

Research Article

Visual Measurement of Air-containing Level in Hydraulic Oil with Lab VIEW

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Abstract: The primary purpose of this research is to construct a visual measurement system with Lab VIEW to measure the air-containing level in hydraulic oil. In this system, signals of pressure, flow and vibration, etc., are recorded by the virtual instrument based hardware platform and Lab VIEW testing panel measures the quantity of hydraulic oil air-containing and then displays the messages on the screen. In the measurement experiment, the significant fluctuation of the pressure signal can be observed through the piezoelectric pressure transducers and displayed when the air-containing level in hydraulic oil changes, which provides a valuable tool for real application.

Keywords: Air-containing level, hydraulic oil, Lab VIEW, measurement system

INTRODUCTION

Since the hydraulic system works under the atmospheric pressure, the oil will be inevitably mixed with the two forms of air: the dissolution and mixing (Pan *et al.*, 2001). The dissolving amount of air in the liquid obeys the Henry's law, for the volume of air dissolving in the liquid is proportional to the pressure under certain temperature and it is also true for the liquid of oil under very high pressure. The dissolving air has not direct influence on the physical properties. However, the air precipitation of the pressure dropping is the latent source of bubbles in the oil flow with the flowing process of the dissolving air. If the spherical bubbles with 0.25-0.5 mm diameter suspend in the oil, this type of mixing air and oil is called bubble oil or bubble flow, which has significant influence on the dynamic characteristics of hydraulic. As a result, the rigidity of oil flow is insufficient, the reaction retardation declines and the phenomenon "crawl" may be revoked and therefore it is necessary to measure the amount of air in the hydraulic system (Kohout *et al.*, 2005; Tiernan, 2010), in order to ensure the operation safety and high efficiency of system.

In recent years, amount of researchers have realized the importance of testing the air amount of the hydraulic system and have reached significant achievements in this field (Wang *et al.*, 2011). However, the testing of the air content in the oil is mainly dependent on the air detection equipment. Although this method can analyze the air content qualitatively, it has the obvious disadvantages, such as

no explicit target, high cost and unfriendly interface (Hu *et al.*, 2010).

The virtual instrument technology has the advantages of friendly interface, complete functions and nice show and it can take full advantage of the resources of powerful computer hardware (Jensen, 2011). The computer simulation technology is the key technologies that promote the development of the virtual instruments; the virtual instruments are divided into the following six types according to the hardware working platform:

- The virtual instrument based on PC bus
- The virtual instrument based on GPIB bus
- The virtual instrument of VXI bus
- The virtual instrument of PXI bus
- The parallel bus virtual instrument
- The serial bus virtual instrument

The mode of PXI bus is the extension of the PCI bus. The PCI system of desktop only has three or four extension slots, but there are eight extension slots using the PXI bus. With the PCI-PCI Bridge, the virtual instrument with PXI bus will be the effective testing system of virtual instrument (Elliott *et al.*, 2007). This study discusses the virtual instrument platform based on the PXI bus and develops a virtual panel of the air testing content of the hydraulic system so as to test the air content of hydraulic system.

Hardware platform of virtual instrument: The plug-in Data Acquisition card (DAQ) is one of the most

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Fig. 1: Virtual instrument hardware composition



Fig. 2: The PXI-6251 multi-function data acquisition card

frequently used interface of the virtual instruments and its function is to collect field data and platform and transfer the processed data between computer and operation object. Therefore, DAQ with the computer

virtual instrument software constitutes a data acquisition control equipment/system (Hu *et al.*, 2010). As shown in Fig. 1, the virtual platform consists of the PXI crate, the display, the zero-slot controller, the data acquisition card, the terminals of TB2705 and BNC2120 and the development of software.

The structure of each module is listed as follows:

The crate:

The PXI-1050: The combined crate of 8-slot PXI and 4-slot SCXI bus.

The controller: The PXI-8196 zero-slot controller: PM7602.0 GHz processor, 512 RAM, 40 G hard drive, one parallel port, one serial port, a GPIB interface, four USB ports and WinXP operating system. The accessories: GPIB interface adapter and parallel adapters.

The data acquisition card: The PXI-6251 multi-function data acquisition card (Fig. 2) 16 analog input channels, 16-bit precision, 1.25 MS/s sampling rate, 2 analog output channels, 16-bit precision, 2.8 MS/s output speed, 24-analog digital I/O, 2 analog timing counter.

