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Research paper

Design and Analysis of Battery Box Lifter

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Abstract

The main objective of this project is to design and analyze the portable hydraulic scissor truck instead of manual pallet truck for the purpose of dropping and lifting battery box in AC Coaches to bring it outside for checking suspension/cradle of battery box for availability of all suspension bolts, signs of any cracks, corrosion, rusting and taking corrective action, if necessary. If suitable hydraulic cylinder with more power is used, this scissor lift can also be designed for heavy load purposes. This equipment will be simple to use. Frequent maintenance is not required for this equipment. In this paper we carried out detailed analysis of scissor mechanism members against bending and buckling failure and also focused on various design aspects and working of scissor mechanism and helpful to lifting and dropping of battery box without any failure with this scissor truck For existing practice the battery box dropping and lifting done by using manual pallet truck. It shows the design is unsafe handling, injury to employee and feel uncomfortable. It is very tedious for human being to lift a vehicle above from the ground. Even when a hydraulic jack is implemented, it requires manual work. In this era, every man in the world wants comfort and hence to relieve the problems faced by lifting and placing the battery box. Our project aims to reduce the manual work involved during the replacement of battery box instead of applying manual pallet truck. To validate our point and to reduce the above said difficulties faced, the design of hydraulic lift has been changed.

Keywords*: Air strainer; Human Error; Scissor Lift; Semi automatic method; Test rig*

1. Introduction

In Indian Railways AC Coach, the battery is fixed underneath inside a battery box. The battery performs in varying atmospheres like dust, vibration, temperature, restricted maintenance time and continuous discharging mode.
For that in every periodic overhauling (POH),we are going to drop the battery box, bring it outside and check suspension/cradle, suspension bolts, signs of any crack, corrosion, rusting and take corrective action necessary. After finishing the battery box is lifted to the coaches.
For existing practice it can be done by using pallet truck. The pallet truck will gives unbalance to lift or drop the battery box, that unbalance will affect unsafe handling, injury to employee and takes more time. Instead of using pallet truck we are going to design the hydraulic scissor lift or truck.
This can be done by hydraulic piston and scissor lift. These hydraulic systems are used mostly in transportation, aviation equipments, machine tools, etc.

1.1 Types of Lifting Devices

Mechanical Jacks usually have high lifting capacity.
i. Screw jack
ii. Scissor jack
iii. Floor jack
iv. Pallet jack

1.2 Drawback with Pallet Jack

- More wear of parts
- Heavy effort needed to operate
- Positioning of jack in exact position is cumbersome
- Unsafe handling
- Unbalance lifting

1.3 Alternate Method

To overcome the above drawbacks hydraulic scissor truck (lift) is used.

1.4 Hydraulic Jack (Lift)

The hydraulic jack is placed underneath the vehicle. Manual effort is required to operate the lever and to lift the battery box. So, if someone uses automatic operations, these difficulties can be overcome and time can be saved.
The braking mechanism used in hydraulic brakes consists of brake fluid, mostly ethylene glycol which enables to move the pressure from the control unit. This control unit is located near the operator who operates the vehicle. Real brake mechanism is located at or very near to the vehicle wheel.

1.5 Design of the Scissor Lift

Floor space area provided 2.1m x 0.87m
Technical Specification of the lift is:

Loading capacity - 1000 Kg
Height of rise - 430mm
Rise time - 40sec
Lowering time - 40sec
Initial height - 0 mm (ground level)
Total Mass - 2100 Kg

Fig. 1: Scissor Lift

2. Design Calculation

In design calculations, the design concepts are discussed. Depending upon the evaluation criteria, the design is modified further to increase the workability of the designed model. The following are the design considerations made during the process of designing and fabrication of the single acting cylinder.

