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Evaluation of the distribution transformer's energy-efficient core material

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ABSTRACT :

The materials used in the transformer system determine its dependability and efficiency. It is an effort to keep up with the expanding demand for the optimization of electrical energy into matter while also meeting escalating expenses. Using better materials is one method to accomplish this. Better materials were used in the transformer core, which significantly increased its lifespan and decreased a number of losses. Through improved core material, the machine's size was gradually increased for a specific categorization KVA. This study aims to document the evolution and application of various materials that have affected cost and performance

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

1. INTRODUCTION

Although transformers are comparatively efficient devices, the annual energy consumption cost is a significant factor. The core uses a significant amount of the losses brought on by the steel's electrical excitation. Transformers require about Rs. 10968 crores in core loss each year to convert generated power into useable voltages for distribution.

So substantial expenditures and energy savings would be gained if low-loss, cost-effective techniques for using core materials were accessible. Technical performance and quality are continuously being improved by core materials. The purpose of this study is to give a general overview of the assessment of existing electrical steel sheets.

1.1. Basic Core Materials

There are two types of basic core materials. They are :- 1) Electrical Steel 2) Amorphous Alloy Steel Grain-oriented steel and non-grain-oriented steel are the two main categories of electrical steel.

A. Electrical Steel:

Non Grain Oriented **:** The magnetic characteristics of these electrical steels are essentially the same in all directions of the material's magnetization. These materials are referred to as "non grain oriented" because of the many manufacturing techniques that give them a specific orientation and directionality of magnetic characteristics.

Grain-Oriented **:** These kinds of electrical steels have materials with magnetic characteristics that are strongly orientated in relation to the rolling direction. Rolling and annealing can create alloys with the right composition and a crystalline metal structure in the grains, which will result in substantially higher magnetic characteristics directed in the rolling direction.

B Amorphous Metal Alloy:

Magnetic materials that are amorphous are not crystalline. They form when the melted metal is quickly cooled, causing it to harden in an uneven pattern. Pouring the metal onto a rotating wheel produces cascades of thin (tens of micrometers) ribbons of metal, allowing for this quick cooling. There is no time for the metal to develop a crystalline structure because it solidifies so fast. A transformer core is then wound with these ribbons. One of this material's benefits as a core material is its low coercivity, which reduces eddy currents within the core.

OPERATING CONCERNS

A number of operational factors, which are determined by material qualities, affect how well a transformer performs. Transformer losses vary depending on the kind of core material used. To minimize the noise level low magnetostriction material should be used.

Iron Boron Conventional CRGO steel has an ordered crystalline structure, whereas silicon amorphous alloy is a unique alloy with a structure that appears in random patterns. The crystalline structure's increased resistance to magnetization and demagnetization causes CRGO's core losses to increase. [15] Figures 1 and 2 illustrate the variations in the magnetization curves of several materials at various frequencies

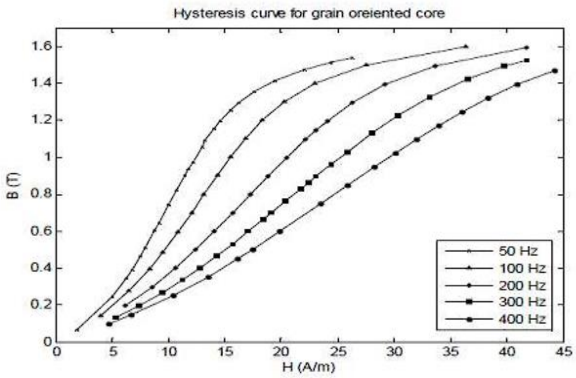

Fig.1 Grain Oriented Core Magnetization Curve for Different Frequencies

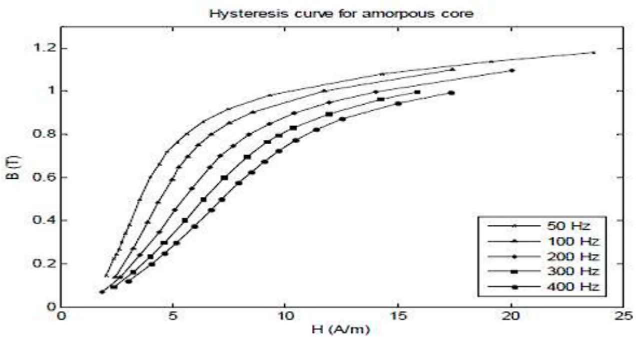

Fig.2 Amorphous Core Magnetization Curve for Different Frequencies

PROPOSED METHODOLOGY

As of right now, no additional research comparing the installation costs and evaluating the transformer's core material has been published. This study compares the starting costs of different transformer core classes in an effort to reduce the financial outlay required for transformer maintenance.

Energy Saving and Increased Profits:

Amorphous cores in particular don't lose any load. Eddy currents are reduced by this core's high electrical resistance and low coercivity, which result in low hysteresis losses. The decreased energy loss in amorphous transformers is displayed in the following tables.After using Amorphous core losses are reduced.They are shown in table.

Table 1. Silicon Steel Energy and Amorphous Transformers energy losses. [23]

Capacity [KVA]	Silicon Steel Transformer		Amorphous Transformer	
	No Load Loss [W]	Load Loss [W]	No Load Loss [W]	Load Loss [W]
100	295	1876	95 (68%)	1801
500	938	4523	240 (74%)	5451

Table 2. Silicon Steel and Amorphous Transformers Energy loss. [19]

Capacity [KVA]	Silicon Steel Transformer		Amorphous Transformer	
	No Load Loss [W]	Load Loss [W]	No Load Loss [W]	Load Loss [W]
250	651	3252	160 (75%)	2298
400	929	4599	211 (77%)	3652
630	1672	6503	300 (77%)	4932

Table 3. Silicon Steel and Amorphous Transformers Energy loss. [12]

Capacity [KVA]	Silicon Steel Transformer		Amorphous Transformer	
	No Load Loss [W]	Load Loss [W]	No Load Loss [W]	Load Loss [W]
50	127	328	40 (68%)	340
100	205	524	50 (76%)	827

CONCLUSION

According to the investment's economic study, amorphous core is 30–50% more expensive than CRGO. However, compared to the CRGO material, its losses are minimal. The importance of amorphous cores is demonstrated by their lower load losses.

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