International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 07 | July - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

NUMERICAL ANALYSIS OF SLINGS WITH SPREADER BARS IN SHIPPING CONTAINERS LIFTING TECHNIQUE

Fathima U[1], S Nabeel[2], Muneera B[3], Raji R.[3]

Department of civil Engineering YCET, Kollam
Department of civil Engineering YCET, Kollam
Department of civil Engineering YCET, Kollam

---***---

ABSTRACT - Containerization is the practice of consolidating multiple cargos in a container for transport as a single unit. Containers are loaded and unloaded using mechanised equipment. This equipment includes lifting gears such as slings and spreader bar. This thesis discusses arrangement of slings and spreader bar to find optimal solution for container lifting with less consumption of time. The models were generated on SOLIDWORKS and then imported onto ANSYS for the further analysis. First model is a container with two slings, second model is a container with two slings and spreader bar, third model is a container with two slings and multiple spreader bars. . A static structural analysis were carried out on these models. Total deformation values and equivalent stress values were generated for these models. From the comparison it shows the third model is the better configuration. . For the feasible configuration inertial load analysis, thermal analysis, fatigue analysis, and limit load analysis were conducted to find the safety of the feasible model. It concludes that the better model shows a percentage reduction of deformation from the first model, the stress generated is within the allowable limit, and it is safe under elevated temperatures.

***Key Words*:** Container, Slings, Spreader bar

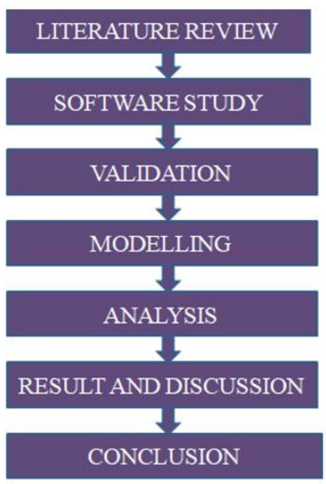
1. INTRODUCTION

Containerization is a system of intermodal freight transport using intermodal containers. Containerization also referred as container stuffing or container loading. They can be loaded or unloaded, stacked, transported efficiently over long distances; transferred from one mode of transport to another container ships and semi-trailer trucks without being opened. Containers lifted using lifting beam use clip mechanism for the fixing of container with the beam. Clip mechanism consumes more time for the fixing and removal of clips. Use of spreader bars and sling arrangement to the lifting beam is an alternative for this mechanism. They consumes a minimum time. A sling is a removable accessory that enables a machine or device, such as a crane for example, to lift a load by linking the lifting device and the load to be lifted. Any beam where the load being lifted mainly puts a compressive stress in the beam is called spreader bar (beam). This evenly distributes the weight of the load across the two slings, which then connect to a crane, hoist, or other lifting machine. Lifting beam is a beam which convert lifting loads into bending forces on the beam. The beam is designed to bend slightly at both ends as the object is lifted, thereby causing the stress to be placed on the bottom slings and through the beam itself.

2. OBJECTIVE

1) To find the total deformation and stress in slings and the container
2) To find the total deformation and stress in slings, spreader bar and the container
3) To find the total deformation and stress in slings, multiple spreader bars and the container
4) To find the total deformation and stress under inertial load
5) To find the total deformation and stress under different temperatures
6) To find the damage in the whole structure when subjected to fatigue loading
7) To find the limiting load for the feasible configuration

3. METHODOLOGY



4. MODELLING

The structure was modelled using SOLIDWORKS, a solid modelling computer-aided design (CAD) and computer-aided engineering (CAE) application published by Dassault

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 07 | July - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

Systems. The rendered model was then imported onto ANSYS for further analysis.

MODEL DESCRIPTION

- Dimension of container = 6m × 2.5m (Values in between standard sizes)
- Load of container = 2.5tonnes
- Poisson's Ratio= 0.290
- Mild steel for slings and spreader bar
- Yield stress ranges from 240 to 300MPa

Model-1: MS (Model With Slings)

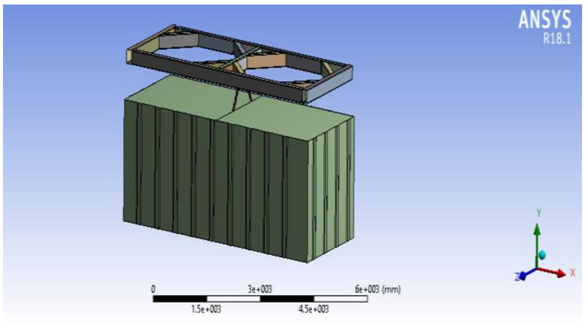


Figure 1: Container with two sling attachment

A clearance of 150mm is provided on both sides of the container along width wise for the attachment of slings on the container.

