

Automatic Monitoring System for Threshing and Cleaning of Combine Harvester

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Abstract. The threshing and cleaning process of combine harvester is easy to break down, so it is necessary to monitor it automatically. This paper takes PLC as the core controller, through the touch screen designing man-machine interface. The hardware and software is designed, and the automatic monitoring system for threshing and cleaning of combine harvester is developed. Threshing and cleaning work parameters is early warned and controlled, and the experimental platform is built to verify the validity and rationality of the system development.

1. Introduction

Combine harvester is harvesting, threshing, separating and cleaning tank and other functions of the complex agricultural machinery, can greatly reduce the labor intensity of farmers, threshing and cleaning device is the key device of grain combine, operation efficiency and reliability of the harvester has an important effect on [1]. Harvesting machine works in the field, due to the harsh and changeable environment, often malfunction, threshing and cleaning device as the harvester important device, once the fault will not only delay the time to repair a lot of farmers will bring direct economic loss [2]. Therefore, in order to give full play to the best operation performance and ensure the harvesting efficiency, it is necessary to monitor the threshing cleaning process automatically.

2. Overall program of monitoring system

On the basis of studying the principle of threshing cleaning and analyzing the main factors influencing threshing cleaning effect, the automatic monitoring system of threshing cleaning is developed with PLC as the core controller, as shown in figure 1. The capacitive moisture sensor for the detection of grain moisture content, the piezoelectric sensor for the detection of feed quantity, dynamic torque sensor for detecting cylinder torque and rotational speed, displacement sensor with speed, threshing clearance, fan speed and the sieve box drive speed sensor detects the speed of Holzer harvest walk; PLC and touch screen serial communication signal, above all the sensor on the touch screen man-machine interface, so that the driver can be directly observed when the key parameters of harvester threshing and cleaning process; the driver through the man-machine interface control directly proportional solenoid valve, adjusting the rotating speed of the threshing cylinder, threshing clearance, fan speed and the sieve box drive speed; touch screen the alarm interface, and based on the experience of handling various acquisition parameters set alarm preset value, if the real-time When the parameter value exceeds the



preset value, the alarm device carries out the sound and light alarm, the triggered alarm interface is ejected automatically, and the warning driver is operated in time to solve the impending problem and avoid the occurrence of the fault.

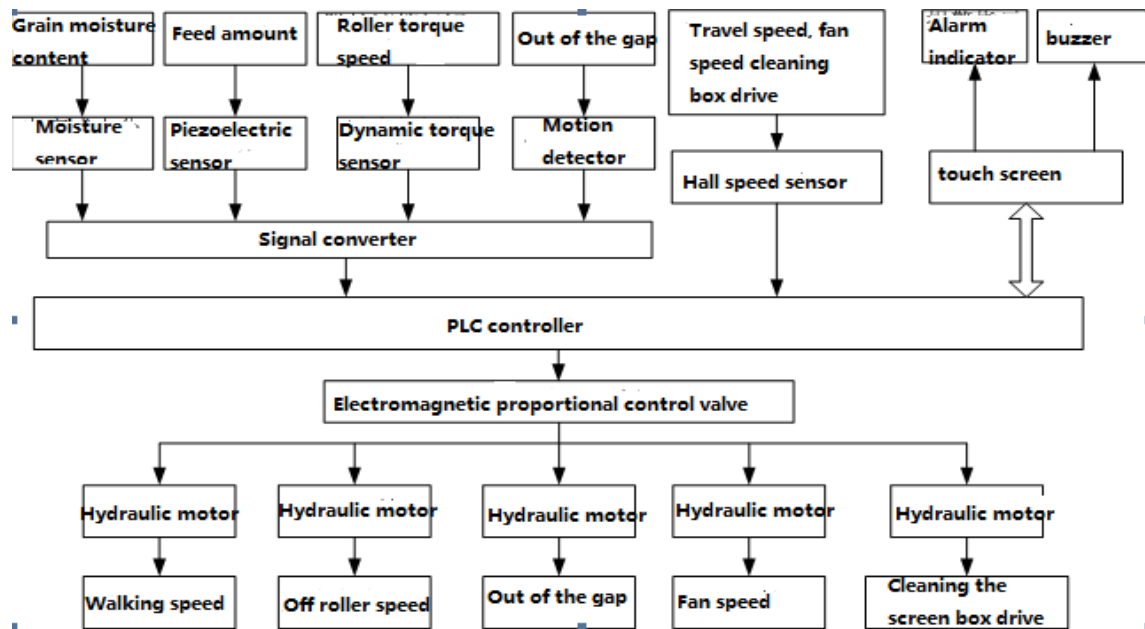
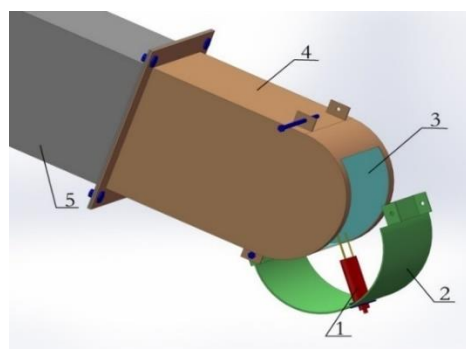


