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Design of Hydraulic Floor Crane

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Abstract: *These hydraulic floor cranes provide an efficient, low-cost alternative to other material handling equipment. Strong, robust, sturdy and built to very standard, these cranes are maneuverable in loading, unloading and shifting of heavy loads. Crane structure consists of chassis, vertical column, horizontal arm, and the hydraulic pump with cylinder assembly. The box crane can take heavy loads effectively, avoids damage under rough and unskilled handling. The hydraulic crane was invented in Newcastle by William Armstrong in about 1845 to help load coal into barges at the Quayside. In this paper the design and analysis of a hydraulic floor crane having arm motion in the vertical.*

Keywords: Hydraulic, Crane, Design, Analysis, etc.

I. INTRODUCTION

A crane mounted on a truck carrier provides the mobility for this type of crane. This crane has two parts the carrier, often referred to as the Lower, and the lifting component which includes the boom, referred to as the Upper. These are mated together through a turntable, allowing the upper to swing from side to side. These modern hydraulic truck cranes are usually single-engine machines, with the same engine powering the undercarriage and the crane. The upper is usually powered via hydraulics run through the turntable from the pump mounted on the lower. In older model designs of hydraulic truck cranes, there were two engines. One in the lower pulled the crane down the road and ran a hydraulic pump for the outriggers and jacks. The one in the upper ran the upper through a hydraulic pump of its own. Many older operators favor the two-engine system due to leaking seals in the turntable of aging newer design cranes. Generally, these cranes are able to travel on highways, eliminating the need for special equipment to transport the crane unless weight or other [Document title] JNEC AURANGABAD 8 size constrictions are in place such as local laws. If this is the case, most larger cranes are equipped with either special trailers to help spread the load over more axles or are able to disassemble to meet requirements. An example is counterweights. Often a crane will be followed by another truck hauling the counterweights that are removed for travel.

In addition, some cranes are able to remove the entire upper. However, this is usually only an issue in a large crane and mostly done with a conventional crane such as a Link-Belt HC -238. When working on the job site, outriggers are extended horizontally from the chassis then vertically to level and stabilize the crane while stationery and hoisting. Many truck cranes have slow-travelling capability (a few miles per hour) while suspending a load. Great care must be taken not to swing the load sideways from the direction of travel, as most anti-tipping stability then lies in the stiffness of the chassis suspension. Most cranes of this type also have moving counterweights for stabilization beyond that provided by the outriggers. Loads suspended directly aft are the most stable, since most of the weight of the crane acts as a counterweight. Factory-calculated charts (or electronic safeguards) are used by crane operators to determine the maximum safe loads for stationary (outrigged) work as well as (on rubber) loads and travelling speeds.

II. LITERATUREREVIEW

Material Handling is the movement, storage, control and protection of materials, goods and products throughout the process of manufacturing, distribution, consumption and disposal [1].

It is mainly used for lifting heavy things and transporting them to other places. It uses one or more simple machines to create mechanical advantage and thus move loads beyond the normal capability of a man. Cranes are commonly employed in the transport industry for the loading and unloading of freight, in the construction industry for the movement of materials and in the manufacturing industry for the assembling of heavy equipment [2].

The focus is on the methods, mechanical equipment, systems and related controls used to achieve these functions. Hydraulic cranes are an important part of the material handling equipment's. The hydraulic cranes that are being used work on electrical supply or manual power [3].

A crane is a type of machine, generally equipped with a hoist, wire ropes or chains, and sheaves, that can be used both to lift and lower materials and to move them horizontally [4]

III. CRITERIA AND CONDITIONS

3.1 Design Criteria

There are three major considerations in the design of cranes. 1. The crane must be able to lift the weight of the load; 2. The crane must not topple; 3. The crane must not rupture.

LIFTING CAPACITY,the lifting capacity of hydraulic crane mainly depends on following.