- Functionality of the design
- Manufacturability
- Cost
- Availability

2.1. The Total Load of the Scissor Truck:

Mass to be put on the lift is 375 Kg
For mass in pallet,
Taking FOS as 1.5,
1000x 1.5 = 1500 Kg
Top frame mass is 360 Kilograms
Each arm of scissor mass is 53.57 Kg
Total mass of four Scissor arms is 214.28 Kg
Cylinder mounting link mass is 8 Kg
Cylinder mass is 18 Kg
So, Total mass is 2100.28 Kg
Total Calculated load is 2100.28x 9.81 = 20603.7468N
The force essential to uplift the load in a scissor lift is completely depend upon angle of link, length of link and cylinder mounting on the link,
Formula used:
End point distance, $S= L^2+a^2 -2aL*Cos\ \alpha$
Scissor arm length is 1.3 m
Angle of the cylinder with the horizontal link is α.
If cylinder is closed position, i.e, when the links of scissor are shut down, full force will be acting on the cylinder.
For calculations,
Let us consider α is 30
Thus, we get
F as 20603.7468 N
Selecting the cylinder with bore diameter of 60 mm,
Bore of the cylinder = $(3.14*602)/2=5652mm^2$
Pressure = (F/A) = (20603.7468/5652×106) = =36.4bar

3. Methodology

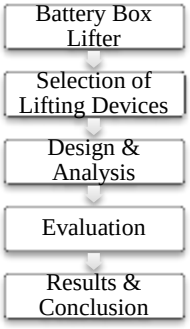

Fig. 2: Proposed Methodology

If the load is applied or removed, every part in the scissor lift has the capacity to accumulate or discharge energy when there is a process of loading and unloading. The deflection can be explained as the variations of all structures to the actual size of the battery box. It takes place in all places of lift i.e. Legs, Base, Structure, and Pinned Joints. In order to decrease the stress level and the redirection in the scissor lift, the force will be moving wih reference to scissor arm pair equally.

4. Design and Analysis

4.1 CAD Model

i) Pallet truck

Fig. 3: Pallet Truck

ii) Hydraulic Lifting Scissor Truck

Fig. 4: Hydraulic Scissor Truck

4.2 Modelling of Scissor Truck

Fig. 5: Top Platform

Fig. 6: Base Frame

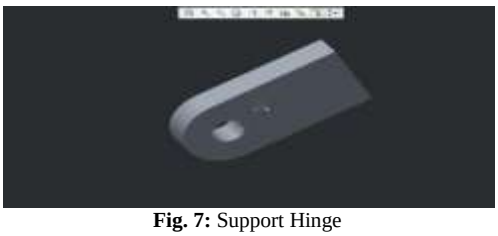

Fig. 7: Support Hinge

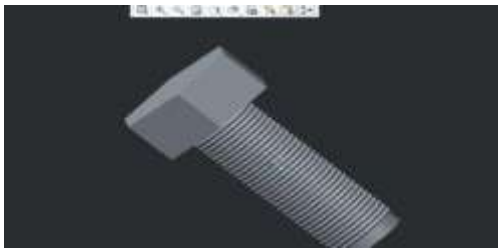

Fig. 8: Bolt

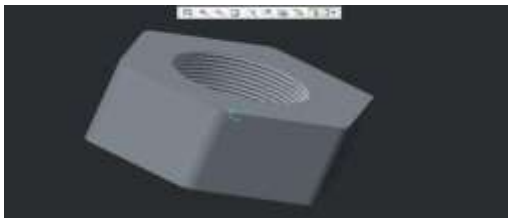

Fig. 9: Nut

4.3 Analysis of the Design

Equipment design with Software Many kinds of constructions exists for the scissors lift platform, but the main constituents of all lift platform are the upper platform, number of pairs of scissors and the bottom platform. In our design we have used wheels with motors attached to it at back for movement from one place to other. The numbers of the scissors pairs and the position of the hydraulic cylinders even have different positions, which lead to different lifting height of the platform. We achieve height of 1m for the upper platform from base. Upper platform dimension is about 2100x870 mm^2 which is enough for carrying bigger rated loading capacity.