Figure 1. the overall program of threshing and cleaning monitoring system of combine harvester

3. Hardware design

3.1. Detecting of grain water content

The arrangement of moisture sensor is critical, which cannot affect the normal operation efficiency of the harvester, and cannot affect the detection accuracy or even cause damage to the sensor due to improper placement. Based on the analysis of the working process and mechanical structure of the combine harvester, the layout scheme of the moisture sensor is determined, as shown in figure 2. The harvester grain elevator connecting head is provided a sampling port, through the design of a movable baffle rotated around the connecting shaft can realize sampling opening, the moisture sensor is fixed on the nut on the movable baffle plate through the movable baffle, closed, in the process of grain elevator to the granary, can detect grain moisture content.

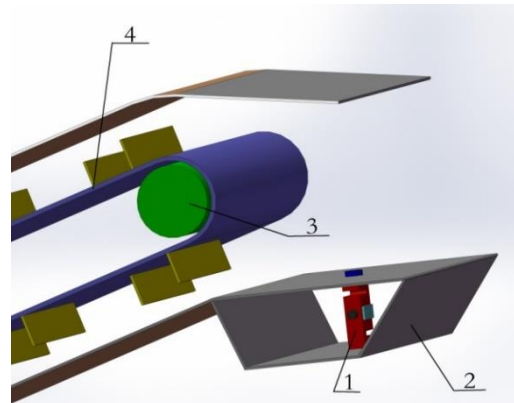


1. Capacitive water sensor 2. Movable baffle 3. Sampling port 4. Lifter connecting head 5. Grain elevator

Figure 2. the device of detecting grain water content

3.2. Detecting of feeding quantity

When the removal of the grain cutting table by the inclined conveyor into the threshing process, will produce a certain pressure on the inclined conveyor floor, fed into a large amount of pressure, and the pressure is small, the piezoelectric sensor can put the pressure signal into electrical signals, so the use of piezoelectric sensors to feed real-time detection. The inclined conveyor is the only channel header after removal of corn ear into the cylinder, the cylinder pressure can directly reflect the actual amount of feed, the piezoelectric sensor is installed in the outlet of the inclined conveyor is the entrance of the threshing roller feed connection, detection device as shown in figure 3.