The other equipment:

The TB2705 terminal: Connecting the PXI-6122 data acquisition card with the SHC68-68-EPM cable.

The BNC2120 terminal: Connecting the PXI-6251 with the SHC68-68-EPM.

The display: The terminal display output.

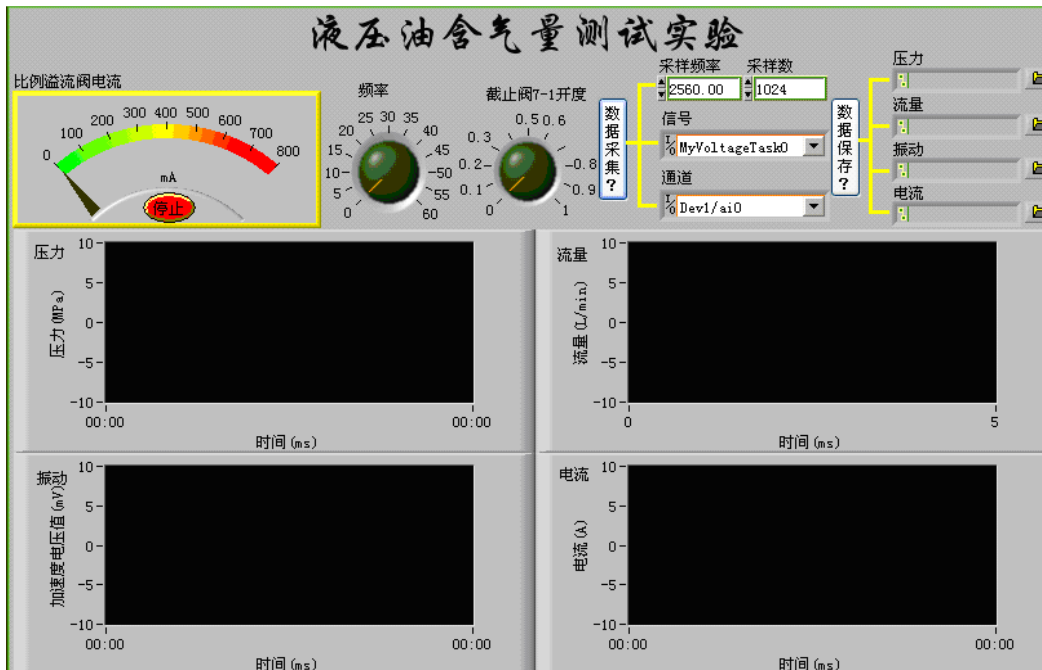


Fig. 3: The hydraulic oil air content testing panel

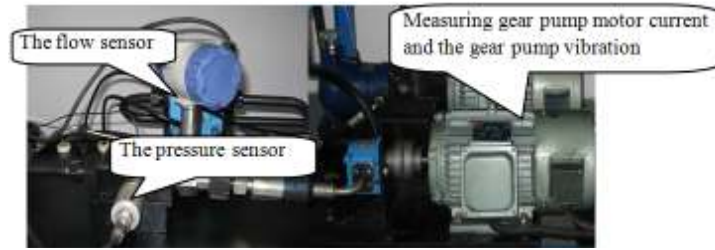


Fig. 4: The sensor installation

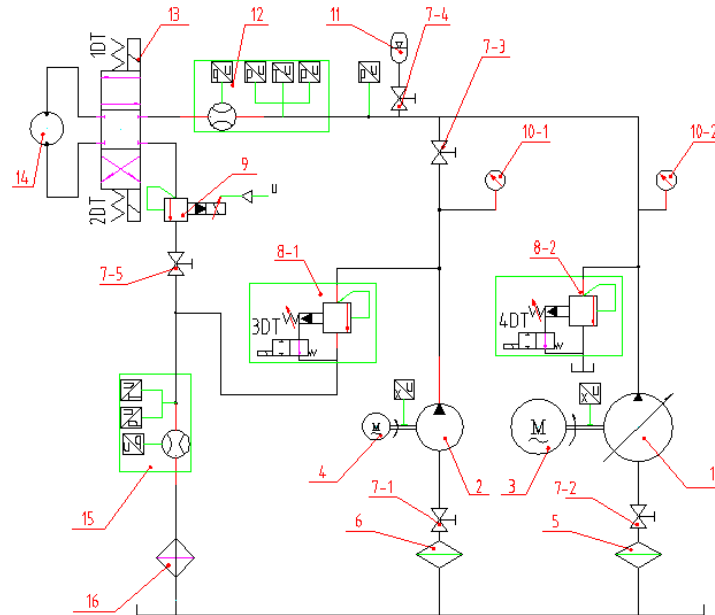


Fig. 5: The bench schematic

1: Piston pump; 2: Gear pump; 3, 4: Motors; 5, 6: Filters; 7-1, 7-5: The cut-off valve; 8-1, 8-2: The relief valve 9 the proportional relief valve; 10-1, 10-2: The pressure gauge; 11: Accumulator; 12, 15: The combination sensors; 13: The electromagnetic valve; 14: The oil motor 16 the radiator

MEASUREMENT EXPERIMENT

The key of measurement experiment is to use software of the virtual instruments to perform the different test (He *et al.*, 2003). The programs in VC, VB and Delphi are often used in the traditional software development platform, but all these software's require the tester to process of the output data. Besides, the tester could use different types of buses for data communication. Therefore, the above mentioned platforms are not suitable for the effective measuring experiment.

Nowadays, some professional software based testing platforms have been widely used, such as HPVIEE, the configuration software platform and the platform of TPS, etc., among which Lab VIEW is produced by the NI Corporation and can create the graphical programming environment. As software based platform, Lab VIEW supports the multiple instruments and data mining hardware as well as the multiple operating systems.

