FIBER BRAGG GRATING BASED FIBER-OPTIC TEMPERATURE MEASUREMENT SYSTEM FOR THE HIGH VOLTAGE CABLE

Aihong TANG, Yangyang ZHAO
Automation School, Wuhan University of Technology
tah@whut.edu.cn, weilaizhy@163.com

Desheng JIANG
Fiber Optic Sensing Technology Research Center, Wuhan University Of Technology
jiangdsh@cae.cn

ABSTRACT

The Fiber Bragg Grating (FBG) sensor is used to detect the temperature of the high voltage cable. The temperature measurement system is constructed and the functions of each part of the system is stated in detail. This temperature measurement systems presented in this paper is useful for the operation of the power cable.

Keywords: The Fiber Bragg Grating sensor, temperature measurement system

1. INTRODUCTION

In high voltage cable transmission line, the space range is very long, the insulation requirements are very high, the electromagnetic interference along the line is very strong, and the environmental is very humidity. So, if there is an adaptive temperature measurement, which can response the temperature of the high voltage cable transmission line in real time and in precisely, not only the ampacity utilization ratio of the cable will be improved but also the service life of the cable will be extended. Conventionally, the thermoelectric couple is used to detect the temperature of the high voltage power cable[1], in which, the configure is very simple with low price. Infrared Thermal Imager is also used to detect the temperature, but the results is effected by the environment situation drastically[2]. Fibre-optic based sensor used in cables and other power facilities for the temperature detection with high sensitivity, rapid response and other unique advantages, is attracting more and more attentions. [3] put the fibre-optic based sensor in the cable distributely when the cable is produced. It can detect the cable temperature accuratelty, but the price is higher relatively. Fibre Bragg Grating (FBG) sensor can detect the cable temperature in precision, it is used to detect the temperature of the high voltage cable in this paper, and the corresponding measurement systems is configured in detail.

2. BASIC THEORY OF FIBER-OPTIC BASED SENSOR[4]

Fibre grating is to use the photosensitive fibre material core formed in the fibre-optic phase grating space. Fibre Bragg Grating sensor
senses the process parameters through the outside of the Bragg grating central wavelength, which modulated to obtain information. It is a wavelength optical-fibre sensor.

Fibre Bragg Grating based fibre-optic temperature measurement system takes fibre optic as the signal transmission and sensing the media, makes use of Bragg grating temperature sensitivity and light reflection theory as the basic principle. This system measures the real-time temperature distributed along the fibre, at the same time can show and give properly alarming. It will be stated in detail as follows:

Removing the coating layer of a part of the optic fibre communication, exposing to the holographic UV, and then the Fibre Bragg grating with the core refractive index of the grating can change periodically is formed. Usually, all of the ray can through the FBG and will not be effected, only the specified wavelength ray will be reflected to the original by the FBG. The variation of the surrounding temperature, measured force or other measured physical parameters will lead to the effected refraction ratio of FBG surrounding or FBG. This will result in the drifting of the Fibre Bragg wavelength, and we can get the measured parameters variations by detecting the drifting of the Fibre Bragg wavelength. The principle of the FBG sensor is shown in Figure1[1]. If the coupling of the force and temperature effecting is ignored, the variation criteria of the FBG wavelength is

$$\Delta \lambda = \frac{\Delta \lambda}{\lambda} = K_P \epsilon + K_T \Delta T$$

Where, $\lambda$ is the central wavelength of the FBG, $\Delta \lambda$ is the drifting values related to the central wavelength of the FBG, $K_P$ is the force variation sensitivity coefficient of the reflection wavelength of the FBG, $K_T$ is the temperature variation sensitivity coefficient, $\epsilon$ is the force variation in axial, For in addition to axial strain, $\Delta T$ is the variation of the temperature.

The variation criteria of the FBG wavelength shows, there is a good linear relationship between the wavelength and both of the force variation and temperature variation. Additionally, the FBG has the WDM characteristics, that is to say, the grating with different central wavelength can be seried in the same fibre, according to the theory of different reflection wavelength corresponding to the specified measured dot, the Simultaneous measurement of quasi-distributed will be implemented. The principle of the distributed measurement systems of the FBG is shown in Figure2.

Fig.1. Principle of the Fibre Bragg Grating sensor

Fig.2. The principle of the distributed measurement systems of the FBG

3. FIBER BRAGG GRATING TEMPERATURE MEASUREMENT SYSTEM

Fibre Bragg grating temperature measurement system is composed mainly by the temperature sensor probe, connecting fibre cable, fibre optic connectors, fibre optic transmission, signal processors, communication cables and computer components. It is shown in Figure3.

In the figure, number1 is the temperature sensor, number2 is the connection fibre cable, number3 is the fibre cable connector, number4 is the transmission fibre cable, number5 is the signal processor, number6 is the signal transmission fibre cable, number7 is the annuciator controller and the number8 is the master controller, which supervises all of the sensors in the field, gives the alarming command, storages and displays all of the history and real time datum, calculates the rated current can be transported by the power cable.

The major role of the signal processor can state as, providing grating light source for detection
to the scene, modulating and demodulating the detection feedback optical signal, output the temperature signal to the computer, carrying out sound and light alarm.

Temperature probe uses fibre Bragg grating as the measurement unit, a number of series between the detection probes to form a linear structure, the series can up to more than 40 probes.

4. TEST RESULTS

In order to verify the measurement system constructed in this paper, the test based on 10 loop fibre grating temperature measurement probes is made. The results as follow, response time is less than 20s, Fibre optic transmission distance can span 20km, the resolution is reach 5km. accompanied with the programme of current-carry capability calculation of the power cable verifies the systems constructed in this paper.

5. CONCLUSIONS

This paper constructs the Fibre Bragg Grating based fibre-optic temperature measurement system. This system is implemented by digital signal measurement. It has high detection precision. It can realize distribution measurement and the measured point can be set arbitrarily, it can also realize radio detection, intrinsically safe explosion-proof, anti-electromagnetic interference, and anti-lightning. Compared with similar fibre-optic sensing products, it has low cost, high accuracy characteristics

REFERENCES


A. TANG        Y. ZHAO        D. JIANG
BIOGRAPHY

Aihong TANG received her PH.D for power systems and its automation from Huazhong University in June, 2007, and MS for power systems and its automation from Wuhan University of hydraulic and electric in June, 1997. Her employment experience included the power supply bureau, electric power design institute and university. Now, she engage in the operation and intelligent controlling for power systems and flexibility AC transmission systems.

Yangyang ZHAO received his bachelor degree in electrical engineering and automation from Wuhan University of technology, China, in 2008. He is major in Power Systems and its Automation at the same university now.