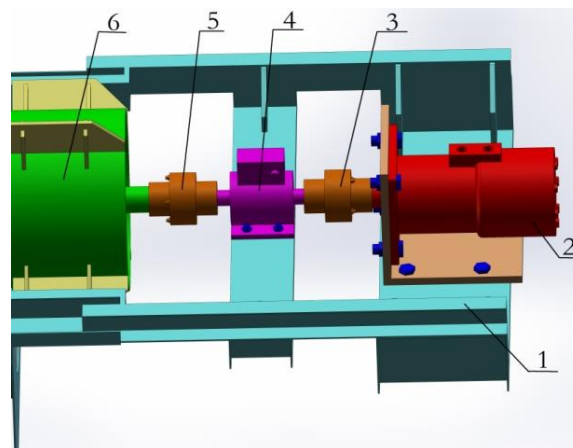


1. Pressure sensor 2.tilt lifter bottom 3.tilt elevator drive shaft 4.conveyor belt

Figure 3. the device of detecting feeding quantity

3.3. Detecting of torque and speed of threshing cylinder

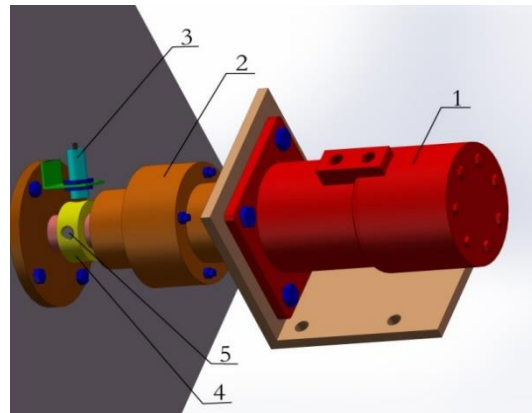
In order to realize the harvester threshing cylinder speed real-time effective regulation to improve the roller drive, hydraulic motor instead of the traditional belt transmission, through two sets of chain coupling will be dynamic torque sensor is arranged between the hydraulic motor and the threshing cylinder shaft, a roll device for detecting cylinder torque and speed, as shown in Figure 4.



1. Support seat 2. Hydraulic motor 3, 5. Coupling 4. Torque sensor 6. Threshing drum

Figure 4. the device of detecting torque and speed of threshing cylinder

3.4. Detecting and adjusting critical speed

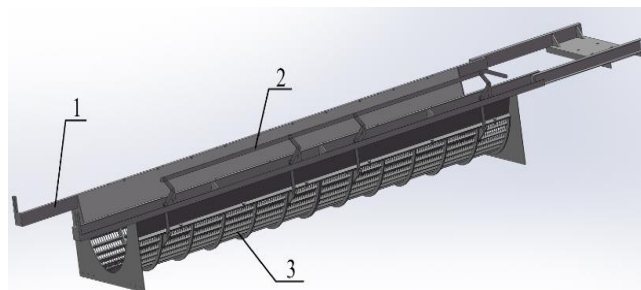


1. Hydraulic motors 2. Couplings 3. holzer switches 4. Magnetic steel pieces 5. Speed measuring bushings

Figure 5. the device of detecting and adjusting speed

Threshing harvester key work process including the detection speed of harvester walking speed, cylinder speed, fan speed and driving speed of 4 sieve box road speed signal acquisition, the cylinder speed by dynamic torque sensor detection, no longer used the way of duplicate detection. Fit the designed speed detector in the proper position of the rotating shaft of the rotating part, as shown in figure 5.

3.5. Detecting and adjusting of threshing clearance



1. Supporting seat 2. Four rod mechanism 3. Concave plate screen

Figure 6. the adjustment mechanism of threshing clearance

The threshing clearance adjusting mechanism is mainly composed of a support seat, a four bar mechanism and a concave plate screen. The structure is shown in figure 6. Concave sieve side connected with the support seat through a pin shaft, a longitudinal rod connected to the other side and four bar, the two ends of the connecting rod of four bar mechanism with the longitudinal rod and the transverse rod is connected between the hinged with the supporting seat, by pulling the transverse rod, the connecting rod drives the longitudinal rod to move up and down, realize the concave sieve axis rotate to adjust the threshing clearance adjustment range of 30-60mm, the median threshing clearance is 45mm.

3.6. Allocating PLC input / output terminal

In the PLC controller, touch screen, digital and analog sensors, proportional control valve and proportional flow valve hydraulic control components, hydraulic motor and hydraulic cylinder hydraulic components, basic indicator lights to display and alarm indicator lamp threshing and cleaning the hardware selection and automatic monitoring system of PLC I/O address assignment, design PLC input and output hardware structure.

4. Software design

4.1. Acquisiting sensor data

(1) acquisiting speed signal

The harvester walking speed, the fan and the screen box driving speed signal acquisition using Holzer speed sensor, because the three speed is relatively low, are within 2000r/min, starting from the cost savings, did not buy the input unit with high-speed counting function, the direct use of the digital quantity input unit CJ1W-ID211 collection. To collect fan speed signal as an example, the preparation of ladder diagram program, as shown in figure 7.