1. **The Lever:** A balance crane contains a horizontal beam (the lever) pivoted about a point called the fulcrum. The principle of the lever allows a heavy load attached to the shorter end of the beam to be lifted by a smaller force applied in the opposite direction to the longer end of the beam. The ratio of the load's weight to the applied force is equal to the ratio of the lengths of the longer arm and the shorter arm, and is called the mechanical advantage.
2. **The Pulley:** A jib crane contains a tilted strut (the jib) that supports a fixed pulley block. Cables are wrapped multiple times round the fixed block and round another block attached to the load. When the free end of the cable is pulled by hand or by a winding machine, the pulley system delivers a force to the load that is equal to the applied force multiplied by the number of lengths of cable passing between the two blocks. This number is the mechanical advantage.
3. **The Hydraulic:** This can be used directly to lift the load or indirectly to move the jib or beam that carries another lifting device. Cranes, like all machines, obey the principle of conservation of energy. This means that the energy delivered to the load cannot exceed the energy put into the machine. For example, if a pulley system multiplies the applied force by ten, then the load moves only one tenth as far as the applied force. Since energy is proportional to force multiplied by distance, the output energy is kept roughly equal to the input energy (in practice slightly less, because some energy is lost to friction and other inefficiencies). The same principle can operate in reverse. In case of some problem, the combination of heavy load and great height can accelerate small objects to tremendous speed. Such projectiles can result in severe damage to nearby structures and people. Cranes can also get in chain reactions; the rupture of one crane may in turn take out nearby cranes. Cranes need to be watched carefully.

3.2 Stability

For stability, the sum of all moments about any point such as the base of the crane must equate to zero. In practice, the magnitude of load that is permitted to be lifted (called the "rated load" in the US) is some value less than the load that will cause the crane to tip (providing a safety margin). Standards for cranes mounted on ships or offshore platforms are somewhat stricter because of the dynamic load on the crane due to vessel motion. Additionally, the stability of the vessel or platform must be considered.

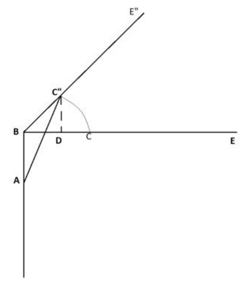
IV. CALCULATION

The angle subtended by the arm for maximum height at point B is calculated by basic construction and trigonometry L (BC”) = 140 mm L (C” D) = 120 mm ∠ C” BC = $\sin^{-1}$ (120/140) = 58.99 ° ∠ C” BC = 59° 2.

Hinge for cylinder to be attached = 140mm from point. ‘B’ along column Hinge for piston to be attached = 140 mm from point ‘B’ along arm

∴∠BAC = ∠ABC = 45°

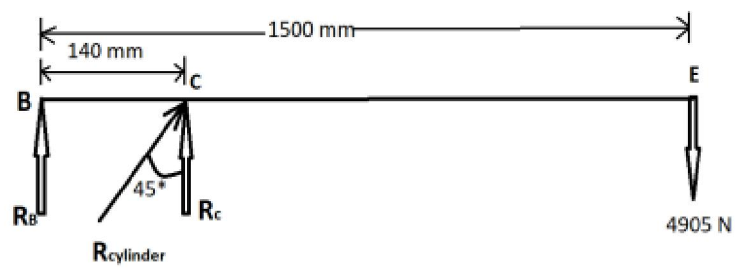
3 In fig. L (AB) = 140 mm. L (BC”) = 140 mm L (AC”) = 278 mm.



Applying Lami's Theorem [l(AB)/Sin(C")] = [l(BC")/Sin(A)] = [l(AC")/Sin(B)] ∴ Sin (A) = 1/ {l (AC")/Sin (B)} x l (BC") Sin (A) = [Sin (90+59)/278] x 140 Sin (A) = 0.259 ∠A = ∠BAC" = 15.03° i.e., Angle subtended by cylinder with vertical column when piston is fully extended i.e., maximum height [upper position]

Forces on cylinder:

Various forces are act on arm at different lifting positions. 1 At zeroth position Overhanging arm is perpendicular to the vertical column.



