Design and Experimental Modeling of variable Flow Radial Piston Pump

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Abstract— This paper present variable displacement linkage which use for desired position displacement. Using this particular displacement run a radial piston pump for variable discharge. This variable Discharge is relation with Control angle and Pressure. In hydraulic power systems, variable displacement pumps save power, increase the productivity or control the motion of a load precisely, safely and in an economical manner .The displacement varying mechanism and power to weight ratio of variable displacement piston pump makes them most suitable for control of high power levels. Positive Displacement Pumps are "Constant Flow Machines" Thus objective of research is defined to develop a variable displacement linkage that will enable to vary the stroke of an two cylinder radial piston pump, thereby offering to vary the discharge of the pump using manual control. Also find relation of Discharge, Control angle and pressure.

Key words: Constant Flow Machines, Radial Piston Pump

I. INTRODUCTION

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps. A Positive Displacement Pump must not be operated against a closed valve on the discharge side of the pump because it has no shut off head like centrifugal pump.[1] A Positive Displacement Pump operating against a closed discharge valve, will continue to produce flow until the pressure in the discharge line are increased until the line bursts or the pump is severely damaged - or both.

Axial piston pumps with constant pressure and variable flow have extraordinary possibilities for controlling the flow by change of pressure. Owing to pressure feedback, volumetric control of the pump provides a wide application of these pumps in complex hydraulic systems, particularly in aeronautics and space engineering.

The major obstacle in application of the bent axis piston pump is extremely high cost over that of the radial piston pump, it ranges in the range of 5 to 6 times the cost of radial piston pump[6]. Hence there is a need to develop a modification in the radial piston pump design that will offer a variable discharge configuration in addition to the advantages of high efficiency and maximum pressure.

Thus objective of project is defined to develop a variable displacement linkage that will enable to vary the stroke of an two cylinder radial piston pump , thereby offering to vary the discharge of the pump using manual control.

II. LINKAGE OVERVIEW

The system design comprises of development of the mechanism so that the given concept can perform the desired operation. The mechanism is basically an inversion of four bar kinematic linkage, hence the mechanism is suitably designed using Grashoff's law and the final outcome is shown in the figure below [5].

It consists of base four bar crank rocker mechanism which includes the input crank, coupler link, and control link. The position of ground pivot of the control link can be adjusted through the dashed arc centered at the adjusted point. The connecting rod joints the oscillating link to the base four bars at the coupler point. When the adjusted ground pivot collinear with axis of oscillation, then oscillating link will exhibit no oscillation when crank is rotated.[3] As the adjustable ground pivot moves away from the axis, the oscillating link translate. An additional benefit of this linkage is that the slider returns to the same top dead center position independent of displacement setting. This means that all the working fluid, can be ejected on every stroke to minimize compressibility losses.

