Study on Intelligent Fault Monitoring System for Corn Combine Harvester

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Abstract. In this paper, functions of intelligent fault monitoring system of corn combine harvester are analyzed. Architecture of the fault monitoring system is presented. Key technologies of the monitoring system are discussed detailed. Key parts of the fault monitoring system such as inspection controller, travel controller and programmable monitor, GPS terminal device, data base server and user interface are developed. As a result, the intelligent monitoring system is of great useful for monitoring the faults of corn combine harvester.

Introduction

Fault is one of the main factors which affect the corn combine harvesters’ working efficiency. Many researches have been done to deal with faults. Two methods are presented by the researchers to decrease the faults. One is improving the reliability the machine’s design and manufacturing process. The other is to detect and eliminate the fault in time. Due to the severe working condition, faults of combine harvester cannot be eliminated completely through the design and manufacturing process. Using the fault monitoring system, fault of the combine harvester can be detected and eliminated rapidly. In the monitoring system, faults are detected by the sensors set on some important parts. Fault monitoring system is seen as one of the key parts of modern harvester by the corn combine harvester machine manufactures such as John Deere[1], Case[2], Yanmar[3], Agco[4], Kubota[5], Zoomlion[6], Lovol[7], etc. Most of the monitoring systems have the following functions: monitoring the temperature of motor cooling water, oil temperature of hydraulic system, transmission system, oil pressure, fuel level, air piper temperature, cooling water flux, electric system’s working condition, etc. The application of the monitoring system greatly improved the constructions’ quality.

Obvious progress have made in the area of monitoring systems’ research and development, however, most of domestic corn combine harvester manufacturer have not developed a useful fault monitoring system for corn combine harvesters. Therefore, this paper proposed a corn combine harvester’s fault monitoring system. The system can meet the requirements of fault monitoring and int

Architecture of the Fault Monitoring System

Architecture is the fundamental to develop a monitoring system. To execute the monitoring function, the monitoring system is designed to be composed of sensors, system controller, motor electrical control unit, traveling controller, detection controller, GPS terminal device, data base server and user interface, etc. System controller is used to receive and display the inspection data. The controller can be divided into programmable controller, programmable monitor and CAN bus. Traveling controller is used to control the machine’s movement. Functions of the detection controller are dealing with detection data. Sensors are used to monitoring the parts’ status and collecting state data. GPS terminal device is used to send the monitoring data to the remote monitoring center and receive the orders from the monitoring center. The remote monitoring center is applied to remote monitoring the machining working status and displays the monitoring data on its screen. When necessary, the
monitoring center can send out instructions to control the corn combine harvester. Construction of
the system is shown in Figure 1.

![Figure 1. Construction of the fault monitoring system.](image)

In the monitoring system, system controller communicates with the motor electrical control unit,
traveling controller and detection controller. Monitoring data is displayed on the screen.

Main functions of the monitoring system are following:
1) Displaying the monitoring parameters on the screen, such as motor water temperature, oil
pressure, oil temperature, electric source voltage, motor velocity, etc.
2) Provide alarm message. Ordinary warning is displayed by words and buzz, important alarm
message is displayed by voice, light and word and warning incessantly. All the alarm messages are
stored and can be transferred when necessary.
3) The corn combine harvester can be locked by the monitoring system according to the GPS
systems instructions.

**Key Parts of the Fault Monitoring System**

To execute the monitoring functions, key parts of the system such as detection controller, traveling
controller, programmable monitor, database server, GPS terminal device, user interface are
researched and developed.

**Detection Controller**

Detection controller is connected with air cleaner sensor, working oil cleaner sensor, traveling oil
cleaner sensor, fuel level sensor, hydraulic oil temperature sensor, travel brake solenoid valve, start
the system battery relay, start battery relay, safety battery relay, and start motor. The controller real
time detects the sensors and analysis the collected data. Using the CAN bus, the analyzed data is
transferred to the monitor. The data is further analyzed by the monitor. If the abnormal signal is found,
the fault message will be informed to the corn combine harvester diver through the words displayed
on the monitor’s screen. The displayed message contains air cleaner clogging, movement oil cleaner
clogging, movement brake magnetic valve fault, hydraulic oil temperature, etc. Detection controller
used in the developed fault monitoring system is shown as figure 2.
Traveling Controller

Traveling controller is connected with traveling systems handle, solenoid valves, travel motor and motor speed sensors. Using the data transferred from the sensors, the controller can make the judgments of the handle potentiometer’s working status, CAN bus’s communication status, solenoid valve’s working status, travel motor’s working status, etc. The judgments accompanied with handle resistance value and motor speed values are transferred to the monitor. The received signals classified and processed by the monitor, and then informed to the driver.