There are three ways for the bottom platform to move as for dragging, automatic control through remote and force application at back. The bottom platform is designed so as to have pair of scissors mechanisms held symmetrically.

Scissor lift has two plates elevated on top of each other parallel to each other through the actuators, with small one on upside and large one is on conveyor railing.

Small one is for lifting the load vertically. Large one is for horizontal movement. Actuator is also attached. Geometric specifications were selected in order to bear standard trolley. By the application of design and analysis software, components can be designed and analysis can be done.

ANSYS Procedure for Static Analysis:

- FE model is built
- Material Properties is listed
- Boundary Condition is applied
- Using LS Command from the ANSYS, problem is solved.

Material Properties of Mild Steel Lift Lift:

- E, Young's modulus is 210 MPa
- NUXY, Poisson's ratio is 0.303
- Mass density is 7860 Kg/m^3
- Co-efficient of Damping is 0.008

Summary for Optimization of Design:

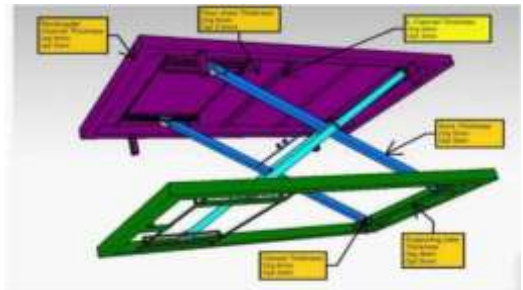

Fig. 11: Optimization of Design

4.3.1. ANSYS Report of Pallet Truck:

Our proposed mechanism was designed using CREO 2.0. Then it was analyzed in ANSYS under variable loading.

