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EFFECT OF CORE MATERIAL ON CORE LOSSES OF TRANSFORMER

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Abstract: Electricity is an essential part of everyone's life henceit is quite impossible to live without it. Each and every appliance which are used for domestic purpose are totally depended onelectricity. That's why Transformer plays a vital role in providing supply of much-needed electricity to homes and offices. For Residential and Commercial properties, electricity is supplied through Transformer that is why Transformer plays an importantrole in our lives. An Ideal Transformer is the transformer which has 100% efficiency This means that the power supplied at the input terminals should be exactly equal to the power supplied to the output terminals, since efficiency can only be 100% if the output power is equal to the input power. But practically, nothing in this universe is ideal. Similarly, since the output power of a transformer is never equal to the input power which happens due to some number of electrical losses inside the core and windings of the transformer,so we never get to see a 100% efficient transformer. Transformer is a static device, i.e., we do not get to see anymovements in its parts, so no mechanical losses exist in the transformer and only electrical losses are observed. In this project, it was studied and compare magnetic (iron) losses in transformer using different type of core materials i.e., silicon steeland air core.

I. INTRODUCTION

The transformer is a valuable apparatus in electrical power systems, as it enables us to utilize different voltage levels across the system for the most economical value.

A transformer is a static device that transmits electrical power from one electrical circuit to another circuit, purely by magnetic coupling. The purpose of a transformer is to step up and step-down electrical voltage to a different value. Essentially, a transformer has two or more windings which are magnetically coupled by mutual magnetic flux. Since distribution transformers has no rotating parts, it has no mechanical losses. This contributes to its high operating efficiency of over 90%.

However, like any electrical device, a transformer has some load losses due to several factors. Transformer losses are produced by the electrical current flowing in the coils and the magnetic field alternating in the core.

The losses which appear in transformer are heat losses which produces a rise in temperature and a drop in efficiency. Losses are classified into two categories: no-load losses (core loss) andload losses (copper loss). No-load losses are constant and appear so long as a transformer is in service, while load losses vary with the square of the load current carried by the transformer and are only significant under higher load conditions. No load loss, otherwise called Iron loss is caused by the alternating flux in the core of the transformer. The iron loss gets divided into hysteresis and eddy current loss.

Hysteresis loss

A hysteresis loop is traced out for each cycle of EMF in the core. The energy that is wasted due to hysteresis is known as hysteresis loss.

Here is the formula for calculation

P=K? 1.6fV Watts

Where 'Ko 'is constant depends on the material of themagnetic core.'

'f' is the frequency in Hertz. 'B' is the highest flux density.

'V' is Material Volume.

Eddy current loss

In simple words, the loss in current flow due to eddy current is eddy current loss. Due to the constantly changing magnetic fields, there is a loss of current in the core.

Here is the formula for calculation

"Pe=KeB2f2t2V" Wattswhere 'Ke' is coefficient constant.

'f' is the frequency in Hertz.

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'B' is the highest flux density in weber per meter square. ''T' is lamination material thickness in meters.
'V' is the material volume in cubic meters.

II. BACKGROUND

The distribution transformers are the largest loss-making components in the electricity distribution networks in any power system. Hence, their loss reduction can bring substantial economic benefits. However, this is a complex issue and the solution should be considered as an optimization problem. Rapid changes and new developments have been made in the field of transformer design [1].
In general, the transformer are classified in two categories: no- load loss and load loss. The no- load losses result from the magnetizing energy required for maintaining the magnetic flux in transformer core, and are known as iron loss. The iron loss ispractically constant and independent of load. Load losses are resistance loss in the transformer windings; they are known as copper loss and are proportional to the square of the load current. Since the transformer is continuously energized, iron loss is more important operating parameter, compared to copper loss that occurs only when it is operating under load.
Apart from the fact that no-load loss is only a fraction of the load loss at nominal operation, the energy consumed by the magnetic core of a typical distribution transformer during a year period of operation is 3-4 times higher than the energy dissipated in the windings at rated load [2]. Given that the lifetime of a standard distribution transformer is more than forty years, operating cost due to no-load loss far exceeds the initial production cost of the transformer. On the other hand, widely seen, the distribution transformers no-load loss components constitute nearly 25% of total transmission and distribution losses of electrical grids. However, importance of the transformer no-load loss impact onthe modern electrical operation is often underestimated [3]. Recently, the loss reduction of distribution transformers, and inparticular the component of no-load loss, has attracted the big interest of researchers and transformer manufacturers.

