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HYDRAULICALLY OPERATED WORKING MODEL OF BACK HOE POWERED BY IC ENGINE

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***Abstract*—In this paper, hydraulically operated working model of back HOE powered by IC engine, who's working on pascals law operated hydrostatic transmission the backhoe is frequently used in many applications other than excavation and with the tilt rotator attachment, serves as an effective tool carrier. Many backhoes feature quick coupler (quick-attach) mounting systems for simplified attachment mounting, dramatically increasing the machine's utilization on the job site Backhoes are usually employed together with loaders and bulldozers. Excavators that use a backhoe are sometimes called "track hoes" by people who do not realize the name is due to the action of the bucket, not its location on a backhoe loader**

***Index Terms*—Component, formatting, style, styling, insert.** *(key words)*

I. INTRODUCTION

A backhoe, sapacious cab feature ergonomic controls for greater operator comfort powerful hydraulic system for fine precision with high productivity travel speed of 25 mph to get between sites. Faster wide range of backhoe attachment including augers, hammers and compactors. A backhoe, also called a rear actor or back actor, is a piece of excavating equipment or digger consisting of a digging bucket on the end of a two-part articulated arm. They are typically mounted on the back of a tractor or front loader. The section of the arm closest to the vehicle is known as the boom, and the section which carries the bucket is known as the dipper or dipper stick (the terms "boom" and "dipper" having been used previously on steam shovels). The boom is attached to the vehicle through a pivot known as the kingpost, which allows the arm to slew left and right. Modern backhoes are powered by hydraulics. Most backhoes are at their strongest curling the bucket, with the dipper arm next most powerful, and boom movements the least powerful. Backhoes can be designed and manufactured from the start as such, or can be the result of a farm tractor equipped with a Front End Loader (FEL) and rear hoe. Though similar looking, the designed backhoes are much stronger, with the farm variation more suitable for light work. The farm variation also requires that the operator switch seats from sitting in front of the backhoe controls to the tractor seat in order to reposition the equipment while digging, and this often slows down the digging process.

II. PRINCIPLE OF HYDRAULICS

PASCALS LAW:-In the physical sciences, Pascal's law or the principle of transmission of fluid-pressure states that "pressure exerted anywhere in a confined incompressible fluid is transmitted equally in all directions throughout the fluid such that the pressure ratio (initial difference) remains the same." The law was established by French mathematician Blaise Pascal.

$$\Delta P = \rho g(\Delta h)$$

Where

ΔP is the hydrostatic pressure (given in Pascal in the SI system), or the difference in pressure at two points within a fluid column, due to the weight of the fluid;

Δh is the fluid density (in kilograms per cubic meter in the SI system);

g is acceleration due to gravity (normally using the gravity in meters per second squared);

is the height of fluid above the point of measurement, or the difference in elevation between the two points within the fluid column (in meters in SI).

The intuitive explanation of this formula is that the change in pressure between two elevations is due to the weight of the fluid between the elevations.

Note that the variation with height does not depend on any additional pressures. Therefore Pascal's law can be interpreted as saying that any change in pressure applied at any given point of the fluid is transmitted undiminished throughout the fluid. Hydraulic machines are machinery and tools that use liquid fluid power to do simple work. Heavy equipment is a common example.

In this type of machine, hydraulic fluid is transmitted throughout the machine to various hydraulic motors and hydraulic cylinders and which becomes pressurised according to the resistance present. The fluid is controlled directly or automatically by control and distributed through hoses and tubes. The popularity of hydraulic machinery is due to the very large amount of power that can be transferred through small tubes and flexible hoses, and the high power density and wide array of actuators that can make use of this power. Hydraulic machinery is operated by the use of hydraulics, where a liquid is the powering medium.

