# Design and Strength Analysis of Roof Lifting Tackle Arrangement

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**Abstract -** This project work is carried out in a car manufacturing industry along the assembly line for the material handling of car roof. A new assembly line is to be design for the plant and hence roof lifting tackle arrangement needs to be optimized. To improvise the model for the system the table and the tackle are redesign for mass reduction and improve strength characteristic.

The analysis carried out on the BIW fixture table by putting up the load of 275 kg at 11 resting points of pneumatic cylinders. Then the BIW fixture table is optimized by reducing the thickness of the top plate surface of 22mm to 12mm. Further to which the secondary resting arrangement of roof lifting tackle clamping is designed and analyzed by putting up the load of roof of 20 kg at each clamping. Then the mid attachment of roof lifting tackle which is constraint on hooking arrangement is designed and analyzed by putting up the load of 500kg on each resting point. The validation is carried out by comparing theoretical and FEA results. Thus the results are under good agreement.

***Key Words***: **BIW fixture table, Roof lifting tackle clamping, Mid attachment, Finite element analysis, Von-Mises stress**

## 1. INTRODUCTION

The movement, handling, storage and controlling of materials throughout the manufacturing process is known as material-handling system. To ensure that the material in the right amount is carefully delivered to the desired destination at the right time at minimum cost is the main purpose of using a material handling system. Material handling is not a production process and hence does not add to the value of the product.

### 1.1 Significance of Material Handling System in Industry

Material handling is an significant and essential component of any productive activity. It is something that goes on in every plant all the time. It is simply lying down and moving, picking up, of materials through manufacture. The movement of raw materials, parts in process, finished goods, packing materials, and disposal of scraps it is applied. In general, the movement of materials takes place from one processing area to another or from one department to another department of the plant while hundreds and thousands tons of materials are handled daily requiring the use of large amount of manpower. Significantly the cost of material handling contributes to the total cost of manufacturing.

### 1.2 Factors and Considerations for Design of Material Handling System

The benefits associated with material handling is usually difficult to identify and quantify; the costs of material handling is much easier to identify and quantify (e.g., the cost of indirect material handling labour, the cost of material handling equipment, etc.). Depends on the degree to which the other aspects of the production process are able to be changed the material handling system cost as the sole criterion to select a material handling system design. The total cost of production is the most appropriate criterion to use in selecting a material handling system if a completely new facility and production process is being designed the lowest cost material handling system may not result in the lowest total cost of production. In actual practice, it is difficult to consider all of the components of total production cost simultaneously. Material handling system cost is the only criterion that need to be considered if it is too costly to even consider changing the basic layout of a facility and the production process.

The material movement from the place where it is needed where it is to the place can be time consuming, expensive, and troublesome. The material can be lost or damaged in transit. It is important that it be done directly, smoothly, with the proper equipment and it is under control at all times.

## 2. LITERATURE SURVEY

J. D. Tew, S. Manivannan, D. A. Sadowski, and A. F. Seila [1] were illustrate the simulation methodologies used in the design of Automated Material Handling Systems (AMHS) at Intel wafer fabs for semiconductor manufacturing. The models used in AMHS design has categorized as AMHS models and production models. The AMHS models support the design of Interbay and Intrabay systems. The Inter bay systems handle the material flow between different bays (production centers). The Intrabay systems handle the material flow within the bays. The production models compliment the AMHS models. In modeling framework, they approaches AMHS and the production process models use a consistent set of assumptions. This de-coupling approach typifies the general philosophy to using simulation in design. Authors review the general model structures and simulation examples under these categories used in actual system implementations. In this paper the main purpose of using simulation is to ensure that the material handling system design meets material storage and transport requirements.

Prasad Karande and Shankar Chakraborty[2] have carried out the selection method for suitable MH equipment . They had proceed with multicriteria decision-making (MCDM) problem. As wide range of MH equipment is available today, for this complicated task they applied a multicriteria decision-making (MCDM) tool to select the most suitable MH equipment. They implement weighted utility additive (WUTA) method to solve an MH equipment selection problem. They have also observed a comparison of ranking obtained with the past researchers and found its potentiality, applicability, and accuracy to solve complex decision-making problems. They have explained that the WUTA method has a strong mathematical base and proficient of deriving more precise ranking of the considered alternatives. They have also concluded that it can also be useful for any decision-making problem with any number of selection criteria and feasible alternatives.

