Distributed monitoring and diagnosis system for hydraulic system of construction machinery

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

Keywords construction machinery, hydraulic system, distributed condition monitoring, controller area net (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. A hydraulic system, as an important part of construction machinery, plays an utmost role. However, with the extensive application of the hydraulic system, its fault rate increases rapidly and highly, and more than 50% of the fault of construction machinery is related to its hydraulic system. Generally, the hydraulic system of construction machinery is a complex nonlinear dynamic system. It is a complex electromechanical system in configuration, which integrates the mechanism, hydraulic equipment, and electrical system. The 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, the traditional method for condition monitoring and fault diagnosis is low efficient and time-consuming, while the distributed condition monitoring and fault diagnosis system can realize data acquisition and signal processing of important systemic parts synchronously and in parallel. Furthermore, the efficiency of the 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, the distributed condition monitoring and fault diagnosis system offers a very efficient approach of condition monitoring and fault diagnosis for the hydraulic system [1,2]. This paper develops a distributed condition monitoring and fault diagnosis system for the hydraulic system and its application domain is mainly large complex construction machinery. The hardware design is presented and the software program is introduced. Two successful application examples of the distributed condition monitoring and fault diagnosis system are taken.

2 Hardware design

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

2.1 Sensors

The types of sensors adopted in the distributed monitoring and diagnosis system are mainly pressure sensors, flux sensors, temperature sensors, acceleration sensors, etc. They are divided into 0–5 V voltage type and 4–20 mA electric current type according to their outputs. In the following design of data acquisition units, different sensors’ outputs are considered and different signal input
methods can be chosen according to their output types through the simply jumping line.

2.2 Distributed data acquisition unit

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

2.3 Central signal processing unit

An embedded computer with a PC104 field bus is adopted as the hardware platform of the central signal processing unit. The main function of the central signal processing unit is the management of distributed data acquisition units. It also transmits acquisition orders and receipt signals between the central signal processing unit and the distributed data acquisition units. Moreover, the central signal processing unit can realize the functions of showing, saving, and analyzing the data acquired. As the center of the distributed monitoring and diagnosis system, condition monitoring and fault diagnosis can be realized through it. If there are abnormal conditions in the hydraulic system, it can give an alarm to operators and present corresponding measures. At the same time, the 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 the central signal processing unit, most modules adopted are PC104 field bus modules of PCM series developed by Advantech Com. Ltd. and the signal condition card is designed by us. The hardware structure of the central signal processing unit is shown in Fig. 3.

2.4 CAN field bus communication

As above, the distributed condition monitoring and fault diagnosis system is mainly composed of the central signal processing unit and several data acquisition units. The data acquisition unit can acquire the signals of its handy sensors