A. Hydrostatic transmission

A hydrostatic transmission consists of a variable-displacement pump and a fixed or variable displacement motor, operating together in a closed circuit. In a closed circuit, fluid from the motor outlet flows directly to the pump inlet, without returning to the tank. As well as being variable, the output of the transmission pump can be reversed, so that both the direction and speed of motor rotation are controlled from within the pump. This eliminates the need for directional and flow (speed) control valves in the circuit. Because the pump and motor leak internally, which allows fluid to escape from the loop and drain back to the tank, a fixed-displacement pump called a charge pump is used to ensure that the loop remains full of fluid during normal operation. In practice, the charge pump not only keeps the loop full of fluid, but it also pressurizes the loop to between 110 and 360 PSI, depending on the transmission manufacturer. A simple charge pressure circuit comprises the charge pump, a relief valve and two check valves, through which the charge pump can replenish the transmission loop. Once the loop is charged to the pressure setting of the relief valve, the flow from the charge pump passes over the charge relief valve, through the case of the pump or motor or both, and back to the tank.

B. How does this apply to hydrostatic transmissions?

When applying this technique to a hydrostatic transmission, charge pump flow must be considered. In most transmissions, the charge pump relief valve vents into the case of either the pump or the motor. This means that in the circuit described by our reader, where the motor case drain flushed through the transmission pump case to tank, you would expect to see the flow meter in the transmission pump case drain line reading design charge pump flow. Here's why: Say charge pump flow was 10 GPM, of which 4 GPM was leaking out of the loop through the motor's internals (case drain) and 2 GPM was leaking out of the loop through the pump's internals. The balance of 4 GPM must therefore be going over the charge relief - but still ends up in either the pump or motor case, depending on the location of the relief valve. In this particular circuit, because the motor case drain flushed through the transmission pump case to tank, you would expect to see the flow meter in the transmission pump case drain line reading the sum of these three flows (10 GPM).Before any meaningful conclusions can be drawn, the case in which the charge pump relief is venting (motor or pump) must be determined and the two case drain lines (motor and pump) must be isolated from each other. If the charge relief vents into the case of the pump, then it is possible to determine the condition of the motor by measuring its case drain flow, but not the pump. If the charge relief vents into the case of the motor, then it is possible to determine the condition of the pump by measuring its case drain flow, but not the motor. It is not possible to determine the condition of the component that has the charge relief valve venting into it because there is no way of telling what proportion of the total case drain flow is due to internal leakage - unless of course the charge relief can be vented externally while the test is conducted. While it is possible to do this on most transmissions, it's not usually a simple exercise.

III. MINI BACKHOE MECHANISM

Parts of backhoe:-
1.) Bucket
2.) Boom
3.) Dipper stick
4.) Chasis
5.) I.C.Engine
6.) Hydraulic mechanism
7.) Wheels

Chassis:- A chassis is a base upon which the whole body is constructed. Various design consideration are done for its strength in tension, compression, shear, torsion and bending.

I.C.Engine:- A two stroke engine is used to provide power to the backhoe. Engine output shaft is coupled to drive a hydraulic pump.

Hydraulic mechanism:- A hydraulic mechanism is used to convert the engine power into pressure energy to drive the actuators

Wheels:- 4 P.V.C. wheels are used to move the vehicle

A. Components and its description

1) Power-pack Reservoir

The hydraulic fluid reservoir holds excess hydraulic fluid to accommodate volume changes from: cylinder extension and contraction, temperature driven expansion and contraction, and leaks. The reservoir is also designed to aid in separation of air from the fluid and also work as a heat accumulator to cover losses in the system when peak power is used. Design engineers are always pressured to reduce the size of hydraulic reservoirs, while equipment operators always appreciate larger reservoirs.

B. Hydraulic Cylinder

1) Operation

Hydraulic cylinders get their power from pressurized hydraulic fluid, which is typically oil. The hydraulic cylinder consists of a cylinder barrel, in which a piston connected to a piston rod moves back and forth. The barrel is closed on each end by the cylinder bottom (also called the cap end) and by the cylinder head where the piston rod comes out of the cylinder. The piston has sliding rings and seals. The piston divides the inside of the cylinder in two chambers, the bottom chamber (cap end) and the piston rod side chamber (rod end). The hydraulic pressure acts on the piston to do linear work and motion.

