Experimental Research on Gear Flowmeter Based on LABVIEW

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Abstract. In order to measure the dynamic instantaneous flow of the gear flowmeter, a volumetric gear flowmeter was used as the research object to simulate the measurement of the dynamic flow signal on the high pressure side. The flowmeter speed simulation experiment platform was built, and the inverter was driven by the PLC. When the inverter was activated, the inverter driven the motor to make the motor achieve different speeds, which was convenient for simulating the steady state experiment and dynamic experiment of the gear flowmeter. The program of measuring the signal of the dynamic flowmeter by using the virtual instrument was written. The response frequency of the dynamic gear flowmeter was 25Hz in the experiment. Experiments show that this measurement method is highly accurate and highly flexible, and it is easy to measure dynamic flow.

Introduction

Dynamic flow measurement of flow meters has always been a problem in the hydraulic field. Due to the large pulse of flow and pressure, it has been the main problem in China, and because of the mutual meshing of the gears in the flowmeter, the complexity of vibration and oil flow is generated, so that flow will be generated during its operation. The transient changes in pulsation, especially in high-pressure environments, will have greater hazards and effects. At present, there are many dynamic flow measurement methods on the high-voltage side of the country. The most commonly used method is the indirect measurement method. Due to various factors, the dynamic instantaneous flow detection effect is not achieved, and it is not applicable to all environments. The gear flowmeter obtains the required measurement value by converting the flow signal in the pipeline into the rotational speed signal of the gear that can be measured by the rotational speed sensor. Since the interference of the fluid itself is small and the influence of the flow state is not large, Therefore, in the field of high-speed side dynamic flow measurement of the system, the research on gear flowmeter is of great significance.

Experimental Platform and Programming

Composition of the Experimental Platform

The whole working principle consists of three parts: dynamic signal simulation, flowmeter housing simulation and acquisition signal. The dynamic signal of the gear flowmeter is simulated by forming an analog test bench. As shown in Fig. 1, the analog part of the dynamic signal is composed of PLC, frequency converter, motor and gear; the test of the flowmeter housing is composed of test caps with different thicknesses of different materials; composed of sensor, high-speed acquisition card and computer. The signal part is collected. Through the written PLC program, the program is transferred to the PLC, the PLC is used to drive the inverter, and then the inverter drives the motor to work. The
modified PLC program can be modified to change the multi-stage speed of the motor to achieve the steady flow of the analog flow meter. Changes with dynamic traffic.

**PLC Programming**

The external wiring diagram of the PLC is shown in Fig.2. The high frequency button is connected to the X0 input end of the PLC, the low frequency button is connected to the X2 input end of the PLC, the stop button is connected to the X22 input end of the PLC, and the Y20, Y21, Y22, Y23, Y24 of the PLC output terminal are respectively connected to the inverter port P4, P2, P3, P1, P5.

When the high frequency button is pressed, the PLC input port X0 is turned on, that is, the high frequency signal of the dynamic flow is simulated at this time; and when the low frequency button is pressed, the PLC input port X2 is turned on, that is, the dynamic flow is simulated. Low frequency signal; when the stop button is pressed, the PLC will stop working. M100 represents a high-frequency dynamic flow signal; M101 represents a low-frequency dynamic flow signal; and ZRST T200-T203 and ZRST T0-T3 represent reset operations of the counters T200-T203 and T0-T3, respectively. The input frequency changes by changing the count value in the program.

In order to measure the simulated dynamic flow and apply it to the flow of the high-pressure side hydraulic system, the motor controlled by the PLC-controlled inverter reflects the dynamic change of...
the gear speed\textsuperscript{[1]}. By writing a certain PLC program, this program is transmitted to the PLC to obtain the dynamic test frequency of the flow signal.

**Dynamic Flowmeter Data Acquisition**

Through the built-in flowmeter speed simulation experiment platform, the analog gear flow meter can be used in the hydraulic system to measure the dynamic flow under high pressure. In order to make the experiment as close as possible to the measurement results of the gear flow meter, in the simulation experiment, the interval time of each speed of the motor is adjusted to be small, so as to reflect the real situation as much as possible\textsuperscript{[1]}. The fastest time of motor operation is 0.01s, the response frequency of the sensor is 0.001s when the speed is 50~10000r/min. The 25-tooth gear is used in this experiment. The gear is rotated by the motor, and the CZ300 magnetoelectric is used. The speed sensor measures the speed of the change of the gear speed and outputs the signal in time. In addition to this, you need to set the sampling rate of the capture card. Due to external interference in the experiment, such as motor noise, data transmission and conversion, external disturbances and internal interference, etc., for these conditions, the USB-9229 capture card will be used. Because the USB-9229 capture card has its own "anti-aliasing filter interference for real signal measurement", its sampling frequency is high, so that the collected data will not be distorted, so you can solve such problems as much as possible to achieve better effect.

