DESIGN AND ANALYSIS OF MULTI-DIRECTIONAL LOAD TRAILER WITH IN-BUILT JACK SYSTEM

K.M.Sathish Kumar[1*] and Dhanush.N[2]

[1]*BMS Institute of Technology&Management, Avalahalli, Bengaluru, 560064, India*
[2]*BMS Institute of Technology&Management, Avalahalli, Bengaluru, 560064, India*

Abstract

Trailer finds a larger application in the material movement and storage. The mechanism for unloading the material is to be given a due importance. Generally, the material gets unloaded from the trailer in only one direction. This has made the unloading of materials a difficult task in the compact streets. This paper is an attempt to design and analyse a mechanism which involves an inbuilt jack system which helps for multidirectional unloading. Finite element method was used to build the model and analyse considering the appropriate load and the constraints. Analysis was carried for Rear and left side dumping. The values of Von mises stress, Maximum and Minimum principal stress, Shear stress and Deformation values was obtained. It was observed that the stress and deformation values obtained are within the permissible limits. This inbuilt jack system can be considered as an effective system for multidirectional dumping of materials.

Keywords: Three way tipping mechanism, hinges.

1. Introduction

Material handling is considered as a process which involves the movement, storage, control and protection of materials. The focus is based on the various methods, mechanical systems and related controls used to achieve these functions. The material handling forms an essential element of any industrial and commercial environment. The cost involved in the material handling varies from 10-80% of the total cost. Hence, it is essential to design an efficient and safe material handling system. Trucks, tractors and tippers can be used for the material handling.

Un-loading of the material will be done using the hydraulic mechanism which lifts the trailer from one side when pivoted at the other end. The current mechanism is having only one side lifting mechanism. Generally, unloading of trailers will happen in a unidirectional way requiring larger amount space, time and fuel. Hence a multidirectional trailer mechanism can be introduced.

2. Literature Review

The important work done by the researchers are presented here to know the mechanism of the trailer.

Kiran Prakasha et al [1] have used a rotating hydraulic system for tilting the truck trolley at any given angle, lock it and unload the material in that position. They have used hand lever mechanism and used hand lever pumping. Construction of the prototype was made and used the power of an engine for getting the actuation.

Ashish R. et al [2] have designed and manufactured the multidirectional trolley. They have observed the difficulty of unloading the material in a compact area. They focussed mainly on the space limitations aspects. They have used the turn table cylinder to provide the rotational movement to unload the material.

Swapnil E et al [3] in their paper explained how the modern trailer can be modified and subsequently be manufactured. They have used the worm gear mechanisms and the pneumatic based working system which allows the multidirectional unloading of materials.

Ganesh Shinde et al [4] have developed a multidirectional dumping trailer. Here they have not used the impact force for the purpose of unloading. This mechanism is resulted due to the various difficulty observed during the dumping process. They have used the directional control to actuate the ram of a hydraulic cylinder. This will in turn lift the cabin of a trailer.

Roshan A et al [5] have discussed the development of three axis pneumatic advance trailer. The difficulties of the unidirectional dumping mechanism was addressed while fabricating this mechanism. They have used a compressor air which was stored when an engine drive is coupled to the compressor engine. This stored compressed air was later used to actuate the pneumatic cylinder which unloads the trailer.

P. Manasa et al [6] have used the pneumatically operated system to design and develop the trolley which unloads the material in three axes. They have analysed the various problems encountered during the dumping process because of the lack of availability of the space. They have developed the dumping mechanism which was efficient in operation.

3. Methodology

This paper considers the challenges come across during material unloading. This system involves use of 3-way tipping mechanism for the operation. The hinge joints of special type were used. Here, the unloading of the materials will happen in three various directions. While dumping the material rightwards, the cylinders will be in operation and the manual disconnections of the hinges was made. Similar procedure adopted while dumping the material sideways. In addition to that in-built jack has been provided on either side of the vehicle which will provide support while unloading materials and also acts as lifting device for maintenance purpose.

