Gas Detector for Hydrogen Dissolved in Transformer Oil

Ho-Joon Seo† , Kyu-Hyun Hwang* and Dong-Hee Rhie*

Abstract - In oil-filled equipment such as transformers, partial discharge or local overheating will precede a final shutdown. Accompanied with such problems is a decomposition of insulating material into gases, which are dissolved into the transformer oil. The gases dissolved in oil can be separated with some membranes based on the differences in permeability of membranes to different gases. This paper discuss the permeability characteristics of several membranes for separation hydrogen gas in oil. With result of this paper, it may become possible to detect fault-related gases from transformer oil and predict incipient failures in the

Keywords: Partial discharge, Degradation, Insulating oil, Hydrogen gas, Gas detector

1. Introduction

Due to the improvement of recent living standard, and the rapid progress toward the industrialized and information oriented society, the demand of electric energy is continuously increasing. According to this increasing demand for electric energy and relavant expansion of the power equipment is keep moving ahead. Nowdays in addition, for improving the power quality, the stable operation of power transformer and the necessity for developing the on-line monitoring diagnosing the degradation of the oil are still more increasing. Generally, the possibility of the insulation breakdown exists constantly in the oil-filled transformer by overheating resulting from full-time stressed operation of transformer. The insulation materials such as (oil, insulation-paper, press board or bakelite, etc) in contact with fault source are affected by the heat or the electric discharge. Then discomposition of oil molecules occur and the hydrocarbon gases, such as carbon dioxide, carbon monoxide, hydrogen, methane or ethane, etc. are dissolved in the oil. Among these gases the hydrogen is well known as characteristic gas which stands for the internal problems. In this essay, the composed process of gas detect system for the dissolved hydrogen in oil using polymer membrane and circuit lotation pump to measure the hydrogen density in dissolved. Also the experimental result of the gas detection system for the dissolved gases in oil is evaluated which is about the way of measure indirectly from the gas phase of our laboratory dissolved hydrogen detection system.

† Corresponding Author: Dept. of Electrical Engineering, Suwon Univerity, Korea. (hojoon@ suwon.ac.kr)

* Dept. of Electrical Engineering, Suwon Univerity, Korea. (tairoo2000@hotmail.com, dhrhie@suwon.ac.kr)

Received January 17, 2005 ; Accepted March 18, 2005

2. Detection System for Hydrogen Gas Dissolved in Oil

Hydrogen gas sensor used in this paper is ready-made goods and external appearance of gas sensor is shown in fig. 1. In fig.2, there is operating circuit for the hydrogen gas sensor. From the ciruit in fig.2, when the different concentration of hydrogen gas face into the sensor, the changed resistance of the sensor is checked by the voltmeter signal. Fig. 3 shows characteristic curve of the hydrogen gas sensor, and that curve is used to calculate the density of hydrogen gas using the output voltage and the loaded.

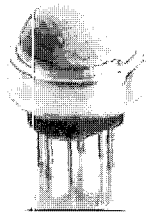


Fig. 1 Gas Sensor

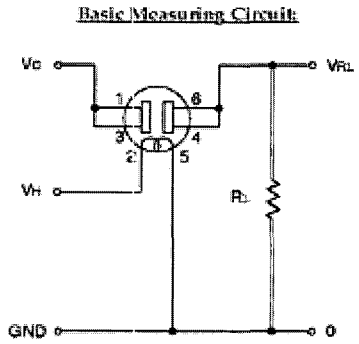


Fig. 2 Operating circuit for the gas sensor .

