Evaluation of Different Grades of Steel CRGO Distribution Transformer

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Abstract: Transformers are relatively efficient devices but the total annual energy spent in losses occurring during its use is very significant. A large fraction of these losses result from the excitation of electrical steels used for cores. In pursuit to improve these core losses, core materials with improved electrical and mechanical properties are constantly being developed. This paper tries to evaluate the performance of the various grades of cold rolled grain oriented electrical steel as core material in transformer with respect to its total cost of owing over a span of 25 years. The calculated total owing cost consists of the sum of the initial cost of the transformer and the discounted present value of the future load and no-load losses.

Keywords: Transformer Losses, Core Material, Capitalization of Losses

I. INTRODUCTION

In transformer much of the energy is wasted during operation in the form of core loss. In today's environment, where everyone is facing energy crisis due to shortage of energy resources, reduce the loss of base could be an effective method for energy conservation. The requirement for a decrease in the elementary loss is the main reason for the development of improved electrical steel.

Grain oriented steel was introduced in America in the 1930s. It was produced by cold rolling steel having the composition of scientific care silicon, aluminium, manganese and phosphorus. For steel and 60 oriented 50 cold rolled grains was added. The 70s and 80s saw the arrival of low loss high permeability materials. Over the year's development of different methods were used to reduce the loss of base. 1990 saw the development of the test field of fine materials heated recorded groove. This material has excellent properties of low magnetic field and is suitable for depletion of noise. In the recent new RGH 90s with a dimension of 0.23 mm was created which represented a minute decrease in iron loss and small size transformers breakout. Although today oriented electrical steel grain is already a product with a high degree of completion, it is considered possible to provide electrical steel grain further directed each unique technology element bringing closer to resting conditions, and therefore contribute to energy conservation.

II. GRADES OF CRGO

The magnetic properties of grain oriented electrical steel are evaluated on the basis of induction and loss of iron. Material with a good induction reduces the drive current while the low loss material base saves wasted as thermal energy and therefore save energy consumption possible.

There has been a steady improvement in these properties in recent years as new technologies are adopted as a result there are different types of material with different properties available. CRGOs commonly used are:

2.1. Conventional Grain Oriented Steel (CGO)

It is manufactured in different degrees under different trade names :Orientation ratings grain size are commonly used inhibitor CGO M4 , M5 , M6 and (RG) .In this type the grain orientation is ordered by MnSe or MnS.

Properties of CGO

- Has a core of increased same magnetic and mechanical properties throughout.
- Has a core of poor loss and greater induction.
- It is covered with an insulating coating called D topcoat.
- Has a high cold rolling providing a smooth surface and the same thickness of lamination factor.

TABLE 1.TYPICAL PROPERTIES OF CGO STEEL

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

2.2. HI-B Steel

These are low-loss high permeability materials.

Properties of HI-B Steel

- Steel shows improved tensile strength with a phosphate coating.
- Due to improved grain orientation hysteresis loss is reduced.
- Low eddy current loss.

TABLE 2.TYPICAL PROPERTIES OF HI-B

Grade	Thickness mm (in)	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

2.3. Thin Gauge HI-B

Eddy current loss is reduced by reducing the thickness of the increase in the hysteresis loss and the sheet thickness of the sheet is reduced. The thickness of the sheet to minimize the total loss, which is the sum of hysteresis loss and eddy current is between 0.15 to 0.23 mm.

TABLE 3.TYPICAL PROPERTIES OF THIN GAUGE HI-B

Grade	Thickness mm (in)	Core-Loss Watts per Kilogram (W/Kg)	
		$W_{17/50}$	$W_{17/50}$
8 mil MOH	0.20 mm	<0.98	0.88
9 mil MOH	0.23 mm	1.00	0.92

2.4. Domain Refined Sheet Steel (ZDKH)

Domain technical refinement is a physical process to reduce eddy current losses abnormal. In a grain-oriented material eddy current abnormal loss is proportional to the distance of the domain wall, and inversely proportional to the thickness of the sheet.

2.5. Laser Treated Domain Refined Sheets (RGHP)

Domain refinement cannot be obtained by the method of laser irradiation. When the laser engraved leaves high permeability, hysteresis loss is slightly modified applies, but the eddy current loss decreases significantly.

