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Original Article

Design of Open Hydraulic Jack and Analysis

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Abstract: *Now a day, infrastructure development is very fast growing, for that the use of R.C.C construction machinery is very widely used, but in any R.C.C construction machinery proper Mixing of raw material for Concrete is major problem. Proper mixing of raw material is important task in any construction, for that we are use latest equipment's which are mechanically and hydraulically combined operated mostly. Design Of Open Hydraulic Jack & Analysis is one of them which are operated by two prime movers one prime mover is use for hydraulic system operation for operating the hoper and other for operating drum for proper mixing of concrete work presented herein is mainly divided into the three chapters. The first chapter introduces the concrete benching mixing machine with problem formulation and provides motivation for the project. The second chapter presents the current state of mixing machine research as presented in the form of scientific literature review.*

Keywords: *Hydraulic Jack, RCC Construction Machinery, Raw Materials.*

I. INTRODUCTION

A hydraulic jack is a jack that uses a liquid to push against a piston. This is based on Pascal's Principle. The principle states that pressure in a closed container is the same at all points. If there are two cylinders connected, applying force to the smaller cylinder will result in the same amount of pressure in the larger cylinder. However, since the larger cylinder has more area, the resulting force will be greater. In other words, an increase in area leads to an increase in force. The greater the difference in size between the two cylinders, the greater the increase in the force will be. A hydraulic jack operates based on this two cylinder system. Pressure on a confined fluid is transmitted undiminished and acts with equal force on equal areas and at 90 degrees to the container wall.

A fluid, such as oil, is displaced when either piston is pushed inward. The small piston, for a given distance of movement, displaces a smaller amount of volume than the large piston, which is proportional to the ratio of areas of the heads of the pistons. Therefore, the small piston must be moved a large distance to get the large piston to move significantly. The distance the large piston will move is the distance that the small piston is moved divided by the ratio of the areas of the heads of the pistons. This is how energy, in the form of work in this case, is conserved and the Law of Conservation of Energy is satisfied. Work is force times distance, and since the force is increased on the larger piston, the distance the force is applied over must be decreased.

The Origin Of Hydraulic Jacks Can Be Dated Several Years Ago When Richard Dudgeon, The Owner And Inventor Of Hydraulic Jacks, Started A Machine Shop. In The Year 1851, He Was Granted A Patent For His Hydraulic Jack. In The Year 1855, He Literally Amazed Onlookers In New York When He Drove From His Abode To His Place Of Work In A Steam Carriage. It Produced A Very Weird Noise That Disturbed The Horses And So Its Usage Was Limited To A Single Street. Richard Made A Claim That His Invention Had The Power To Carry Near About 10 People On A Single Barrel Of Anthracite Coal At A Speed Of 14 M.P.H. Dudgeon Deserves A Special Credit For His Innumerable Inventions Including The Roller Boiler Tube Expanders, Filter Press Jacks, Pulling Jacks, Heavy Plate Hydraulic Hole Punches And Various Kinds Of Lifting Jacks.

II. LITERATURE REVIEW

If the word hydraulics is understood to mean the use of water for the benefit of mankind, then its practice must be considered to be even older than recorded history itself. Traces of irrigation canals from prehistoric times still exist in Egypt and Mesopotamia; the Nile is known to have been dammed at Memphis some six thousand years ago to provide the necessary water supply, and the Euphrates River was diverted into the Tigris even earlier for the same purpose.

Though both the art and the science of hydraulics treat of such flows, they obviously differ significantly in time and substance. Hydraulic practice necessarily originated as an art, for the principals involved could be formulated only after long experience with science in general and water in particular.

This science actually had its origins some two millenia ago in the course of Greek civilization. It must be granted, however, that Greek physics was of such a hypothetical nature that with one exception it had little positive influence in the millenia to follow. The part that concerns us here is the then-prevailing belief that the universe consists of four elements (fire, air, water, and earth), that each is displaced by the next in order of increasing weight, and that the space around us must be occupied by one element or another. "Nature," in other words, "abhors a vacuum." In due time the concept of a fifth element, ether, came into being, for want of something to fill outer space.

The Greekwho made the most lasting contribution to hydraulics was the Sicilian mathematician Archimedes (287-212 B.C.), who reasoned that a floating or immersed body must be acted upon an upward force equal to the weight of the liquid that it displaces. This is the basis of hydrostatics and also of the apocryphal story that Archimedes made this discovery in his bath and forthwith ran unclothed through the streets crying "Eureka!" Nevertheless, even though Archimedes' writings, like those of his fellow Greeks, were faithfully transmitted to the West by Arabian scientists, further progress in hydrostatics was not to be made for another 18 centuries.