The air content panel of the hydraulic oil is shown in Fig. 3, which adjusts the current of the proportional pressure relief valve and sets data acquisition parameters. After the data path is set, the experiment then begins, observing the changes of pressure, flow and vibration by the sensors (Fig. 4), especially the fluctuation of air pressure, so as to analyze the relation between system pressure change and air content (Wang *et al.*, 2012).

The overall experiment is carried out through the multi-source diagnostic information platform of the hydraulic power system and the procedure is shown in Fig. 5.

Three types of signal charactering the oil pressure, flow, current and vibration acceleration are recorded and then all these data are used to measure the changes of air content through observing the system air pressure.

Button the normal motor 4 and the gear pump system then works. According to the system simulation air content, three levels (normal, mild, severe) are

required: adjusting the cut-off valve 7-1 to reach 3 levels, opening (full, 3/4 open, 2/4 open) the cut-off valves 7-1 moderately, opening the cut-off 7-3 and 7-5, closing the 7-2, the 1DT, 3DT and 4DT to maintain energy, setting the pressure of the relief valve 8-1 as 12 MPa, setting the pressure value of the relief valve 8-2 over 12 MPa, the electromagnet 1DT of the electromagnetic valve 13 for energy saving, setting the proportional relief valve amplifier board input current

as 300 and 400 mA and collecting these four kinds of signal of system oil pressure, the flow and the vibration acceleration.

RESULTS AND FINDINGS

Setting 2560 Hz as the working frequency and 1024 as the sample collecting points, then the data can be recorded in experiment process and the

