Distributed Monitoring and Diagnosis System for Hydraulic System of Construction Machinery

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Abstract: This paper mainly presents a distributed monitoring and diagnosis system for hydraulic system of construction machinery based-on CAN field bus. The hardware of the system is designed. Its structure, including sensors, distributed data acquisition units, central signal processing unit and CAN field bus is also introduced. The general software design and its realization are studied in detail. Experiments and applications indicate that distributed condition monitoring and fault diagnosis system can effectively realize its function of real time online condition monitoring and fault diagnosis for hydraulic system of construction machinery.

Keywords: construction machinery, hydraulic system, distributed condition monitoring, CAN field bus, fault diagnosis

1. Introduction

The application and function of construction machinery are more extensive than ever before in economic development and defense construction. Hydraulic system, as an important part of construction machinery, plays an utmost role. However, with the extensive application of hydraulic system, its fault rate increases rapidly and highly and more than 50 percent of fault of construction machinery is related with its hydraulic system. Generally speaking, hydraulic system of construction machinery is a complex nonlinear dynamic system. It is a complex electromechanical system in configuration which integrates mechanism, hydraulic equipments and electrical system. Hydraulic system is also a multilayer system in systemic function in which mechanical fault, electrical fault and hydraulic fault are interlaced together. On the special background, traditional method of condition monitoring and fault diagnosis is low-efficient and time-consuming while distributed condition monitoring and fault diagnosis system can realize data acquisition and signal processing of important systemic parts synchronously and in parallel. Further more, the efficiency of distributed condition monitoring and fault diagnosis system is raised greatly and the signals acquired are synchronous relevancy. By relating the theories and methods of information fusion, distributed condition monitoring and fault diagnosis system offers a very efficient approach of condition monitoring and fault diagnosis for hydraulic system. [1，2]In this paper, we develop a distributed condition monitoring and fault diagnosis system for hydraulic system and its application domain is mainly large complex construction machinery. The hardware design is presented in the next section and the software program is introduced in section 3. In section 4, we give two successful application examples of distributed condition monitoring and fault diagnosis system. And the last section is the conclusion.

2. Hardware Design

The hardware of distributed condition monitoring and fault diagnosis system for hydraulic system is mainly composed of various sensors, distributed data acquisition units, central signal processing units and CAN field bus. The hardware framework is showed in Fig.1.

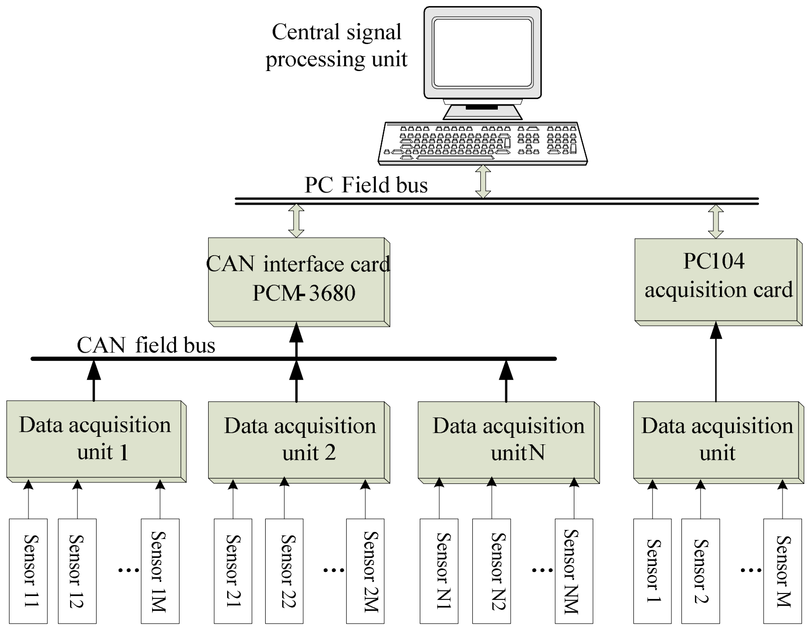

Fig.1 hardware framework of distributed condition monitoring and fault diagnosis system

Sensors

The kinds of sensors adopted in distributed monitoring and diagnosis system are mainly pressure sensors, flux sensors, temperature sensors, acceleration sensors, and so on. They are divided into 0-5V voltage type and 4-20mA electric current type according to their outputs. And in the following design of data acquisition units we consider sensors' output difference and can choose different signal input methods according to their output types by simply jumping line.