In the course of the millenium following the time of Archimedes, the science of hydraulics retrogressed rather than advaneed. True, though the Romans developed extensive water-supply and drainage systems, and windmills and water wheels appeared on the scene in increasing numbers, these represented the art rather than the science.

Whereas the Greeks tended to reason without recourse to observation, it was the Italian genius Leonardo da Vinci (1452-1519) who first emphasized the direct study of nature in its many aspects. Leonardo's hydraulic observations extended to the detailed characteristics of jets, waves, and eddies, not to mention the flight of birds and comparable facets of essentiality every other field of knowledge. In particular, it was Leonardo who first correctly formulated the basic principle of hydraulics known as continuity: the velocity of flow varies inversely with the cross-sectional area of a stream. Unfortunately, not only were his copious notes written in mirror image (probably for reasons of secrecy), but, in addition, most of them were lost for several centuries after his death. Thus his discoveries had little effect on the growth of the science.

The second essential contribution to hydrostatics was made by the Dutch hydraulic engineer Simon Stevin (1548-1620) in 1586, nearly two millenia after the time of Archimedes. Stevin showed that the force exerted by a liquid on the base of a vessel is equal to the weight of a liquid column extending from the base to the free surface. That this force does not depend on the shape of the vessel became known as the hydrostatic paradox.

If Leonardo was the first scientific observer of note, it was Galileo (1564-1642) who added experimentation to observation, thereby throwing initial light on the problem of gravitational acceleration. In his study of the phenomenon, he noted that a body sliding freely down an inclined plane attained a certain speed after a certain vertical descent regardless of the slope; it is said that he hence advised an engineer that there was no point in eliminating river bends, as the resulting increase in slope would have no effect! Whereas Leonardo was a loner, Gallleo gathered a small school around him.

The French scientist Edme Mariotte (1620-84) is often called the father of French hydraulics because of the breadth of his experimentation; this included such matters as wind and water pressure and the elasticity of the air, a quality which we usually associate with the name of the Englishman Robert Boyle (1627-91) whereas the latter appears to have coined the word *hydraulics*, in France Boyle's law bears the name of Mariotte. Only a few years younger than Mariotte, the Italian Domenico Guglielmini (1655-1710) is similarly considered by many to have been the founder of the Italian school. But whereas Mariotte was a laboratory experimenter, Guglielmini made extensive field measurements of river flow. Interestingly enough, Guglielmini eventually became a professor of medicine.

At about the same time, the short-lived French savant Blaise Pascal (1623-62) concerned himself with the same barometric problems as the equally short-lived Torricelli (not to mention Mariotte), but it was Pascal who finally completed the principles of hydrostatics. Not only did he clarify the transmissibility of pressure from point to point and its application to the hydraulic jack, but he also showed that the barometric (i.e., atmospheric) pressure must vary with elevation and hence that the barometer would have a zero reading in a vacuum.

Rene Descartes (1596-1650), the French scientist to whom we owe the Cartesian coordinate system, sought valiantly to reconcile the Aristotelian teachings that had been adopted by his church with the mechanics of the solar system. He thus hypothesized that the planets were carried in their orbits by a system of giant vortices endowed with a fixed "quantity of movement."

Newton's German contemporary Gottfried Wilhelm von Leibniz (1646-1716) conceived the principle of energy, though without the fraction one-half in the kinetic-energy term, and as a result his principle gave different results from Newton's momentum principle when used to describe the same phenomenon. Leibniz also developed a form of the calculus, and his colleagues and Newton's soon began to accuse the other of plagiarism, a dispute which, though largely unjustified, produced a considerable rift between the English and the German scientists.

One of the earliest mathematicians to apply Leibniz's calculus (and even to contribute some of the nomenclature still used today) was the Swiss Johann Bernoulli (1667-1748), who was also noteworthy for the mathematical training of his son Daniel (1700-82) and his son's comrade Leonhard Euler (1707-83). Johann thereafter went to Paris to collaborate with the French nobleman the Marquis de Daniel's work contained much that was new for example, the use of manometers, the kinetic theory of gases, and iet propulsion but nowhere in the book (or in his father's either) can one find what is known as the Bernoulli theorem. Just as its source, Leibniz's energy principle consisted of only potential and kinetic terms, so too did the Bernoulli equation; the corresponding pressure term was evaluated separately by means of Newton's momentum equation.

In actuality, the first true Bernoulli equation was derived by Euler, an outstanding mathematician, from his equations of acceleration for the conditions of steady, irrotational flow under gravitational action. Euler also deserved credit for a number of equations of hydraulics and for inventing at least on paper a workable hydraulic turbine. Worthy of mention in the same breath as Euler and the Bernoullis was Jean Lerond d'Alembert (1717-83), best known for his co-editorship of the French encyclopedia but also a mathematician in his own right.