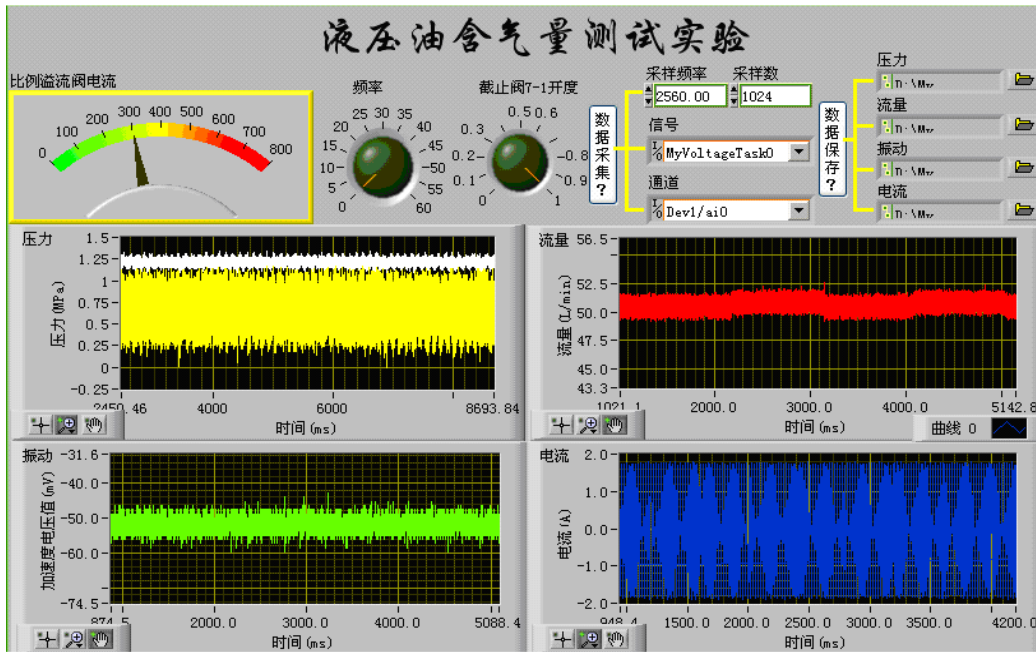


Fig. 6: The signal display when air content is normal and the proportional cut-off valve is 300 mA

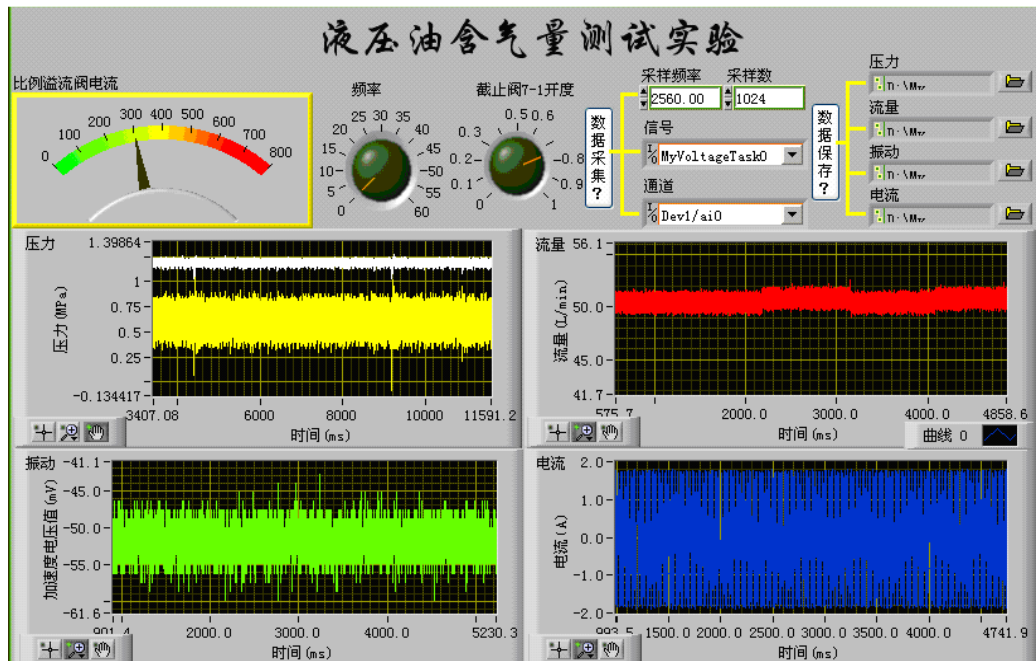


Fig. 7: The signal display when air content is mild and the proportional cut-off valve is 300 mA