Flanges, trunnions, and/or clevisses are mounted to the cylinder body. The piston rod also has mounting attachments to connect the cylinder to the object or machine component that it is pushing.

A hydraulic cylinder is the actuator or "motor" side of this system. The "generator" side of the hydraulic system is the hydraulic pump which brings in a fixed or regulated flow of oil to the bottom side of the hydraulic cylinder, to move the piston rod upwards. The piston pushes the oil in the other chamber back to the reservoir. If we assume that the oil pressure in the piston rod chamber is approximately zero, the force F on the piston rod equals the pressure P in the cylinder times the piston area A:

$$F = P \cdot A$$

The piston moves instead downwards if oil is pumped into the piston rod side chamber and the oil from the piston area flows back to the reservoir without pressure. The fluid pressure in the piston rod area chamber is (Pull Force) / (piston area - piston rod area)

IV. PARTS OF A HYDRAULIC CYLINDER

A hydraulic cylinder consists of the following parts:

A. Cylinder barrel

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

B. Cylinder base or cap

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. (See "Tie rod cylinder", below) In this type the barrel can be disassembled and repaired.

C. Cylinder head

The cylinder head is sometimes connected to the barrel with a sort of a simple lock (for simple cylinders). 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.

D. Piston

The piston is a short, cylindrical metal component that separates the two parts of the cylinder barrel internally. The piston is usually machined with grooves to fit elastomeric or metal seals. These seals are often O-rings, U-cups or cast iron rings. They prevent the pressurized hydraulic oil from passing by the piston to the chamber on the opposite side. This difference in pressure between the two sides of the piston causes the cylinder to extend and retract. Piston seals vary in design and material according to the pressure and temperature requirements that the cylinder will see in service. Generally speaking, elastomeric seals made from nitride rubber or other materials are best in lower temperature environments, while seals made of Vinton are better for higher temperatures. The best seals for high temperature are cast iron piston rings.

E. Piston rod

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.

F. Rod gland

The cylinder head is fitted with seals to prevent the pressurized oil from leaking past the interface between the rod and the head. This area is called the rod gland. It often has another seal called a rod wiper which prevents contaminants from entering the cylinder when the extended rod retracts back into the cylinder. The rod gland also has a rod wear ring. This wear ring acts as a linear bearing to support the weight of the piston rod and guides it as it passes back and forth through the rod gland. In some cases, especially in small hydraulic cylinders, the rod gland and the rod wear ring are made from a single integral machined part.

G. Other parts

A hydraulic cylinder should be used for pushing and pulling only. No bending moments or side loads should be transmitted to the piston rod or the cylinder to prevent rapid failure of the rod seals. For this reason, the ideal connection of an hydraulic cylinder is a single clevis with a spherical ball bearing. This allows the hydraulic actuator to move and allow for any misalignment between the actuator and the load it is pushing. Completely encapsulated mechanism for protection against dirt. Five chamber design for better reduction in dynamic forces and longer valve life. Available as spring centred, spring off-set or detente model. Operating head can be rotated by 90° x 4 around spool axis for flexibility in mounting. Valve mounting interface conforms to ISO 4401-03-02. Five chamber body and spool design provides low-pressure drop, with maximum performance. Balanced spool design ensures proper shifting force for maximum reliability and long life. All spools and bodies are interchangeable, simplifying maintenance.

1) Vane pump

While vane pumps can handle moderate viscosity liquids up to 500 CPs, they excel at handling low viscosity liquids such as LP gas (propane), ammonia, solvents, alcohol, fuel oils, gasoline and refrigerants. Vane pumps have no internal metal-to metal contact and self compensate for wear, enabling them to maintain peak performance on these non-lubricating liquids.

Vane pumps are available in a number of vane configurations including sliding vane, flexible vane, swinging vane, rolling vane, and external vane. Vane pumps are noted for their dry priming, ease of maintenance, and good suction characteristics over the life of the pump. Moreover, our vane pumps can handle fluid temperatures from -100°C to +200°C and differential pressures to 14 Bar.