Model-2: MSS (Model with slings and spreader bar)

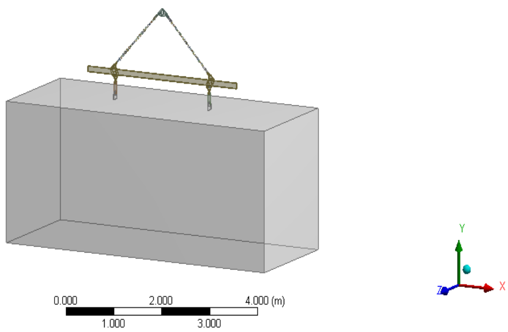


Figure 2 Container with two sling and spreader attachment

Model -3: MSMS (Model with slings and multiple spreader bars)

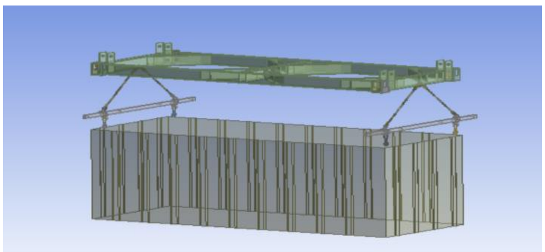


Figure 3 Container with slings and multiple spreader bar attachment

MESH REFINEMENT STUDY

Mesh refinement study carried out by producing various deformations for different mesh sizes.

Table of Design Points

	A	B	C
1	Name	P1 - Body Sizing Element Size	P2 - Total Deformation Maximum
2	Units	mm	mm
3	DP 0 (Current)	200	114.93
4	DP 1	220	114.85
5	DP 2	250	114.79
6	DP 3	180	114.35
7	DP 4	160	114.33
8	DP 5	150	114.23

Figure 4 Data's of different mesh sizes and corresponding deformation

The mesh size used for the present study is 200mm. For 220mm, 250mm, 180mm, 160mm, 150mm element sizes there is small variation in deformation values.

5. ANALYSIS

The three configurations used for the present study is analysed using ANSYS software. Finite element analysis is done for all the three models. Static structural simulation is carried out to determine the static loading on the structure. This helps to identify weak areas with low strength and durability at the design stage and avoid failures.

MODEL-1(MS-MODEL WITH SLINGS)

The first model is analysed to obtain the total deformation and stress values.

Total deformation

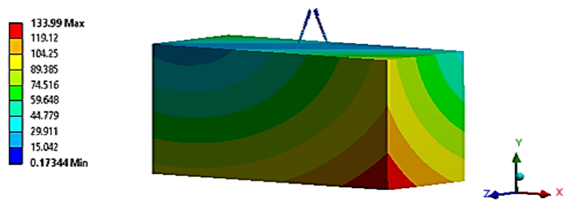


Figure 5 Total deformation of MS

The total deformation in the slings are ranging from 15mm to 59mm,but the maximum value of total deformation on the top of the container is 104mm.133.99mm of deformation occurs at the bottom most corner of the container. When lifting a container using the two sling arrangement, the slings will subjected to a minimum deformation, but the load being lifted is subjected to a tilt. So for the time of lifting this arrangement can't make the load in centre position.

When analyzing directional deformation along y-axis, the nature of the load shows the exact tilting behavior.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 07 | July - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

Directional deformation

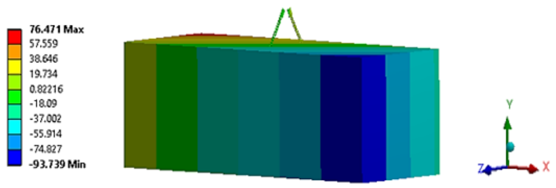


Figure 6 Directional deformation of MS along y-axis

The maximum deformation in the slings is nearly zero. On the top corner of the container, the deformation value is 76mm where as in the opposite corner of the top face of the container, its value is -94mm. From the deformation values it is clear that the container can't be reused for further lifting when using this kind of attachment (two slings) to the lifting beam.

Equivalent stress

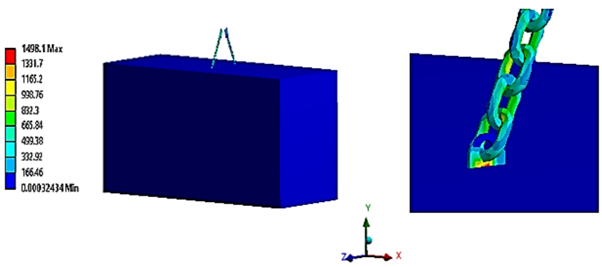


Figure 7 Equivalent stress of MS

The allowable limit for the stress value is ranging from 240-300MPa. The stress developed in the slings during lifting is 1165.2MPa, which exceeds the limit. Hence this configuration is not feasible.

