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Asset Management Strategy for Distribution Transformers in Indian Power Utilities

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Abstract

Distribution Transformer (DT) is the heart of a power distribution system. The DTs, especially of ratings 25 kVA to 250 kVA, are large in number in Indian power distribution utilities and most of these are old transformers, with high No load losses and Load losses. They fail frequently predominantly due to ageing, overload, and poor maintenance, causing huge monetary loss to the utilities and power interruptions to the customers. As it is most economical and faster way of restoring power supply to the affected area and customers, the failed DTs are repaired and put into service again, instead of providing a new DT there. Frequent failure and repair has led to the DTs losing their functionality, and maintainability. The DTs are also showing operational issues in terms of huge losses. A study is done in this paper, to find out the effect of replacing all these old Repaired Good DTs (RGDTs) by Amorphous Metal core DTs (AMDTs), on the net saving in system losses. This kind of asset management strategy, which is usually performed for large power transformers, is carried out for DTs in this paper, with thorough analysis and calculation of payback period. The study revealed encouraging results.

Keywords:*Ageing, Amorphous metal core, distribution transformer, losses, repair, asset management, payback period.*

INTRODUCTION

Electric Power Distribution Utilities, mostly government owned companies, in India and other developing countries, are now under pressure to deliver power, to all its consumers, with a satisfactory level of continuity, at rates fixed by its regulatory bodies. In this regard, maintenance of all equipment, especially Distribution Transformers (DT), which is the heart of the system, to reduce the likelihood of its failure, is a key challenge to its utility [1]. The DTs are very important components in any power distribution company. They act as a link between transmission system and end consumers. They are behind-the scene equipment in virtually every Government and commercial building. They are energized round the clock, providing power to the building's electrical equipment and consuming energy whether or not the equipment is operating [2]. Their failure causes power supply interruptions as well as financial burden on the company. The no load and load losses in DTs also leads to huge financial loss to the utilities. Hence, more attention is required regarding their maintenance, ageing, losses, failure, etc. Unfortunately, the required attention is not visible in Indian Power Utilities. Rural DTs, usually 25 kVA, 63 kVA and 100 kVA capacities, fail more frequentlycompared to town DTs. More attention on maintenance/replacement strategy is required there. [3].

DT failure and its effect on Consumers and Utilities

Every DT failure, in India and other developing countries, involves lot of inconvenience to power consumers as well as utilities. The power interruption to consumers will range from 6 hours to 2 days! The utility has to suffer in terms of arranging alternate DT, repairing the failed DT, and loss due to not able to supply power to the affected area for so many hours, besides facing continuous consumers' wrath on in-efficiency. Preventive maintenances and corrective maintenances may not be sufficient in cases where the DT is very old and has been repaired several times. To come out of this situation, the utility can think of replacement of all or a part of these RGDTs by energy efficient DTs like AMDTs [4].

The usage of amorphous core DTs, in place of conventional Cold Rolled Grain Orientation (CRGO) DTs reduces the no-load losses by 75% approximately. When the losses reduce, the DTs get less heated up, and hence the DT failure will also come down drastically.

In this paper, an attempt is made to find out the cost savings by replacement of repaired good conventional CRGO DTs by Amorphous Core DTs. The asset values of DTs are taken as the initial purchase cost of DTs. The load losses and no-load losses are calculated, in simple method to find out the cost of owning the DTs. The same exercise is performed, after replacing100 % of RGDTs. The results show that it is a worthwhile exercise.

AMORPHOUS METAL DISTRIBUTION TRANSFORMER

Amorphous Metal Distribution Transformer (AMDT) is a type of energy efficient DT, whose magnetic core is made with a ferromagnetic amorphous metal. This material is an alloy of iron with boron, silicon and phosphorous in the form of thin foils, having high magnetic susceptibility, very low co-ercivity, and high electrical resistance.

The eddy current losses and hence the no-load losses in AMDT type of DTs are less because the resistance of the material is high and the material is made up of thin foil. The comparison of No-load losses and cost of purchase of CRGO type DT and Amorphous Metal core DT are shown in Fig. 1 and Fig. 2 respectively.

