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Integrated CAD/CAE analysis for frame design of a two-post lift

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Abstract
*The aim of this paper is to determine the effect oftemperature o linear alkylbenzene (LAB) yield from a Nigeria Refinery LAB plant. The rerun (LAB) column was simulated using Aspen HYSYS. The simulation was done at temperatures between 280°C and 360°C at temperature difference of 20°C (ΔT =20°C).*There was an *increase in the average weight percentage fraction of linear alkylbenzenes at the bottom stream temperature from 280°C to 340°C and a slight decrease at 360°C. Bottom stream temperature280°C and pressure of 115Kpa yielded the highest LAB percentage yield of 99.4%.*
Keywords: *lifting bridge; automobiles; garage; scissor; two-post lift; lifting column; lifting arm*

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I. INTRODUCTION

The rapid expansion of the automotive industry has led to a significant increase in the number of vehicles worldwide. This growth has underscored the importance of high-quality maintenance and repair solutions to ensure vehicle reliability and safety. Among the essential tools in automotive maintenance workshops are car lifts, which facilitate under-chassis inspections and repairs by providing easy access for technicians.[1][2]

Car lifts are categorized into various types, including single-post, two-post, four-post, and scissor lifts, each with distinct capabilities and applications. However, the two-post lift stands out due to its versatility, stability, and capacity to handle a wide range of vehicle sizes, from passenger cars to light trucks. Despite its widespread use, optimizing the design of two-post lifts to meet evolving demands for efficiency, safety, and cost-effectiveness remains a critical engineering challenge.[3]

This study focuses on the structural design and strength calculations for a two-post lift to address the specific requirements of modern automotive workshops. By employing precise engineering methods, the research aims to ensure that the lift meets durability and stability criteria under static loads while maintaining a compact and cost-efficient design. Furthermore, this work lays the groundwork for future optimization in terms of material usage and dynamic load considerations.

The remainder of this paper is organized as follows. Section 2 provides an overview of lifting equipment for automobiles, detailing the design and operational principles of various lift types. Section 3 presents the research methodology and key findings, including geometric and strength calculations for the two-post lift. Finally, Section 4 concludes with recommendations for further research to enhance the performance and reliability of lifting systems.

II. OVERVIEW OF LIFTING EQUIPMENT FOR AUTOMOBILES

A. Overview of Lifting Equipment

Automobile lifting equipment is a type of lifting machine used in maintenance and repair. Its primary purpose is to raise the vehicle, creating ample space underneath the chassis for technicians to work easily. There are various types of lifting equipment with different capacities and lifting power. Some use mechanical transmission, others use hydraulic transmission, or a combination of mechanical and hydraulic systems. Mechanical transmission can involve chain drives, screw-nut drives, or a combination of both. However, they all share the same primary power source: electrical energy. This energy, through an electric motor and gear or chain transmission, can convert the rotational motion of the motor shaft into rotational motion of a screw shaft. The screw-nut mechanism then converts this rotation into linear upward or downward motion of the lifting frame, thus lifting or lowering the vehicle. Alternatively, through a hydraulic pump, the rotational motion of the electric motor can be converted into potential energy in the form of high oil pressure. This oil pressure is then transformed into the linear motion of the lifting frame using hydraulic cylinders and parallelogram mechanisms.

B. Common Types of Car Lifts

a) Single-Post Lift

This type of lift has a simple design and uses hydraulic oil for transmission. However, its stability is low, and its lifting capacity is small, making it suitable only for small vehicles such as 4-seater passenger cars.

Figure 1. Single-post lift with four lifting arms

b) Two-Post Lift

The two-post lift is similar to the single-post lift but provides higher stability and a greater lifting capacity.

Figure 2. Two-post lift with overhead structure

c) Four-Post Lift

The four-post lift can handle heavier vehicles and offers high stability due to its large base area. However, it has limited working space and occupies a significant area in garages or workshops.

Figure 3. Four-post lift

d) Scissor Lift

This type of lift can raise heavy vehicles and offers high stability. It provides a relatively spacious working environment. Some models are highly portable and can be moved anywhere within a garage.

