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Evaluation of Energy Efficient Core Material of Distribution Transformer

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***Abstract*: The dependable and efficient operation of transformer is based on the materials used and the detection system. It is an attempt to meet rising costs while maintaining the growing demand for the optimization of electrical energy into matter. One of the possible ways to do this is to use better materials. The use of better materials in the transformer core led to a significant improvement of the lifetime and reduces various losses. The size of the machine was successively for a given classification KVA through better core material. This work attempts to trace the development and use of different materials which have made their impact on the performance and cost.**

Keywords: **Electrical steel, amorphous alloy steel, reduced losses, economic analysis.**

I. INTRODUCTION

Transformers are relatively efficient devices, but the total annual cost of the energy consumption is very important. A large portion of these losses resulting from the electrical excitation of the steel is used for the core. There are about 15 lakhs distribution transformers of average capacity 63KVA in Indian power system. In the process of converting electricity generated to useful voltages distribution, transformers annually consumes approximately Rs. 10968 crores as core loss.

So, if cost-effective methods for the use of core materials were available to low-loss, energy savings and significant investments are made. Core materials are constantly improving the quality and technical performance. Propose of this study is to provide an overview of the evaluation of electrical steel sheets which are available.

II. BASIC CORE MATERIAL

Basic core materials are classified as: 1) Electrical steel and 2) Amorphous alloy steel.

Electrical steel is broadly classified as non grain oriented steel and grain oriented steel.

II . A. Electrical Steel:

Non Grain Oriented. In these types of electrical steels the magnetic properties are practically the same in all direction of magnetization of the material. The term "non grain oriented" is used to these materials as the processes that are different manufactures to create a defined orientation and directionality of the magnetic properties.

Grain-Oriented. In these types of electrical steels the materials possess magnetic properties which are strongly oriented with respect to the direction of rolling. By a rolling process and annealing, alloys of suitable composition with a crystalline structure of the metal in the grains can be produced, so that the magnetic properties are oriented in the rolling direction are produced much higher.

II. B Amorphous Metal Alloy:

Amorphous magnetic materials are non-crystalline. They are made by rapidly cooling the melted metal, thus making it solidify in an irregular pattern. This fast cooling is achieved by pouring the metal on a spinning wheel which creates cascades of thin (tens of micrometers) ribbons of metal. The metal solidifies so quickly that it does not have time to form a crystalline structure. These ribbons are then wound into a transformer core. Advantages of this material as a core material include low coercivity, which decreases eddy currents in the core.[24]

III. OPERATING CONCERNS

The efficient performance of transformer depends upon various operating aspects, which are functions of material properties. Losses occur in transformer which varies with different types of core material. Noise levels can be reduced by using materials having low magnetostriction.

Iron Boron Silicon amorphous alloy is one of its kind alloy whose structure occurs in random patters as opposed to conventional CRGO steel which has an organized crystalline structure. The higher resistance to magnetization and demagnetization through the crystalline structure leads to higher core losses in CRGO.[15] The fig.1 and 2 show the difference in the curves of magnetization of different materials at different frequencies.

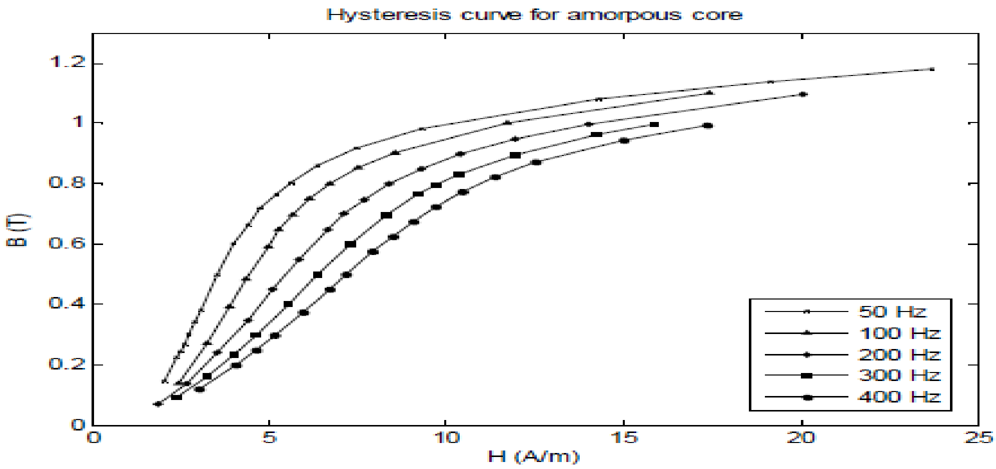

Fig.1 Magnetization Curves For The Amorphous Core At Different Frequencies.[3]

