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Development of a Mini Hydraulic Jib Crane

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ABSTRACT
A mini hydraulic manual-operating jib crane capable of lifting loads up to 1000kg was designed and constructed to address the need for material handling in workshops, maintenance facilities and small industrial applications. The design analysis of the crane was conductedusing Solid Works 2022 Version and ANSYS 2021 R1 Version.Structural analysis was carried out to ensure material strength, stability and ergonomic features for improved operator comfort and safety. At the maximum load of 1000kg the stress of the arm was 8.37MPa and deformation was 0.95mm. Stress of the column was 1.2MPa and deformation is 0.003mm. Hydraulic pressure was 6.175MPa (895.6 psi).Low carbon steel was used for fabrication of the crane's components due to its ductility, toughness, weldability, adequate strength, cost-effectiveness and ease of use.After the design and construction, the crane was tested, and it demonstrated the ability to lift 1000kg loadwith a minimum and maximum lifting height of 600mm and 2200mm respectively.The crane meets safety and functional requirements for material handling in workshops, maintenance facilities and it can be useful in small and medium scale enterprises.

KEYWORDS: Jib Crane, Manual Operating, hydraulic, FEA

I. INTRODUCTION

Hydraulic jib crane is a specialized type of portable jib crane equipped with a hydraulic cylinder to raise and lower the jib boom efficiently and smoothly. The hydraulic lifting system may be powered by electric power or manual hand pump, allowing precise control when maneuvering heavy loads. This enhanced lifting mechanism offers more consistent performance compared to manual cranes, and is commonly used for automotive repair, small-scale manufacturing, or any application where variable lifting heights and reduced operator effort are important.Activities like welding, fabrication, molding, overhauling, and repairs take place in a workshop environment [1]. In all these activities, the movement of parts and components of varying weights is involved. There are many ways of moving such items from one place to another, including lift trucks, electric cranes, trolleys, and manual cranes [2].

Today, jib cranes are widely used in construction, manufacturing, and shipping industries for lifting and moving heavy loads [12]. They are available in many different sizes and configurations, with lifting capacities ranging from a few hundred pounds to tens of thousands of pounds. The jib crane continues to be an important tool in the modern world, enabling the transportation of heavy goods and the construction of large buildings and structures [13].

The hydraulic jib crane works on the principle of Pascal's law. When the handle is operated, the plunger reciprocates, then the oil from the reservoir is sucked into the hydraulic cylinder during the upward stroke of the plunger. This pressurized oil lifts the load up, which is placed on the crane arm [5].

Manual lifting of heavy materials in the workshop is accompanied by hazards associated with lifting, which include back pains, spinal cord injuries, and dropping of heavy items, which leads to damage of equipment. The use of the jib crane for movement of heavy equipment and loadswill increase safety and efficiency in material handling operations, enabling sound professional best practices aimed at reducing causes of injury, accident prevention, and reduction. Hence, the design and construction of the jib crane to increase efficiency and reducingthe cost of production. This work aims to design, construct and testing of mini hydraulic manual operating jib crane with a maximum lifting capacity of (1000kg), with a minimum and maximum lifting height of 600mm and 2200mm respectively.

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II. METHODS

Solid Works and ANSYS were used for carrying out the design analysis of the jib crane.

Factors considered in design of the jib crane

Designing a mini hydraulic manual operating jib crane involves considering various design factors to ensure safety and functionality. Here are thedesign factors considered:

- **Load Capacity:** Determine the maximum weight the crane will need to lift. Ensure that crane's structural components and materials can handle the load safely.
- **Arm Length:** Decide on the length of the jib arm based on the required reach and clearance. Ensure that the arm can support the load at its maximum reach.
- **Materials:** Choose materials for the crane's construction, such as steel, based on strength, durability, and weight considerations.
- **Base and Mounting:** Design a stable base or mounting system to support the crane. Ensure it is securely anchored to the base structure.
- **Maintenance Access:** Ensure that components requiring maintenance, such as lubrication points or inspection areas, are easily accessible.
- **Compliance with Standards:** Follow relevant industry and safety standards sand regulation for crane design and construction.
- **Testing and Inspection:** Conduct through testing and inspection to verify the crane functionality and safety before putting it into service.
- **Environmental Condition:** Consider the environment in which the crane will operate. If it's outdoors, it accounts for factors like weather resistance and corrosion protection.
- **Future Expansion:** Leave room for potential future modification such as adding electric motor.
- **Quality Control:** Implement quality control measures during fabrication and assembly to ensure the crane meets design specifications.
- **Load Testing:** Perform load testing to verify that the crane can safely handle its maximum rated load.