In order to find the nature of stress developed, we can analyse the normal stresses in X and Y direction.

Normal stress (x-axis)

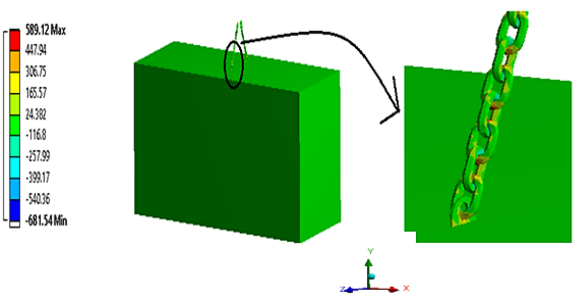


Figure 8 Normal stress of MS along x- axis

The maximum stresss developed in the slings is 589.12MPa, which exceeds the allowable limit.

Normal stress (y-axis)

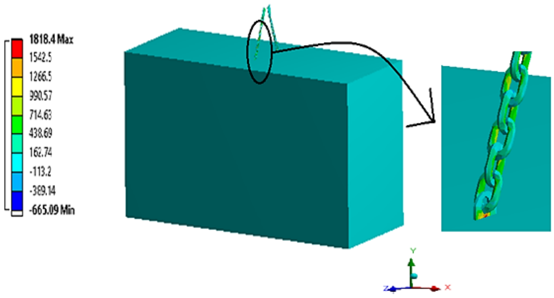


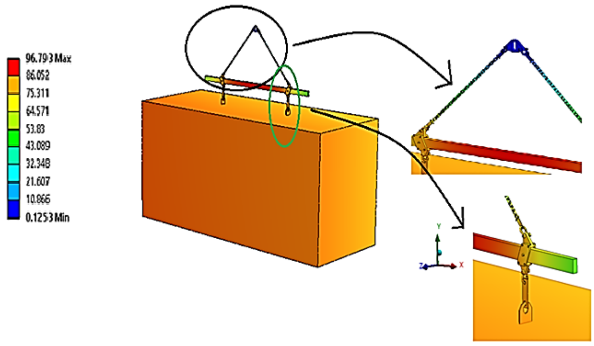
Figure 9 Normal stress of MS along y- axis

The maximum stress developed as stress concentration at a point. The stress developed in the slings are 1266MPa, which is greater than the allowable limit. Among the two normal stresses the maximum stress generated is in y-direction. Hence we can conclude that during lifting the slings subjects to tensile stresses and causes failures.

MODEL-2(MSS-MODEL WITH SLINGS AND SPREADER)

The second model is analyzed for better deformation and stress result.

Total deformation



9-

The maximum deformation in the sling is 64.57mm whereas in spreader bar it is 96.793mm, in container the value is 86mm. Here also a tilting of container occurs and the whole attachment assembly deforms and cannot be used for further lifting.

Equivalent stress

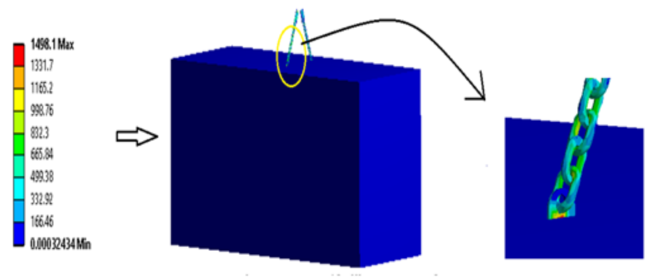


Figure 11 Equivalent stress of MS

The maximum stress developed in the sling is 1082.2MPa, which is greater than the allowable limit, whereas in spreader bar its value is minimum (120MPa).Since the slings are subjected to higher stress value, the lifting cause breakage of the slings.

MODEL-3 (MSMS-MODEL WITH SLINGS AND MULTIPLE SPREADER BARS)

The third model is analysed for total deformation and equivalent stress.

