Performance Monotiring And Analysis Of High Pressure Axial Piston Pumps

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ABSTRACT
The enhancement of the performance of hydraulic pumps is still a major task for hydraulic component manufacturer. They focus their activities to improve the characteristics regarding delivery rate, fluctuation, efficiency, suction behavior and noise generation. Hydraulic pumps are very complex systems with working conditions. Now days only the experimental analysis is ineffective and not all enough. The design and dimensioning as well as the optimization can be supported by approximate simulation tool like simhydraulic.simhydraulic is the extension of mat lab's simulink software which can be used for modeling and simulating hydraulic power and control systems. In this work mathematical modeling is carried out by using mat lab and is again comp aired with mat lab's simhydraulic which is extension of simulink.

General Terms
SimHydraulics software uses the Simscap**e** library as its main library.Simscape modeling environment provides the Physical Network approach for modeling and solving systems under design as one-dimensional networks.

SimHydraulics software utilizes these basic modeling principles and contains a library of specialized hydraulic blocks that seamlessly interact with basic Simscape blocks.

Key Words
Swash Plate, Pintle, simulink, simscape, simhydraulic, variable displacement

1. INTRODUCTION
Axial piston pumps have a simple construction and are employed most commonly in hydraulic applications. Axial piston pumps can be designed as fixed displacement or variable displacement systems. For fixed displacement pumps, the output flow is not adjustable. Some axial piston pumps can deliver different output flows by changing the angle of swash plate, and these are called variable displacement axial piston pumps. Variable displacement axial piston pumps convert mechanical power into hydraulic power by delivering different flows at different load pressures at the pump output. Variable displacement is accomplished by changing the swash plate angle about the pintle. The main subcomponents of this kind of pump are the pistons, barrel, swash plate, bearings, drive shaft, valve plate, and the control piston.

Consider Figure 1. The drive shaft passes through a hole in the swash plate. One end of drive shaft is supported by a needle bearing in the valve plate. The other end of the drive shaft is supported by a deep groove ball bearing in the pump casing and connects to an electric motor through an appropriative coupling. The swash plate rotates about the pintle and is balanced by a control piston and a return spring.

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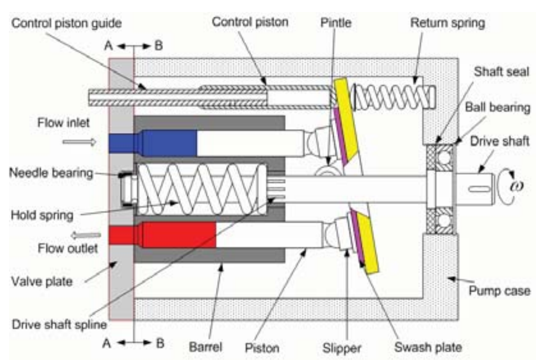
The angle of the swash plate can be controlled by the control piston that is modulated by some valve outside of the pump casing. The swash plate can be moved on a plate perpendicular to the axis of the drive shaft to obtain different displacements. The barrel is attached directly to the drive shaft. As the drive shaft rotates, the barrel rotates. The pistons slide inside the barrel and the piston ends move along the swash plate on "slippers". The pistons reciprocate inside the barrel holes (called barrel cylinders) due to the action of the piston ends (via the slippers) on the swash plate. This reciprocating action is responsible for the pumping capability of the unit.



2. EXPERIMENTAL INVESTIGATION
The experimental set up consist of the axial pump test rig which is designed and manufactured to facilitate to study performance of pump at different operating conditions .axial pumps are extensively used for pumping high viscous fluid like lubricating oil. The setup consist of electric motor driven

axial pump which is positive displacement, the electric motor having capacity of 7.5 HP at 1500 RPM.The oil is pumped from sump tank and discharged into overhead measuring tank. The tank has dimensions of 30 cm x 30 cm.The discharge pressure can be adjusted to different settings using pressure regulating valve & back pressure valve so that pump performance characteristics can be studied for different pressure settings. The pressure gauge has range of 0-200 bar.Vacumm Gauge is used to check the suction pressure of pump having range 0-760 mm of Hg.The time required for the rise in oil level is measured using float switch & timer. Power Consumed by electric motor is measured using a digital wattmeter. Corrosion resistant M.S.tank is used as sump tank.oil is pumped from the tank and discharged back to the sump. The oil pumped is discharged into measuring tank. By recording the time required for certain rise in level, flow rate of the pump can be determined.