Design analysis of the jib crane

The following components of the jib crane were modelled and analyzed using FEA in Solid Works 2022 and ANSYS 2021 software: the arm, the column and the base.

Design analysis of the Arm

The arm of the jib crane was analyzed using the FEA in ANSYS. Static structural tool in which the model and loading behavior of the arm can be analyzed was used. The arm was then converted to STEP file in order to export the model into the ANSYS FEA workbench for the analysis [23].

Meshing of the arm (Figure 1) was carried out using tetrahedron element of size of 10mm, which produces 56,523 nodes and 28,049 elements on the arm with high smoothing.

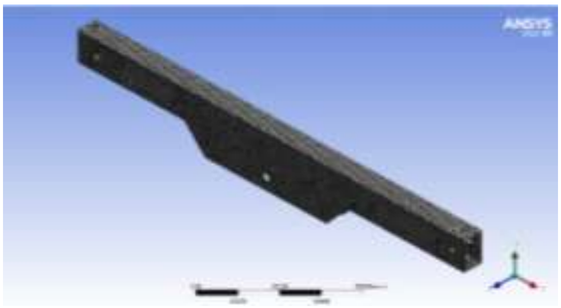

Figure 1: Meshing of the arm of the Jib crane

The boundary conditions were applied to arm and force of 9810N, the load that is to be lifted by the crane was applied to it to simulate the lifting process. The analysis was conducted. The results were computed and documented.

Design analysis of the Column

The column of the jib crane was analyzed, static structural tool and the eigen value buckling tool in the ANSYS workbench to analyze the loading behavior of the column. The model of the column was converted to STEP file for the analysis [24]. The properties of the low carbon steel were defined in the engineering material tab. The column was discretized using tetrahedron element mesh method to achieve patch conformity on the column (Figure 2). The mesh element body size used is 10mm which produces 140,583 number of nodes and 93,695 number of elements on the mast of the jib crane with high smoothing. Boundary conditions were applied to the column and a force of 9991.1N was applied to the arm of the jib crane which is connected to column. The analysis was conducted, and the result was computed.

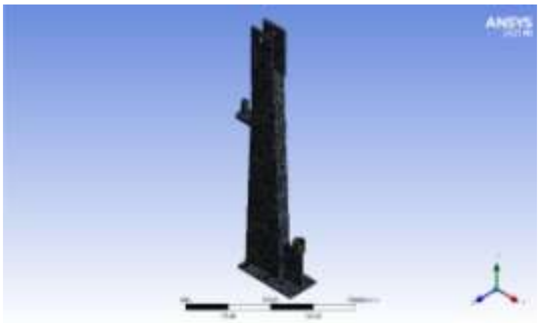

Figure 2: Meshing of the Jib crane column

Design analysis of the Base

Analysis was also carried out on the base of the jib crane. Static structural analysiswas to study the behavior of the loads applied to the base of the jib crane. The model of the base was converted to STEP file for the analysis. Properties of the low carbon steel were used in the analysis of the base.

The model of the base was meshed using tetrahedron element mesh method using elementsof body size of 20mm (Figure 3). The meshing produces 76,674 nodes and 38,138 elements on the base with high smoothing.Boundary conditions were applied to the base. A force of 11,616N was applied to the top surface of the base to simulate the all the load that is acted on the base. The analysis was conducted and result computed.

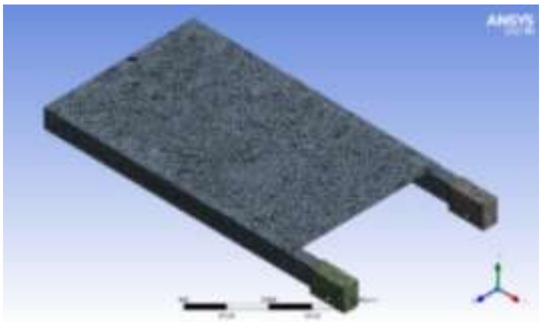

Figure 3: Meshing of the base of the Jib crane

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Design analysis of lifting mechanism (hydraulic jack)

A hydraulic jack in a jib crane refers to a component used for raising and lowering the jib (the movable arm) or for other lifting or supporting tasks. Jib cranes often utilize hydraulic jacks to provide the necessary force and precision for lifting and maneuvering heavy objects. The capacity of the hydraulic jack to be used is determined based on the load to be lifted which is 1000kg in this case.