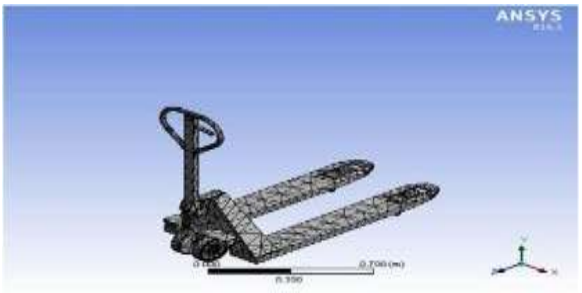

Fig. 12: Mesh

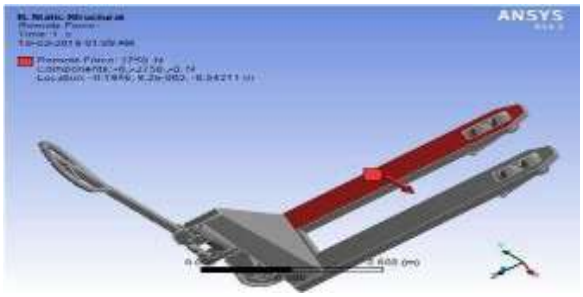

Fig. 13: Force

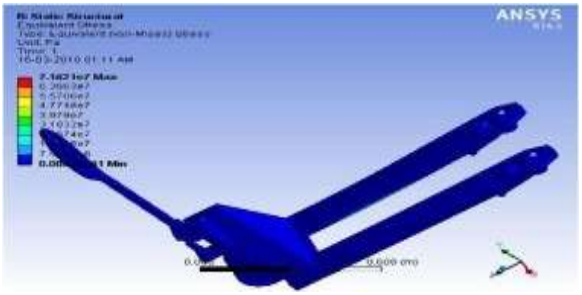

Fig. 14: Equivalent stress

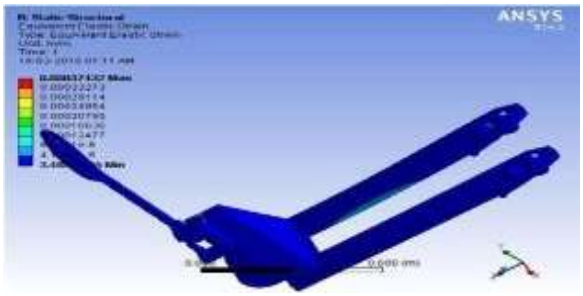

Fig. 15: Equivalent strain

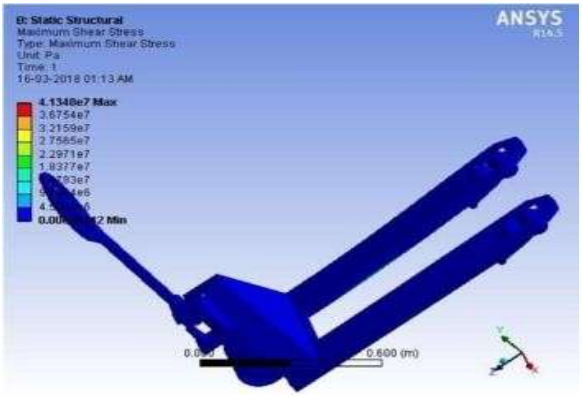

Fig. 16: Maximum shear stress

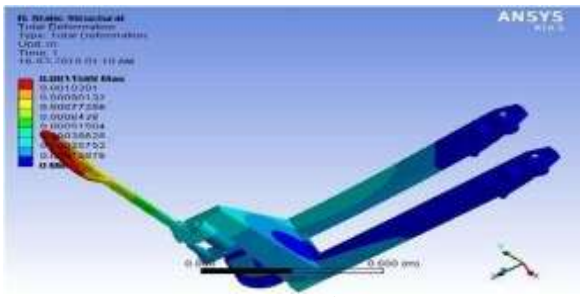

Fig. 17: Total Deformation

4.3.2 ANSYS Report of Hydraulic Scissor Truck

Our proposed mechanism was designed using CREO 2.0. Then it was analyzed in ANSYS under variable loading.