III. SELECTION OF TRANSFORMER

The transformer and testing facility was readily available at theindustry D Rohitra Pvt. ltd, Bhosari, Pune and we requested them to permit us to perform experiment on 100 KVA, 11KV:415V transformer.

Fig.1 Test bench used

TEST BENCH USED FOR TEST
Capacity= 200 KVA
Components used in Test Bench: -
1. A.C Voltmeter (0-600) V
2. A.C Ammeter (0-500) A3. CT (500:5) A
4. Digital Frequency Meter
5. Timer
6. Digital KV meter
7. 3 phase power analyzers

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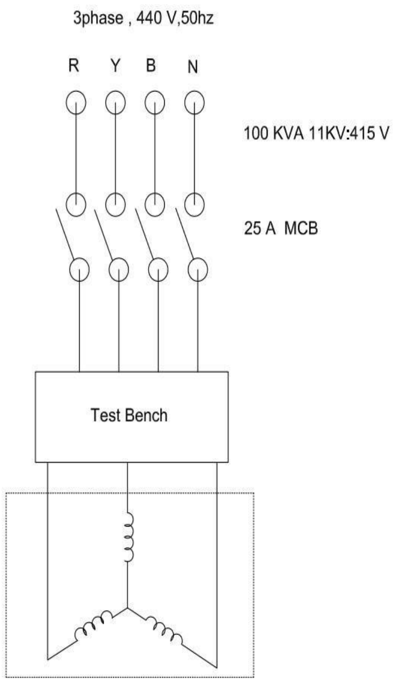

Fig.3. NO LOAD TEST SETUP Test

This is the test using 100KVA transformer in its original condition with silicon steel laminated core. For this purpose, 3 phase 450 V AC supply was connected to the low voltage winding of the transformer through the test bench. Connection diagram of the test bench of the transformer is as shown in fig 1.

Fig.4 Air core

TABLE I. OBSERVATION TABLE

VOLTAGE BETWEEN R & N (volt)	VOLTAGE BETWEEN Y & N (volt)	VOLTAGE BETWEEN B & N (volt)	CURRENT THROUGH R TO N (Amp)	CURRENT THROUGH Y TO N (Amp)	CURRENT THROUGH B TO N (Amp)	TEMPRETURE (°C)
124.08	130.26	128.01	0.6496	0.5882	0.7028	34.08

FREQUENCY (Hz)	POWER FACTOR	LOSSES (Watt)	OVERALL VOLTAG E (volt)	MAXIMUM VOLTAGE (volt)	OVERALL CURRENT (Amp)	PEAK CURRENT (Amp)
49.889	0.67	153.59	125.38	125.33	0.6083	0.9088

TABLE II. OBSERVATION TABLE

VOLTAGE BETWEEN R & N (volt)	VOLTAGE BETWEEN Y & N(volt)	VOLTAGE BETWEEN B & N(volt)	CURRENT THROUGHR TO N (Amp)	CURRENT THROUGH YTO N (Amp)	CURRENT THROUGHB TO N (Amp)	TEMPRETURE(°C)
124.08	130.26	128.01	5.99	5.63	6.01	73

FREQUENCY (Hz)	POWER FACTOR	LOSSES (Watt)	OVERALL VOLTAGE (volt)	MAXIMUM VOLTAGE (volt)	OVERALL CURRENT (Amp)	PEAK CURRENT (Amp)
49.889	0.85	625.78	125.38	125.33	5.87	6.01

V ANALYSIS

Fig. 5 Comparison of losses in silicon core and air core

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CONCLUSION

It was concluded that magnetic losses in air core transformerare comparatively larger than silicon steel core. So, silicon steel is most commonly used among other core materials used in industry. A lot of scope is there to improve upon the materials and enhance its magnetic properties so that the core losses can be still minimized.

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