Fig.2 a) Experimental Set Up

3. MATHEMATICAL SIMULATION MODEL

In an axial piston pump, piston delivers flow in a sine wave pattern. The total flow from the pump outlet is the sum of all flows delivered by each piston, which is given by a simplified mathematical "kinematical" model shown in Equation 1.

$$Q_k = \omega \frac{\pi d^2 R_p}{4} \tan \beta \sum_{k=0}^{m-1} \sin(\omega t - k\alpha),$$

Eq n.(1)

where Q_k = Pump kinematical flow (total pump flow from the pistons) [m3/s]

ω= Angular velocity of drive shaft [rad/s]

d = Diameter of piston [m]

Rp= Piston pitch radius on barrel [m]

β= Angle of swash plate [rad]

m = Number of pistons

t = Time [sec]

k = 0, 1, 2, 3…... m-1

α= Phase delay [rad], equal to 2π/m

Equation (1), Only defines the kinematical factor of the pump. The output flow can be affected by other factors such as leakage between the valve plate and cylinder bore, leakage between the slipper and swash plate, and leakage between the cylinder bore and piston.

In developing the simulation, the following assumptions are made:

1) The pump worked at constant temperature and constant swash plate angle.

2) The flow losses due to slipper leakage and valve plate leakage were ignored.

3) The fluid density and bulk modulus are constants.

4) The pump rotational speed is constant.

5) The load in this system was constant (the needle valve area is constant).

Pressure ripple could be a more effective way to find the performance of the pump. It is easiest way to measure the output flows. For this reason flow rate and pressure variations are simulated with time by using mat lab's 7.1 software and following wave forms are drawn by using equation 1.

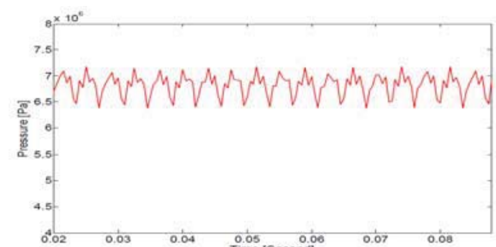


Fig. 3a

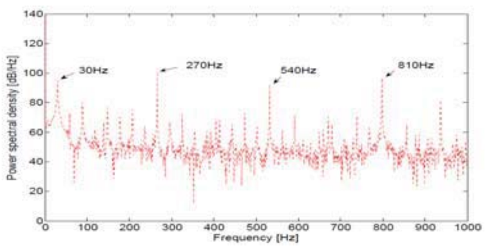


Fig. 3b

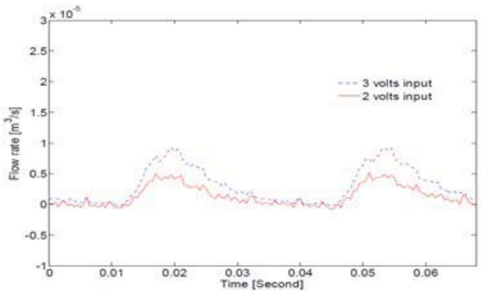


Fig. 3c

Fig 3. Simulation Results (Mathematical Modeling)

4. SIMULATION BY USING SIMULINK'S SIMHYDRAULIC SOFTWARE

For carrying simulation by using simhydraulic software following rules are followed.

i) Create a Simulink model that includes hydraulic or hydro-mechanical components using

Sims capes and SimHydraulics blocks.

ii) Define component data by specifying hydraulic or mechanical properties.

iii) Specify Simulation Parameters.

iv) Fluids are assigned which are provided in simhydraulic library.

v) Configure the solver options.

vi) Run the simulation.