Properties of Laser Treated Steel:

- It has minimal iron loss then RG or RGH plate.

TABLE 4.PROPERTIES OF RGHPJ

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

Note: M4, M5, HI - B, ZDKH are trade names of steel made by ARAMCO Company.

While RG, RGH, RGHPJ, etc are trade names of shades made by Kawasaki Steel Corporation.

Their data were taken by manual Business and Society ARAMCO and KAWASAKI reference.

III. 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 = Number of Service hours per year of transformer.

- r = Rate of Interest
- Ec = Energy cost i.e. cost of electrical energy at the bus to which the transformer is to be connected (Rs/KWhr).
- n = Life of transformer in years.
- LS = Loss load factor.
- IC = Initial cost of transformer.
- W_i = No load losses (KW).
- W_c = Load Losses (KW).

The values decided by the committee for the various parameters are as follows:

- *Hours of service processors (H):* It was decided to assume that no processors in use for 15 days a year due to repairs, maintenance, etc. so that the number of hours of service processors running at 350 x 24 = 8400 hours (. This is consistent with the hypothesis of the formula CBI & P).
- *Transformer life (n):* The Government of India has notified, the Department of Energy to power transformers and distribution of life is supposed to calculate depreciation 25 years. Based on the above, it was decided to take the life of the transformer 25.
- *Interest rate (r):* The draft of the Commission's Division of Planning, Evaluation after taking into account several factors determines the discount rate for the investment of public funds. Currently the discount rate is 12%, which was stopped after deducting the inflation rate. In addition, there has been no change in this value for 4-5 years. Therefore, it was decided to adopt the interest rate on the funding formula of 12%.
- *Loss of load factor (LS) :* It has been decided to adopt the value of the load factor of 0.3 (30 %) and load factor formula of the loss would be

$$LS = 0.2\ LF + 0.8\ LF^2$$

Therefore the load factor is 0.172 in accordance with the above formula.

- *Cost of energy E:* The committee has decided to adopt the long run as energy costs in the form of funding for the following reasons.

  a) It is a scientific method and is accepted in all international funding agencies.

  b) The additional costs involved in creating additional generation, transmission and distribution capacity is also included for meeting additional 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 +1, 92,873x Wi + 25,479x Wc

Where Wi & Wc are the No Load Losses and Load Losses in KW respectively. Based on the above formula the capitalized cost of various rating of transformers with HI-B, ZDKH and CGO core is calculated and compared.

IV. RESULT AND DISCUSSION

The results and comparison of salient performance aspects of various grades of core steel is presented in the form of table 5.

4.1. Cost

The overall cost of the transformer can be divided into two part base cost and the total cost of materials. In comparison, we found that the cost of basic materials increases as we use a material with low losses and high permeability base. The basic cost is 20 % of the total cost of the transformer in the overall cost of the transformer is also growing as the quality of the core material is improved (for the same size and rating) .Besides reducing the amount of loss. So we can say that the price increase is the reduced loss. Dimensions Otherwise, for the same losses and kVA transformer with a better base material is reduced.

The other very important aspect of the operation of the transformer is the expenditure required to comply with all the losses that occur in the transformer on its expected life (25 years) REC (for distribution transformer). These costs must be added to the original price of the transformer. Therefore, by choosing the capitalization of losses as a basis for comparison, we found that the use of high quality materials 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, HI -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 example,500 kVA rated transformer with losses below 13 % quality basic CGO, ZDKH while 5MVA 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.TYPICAL COST COMPARISON OF TRANSFORMERS USING DIFFERENT CORE MATERIAL

Sl.	**Parameters**	**Core Material**			
		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.	Capitalised cost of Transformer	134480.0	126662.5	121276.2	107063.0

TABLE 6.TYPICAL COST COMPARISON OF TRANSFORMERS USING DIFFERENT CORE MATERIAL

Sl.	**Parameters**	**Core Material**			
		CGO	**HI-B**	**ZDKH**	**Amorphous**
1.	Rating (KVA)	5000	5000	5000	5000
2.	Type of Transformer	Core	Core	Core	Shell
3.	Losses Capitalization	1597928.0	23229193.0	1091923.0	-
4.	Initial Cost	1070000.0	1177000.0	1198400.0	-
5.	Capitalised cost of Transformer	2667826.0	240993.0	2290323.0	-

V. 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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