Each type of vane pump offers unique advantages. For example, external vane pumps can handle large solids. Flexible vane pumps, on the other hand, can only handle small solids but create good vacuum. Our ranges of sliding vane pumps can run dry for short periods of time and handle small amounts of vapour.

2) Tubes, Pipes and Hoses

Hydraulic tubes are seamless steel precision pipes, specially manufactured for hydraulics. The tubes have standard sizes for different pressure ranges, with standard diameters up to 100 mm. The tubes are supplied by manufacturers in lengths of 6 m, cleaned, oiled and plugged. The tubes are interconnected by different types of flanges (especially for the larger sizes and pressures), welding cones/nipples (with o-ring seal), and several types of flare connection and by cut-rings. In larger sizes, hydraulic pipes are used. Direct joining of tubes by welding is not acceptable since the interior cannot be inspected.

Hydraulic pipe is used in case standard hydraulic tubes are not available. Generally these are used for low pressure. They can be connected by threaded connections, but usually by welds. Because of the larger diameters the pipe can usually be inspected internally after welding. Black pipe is non-galvanized and suitable for welding.

Hydraulic hose is graded by pressure, temperature, and fluid compatibility. Hoses are used when pipes or tubes cannot be used, usually to provide flexibility for machine operation or maintenance. The hose is built up with rubber and steel layers. A rubber interior is surrounded by multiple layers of woven wire and rubber. The exterior is designed for abrasion resistance. The bend radius of hydraulic hose is carefully designed into the machine, since hose failures can be deadly, and violating the hose's minimum bend radius will cause failure. Hydraulic hoses generally have steel fittings swaged on the ends. The weakest part of the high pressure hose is the connection of the hose to the fitting. Another disadvantage of hoses is the shorter life of rubber which requires periodic replacement, usually at five to seven year intervals.

Tubes and pipes for hydraulic applications are internally oiled before the system is commissioned. Usually steel piping is painted outside. Where flare and other couplings are used, the paint is removed under the nut, and is a location where corrosion can begin. For this reason, in marine applications most piping is stainless steel.

3) Hydraulic Fluid

Also known as tractor fluid, hydraulic fluid is the life of the hydraulic circuit. It is usually petroleum oil with various additives. Some hydraulic machines require fire resistant fluids, depending on their applications. In some factories where food is prepared, either an edible oil or water is used as a working fluid for health and safety reasons. In addition to transferring energy, hydraulic fluid needs to lubricate components, suspend contaminants and metal filings for transport to the filter, and to function well to several hundred degrees Fahrenheit or Celsius.

4) Filters

Filters are an important part of hydraulic systems. Metal particles are continually produced by mechanical components and need to be removed along with other contaminants. Filters may be positioned in many locations. The filter may be located between the reservoir and the pump intake. Blockage of the filter will cause cavitation and possibly failure of the pump. Sometimes the filter is located between the pump and the control valves. This arrangement is more expensive, since the filter housing is pressurized, but eliminates cavitation problems and protects the control valve from pump failures. The third common filter location is just before the return line enters the reservoir. This location is relatively insensitive to blockage and does not require a pressurized housing, but contaminants that enter the reservoir from external sources are not filtered until passing through the system at least once.

5) Seals, fittings and connections

In general, valves, cylinders and pumps have female threaded bosses for the fluid connection, and hoses have female ends with captive nuts. A male-male fitting is chosen to connect the two. Many standardized systems are in use.

Fittings serve several purposes;

To bridge different standards; O-ring boss to JIC, or pipe threads to face seal, for example.

To allow proper orientation of components, a 90°, 45°, straight, or swivel fitting is chosen as needed. They are designed to be positioned in the correct orientation and then tightened.

To incorporate bulkhead hardware.

A quick disconnect fitting may be added to a machine without modification of hoses or valves

A typical piece of heavy equipment may have thousands of sealed connection points and several different types:

6) Pipe fittings, the fitting is screwed in until tight, difficult to orient an angled fitting correctly without over or under tightening.

