Research on Fault Diagnosis of Hydraulic Oil Leakage in the ABS System of Automobile

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Abstract: At present, the self-test of ABS system cannot detect faults in mechanical parts, such as solenoid valve clamping and hydraulic oil leakage. In an indoor environment, a dynamic monitoring system is built that uses sound signals, vibration signals and pressure signals to detect mechanical parts of the ABS system. The hydraulic oil leakage failure will cause the oil pressure to decrease, fail to meet the working conditions of the hydraulic system, and reduce the working efficiency. In severe cases, the hydraulic system may even fail, which may cause the ABS system to malfunction and cause a traffic accident. The mechanical fault diagnosis of the automotive ABS system is an important way to ensure the safe operation of the vehicle and the good performance of the ABS system.

1 INTRODUCTION

At present, the self-test of the ABS system can only detect electrical faults such as open circuit and short circuit, while typical faults of the mechanical part, such as hydraulic oil leakage faults, are not within the scope of its self-test. Independently build a dynamic monitoring system built in an indoor environment, using sound signals, vibration signals and pressure signals to detect mechanical parts of the ABS system. The mechanical fault diagnosis is an important way to ensure the safe operation of the vehicle and the good performance of the ABS system.

In addition to the in-depth research conducted by manufacturers of ABS systems, scholars currently studying in universities and research institutes in China have studied the fault diagnosis technology of ABS systems, they have proposed many simulation analysis of the faults diagnostic methods, these studies have laid the foundation for further in-depth research, which greatly stimulated the research interest in the field of ABS system fault research and urged efforts to solve the faults. (Struss P, 1997) The ABS system and its failures have been studied very early in the world, such as Peter Struss of the Technical University of Munich, and Martin Sachenbacher of BOSCH, who use the automation and intelligent inference techniques to troubleshoot the ABS system. A team of Professor Harald Straky from Darmstadt University of Technology built a real-time observation system for hydraulic brakes based on the residual method, they used hydraulic control models to detect hydraulic system air mixing and brake fluid leakage.

2 THE FAULT OF HYDRAULIC OIL LEAKAGE

During the operation of the hydraulic system, due to the high pressure value in the hydraulic pipe or the gap between the installation components of the hydraulic system. (Sachenbacher M, Struss P, Carl, et al, 2000) When the pressure reaches a certain value, a small amount of hydraulic oil leakage will occur in the gap between the systems or components. This leakage will result in a reduction in oil pressure in the hydraulic system and will not meet the operating conditions of the hydraulic system. It will also reduce the working efficiency of the hydraulic system. When a hydraulic oil leak occurs in the hydraulic system of the ABS system, the pressure in the hydraulic cylinder and the amount of leakage in the cylinder Q determine the value of a leak. The pressure P is a linear relationship with the brake

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torque T . R is the leakage coefficient, K_t is the factor of the brake pedal brake, and obtains a leakage equation (1):

$$\begin{cases} \frac{V_a}{\beta_\varepsilon} \cdot \dot{P}_a = Q_i - Q_l \\ Q_i = P_b \cdot R \\ T_b = K_t \cdot P_b \end{cases} \tag{1}$$

3 A SIMULATION MODEL

According to the control and logic of BOSCH, the threshold value of the addition and deceleration speed, with reference to the slip rate threshold, a single wheel model is established. This is a fault simulation model for establishing (Yue Liang, 2018) ABS system oil leakage in Matlab/Simulink. As shown in Figure 1 below:

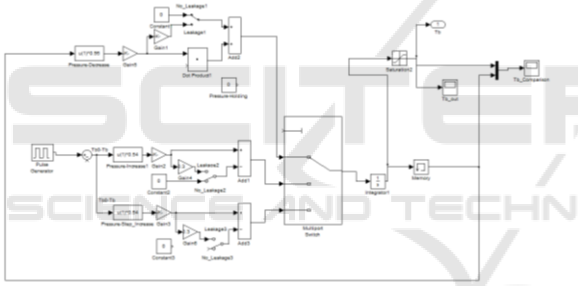

Figure 1. Simulation of oil leakage fault of ABS system.

4 HARDWARE COMPONENTS OF THE DYNAMIC MONITORING SYSTEM

Independently build an indoor hardware experiment platform, through the seamless integration of software and hardware through dSPACE. The sound sensor is equivalent to a microphone, placed as close as possible to the solenoid valve, receives sound waves, and will display a vibration image of the sound generated by some ABS solenoid valves. Between the sound sensor and the computer, a sound amplifier is connected to make the acquired data more accurate. On the experimental platform, the leak port was selected as the screw mounting hole on the hydraulic cylinder of the ABS system. The main reason for selecting this hole as the hydraulic oil leakage port is that the hole is located above the hydraulic pipe, and there is no oil leakage in the hydraulic pipe when the brake pedal is not depressed. This position is convenient for sampling when simulating the leakage of hydraulic oil, and it can also reduce the error.

5 DYNAMIC SIGNAL MONITORING OF MECHANICAL FAULTS

5.1 Sound Signal

Since the collected sound signal data is large and continuous, the feature value parameter is extracted from the sound information, and the health state of the ABS system can be confirmed by comparing the reference template corresponding to the sound.

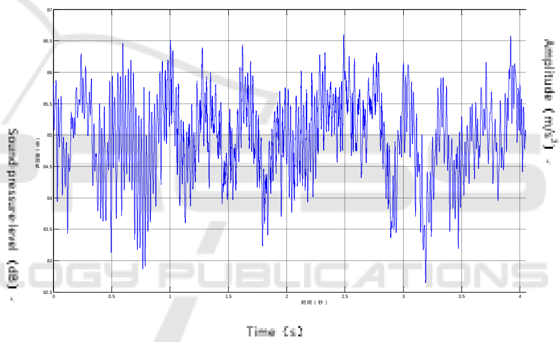

Figure 2. Sound signal under oil leakage.

