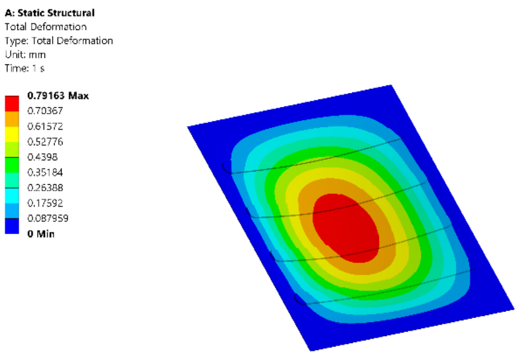
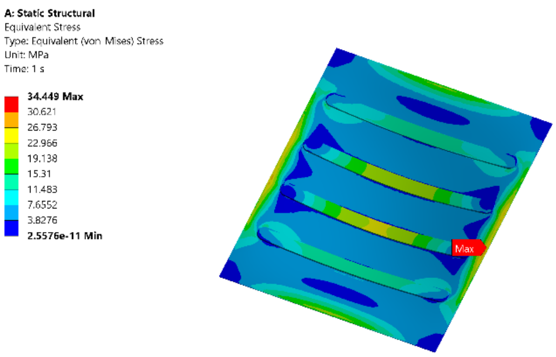


Fig 4.2 Stress distribution of corrugated sheet with two corrugations

Adding the corrugations to the sheet makes the sheet stronger. The strength of the sheet with more number of corrugations, but the cost of manufacturing is more for more corrugations. In the sheet the maximum stress is at the extreme ends of the sheet.

Table 4.1 Ansys results and the status of the corrugated sheet with 3 and 4 corrugations

Sheet	***ANSYS Result***	***Status***
Sheet with 3 corrugations with draft angle 21°	 ***Fig 4.3 Deformation in corrugated sheet with 3 corrugations***	Deformation is about 0.850 mm The deformation for the sheet with 3 corrugation si 13% less than that of the sheet with two corrugations.
	 ***Fig 4.4 Stress in corrugated sheet with 3 corrugations***	Stress distribution is 35.947 This maximum stress is 14% less than that of sheet with two corrugations.
Sheet with 4 Corrugations with draft angle 21°	 ***Fig 4.5 Deformation in corrugated sheet with 4 corrugations***	Maximum Deformation in the sheet is 0.792 mm The deformation is 18.8% less than that of sheet with two corrugations
	 ***Fig 4.6 Stress in corrugated sheet with 3 corrugations***	Maximum stress generated in the sheet is 34.449 The maximum stress in the sheet with four corrugation is 20.25% lesser than that of sheet with two corrugations

Corrugated sheet with two corrugation is less reliable when compared with the corrugated sheet with three and four corrugations. Because the deformation experienced by the sheet with 4 deformation sis 0.792 mm under the load of 400 N and the same condition is experienced by the sheet with three corrugations. The deformation in the corrugated sheet with three corrugation is 0.85 mm.. When we compare corrugated sheet with 3 and 4 corrugations, sheet 4 has 6.8% lesser deformation.

4.2 Effect of dimension of corrugations

Table 4.2 Ansys results and the status of the corrugated sheet with 30 mm and 40 mm width of corrugations

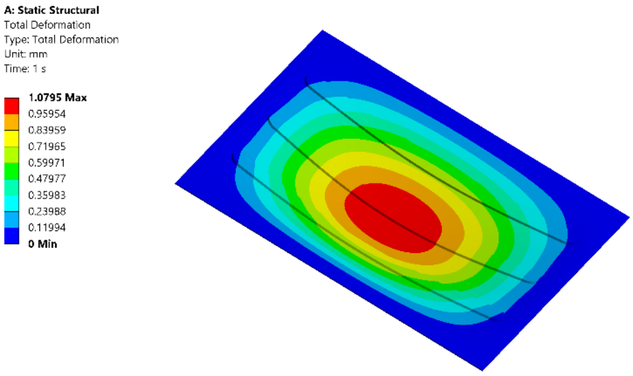
<table>
<tr><th>Sheet</th><th>ANSYS Results</th><th>Status</th></tr>
<tr><td rowspan="2">Corrugated sheet with 30 mm width of corrugation with draft angle 21°</td><td>