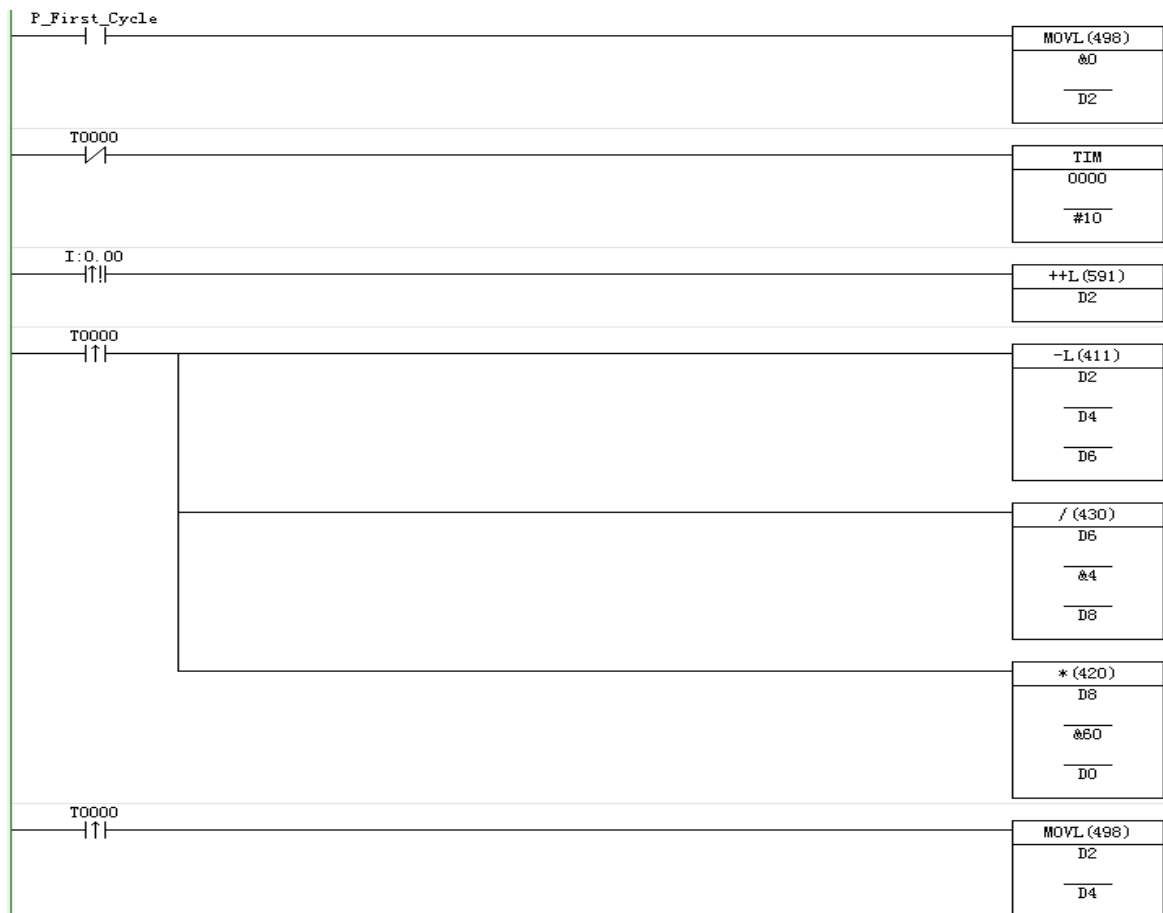


Figure 7. ladder diagram of acquisiting speed signal

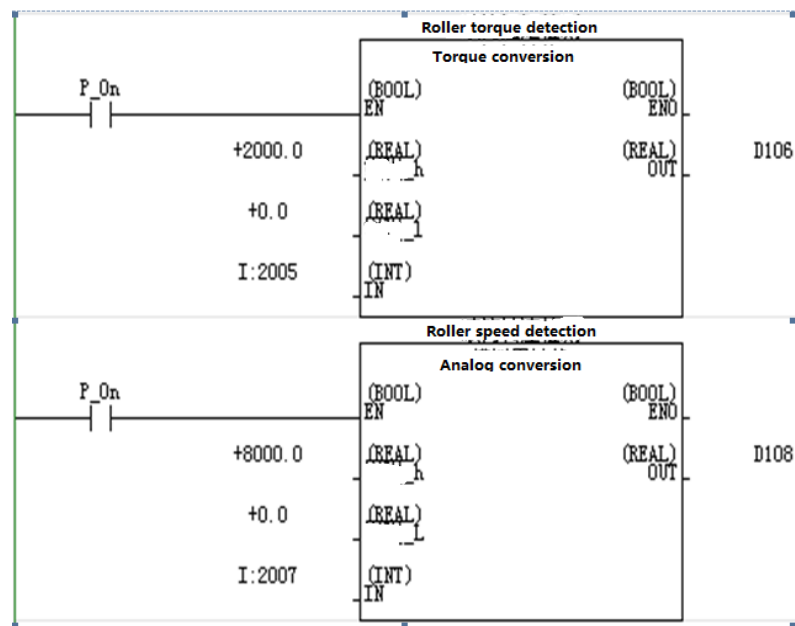


Figure 8. dynamic torque sensor signal acquisition and conversion ladder diagram

(2) *acquiring analog signal*

Taking dynamic torque sensor for real-time detection of cylinder torque and speed as an example, the ladder diagram program is written by function block, as shown in figure 8. Roller torque and speed, actual engineering value and output OUT are put into D106 and D108 channels respectively, and PLC is communicated with touch screen to display in the corresponding man-machine interface, and real-time display and monitoring of key parameters are realized.

4.2. *Controlling hydraulic actuator*

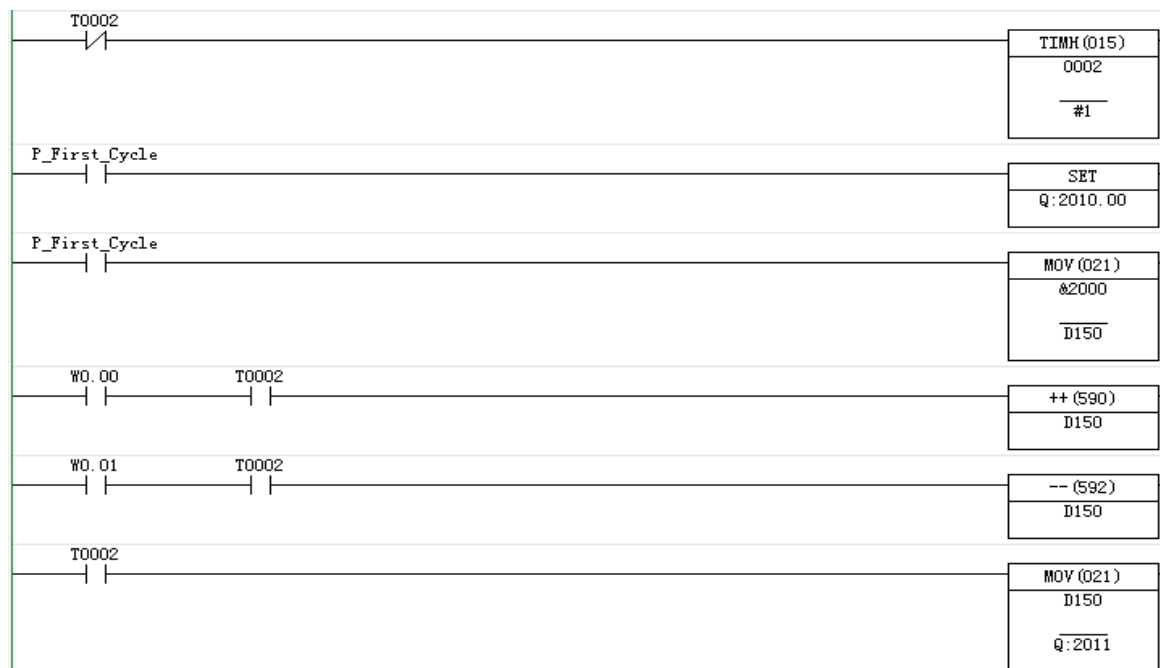


Figure 9. controlling ladder diagram of fan hydraulic motor

The PLC controller controls the proportional speed control valve and proportional flow valve through the analog output unit CJ1W-DA041-V1, and realizes the hydraulic motor speed regulation and the hydraulic cylinder pitch adjustment. Take the fan hydraulic motor speed control as an example, write the ladder diagram program, as shown in figure 9. PLC internal auxiliary relay area w0.00 and w0.01 are the hydraulic motor speed up and deceleration connection mark bits, and the control input is put into D150. In order to avoid the large impact of the proportional control valve and hydraulic motor, a 10ms timer is connected before the sign on position is added and the command is added and reduced.

4.3. Designing man-machine interface

Through the designed monitoring interface, the driver can control the monitoring system quickly and reliably, and improve the control comfort while ensuring the harvesting machine is always in the best operating performance.