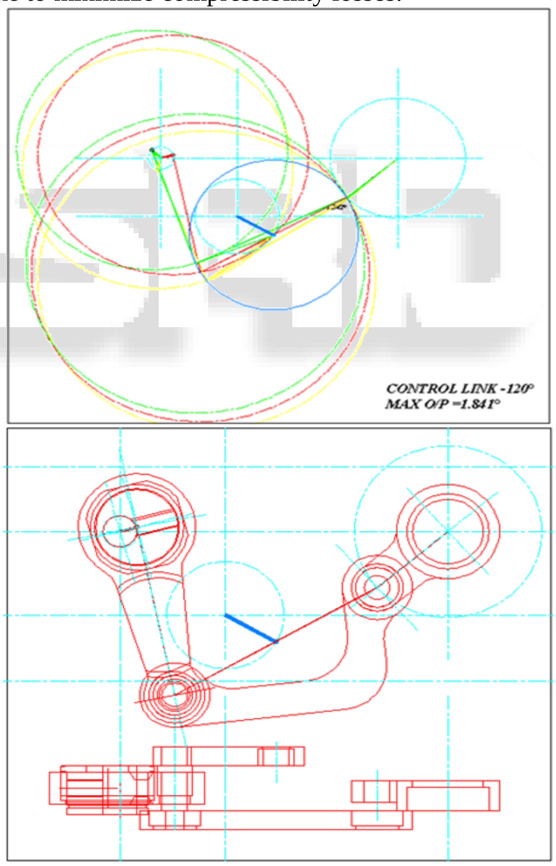


Fig. 1: Design

III. EXPERIMENTAL SETUP

Suitable manufacturing methods will be employed to fabricate the components and then assemble the test set –up for Design of variable flow radial piston pump using variable displacement linkage. The speeds are instantly changed by turning the handle indicated by 'G' . On the drive shaft A is mounted a series of eccentrics B. These eccentrics are connected to connecting links C by connecting rod D.

As the drive shaft rotates, the eccentrics impart an oscillating movement to the left hand ends of the connecting links ‘C’ and as these are pivoted to the output yoke E they impart oscillatory movement to the roller clutches within yokes ‘E’. Each reciprocating movement of clutch will cause the drive shaft to rotate a fraction of a revolution, and as the eccentrics are spaced uniformly about the drive shaft , the impulse given to the driven shaft will be successive and over lapping .In this way a uniform rotary movement of the driven shaft is obtained .

The oscillating movement of the right hand end of the link C determines the amount the driven shaft turns during each impulse, and this oscillating movement depends upon the position of joint M along the path determined bi the control link end when the control shaft is rotated about hinge K by handle G

For example if joint M is moved towards the right by which reciprocating movement of clutch will be shorter , and a longer time will be required to rotate the driven shaft thereby reducing the speed of the output shaft..

Obviously an entire range of speeds is covered smoothly, enabling the mechanism to glide from one speed to another.

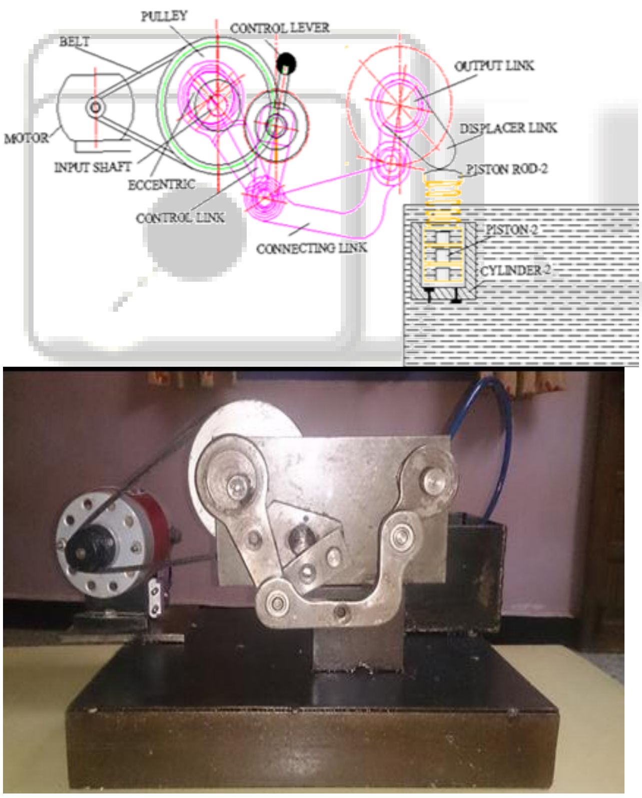


Fig. 2: Design

IV. SAMPLE OBSERVATION SET

Control link at 120^0 position

A. Comparative observation of Flow Rate, Control angles and pressure at constant 100 rpm speed

Sr. No.	Control Angle (°)	Pressure (kg/cm²)	Flow rate (lpm)
1	0	0.40	0.0317
2	20	0.40	0.0310
3	40	0.40	0.0250
4	60	0.40	0.0190
5	80	0.35	0.0120
6	100	0.40	0.0062
7	120	0.32	0.0029