7) O-ring boss, the fitting is screwed into a boss and orientated as needed; an additional nut tightens the fitting, washer and o-ring in place.

8) Flare fittings, are metal to metal compression seals deformed with a cone nut and pressed into a flare mating.

9) Face seal, metal flanges with a groove and o-ring are fastened together.

10) Beam seals are costly metal to metal seals used primarily in aircraft.

11) . *Swaged seals*, tubes are connected with fittings that are swaged permanently in place. Primarily used in aircraft.

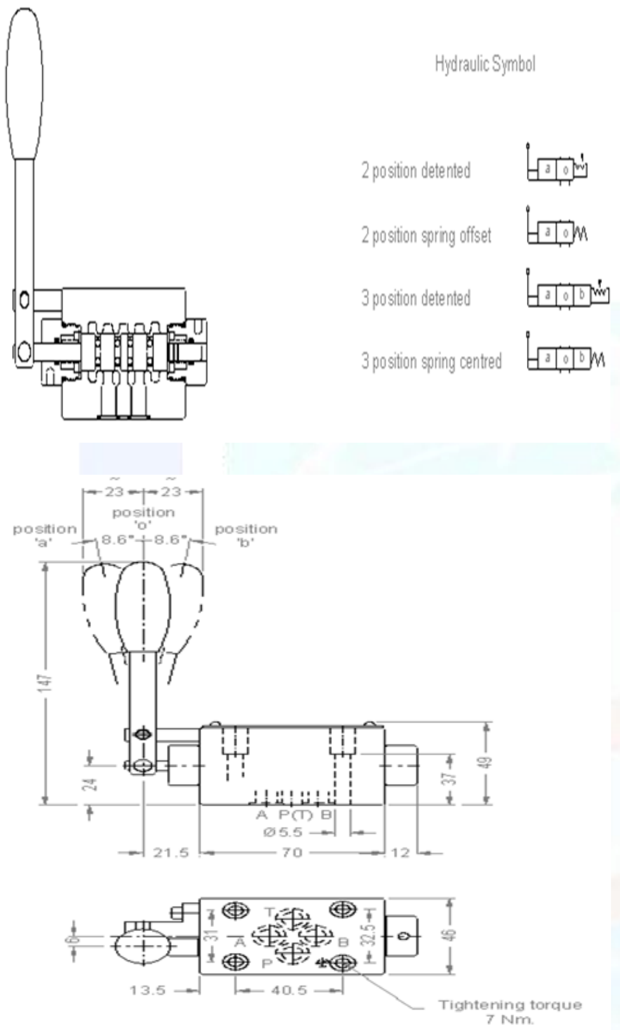

Figure.1 . Unit Dimensions Of Sub-Plate Type Body (O'Ring size at port P, A, B & T : 9.25 i.d. x 1.78 c.s.d.)

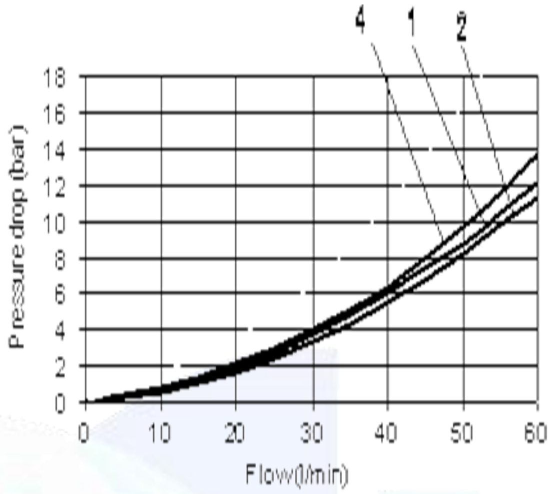

Figure.2 Graph between pressure drop and flow

Construction Mounting type	Spool type Sub plate body as per ISO 4401-03-02.
Mounting position	Optional
Operating Pressure	For Ports P, A, B .... 315 bar Port T .... 150 bar. (For spool type A & B, port T to be used as a drain line, if the operating pressure exceeds 150 bar.)
Nominal flow handling capacity Maximum flow handling capacity Flow direction	63 lpm Refer graph Refer spool chart
Hydraulic medium Viscosity range Working temperature range	Mineral oil. 10 to 380 cSt. -20 ºC to +70 ºC.
Fluid cleanliness requirement	As per ISO code 16/13 or better.
Weight	0.75 kg.