5. Experimental verification

Setting up threshing cleaning monitoring system experimental platform, as shown in figure 10. Due to the limitation of the experimental conditions, only a Holzer switch is installed, and the rotation of the hydraulic motor is simulated by the rotation of the rotating shaft. The speed signal acquisition is carried out to verify the validity of the speed signal acquisition. The moisture sensor collects the moisture content signal of the grain, the pressure sensor collects the feed quantity signal, the torque sensor collects the cylinder torque and the speed signal, also carries on the verification through the simulation way. A range sensor based on photoelectric switches is used to simulate the detection of the threshing gap by a displacement sensor. Through the CX-Programmer software monitoring mode to achieve proportional control valve and proportional flow valve for real-time control verification.

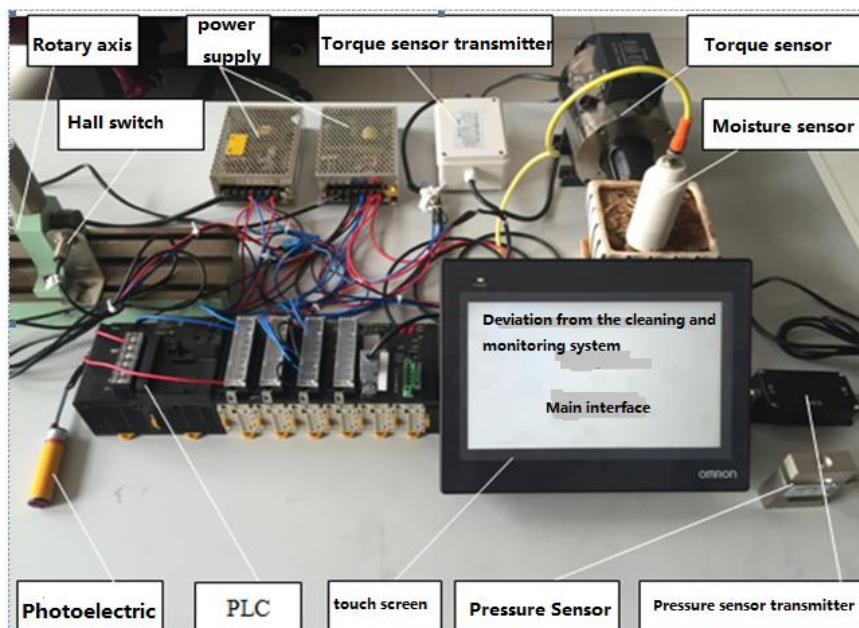


Figure 10. the experiment platform of threshing cleaning monitoring system

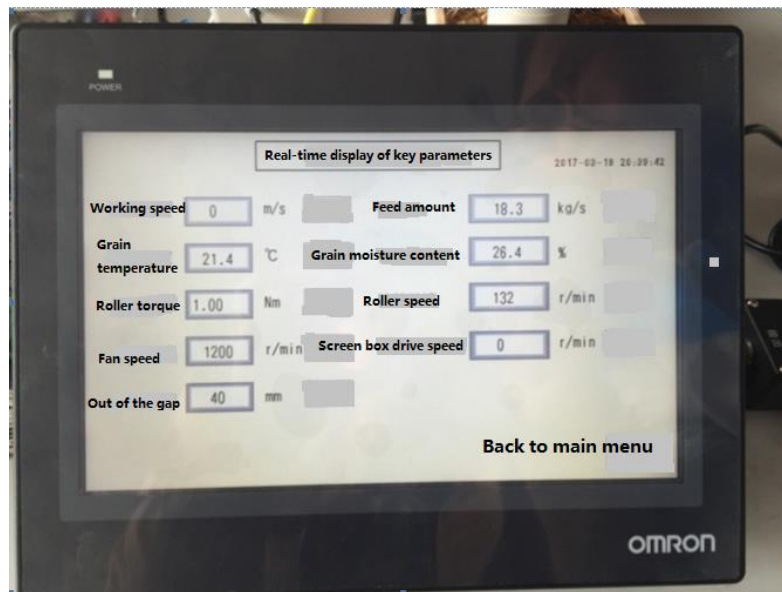


Figure 11. real-time display of key parameters

The validity and rationality of the threshing and cleaning monitoring system of combine harvester are validated by an experimental platform. The key parameters such as feed quantity, grain temperature and grain moisture content, roller torque and rotation speed, fan speed and threshing gap are simulated and simulated, as shown in figure 11.

