



Design of Sensor System for Detection of Heat Generated from Transformer

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ABSTRACT: A network of electrical components which is used to supply, transmit and use electric power is known as an electrical power system. Load variations affect the working of transformer. Load variations due to increasing demand of power generates heat in the transformer, which affects the overall efficiency and life of transformer. Heat is generated in transformer due to different types of losses i.e., load losses and no load losses. These losses then converted in the heat and hence rising the temperature of the windings, core, oil and the tank of transformer. Experiments are carried out analyze the increase in ambient temperature of power system with various range of load impedance connected to it.

KEYWORDS: Power system, TEG, Heat sink, Digital thermometer.

I.INTRODUCTION

A network of electrical components which is used to supply, transmit and use electric power is known as an electrical power system. The network that supplies a region's homes and industry with power can be considered as an example of power system. This electric power system is called as the grid and can be further divided into the generator that generates the power, the transmission system that carries the power from generating centres to load centres and the distribution system that feeds power to nearby homes and industries. Distribution can be done by using transformers. So, transformers are one of the important components of power system, as power is mainly consumed at homes and industries where low voltage supply compared to generated supply is required, which can be done by transformers only [1].

Therefore we can say that transformers are mostly used in applications where the conversion of AC voltage from one voltage level to another is done. There are two types of transformers used, first one is electronic transformers, which operate at very low power levels, and second one is power transformers, which operate at very high power levels (thousands of watts of power). Electronic transformers are used in consumer electronic equipment like television sets, VCRs, CD players, personal computers, and many other devices, to reduce the level of voltage from 220V (available from the AC mains) to the required level at which the device operates. Power transformers are used in power generation, transmission and distribution systems to raise or lower the level of voltage to the required levels. The basic principle of operation of both types of transformers is the same [2-3].

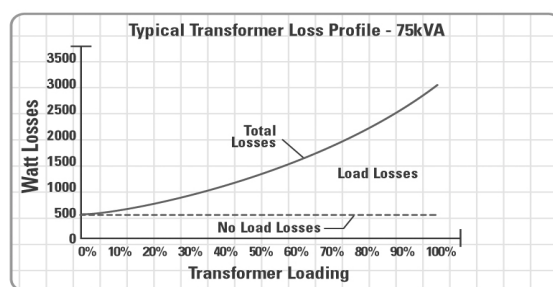


Fig. 1 Variation of transformer losses with loading.

The losses in a power transformer can be classified as no-load losses and load losses. No-Load Losses: Eddy current and hysteresis losses are included in such type of losses. For minimizing eddy losses, core material with high resistivity



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and thinner lamination are used. This loss decreases very slowly with rise in temperature. Eddy losses generate about 50% of the core losses. Hysteresis losses are affected by material, frequency and maximum magnetic density. It can be reduced by optimizing the maximum magnetic density and selecting economically best material while taking this loss into mind [4]. Load losses: The coil losses, generally called as load losses, are connected to the feeding power to the connected load. For linear loads, load losses are mostly I^2R losses, it means that load losses are directly proportional to the square of current from no- load to full- load, driven by coil resistance [5].

Overall rating of the transformer can be affected by stray losses because hot spots can be created when the current leads become excessive and hence overall life of the transformer is affected. Transformer losses are of the order of 1% of its full load KW rating shown in Fig. 1. These losses then converted in the heat and hence rising the temperature of the windings, core, oil and the tank [6-8].

Heat generation process can be defined by the energy balance equation:

$$q \times dt = c_{th} \times d\theta + \frac{\theta - \theta_{amb}}{R_{th}} \times dt$$

where q is the heat generation, c_{th} is the thermal capacitance, θ is temperature, R_{th} is the thermal resistance, and θ_{amb} is the ambient temperature. The equation may be rewritten as follows:

$$q = c_{th} \times \frac{d\theta}{dt} + \frac{\theta - \theta_{amb}}{R_{th}}$$

II. LITERATURE SURVEY

Kweon et.al (2012) briefly present that the life of a power transformer is dependent on the life of the cellulose paper, which Influenced by the hot spot temperature. Thus, the determination of the cellulose paper's life requires Identifying the hot spot temperature of the transformer [9].

Taghikhani (2012) briefly shows that the Power transformer outages have a considerable economic impact on the operation of an electrical network. In order to draw maximum power from transformers and, at the same time, avoid thermal mishaps, it is essential to carefully study its thermal behaviour [6].

Su et.al. (2014) presents his article which describes the principles and characteristics of wireless temperature measurement technology build a real-time online monitoring wireless temperature measurement system [10].

Betta (2001) represent the paper which deals with a sensor for temperature measurements In fluids. The sensor is based on a fiber-optic sensing element and on microcontroller-based signal processing hardware. The physical principle behind its operation is briefly reviewed, and its application to power transformer hot-spot temperature measurement is reported [11].

Sharma et. al. (2014) in their paper told that knowledge of temperature fluctuations in fast reactor subassembly is very important from a safety point of view. The time constant of thermocouples which are used for measuring coolant temperature in a fast reactor varies owing to various factors [12].