Reaction on horizontal arm

Taking moment @ point 'B' M_B = 0 = 4905 x (1500) – R_C x (140) R_C = 52.553 KN Reaction indirection of cylinder will be given by $R_{Cylinder}$ = 52.553 x (1/√2) = 37.272 KN

From Calculation we got,

R_B = 47.648 KN, R_C = 52.553 KN, Cylinder = RC Cos (15.03°) = 50.755 KN

Calculation for Crane Stability

Forces on part one- Load applied to the arm at the hook is 500kg i.e., =500*9.81=4905 N Volume of overhanging arm= L*B*H =900*48*48 – 900*45*45 = 251100 cu mm = 251100 x10-9 cu m Density of the material used is = 7850 kg/cu m Mass of the overhanging arm= Volume*Density=251100 x 10-9 x7850 = 1.971 kg • Weight of the overhanging arm = 1.971 *9.81= 19.335 N

Force on part two- Volume of remaining arm= L*B*H= 600*48*48 – 600*45*45= 167400 cu mm= 167400 x 10-9 cu m Density of material used = 7850 kg/cu m • Mass of the remaining arm = Volume*Density = 167400 x 10-9 x 7850 =1.314 kg Weight of remaining arm = 1.314 x 9.81 = 12.89 N

Force on part three- Volume of column = L*B*H = 1500*72*72 – 1500*69*69 = 634500 cu mm = 634500 x 10-9 cu m Density of material used= 7850 kg/cu m Mass of the column = volume*Density = 634500 x 10-9 *7850 = 5 kg Weight of the column = 5 * 9.81 = 49.05 N

Force on part four- • Volume of base = L*B*H= 400*48*48 – 400*45*45 = 111600 cu mm = 111600 x 10-9 cu m Density of material used= 7850 kg/cu m Mass of the base= volume*Density= 111600 x 10-9 x 7850 = 0.876 kg Weight of the base= 0.876*9.81 = 8.594 N

Force on part five- Volume of base legs= L*B*H = 1100*48*48 – 1100*45*45 = 306900 cu mm = 306900 x 10-9 cu m Density of material used= 7850 kg/cu m • Mass of the base arm= volume*Density = 306900 x 10-9 x7850 =2.5 kg Weight of the base arm= 2.5*9.81 = 24.525 N

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DESIGN OF CYLINDER

Assuming the internal pressure, (Pi)= 110 N/mm2 Material used for cylinder is Mild steel =226 Yield strength of mild steel = 250 N/mm2 • Ultimate tensile strength of mild steel = 410 N/mm2 Factor of safety = 1.5 (assumed) • Pi= F/A A = F/Pi= 35124/110 A = 319.30 mm2 d =20.16mm

Now, allowable tensile strength σall = Syt/ FOS = 250/1.5 = 166.66 N/mm2, Tall = 0.5Syt/ FOS = 0.5*250/1.5 = 83.33 N/mm2