Figure 4. Scissor lift

III. RESEARCH RESULTS

A. Establishing objectives and input parameters for the two-post lift

The descriptive method used here disregards the effects of dynamic loads. In practice, during operation, dynamic loads occur whenever the mechanism moves, starts, or stops. The magnitude of these loads depends on the mass and acceleration during movement.

a) Structural diagram and input parameters

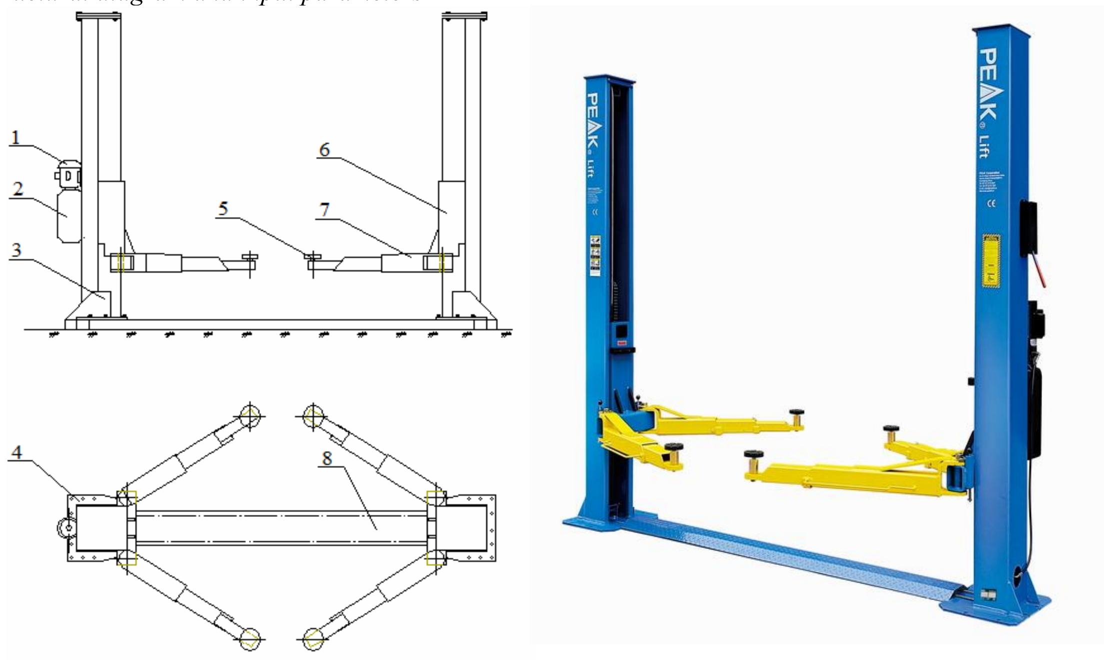

Figure 5. Two-post lift

1. Electric motor; 2. Hydraulic oil tank; 3. Lift leg; 4. Baseplate; 5. Pad; 6. Lift platform; 7. Lift arm; 8. Steel cable cover

b) Input parameters

The car lift must be capable of lifting all types of four-seater vehicles brought into the garage. Therefore, the specifications of the vehicle with the largest size and weight among the aforementioned cars were chosen, such as the Honda Civic or pickup trucks.

Wheelbase	Overall length	Overall width	Overall height	Ground clearance	Curb weight	Gross weight
2700 mm	4630 mm	1799 mm	1416 mm	133 mm	1317 kg	1740 kg

Table 1. Dimensions of the Honda Civic

B. Some calculation results

a) Geometric Parameters

Based on the reference data, the input parameters are selected as follows:

- H1 - Average height of the technician (taken as 1800 mm).

- H2 - Safety height from the technician's head to the underside of the vehicle (taken as 260 mm).
- H3 - Height of the lifting platform (600 mm).
- H4 - Additional height for the top of the column (chosen as 160 mm).
- H5 - Height of the lift when in the lowest position (approximately equal to the ground clearance of the vehicle, taken as 100 mm).

From these dimensions, the following column parameters are determined:

- Column height: $H_{column} = H1 + H2 + H3 + H4 + H5 = 2820$ mm
- Lifting height at the highest position: $H_{lift} = H1 + H2 = 2060$ mm
- Lifting height at the lowest position: H5 = 100 mm
- L1 - Average width of the vehicle (taken as 1900 mm).
- L2, L3 - Safety width from the side of the vehicle to the column surface (both taken as 460 mm).
- L4 - Maximum length of the lift arm.
- L5 - Minimum length of the lift arm.