Even Franklin was not the first to conduct scale-model tests, credit for which is due John Smeaton (1724-92), an English engineer who was one of the very few practical people in his country to become a member of the Royal Society in the course of the next century or so. In his prize-winning paper of 1759, "An experimental Inquiry concerning the Natural Powers of Water and Wind to turn Mills, and other Machines, depending on a Circular Motion", Smeaton described experiments on models of undershot wheels, overshot wheels, and windmills, evaluating there from the general power relationships.

Two essential measuring instruments came into being at this time, the Pitot tube and the rotating arm. The first still bears the name of its inventor, the Frenchman Henri de Pitot (1695-1771), who called it a "machine" for determining the speed of flowing water.

The matter of fluid resistance is probably the most important one in the field of hydraulics. Until the latter part of the eighteenth century, little was known about the phenomenon, whether in connection with flow through conduits or around immersed bodies. The d'Alembert paradox, obviously, was of little engineering use. On the other hand, d'Alembert's contemporary Antoine Chezy (1718-98) discovered a simple resistance relationship for streams which is now known by his name.

Granted thatthe Italians, Germans, and to some degree the English made notable contributions in the course of the eighteenth and nineteenth centuries, the leadership was definitely French, mainly through the influence of the Corps des Ponts et Chaussees, which had been functioning effectively since its founding in 1719. For example, in 1822 Louis Marie Henri Navier (1785-1836), a bridge engineer, was the first to attempt the extension of the Euler equations of acceleration to include the flow of a viscous fluid.

Though countless contributors to hydraulic science of this period are to be found in the ever-growing literature, only a few can be mentioned at this point. These include the Italian Giovanni Battista Venturi (1746-1822) and the Germans Johann Albert Eytelwein (1764-1848) and Julius Weisbach (1806-71).In addition to Bernoulli, the men whose names are now best known in hydraulics were two Englishmen who lived in the latter part of the last century. One was the Manchester professor Osborne Reynolds (1842-1912), who in 1873 also experimented with flow through tubes, introducing the viscosity to form a parameter marking the borderline between laminar and turbulent flow. Now known as the Reynolds number. Reynolds also showed bv the injection of dye the difference between the two states of motion, for which he is given the credit really due Hagen for his work 20 years earlier.

III. DESIGN OF HYDRAULIC JACK

A. Hydraulic Basics

Hydraulics is the science of transmitting force and/or motion through the medium of a confined liquid. In a hydraulic device, power is transmitted by pushing on a confined liquid.Figure 1-1 shows a simple hydraulic device. The transfer of energy takes place because quantity of liquid is subject to pressure. To operate liquid-powered systems, the operator should have a knowledge of the basic nature of liquids. This chapter covers the properties of liquids and how they act under different conditions.

Pressure is force exerted against a specific area (force per unit area) expressed in pounds per square inch (psi). Pressure can cause an expansion, or resistance to compression, of a fluid that is being squeezed. A fluid is any liquid or gas (vapor). Force is anything that tends to produce or modify (push or pull) motion and is expressed in pounds a. *Pressure*. An example of pressure is the air (gas) that fills an automobile tire. As a tire is inflated, more air is squeezed into it than it can hold. The air inside a tire resists the squeezing by pushing outward on the casing of the tire. The outward push of the air is pressure.
Equal pressure throughout a confined area is a characteristic of any pressurized fluid.

