[ICAME-2018]
ISSN 2348 – 8034
Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

MOTION ANALYSIS OF PISTON WITH VARIATION OF PRESSURE OF HYDRAULIC OIL USING H-SIMULATOR

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ABSTRACT
Hydraulics is the science of force and movements transmitted by means of liquids. It belongs alongside hydro-mechanics. A distinction is made between hydrostatics–dynamics effect through pressure time's area-and hydrodynamics-dynamic effect through mass time's acceleration. The work is focused on the time analysis and force analysis for single acting cylinder and double acting cylinder and it is calculated with the variation of pressure and it is observed that incase of single acting cylinder the piston movement to return back to its original position is very fast then compared with double acting cylinder. Experimental values are analyzed by using H-simulator.

Keywords: *Hydraulic kit, pressure gauge, flow meter, SAE 10 oil, H-simulator.*

I. INTRODUCTION

Hydraulic cylinders are basic components of hydraulic control and actuation of hydraulic systems. The hydraulic cylinders convert the hydrostatic energy into mechanical energy, by achieving, within a certain time, a certain force, with a certain speed in a straight stroke [1]. A single-acting cylinder in a reciprocating engine is a cylinder in which the working fluid acts on one side of the piston only. A single-acting cylinder relies on the load, springs, other cylinders, or the momentum of a flywheel, to push the piston back in the other direction [2]. Single-acting cylinders are found in most kinds of reciprocating engine. They are almost universal in internal combustion engines and are also used in many external combustion engines such as sterling engines and some steam engines. They are also found in pumps and hydraulic rams. Single acting cylinder shown in fig 1.

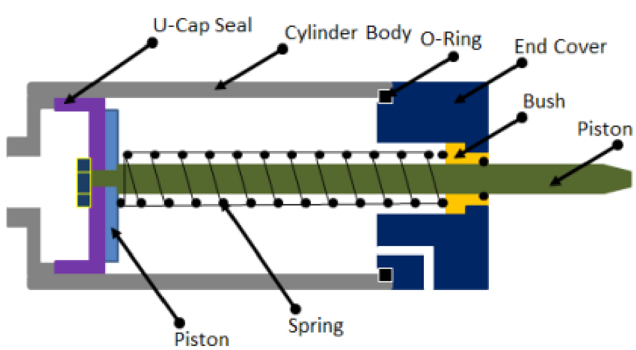

Fig.1 Single acting cylinder

A double-acting cylinder is a cylinder in which the working fluid acts alternately on both sides of the piston. In order to connect the piston in a double-acting cylinder to an external mechanism, such as a crank shaft, a hole must be provided in one end of the cylinder for the piston rod, and this is fitted with a gland or stuffing box to prevent escape of the working fluid. Double-acting cylinders are common in steam engines but unusual in other engine types. Many hydraulic and pneumatic cylinders use them where it is needed to produce a force in both directions [3]. A double-acting hydraulic cylinder has a port at each end, supplied with hydraulic fluid for both the retraction and extension of the piston. A double-acting cylinder is used where an external force is not available to retract the piston or where high force is required in both directions of travel.