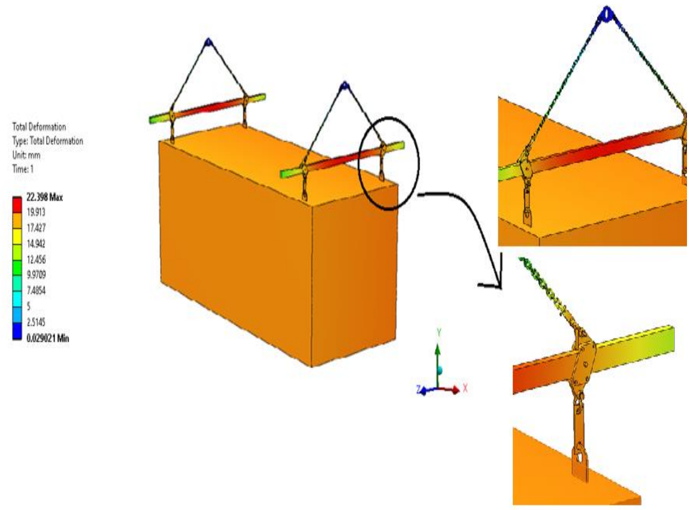


Figure 12 Total deformation of MSMS

The maximum deformation in the sling is 5mm, in spreader the value is 22.4mm, in container the value is 19.9mm.

Equivalent stress

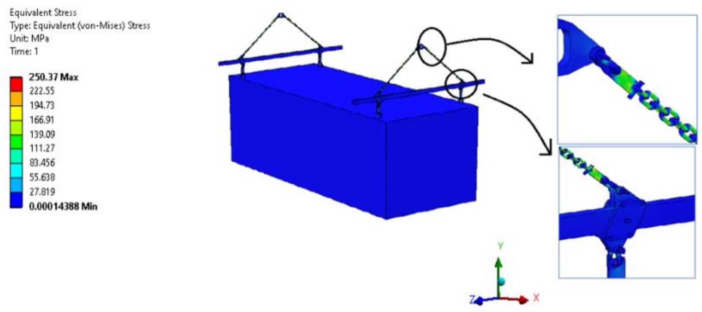


Figure 13 Equivalent stress of MSMS

The maximum stress developed in the sling is 250.37MPa, in spreader bar the value is nearly zero. The stress value generated is within the allowable limit.

Inertial load

The force of inertia resulted from the acceleration and deceleration of the transverse motion travel motion shall generally be considered as β times of the weight of the moving parts and the hoisting load. (As per IS 807:2006, Section 6.1.3.1). For transverse travel motion, $\beta = 0.01\sqrt{v}$

Where v is the speed of respective motion. However in case of transverse motion and travel motion, it shall be taken as 15 percent of the load of the driving wheel at maximum.

Total deformation

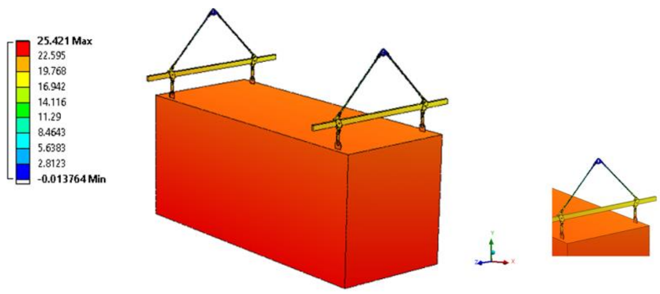


Figure 14 Total deformation of MSMS under inertial load

The maximum deformation in the sling is 19.8mm. In spreader the maximum value is 22.6mm, but in container the value is 25.4mm.

Equivalent stress

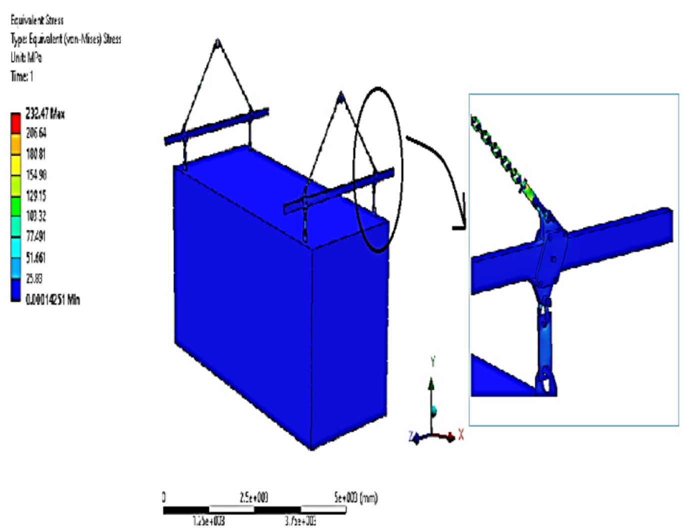


Figure 15 Equivalent stress of MSMS under inertial load

The maximum stress value in the sling is 237.5MPa, where as in spreader and the container it is nearly zero.

THERMAL ANALYSIS

The feasible model was analysed for different temperatures inorder to find its performance in different climates. Deformation values and stress values obtained at 40, 50, and 60ºC are shown below.