From these dimensions, the following parameters for the distance between the two lifting columns are determined:

- Width between the two columns: 2820 mm.
- Maximum length of the lift arm: 1170 mm.
- Minimum length of the lift arm: 762 mm.
- Maximum lifting capacity: 4000 kg.

The selected material for construction is CT38 steel, with the following properties:

- Density: $\gamma = 7800$ kg/m^3
- Yield strength: $\sigma_{ch} = 3800$ kg/cm^2

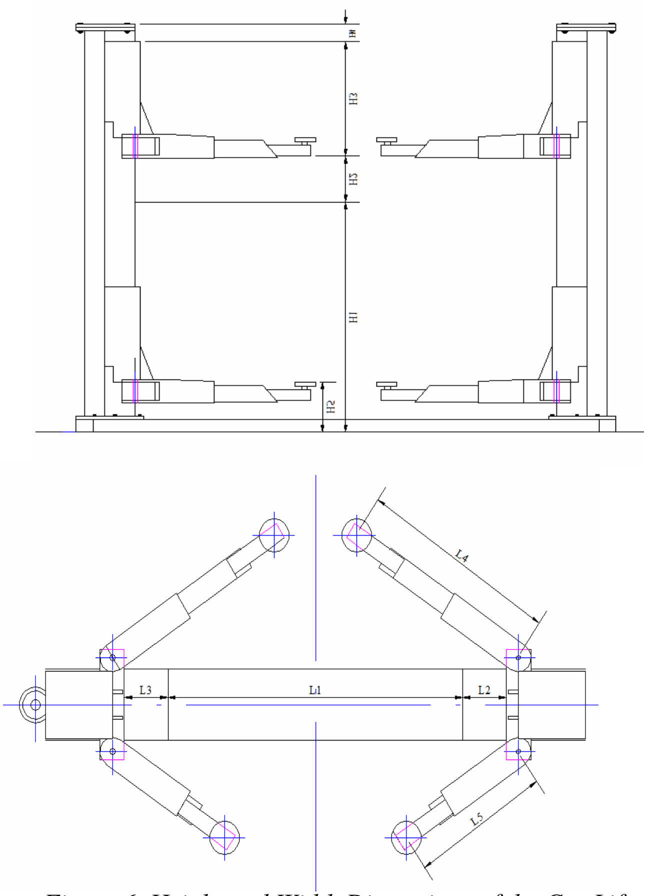

Figure 6. Height and Width Dimensions of the Car Lift

b) Strength calculation for the lift arm

Structural Diagram:

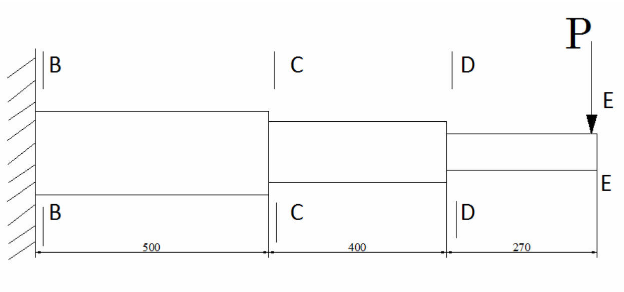

Figure 7. Strength calculation diagram of the lift arm

The structure of the arm consists of three rectangular pipe sections nested together to adjust the arm's reach (the arm can extend or retract to adapt to the type of vehicle being repaired).

The cross-section is designed as shown in the figure:

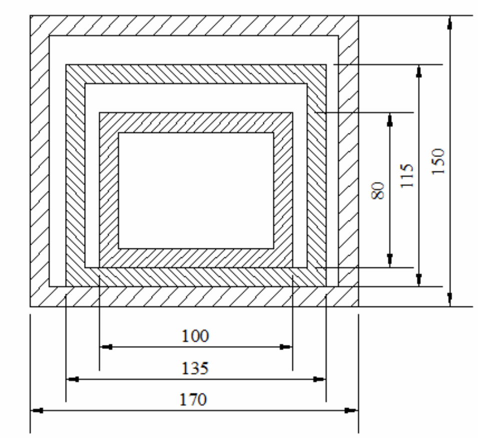

Figure 8. Cross-sectional view of the lift arm

The bending moment at each cross-section is determined using the formula:

In which:

- Bending moment at the cross-section
- Weight of the lifted load applied (since the lift has four arms,)
- Length of the section being calculated

Using the formula above, we get:

