Design of storage and management device of packaged FBG sensors based on RFID

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ABSTRACT: In the application of fiber Bragg grating (FBG) sensor in structural condition monitoring, the reasonable layout scheme is designed according to its central wavelength. However, the paper label with FBG central wavelength information may be lost when FBG is used, therefore it is difficult to store and manage FBG sensors. This paper designs a storage device and its management system of packaged independent FBG sensor based on RFID technology. The oblique grid structure can store the FBG sensors with the same central wavelength. The RFID reader module is arranged on the top of the box-type device with multi-layer oblique grid. The packaged FBG sensors are stored, read and classified with the help of special software.

1. Introduction

In order to avoid safety accidents caused by various equipment failures, more and more researchers pay attention to sensor technology in fault detection. Compared with traditional sensors, fiber Bragg grating sensors have the advantages of small size, anti-electromagnetic interference and high temperature resistance, and FBG can be used to measure the deformation and temperature of target objects, so it is widely used in the safety detection of various facilities and equipment in the field of bridge, aviation and energy [1]. However, due to the demodulation principle of FBG sensor, it is difficult to read the its central wavelength without special valuable optical equipment. Moreover, FBG sensor entangles each other easily, and sometimes even lead to fiber fracture.

A storage device and management system for packaged FBG sensors based on RFID technology is designed. This system is of good characteristics, such as good reliability and high cost and performance ratio. It is convenient for the users in the field.

2. Design of the system

The system is composed of FBG sensor with RFID chip, storage device and management system based on STM32, as shown in Fig.1. The RFID chip is packaged into the FBG sensor by Hot-Press technology, and the parameter is recorded in the RFID chip, which can be read by the RFID Read-Write module. The oblique grid and velcro are used in the storage box, which can efficiently store the FBG sensor and solve the problem of fiber winding. The management system can query the maximum amount of sensor wavelength, as well as the existing sensor wavelength and its number.
2.1. Fabrication of packaged FBG sensor with RFID chip

Bare optical fiber is fragile and has poor shear resistance. It is necessary to use adhesive to directly adhere it to the measured substrate or package it with a specific structure [2]. In this design, the RFID chip is a non-contact IC card with a diameter of 8 mm. The sensor parameters are written into the RFID chip, and then the FBG sensor and RFID chip are packaged with glass fiber.

1) RFID chip: The storage space of RFID chip is divided into 16 sectors, each sector is 4 blocks. Sector 0 data block 0 is used to store the manufacturer code, and sector 3 data block 3 is used for password and storage control. Each data block stores a sensor parameter, with a total of 46 sensor parameters, which is enough to store the required sensor information. The RFID chip storage structure and sensor information storage position are shown in Fig.2.

2) FBG sensor packaging: Cut two pieces of glass fiber with the same size. Lay the FBG sensor and RFID chip between two pieces of glass fiber and preheat and fix it. Place the whole body on the hot press for hot pressing [3-4]. The structure of packaged FBG sensor and its sample are shown in Fig.3.
2.2. Design of storage device

The storage device adopts modular design, which is composed of storage module and reader control module. Modules can be combined flexibly to adapt to different numbers of FBG sensors and different working environments. The structure of storage device and prototype are shown in Fig.4 and Fig.5.

1) There are several storage grid in the storage box. Each grid stores one FBG sensor, which avoids the entanglement between fibers and fibers. Moreover, the oblique placement of each grid improves the space utilization rate of the storage box. A velcro is designed on the oblique grid. When using, the FBG sensor needs to be wound in a circle, placed in the middle of the velcro and pasted to complete the storage.

2) The reader control module is composed of STM32 microcontroller unit, RFID read-write module, interactive display screen and power module. The read-write device module can read and rewrite the information of RFID chip on the FBG sensor, and analyze the sensor using information through the management system carried in STM32.

3. Design of software of management system

The management system is carried by STM32 microcontroller unit, including information input module, storage processing module and outbound processing module. The program framework diagram of the management system is shown in Fig. 6.

1) The information input module is used to input the data of FBG sensors, and allocate the storage position for each FBG sensor. The specific idea is as follows: the type of FBG sensor and the central wavelength are used as the parameters for allocating the storage position, and the storage box can be allocated according to the following formula:

\[ T_i = \sum \frac{n_i}{Z} \]  

(1)

\( T_i \) is the number of boxes available for type \( i \) sensors, \( n_i \) is the number of type \( i \) sensors, \( \sum n \) is the total number of sensors to be stored, and \( Z \) is the total number of boxes.

\[ l_{r_i} = \frac{l_{\text{max}} - l_{\text{min}}}{T_i} \]  

(2)

\( l_{r_i} \) is the wavelength range of a box for type \( i \) sensor, \( l_{\text{max}} \) is the maximum wavelength of type \( i \) sensor, \( l_{\text{min}} \) is the minimum wavelength of type \( i \) sensor, and \( T_i \) is the number of storage boxes available for type \( i \) sensor.
2) The storage processing module is used to reclaim the sensor to the storage device. Place the sensor in the read-write module, the system will display the storage position and then store the sensor according to the storage position.

3) The outbound processing module is used to retrieve and take out the target sensor. The information of the target sensor displayed through the interactive display screen. Take out the target sensor according to the retrieval information.

4. Conclusion
A device that can store the packaged FBG sensors is designed. With the help of the RFID technology, the FBG sensors are classified and read according to its central wavelength. The management system is based on STM32 microcontroller unit. The management program can avoid reading sensor information by special valuable optical instruments. The storage device is accurate, efficient, convenient and suitable for indoor and field use.

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