4.1 Simulation Procudere

SimHydraulics blocks, in general, feature Conserving ports and Physical Signal in ports and out ports .There are three types of Physical Conserving ports used in SimHydraulics blocks: hydraulic, mechanical translational, and Mechanical rotational. Each type has specific through and Across variables associated with it. You can connect Conserving ports only to other Conserving ports of the same type The Physical connection lines that connect Conserving ports together are bidirectional lines that carry physical variables (Across and Through variables, as described above) rather than signals. You cannot connect Physical lines to Simulink ports or to Physical Signal ports Two directly connected Conserving ports must have the same values for all their Across variables (such as pressure or angular velocity).

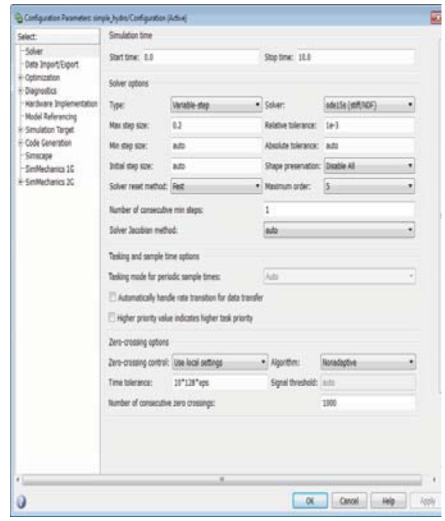


Fig 4a) Specifying simulation Parameters

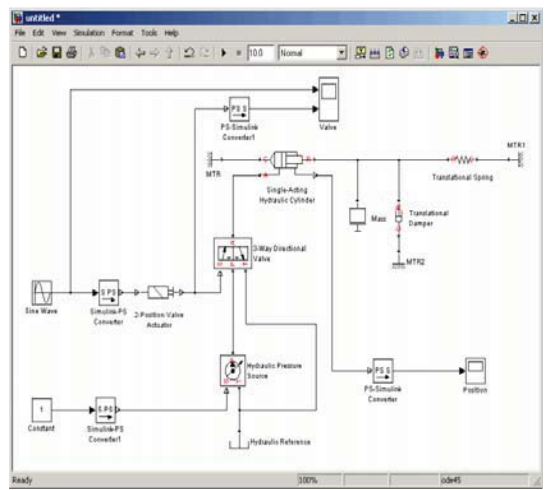


Fig.4 a) Construction of models

The input signal for the valve opening is provided by the Sine Wave block. The Valve scope reflects both the input signal and the valve opening as functions of time. The Position scope outputs the cylinder rod displacement as a function of time. Double-click both scopes to open them.

Modeling solver evaluates the model, calculates the initial conditions, and runs the simulation once the simulation starts running, the Valve and Position scope windows display the simulation results.

