# NOISE REDUCTION IN HYDRAULIC SYSTEM DRIVEN BY SWASH PLATE PUMP BY OPTIMIZING THE CONTROL UNIT

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## 1. INTRODUCTION

Swash plate pumps are used in wide range of mobile and stationary applications, where they exhibit certain advantages in comparison to the other modes of power transmission. Some of these advantages are: high specific power, enhanced static and dynamic characteristics, and lower power requirements, when equipped with control unit to deliver specific flow rate that matches the load. However, the pump generates excessive noise when equipped with a double feedback control unit implementing a PD controller. Many approaches were followed to reduce the noise at the design stage. Some of these are implementing a pair of silencing grooves. However, none of the previous studies investigated the effect of the control unit on the quietness of the pump. In the present paper, the effect of using a novel control strategy with a single PID controller on noise levels will be evaluated and compared with the current control strategy.

## 2. PUMP DESCRIPTION

Swash plate pump mainly consists of a swash plate mechanically connected to a finite number of pistons, which are distributed in a circular array. The pistons are reciprocating in their cylinders and they are nested in a cylinder block. The fluid traffic from cylinders are controlled by means of a port plate. The length of the piston stroke is determined by the angle of inclination of the swash plate, which is varied by a control cylinder.

## 3. CONTROL UNIT

In order to save on the pump power and to keep the fluid properties within specifications, the pump is equipped with a control unit. The control unit determines the swiveling angle of the swash plate and in turn the piston stroke. In order to push the swash plate and generate the required angle, there is a need for two inputs which are a hydraulic input and an electronic input. The hydraulic input is generated by the hydraulic unit which consists of a secondary pump to generate the pressurized fluid on the control cylinder, and it is connected to the inlet of a hydraulic proportional valve. The valve has a moving part (spool), its housing (sleeve), and two restoring springs that push the spool against a solenoid. The solenoid is activated by the control current, which is generated by the electronic part of the control unit.

## 4. CONTROL UNIT AND NOISE

There is a relationship between the noise and the control unit, where the type of the controller improves or worsens the quietness of the pump. The control unit follows different strategies such as PD, PID, or PI. It is known that the operation of the pump causes noise, and that noise can be expressed in sinusoidal form, where it has small amplitude and high frequency, as follows:

$$y(t) = A \sin(\omega t) \quad (1)$$

where y is the noise, A is the amplitude of the noise, $\omega$ is the noise frequency, and t is time.

Accordingly, in PD controller, the derivative gain amplifies the noise and PID suppresses the noise.

## 5. CONTROL STRATEGIES

The current model of the pump comes with a double negative feedback controller (the inner loop with a PID controller to control the position of the spool, and the outer loop with a PD controller). A single PD controller proposed by Khalil et al [2] causes excessive noise. Hence, it is proposed to investigate the improvement in the pump performance that can be achieved by replacing the PD by a PID controller.

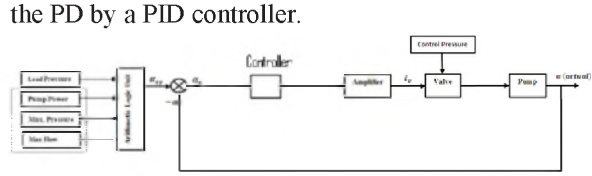


**Figure 1: Swash plate pump with single feedback control loop**

Figure 1 shows the control strategies with two different controllers (PD/ PID).The two strategies have almost the same structure, and the only difference is the kind of the controller.

## 6. RESULTS

The noise levels are investigated for a control strategy with a single PD controller proposed by Bhat and Khalil (2002), where the parameters of the controller are the proportional gain of unity and the derivative gain equals 0.02. Also, the noise levels of a control strategy with a

PID controller proposed by Chikhalsouk and Bhat (2008) are studied. The PID is parameterized to have the following gains: The proportional gain equals1.9, the integral gain equals 8.4 and the derivative gain is equal to 0.01. The measured noise levels are shown in Figure 3.

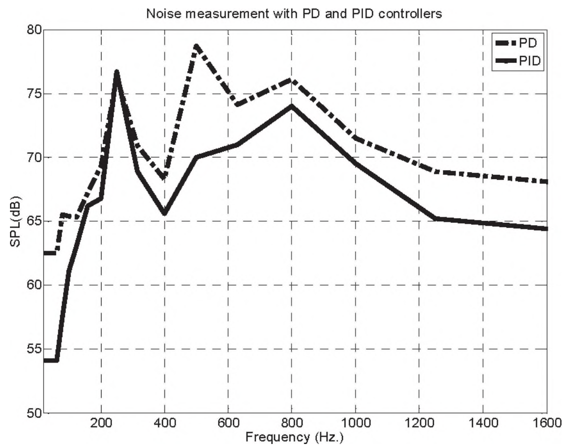


**Figure 2: Noise measurement with PD and PID controllers**

Figure (2) shows the noise levels measured when the pump is equipped with two different controllers (PD and PID). It can be noticed that the noise levels decrease by replacing the PD controller by the PID controller, particularly at the higher frequencies. The only exception happens at 270 Hz. where they have the same value regardless of the implemented controller.

## 7. CONCLUSIONS

Swash plate pump must be equipped with a control strategy to save on the pump power and maintain the pump in good quality. The kind of the controller determines the quietness of the pump, where the current model implements a PD controller which amplifies the noise and makes the pump noisy. Using a suitable PID controller with the optimum gain reduces the noise remarkably.

## REFERENCES

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[2] Khalil, M. K. B., Yurkevich, V., Svoboda, J., and Bhat, R. B., (2002).”Implementation of Single Feedback Control Loop for Constant Power Regulated Swash Plate Axial Piston Pumps”. International Journal of Fluid Power, Vol. 3, No. 3, pp. 27-36.