2P-5

Proceedings of Symposium on Ultrasonic Electronics, Vol. 31 (2010) pp. 299-300
6-8 December, 2010

# Acoustic Detection of Fiber Optic Sensor Array in Transformer Oil

Jongkil Lee[1†] ([1]Mechanical Engineering Education, Andong National University, Korea)

## 1. Introduction

Fiber optic sensors are widely used in the industrial and military fields[1]. To detect partial discharge phenomena generated in transformer oil due to the degradation of electric power facilities, optical fiber sensor technique can be used. There are numerous types of fiber optic interferometers being developed as acoustic sensors.

To detect external sound signals on the mandrel structure, Sagnac interferometer can be fabricated and tested. Generally hollow cylinder mandrel has been widely used to make fiber optic sensor[2-3]. The Sagnac fiber optic interferometer is as shown in **Fig. 1**.

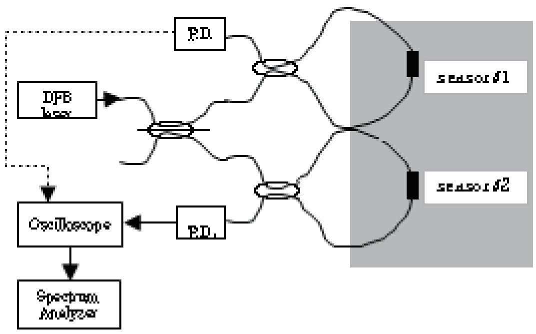


Fig. 1 Sagnac interferometer with array

The principle is input light split into two parts at the 2×2 coupler (beam splitter) and the two lights rotate opposite direction each other, then come together in 2×2 coupler. P.D.(Photo diode) detected the output signal with information of physical variation which experienced in the loop[4-5].

Therefore, in this paper, it was manufactured an interferometer optical fiber sensor and measured external acoustic signal caused by defect of power facilities such as power cables, transformers and gas insulation[6].

## 2. Experiment

Carbon and teflon mandrels wound with fiber-optic were chosen as optical fiber sensor as shown in **Fig. 2**.

E-mail: jlee@andong.ac.kr

Sagnac interferometers were chosen to detect external acoustic signalss. Discharge experiment sets in the discharge imitation cell in transformer oil tank and the discharge phenomena was generated as shown in **Fig. 3** and **4**.


Fig. 2 Photographs of the actuator(a), carbon sensor(b) and teflon sensor(c)

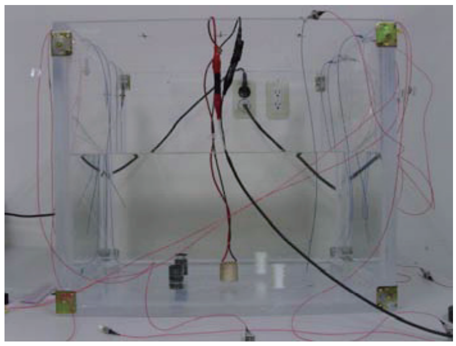

Fig. 3 Photograph of the experimental set-up

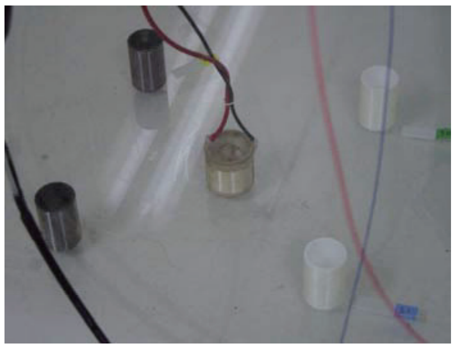

Fig. 4 Fiber optic sensor arrays in transformer oil

Mandrel sensor fabricated with dimension of 30mm in diameter and 2.5cm in height, the optical fiber, 50m in length, wounded on the mandrel. For the detection of the sound signals, single mode fiber, a laser with 1,550nm in wavelength, 2x2 coupler were used. As a sound source PZT was used as shown in Fig. 2(a).

## 3. Results and discussions

Acoustic detection performance of the each sensor was experimented and the results are shown in **Fig. 5** and **6**. Fig. 5 shows experimental results of the fiber optic sensor arrays in transformer oil under 1kHz. Fiber optic sensors were made by using carbon and teflon mandrel which is hollow cylinder Detected magnitude of the carbon sensor is -51.4dBV and teflon sensor is -69.5dBV. In fig. 5 carbon sensor is more sensitive rather than teflon sensor.