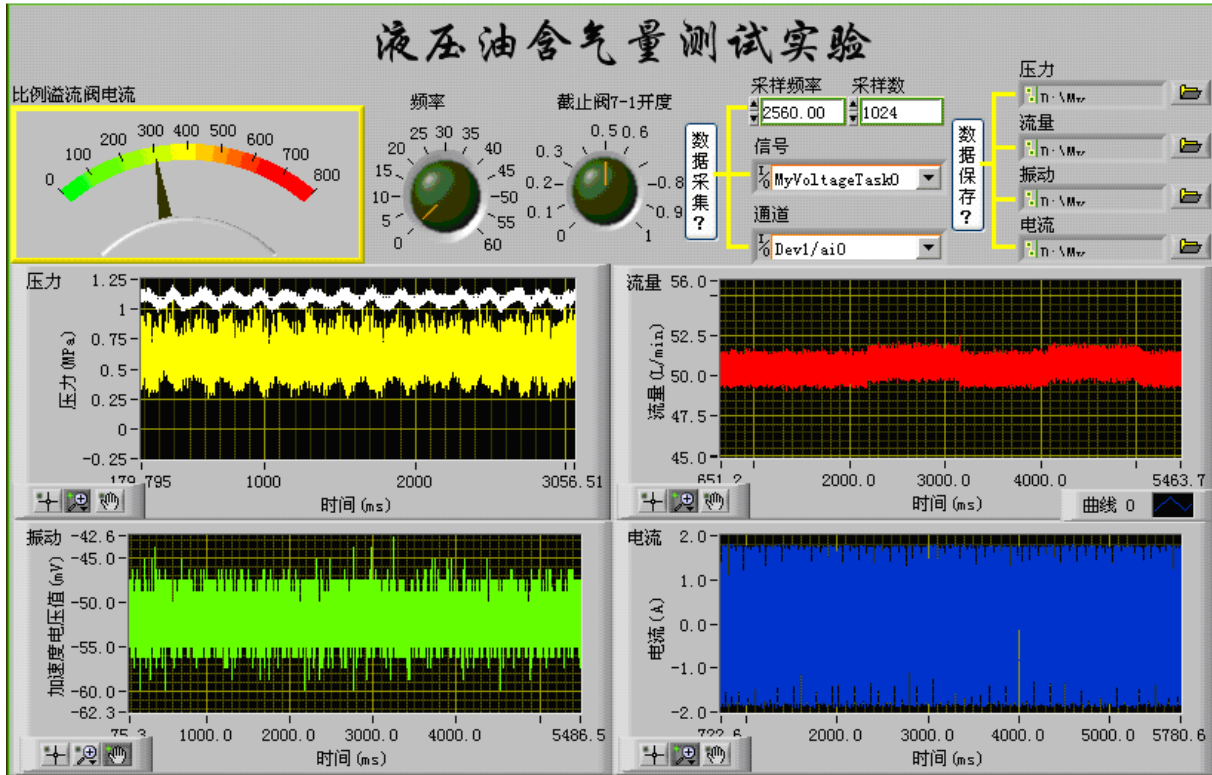


Fig. 8: The signal display when air content is severe and the proportional cut-off valve is 300 mA