**Test System Structure**

Take NI LabVIEW as the platform and use NI data acquisition card to implement the test system\textsuperscript{[2]}. This system is designed to capture single-channel, dual-channel or even multi-channel analog signals and the occurrence of fictitious signals, and to analyze the processing of signals. The acquisition of front-end data and subsequent signal processing make the core part of the system\textsuperscript{[3]}. After the LabVIEW platform is designed, the data acquisition signal can be simulated, and the signal is analyzed and processed. On this basis, the virtual module signal suitable for the generator is developed, so that the signal sent by the generator in the virtual module signal can also be analyzed and processed. The block diagram is shown in Figure 3.

![Data acquisition and signal processing system diagram](image)

**Labview Programming**

In this experiment, the experimental block diagram shown in Fig.4 will be used for the experiment.
Figure 4. Experimental program block diagram.

As can be seen from Figure 4, the AI voltage channel is created by "DAQmx create virtual channel", and then the voltage signal in the AI voltage channel is transmitted to "DAQmx timing", where the sampling rate and number of samples of "DAQmx timing" are set; "DAQmx Start Task", "DAQmx Read", "DAQmx Stop Task". After the "DAQmx read", the read signal needs to be calculated accordingly. Therefore, the time domain waveform needs to be used, and then the time domain waveform is converted into spectrum analysis by spectrum measurement to obtain its frequency domain waveform. Leaf transformation (FFT) and correlation operations yield the frequency of the gear speed. In the experiment, first set the data sampling rate of high (generally 10 times the maximum signal frequency), and then take the real-time processing of the large sampling rate data, and then meet the segmentation sampling to make the motor work. The time is greater than the sum of the cycle time and the sampling time. Finally, the cycle time and the segmentation sampling time are separately optimized, and the data buffer is set.

As shown in the experimental front panel shown in Figure 5, the relationship between time domain waveforms, spectrum analysis, and frequency can be clearly seen.

Figure 5. Front plane of the experiment.

Experimental Results and Analysis

In order to make the experiment as true as possible, the PLC is used to control the inverter, and then the inverter drives the motor to achieve multi-speed operation. First set the inverter, then set the clock of the internal timer of the PLC. Every time you do an experiment, you need to modify the value of the timer. The speed of the gear speed change can be obtained according to the length of the motor operation time. The following experiments using gears mainly measure the acquisition and distortion
of the speed signal in the high frequency and low frequency, and the motor operation time and sampling rate. Table 1 is the relevant data settings. Table 1. Experimental data Settings.

<table>
<thead>
<tr>
<th>Motor action time(s)</th>
<th>Sampling number</th>
<th>Sampling rate</th>
<th>Cycle delay time(ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>300</td>
<td>5000</td>
<td>50</td>
</tr>
<tr>
<td>0.07</td>
<td>400</td>
<td>20000</td>
<td>100</td>
</tr>
<tr>
<td>0.04</td>
<td>600</td>
<td>30000</td>
<td>50</td>
</tr>
<tr>
<td>0.01</td>
<td>800</td>
<td>50000</td>
<td>1</td>
</tr>
</tbody>
</table>

After many experiments, select the best experimental results, as shown in Figure 6.

![Figure 6](image)

Figure 6. Experimental results.

From the experimental results shown in Figure 6, it can be seen that it yields a sinusoidal signal and is a period consisting of four segments of velocity. The experimental results of each of the graphs represent different times of motor operation, that is, the flow rate of the analog flowmeter. The motor operating time is not the time taken for one cycle of the motor to operate, but the time at each speed, so that the period T=4t and the frequency f=1/T=1/(4t) can be obtained. The experimental results are shown in Table 2.

Table 2. Experimental results.

<table>
<thead>
<tr>
<th>Frequency(Hz)</th>
<th>Period (s)</th>
<th>Time interval (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>0.25</td>
<td>4</td>
</tr>
<tr>
<td>(b)</td>
<td>3.57</td>
<td>0.28</td>
</tr>
<tr>
<td>(c)</td>
<td>6.25</td>
<td>0.16</td>
</tr>
<tr>
<td>(d)</td>
<td>25</td>
<td>0.04</td>
</tr>
</tbody>
</table>

It can be seen from the experimental results that the longer the motor works, the better the acquired signal is obtained, and when the motor operates faster and faster, the signal is relatively inferior. The experimental results show that when the frequency of acquisition is higher, the acquisition is not very good. This is due to the external interference in the experimental conditions and the noise of the motor inverter itself, which causes the signal to be distorted. As shown in Table 2, it can be observed that the current dynamic frequency of the flowmeter will reach 25 Hz.

**Conclusion**

A solution is proposed for the measurement of dynamic flow in the flowmeter, and the dynamic flow on the high pressure side is simulated. The composition of the flowmeter simulation experiment
platform is introduced, its structure is described, and the PLC related program is designed. The test system for simulating the high-speed side dynamic flow signal measurement is designed. The program is programmed by Labview, and then the relevant experimental parameters are set. Finally, the conclusion is obtained through experiments: when the motor operation time interval is 0.01 seconds, the dynamic gear flowmeter reaches The response frequency is 25Hz, and the flowmeter speed simulation experiment platform is also the place to be improved in the future. Due to the convenience of experimental research using the experimental platform, for the later study of the gear flowmeter, it can be studied first, through the actual Experiments are compared to provide a reference for future experimental research.

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References