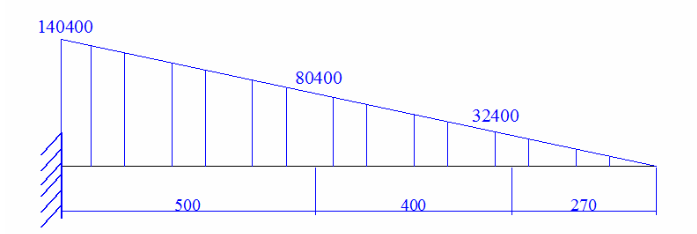

Figure 9. Bending moment diagram of the lift arm

Bending strength verification at critical cross-sections.

- The D-D cross-section is a hollow rectangular shape, as shown in the diagram:

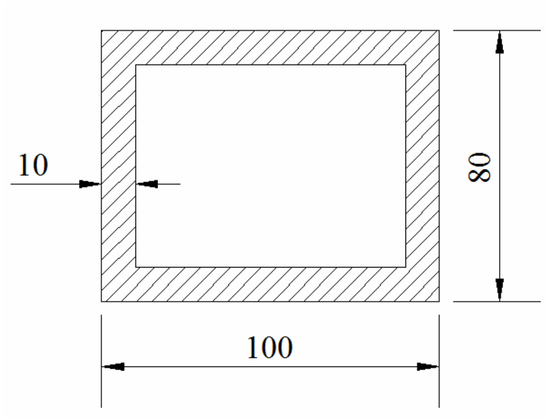

Figure 10. Cross-Section D-D

- Width
- Height
- Thickness

Cross-Sectional Area:

Bending Resistance Moment:

Stress at Cross-Section D-D:

Thus, the selected cross-section D-D satisfies the load-bearing condition.
- The C-C cross-section is a hollow rectangular shape, as shown in the diagram:

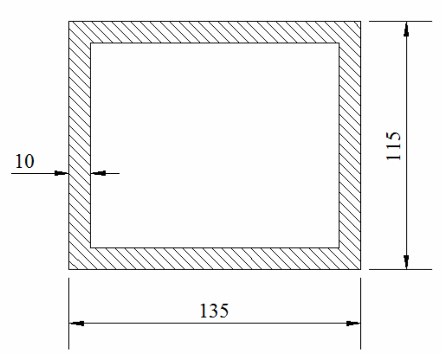

Figure 11. Cross-Section C-C

- Width
- Height
- Thickness

Cross-Sectional Area:

Bending Resistance Moment:

Stress at Cross-Section C-C:

Thus, the selected cross-section C-C satisfies the load-bearing condition.
- The B-B cross-section is a hollow rectangular shape, as shown in the diagram:

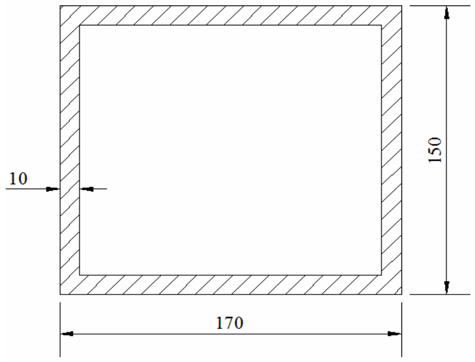

Figure 12. Cross-Section B-B

- Width
- Height
- Thickness

Cross-Sectional Area:

Bending Resistance Moment:

Stress at Cross-Section B-B:

Thus, the selected cross-section B-B satisfies the load-bearing condition.

To ensure the arm achieves high durability during operation, additional steel plates with a thickness of 10 mm are added to the steel tubes of the arm. The cross-section is designed as shown in the illustration.

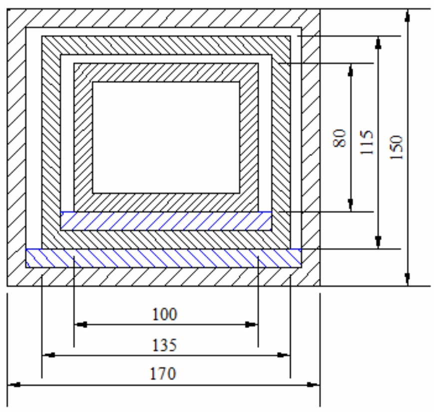

Figure 13. Cross-section of the arm with additional steel plates added

c) Determining the force on the piston rod

The most critical cross-section is calculated at the base of the column under the load applied to the lifting arms when they are at their highest position.