- **Force (F)** required to lift a 1000kg load:

F = mass (m) x acceleration due to gravity (g)…...1
F = 1000 kg x 9.81 m/s²
F ≈ 9810 N

- **Area of the piston(A):**

$A = \pi \times (\text{diameter}/2)^2$ …….2
$A = \pi \times (0.045\ m / 2)^2$
$A \approx 0.001588\ m^2$

- **Hydraulic pressure (P):**

P = F / A ……18
$P = 9810\ N / 0.001588\ m^2$
P ≈ 6,175,000 Pa or 6.175 MPa or 895.6 psi

- **Piston diameter (d)**.

$A = \frac{\pi d^2}{4}$ ………19

$d^2 = \frac{4A}{\pi}$

$d = \sqrt{4A/\pi}$

$d = \sqrt{\frac{4 \times 0.001588}{3.142}}$

d = 0.04496m = 44.9mm

- **Volume of the hydraulic tank (V).**

$V = l * w * h$ ……20

$V = 100mm * 100mm * 400mm$

$V = 4{,}000{,}000\ cubic\ millimeter\ (mm^3)$

But

$1\ liter = 1{,}000{,}000\ mm^3$

So, $4{,}000{,}000\ mm^3 = 4 liters$

Therefore, the volume of the hydraulic tank is $4\ liters$.

Fabricationof the Jib Crane

The fabrication of the jib crane involved several stages, which varied depending on the design and materials used. The following stages were used in the fabrication of the jib crane:

- **Material selection and procurement**: This stage involves selection and procurementof the necessary materials for the fabrication of the components of the jib crane. The components are hydraulic jack, metal sheets, rod, wheels, and other components required for the jib crane.

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- **Fabrication of components**:The fabrication process typically began with the fabrication of the frame, base, column and jib (arm) of the crane using cutting, drilling and welding to produce the various components of the jib crane.
- **Assembly of components:** The fabricated components were assembled as shown in Figure 4. The entire assembly was checked for stability and smooth operating of all moving components. The jib crane was cleaned, rough edges were smoothed, and the entire unit was painted with corrosion-resistant paint suitable for outdoor use.
- **Cost of fabrication:** The total cost of fabricating the jib crane is N523,000:00

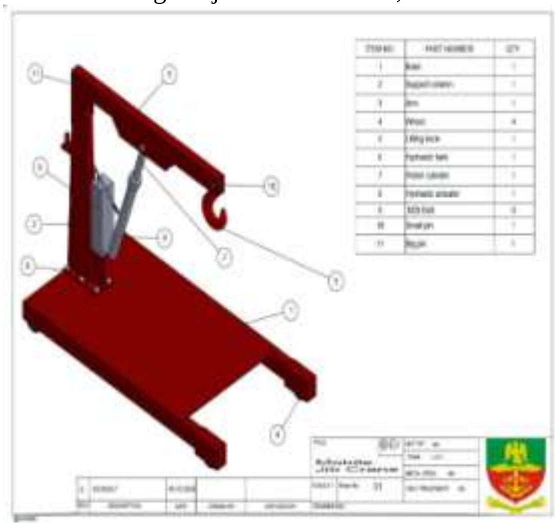

Figure 4: Isometric view of the assembled jib crane

Testing of the Jib Crane

After fabrication and assembly of the crane, testing of the jib crane was conducted to ensure that it is functioning properly, and it meet the required material handling standards. The test was carried out with various loads ranging from 50-1000 kg and the test showed that as the load is increased, the effort required for actuating of the lift cylinder increased i.e. Increase in load is directly proportional to effort required.

III. RESULTS AND DISCUSSION

The results and discussions for the design analyses of the components of the jib crane: the arm, column, and base are presented below:

Deformationresult for the analysis of arm

The deformation result (Figure 5) shows that the arm has a maximum displacement of 2.27mm occurring at the free end of the arm. This indicates that the 1000kg weight subjected at the end will cause deflection of 2.27mm on the arm. The average deformation in the arm is 0.95mm meaning that the arm will only have small deflection.

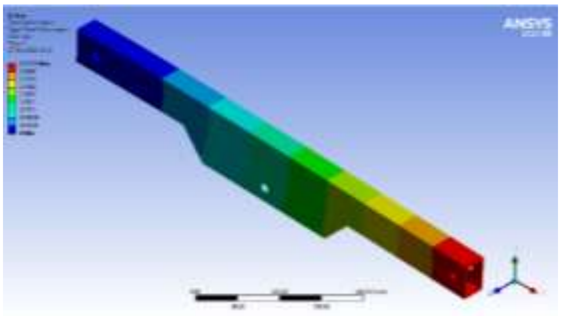

Figure 5: Result of deformation of the arm

Stress result for the analysis of arm

The arm is subjected to stresses due to the applied load acting on the arm, the result of the stress (Figure 6) shows that the maximum stress of 218.66MPa occur at the hole where the arm is located to the column, this happened due to the stress concentration of the hole, the average stress of the arm is 8.37MPa, this showed that the body other than the stress concentrated area will experience little stresses.