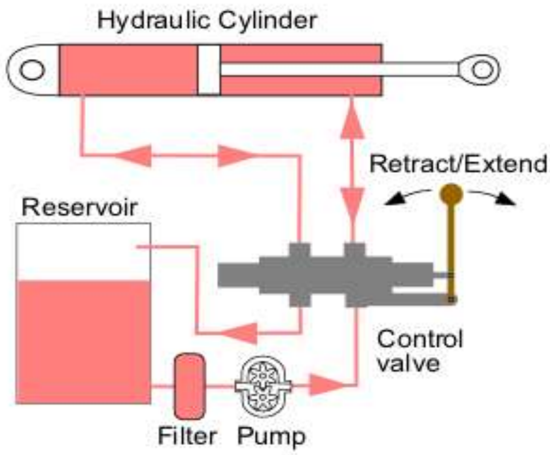

Fig.1. Hydraulic circuit

Fig.1. shows the hydraulic circuit, The power required for the cylinders is obtained from the pressurized hydraulic fluid. The cylindrical barrel in which a piston connected to a piston rod moves back and forth within the hydraulic cylinder for every cycle of operation. The one end of the barrel is closed by the cylinder bottom and the other end by the cylinder head where the piston rod comes out of the cylinder. The sliding rings and seals are present in the piston. The inside part of the cylinder is divided into two chambers, the bottom chamber, and the piston rod side chamber.

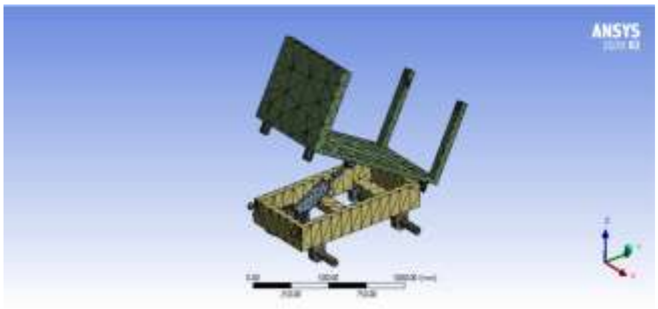

Fig.2. FE Model of chassis frame

Fig.2. shows the FE model of chassis frame assembly. The model is assigned with the respective materials based on design criteria and the various material properties is appropriately entered. From the analysis data, 23909 nodes and 8763 elements were created. The constraints have been designated for all the three ways of dumping. Here, displacement and rotational constraint was given in Y direction. A 1000 kg force in the negative Y direction was distributed on the upper frame of the trailer. Von Misses stress, Maximum and Minimum principal stress, Shear stress, Deformation values will be obtained for all the 3 ways of dumping.

4. Results and Discussions

The analysis results of the rear dumping and left side dumping are presented here:

4.1 Rear dumping analysis:

4.1.1 Von Mises stress:

Based on the load applied and with the given constraints, the Von mises stress of 1365 MPa was observed as shown in Fig. 3. For the stresses above 1365 Mpa, fracture of the model takes place. But theoretical stress calculations reveal a lesser value compared to maximum limit indicating the safe design.

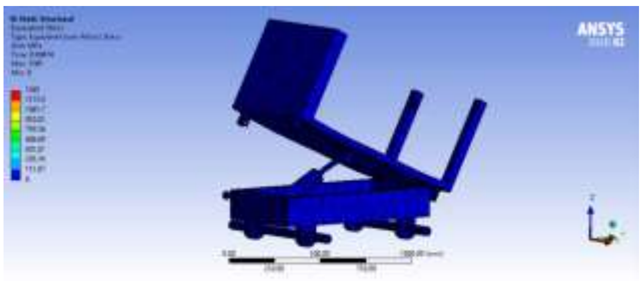

Fig.3. Von-mises stress

4.1.2 Deformation:

For the applied load and boundary condition the deformation is found to be 1.193 mm as shown in the Fig. 4.