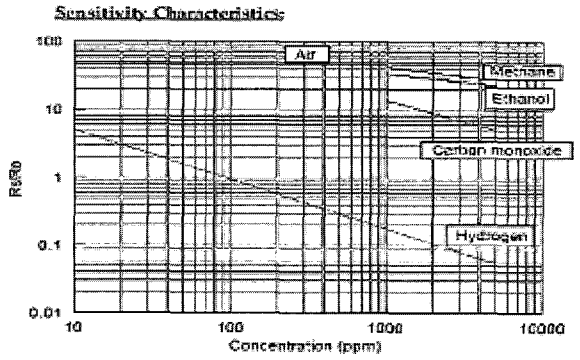


Fig. 2 Characteristic curve of gas sensor

3. The Hydrogen Detection System using The Membrane

Fig. 4 shows the proposed detection system for hydrogen gas dissolved in oil base on the membrane filter.

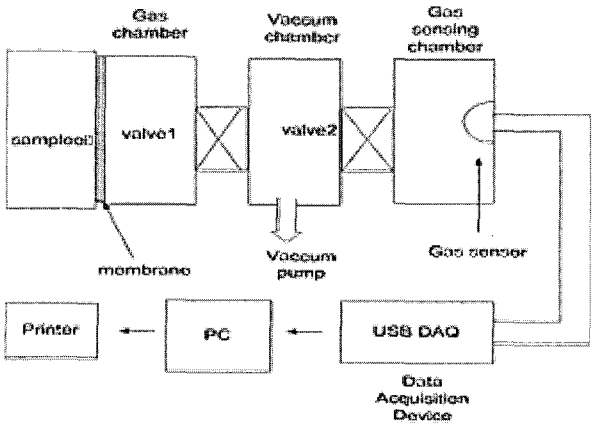


Fig. 3 Gas detection system of dissolved gas in oil using Membrane

In this system, there is the gas extraction part and the gas density measurement part. The gas extraction part using the membrane filter extracts the dissolved gas from oil filled transformer. The gas density measurement part using hydrogen gas sensor measures the concentration of hydrogen gas of output come from the gas extraction part. The gas extraction part was built as the chamber of sample oil, the vacuum chamber and the gas sensing chamber.

Fig. 5 shows the gas extraction part. The membrane filters used in this paper are the micro filtration, ultra filtration and the reverse osmosis filters, and the result of the experiment is on the Table 1. The micro filtrtion filter which is made of cellulose acetate has too big pore size(0.1 0.2 0.45um), so the oil in chamber flow out through these filters. For the ultra filtration filter is suitable for extrating gas dissolved in oil.

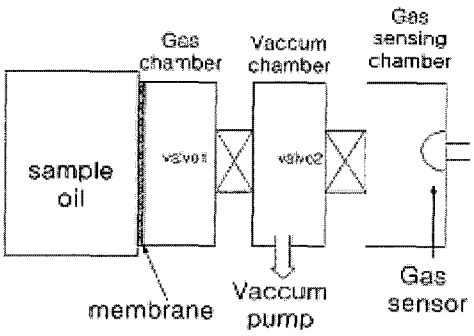


Fig. 4 The Extraction Part for Hydrogen Gas from Oil

Table 1 Kind of membrane & permeated result

	Pore size	Experiment result	Remarks
(MF) Micro-filtration	0.1 ㎛	Oil leakaged	Unfit for this experiment
	0.2 ㎛		
	0.45 ㎛		
(UF) Ultra-filtration	< 0.01 ㎛	Gas permeated	fit for this experiment, need to improve permeation velecity
(RO) Reverse Osmosis	< 20 Å	Impossible to provide operation condition	Impossible to apply

The reverse osmosis filter is not suitable for extracting the gas from oil. The reason is that to operate the reverse osmosis filter normally, over 20atm pressure is needed but the chamber of sample oil can't stand for that pressure.

The experimental results using ultra filtration filter are shown in fig.6-fig.7.