Total deformation

The figure below shows the total deformation of the model MSMS at a temperature of 40ºC. The maximum deformation is 25.258mm and the value is at the spreader bar, whereas in slings the maximum value is 8.4mm, but in container the value is 22.46mm.

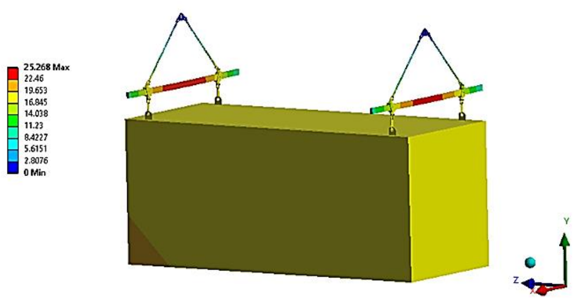


Figure 16 Total deformation of MSMS at 40ºC

Equivalent stress

The figure below shows the equivalent stress value of model MSMS at a temperature of 40ºC. The maximum stress value(250.37) is at the slings. In spreader bar the maximum value is 166.91mm. In container the stress is zero.

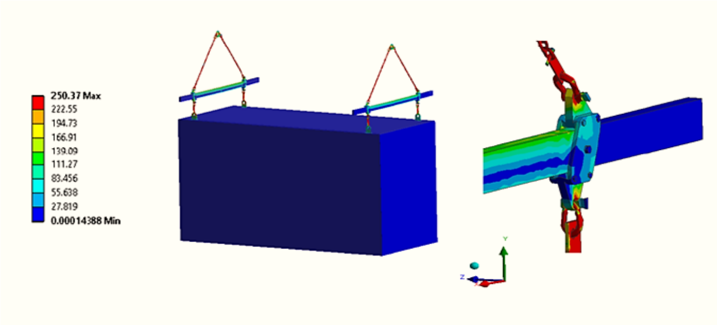


Figure 17 Equivalent stress of MSMS at 40ºC

Total deformation

The figure below shows the total deformation of the model MSMS at a temperature of 50ºC. The maximum value of deformation is at the spreader bar (25.41mm). In slings the maximum value is 7.3mm. In container the maximum value is 22.587mm.

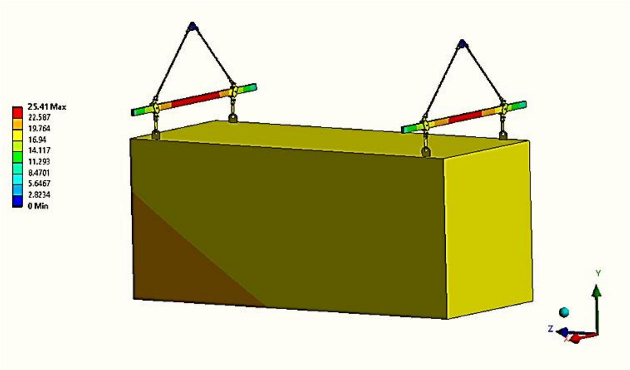


Figure 18 Total deformation of MSMS at 50ºC

Equivalent stress

The figure below shows the equivalent stress value of model MSMS at a temperature of 50ºC. The maximum value of stress is 253.12mm, it is at the slings. In spreader bar the maximum value is 139.15mm. In container it is zero.

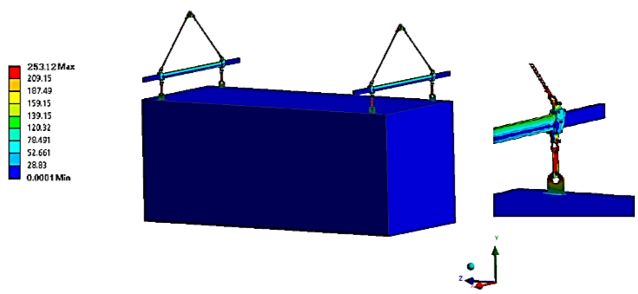


Figure 19 Equivalent stress of MSMS at 50ºC

Total deformation

The figure below shows the total deformation of the model MSMS at a temperature of 60ºC. The maximum value is 25.5mm, is at the spreader bar. In slings the maximum value is 8.5mm. In container the maximum value is 22.715mm.

