Automatic detection system for performance curve of exhaust valve of tractor turbocharger

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Abstract: The matching of the tractor turbocharger and the engine has a great influence on the vehicle's dynamics, economy and other parameters. The bypass air release adjustment scheme has been widely used due to its simple structure and high reliability. Therefore, a platform capable of qualification testing is needed to test and evaluate the performance of the air release valve. This article carried out the design of the hardware detection platform of the bypass valve, and completed the program design based on the force control configuration program platform, which mainly includes manual static, automatic static and dynamic detection of the tractor turbocharger exhaust valve Procedures etc. The detection system has the characteristics of low cost, high degree of automation, high detection accuracy, and strong stability, and can perform detection of different types of bypass valves. The performance of the hardware platform and software was verified through experiments. The experimental results show that the detection system can meet various requirements and can be used for the detection of actual vent valve production.

1. Introduction

The supercharging technology uses the energy of the exhaust gas discharged from the internal combustion engine to drive the turbine, which drives the coaxial centrifugal compressor to compress the air and increase the density of the intake air, thereby improving the performance of the internal combustion engine[1]. As the degree of enhancement of turbocharged diesel engines for tractors has been greatly improved in recent years, compared with diesel engines without turbochargers, the power can be increased by 23-28 horsepower/liter, and the corresponding increase in power per litre is 40%-50%. Can greatly increase the labor rate of agricultural production.

When the turbocharger is matched with the engine, if the matching is not good, the boost pressure is too large or too small, the mechanical load is too large, the internal combustion engine and the turbocharger are seriously overspeed, the internal combustion engine torque is insufficient, and the emissions deteriorate. Therefore, the turbocharger needs to be adjusted to achieve a good match between the tractor turbocharger and the engine in the full range of working conditions. At present, the most commonly used adjustment method is the bypass method[2-3].

[1] The matching of the tractor turbocharger and the engine has a great influence on the vehicle's dynamics, economy and other parameters. The bypass air release adjustment scheme has been widely used due to its simple structure and high reliability. Therefore, a platform capable of qualification testing is needed to test and evaluate the performance of the air release valve. This article carried out the design of the hardware detection platform of the bypass valve, and completed the program design based on the force control configuration program platform, which mainly includes manual static, automatic static and dynamic detection of the tractor turbocharger exhaust valve Procedures etc. The detection system has the characteristics of low cost, high degree of automation, high detection accuracy, and strong stability, and can perform detection of different types of bypass valves. The performance of the hardware platform and software was verified through experiments. The experimental results show that the detection system can meet various requirements and can be used for the detection of actual vent valve production.

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At present, the detection of the bypass valve is mainly completed by manual manual detection, and its detection efficiency and detection results are greatly affected by the quality of the workers. By adopting automated test technology, both test efficiency and measurement accuracy can be improved [4-6].

2. Automatic detection system scheme design

2.1 Test bench composition

In order to realize the measurement experiment of the turbine wastegate valve parameters, the test test of the pressure-stroke static and dynamic curve of the exhaust valve, and the qualification judgment of the test results, the test bench should include the following main components: test bench, inlet Air pressure control device, data acquisition and monitoring system, etc. The test bench is equipped with a pressure sensor and a displacement sensor, which can detect the pressure and displacement parameters of the wastegate valve.

2.2 Technical requirements of the test bench

According to the functional requirements of the wastegate valve, the measurement parameters and measurement range of the test bench test system should meet the requirements of Table 1.

Table 1 Main measurement parameters and measurement accuracy of the test bench

| No. | Name                                  | Unit | Range  |
|-----|---------------------------------------|------|--------|
| 1   | Bleeding bypass valve pressure 1      | kPa  | 0~650  |
| 2   | Bleed bypass valve pressure 2         | kPa  | 0~400  |
| 3   | Laser displacement sensor             | mm   | 0~50   |

At the same time, the experimental platform has the following output parameters, and the output signal types are shown in Table 2.