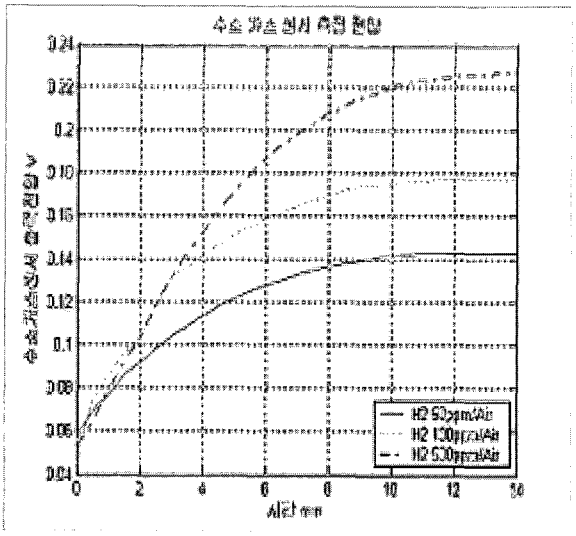


Fig. 6 Output Voltage of Hydrogen Gas Sensor

4. The Hydrogen Detection system using The Air Circulation Pump

In fig.8, there is the hydrogen detection system based on the air circulation pump.

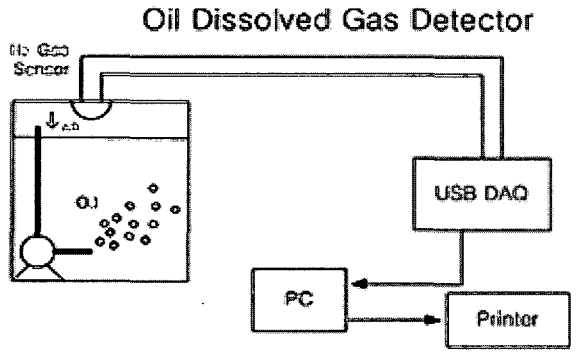


Fig. 8 The Gas Detector for Hydrogen Gas Dissolved in Oil based on The Air Circulation

In this system, the hydrogen gas dissolved in oil was seperated by the circulation effect of the air pump. It circulated with air then it dissolved as dissolved gas again. If this process repeated, then the amount of dissolved gas in oil and the amount of gas in air of upper block of chamber become same amount. And the gas sensor can achieve the density of hydrogen gas dissolved in oil. In fig. 9, there is the output voltage of the gas sensor. Fig. 10 is concentration curve of extracted hydrogen gas based on the air circulation pump.

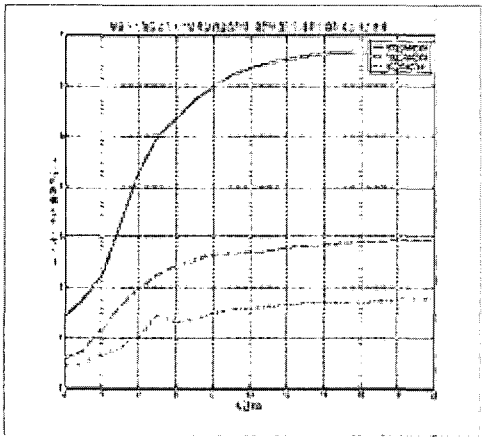


Fig. 9 Output Voltage of Hydrogen Gas Sensor based on The Air Circulation

5. Conclusion

This paper describes the detection system for hydrogen gas dissolved in oil. We examine the detection system in two ways, the one is based on membrane filter and the other is based on air circulation pump.

In the detection system based on membrane filter, we experiment three types of membrane filter, i.e. micro filtration, ultra filtration and reverse osmosis filter. Resulting of the gas detecting experiment by using micro filtration filter, the pore of the filter was too big for extract the gas dissolved in oil. For the ultra filtration filter, by the experiment, it was suitable for the detecting dissolved gas. And the reverse osmosis filter is not suitable for extracting the gas from oil. The reason is that to operate the reverse osmosis filter normally, over 20atm pressure is needed but the chamber of sample oil can't stand for that pressure.