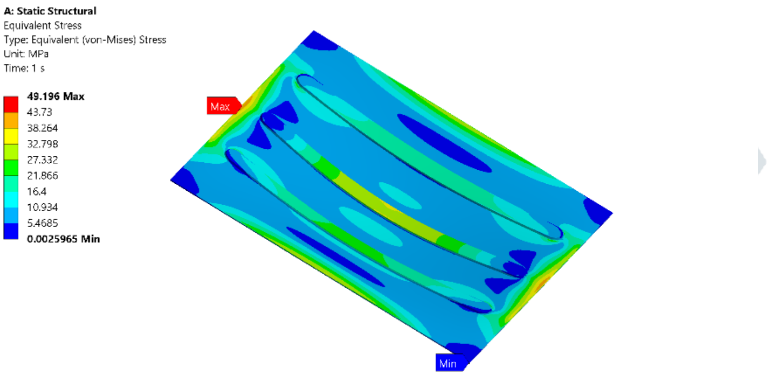
Fig 4.7 Deformation in corrugated sheet with 3 corrugations with 30 mm width</td><td>Deformation experienced by the corrugated sheet with three corrugations is 1.07 mm as shown in figure 4.7</td></tr>
<tr><td>

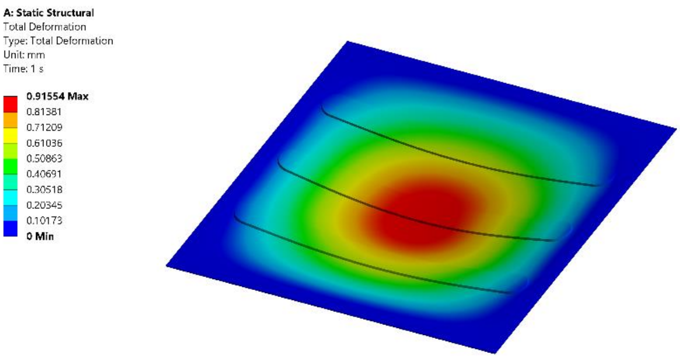
Fig 4.8 Stress in corrugated sheet with 3 corrugations with 30 mm width corrugation</td><td>The stress distribution for this sheet can be seen in figure 4.8, which is 49.196 MPa. The maximum stress experienced by the sheet is along the edges.</td></tr>
<tr><td rowspan="2">Corrugated sheet with 40 mm width of corrugation with draft angle 21°</td><td>

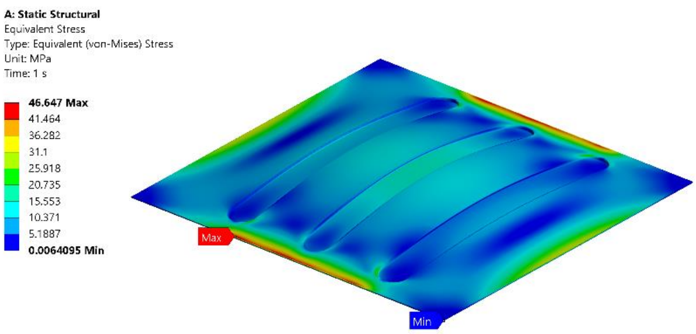
Fig 4.9 Stress in corrugated sheet with 3 corrugations with 40 mm width corrugation</td><td>The deformation experienced by this sheet is 0.5154 mm. The deformation experienced by this sheet is 51.83% less than that of sheet with 30 mm corrugation width.</td></tr>
<tr><td>

Fig 4.10 Stress in corrugated sheet with 3 corrugations with 40 mm width corrugation</td><td>The stress distribution can be seen in fig 4.10, The maximum stress is 45.647 MPa which is 7.2% less than that of corrugated sheet with 30 mm width of corrugation.</td></tr>
</table>

4.3 Effect of Draft angle on the strength of the sheet

Table 4.3 Ansys results and the status of the corrugated sheet with 30 mm corrugation with draft angle 35º

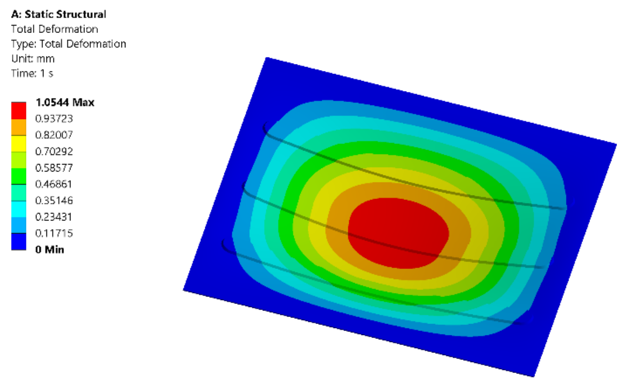
<table>
<tr><th>Sheet</th><th>ANSYS results</th><th>Status</th></tr>
<tr><td>Corrugated sheet with 35º draft angle for the corrugation</td><td>