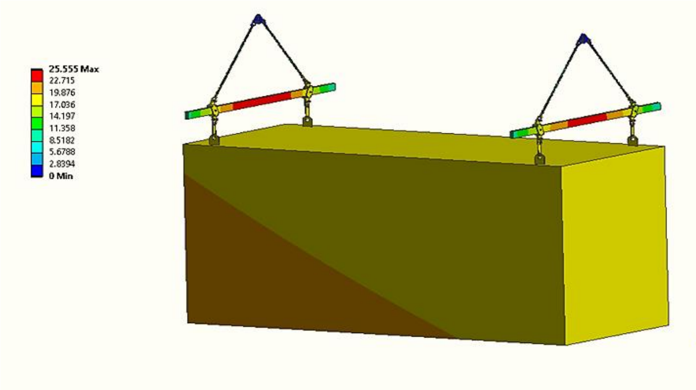


Figure 20 Total deformation of MSMS at 60ºC

Equivalent stress

The figure below shows the equivalent stress value of model MSMS at a temperature of 60ºC. The maximum value of stress(26.18MPa) is at the slings. In spreader bar the maximum value is199.19MPa. In container the value is zero.

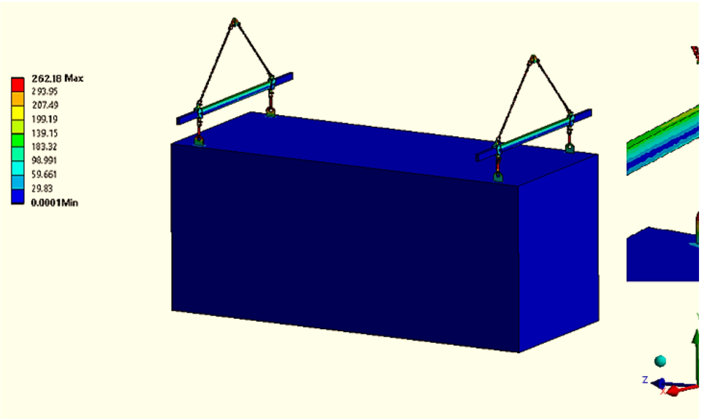


Figure 21 Equivalent stress of MSMS at 50ºC

Fatigue analysis

Safety factor for one lakh cycle is generated to obtain the following results.

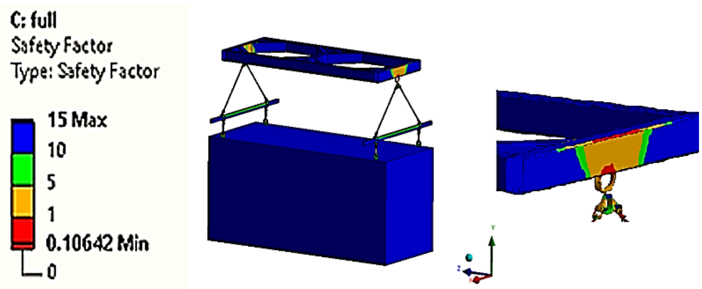


Figure 22 Safety factor of whole structure

From the results obtained it is clear that for one lakh cycle, a top portion in lifting beam shows minimum safety factor; the top of the slings, at the centre of two sides of the lifting beam and the connecting part between the sling and the lifting beam also shows a lack of safety factor.

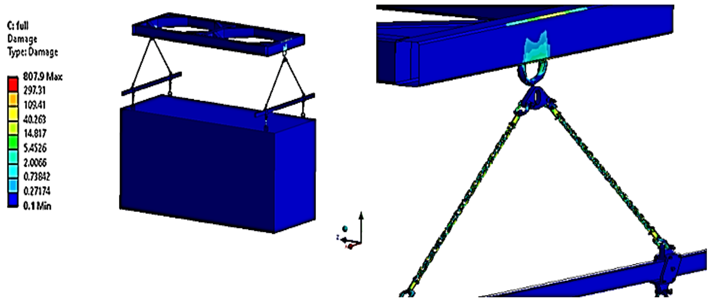


Figure 23 Damage in the whole structure

The figure above shows the damage that can form in the whole structure under one lakh cycles of fatigue loading. It shows, at the sling,on the sides of the lifting beam and the connection between the slings and the lifting beam have to be strengthened for these kind of loading and unloading.

Limit load analysis

Limit load analysis were conducted to find the maximum load that the better configuration can lift without failure.

Total deformation

The maximum deformation is 17.978mm is at the spreader bar. In slings the maximum value is 11.985mm, whereas in container the value is 15.98mm.

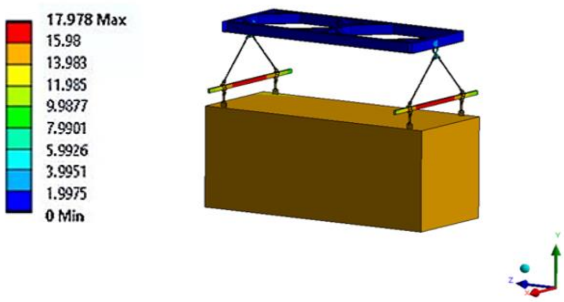


Figure 24 Total deformation at 100% loading

Equivalent stress

The maximum value of stress is at th top of the lifting beam(221.3MPa). In slings the value is 154.98MPa, whereas in spreader bar and the container the stress is zero.

