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A Study on PWM Parameters Range of on-off Electromagnetic Valve in Fluid Control Systems

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Abstract:
On-off electromagnetic valve driven by pulse width modulation (PWM) is used for adjustment of flow in fluid control systems. The parameters of a basic PWM driver include operating voltage, duty ratio and frequency. Regularly, operating voltage is fixed and given by manufactory, users can adjust PWM frequency and duty ratio to control flow and flow characteristics. Flow deviation led by unsuitable parameters selection results in deterioration of performance in fluid control system. By measuring flow-frequency data at a fixed duty ratio and flow-duty ratio data at a fixed frequency, this study revealed that in the frequency range of 45-105Hz under a fixed duty ratio at 50% or in the duty ratio range of 10% -90% by fixing frequency at 50Hz, the tested on-off electromagnetic valve possesses good linearity. This result provides references for the design of PWM driver.

Keywords: *On-off Electromagnetic Valve, PWM Parameters Range, Linearity*

1. Introduction

In field of fluid control, on-off electromagnetic valves have been widely applied for flow control as actuators because of their fine quality and competitive prices. Since traditional on/off electromagnetic valves have only on/off states, in order to obtain continuous variation of the flow, on/off valves should be operated under pulse width modulation (PWM) method. PWM technology is one of the modulation methods for electrical pulse signals [1, 2]. At a certain pressure and temperature, to adjust switch turn-on time (t_{on}) of square signal in a fixed frequency switch cycle (T) can control flow proportionally (shown in Fig.1). The parameters of a basic PWM driver include operating voltage (V), duty ratio (D) and frequency (F), D is defined as $D= t_{on}/T$. A higher PWM frequency is helpful to improve the control precision and reduce the pressure fluctuations; a wider duty ratio range leads to a larger flow regulation. Both increases of PWM frequency and duty ratio range are limited by the performance of on-off electromagnetic valves, excessive high frequency and wide duty ratio range cause unexpectedly nonlinearity. This study strives to describe available ranges of frequency and duty ratio to guide the rational use of this electromagnetic valve.

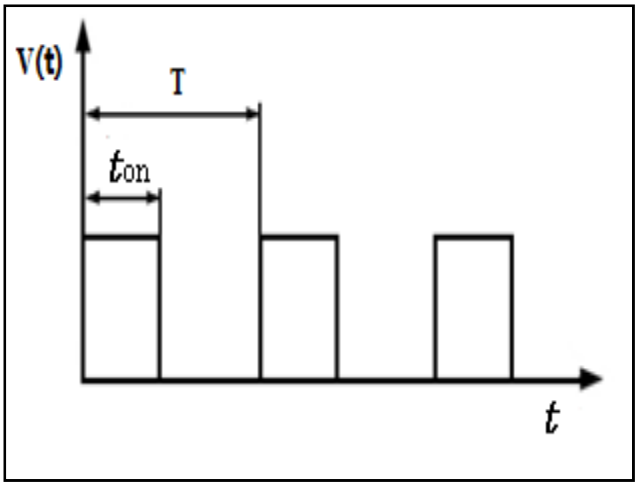

Figure 1: PWM operating method

2. Materials and Methods

2.1. Draft of test-bed

The test-bed is composed of liquid container, pump, pressure regulator, pressure meter, PWM driver, electromagnetic valve and graduated cylinder (shown in Fig.2).

The tested valve in this study is BOSCH 0 280 156 065.

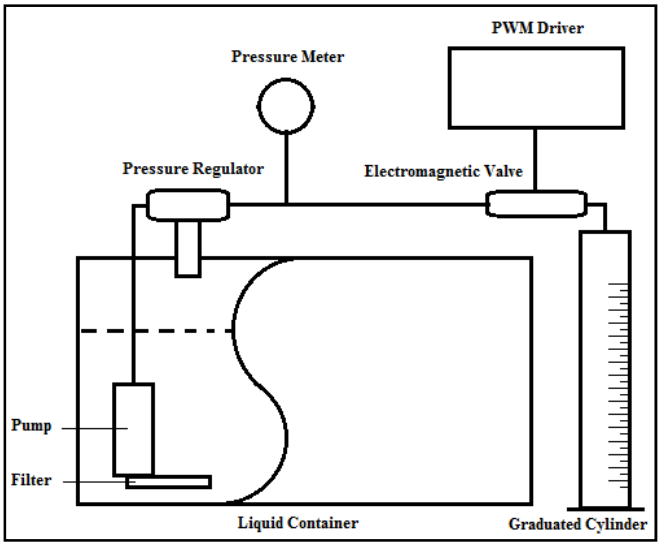

Figure 2: Draft of test-bed

2.2. Frequency Limit Test

After start pump, the flow data was recorded under the following conditions:

- Room Temperature: 21°C
- Test Media: Diesel Fuel
- Voltage: 12Vdc
- Test Pressure: 0.3MPa
- Fixed Duty Ratio: 50%
- Started Frequency: 30Hz
- Frequency Amplitude: 5Hz
- Test Time：60Sec

2.3. Duty Ratio Range Test

In this test, the flow data was recorded under the following conditions:

- Room Temperature: 21°C
- Test Media: Diesel Fuel
- Voltage: 12Vdc
- Test Pressure: 0.3MPa
- Fixed Frequency: 50Hz
- Started Duty ratio: 95%
- Duty Ratio Amplitude：5%
- Test Time: 60Sec

3. Result and Discussions

3.1. Frequency Limit

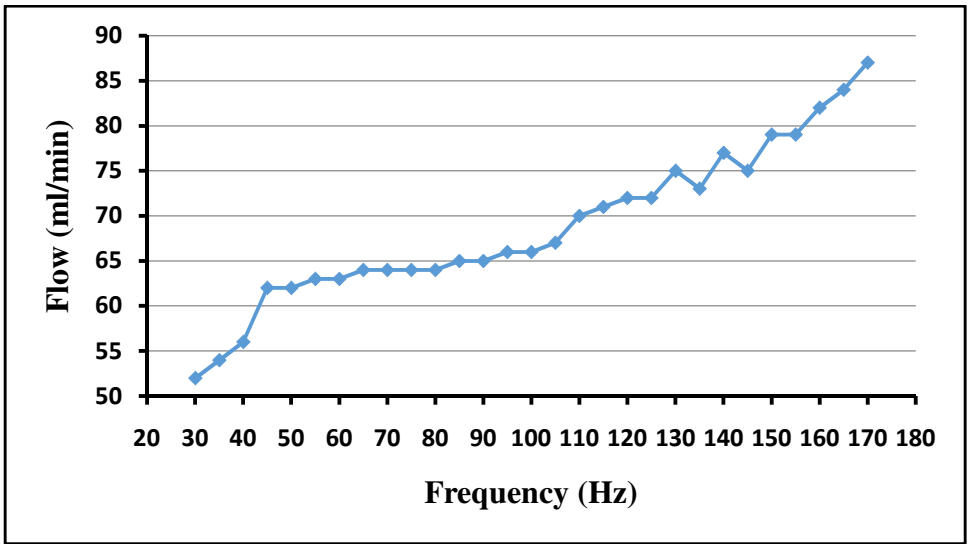

Figure 3: Flow-Frequency

As shown in Fig. 3, the results show that fixed duty ratio at 50%, the PWM perform linearity of flow within 45-105Hz of frequency, while outside range of 45-105Hz the flow changes are rapid.

3.2. Duty Ratio Range

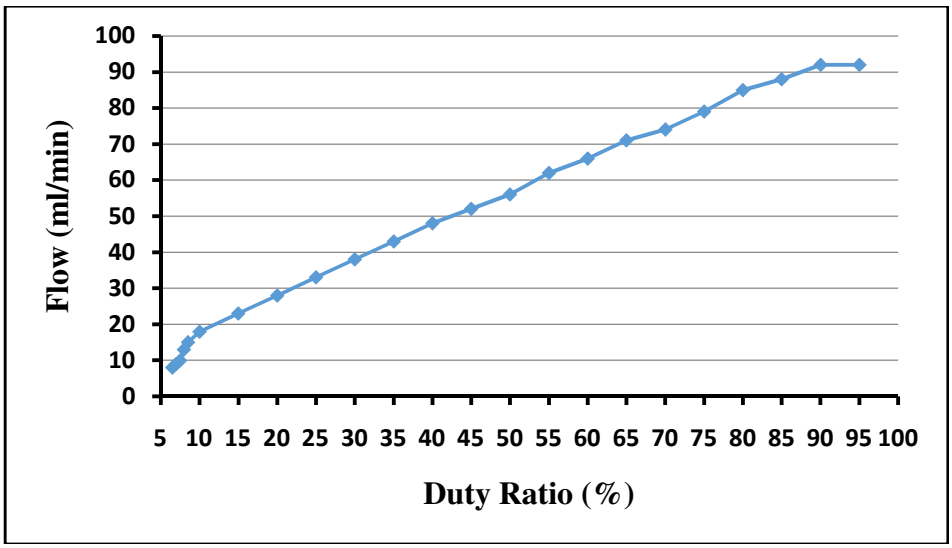

Figure 4: Flow-Duty Ratio

As shown in Fig. 4, the results show that under the condition of fixed frequency at 50Hz, the flow get a good linearity within 10-90% of ratio duty. Duty ratio that outside range of 10-90% resulted in nonlinearity of flow extremely.

This study indicated the valve possesses good linearity and get perfect flow regulation either in the frequency range of 45～105 Hz by fixing duty ratio at 50% or in the duty ratio range of 10%～90% by fixing frequency at 50Hz. These results will provide the parameters for PWM design.

4. References

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