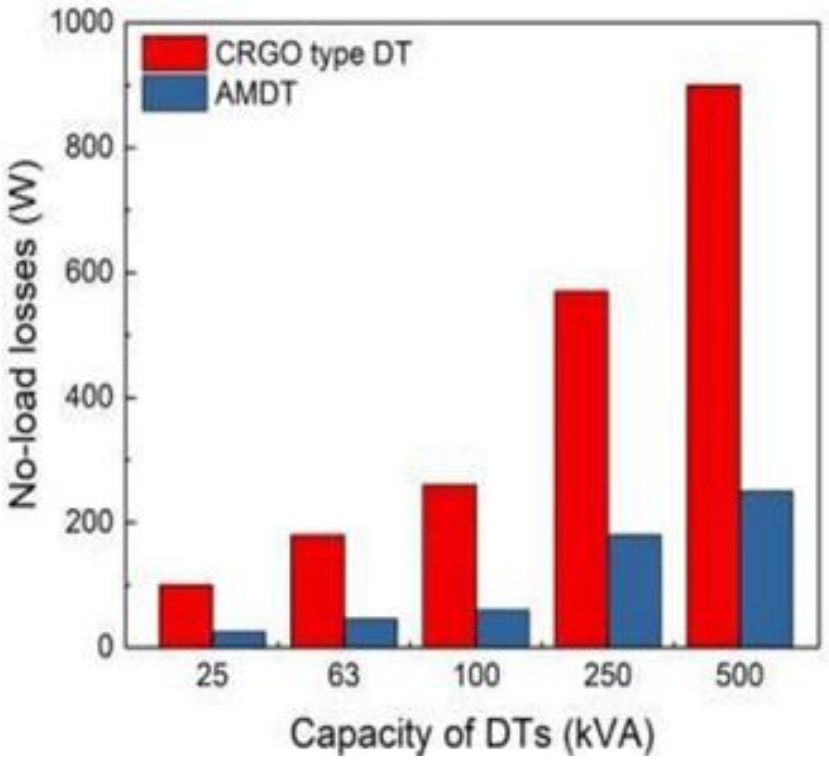

Fig. 1 Comparison of No-Load Losses of CRGO type DT andAmorphous Metal Core DT

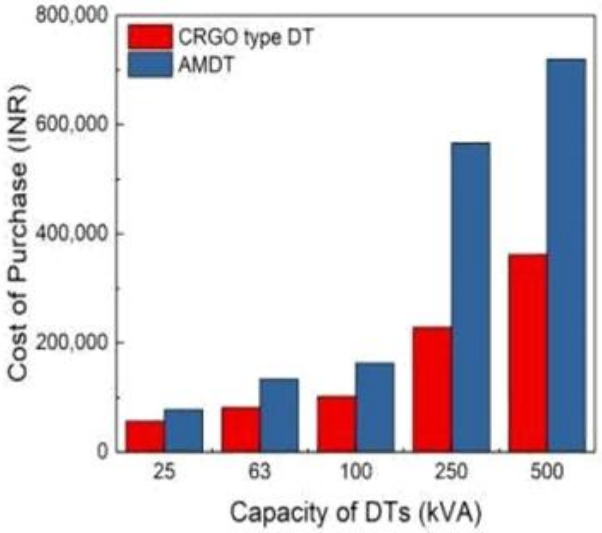

Fig. 2 Comparison of Cost of Purchase of CRGO type DT andAmorphous Metal Core DT

METHODOLOGY

For a detailed study of impact of replacement of old RGDTs by AMDTs, the circle A is chosen. Power Distribution Utilities in India are usually divided mainly into Zones, and then into Circles, and then into Divisions, and so on, for administrative reasons. The Circle A has 1650 number of 25 kVA RGDTs, 1963 number of 63 kVA, 864 number of 100 kVA, 315 numbers of 250 kVA and 75 number of 500 kVA RGDTs, a total of 4867 RGDTs in service as on 31.3.2018. As there are total of 6424 number of DTs in service as on 31.3.2018, in Circle A, the percentage of RGDTs is a whopping 76! The Asset values of all these RGDTs, as on 31.3.2018, is INR 4 million, which is taken from the asset section of the Circle A. The asset values are taken as the initial purchase cost of RGDTs.