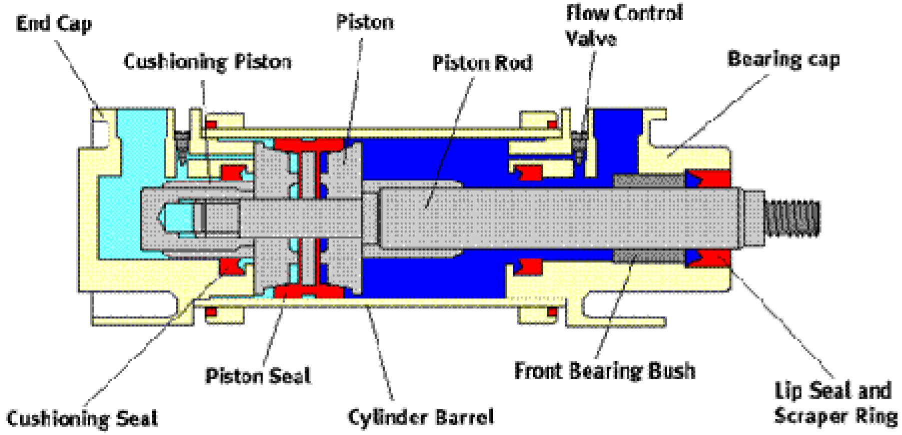

Fig 2. Double acting cylinder

Direction control valve

Three-way valves either block or allow flow from an inlet to an outlet. They also allow the outlet to flow back to the tank when the pump is blocked, while a two-way valve does not. A three-way valve has three ports, namely, a pressure inlet (P),an outlet to the system(A) and a return to the tank(T). Figure 3 shows the operation of a 3/2-way valve normally closed.

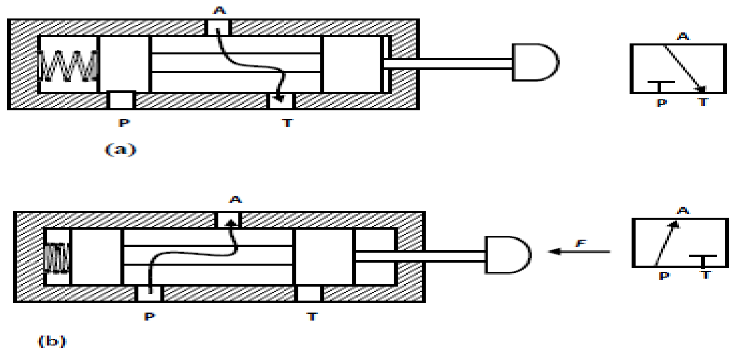

Fig 3. 3/2-way DCV (normally closed). (a) Ports A and T are connected when force is not applied (valve unactuated). (b) Ports A and P are connected when force is applied (valve actuated).

Direction control valve

Four-way DCVs are capable of controlling double-acting cylinders and bidirectional motors. Figure 4 shows the operation of a typical 4/2 DCV. A four-way has four ports labeled P, T, A and B. P is the pressure inlet and T is the return to the tank; A and B are outlets to the system. In the normal position, pump flow is sent to outlet B. Outlet A is connected to the tank. In the actuated position, the pump flow is sent to port A and port B connected to tank T [4]. In four-way DCVs, two flows of the fluids are controlled at the same time, while two-way and three-way DCVs control only one flow at a time.

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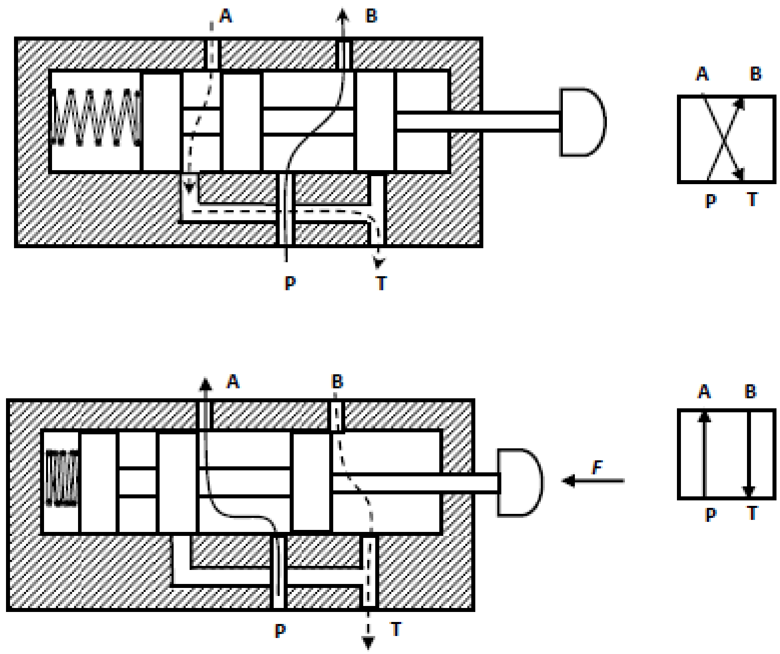

Fig 4. Four-way DCV

SAE 10:

SAE 10 was expressly designed for hydraulic systems on off-road machinery such as the yellow machines. It is customary in this industry to use 10 weight engine oils for hydraulic fluids. For extra heavy duty performance, specifications require a minimum of 900 parts per minute of zinc from the anti-wear additive. This is far beyond the zinc levels for industrial anti-wear hydraulic oils. SAE 10 is specially formulated just for off-road equipment. They meet all the specifications for zinc content and other requirements [5]. Hydraulic SAE 10 will give you better hydraulic performance at a significantly lower price than 10 weight engine oils. Benefits of oil are Excellent Oxidation Resistance, Excellent Thermal Stability, Excellent Anti-wear Protection, Excellent Additive Stability, Excellent Rust Protection, Superior Wet or Dry Filterability, Good Hydrolytic Stability, Low Pour Point for All Season Use, Low Cost of Operation.

Methodology

Industrial hydraulics works on Pascal's principle it states that when a force is applied to a stationary liquid it causes a pressure inside of the liquid. This pressure is then transmitted equally in all directions through the liquid. Pascal's law shown in fig 5.

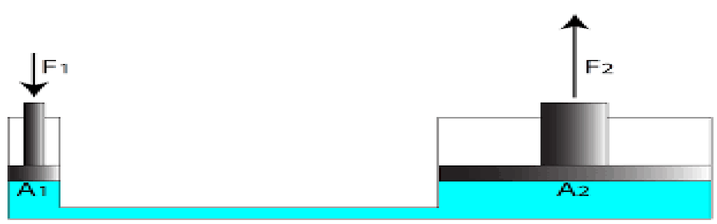

Fig 5: Pascal's law

The total experimentation carried out on electro-hydraulic trainer kit as shown in fig 6.

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Fig 6.Electro hydraulic kit

Variation of pressure:

In this effectively keeping diameter of hydraulic cylinder as a constant and varying pressure of hydraulic oil. In this the diameter of the cylinder kept as 10 mm. The starting inlet pressure kept as 5 N/mm^2 and incrementally values are varied up to 20 N/mm^2.The variation of pressure and time is shown in table 1.The values are varied with respect to single acting cylinder and double acting cylinder. Here for single acting cylinder with 3/2 direction control valve is used and for double acting cylinder 4/2 DCV used for experimentation.

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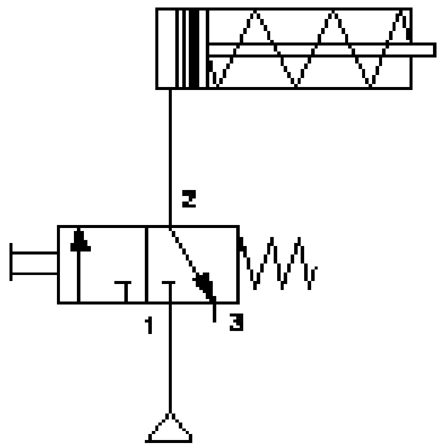
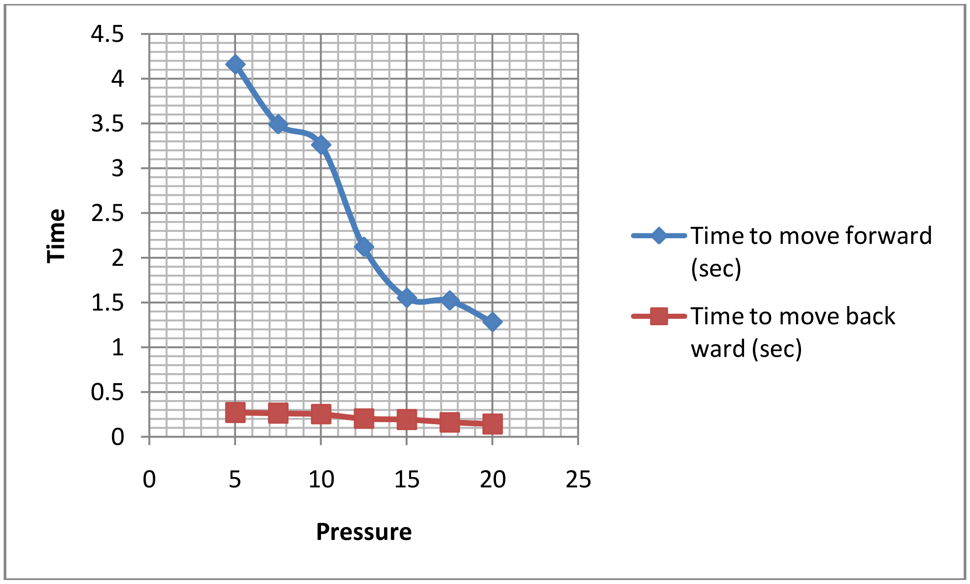


