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ORIGINAL ARTICLE

Pressure Based Control For A Variable Speed Diesel Engine Driven Pump Controller

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ABSTRACT – Chemical cleaning is a process that utilizes chemical as a cleaning medium to remove unwanted contaminants. The chemical cleaning process may involve with the use of pump to circulate the chemical during cleaning process. The pump for the cleaning process can be driven by electrical or internal combustion engine. This paper presents the development of a variable speed diesel engine driven pump controller for chemical cleaning application. The controller utilize proportional control method as the control scheme. The variable speed diesel engine driven pump system includes a diesel engine coupled with centifugal pump, a controller, pressure sensor, and battery powerpacks. All the components are mounted on a skid platform for the ease of use as a system. Proportional control method were used in order to get the critical gain parameter to compute PID parameter gains using Ziegler Nichols tuning method.

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INTRODUCTION

Chemical cleaning is one of the method used in Oil and Gas (O&G) industries to dissolve or loosen the contaminant from surfaces and walls of equipment, pipelines, vessels, heat exchangers [1], and remove it through chemical circulation in the system [2]. Pumping system is used to circulate chemicals into the process equipment. Proper design and selection of pumping system and controls can help to reduce pumping energy consumption [3]. Pumping applications with a variable flow can be achieved through a throttle valve, piping and/ or variable speed pump to deliver the desired process flow rate [4]. The use of valve to control the flow rate can reduce the efficiency of the system by restricting the pump discharge. The most efficient way to control the process flow rate is by adjusting the pump rotation speed [5]. This research aims to develop a variable speed drive system for chemical cleaning process based on pressure control.

To develop a system for the automatic control diesel engine pump, the research should be involved with the suitable control method to implement with the diesel engine pump. Thus, parameter and external condition such as the specification of the diesel pump should be considered to design the model and control of the diesel engine pump. In term of the control parameter, the output pressure after the pump is the indicator to control the diesel engine pump.

This research on the development of the control system is focus on the finding suitable proportional gain parameter before implementing it into proportional, integral, derivative (PID) controller using Zieler-Nichols tuning method. The premiliminary works will help to find critical gain parameter to compute suitable PID gain parameters for the future works.

METHODOLOGY

The development of the controller is based on the diesel engine driven centrifugal pump. The detail parameters for the diesel engine driven centrifugal pump are listed in Table 1.

Table 1. Diesel engine driven centrifugal pump parameters

Parameter	Value
Maximum diesel engine rotational speed	2200 RPM
Maximum pump power	140 HP
Maximum pump head	196 m
Pump type	Centrifugal
Pump size	200 mm Suction / 150 mm Discharge
Maximum flowrate	1000 GPM | 227.3 m^3/hr
Maximum pressure	6.9 bar
Starter medium	Air

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The development of the overall system is shown in Figure 1. The system consists of a control panel where the user can monitor the current pressure during operation, control pressure input form the user. The control input feeds the data to the reconfigurable input/ output (I/O) ports where all the computations for the controller are calculated and translate the information to control the throttle for the diesel engine. The throttle is used to control the rotational speed of the centrifugal pump. The outlet pressure from the centrifugal pump is feed to the instrumentation amplifier to amplify the value and transfer it into reconfigurable I/O to complete the system as a feedback for a closed loop system.