In the detection system based on the air circulation pump The circuit pump was used to extract the gas dissolved gas in insulating oil and the gas detection system of dissolved gas was used to measure the density of hydrogen gas. This system is suitable to detect the density of the hydrogen gas dissolved in insulating oil.

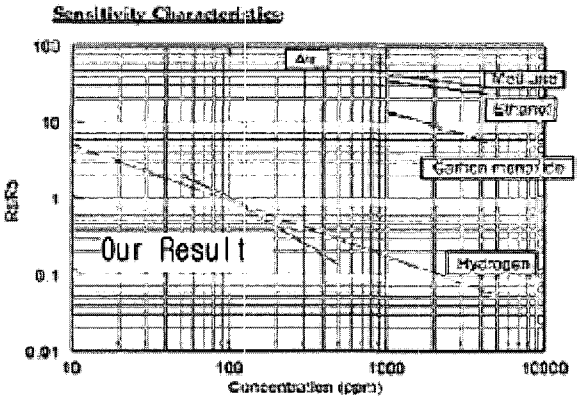


Fig. 10 The Characteristic Curve of Gas Detector

Acknowledgements

This work has been supported by KESRI(R-2003-B-108), which is funded by MOCIE(Ministry of commerce, industry and energy.

References

[1] H. Tsukioka, K. Sugawara, "Apparatus for Continuously Monitoring Hydrogen Gas Dissolved in Transformer Oil," *IEEE Tans. on Elec. Insulation*, Vol. EI-16, No.6, pp502-509, Dec. 1981

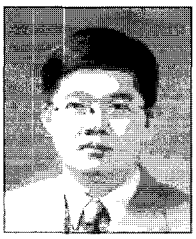
[2] Hamada, M.M., Zeitoun, A.G., Ismail, G., "A newly modified forced oil cooling system and its impact on in-service transformer oil characteristics," *IEEE Tans. on Power Delivery*, Volume: 18, Issue: 3, pp827-834, Aug. 2003

[3] Lehr, J.M., Agee, F.J.; Copeland, R.; Prather, W.D "Measurement of the electric breakdown strength of transformer oil in the sub-nanosecond regime," IEEE Transactions on Dielectrics and Electrical Insulation Vol.5, Issue: 6, pp. 857-861, Dec. 1998

[4] Jagadish, R., Poovamma, P.K., "Flow electrification characteristics of transformer oil by rotating electrode systems," *IEEE Transactions on Power Delivery*, Vol.10, pp. 1326-1331, July 1995

[5] E. B. Shim and S. O. Han, "The Lighting Current Parameters that Impacts on the Surge Analysis of the EHV Gas Insulated Substation by EMTP," KIEE Int. Trans. On EA, Vol.5-C, No.1, pp. 1-7, 2003.

[6] Rasaruk, M., Petcharaks, K. "Thermal effect on AC breakdown characteristic of transformer oil under inhomogeneous fields," *Power Engineering Society Winter Meeting, 2000. IEEE*, Vol. 3, pp. 2176-2180, Jan. 2000

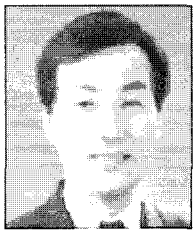


Ho-Joon Seo

He received the PH. D degree in electrical engineering at Korea University in 2001. Currently he is a invited lecturer in the department of electrical engineering at Suwon University in Korea. His research interests include surge protection countermeasure and diagonosis of power transformer.

Kyu-Hyun Hwang

He received the B.S. degree in electrical engineering at Suwon University in 2002. Currently he is studying in M.S. degree in the department of electrical engineering at Suwon University in Korea. His research interests include surge protection countermeasure and diagonosis of power transformer.



Dong-Hee Rhie

He received the PH. D degree in electrical engineering at Korea University in 1990. Currently he is a associate professor in the department of electrical engineering at Suwon University in Korea. His research interests include surge protection countermeasure and diagonosis of power transformer.