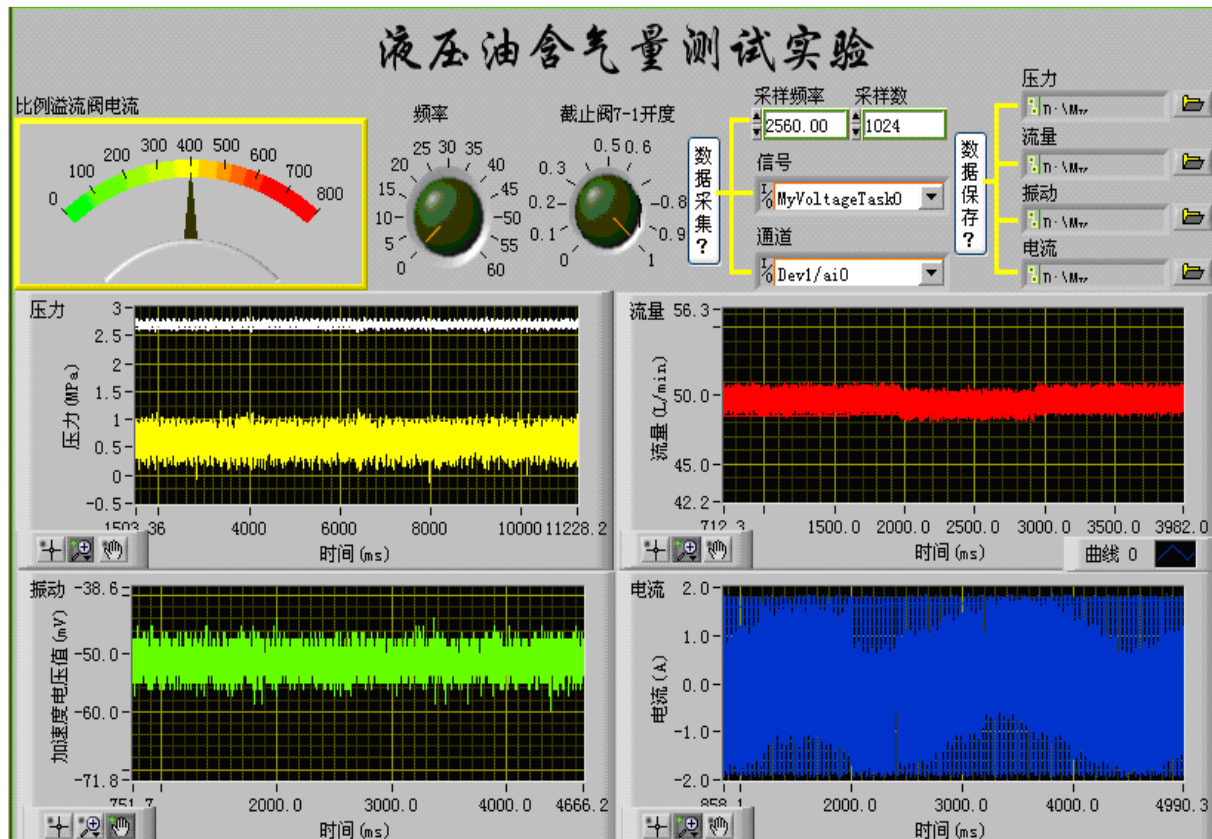


Fig. 9: The signal display when air content is normal and the proportional cut-off valve is 400 mA

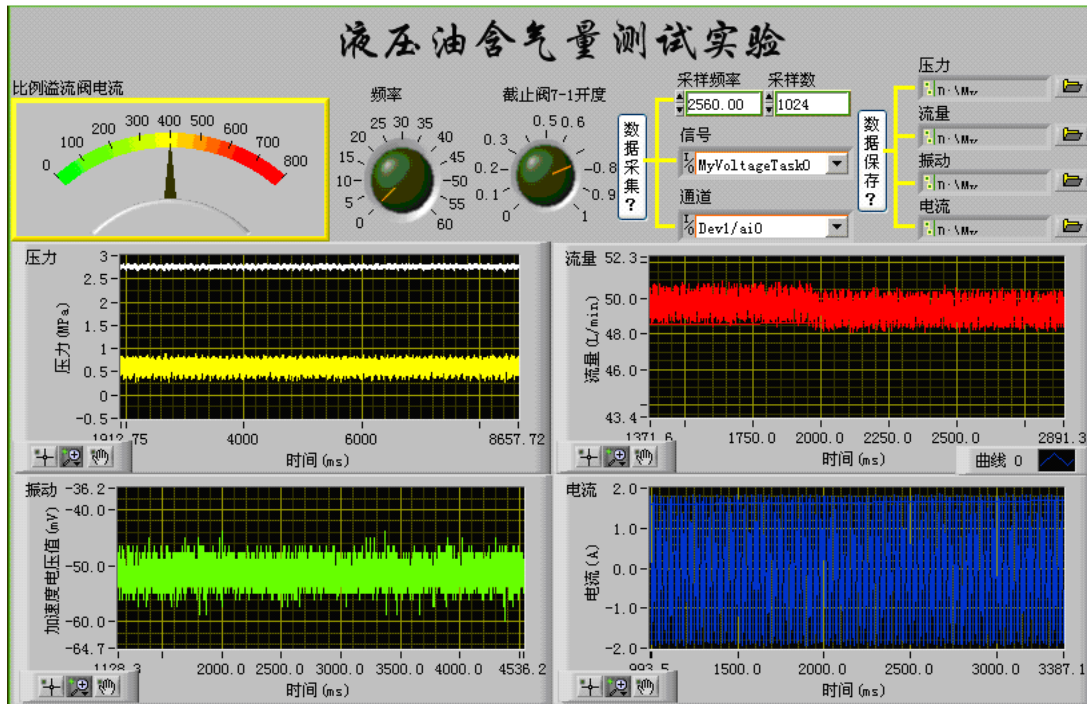


Fig. 10: The signal display when air content is mild and the proportional cut-off valve is 400 mA