## 3. FE ANALYSIS OF MODELS

### 3.1 Existing BIW fixture table

The CAD model is modeled in CATIA and then the model is imported for meshing in Hypermesh software v14.0 , the meshed model is as shown in the figure

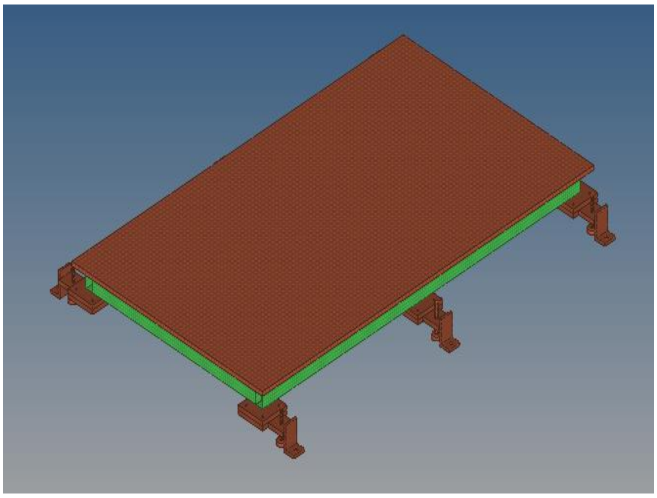

**Fig. 1 Existing Meshed Model of BIW Fixture Table**

Max. stress observed 12.8MPa so it is Safe.

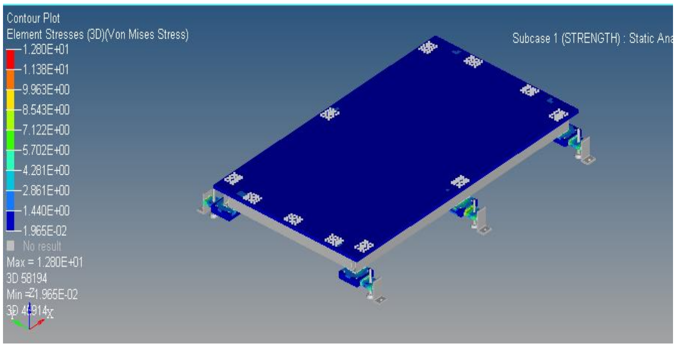


**Fig.2 Existing Von Mises Stress Plot**

### 3.2 Optimized BIW fixture table :

In optimization the thickness of the BIW fixture table top surface of 22 mm is reduced to 12 mm. Due to the reduction of the thickness of the table the weight of the BIW fixture bed is reduced.

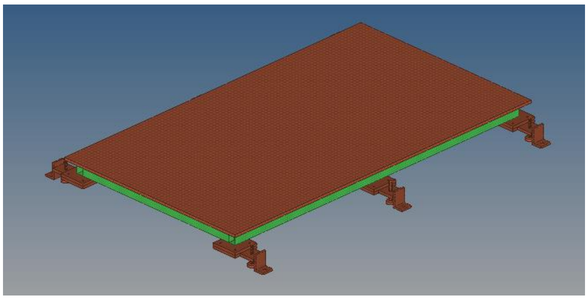

**Fig.3 Optimized Meshed Model of BIW Fixture Table**

Max. stress observed 15.76 MPa so it is Safe.

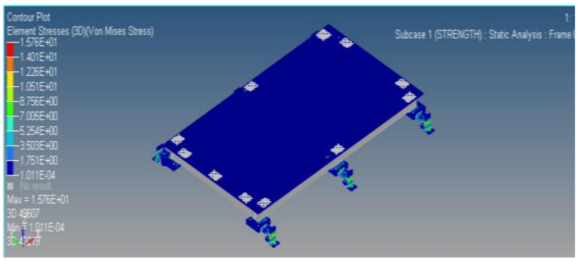


**Fig.4 Optimized Von Mises Stress Plot**

### 3.3 Roof Lifting Tackle clamping

The CAD model is modelled in CATIA and then the model is imported for meshing in Hyper mesh software v14.0 , the meshed model is as shown in the figure

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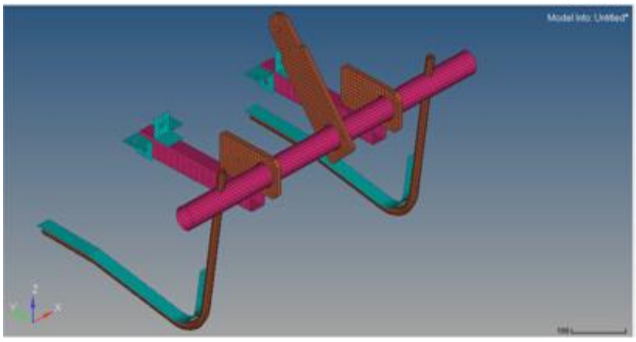