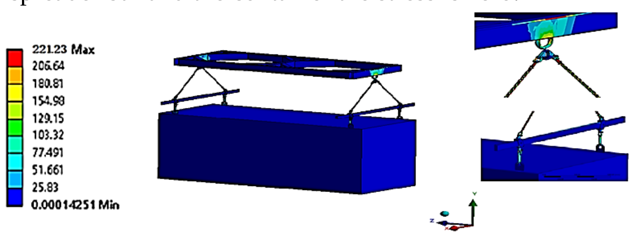


Figure 25 Equivalent stress at 100% loading

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 07 | July - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

Total deformation

The maximum deformation is 27.449mm is at the spreader bar. In slings the maximum value is 15.249mm, whereas in container the value is 24.399mm.

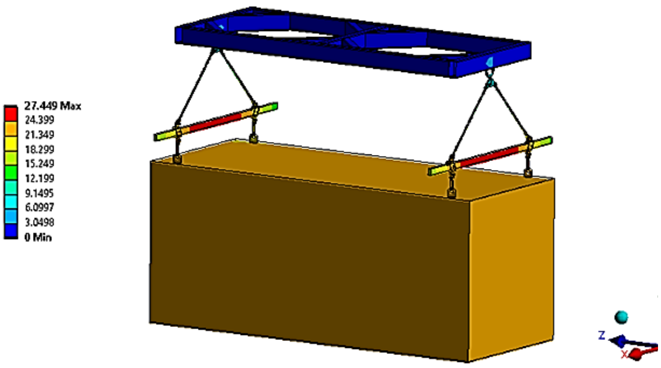


Figure 26 Total deformation at 120% loading

Equivalent stress

The maximum value of stress is at th top of the lifting beam and in slings(266.72MPa). In spreader bar the maximum value is 118.54MPa, but in the container the value is zero.

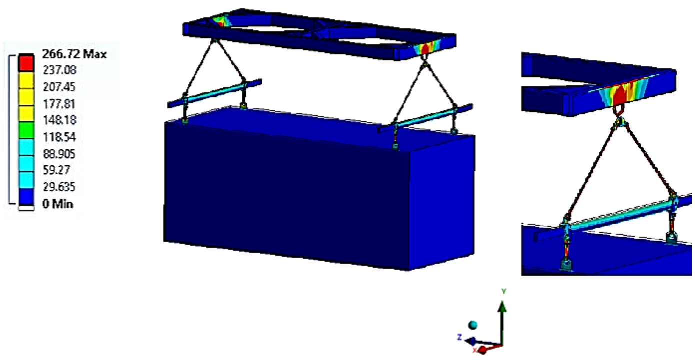


Figure 27 Equivalent stress at 120% loading

Total deformation

The maximum deformation is 38.991mm is at the spreader bar. In slings the maximum value is 21.662mm, whereas in container the value is 34.658mm.

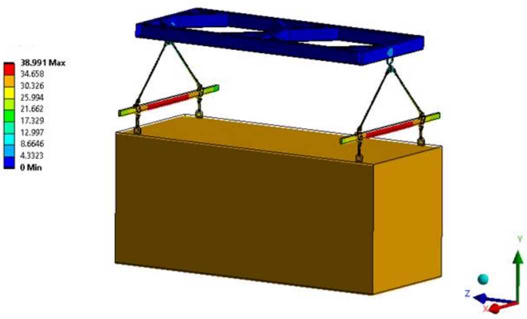


Figure 28Total deformation at 150% loading

Equivalent stress

The maximum value of stress is at th top of the lifting beam and in slings(321.23MPa). In spreader bar the maximum value is 183.32MPa, but in the container the value is zero.

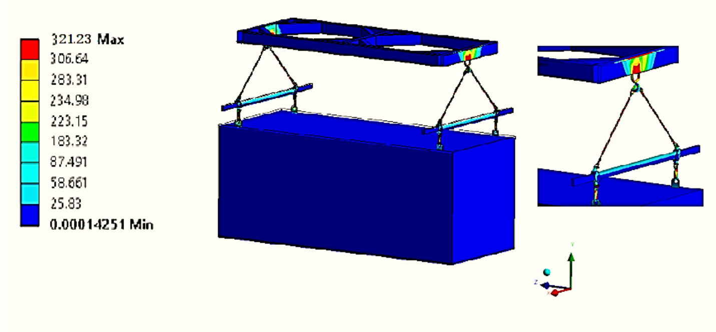


Figure 29 Total deformation at 100% loading

6. RESULT AND DISCUSSION

Table 1 Comparison of deformation and stress

Model name	MS	MSS	MSMS
Total deformation (mm)	133.99	96.793	22.398
Equivalent stress (MPa)	1498.1	1082.2	248.47