Table.1Technical Specifications

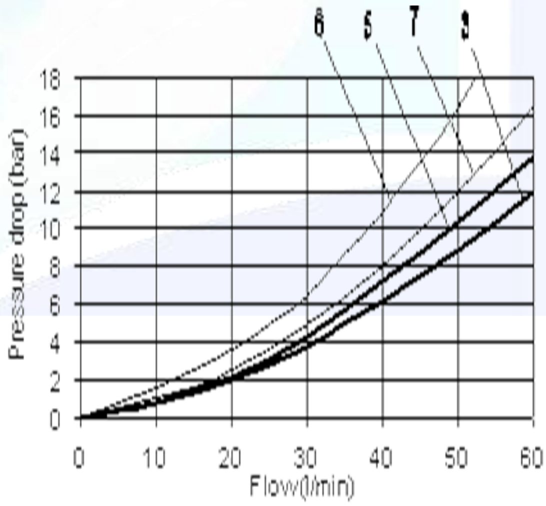

Figure.3 Graph of performance (Performance Curves)

V. .DESIGN CALCULATION FOR THE REQUIRED ENGINE

We make some assumptions in this design

Required load which has to be lifted=50kg

Number of actuators depends upon the motion of bucket required.

There are three motions therefore the number of actuators required for the desired motion is also equal to three

Specification of the actuator is as per the following

Bore diameter=40mm

Length of the stroke=250mm

From the energy conservation principle, we get

M*g*h=p*v

(Where m=mass to be lifted
g=acceleration due to gravity
h=height up to which load is to be lifted
p=pressure inside the actuator
v=volume)

Therefore this gives

50*9.81*1=p*π/4*(0.04)2*(0.25)

On solving the algebraic equation, we get

P=15.61*105 n/m2

Or p=15.61 bar

We take the load factor as 2

Maximum pressure of the actuator=15.61*2
=31.22 bar

More approximately=32 bar

Capacity of pump=Maximum pressure of the actuator*number of actuator
=32*3
=96 bar

Therefore we take a 100 bar capacity pump

A pump from yuken kogyo pumps pvt.ltd. Of Japan manufactures such a pump with the following specifications:

Discharge=6 liters/minute
= 0.006 m3/min
=10-4 m3/s

The efficiency of the pump=ή=85%

Therefore the power of the engine=(p*q)/ ή
=1176.4 watt
=1.57 HP

VI. ADVANTAGES & LIMITATIONS

Following advantages can be concluded from the above present model:

Small construction Work: Present machine can fulfil our requirement where work space is small and construction work is small.

Low Capital cost: Initial cost is less because of its small construction

Low Operating Cost: Because of use in small construction it consist of small parts, in which there is less friction and other energy losses results high efficiency of working gives low operating cost.

Suitability: Due to smaller construction, it require low work space for working, therefore it can be used in domestic purposes like digging out septic tank, digging out gutter lines,etc

High skill: is not essential in such cases because of its easy construction and operation.

Low Transport Cost: It require less space, so during movement from one place to another, it requires low transport cost.

Low Maintenance Cost: Because of its easy design, it is easy to maintain.

Affordability: It is affordable for every class.

There also few limitation of the model which can be explained as:

Large construction work: It cannot be used in large construction work.

Rigidity: Because it is smaller in shape and size, it is less rigid.

Time Consumption: Time consumption is more because it works in fewer radiuses.

Large Space Requirement: It is not suitable where large space is required.

Range of work is limited.

It cannot be used in inclined surfaces.

Stability of vehicle is very poor.

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