Distributed data acquisition unit

The distributed data acquisition units mainly acquire and condition sensors' signals and transmit data acquired to central signal processing unit. We adopt two kinds of acquisition units, SCM acquisition unit and PC104 acquisition card. In the hardware structure, SCM acquisition unit communicates with interface card of CAN field bus, PCM-3680, in the form of CAN communication, which can realize distant transmission of vast data. Interface card of CAN field bus and PC104 acquisition card communicate with central signal processing unit by adopting PC field bus to boost the systemic running speed. Fig.2 shows the hardware structure of SCM acquisition unit.

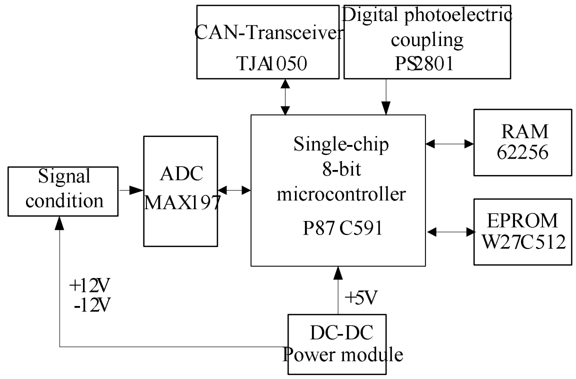

Fig.2 hardware structure of SCM acquisition unit

Central signal processing unit

We adopt embedded computer with PC104 field bus as the hardware platform of central signal processing unit. The main function of central signal processing unit is management of distributed data acquisition units. It also takes charge of transmission of acquisition orders and receipt signals between central signal processing unit and distributed data acquisition unities. Moreover, central signal processing unite can realize the functions of showing, saving and analyzing of data acquired. As the center of distributed monitoring and diagnosis system, condition monitoring and fault diagnosis can be realized by it. In case there are abnormal conditions in hydraulic system it can give an alarm to operators and present corresponding measures. At the same time, central signal processing unit will acquire mass data thick and fast and analyze data to realize fault diagnosis and location estimation to present maintenance and decision-making advices. In view of the hardware structure of central signal processing unit, most modules adopted are PC104 field bus modules of PCM series developed by Advantech Com. Ltd. and we designed the signal condition card. The hardware structure of central signal processing unit is showed in Fig.3.

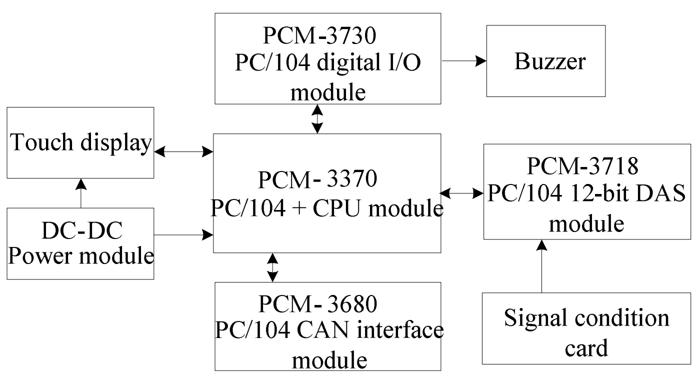

Fig.3 hardware structure of central signal processing unit

CAN field bus communication

As above, distributed condition monitoring and fault diagnosis system is mainly composed of central signal processing unit and several data acquisition units. Data acquisition unit can acquire the signals of its handy sensors and central signal processing unit can manage and process data. In order to realize high anti-jamming communication between them, we adopt interface card of CAN field bus , PCM-3680, in central signal processing unit. It is PC field bus communication between central signal processing unit and PCM3680 while CAN field bus communication between PCM3680 and distributed data acquisition units[3]. There are two independent interface of CAN field bus in PCM3680 which can realize data transmission at the rate of 1Mbps. It also has the functions of bus arbitration and error detection to avoid losing data and guarantee the reliability of CAN field bus to the greatest extent.

We can effectively realize main functions, such as data acquisition, signal processing, man-machine conversation, distributed condition monitoring and fault diagnosis, in distributed condition monitoring and fault diagnosis system established.

3. Software program

General design

Software system of distributed condition monitoring and fault diagnosis system is designed by modularization theory. It is mainly composed of system management module, condition monitoring module, virtual display panel, fault diagnosis module, data acquisition module, CAN field bus communication module and remote data transmission module. The software structure and data stream are showed in Fig.4.