**Fig.5 Meshed Model of Roof Lifting Tackle Clamping**

Stress observed for 20 kg load is 76.89Mpa

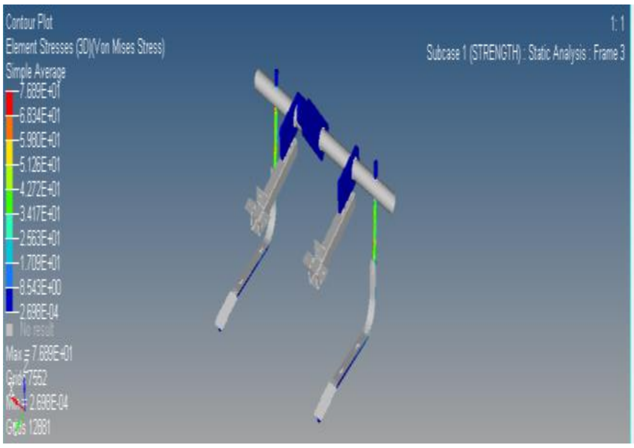


**Fig.6 Von Mises Stress Plot Showing 3D Stresses**

### 3.4 Mid Attachment

The CAD model is modelled in CATIA and then the model is imported for meshing in Hyper mesh software v14.0 , the meshed model is as shown in the figure

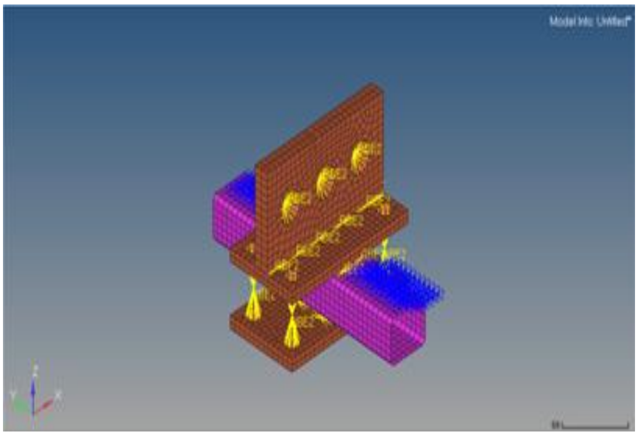

**Fig.7 Meshed Model of Mid Attachment**

Stress Observed 108.9 Mpa

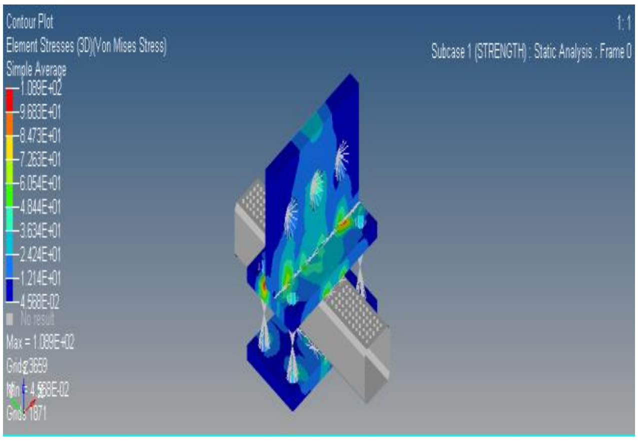


**Fig.8 Von Mises Stress Plot Showing 3D Stresses**

## 4. THEORETICAL DESIGN CALCULATIONS

### 4.1 BIW Fixture Table

At the beginning the self mass of BIW fixture table was taken to be 815.151 kg. The BIW fixture table has a top plate surface of thickness 22mm then reducing the thickness of top plate surface as 12mm for optimization.

**USING THE FORMULAS**

$$M1 = \frac{\psi \times (Wd + Wt) \times (\frac{S - Tc}{2})^2}{S} \quad (1)$$

$$M2 = 0.25 \times M1 \quad (2)$$

$$M3 = W_g \times S \quad (3)$$

Total Moment = M = M1 + M2 + M3

$$\sigma = \frac{M}{Z}$$

Substituting the values in the above equations we get the stress values as 12.8 MPa and 15.76 MPa for existing and optimized BIW fixture table. So the equivalent von mises stress observed in the component is well below the failure limit of the material, thus the design is safe.

### 4.2 Roof Lifting Tackle Clamping

Using the formulas,

$$\sigma_x = \frac{P}{A} + \frac{P \times e}{Z} \quad (4)$$

$$\tau_x = \frac{4 \times P}{3 \times A} \quad (5)$$

$$\sigma_{1,2} = \frac{\sigma_x}{2} \pm \sqrt{\left(\frac{\sigma_x}{2}\right)^2 + \tau_x^{\,2}} \quad (6)$$

$$\sigma_{von} = \sqrt{\sigma_1^{\,2} + \sigma_2^{\,2} - \sigma_1 \sigma_2} \quad (7)$$

Substituting the values in the above equations we get the von mises stress values as 75.26 $N/mm^2$ for roof lifting tackle clamping. So the failure limit is under the tensile stress, thus the design is safe.

## 5. CONCLUSION

The main objective of the study has been concluded that have good agreement with the two types of analysis carried out. From the analysis results following conclusions are drawn.

1. For the geometry of BIW fixture table static analysis is carried out, which is in use for car manufacturing industry. The optimized design has 82.7 kg lesser mass compared to the existing fixture table.
2. The roof lifting tackle clamping has lower deformation and is under yield limit and hence is considered to be safe.
3. FEM results are validated with the theoretical calculations and thus are in good agreement.

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