The no-load losses and load losses of all these RGDTs are calculated, using simple formula: standard losses of each capacity with average power purchase cost. The Initial Purchase Cost is taken as the asset value of DTs as on 31.3.2018 and the Cost of Owning, for all RGDTs is calculated as the sum of Initial Purchase Cost, cost of no load losses and cost of load losses. It is found as shown in Table I, that the cost of losses of these RGDTs for 1 year is 421 million INR, which is 105 times the initial purchase cost (asset value as on 31.3.2018)! Hence, better efficient DTs need to be put into service for better performance. This is an asset management decision, which gives profitability, reliability, and safety.

Table I Total Cost tothe Utility Due To Usage of Repaired Good DTSfor 1year

DT capacity	Number of RGDTs	No load loss in watts	Cost, in Million INR, of No load loss for 1 year	Load loss in watts	Cost, in INR, of Load loss for 1 year	Total cost due to losses because of usage of RGDTs, for 1 year, in Million INR
A	B	C	D	E	F	G
25 kVA	1650	100	7	770	56	63
63 kVA	1963	180	15	1800	155	170
100 kVA	864	260	10	2400	91	101
250 kVA	315	570	8	4000	55	63
500 kVA	75	900	3	6550	22	24
Total	4867		43		378	421

Sample Calculation for 25 kVA DTs

1. No load losses of each 25 kVA DT= 100 watts= 0.1 kW
2. Load losses of each 25 kVA DT =770 watts= 0.77 kW
3. Average power purchase cost = INR 5/-
4. Total cost of load losses and no-load losses of 1650 number of 25 kVA DTs= 1650 (0.87*5*8760) = 63 million INR

Replacing all RGDTs by AMDTs

Usually the power distribution utilities go for repairing the failed DTs, even if the DT has already been repaired for more than 3 times, rather than going in for replacing it with a new DT, because repairing is a small revenue budget whereas replacing with a new one is a big capital budget. But the utilities can think of all or part of RGDTs, looking at their available capexand return on investment.

A detailed analysis is given in Table II.

Sample calculation for 25 kVA AMDTs:

1. No load losses of 25 kVA DT= 0.025 kW (column J)
2. Load losses of each 25 kVA DT =0.65kW (column L)
3. Total losses=0.025+0.65=0.675 kW
4. Average power purchase cost = INR 5/-
5. Total cost of losses of 25 kVA DTs= 1650(0.675*5*8760) /10,00,000= 49 Million INR
6. (column N)
7. Savings due to replacement of all RGDTs by AMDTs= 63(column G) – 49 (column N) = 14 Million INR
8. But for replacing the RGDTs by AMDTs, we need to consider the cost of AMDT (INR 77880, as in column P) and salvage value of RGDT (INR 5497, as in column Q).Cost of providing AMDTs - Salvage value = 1650*(77880-5497)/10,00,000= 119 Million INR(column R)
9. Payback period = 119 (column R) /14 (column O)= 8.5years.

Table II Detailed Analysis

Capacity of DTs in kVA	Number of RGDTs in service	No load losses of AMDTs in watts	Cost of No Load losses of AMDTs for1 year in Million INR	Load losses of AMDTs in watts	Cost of Load losses of AMDTs for 1 year in Million INR
H	**I**	**J**	**K**	**L**	**M**
25	1650	25	2	650	47
63	1963	45	4	1550	134
100	864	60	2	2100	79
250	315	190	3	3200	44
500	75	250	1	4800	16
Total	**4867**		**11**		**320**

RESULTS

The RGDTs are 20-25 year old, which have failed several times and got repaired equal number of times, during their life time. The asset value of 4867 number of these RGDTs is only 4 million INR. They have huge no-load loss and load loss. As depicted in Fig 3, the asset value, which is considered as the purchase price of 4867 number of DTs, is only 1 % of the total owning cost! Rest all, the losses!

