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Diverse Steel Grades Analysis in CRGO Distribution Transformers

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Abstract - *Abstract: Although transformers are comparatively efficient equipment, the overall amount of energy lost during operation each year is substantial. A significant portion of these losses are caused by the electrical steels used for core excitation. Core materials with better electrical and mechanical qualities are continuously being developed in an effort to reduce these core losses. This study aims to assess the performance of the different grades of cold-rolled grain-oriented electrical steel used as transformer core material in terms of the total cost of ownership during a 25-year period. The sum of the transformer's original purchase price and the discounted present value of the future load and no-load losses represents the total amount owed.*

***Key Words*: Core Material, Transformer Losses, and Loss Capitalization**

1.INTRODUCTION

A significant amount of energy is wasted in transformers during core loss as a sort of operation. In the current climate, where everyone is dealing with an energy crisis because of a lackof energy resources, lowering base loss might be a useful strategy for energy preservation. The primary driver for the development of better electrical steel is the need to reduce elementary loss. In the 1930s, grain-oriented steel made its debut in America. It was made by cold rolling steel that contained phosphorus, silicon, aluminum, and manganese according to scientific standards. 50 cold rolled grains were added to steel and 60 oriented grains.

Materials with high permeability and low loss first appeared in the 1970s and 1980s. Various techniques were developed during the course of the year to lessen the loss of base. The fine materials heated recorded groove test field emerged around 1990. This material works well for noise reduction and has outstanding low magnetic field qualities. New RGH 90s with a 0.23 mm diameter were recently developed, signifying a tiny reduction in iron loss and breakout of tiny transformers. It is thought to be feasible to provide electrical steel grain that is further directed by each distinct technological element, bringing it closer to resting conditions and thereby contributing to energy conservation, even though today's oriented electrical steel grain is already a product with a high degree of completion.

1.1 CRGO GRADES

The induction and loss of iron are used to assess the magnetic characteristics of grain-oriented electrical steel. While low loss material bases save wasted thermal energy and hence reduce energy consumption, materials with good induction lower the drive current. These qualities have steadily improved in recent years due to the adoption of new technologies, which has led to the availability of many material types with various features. Commonly utilized CRGOs are

1.1.1 Conventional Grain-oriented steel (CGO)

It is produced in varying quantities under many trade names:Grain size orientation ratings are frequently employed for inhibitors CGO M4, M5, M6, and (RG).MnSe or MnS orders the grain orientation in this kind.

CGO's characteristics

1 It has a core with improved mechanical and magnetic properties throughout.

2. A core with poor loss and better induction, an insulating coating known as D topcoat.

3. A high cold rolling that creates a smooth surface, and the same lamination factor thickness.

Table -1: TYPICAL CGO STEEL PROPERTIES

Grade	Thickness mm (in)	Core-Loss Watts per Kilogram	
		$W_{17/50}$	$W_{17/60}$
M-3	0.27	1.17	1.52
M-4	0.27	1.22	1.59
M-4	0.30	1.24	1.63

1.1.2 HI – B Steel

HI-B Steel's characteristics

1. A phosphate coating increases the tensile strength of steel.
2. Hysteresis loss is lessened as a result of better gain orientation.
3. Low loss from eddy current.

Table 2. TYPICAL PROPERTIES OF HI-B

Grade	Thickness in (mm)	Core Loss Watts Per Kilogram			
		$W_{15/50}$	$W_{17/50}$	$W_{15/60}$	$W_{17/60}$
M-0H	0.27	0.72	1.01	0.95	1.32
M-1H	0.27	0.74	1.05	0.97	1.37

1.1.3 Thin Guage of HI-B

By decreasing the thickness of the eddy current loss is decreased. The sheet should be between 0.15 and 0.23 mm thick to reduce the overall loss, which is the sum of eddy current and hysteresis loss.

Table 3. TYPICAL PROPERTIES OF THIN GUAGE HI-B

Grade	Thickness in (mm)	Core Loss Watts Per Kilogram (w/kg)	
		$W_{17/50}$	$W_{17/50}$
8 MIL MOH	0.20	0.98	0.88
9 MIL MOH	0.23	1.00	0.92

1.1.4 Domain Refined Sheet Steel (ZDKH)

A physical procedure called domain technical refinement is used to lessen anomalous eddy current losses. The abnormal loss of eddy current in a grain-oriented material is inversely related to the thickness of the sheet and proportional to the distance of the domain wall.

1.1.5 Laser Treated Domain Refined Sheets (RGIHP)

It is not possible to achieve domain refinement using the laser irradiation approach. High permeability laser-engraved leaves result in a somewhat altered hysteresis loss but a large decrease in eddy current loss. Laser-treated steel has the following characteristics:

1. It loses less iron than RG or RGH plate.

Grade	Thickness in (mm)	Core Loss Watts Per Kilogram (W/KG)	
		$W_{17/50}$	$W_{17/60}$
23RGHPJ090	0.23(0.0091)	0.84	1.09

Note: ARAMCO Company manufactures steel under the trade names M4, M5, HI-B, and ZDKH. whereas Kawasaki Steel Corporation manufactures shades under the trade names RG, RGH, RGHPJ, and so on.

Handwritten Business and Society ARAMCO and KAWASAKI reference were used to collect their data.