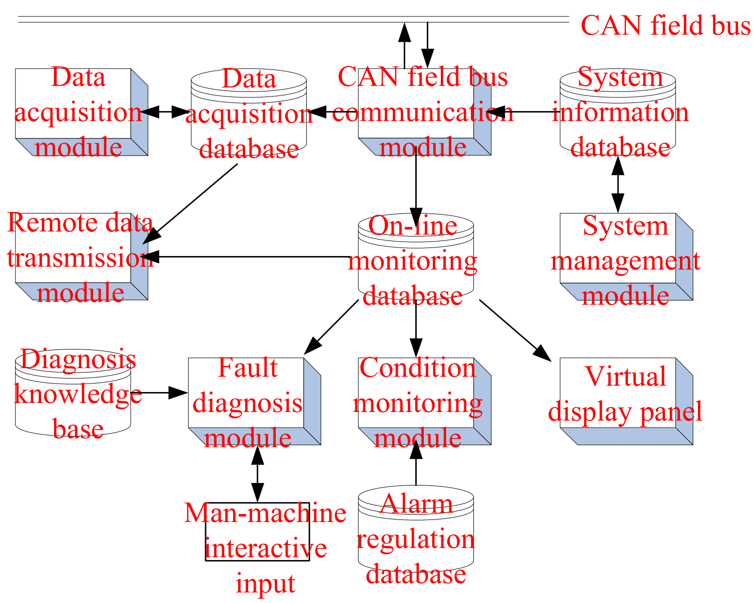

Fig.4 software structure and data stream of distributed condition monitoring and fault diagnosis system

Every system module can realize its special function according to system assignment. System management module mainly takes charge of log files and management of distributed data acquisition units, detection nodes and system running states. Acquiring and saving of detection parameter is accomplished by condition monitoring module. It can also give an alarm according to alarm regulation and on-line detection data. The detection parameters of system condition can be showed in dynamic virtual display panel. And fault diagnosis and location estimation can be realized by fault diagnosis module on the base of detection data and man-machine interactive inputs. If needed, acquisition of mass data can be accomplished with different sampling frequencies and different sampling counts by data acquisition module and data acquired can be saved in acquisition database. The main functions of CAN field bus communication module are to transmit acquisition orders to data acquisition units and receive signals acquired to realize communication between central signal processing unit and SCM acquisition units. In order to realize remote condition monitoring and fault diagnosis, we design remote data transmission module, which can communicate with remote fault diagnosis center by internet and transmit data of local database to remote database center on the base of Socket technique.

System realization

We adopt Windows98 operating system of Microsoft as running platform of distributed condition monitoring and fault diagnosis system. Software program is designed by adopting C++Builder6.0 language of Borland Com. Ltd. Its main program interface is showed in Fig.5.

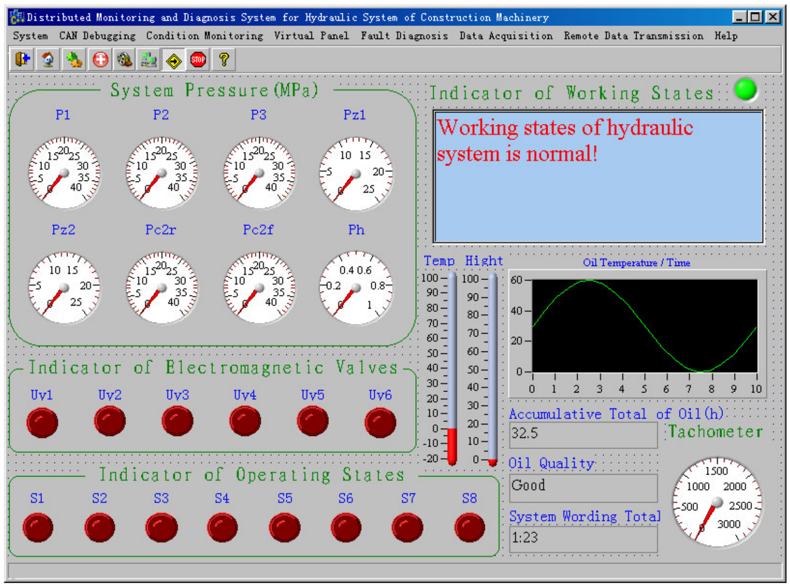

Fig.5 main program interface of distributed condition monitoring and fault diagnosis system

According to the function compartmentalization of main program, system menu can be compartmentalized into 7 parts, which are system management, CAN communication debugging, data acquisition, condition monitoring, fault diagnosis, remote data transmission and help. System menus and their submenu are showed in Fig.6.