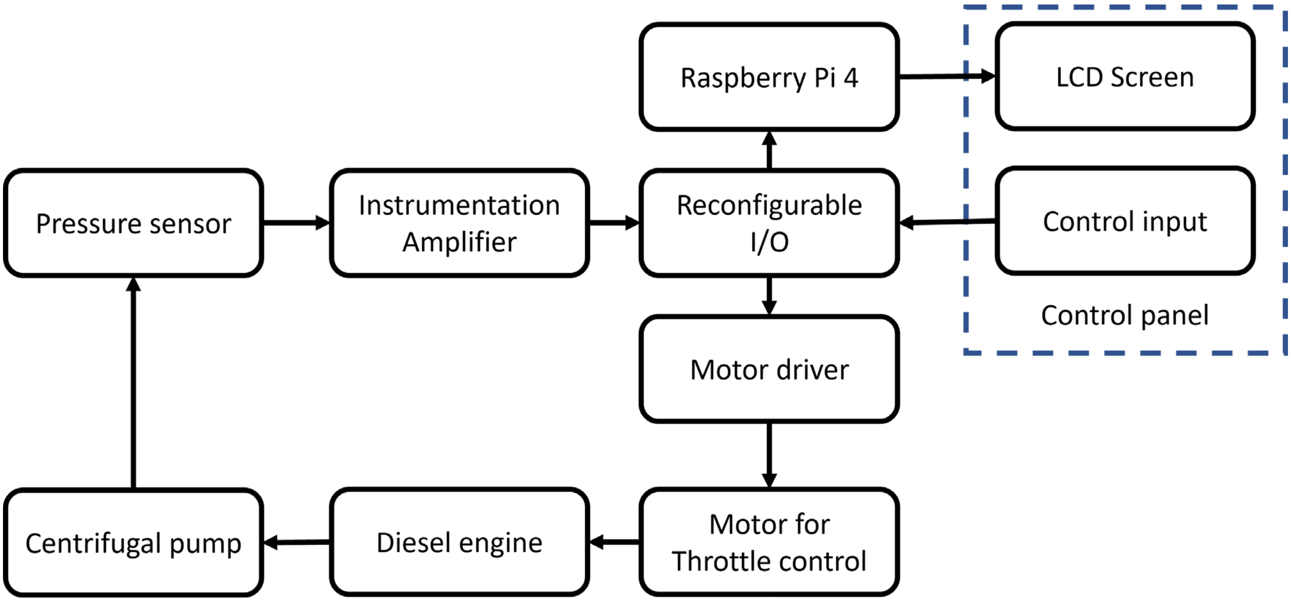

Figure 1. The block diagram of the system

Figure 2 showed the control panel used by the system. The motor for the throttle control is mounted on the control panel. The system is developed where the user can used automatic control scheme or manually control the rotational speed to operated the system.

Figure 2. The Control panel used for the system

RESULT AND DISCUSSION

To find suitable proportional gain to control the pump, few gain parameters were used for the tsting purpose. The proportional gains, Kp are set to 0.1, 0.2 , 0.4, 0.6, and 1. Control input to the pump is set at 0.9 bar. The output of the responses are shown in Figure 3.

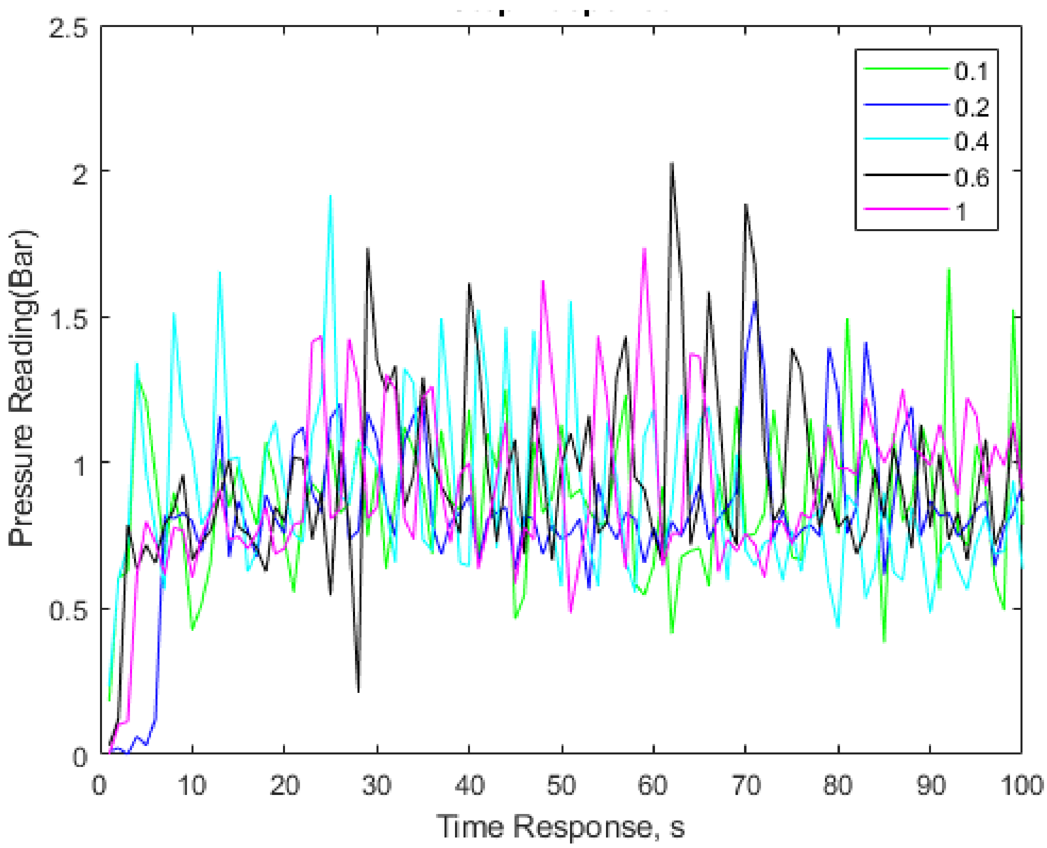

Figure 3. Output responses with different Kp

Based on the Figure 3, the output response for proportional gain equal to 0.2 have the most stable reading. For the overshoot, the system with proportional gain equal to 0.2 have the least overshoot compared with the other proportional gain. To test the system with different input parameters, proportional gain equal to 0.2 is chosen to be test. The control input pressure are configured at 0.6, 0.85 and 1 bar.