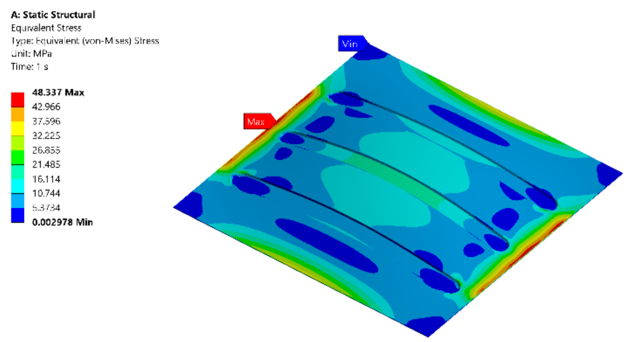
Fig 4.11 Deformation in corrugated sheet with 3 corrugations with 35º draft angle corrugation</td><td>The deformation experienced (fig 4.11) by the sheet is 1.054 mm. The deformation experienced by the sheet with 21º draft angle is 1.07 mm. The difference in the deformation is 0.016 mm which is 1.49% of sheet with less draft angle.</td></tr>
<tr><td></td><td>

Fig 4.12 Stress in corrugated sheet with 3 corrugations with 35º draft angle corrugation</td><td>The stress distribution is 48.357 MPa as shown in fig 4.12.
The maximum stress in the sheet with 35º draft angle is 1.76% less than the sheet with 21º draft angle.</td></tr>
</table>

5. CONCLUSIONS

The conclusions that are drawn from the simulation results of ANSYS, these conclusions are as a result of design changes made. The design changes are made with an intention of reducing the deformation and stress, so the conclusions drawn from the simulation results are as follows:

1. For a sheet (500 x 500 x1.5) experiencing 400 N vertical load, the deformation produced by sheet with corrugation width 30 mm is 49.19% more than that of sheet with corrugation width of 40 mm. The stress distribution is also 7.2% lesser in 40 mm width corrugation than from 30 mm width corrugation sheet. So increasing the width of corrugation would drastically reduce the deformation and stress.
2. Another design optimization method for reducing the stress and deformation would be to increase the number of corrugations. The deformation produced by sheet with 4 corrugations is 18.8% less than that with 2 corrugations. For the stress distribution, sheet with 4 corrugation has experienced 20.28% lesser stress than that of sheet with 2 corrugations> Thus, increasing the number of corrugations would reduce the stress and deformation to a good extent.
3. Another method of reducing the stress and deformation for the smaller extent is by changing the draft angle of the corrugations. The sheet with 21^0 draft angle corrugation produces a deformation of 1.07 mm and the sheet with 35º Corrugation is 1.054, the reduction of 1.49% deformation. Hence by changing the draft angle the deformation would vary with less magnitude.

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REFERENCES

1. Sara Mantovani. Feasibility Analysis of a Double-Acting Composite Cylinder in High-Pressure Loading Conditions for Fluid Power Applications. Appl. Sci. (2020), 10, 826
2. Marczewska,T. Bednarek,I.R.K RAJU. Strength Evaluation Of Tipper Chassis Under Static And Dynamic Load Conditions. International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 11 | Nov (2018)
3. D. FORSSTRÖM, P. JONSÉN. Load Intensity Calculations On Tipper Body Using Fem Coupling. 11th World Congress on Computational Mechanics (WCCM XI) (2017)
4. Praveen Kumar Loharkar, Asha Ingle, Microwave-assisted corrosion resistant pure polyester coating of cold rolled closed annealed steel, Materials Today: Proceedings 44 (2021) 1676–1680
5. Badirujjaman Syed, Sulthan Mohiddin Shariff , Gadhe Padmanabham, Influence of laser surface hardened layer on mechanical properties of reengineered low carbon steel sheet, *Materials Science & Engineering, A*http://dx.doi.org/10.1016/j.msea.2016.12.124
6. Sankararao Vinjavarapu , Unnam Koteswararao , V. Lakshmi Narayana. Design Optimization of Tipper Truck Body. International Journal of Engineering Research and Development e-ISSN: 2278-067X, p-ISSN : 2278-800X, www.ijerd.com Volume 4, Issue 9 (November 2012), PP. 11-20.
7. Nissankararao Bhavani Shankar, Muttamsetty Lakshmi Sramika. Optimization of Material Usage in The Fabrication of Dump Body. (IJITR) INTERNATIONAL JOURNAL OF INNOVATIVE TECHNOLOGY AND RESEARCH Volume No.4, Issue No.5, August – September (2016), 3596 – 3604
8. Deepesh Garg , Dr. R S Bindu. Design Optimization of Truck Body Floor for Heavy Loading. IOSR Journal of Engineering (IOSRJEN) ISSN: 2250-3021 Volume 2, Issue 8 (August 2012), PP 48-52.