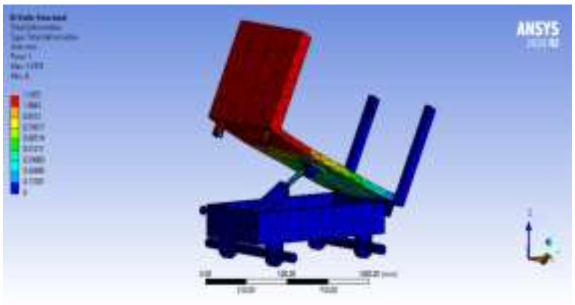

Fig.4. Deformation

4.1.3 Minimum principal stress:

Fig. 5 indicates the minimum principal stress which indicates the lower magnitude of Eigen value and observed to be 618.04 Mpa.

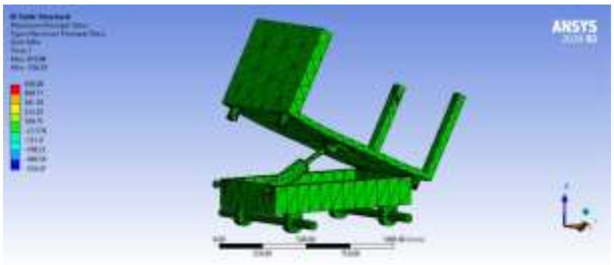

Fig.5. Minimum principal stress

4.1.4 Maximum principal stress:

For the given load and boundary conditions, the maximum principal stresses are observed to be 729.41Mpa and is as shown in Fig. 6.

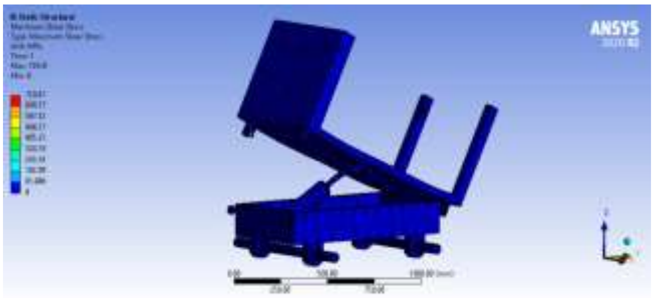

Fig.6. Maximum principal stress

4.2 Left side dumping Analysis.

4.2.1 Von Mises stress:

Fig.7. reveals the Von mises stress for left side dumping. Materials gets unloaded in the sideways. The stress obtained is 6870.5 MPa for the given load and boundary condition.

Fig.7. Von mises stress for left side unloading

4.2.2 Deformation:

For the load conditions applied, the value of deformation is found to be 1.1102 mm as shown in Fig. 8.

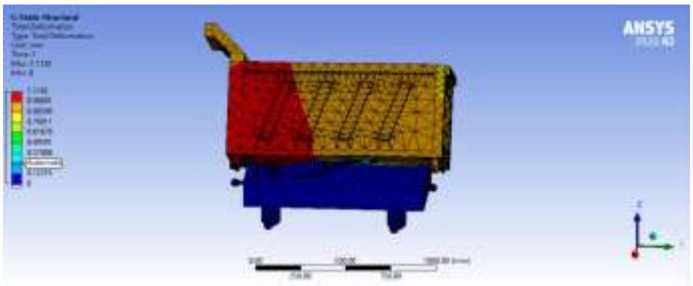

Fig.8. Deformation for left side dumping

4.2.3 Maximum principal stresses:

For the sideways method of dumping the maximum principal stress is found to be 883.71 Mpa.

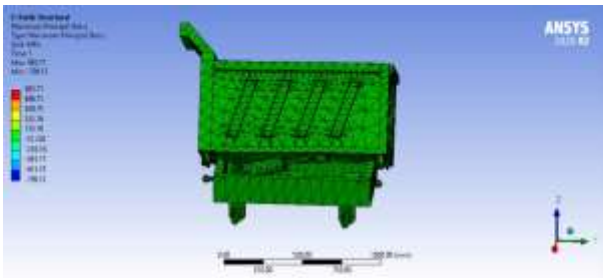

Fig.9. Maximum principal stress for left side dumping

4.2.4 Minimum principal stress:

Fig.10 represents the results of minimum principal stress for the sideways dumping and is observed to be 93.672 Mpa.