Fig 7.Single acting cylinder with 3/2 DCV

Table 1

Pressure (N/mm^2)	Time to move forward (sec)	Time to move back ward (sec)	Force (N)
5	4.16	0.27	392.65
7.5	3.49	0.26	588.975
10	3.26	0.25	785.3
12.5	2.12	0.2	981.625
15	1.55	0.19	1177.95
17.5	1.52	0.16	1374.275
20	1.28	0.14	1570.6



Graph 1.Variation of pressure with respect to time (Single acting cylinder)

The same experiment carried out through double acting cylinder with 4/2 DCV by keeping diameter of cylinder as 10 mm . The values are shown in table 2.

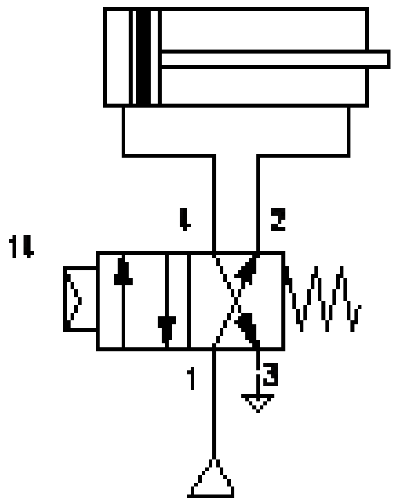
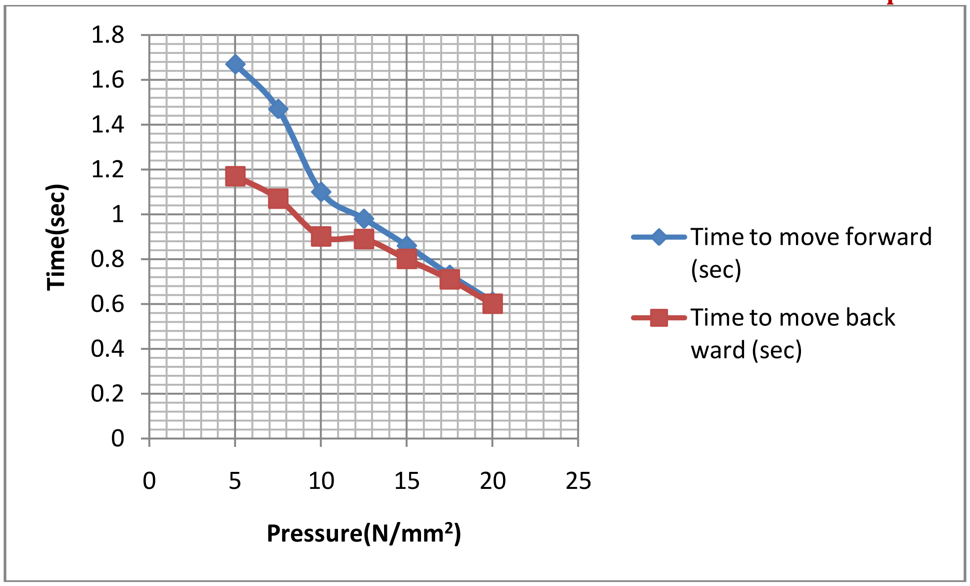