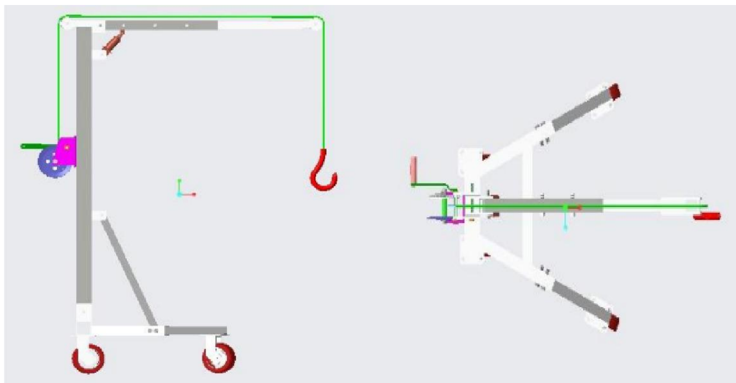


Figure: a) Front view b) Top view

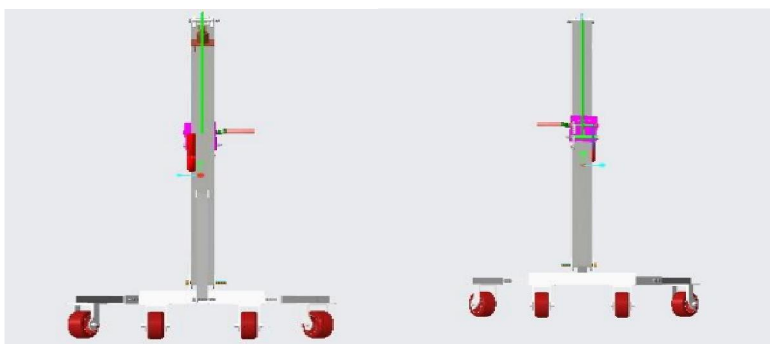
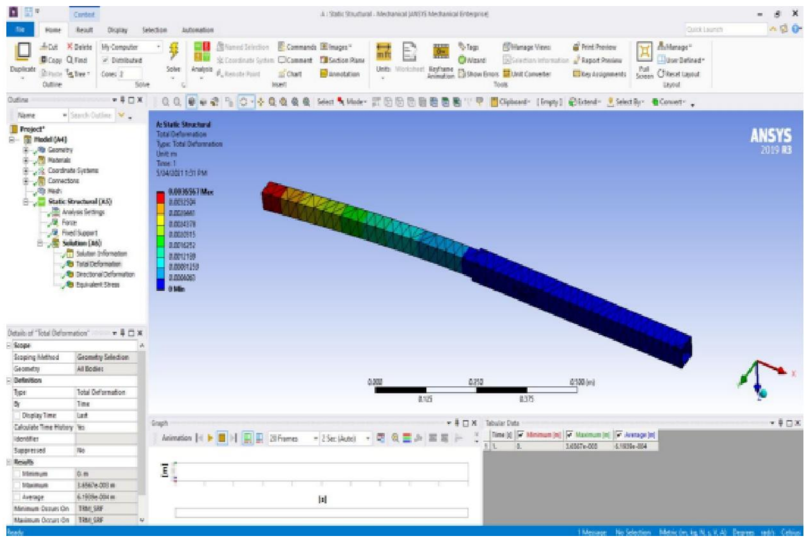


Figure: a) LHSV b) RHSV

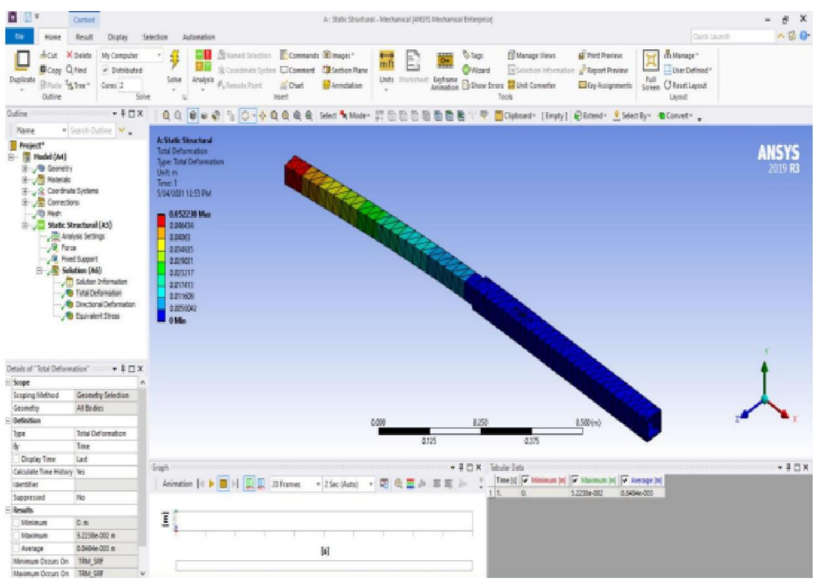
Figure: Isometric view

V. LOAD ANALYSIS

Force applied- 5000N Eq.~ 500kg Total Deformation- 0.0036567m ~ 3mm



Force applied- 10000N Eq.~ 1000kg Total Deformation- 0.0052238m ~ 5mm



VI. CONCLUSION

The aim of our project was to design a fully functional "HYDRAULIC FLOOR CRANE" mechanism which is capable of lifting load up to 500 kg. We accurately achieved our goal of lifting load from hook of vertical column with approximately 3mm of arm deflection and down movement of horizontal arm. We feel that our design and analysis is a great success both in terms of strength and stiffness. Our project is able to lift load up to 500 kg using hydraulic jack.

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