Performance Evaluation of 2 KVA Single Phase Transformer with Different Cooling Medium.

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Abstract

New 2KVA, 230/110V, transformer has been design, constructed and analysed with various cooling medium. Transformer is an essential electrical machine for electrical transmissions and distributions. Major loss of transformer is cooper loss and it rises with heating effect of electric current. In present research paper, a comparative performance of 2 KVA single phase transformer for a natural air, oil and liquid nitrogen (LN_2) cooling systems was analysed. It was found that the copper loss and the iron loss also get reduced with air, oil and liquid nitrogen cooling. Hence, in comparative analysis it is observed efficiency of transformer get improved in liquid nitrogen as compare to natural air and oil cooling.

Keywords —*Transformer, liquid nitrogen, cooling medium*

I. INTRODUCTION

Transformer is an essential machine for electrical power system, which transfer electrical power from one alternating circuit to other alternating circuits at constant frequency. It can increases or decreases voltage in a circuits with decreases or increases respective current. Transformer is the stationary device there is no rotating parts and it works on mutual inductions phenomenon. Mechanical losses i.e. frictional and windage losses are absent. Only electrical losses occur in transformer. Iron loss is in the core of transformer and copper loss occurred in windings of transformer. Copper loss is varies with square of the current flowing through coils, iron loss is constant. Copper loss is due to ohmic resistance of windings. It is proportional to square of current or KVA^2. To improve performance and efficiency, losses of transformer get reduced. If copper loss get lowered up to the value of iron loss, (P_i=P_{cu}) performance and efficiency of transformer get raised. Insulation degradation is due thermal degradation which affects life span of machine. Due to thermal effect of electric current temperature of machine increases which lead to rise in iron and copper loss. To maintain temperature of static electrical machine cooling system is necessary. Various cooling methods are normally used to cool transformer. [1]

1) For dry type of Transformers
   a) Air Natural (AN)
   b) Air Blast
2) For oil immersed transformers
   a) Oil natural air natural (ONAN)
   b) Oil natural air forced (ONAF)
   c) Oil forced air forced (OFAF)
   d) Oil forced water forced (OFWF)

Nowadays apart from above cooling methods liquid-nitrogen cooling systems has been developed for the HTS power equipment like HTS transformer, grid applications and terminals of transmission cable [2]. Liquid nitrogen has admirable dielectric properties and easy for handling. In present research work designed and built 2 KVA prototype transformer and analysed its comparative performance with air natural, oil natural air natural (ONAN) and liquid nitrogen (LN2) natural cooling system.

II. TRANSFORMER DESIGN

2 KVA single phase shell type of transformer has been designed for the performance evaluation with different cooling system.

Figure 1: Photograph of 2 KVA single phase shell type Transformer

TABLE I
Specification of 2 KVA Single Phase shell type Transformer

Parameters	Specifications
Primary Input	230V,9A
Secondary Output	110V,18A
Winding	Copper Material
	S.W.G- 15,
	Diameter- 1.829mm
	Weight-5Kg
Core	Material- High Grade Silicon steel stamping
	Type- Rectangular cored

III. EXPERIMENTAL SETUP

Experimental set up was arranged for three different cooling medium. Load given to transformer was resistive in nature; single phase lamp load bank was used. Where the load was approximately 230V, 9 to 10 A with the power factor of about unity. For efficiency and voltage regulation direct loading test was carried out. For copper and core losses short circuit and open circuit test was performed with different cooling medium.

Experimental Setup with Air Cooling Medium:-

Transformers are consisting with copper loss, iron loss, dielectric loss and stray loss. These losses are proportional to size and weight of transformer. The simplest power transformer cooling system is air natural. In this method, heat generated within transformer core and winding is transformed to air. [3] In experimental set up air naturally circulated around the transformer.

Figure 2: Photograph of air cooling experimental setup.

Experimental Setup with oil Cooling Medium:-

The simplest power transformer cooling system is oil natural air natural. In this method, heat generated within transformer core and winding is transformed to oil. In experimental setup, designed 2 KVA transformer is immersed in oil and performance was evaluated.

Figure 3: Photograph of oil cooling experimental setup.

Experimental Setup with liquid nitrogen Cooling Medium:

Liquid nitrogen is an effective and appropriate refrigerant due to its ease of use. In experimental setup Built 2 KVA transformer immersed in to LN_2. Boiling temperature LN_2 is extremely low i.e. -195.8^0C. It's also having high refrigeration capacity at atmospheric pressure. In the experimental setup hard thermocol is used to perform the experiment. The transformer is kept in the box and liquid nitrogen is poured.

Figure 4: Photograph of liquid nitrogen cooling experimental setup.

IV. RESULT AND DISCUSSION

It was observed that efficiency of transformer for first experimental setup i.e. natural air cooling of test model was 71.65 % and for second cooling medium i.e. oil cooling was 82.09%. The efficiency of the test model gets raised for LN_2 as a cooling medium. Calculated efficiency of LN_2 cooling medium was 88.43%. After conduction of open circuit test with different cooling medium, core loss measured for air cooling medium was 28 watt. For oil medium it was measured 20 watt and during LN_2 it was reduced to 10 watt. For copper loss short circuit test was performed. For air cooling medium measured cooper loss was 100 watt. For oil and LN_2 it was 84 watt and 64 watt respectively.

TABLE II
Test Result

Cooling Medium	Efficiency (%)	Core loss (Watt)	Copper loss (Watt)
Air	71.67	28	100
Oil	82.09	20	84
LN_2	88.43	10	64

V.CONCLUSION

This paper has presented performance evaluation of transformer with different cooling medium. It was observed that test model efficiency with liquid nitrogen cooling was high as compared to air and oil used as cooling medium. Copper loss rapidly decreased when liquid nitrogen cooled the test model.

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