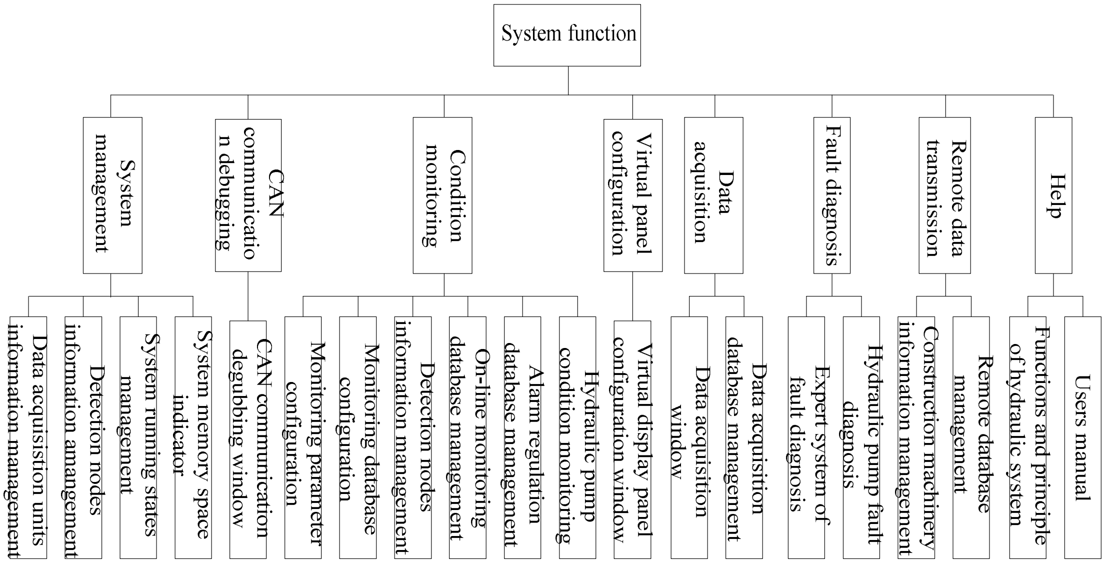

Fig.6 menu and submenu of distributed condition monitoring and fault diagnosis fault system

4. Applications

Aiming at the characteristics of hydraulic system of construction machinery, we designed a general distributed condition monitoring and fault diagnosis system for hydraulic system of construction machinery on the base of theories and techniques mentioned above. After design and configuration, we carried out spot debugging and application experiments of distributed condition monitoring and fault diagnosis system on one QYJ40B crane of the Changjiang crane Com. Ltd. in LuZHou, SiChuang province. The experiments indicate that distributed condition monitoring and fault diagnosis system can realize its scheduled functions. In its running period, it has successfully diagnosed two faults occurred on the QYJ40B crane. The details is analyzed as follow:

(1) Fault: The steeve of crane can't be lifted.

Diagnosis: Applying expert system of fault diagnosis to diagnose the steeve, we ascertained that the moment restriction electromagnetism valve, which controls lift of the steeve, was always in the state of opening. We examined its correlative parts and found there was something wrong with the moment restriction controller, which controls the states of the moment restriction electromagnetism valve. Its disordered outputs made the moment restriction electromagnetism valve switch on in error.

(2) Fault: There was no pressure in the left-latter hydraulic stanchion.

Diagnosis: We acquired mass data thick and fast on the left-latter hydraulic stanchion by applying data acquisition module. Analyzing the data, we ascertained that its hydraulic lock was wrong. Examining on the base of disassembly, we found the hydraulic lock could not be pressurized to discharge pressure of the left-latter hydraulic stanchion.

5. Conclusions

With the development of computer and information techniques, it is possible to realize distributed monitoring and diagnosis system for hydraulic system of large complex construction machinery. In this paper, a distributed monitoring and diagnosis system, which adopts three-tie hardware structure and modularization software program, has been designed and applied. It can acquire data synchronously and in parallel and realize multi-sensor information fusion. Applications indicate it has high efficiency and strong diagnosis ability.

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