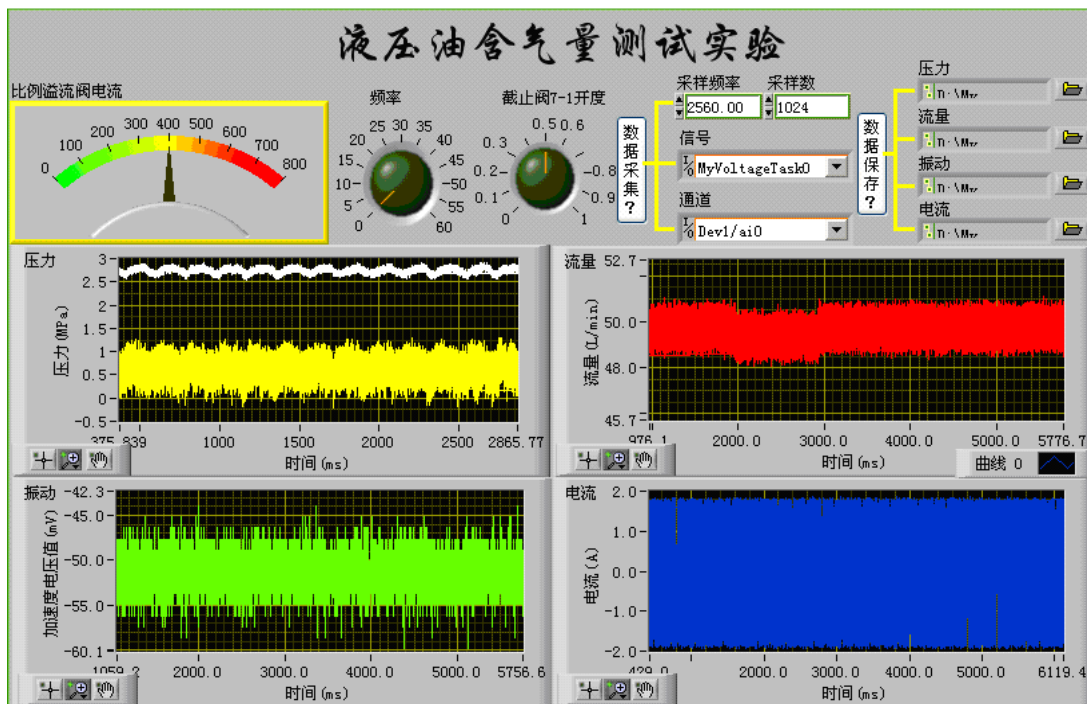


Fig. 11: The signal display when air content is severe and the proportional cut-off valve is 400 mA

change of signal wave is displayed on the screen. Especially, the data can be saved in the specified directory. The pressure signal display includes the output signal of the resistance strain pressure sensor and the output signal of the piezoelectric pressure fluctuation sensor. The first curve of the pressure signal

(the white one) is collected by the resistance strain pressure sensor and the second one (the yellow one) is by the piezoelectric pressure fluctuation sensor.

Three kinds of signal display are as shown in Fig. 6 to 8 under normal, mild and severe conditions with the proportional cut-off valve 300 mA.

Three kinds of signal display are shown in Fig. 9 to 11 under normal, mild and severe conditions with the proportional cut-off valve 300 mA.

Obviously, the signal from the piezoelectric sensor reflects the fluctuation of air pressure, compared with that from the resistance strain sensor, when the proportional cut-off valve remains the same, the amplitude and frequency of the pressure fluctuation increase with the increasing of air content, the flow changes a little, the vibration condition aggravates and the current increases. Therefore, this type of signal helps judge whether the air content is normal; under the same air content, the load becomes larger and the pressure frequency as well as amplitude both increase, if the proportional cut-off valve current increases.

CONCLUSION

The hydraulic oil air content information acquisition system is developed based on the virtual instrument hardware platform and Lab VIEW testing software. When the hydraulic oil air content changes, the signal of pressure, flow, fluctuation and current all change, but the pressure fluctuation signal changes more obviously than the other signal which could be used to judge the degree of the hydraulic oil air content. The piezoelectric pressure fluctuation sensor is more sensitive and accurate than the resistance strain pressure sensor and the fluctuation and current signal collected by this system therefore can be used for monitoring and diagnosing the hydraulic oil system.

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