Table 2 Test bench control parameters and adjustment range

| No. | Name                               | Unit | Adjustable range | Remarks          |
|-----|------------------------------------|------|------------------|------------------|
| 1   | Pressure regulator control signal  | V    | 0 ~ 5.0          |                  |
| 2   | Reset signal                       | V    | 0 ~ 5.0          |                  |
| 3   | Yellow light                       | V    | 0 ~ 5.0          | Stopped state    |
| 4   | Green light                        | V    | 0 ~ 5.0          | Detection status |
| 5   | red light                          | V    | 0 ~ 5.0          | Alarm status     |
| 6   | buzzer                             | V    | 0 ~ 5.0          | Alarm sound      |

2.3 Measurement and control system hardware selection

The selection of each part is shown in Table 3.

Table 3 Hardware selection

| Hardware name                        | model          |
|--------------------------------------|----------------|
| Positive pressure proportional valve | SMC- ITV2030   |
| Negative pressure proportional valve | SMC- ITV2050   |
| Data acquisition card                | Advantech- PCI-1711 |
| Pressure Sensor                      | Drucker-PTX5072 |
| Motion detector                      | HG-C1030       |
The completed turbocharger exhaust valve performance curve detection system is shown in Figure 1.

Figure 1 Turbocharger gas release valve detection system bench

3. Programming platform and overall plan

According to the performance testing requirements of the bypass valve, the overall program design is shown in Figure 2.

Figure 2 Overall block diagram

The program interface after the software design is completed is shown in the Figure 3.
4. Consistency test research

Based on the combination of the completed software program and the hardware platform, the performance curve of the turbocharger bleed valve was tested. Through multiple experiments, the consistency results were obtained, which meant whether the test results were consistent for the same test object, which also reflected the stability of the test system. The verification experiment settings were shown in Table 4.

Table 4 Consistency verification experiment settings

| Test group number | Dynamic/static | Test speed (kPa/s) | repeat times |
|-------------------|----------------|-------------------|--------------|
| 1                 | Dynamic        | 10                | 10           |
| 2                 | Dynamic        | 15                | 10           |
| 3                 | static         | /                 | 10           |

4.1 Dynamic mode consistency experiment of positive pressure valve

Table 5 Dynamic consistency experiment results of bypass valve

| Data location   | Average displacement of group 1 | Average displacement of group 2 | Standard deviation of group 1 | Standard deviation of group 2 |
|-----------------|---------------------------------|---------------------------------|------------------------------|------------------------------|
| 50kPa process   | 3.79                            | 4.20                            | 0.167                        | 0.157                        |
| 50kPa return    | 2.89                            | 2.56                            | 0.150                        | 0.178                        |
| 80kPa process   | 9.10                            | 9.65                            | 0.116                        | 0.327                        |
| 80kPa return    | 8.02                            | 7.53                            | 0.174                        | 0.205                        |
| 110kPa process  | 15.47                           | 15.84                           | 0.194                        | 0.278                        |
| 110kPa return   | 14.24                           | 13.88                           | 0.162                        | 0.229                        |

Some rules could be found by comparing the two sets of data of the bypass valve. At the same pressure point, the progress displacement value was obviously greater than the return displacement value. And as the measurement speed increased, the process displacement value at the same pressure point also increased, while the return displacement value decreased, and the data standard deviation basically increased. That is, an increase in speed will increase the error of the measured curve data.

4.2 Static mode consistency experiment of positive pressure valve

The mean and standard deviation data of displacement data were obtained at several pressure points.
According to the above data, in static measurement, the process displacement value at the same pressure point was slightly smaller than the return displacement value. The standard deviation was smaller than that of the dynamic mode as a whole, that is, the measurement consistency of the static mode was relatively stronger.

5. Conclusions

This paper completed a good performance curve detection platform for the bypass bleed valve of tractor turbocharger. The results of many experiments showed that the performance curve detection platform could effectively complete the detection of the static curve and the dynamic curve of the bypass valve, and made the correct qualification judgment. It had high accuracy and a high degree of automation which had strong operability. In addition, the consistency verification experiment proved that the hardware platform had good stability, low detection error rate and low failure rate.

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