Travel controller has protection function for corn combine harvester’s safety start. When the handle is not on the neutral position, the monitor will disconnect motor starting control circuit. Therefore, the engine can be start only when the handle is on the neutral position. Through this way, accident caused by startup can be avoided. At the same time, the handle has a switch. When the engine is start and the corn combine harvester doesn’t walk, the switch will be turned off. Only when the switch is turned on, the handle can control the machine freely. Traveling controller used in the developed fault monitoring system can be shown as figure 3.

Programmable Monitor

The programmable monitor is composed of ARM series CPU, 2M memories FLASH, real-time clock chip, memories for the parameters storage, monitor control chip, LED light control chip, etc. The whole system runs under the control of the ARM CPU. The monitor communicate with engine and controllers through CAN bus. Monitor received the monitoring information through the CAN bus, judge and displays the analogs (such as engine cooling water temperature, oil pressure, fuel quantity, and so on), switch information and alarm messages. The structure of the monitor is shown in Figure 4.

1) Functions of the monitor
Functions of the monitor are following:
- The monitor displays the engine running information and engine fault information, such as engine speed, engine total running time;
- The monitor displays machine running parameters, such as speed, hydraulic system parameters, and so on (Figure 5).
• The monitor displays the whole machine malfunction of all electrical systems, alarm information can also be enquired historical information (Figure 6).

Figure 6. History fault parameter query interface. Figure 7. Displayer’s structure.

• The monitor can perform user settings; make the password settings, and so on;
• Using monitor buttons, the vehicle electrical system can be controlled, such as modifying parameters of temperature controlled fan.

(2) Display of the monitor
As shown in Figure 7, the displayer is composed of four pointer instrument, liquid crystal display and twelve lamp alarm unit. The monitoring parameters are displayed on the display.

The appearance of the programmable monitor applied in the developed fault monitoring system is shown in a Figure 8

Figure 8. The appearance of the programmable monitor. Figure 9. GPS terminal device.

Database Server
Database server is used to store corn combine harvester’s fundamental information, historical running information, user’s information, etc.

Database server is developed using the software SQL Server 2000. SQL Server 2000 presents a powerful client server platform which can simultaneously support multiple concurrent users. The SQL SERVER2000 database engine provides a complete XML support. SQL SERVER2000 has scalability, availability and security which are of great useful for web site development. Web application program can be developed using SQL Server2000 programming model and Windows DNA framework. SQL Server2000 support English Query and Microsoft search services and other functions. Using SQL Server2000, web application program contains a user friendly query and a powerful search function. SQL Server 2000 relational database engine supports the demanding data processing environment required function. The database engine can fully protect the integrity of data and manage thousands of concurrent modification of the database user overhead to a minimum. SQL Server2000 enable distributed query users to quote data from different sources. Replication function allows users to maintain multiple data copies. A set of data can be copied to a mobile connecting-tripping user, make the user to work independently, and then send the changes back to the server.
GPS Terminal Device
GPS terminal device is composed of control module, GPS receiving module, input and output module and communication module. Main function of the control module is processing the received information. GPS module is used to positioning the corn combine harvester. Communication module is used to send and receive the wireless signal. Input and output’s module is used to receive the information transferred by the CAN bus. GPS terminal device used in the developed system is as Figure 9.

User Interface
User interface is developed to display the monitoring information of corn combine harvesters. Through the interface, information of the corn combine harvester, working time, and monitoring parameters can be displayed.

Conclusions
The monitoring system presented (proposed) in this paper has been applied on the corn combine harvesters of Changlin Agriculture Machinery Co., Ltd. The application shown that the fault monitoring system is great useful to aid in time finding and dealing with the corn combine harvesters’ faults.

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