From this, the moment diagram of the lifting column under the load (when lifting the car to the highest position) can be constructed.

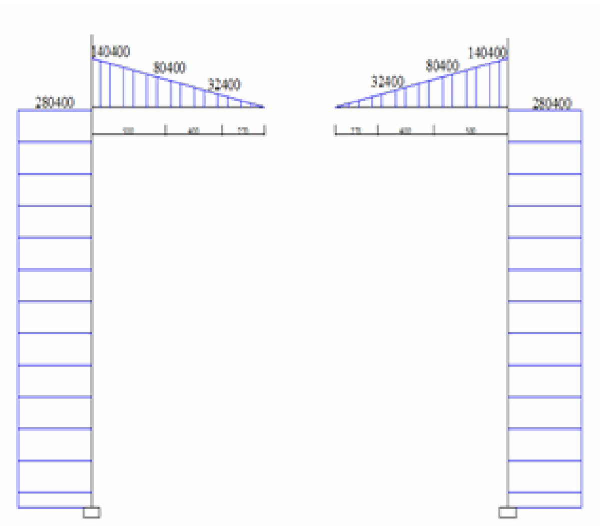

Figure 14. Moment diagram of the lifting column

The cross-section of the column is selected with a shape as illustrated:

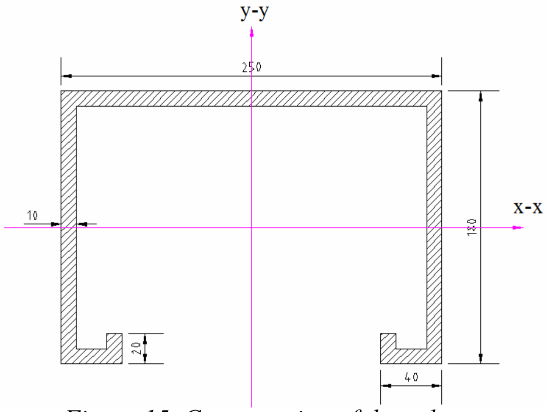

Figure 15. Cross-section of the column

The cross-sectional area is determined using the formula:

In which:
 is the area of the outer rectangular shape:
 are the areas of the hollow inner components

Therefore,

The thickness of the steel is chosen as
Calculating internal forces at the critical cross-section of the column:

In which
 : Force acting on one arm,
 : Weight of the column itself,
 : Weight of the lifting arm,
 : Weight of the lift platform,
Substituting into the formula:

The stress at the column's cross-section is determined using the formula:

We need to determine the section modulus :

In which
 is the moment of inertia of the column's cross-section
 is the distance from the farthest point to the y-axis,

With is the moment of inertia of the outer rectangular section
are the moments of inertia of the individual inner sections relative to their central axes

Substituting into the formula:

From this, we deduce

Thus, the selected steel structure of the column satisfies the load-bearing condition.

d) Stability assessment of the lifting column

To ensure proper functioning of the column under load conditions (during vehicle lifting), its stability must be evaluated.

The column is evaluated using the following formula:

In which
is the force acting on the lifting arm,
is the cross-sectional area of the column
is the slenderness coefficient, determined from tables based on the slenderness ratio
is the allowable bending stress

Determine the Slenderness Coefficient :

In which
- Length conversion coefficient (for the load diagram acting on the column of the lift,)
- Height of the column ()
- Radius of gyration:

Substituting the given values into the formula, the calculation proceeds as follows:

From the table, we have = 0.89

Conclusion: The lifting column satisfies the stability condition during operation.

e) Simulation results

In this section, we present the outcomes of the finite element analysis (FEA) conducted using CAD/CAE software. The results provide critical insights into the structural integrity and performance of the two-post lift under loading conditions. The simulations were carried out with a maximum lifting capacity of 4,000 kg, and the findings are summarized as follows:

The Von Mises stress distribution (*Figure 16*) reveals the critical stress zones within the lifting arms and columns. The maximum stress occurred at the joint between the lifting arms and the baseplate. This stress value remains below the yield strength of the material (CT38 steel, 380 MPa), confirming the structural safety under static load conditions.