III.METHODOLOGY

The research work is carried out estimate the heat generated from the transformer with load connected to it. In this experiment, the relationship between heat sensed and corresponding amount of voltage generated by TEG single and array of sensor are analysed. The detailed steps carried out are explained below to measure the voltage generation. Figure 4.17 shows the block diagram of experiment I. First single sensor was connected to the system and response was noted. In the second experiment an array of sensor was connected to the system and response was noted. Different combination of load connected to the system is given in Table 1. The system voltage at different load was also recorded using a Goldwave software through a voltage divider circuit and sound card connected to current transformer (CT).

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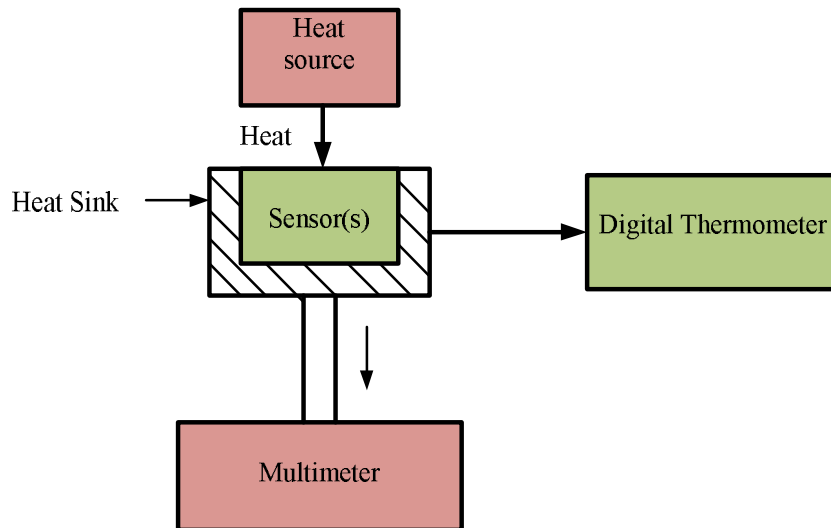


Fig. 2 Schematic of experimental setup.

Table 1. Various combination of load impedance.

Resistance (Ω)	Capacitance (μF)	Inductance (mH)	Impedance(Z) $Z = \sqrt{R^2 + [\omega L - \frac{1}{\omega C}]^2}$
124	50	300	127.73
		400	138.60
		500	155.31
		600	176.04
		700	199.60
		1000	279.60
		1200	337.16
		1800	517.19

IV.RESULT AND DISCUSSION

The output voltage response from sensor with varying ambient temperature is given in Table 2. It can be observed from the response that as the temperature increase the output voltage proportionally increases. Figure 3 show output voltage with respect to ambient temperature for single and array of sensor. Table 3 shows the output voltage from the sensor when load is connected to the power system for constant interval of time. The load causes the system to heat up and increase the ambient temperature. The data from the observations can be correlated with the sensor output with temperature to predict the ambient temperature of the power system.

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Table 2. Sensor output response w.r.t ambient temperature.

Temperature (°C)	O/P single sensor (V)	O/P sensor array (V)
30	0.2	0.34
32	0.3	0.74
34	0.8	0.98
36	0.9	1.26
38	1.08	1.34
40	1.2	1.52
42	1.34	1.7
44	1.48	1.98
46	1.8	2.4
48	1.93	2.58
50	2.2	2.83

Figure 3 show output voltage with respect to ambient temperature for single and array of sensor.

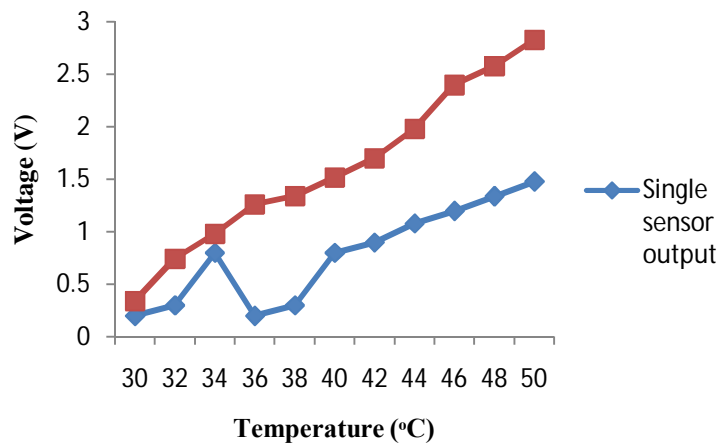


Fig. 3 Sensor output response w.r.t temperature.

Table 3 shows the output voltage from the sensor when load is connected to the power system for constant interval of time.

Table 3. Sensor output response w.r.t load connected to power system.

Load Impedance	Sensor O/P (V)
127.73	0.32
138.60	0.81
155.31	0.93
176.04	1.10
199.60	1.32
279.60	1.54
337.16	1.61
517.19	1.97



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V.CONCLUSION

The research work is carried out to predict the heat generated in the power system with various range of load connected to it. Single sensor and array of sensor is tested to investigate its performance with varying the heat in the surrounding. Various ranging of load (127.73 to 517.19 ohms) is connected with the power system and rise in the ambient temperature of the system is observed. The sensor output for lowest and highest value of impedance is 0.32 V and 1.97 V respectively. Future scope the research work is to design a system detecting rise in temperature and switch the cooling system.

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