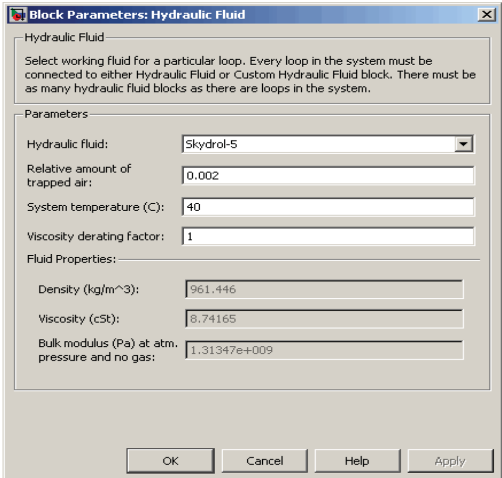


Fig.4c) Assigning of Fluids

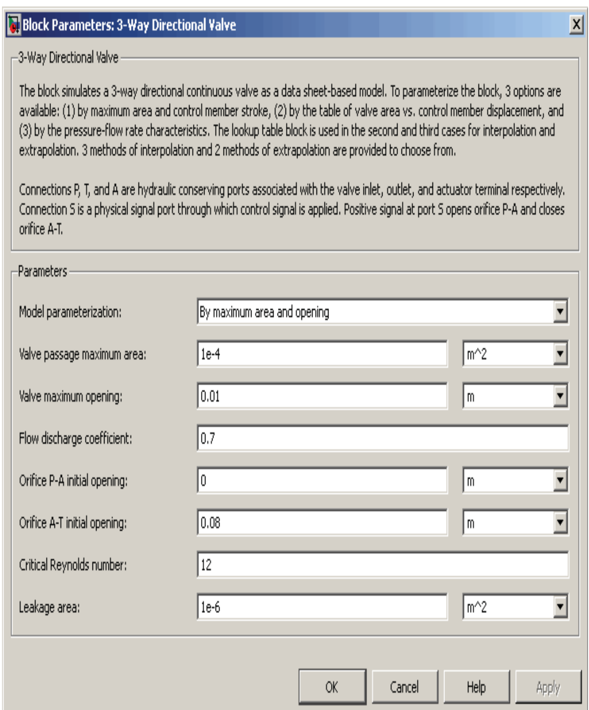


Fig. 4d) Parameters assigned to direction control valve

After running the simulation the following graphs are plotted by using simhydraulic simulation tool which displays the following results in graphical form.

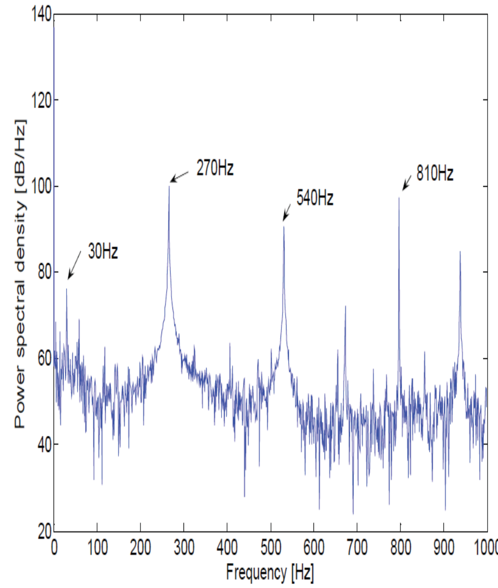


Fig. 5a

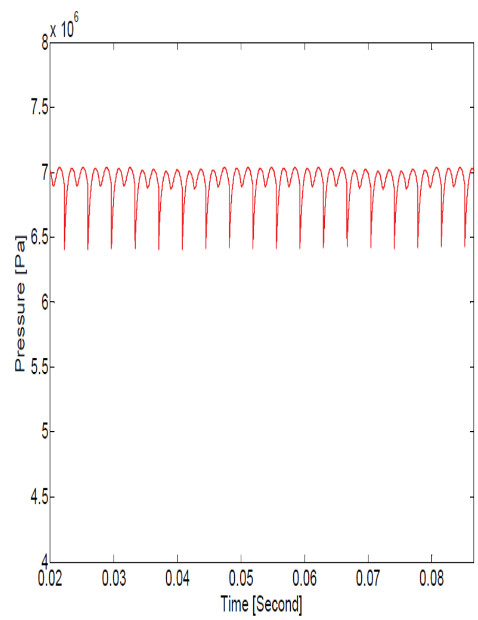


Fig.5b)

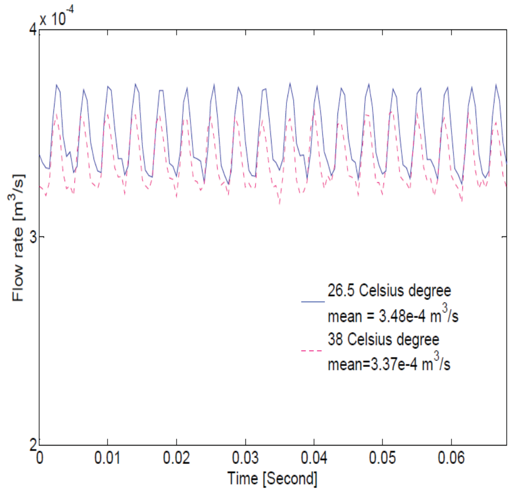


Fig. 5c)

Fig 5. Simulation Results (By simhydraulic Software)

5. CONCLUSIONS

Following conclusions are drawn are drawn from mathematical modeling and simhydraulic simulation of axial piston pump

1. Pressure Fluctuation Influence the output performance of piston pump.

2. Increasing piston pressure would effect on the pump output and flow.

3. Pressure fluctuations remain constant with the variation of time.

6. ACKNOWLEDGEMENT

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