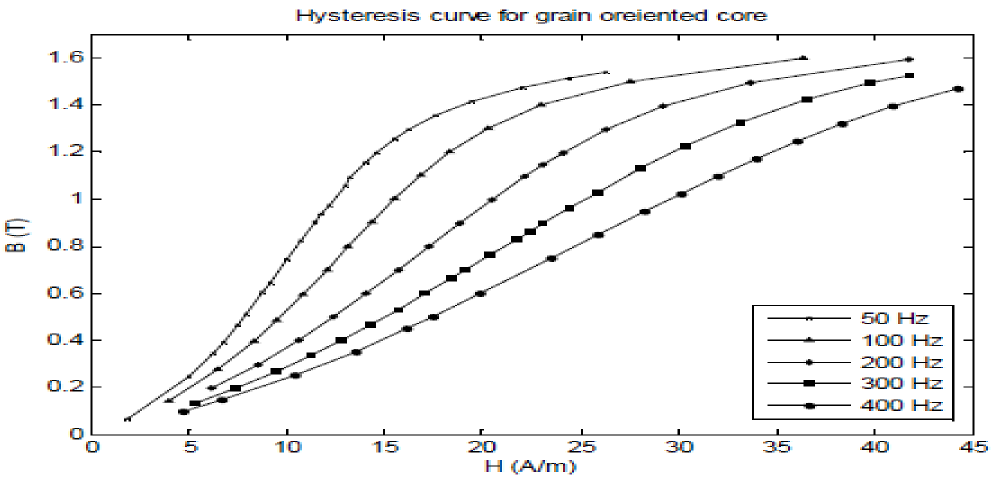

Fig.2 Magnetization Curves for the Grain Oriented Core at Different Frequencies.[3]

IV. PREVIOUS WORK

In previous year there has been lot of research work on the core material of transformer. In [1] to reduce the cost of amorphous core designing of core of transformer is been done. In [2] amorphous core is used for calculating the losses of transformer in on load and no load condition. In [20] the paper covers design of transformer using a new technology superior magnetic material with thin sheets of lazer grade or amorphous core. Iron Boron Silicon amorphous alloy is a unique alloy whose structure of metal atoms occurs in random patters as opposed to conventional CRGO steel which has an organized crystalline structure. The paper covers design of distribution transformer using conventional material and the new technology improved core materials. There are several researches been done on saving energy and power which is been used in transmission and distribution [21, 22, 23, 24, 25].

V. PROPOSED METHODOLOGY

Till now no more work has been reported of comparing the cost of installation and evaluation of core material of transformer. This work is an attempt to compare the initial cost of the various grades of core of transformer in order to save the monetary funds which is involved in the maintenance of the transformer.

V. A Energy Saving and Increasing Profits:

Amorphous core produces very low losses especially no load losses. This core has low coercivity, which leads to low hysteresis losses and high electrical resistance which leads to the reduction of eddy currents. The following Tables show the reduced energy loss in amorphous transformer.

Table I: Energy Loss in Silicon Steel And Amorphous Transformers. [23]

Capacity [kVA]	Silicon Steel Transformer		Amorphous Transformer	
	No-Load Loss [W]	Load Loss [W]	No-Load Loss [W]	Load Loss [W]
100	300	1875	95 (68%)	1800
500	939	4522	240 (74%)	5450
100	1670	7880	440 (74%)	9170

Table II: Energy Loss In Silicon Steel And Amorphous Transformers. [25]

Capacity [kVA]	Silicon Steel Transformer		Amorphous Transformer	
	No-Load Loss [W]	Load Loss [W]	No-Load Loss [W]	Load Loss [W]
250	650	3250	160 (75%)	2300
400	930	4600	210 (77%)	3650
630	1670	6500	300 (77%)	4930

Table III: Energy Loss In Silicon Steel And Amorphous Transformers [26]

Capacity [kVA]	Silicon Steel Transformer		Amorphous Transformer	
	No-Load Loss [W]	Load Loss [W]	No-Load Loss [W]	Load Loss [W]
50	126	327	40 (68%)	340
100	206	523	50 (76%)	826

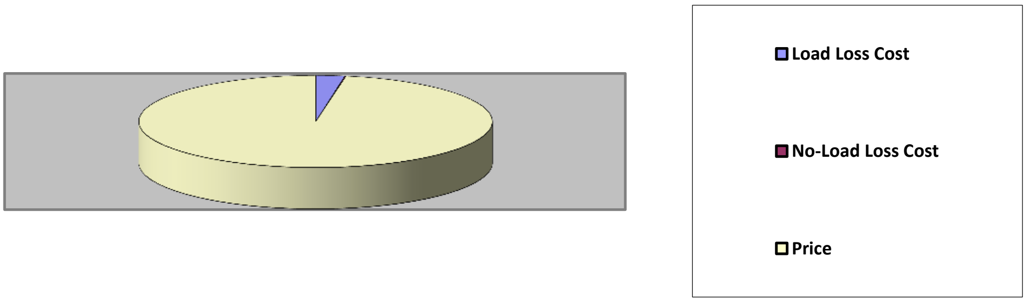

Fig. 3 Pie Chart of Silicon Steel Transformer overall cost

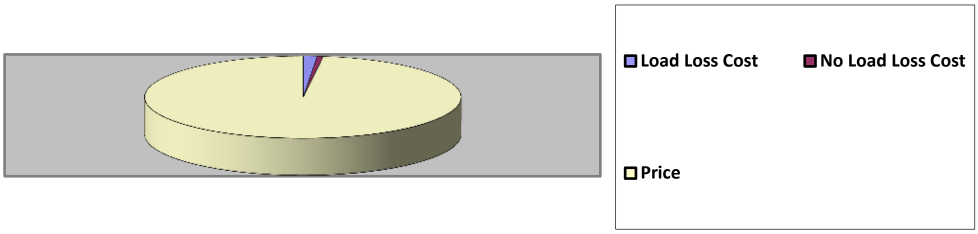

Fig. 4 Pie Chart of Amorphous Transformer Overall Cost

VI. CONCLUSION

The economic analysis on the investment shows that amorphous core is 30-50% expensive than that of CRGO. [10] But it has low losses in comparison to the CRGO material. The reduced load losses of amorphous core show the significance of it.

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