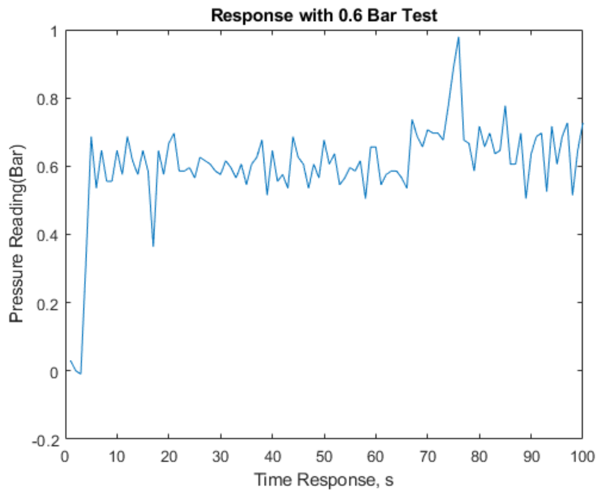

Figure 4. Output response with 0.6 bar control input

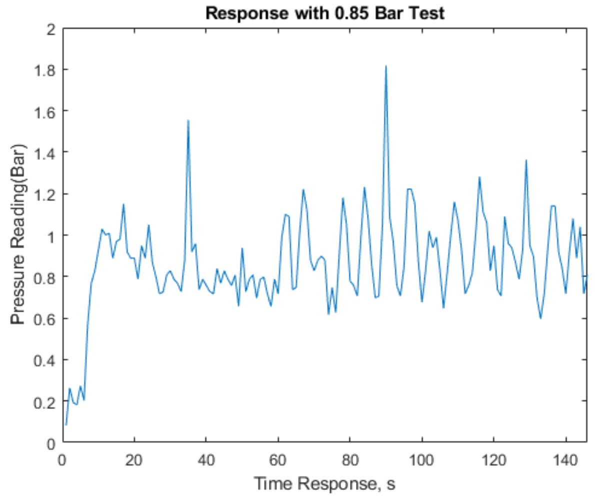

Figure 5. Output response with 0.85 bar control input

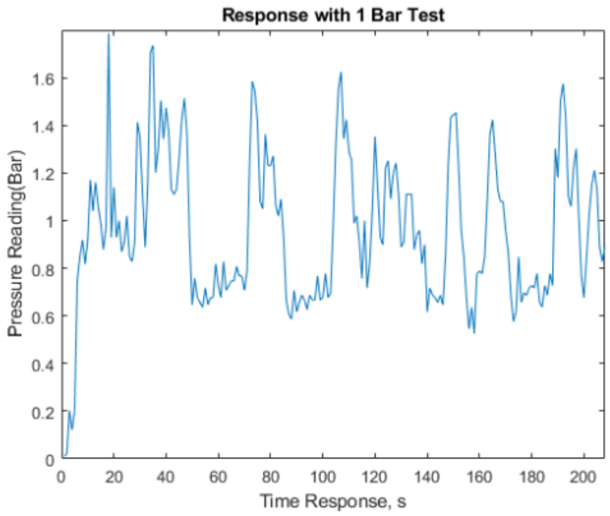

Figure 6. Output response with 1 bar control input

Based on Figures 4, 5, and 6, the output responses shows oscillation on the output. Critical gain parameter is chose as 0.2 based on the proportional gain value. The critical gain parameter value is then used to compute proportional, integral and derivative gains using Ziegler-Nichols tuning method.

Ziegler-Nichols Tuning Method

By using Ziegler-Nichols Second-Method tuning rule, increasing the K_P from 0 to a critical value K_{cr} at which the output first exhibits sustained oscillations [6]. Based on the rule, the result from the Figures 4,5, and 6 were the most suitable for this method. From the result, the computed values for the P_{cr} is equal to 1.4283 and the K_{cr} is equal to 1. Based on the P_{cr} and K_{cr} values, the values for K_p, T_i, and T_d are shown in Table 2.

Table 2. Ziegler–Nichols Tuning Rule Based on Critical Gain K_{cr} and Critical Period P_{cr} (Second Method)

Type of Controller	K_p	T_i	T_d
Proportional	0.5	∞	0
Proportional-Integral (PD)	0.45	1.1903	0
Proportional-Integral-Derivative (PID)	0.6	0.7142	0.1785

CONCLUSION

Based on the preliminary work done by this research, the PID parameter are able to be computed. The computed values can be implemented in the future works to test the diesel engine driven centrifugal pump using PID as a controller scheme.

In conclusion, the objective for this project is achieved that is to develop a pressure based control for a variable speed drive diesel engine driven pump controller. Proportional control scheme were chose as the control method to find the critical gain. The critical gain were then used to compute the PID parameter. The PID parameter were calculated using Ziegler–Nichols Tuning Method.

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