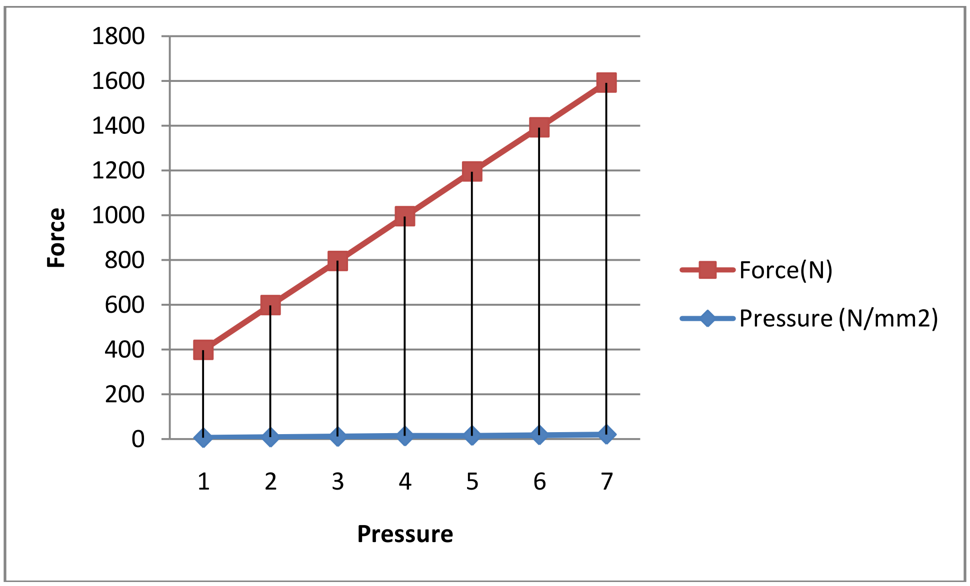
Fig 8.Double acting cylinder with 4/2 DCV

Table 2

Pressure (N/mm^2)	Time to move forward (sec)	Time to move back ward (sec)	Force(N)
5	1.67	1.17	392.65
7.5	1.47	1.07	588.975
10	1.1	0.9	785.3
12.5	0.98	0.89	981.625
15	0.86	0.8	1177.95
17.5	0.73	0.71	1374.275
20	0.61	0.6	1570.6



Graph 2.Variation of pressure with respect to time (Double acting cylinder)



Graph .3 Variation of pressure with respect to force

II. RESULTS & DISCUSSIONS

In this experimentation, analysis of piston movement is carried out with the variation of pressure of oil. The time required to move piston from one place to another also calculated. It is observed that in the single acting cylinder keeping diameter of cylinder as constant and varying pressure of the fluid the time taken for piston movement is low compare to double acting cylinder, because of in single acting cylinder constant spring return mechanism with aid of hydraulic fluid pressure. Force exerted by the fluid also calculated for the single acting cylinder and double acting cylinder under the constant diameter of cylinder. These experimental values are simulated by H-simulator.

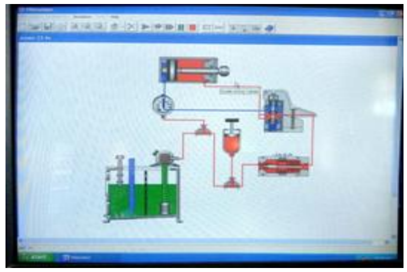


Fig 9. Double acting cylinder with variation of diameter of cylinder

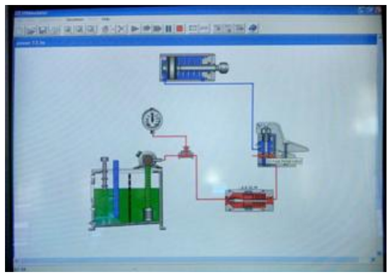


Fig 10. Single acting cylinder with variation of diameter of cylinder

III. CONCLUSION

To study the effect of the piston movement on the variation of inlet pressure and the diameter of the hydraulic cylinders, different types of inlet pressure were proposed and simulated on H-simulator. A single acting cylinder and a double acting cylinder with different diameters were simulated under the inlet pressure of 10 N/mm^2. The relations between time required moving piston to reach end position in forward stroke and the outlets diameters were best described. In case of constant cylinder diameter 10 mm the time taken to move the piston in forward stroke depending on the operating pressures.

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