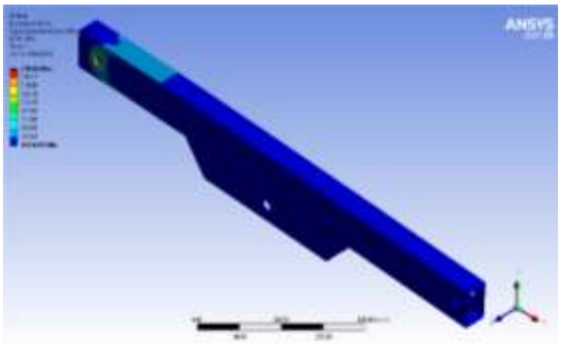

Figure 6: Stress result of the arm

Factor of Safety of the analysis of arm

The results of Factor of safety in the analysis of the arm shows that the minimum factor of safety is 1.92 which occurs at the same location where the maximum stress occur, the factor of safety is greater than 1 which indicates that the jib crane arm will not fail under the applied load.

Deformation result for the analysis of column

The deformation result of the column (Figure 7) shows that the column has the maximum deformation of 0.0147mm at the top of the column where the arm is connected to the column, the average deformation in the column is 0.003mm

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which is negligible, this showed that the column will only have little deflection.

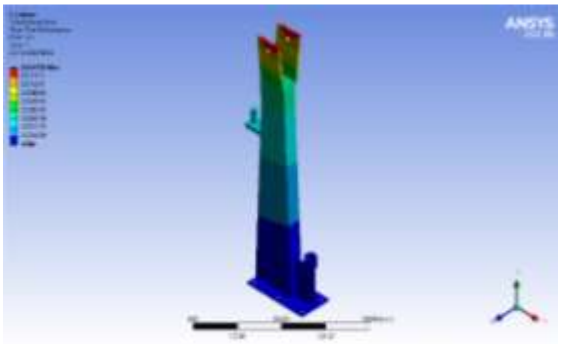

Figure 7: Result of the deformation of the column

Stress result for the analysis of column

The result of stress for the analysis of the arm is shown in Figure 8. The maximum stress on the column of the jib crane is 12.445MPa due to the applied load acting on the connecting point between the column and the arm of the jib crane, the average stress of the column is 1.22MPa, this showed that the body other than the stress concentrated area will experience little stress.

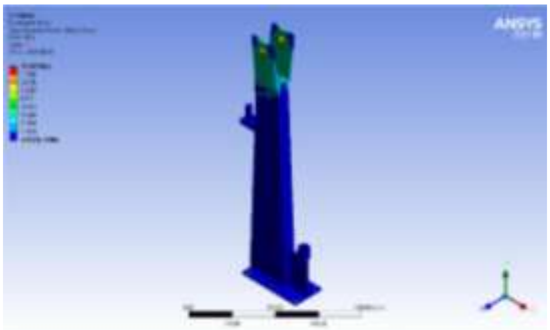

Figure 8: Stress result of column

Buckling result for the analysis of column

The result(Figure 9) shows that the buckling behavior of the column when load is subjected to it. The buckling load from Euler's theory shows that the load multiplier of 26.90mm will cause the column to deform 1mm when subjected to the design and weight of the arm on the column.

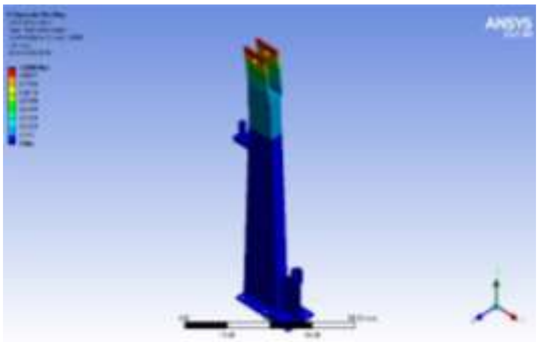

Figure 9: Buckling result of the column

Deformation result for the analysis of base

The deformation result (Figure 10) shows that the base of the jib crane has a maximum displacement of 2.27mm which occurs at the top surface of the base, this shows that the base will support the load on it without alarming deflection, the average deformation in the base is 0.95mm.

