Wavelength Division Multiplex Optic Fiber Bragg Grating Temperature array for Ocean Detection

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ABSTRACT

The wavelength division multiplex FBG sensor system was researched.The sensor array was designed, and this system was used in ocean water temperature detection.This experiment was achived in South China Sea with 300 meters long Bragg grating array and got original signal wavelength.The wavelength data was processed and transformed into temperature.By curve fitting,the seawater profile temperature can be obtained.Simultaneously,contrastive test was completed with CTD,which was recommended by experts. By processing the data with MATLAB,the resolution attained 0.1℃, and the precision attained 0.2℃,the temperature changed trends was the same with CTD,and small deviation was exsited.

Key words: optic fiber grating; wavelength division multiplex; fiber grating array ;contrastive test

1 INTRODUCTION

FBG is a kind of special optic component.It can be used as sensor.Simultaneously,the optic fiber can be used as transmission channel to transfer data[1,3].FBG sensor is easy to achieve wavelength division multiplex and time division multiplex,so it can be constituted large number of sensor array[2].Optic fiber has many advantages,such as high sensitivity,fast response, anti-electromagnetic interference and so on[3,4]. FBG is drawing more and more attention as a novel optic fiber sensor.Now FBG sensor has been used widely in construction structure field,but according to other literatures,it's the first time that FBG sensor was used in deep sea detection.

2 THE PRINCIPLE OF WAVELENGTH DIVISION MULTIPLEX DISTRIBUTED FBG SENSING SYSTEM

FBG sensor has many advantages,one of them is easy to construct sensing network. Using this

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sensing network,some measurand which is usually not a spot,but a field,for instance, temperature field,strain field,can be measured completely[2,8].

Wavelength division multiplex distributed FBG sensing system can series connect multiple FBG sensors in one sensing fiber.when the fiber is irradiated by light source,every FBG will reflect a narrow wave whose wavelength is equal to Bragg wavelength,where wavelength is seperated from each other[9].These reflected lightwave was taken out after passing 3dB coupler,then every fiber grating's wavelength or wavelength deviation was examined with wavelength demodulation system.After data analyzing,the informations include temperature and strain will be taken out[9,10].

The multiplexing capacity of the wavelength division multiplex distributed FBG sensing system is one of the key problems when the sensing system is been designing,especially in distributed sensing field,if the light source has a relatively wide wavelength range,then the sensing system can series connect more fiber grating sensors. With the multiplexing sensor added in a system, and by sharing light source and electronic processing,the cost of every sensor will be greatly reduced.

3 EXPERIMENT SYSTEM DESIGN

According to other literatures,many fiber grating sensing system schemes had been designed[2-4].In the experiment,the Fabry-Perot filter was selected to accomplish wavelength scan,its priciple chart was shown as Fig1:

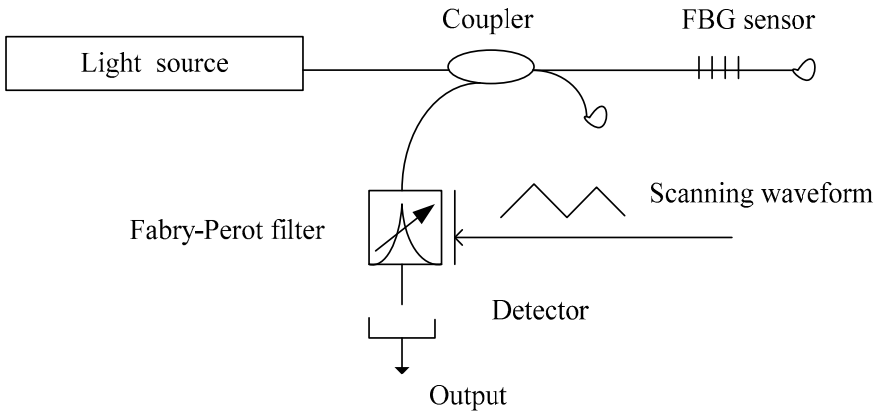


Fig1 The demodulation diagram for tunable Fabry-Perot filter

Light entried into a series of fiber grating sensors which were linked in a fiber and reflected,the FBG reflected light passed by coupler then entered the tunable bandpass fiber F-P filter,and the F-P filter bandpass can be altered by changing the F-P cavity length from electronic controlled piezoelectric. Under the effect of control signal,the fiber F-P filter bandpass scanned all the reflected light spectrum,if the transmission peak wavelength were coincided with FBG reflected wavelength,then the maximum light intensity can be probed by the detector,while the voltage which was applied to the F-P cavity corresponds to FBG reflected wavelength.

In this experiment,the light source was broadband spectrum,and its wavelength was 1550nm, the wavelength range was 40nm,the scan frequency of tunable F-P cavity was 1Hz. 60 sensors were used in this experiment.On account of each sensor occupied range was about 2nm,so it can conjuncted no more than 20 sensors in a fiber,and that four fibers were needed.Every fifteen sensors were connected in a fiber to avoid wavelength overlap. It was about five meters between two sensors,so all the length of the FBG grating array was 300m.The fiber Bragg grating sensor was smartly packaged to eliminate the seawater pressure interference before the experiment. The FBG sensor array was shown as Fig2.