Fig. 6 shows comparison of the detected signals in air and transformer oil under 3kHz. **Table 1** also shows the sensitivity. Carbon sensor in air is less sensitivity than in transformer oil. Because of the density differences of the two fillets of the tank detection difference also comes out. Teflon sensor also has same results like carbon case. In teflon about 53% improvement was found just changing the fillet material.

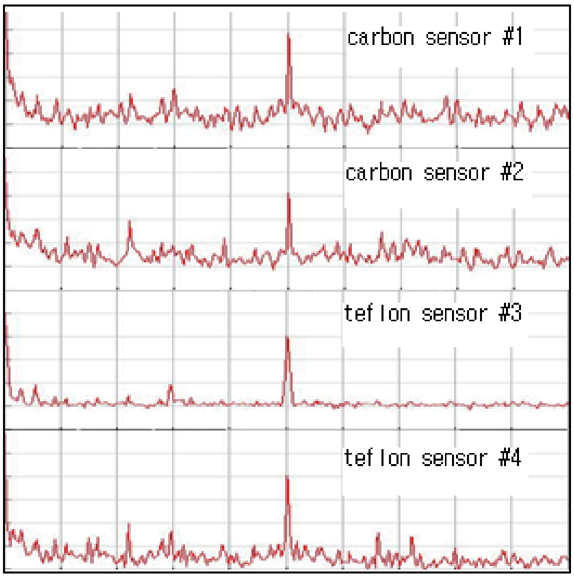


Fig. 5 Experimental results of the fiber optic sensor arrays in transformer oil under 1kHz(Horizontal axis: frequency(200Hz/div.), Vertical axis: magnitude (10dBV/div.))

Table 1. Average detected signal magnitude of the fiber optic sensor(in the case of 3kHz input)

| Sensor types | In air (dBV) | In transformer oil (dBV) |
|---|---|---|
| carbon | -77.8 | -46.8 |
| teflon | -90.3 | -41.9 |

Based on the experimental results sensitivity of the fiber optic acoustic sensor is depended upon the mandrel materials. This system can be expanded to fiber optic health monitoring system in the electric power system.

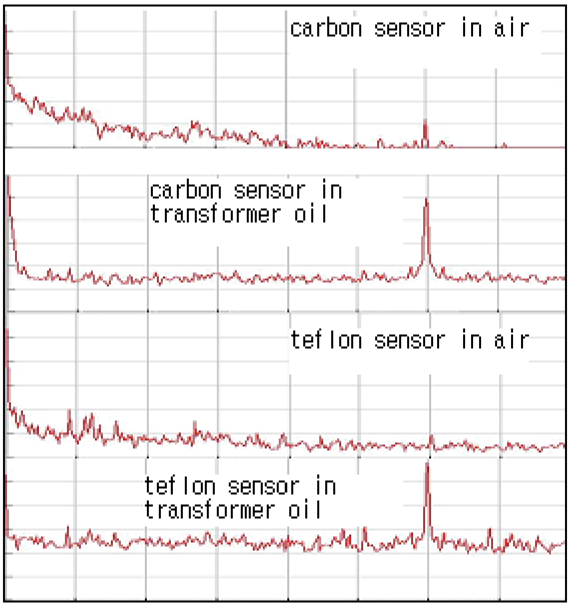


Fig. 6 Comparison of the detected signals in air and transformer oil under 3kHz(Horizontal axis: frequency(500Hz/div.), Vertical axis: magnitude (10dBV/div.))


**Acknowledgment**

This work was supported by the Korean Electrical & Science Research Institute(R-2008-25) and the Ministry of Knowledge Economy of Korea.


**References**


1. J. Lee: *Proceedings of the ASK-ASJ Joint conference on acoustics*, (2009) pp.163-166.
2. P. J. Nash and J. Keen: *Proceedings of the Institute of Acoustics*, **12**(1990) 201-212.
3. D. A. Jackson, and J. D. C. Jones: OPTICA ACTA, **33**(1986) 1469-1503.
4. L. M. Lyamshev and Y. Smirnov: Sov. Phys. Acoust., **29**(1983) 169-180.
5. G. McMahon and P. Cielo: Applied Optics, **18**(1979) 3720-3722.
6. J. Lee: ASJ-ASK Joint Conference on Acoustics, (2003)5-8.