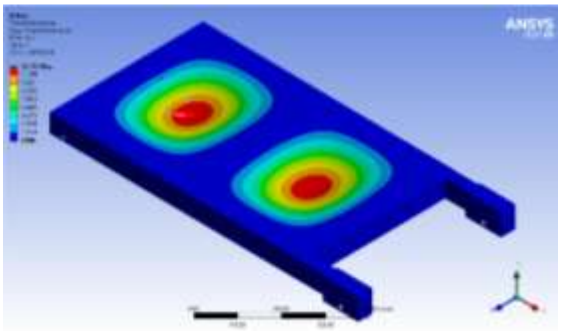

Figure 10: Result of the deformation of the base

Stress result for the analysis of base

The stress induced on the base of the jib crane is shown in the (Figure 11), the maximum stress on the base is 143.56MPa which occur where the load to be lifted is placed as well as the location where the hydraulic tank, hydraulic cylinder and the mast are mounted due to the applied load on the base, the average stress of the arm is 20.57MPa, this showed that the base is not subjected to high stress.

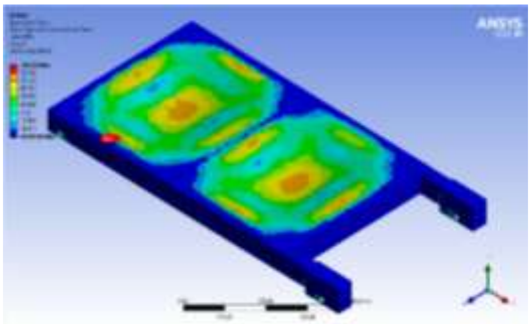

Figure 11: Stress result of the base

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Factor of Safety for the analysis of base

The FEA results (Figure 12) showed the Factor of safety of the jib crane base as the strength of the material is compared to the stresses of the base to determine if the arm will fail or not under the loading condition, the results shows that the minimum factor of safety is 2.43 that occur at the location where the wheels are connected, the factor of safety is greater than 1 which indicates that the base of the jib crane will not fail under the applied load.

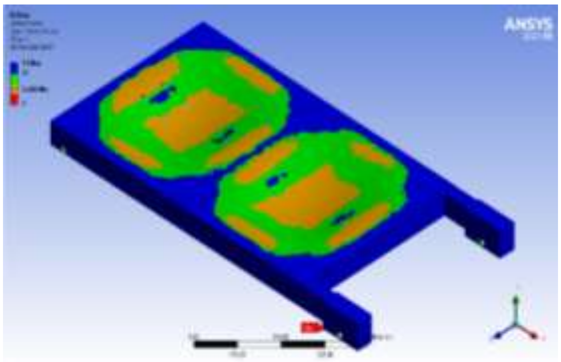

Figure 12: Factor of safety of the jib crane

IV. CONCLUSION

A mini hydraulic jib crane that handled a load of 1000kg was successfully developed. Design analysis of the components of the crane was performed using FEA approach in SOLIDWORKS version and ANSYS. Materials were locally sourced for the fabrication and assembly of the components of the jib crane. The assembled jib crane was subjected to lifting and lowering tests to evaluate its performance and stability. The crane was able to lift the load of 1000kg successfullywith a minimum and maximum lifting height of 600mm and 2200mm. The crane demonstrated efficient performance during both unloaded and loaded tests.

REFERENCES(REVIEW THE LIST OF THE REFERENCE BASED ON THE NEW CONTENT)

[1]. Annett, M., Grossman, T., Wigdor, D., and Fitzmaurice, G. (2019). Exploring and understanding the role of workshop environments in personal fabrication processes. ACM Transactions on Computer-Human Interaction (TOCHI), 26(2), 1-43.

[2]. Kay, M. G. (2012). Material handling equipment. Fitts Dept. of Industrial and Systems Engineering North Carolina State University, 65.

[3]. K Sainath, M.M Baig, M.A Farooky, (2014); Mohammed Siddique Ahmed, M. Uddin, F.R Azhar, M. Shaffi. IOSR Journal of Engineering 4(7), 15-28.

[4]. Zhang, D., Li, H., Li, Z., Guo, C., Shen, X., Xiong, Z., & Qu, F. (2024). Heavy Lift Cargoes Handling Machinery. In Handbook of Port Machinery (pp. 1691-1813). Singapore: Springer Nature Singapore.

[5]. Zhang, Z., Pan, W., and Pan, M. (2022). Critical considerations on tower crane layout planning for high-rise modular integrated construction. Engineering, Construction and Architectural Management, 29(7), 2615-2634.

[6]. Xiaolin C, Liu Y (2019) Finite element modeling and simulation with Ansys (2nd ed) Taylor and Francis

[7]. Beer P. F. (2020). Mechanics of Materials(8th ed.). McGraw-Hill.