When collecting the sound signal, start the ABS system of the test bench and press the brake pedal until the bottom. According to the pressure of the pressure, the amount of hydraulic oil sprayed is not the same, generally in the range of 1ml - 8ml.

(Shi Z, Gu F, Ball A, 2010) For example, when the oil leakage in a test is 3.8ml, the maximum value of the sound data collected by the test bench is 86.5977, the minimum value is 82.6429, and the covariance value is 62.4611. Comparing the data of the same condition ABS system under normal state, the maximum value of sound is 84.0733, the minimum value is 83.7740, and the covariance value is 41.5371. Make a type match and get the difference value. According to the graph and data, it can be concluded that the ABS system works louder in the event of oil leakage.

5.2 Vibration Signal

A frequency domain vibration signal diagram of the dynamic detection of the ABS system, with frequency as an independent variable, established a relationship between the amplitude, phase and frequency of a vibration signal. The abscissa is Hertz and the ordinate is the magnitude.

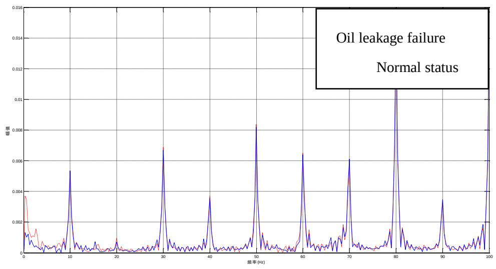

Figure 3. Vibration signal of the oil leakage fault (frequency domain).

The time-domain vibration signal diagram of the dynamic detection of the ABS system is time independent variable, which describes the characteristics and relationship of these vibration signals over time in the oil leakage state.

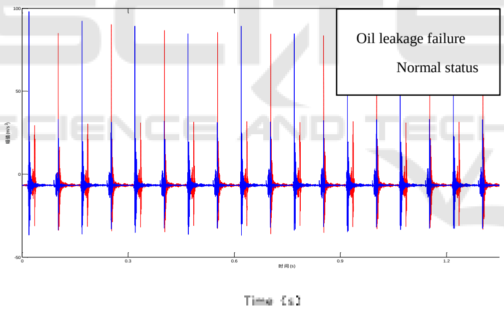

Figure 4. Vibration signal of oil leakage fault (time domain).

It can be seen from the frequency domain image that the fundamental frequency of the vibration signal is lower than the normal state in the fault state, and the vibration is weakened; It can be seen from the time domain image that in the oil leakage fault state, the vibration amplitude is significantly lower than the normal state, and the vibration is weak. This is because when the oil leakage occurs, the pipeline pressure is reduced and the vibration is naturally weakened. Connect to the dynamic signal collector via a pressure transmitter to collect the pressure of each hydraulic line. The experimental results show that when the hydraulic oil leaks, the hydraulic pipeline pressure drops, which in turn affects the working effect of the ABS system.

5.3 Pressure Signal

Figure 5 shows the pressure change curve of each channel collected when the pipeline of the left rear wheel leaks oil. It can be clearly seen that the oil pressure causes the pipeline pressure to drop. Due to the three-channel structure of the ABS system, that is, the left rear wheel and the right rear wheel are the same channel, comparing the pressure changes of the two channels, It can be seen that the left rear wheel pressure (blue line) where the oil leakage occurred is significantly lower than the right rear wheel pressure (red line) without oil leakage.

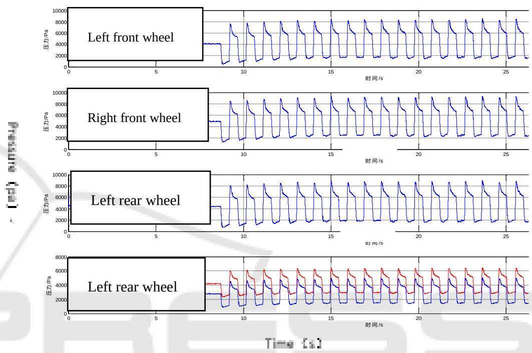

Figure 5. Pressure curve of each channel when the left rear wheel hydraulic line leaks oil.

6 SUMMARY

The real-time monitoring system of the dynamic signal explores the health status of the ABS system through the characterization of these sound signals, vibration signals and pressure signals, and studies the oil leakage faults that cannot be detected in the self-checking function. The experimental results prove that these dynamic signals can indeed reflect the working state of the ABS system. In the oil leakage fault state, the dynamic signal changes reflect the changes in the health status of the ABS system. The purpose of this study is to find a way to directly detect the internal mechanical failure of the ABS system by enclosing the external layer magnets, that is, to reflect the working state by the characteristics of the dynamic signals. However, due to the limited faults that can be simulated, the core technology of the ABS system is unknown, and it can only be modeled according to its working principle. However, the accuracy of the model can the parameters are constantly adjusted according to the actual vehicle condition. At present, the accuracy is still lacking, and the simulation model needs to be continuously optimized. It can be adjusted according to the ABS system data of different models, considering multiple external factors, improving the accuracy of the simulation model and the accuracy of the simulation results. There are many aspects of the mechanical failure of the ABS system, but due to the current inspection requirements, the overall disassembly inspection cannot be performed. Therefore, many internal structural mechanical faults are difficult to detect, and it is difficult to simulate the internal structure of the ABS system. In the indoor environment, more faults are explored and simulated, the characteristics of the dynamic signals are analyzed, and more fault databases are established. This will be the future development direction of the health monitoring of the ABS system.

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