Table 2 Comparison of deformation and stress in slings

Model name	MS	MSS	MSMS
Total deformation in slings(mm)	59	64	17
Equivalent stress in slings(MPa)	1498.1	1082.2	248.47

Table 3 Comparison of deformation in spreader bar

Model name	MSS	MSMS
Total deformation in spreader bar(mm)	96.793	22.398

Table 4 Deformation and stress of model MSMS under inertial load

Total deformation (mm)	25.421
Equivalent stress (MPa)	232.47

Table 5 Deformation and stress of model MSMS with same model at different temperatures

Model name	MSMS	MSMS @40°C	MSMS @50°C	MSMS @60°C
Total deformation (mm)	22.398	25.268	25.41	25.55
Equivalent stress (MPa)	248.47	250.37	253.12	262.18

Table 6 Comparison of deformation and stress in MSMS at different percentage of loadings

Percentage of loading	100%	120%	150%
Total deformation (mm)	17.978	27.449	38.991
Equivalent stress (MPa	221.23	266.72	321.23

Modal 3 MSMS shows a drastic change in deformation when compared to Model 1 MS. In aspect of equivalent stress values, model MSMS shows a value of 248.47 MPa which is within the allowable limit. The allowable limit is taken as 240 to 300 MPa of mild steel. When conducting a thermal analysis on the feasible model, the total deformation and equivalent stress value shows an increment by 12.9%. When analyzing the damage of the whole combination by fatigue analysis, it is clear that the lifting beam and slings has weak point, so that they have to be strengthen. By following fatigue, a limit load analysis is conducted in the whole structure. It shows at 150 % loading, the system starts to fail. So the loading that can hold by the combination is within 150% of design load.

3. CONCLUSIONS

The project deals with the analysis of container lifting equipment such as slings and spreader bar. Three models were analyzed and an optimum model is finalized. Deformation and stress values were generated for all the three models. The optimum model shows a drastic change in deformation and stress value from the first model. The maximum deformation in the better model is 22.398mm. The stress value is 248.47MPa, which is within the allowable limit(240-300MPa).A thermal study conducted in the better modelThermal results shows the model is suitable for elevated temperatures. Fatigue analysis conducted in the whole structure and damage is analysed. Limit load analysis conducted to find the maximum range of load that the configuration can lift. It concludes the model with slings and multiple spreaders is an optimum solution for containers lifting mechanism.

ACKNOWLEDGEMENT

Authors would like to thank YCET, Kollam and Civil Engineering Department for providing an opportunity to do this study and making various resources available.

REFERENCES

1. Dhanshree V Damre (2020) "*Structural and Experimental Analysis of Lift Hook Bracket"* International Journal of Engineering Research and Technology (IJERT)ISSN:2278-0181 Vol.9 Issue 07.
2. Che Zaid Bin Zakaria and Nuraini Abdul Aziz (2018) "*Finite element analysis of spreader bar by utilizing the arrangement and connection of padeyes"* Journal of Mechanical Engineering and Technology. ISSN: 2180-1053 Vol. 10 No.2.
3. Yusuf Aytac Onur (2017) "*Investigation of the effect of the sling angle and size on the reliability of lifting hooks"* Transaction of The Society for Modelling and Simulation International. Vol. 94(10) 931–942.
4. Spoorthi Gopagoni, Naresh Kumar D (2017) "*A REVIEW ON LIFTING BEAMS"* International Conference on Research Innovations in Science Engineering and Management.ISBN:978-93-86171-53-5.
5. Zhaohui Qi1, Huitao Song2 "*Dynamic analysis of hook block for polar crane in nuclear power plant*" Journal of vibroengineering. Aug 2017, vol. 19, ISSUE 5. ISSN 1392-8716.
6. Leslie.P.Antalffy ,George A.Miller III , Kenneth D.Kirkpatrick , Anil Rajguru ,Yong Zhu (2016) "*The design of lifting attachments for the erection of large diameter and heavy wall pressure vessels*" International Journals of Pressure Vessels and Piping xxx (2016) 1-10.
7. Chima Clement (2015) *"Offshore Heavy Lift Design and Operations:Sling Tension in Heavy Lifts with Quadruple sling arrangement*". UNIVERSITY OF ABERDEEN.
8. Rashmi Uddanwadiker (2011) "*Stress Analysis of Crane Hook and Validation by Photo-Elasticity"* Engineering, 2011, 3, 935-941.