Table 7.8 Observation for 100 rpm speed at various control angle

B. Comparative Observation of Flow Rate, Control Angles and Pressure at constant 300 RPM Speed

Sr. No.	Control Angle (°)	Pressure (kg/cm²)	Flow rate (lpm)
1	0	0.55	0.920
2	20	0.55	0.890
3	40	0.55	0.074
4	60	0.55	0.056
5	80	0.52	0.037
6	100	0.55	0.018
7	120	0.53	0.007

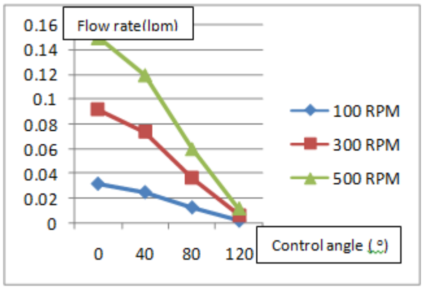
Table 7.9: Observation for 300 rpm speed at various control angle

C. Comparative observation of Flow Rate, Control angles and pressure at constant 500 rpm speed

Sr. No.	Control Angle (°)	Pressure (kg/cm²)	Flow rate (lpm)
1	0	0.67	0.150
2	20	0.67	0.146
3	40	0.70	0.120
4	60	0.67	0.090
5	80	0.68	0.060
6	100	0.67	0.030
7	120	0.58	0.012

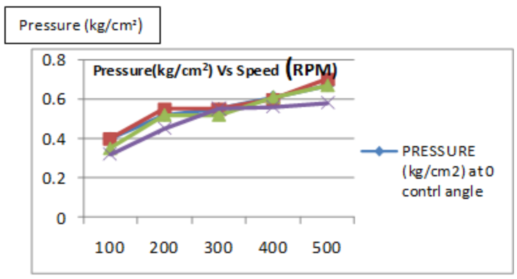
Table 7.10: Observation for 500 rpm speed at various control angle

D. Comparative graph of Flow Rate VS Control angles at various speed



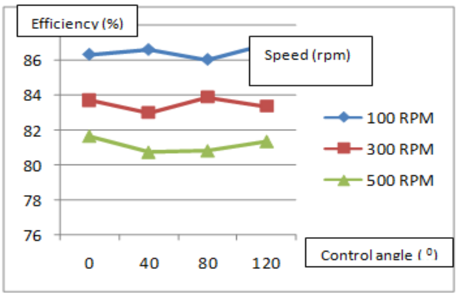
Graph 15 Flow Rate VS Control angles at various speed

E. Comparative graph of Pressure (kg/cm²) Vs Speed (RPM) at Various Control



Graph 16: Pressure (kg/cm²) Vs Speed (RPM) at All Control Angle

F. Comparative graph of Efficiency Vs Control Angles at various speed



Graph 17: Efficiency VS Control Angles at various speed

V. RESULTS

1) At 100 rpm for control angle 00 to 1200 flow rate changes from 0.037 lpm to 0.0024 lpm.
2) At 500 rpm for control angle 00 to 1200 flow rate changes from 0.15 lpm to 0.012 lpm.
3) From observation table, it is concluded that, at constant speed the flow rate is inversely proportional to control.
4) At constant 00 control angle for speed 100 rpm to 500 rpm the flow rate changes from 0.0317 lpm to 0.150 lpm.
5) At constant 1200 control angle for speed 100 rpm to 500 rpm the flow rate changes from 0.0024 lpm to 0.0120 lpm,

VI. CONCLUSION

1) At constant control angle the flow rate is directly proportional to speed.
2) For the constant control angle the flow rate for 500 rpm is 5 times more than the flow rate for 100 rpm.
3) Volumetric efficiency drops nearly of between 4% to 5% as the speed increases in all cases for constant control angle, this is owing to the hysteresis of spring used in the pump and friction between the piston and cylinder.
4) From the seen characteristic of pressure in each control angle it can be safely assumed that the pressure of the pump increases with increase in pump speed for all control angles.
5) Precise control of the control angle will provide a wide range of flow rates there by the pump will find application in multiple industries.
6) As control angle changes from 00 to 1200 flow change with position and speed but not affected efficiency to much.
7) It is conclude that for different control angles, pressure remains almost same but there is change flow rate.

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