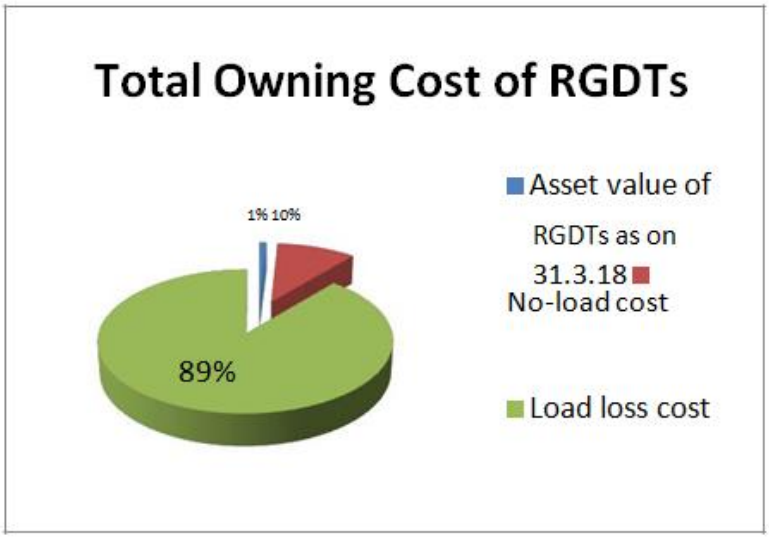

Fig. 3 Total owning cost of RGDTs

If all these RGDTs are replaced by AMDTs, the no-load loss as well as load loss will come down drastically, as explained in Table IV.

Table IV Improvement in No-Load Loss and Load Loss

Capacity of DTs in kVA	No-load losses cost of RGDTs	No-load losses cost of AMDTs	Load loss cost of RGDTs	Load loss cost of AMDTs
25	7	2	56	47
63	15	4	155	134
100	10	2	91	79
250	8	3	55	44
500	3	1	22	16
	43	**11**	378	**320**

The investment on AMDTs is also worth it, as the cost can be recovered in 8 years. Here the steep reduction in DT failure and its associated cost is not considered for savings. In fact, this reduction in failure itself is a big relief.

DISCUSSIONS

Though the DTs are the heart of power distribution system, enough attention is not given to its wellbeing in India. This leads to premature failure of DTs, causing power interruptions to the areas fed by the failed DT. Due to urgency and paucity of funds, the failed DT is replaced by a repaired good DT [7] and the failed DT is sent for repair. The repair is usually done at a cost of INR 15,000/- for a 25 kVA DT, 20,000/- for a 63 kVA DT and 25,000/- for a 100 kVA DT, which is a small amount compared to the new one, which costs ten times this price. Due to outsourcing of repair works, with less stringent conditions and no monitoring, the repair works is not up to standards. The warranty period for the repaired DT is only one year! Since the RGDTs draw 2-3 time the rated no-load and load current, it fails almost just after one year of putting back into service. The loss due to frequent repairs, power interruptions, labour charges to replace and release the DT and the cost of no-load losses/ load losses are usually not counted by utilities as financial losses. In fact this financial loss is more than the cost of new DT.

In this regard, replacement of all or part of old/RGDTs is a good asset management strategy. This research gives a path breaking approach to save money time to Indian power distribution utilities, with a message: It is always justifiable to spend now to save money later; consider all reasonable methods which can be applied to reduce losses and adopt those measures which provide benefits for customers.

CONCLUSIONS

Distribution Transformers (DTs) are in large numbers in Indian power distribution utilities. They fail due to numerous reasons. The utilities blindly repair them and replace the failed DT by a repaired good DT (RGDT). These RGDTs wasteful exercise as it is difficult to stop failure of RGDTs. In this regard, an analysis is made to show that replacement of all RGDTs is an economically feasible solution. If the utilities can't bear the burden of replacement of RGDTs at a time, they can plan to replace the RGDTs whenever they fail. But, it is opined that to reap long term benefits, it is necessary to incur some extra initial investments.

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III. Morne Bosch, "Best Practices in optimising distribution transformer maintenance and replacement strategy", Feb.13, 2018 [Online] Available: http://www.esi-africa.com.draw more than the rated current, leading to more than the rated system losses. Further, the RGDTs fail frequently, repeating the cycle of repair, interruptions and more losses, eventually causing trouble to the power consumers. Any preventive or corrective measure will also be

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