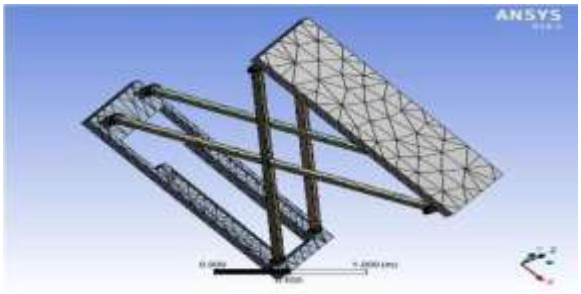

Fig. 18: Mesh

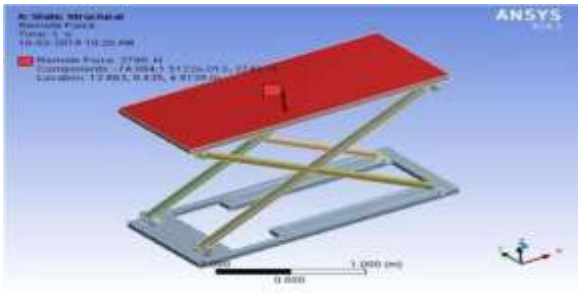

Fig. 19: Force

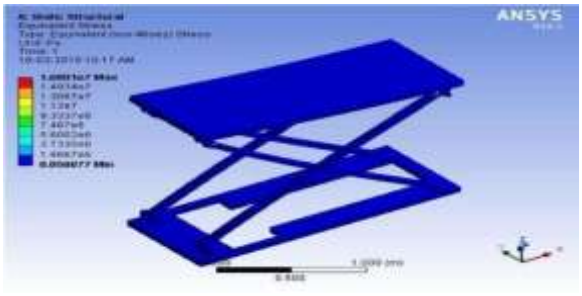

Fig. 20: Equivalent Stress

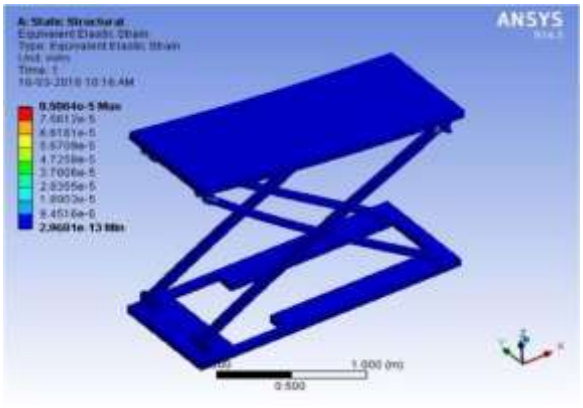

Fig. 21: Equivalent Strain

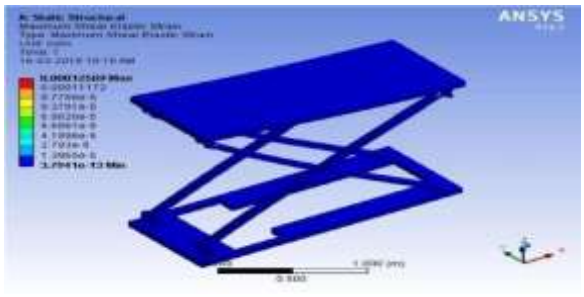

Fig. 22: Maximum Shear Stress

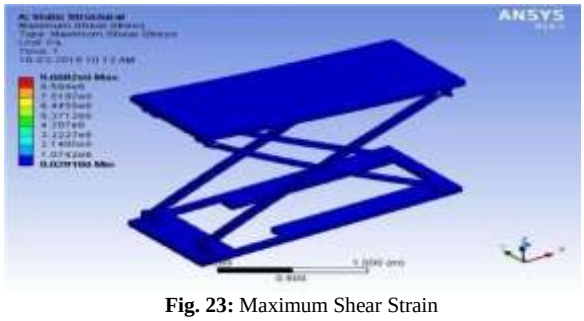

Fig. 23: Maximum Shear Strain

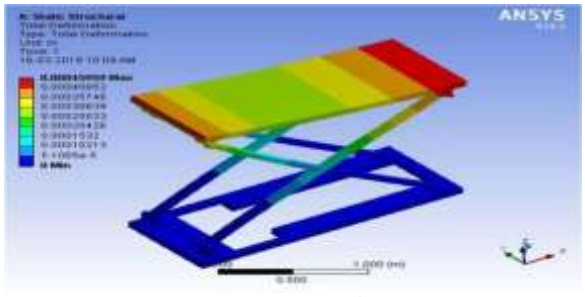

Fig. 24: Total Deformation

5. Results and Discussions

LOAD FACTOR	PALLET TRUCK	SCISSOR TRUCK
Max Shear Stress	4.134×10^7 Pa	9.6682×10^7 Pa
Max Shear Strain	0.000537	0.00012569
Max Equivalent Stress	7.1621×10^7 Pa	1.601×10^7 Pa
Max Equivalent Strain	0.00037432	0.0000851
Total Deformation	0.0011588 m	0.00045959 m

The pallet truck and scissor truck modeling and analysis had been done. Both designs are safe. In max shear stress, max shear strain, max equivalent stress, max equivalent strain, total deformation in the scissor truck is better than pallet truck.

6. Conclusion

This Project focuses on various aspects related to lifting mechanism and its design. The Static analysis reflects that the selected mechanism is functional and most likely reliable for its purpose. Motor operates an hydraulic cylinder which inturn operates the portable work platform.. Also whole device is motorized and with help of control panel allows user to travel from one place to other. The scissor lift can be designed for high load also if a suitable high capacity hydraulic cylinder is used. The hydraulic scissor lift is simple in use and does not require routine maintenance. In this paper we carried out detailed analysis of scissor mechanism members against bending and buckling failure and also focused on various design aspects and working of scissor mechanism and helpful to lift and drop of battery box without any failure with this scissor truck.

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