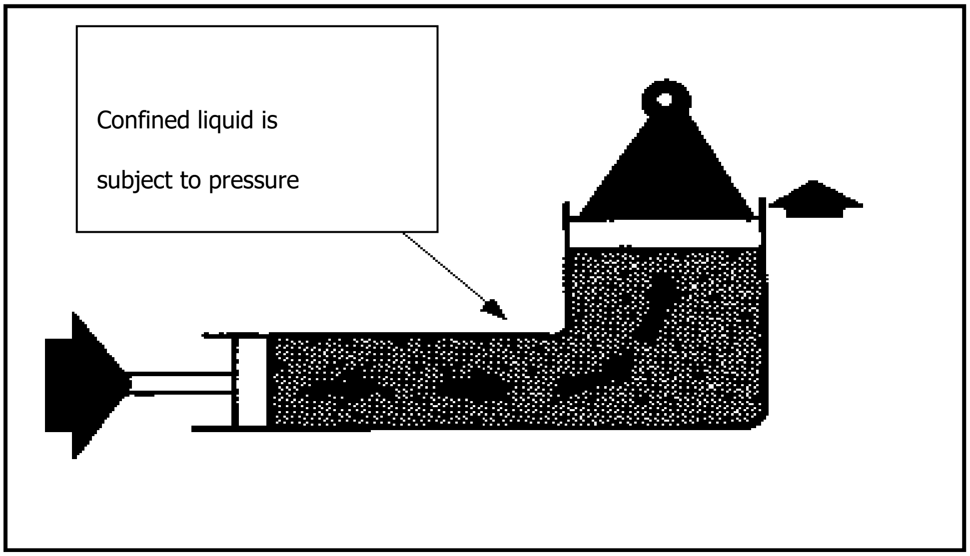

Figure 1: Basic Hydraulic Devices

For example, in an inflated tire, the outward push of the air is uniform throughout. If it were not, a tire would be pushed into odd shapes because of its elasticity. There is a major difference between a gas and a liquid. Liquids are slightly compressible (Figure 2.1). When a confined liquid is pushed on, pressure builds up. The pressure is still transmitted equally throughout the container. The fluid's behavior makes it possible to transmit a push through pipes, around corners, and up and down.

$$D2=F1*D1/F2$$

Where,
F1 = force of the small piston, in pounds
D1 = distance the small piston moves, in inches
D2 = distance the larger piston moves, in inches
F2 = force of the larger piston, in pounds

B. Basic Systems

The advantages of hydraulic systems over other methods of power transmission are:-

- Simpler design. In most cases, a few pre-engineered components will replace complicated mechanical linkages.
- Flexibility. Hydraulic components can be located with considerable flexibility. Pipes and hoses in place of mechanical elements virtually eliminate location problems.
- Smoothness. Hydraulic systems are smooth and quiet in operation. Vibration is kept to a minimum.
- Control. Control of a wide range of speed and forces is easily possible.
- Cost. High efficiency with minimum friction loss keeps the cost of a power transmission at a minimum.
- Overload protection. Automatic valves guard the system against a breakdown from overloading.

The main disadvantage of a hydraulic system is maintaining the precision parts when they are exposed to bad climates and dirty atmospheres. Protection against rust, corrosion, dirt, oil deterioration, and other adverse environment is very important. The following paragraphs discuss several basic hydraulic systems.

C. Hydraulic Jack

In this system a reservoir and a system of valves has been added to Pascal's hydraulic lever to stroke a small cylinder or pump continuously and raise a large piston or an actuator a notch with each stroke. Diagram A shows an intake stroke.

An outlet check valve closes by pressure under a load, and an inlet check valve opens so that liquid from the reservoir fills the pumping chamber. Diagram B shows the pump stroking downward. An inlet check valve closes by pressure and an outlet valve opens. More liquid is pumped under a large piston to raise it. To lower a load, a third valve (needle valve) opens, which opens an area under a large piston to the reservoir. The load then pushes the piston down and forces the liquid into the reservoir.

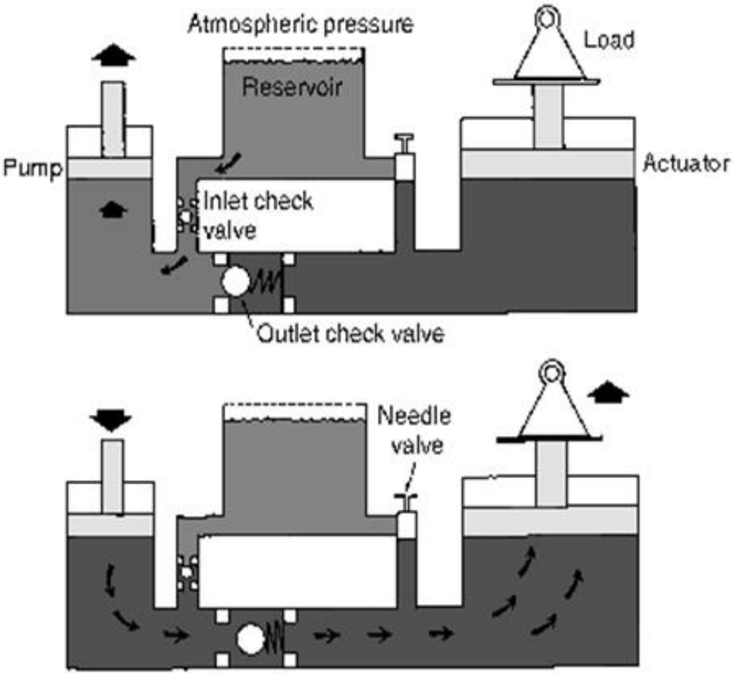

Figure 2: Hydraulic jack

Figure 3-2, shows a power-driven pump operating a reversible rotary motor. A reversing valve directs fluid to either side of the motor and back to the reservoir. A relief valve protects the system against excess pressure and can bypass pump output to the reservoir, if pressure rises too high.