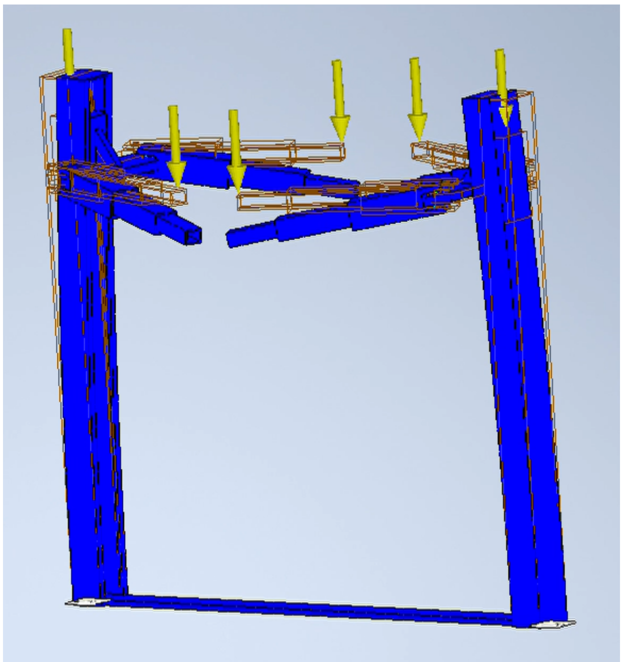

Figure 16. Result of Von Mises Stress

The 1st principal stress analysis (*Figure 17*) identifies the areas subjected to maximum tensile stress. These stresses are predominantly concentrated near the upper section of the lifting columns. The results demonstrate adequate resistance to tensile loading, with no risk of material failure.

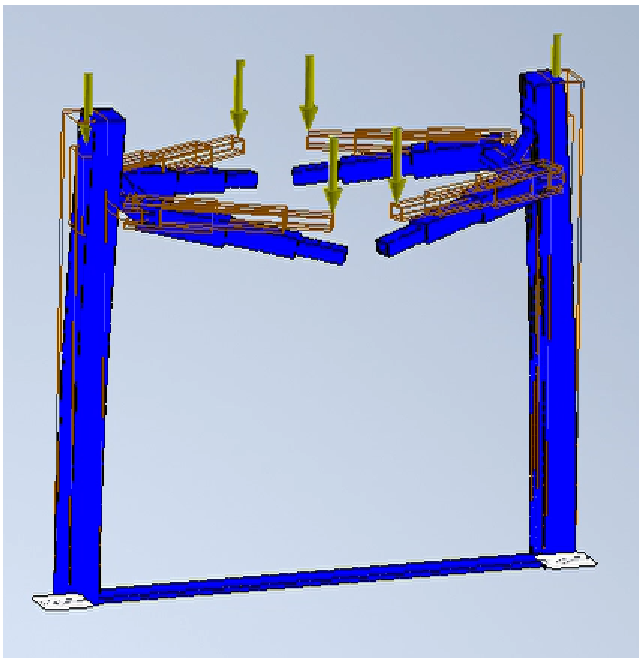

Figure 17. Result of 1st Principal Stress

The 3rd principal stress (*Figure 18*) highlights compressive stress zones. The highest compressive stress is located at the base of the lifting columns. This result is within acceptable limits, indicating that the structure can effectively withstand compressive forces during operation.

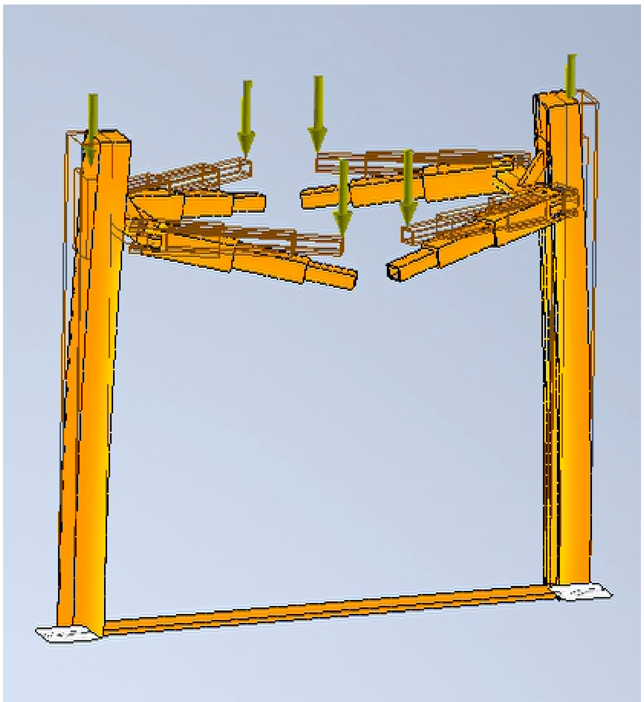

Figure 18. Result of 3rd Principal Stress

The displacement simulation (*Figure 19*) shows the deformation profile of the two-post lift under maximum load. This minimal deformation confirms the rigidity of the design and ensures consistent performance under operational conditions.