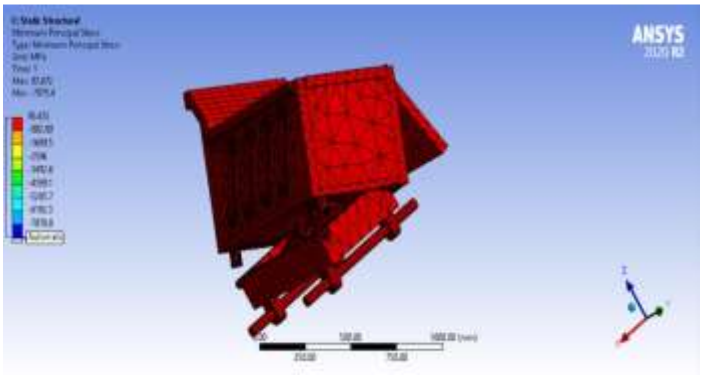

Fig.10. Minimum principal stress for left side dumping

4.2.5 Maximum shear stress:

Fig.11. reveals the maximum shear stress value as 3847.4 MPa for the applied load and boundary condition.

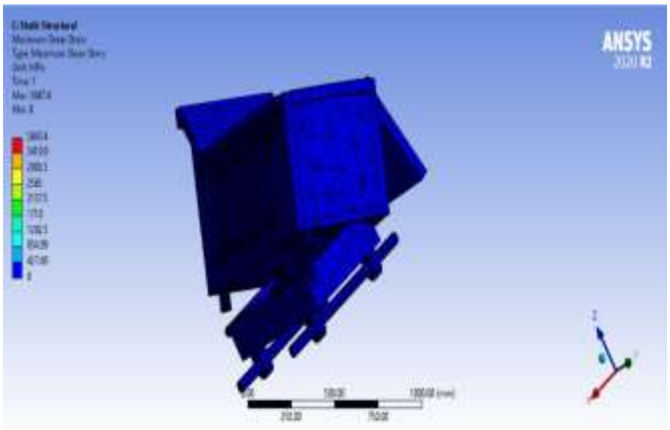

Fig.11. Maximum shear stress for left side dumping

The summary of the various stress and deformation values obtained for Rear and Left side dumping is shown in Table 1.

Table 1: Stress and Deformation values

	Rear dumping	**Left side dumping**
Von Mises stress (MPa)	1365	6870.5
Maximum principal stress (MPa)	729.41	883.71
Minimum principal stress (MPa)	618.04	93.672
Deformation (mm)	1.193	1.1102

5. Conclusions

From Finite Element Analysis, it is noted that the model can be utilised for various applications in efficient manner. The FE model was subjected to analysis in ANSYS software. The analysis was carried out considering the Rear dumping and Left side dumping. The Von Mises stress, Maximum Principal stress, Minimum Principal stress and Deformation values were obtained and studied for the application of the load and the boundary conditions for both the types of analysis. For the Rear dumping the values of the Von Mises stress, Maximum principal stress, Minimum principal stress and Deformation is observed to be at 1365 MPa, 729.41 MPa, 618.04 MPa and 1.193 mm. For the left side dumping the values of the Von Mises stress, Maximum principal stress, Minimum principal stress and Deformation is observed to be at 6870.5 MPa, 883.71 mPa, 93.672 MPa and 1.1102 mm. Results obtained are within the limits and are safer.

Compared to the conventional mechanism of unloading the material, multidirectional unloading promises to be more efficient. This provides the smoother operation. Incorporation of in-built jack will support the system during the unloading operation. This system can be used in the compact places resulting in reduced unloading time with faster operation. Because of the lesser number of components, the efficiency of the mechanism is improved.

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