In this system, a control-valve spool must be open in the center to allow pump flow to pass through the valve and return to the reservoir. This system in the neutral position. To operate several functions simultaneously, an open-center system must have the correct connections, which are discussed below. An open-center system is efficient on single functions but is limited with multiple functions.

The return from the first valve is routed to the inlet of the second, and so on. In neutral, the oil passes through the valves in series and returns to the reservoir, as the arrows indicate. When a control valve is operated, the incoming oil is diverted to the cylinder that the valve serves. Return liquid from the cylinder is directed through the return line and on to the next valve. This system is satisfactory as long as only one valve is operating at a time. When this happens, the full output of the pump at full system pressure is available to that function. However, if more than one valve is operating, the total of the pressures required for each function cannot exceed the system's relief setting.

a) Parts of Hydraulic Jack

- Gland (End Cap)
- Piston Road
- Cylinder

- Base Plate
- Hose Pipe

The cylinder barrel is mostly a seamless thick walled forged pipe that must be machined internally. The cylinder barrel is ground and/or honed internally. In most hydraulic cylinders, the barrel and the bottom portion are welded together. This can damage the inside of the barrel if done poorly. Therefore, some cylinder designs have a screwed or flanged connection from the cylinder end cap to the barrel. In this type the barrel can be disassembled and repaired.

The cylinder head is sometimes connected to the barrel with a sort of a simple lock. In general, however, the connection is screwed or flanged. Flange connections are the best, but also the most expensive. A flange has to be welded to the pipe before machining. The advantage is that the connection is bolted and always simple to remove. For larger cylinder sizes, the disconnection of a screw with a diameter of 300 to 600 mm is a huge problem as well as the alignment during mounting.

The piston rod is typically a hard chrome-plated piece of cold-rolled steel which attaches to the piston and extends from the cylinder through the rod-end head. In double rod-end cylinders, the actuator has a rod extending from both sides of the piston and out both ends of the barrel. The piston rod connects the hydraulic actuator to the machine component doing the work. This connection can be in the form of a machine thread or a mounting attachment, such as a rod-clevis or rod-eye. These mounting attachments can be threaded or welded to the piston rod or, in some cases; they are a machined part of the rod-end.

IV. CALCULATION FOR DESIGN

A. Calculations

Distance the larger piston moves

D2 = F1*D1/F2

Where,

F1 = force of the small piston, in pounds
D1 = distance the small piston moves, in inches
D2 = distance the larger piston moves, in inches
F2 = force of the larger piston, in pounds

The definition of fluid pressure is a force per unit area, or in equation form,

P = F / A

Where,

P = pressure (N/m^2, psi),
F = force (N, lb_f), and
A = area (m^2, in^2).

To Find Inner Diameter of Cylinder Tube

$$P = \frac{\pi}{4} D^2 \times p$$

Where,

P = total pressure
D = Inner diameter
p = working pressure
3 *1000 = 0.785 × D^2 × 300
D=3000/0.785*300
D^2 = 12.76
D= 6CM = 60MM. (inner diameter of cylinder tube)

To Find Outer Diameter of Cylinder Tube

We have already a equation = $\sigma = p \frac{d_o^2 + d_i^2}{d_o^2 - d_i^2}$

Where,

σ = working stress

P = working pressure
d_o = outer diameter of cylinder tube
d_i = inner diameter of cylinder tube
σ = Working stress = 4200/4= 1050 KG/CM^2

$$\sigma = P\,\frac{d_o^2+d_i^2}{d_o^2-d_i^2} \qquad 1050 = 300 \times \frac{d_o^2+12^2}{d_o^2-12^2}$$

1050do -3780000=300do +1080000
750do =2700000
do =2700000*750
do =202500000
do=73mm

Thickness of the Cylinder Tube:-

$$\text{Tube thickness} = \frac{d_o-d_i}{2} \qquad = 73\text{-}60/2 \qquad =6.5\text{mm}$$

B. Design of Piston

We know that cylinder’s inner diameter is equal to piston’s outer diameter so piston outer diameter is 60mm. Generally pistons are made from Mild Steel & Suitable Material.

C. Design of Piston Rod

Material strength EN9 = 1750 kg/cm^2

$$P = \frac{\pi}{4}\,D_o^2 \times \text{Strength}$$

3000=0.785*60*60*1750
3000=4945500kg/mm

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