2. CALCULATION OF CAPITALIZED COST

The calculation method given below is approved by the expert committees of state electricity board is:

• Capitalized Cost of No Load Losses/KW= A Factor = H x E x

• Capitalized Cost of Load Losses/KW = B Factor = A Factor x L.S.

• Capitalized Cost of Transformer = IC + A x Wi + B x Wc

Where
• H is the transformer's annual service hours.
• r = interest rate

• Energy cost, which is the price per kilowatt-hour of electrical energy at the bus to which the transformer is to be connected.

• n = Transformer life in years.

• LS stands for loss load factor.

• IC is the transformer's initial cost.
• WI = No Losses in Load (KW)

• Wc is equal to load losses (KW).

The committee determined the following values for the different parameters:

• *Hours of service processors (H):* In order to calculate the number of hours of service processors operating at 350 x 24 = 840 hours, it was assumed that no processors would be in use for 15 days out of the year owing to repairs, maintenance, etc. This is in line with the formula CBI & P's hypothesis.

• *Transformer life (n):* The Department of Energy has been notified by the Indian government to power transformers and distribute life, which is expected to compute depreciation over a 25-year period. The decision to terminate transformer 25 was made in light of the aforementioned information.

• *Interest rate (r)*: The discount rate for the investment of public funds is determined by the Commission's Division of Planning and Evaluation draft after considering a number of variables. After subtracting the inflation rate, the discount rate was halted at 12%. Furthermore, this value hasn't changed in four to five years. As a result, the interest rate of 12% was chosen for the funding formula.

• *Loss of load factor (LS)*: 0.3 (30%) has been chosen as the load factor value, and the loss's load factor formula is

LS = 0.2 LF + 0.8 LF2.

Therefore, using the method above, the load factor is 0.172.

• Energy Cost E: For the following reasons, the committee has chosen to use the long nm as funding for energy costs.

a) It is recognized by all international funding bodies as a s scientific method.

b) The extra expenses for building more transmission, distribution, and generation capacity are also included in order to accommodate higher load demands.

I. A = Capitalized Cost of No Load Losses. = Rs. 1, 92,873/KW,

II. B = Capitalized Cost of Load Losses. = A Factor x L.S. = Rs. 25,479/KW,

III. Capitalized Cost of Transformer
= IC +I, 92,873x Wi + 25,479x Wc

In this case, Wi and Wc stand for No Load Losses and Load Losses in KW. This formula is used to determine and compare the capitalized cost of different transformer ratings with HI-B, ZDKH, and CGO

3. RESULT AND DISCUSSION

The findings and comparison of key performance characteristics of different core steel grades are shown in Table 5.

3.1 Cost

There are two components to the transformer's total cost: the base cost and the total cost of materials. At the same time, we discovered that the use of a material with high permeability and low losses raises the cost of basic materials. For the same size and rating, the basic cost of the transformer is 20% of its total cost, and this cost increases as the quality of the core material improves aside from lessening the loss. Therefore, we may claim that the price increase represents a smaller loss. Size In contrast, a superior base material reduces the kVA transformer for the same losses.

The other very important aspects of operation of the transformer is the expenditure required to comply with all the losses that occur in transformer on its expected life (25 years) REC (for distribution transformer). Therefore, by choosing capitalization of losses as a basis for comparison, we found that the use of high quality material gives the transformer less capitalized cost versus under rated materials, including kVA.

4.2 Losses

The comparison of different core materials of transformers is shown in Table 5 it is evident that the degree of loss less of ZDKH, 111 -B and CGO cores.

In the KVA rating of the transformer increases with lower losses and increase ZDHK HI - B in comparison to CGO.

For cxamplc,500 kVA rated transformer with losses below 13 % quality basic CGO, ZDKH

SMVA loss transformer with a core material is 38 % less than ZDKH CGO. Fundamental value HI - B of loss is between these two qualities.

Table 5. TRANSFORMER COST COMPARISON USING DIFFERENT CORE MATERIALS FOR 100 KVA TRANSFORMER

Sr. No.	Parameters	Core Materials			
		CGO	HI-B	ZDKH	Amorphous
1.	Rating (KVA)	100	100	100	100
2.	Type of Transformer	Core	Core	Core	Shell
3.	Losses Capitalization	94480.4	85222.4	78356.8	57063.0
4.	Initial Cost	37000.0	41440.0	42920.0	62000.0
5.	Capitalized cost of Transformer (in Rs)	134480.0	126662.5	121276.2	107063.0

TABLE 6. TRANSFORMER COST COMPARISON USING DIFFERENT CORE MATERIALS FOR 5000 KVA TRANSFORMER

Sr. No.	Parameters	Core Materials		
		CGO	HI-B	ZDKH
1.	Rating (KVA)	5000	5000	5000
2.	Type of Transformer	Core	Core	Core
3.	Losses Capitalization	1597928.0	23229193.0	1091923.0
4.	Initial Cost	1070000.0	1177000.0	1198400.0
5.	Capitalized cost of Transformer(in Rs)	2667826.0	240993.0	2290323.0

4. CONCLUSION

The performance of the various grades of CRGO discussed. We see that the low-loss materials gives better performance i.e. favorable efficiency, affordable and light weighted to capitalize. So the use of lower loss materials HI — B, amorphous (scoring up to 1 MVA) and ZDKH materials reduces the cost of ownership and significantly contributes to energy conservation.

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