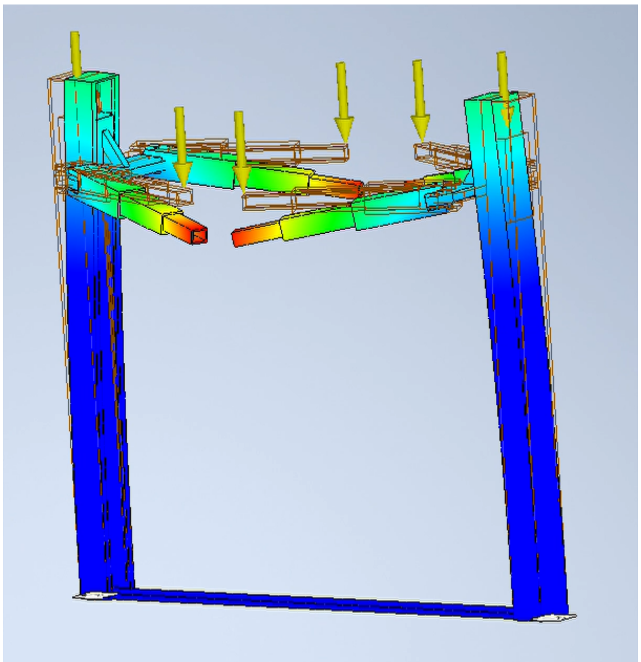

Figure 19. Result of Displacement

III. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

a) With the calculation results presented, it is clear that the mechanisms ensure working conditions as well as meet durability and stability requirements.

b) The optimization problem to reduce material costs, weight, and size of the lift has not been addressed yet.

B. Recommendations

a) Continue researching methods that use artificial intelligence (optimization for continuous variables) and improvements that can be applied to optimization problems to reduce size and weight.

b) The problem has been analyzed at special points and static loads, but the time to dampen oscillations, as well as other resonant oscillations and dynamic loads, has not been controlled yet. It is necessary to consider these parameters in calculations to achieve more accurate results.

REFERENCES

[1]. Abiola K. "Strategy for Development of the Petrochemicals Industry in Nigeria" A paper submitted to the Department of chemical Engineering, University of Lagos.

[2]. Aderogba, K. A. (2011)" Significance of Kaduna River to Kaduna Refining and Petrochemicals Complex" African Journals, Vol. 5 (5), Serial No. 2 Pp.83-98.

[3]. Ahmad Daaboul. "LAB Project - Environmental Impact Assessment" Section 3 pp. 4 – 42

[4]. Irena O. D, Dolganov I.M and Ivanshkina E.N (2001) "Development of Computer Modeling System as a Tool for Improvement of Linear Alkylbenzene Production" J. Petroleum and Coal. Vol. 53,No.4, Pp. 244 – 250

[5]. Sadal O.I.,Marwa S.M.,Wala T.A. (2012) "Linear Alkylbenzene Production from Kerosene" Seminar presented to the Department of Chemical engineering University of Khartoum.

[6]. Thaer, A. A. (2010), "Process Simulation Analysis of HF Stripping Column Using HYSYS Process Simulator" J. of Engineering Sciences /Vol.17/No.2, pp.87 – 96.

[7]. UOP (1990) "Linear Detergent Alkylation Unit, General Operating Manual" pp. 1 –610.

[8]. UOP (2004) "Linear Detergent Alkylation Unit, General Operating Manual" Pp. 1 – 112.

[9]. Xiaoming J, Gang Rong and Shuqing Wang (2003), "Modelling and Advanced Process Control (APC)For Distillation Columns of Linear Alkylbenzene Plant Key Lab of Industrial Control Technology, Institute of Advanced Process Control, Zhejiang University, pp1-6.