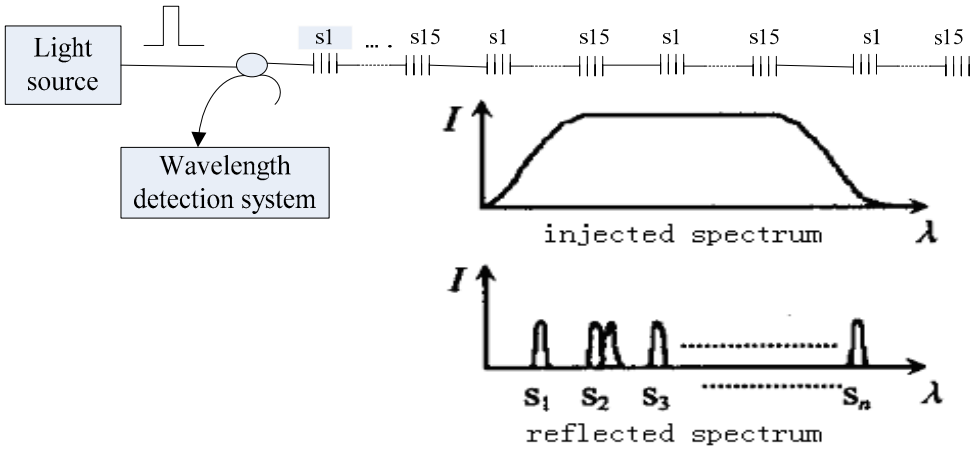


Fig2 The chart of FBG sensor array and the reflection spectrum

The vertical profile temperature of the seawater can be obtained by using such a sensing array.

4 DATA PROCESSING

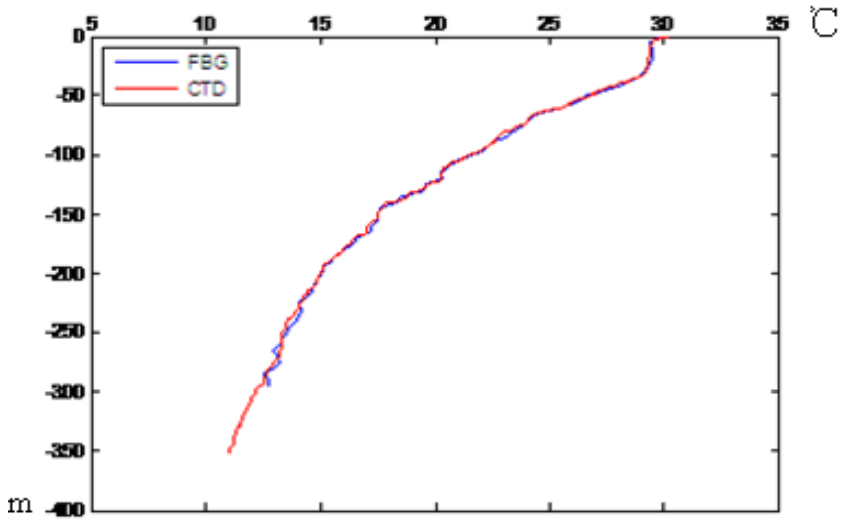
In the experiment,huge amounts of original signal was acquired by wavelength analysis system ,part of them were shown as table1.

Table1 original signal wavelength acquired

Sensor1	Sensor2	Sensor3	Sensor4	Sensor5	Sensor6
1527.034	1531.03	1533.974	1536.053	1538.067	1542.07
1527.034	1531.03	1533.974	1536.053	1538.068	1542.071
1527.036	1531.03	1533.974	1536.054	1538.068	1542.071
1527.034	1531.03	1533.975	1536.053	1538.067	1542.071
1527.036	1531.03	1533.977	1536.053	1538.067	1542.071
1527.035	1531.03	1533.975	1536.053	1538.067	1542.071
1527.035	1531.03	1533.974	1536.053	1538.068	1542.071
1527.035	1531.03	1533.975	1536.053	1538.067	1542.071
1527.035	1531.03	1533.975	1536.054	1538.067	1542.071
1527.035	1531.03	1533.975	1536.054	1538.067	1542.071

In table1, it concluded six sensors' wavelengthes,these data was acquired once a second.From the table,it can be seen that every sensor's wavelength was not constant,because the water was flowing and these sensors were not in a plane. In order to abtained the seawater profile temperature information,these wavelength data need to be processed.From the basic priciple of FBG sensor,it was known that the temperature and wavelength existed relatively linear.The polynomial fitting was introduced,it can be assumed that the relations between temperature and wavelength were $y=ax^2+bx+c$, where y was the temperature,and x represented wavelength, a,b,c were parameters which need to be worked out.These parameter had all be determined in laboratory with quadratic-multinomial fitting,so used these wavelength which were acquired in the experiment,the seawater profile temperature can be computed out.

Contrastive tested with CTD was made in this experiment.The CTD was recommended by experts ,whose precision was about 0.01℃.By processing the acquired data with MATLAB,the curve can be achieved as Fig3.



Fit3 The contrastive tested curve betwween FBG temperature array and CTD

5 ANALYSIS

It was shown in Fig3 that less deviation was existing between FBG and CTD,it was mainly induced by the system.In this chart,the CTD curve included over 10 thousands of spots,and the FBG curve included only 60 spots,however,the error of them was so little,and the trend was similar.From this curve,the temperature in this area can be clearly watched.By calculating,the resolution of fiber Brag grating sensing system was 0.1℃ and the precision was 0.2℃.

6 CONCLUSION

FBG sensor has been widely used in constructing and things,but it was used mainly on land.This experiment was completed in South China Sea.The accomplishment of this experiment will opened the development space for the FBG sensor.Althought its precision was pretty low,then fiber grating array can be recycled and reused,so it can reduce cost in comparison to XBT,CTD.After the improvement of sensor processing technique and signal processing methods,it can be predicted that the FBG sensor array will be widely used in ocean detection.

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