The rotating speed of the simulated fan is accelerated by the rotating shaft of the driving experimental table, and the speed display value of the current fan is 1200r/min. On a block weighing, weight is 18.26kg, a pressure sensor after the display value is 18.3kg. A moisture sensor is placed in a flowerpot, and the soil temperature is 21.4 degrees, and the moisture content is 26.4%, which conforms to the actual situation. An initial speed is applied to the torque sensor, the torque display value is 1.00N = m, and the speed display value is 132r/min, which conforms to the actual situation. The sensing distance of the photoelectric switch is adjusted to 40mm. After receiving the signal, the decimal number 40 is transmitted to the data channel corresponding to the threshing gap, and the threshing gap is displayed 40mm.

Click on the fan speed corresponding to the trend chart can view the fan speed trend, as shown in Figure 12, the trend chart is set to refresh per second, the current display value 1320r/min, display 1440r/min 1s, and the actual speed of the same trend record. Fan speed preset range is 900-1500r/min, the growth rate gradually in the process, when the speed exceeds 1500r/min to automatically trigger the alarm interface, as shown in Figure 13, provide solutions and warning, which verifies the validity of the hardware and software.

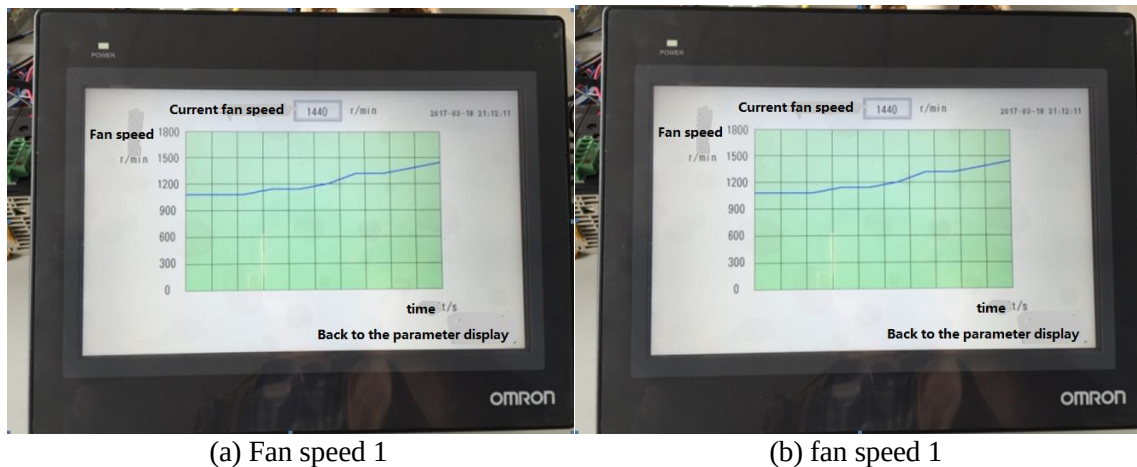


Figure 12. The trend diagram of fan speed

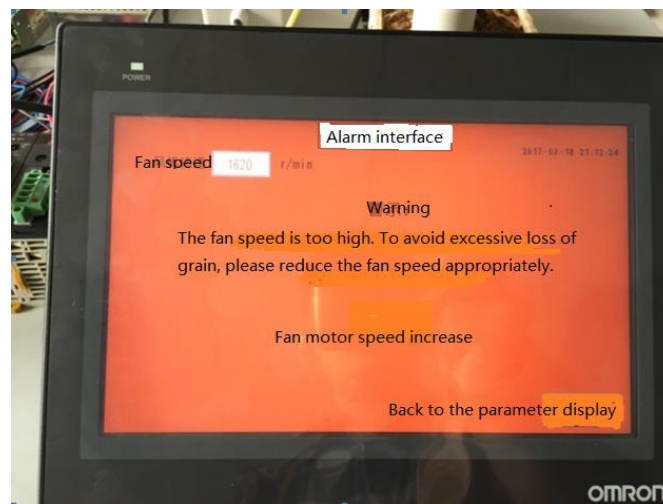


Figure 13. The alarm interface of fan speed too high

6. Conclusion

Make the harvester automatic monitoring system scheme, the hardware design and software design, set up automatic monitoring system of the test bench, the key parameters of the monitoring and early warning and control of hydraulic motor and hydraulic cylinder, the verification of the developed system is effective and reasonable.

Acknowledgements

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