http://www.jctjournals.com ISSN(ONLINE):2278 – 3814

Volume-8, Issue-10, October, 2019

JOURNAL OF COMPUTING TECHNOLOGIES (JCT)

International Journal

Impact Factor: 3.017

A Transformer Techno Economical Cost Analysis using Modified Object Function using MATLAB

[1] **Aftab Alam,** (M.Tech Scholar), [2]**Prof Madhu Upadhyaya**

[1]Research Scholar [2]Assistant Professor

Department of Electrical Engineering

NRI Group of Institution, Bhopal (M.P), India

a.alam@bhel.in ,

***Abstract*—Transformer is one of the important part of electrical engineering. Therefore life cycle of the transformer an emerging topic in electrical industry. In the last decade there are different research work present in the this field, they predict the techno economical cost and life cycle of transformer. In this research work proposed modified objective function based techno economical cost analysis of transformer. The modified objective function is simulated on the matrix laboratory (R -2013b). The simulated outcome shows the better accuracy in life cycle calculation of transformer as compare to other previous methods.**

***Keywords*—Transformer, Total Owning Cost, Life Cycle and Object function etc …**

I. INTRODUCTION

The distribution transformer is the most important single piece of electrical equipment installed in electrical distribution networks with a large impact on the network's overall cost, efficiency and reliability. Selection and acquisition of distribution transformers which are optimized for a particular distribution network, the utility's investment strategy, the network's maintenance policies and local service and loading conditions will provide definite benefits (improved financial and technical performance) for both utilities and their customers. Many electrical distribution utilities claim that they purchase distribution transformers using some type of loss evaluation procedure. Over the past 25 years, these purchasing practices have been established, as the utilities have apparently become aware of the range and the value of distribution transformer losses. On the other hand, very few industrial and commercial customers include evaluation of distribution transformer losses in the purchasing process. proposed an evaluation technique from the industrial and commercial customers' point of view. Moreover, the expected large increases in energy demand and the need to undertake effective measures to protect the environment could be partially solved by improvements in energy efficiency of distribution transformers. Optimized distribution transformers (cost-effective and highly efficient designs) would provide numerous global benefits to the wider public as well as local benefits to electrical distribution companies, their customers and other users of distribution transformers.

II. LITERATURE SURVEY

Marchi, B., Zanoni, S., Mazzoldi, L., & Reboldi, R. (2016) Steel industry is one of the largest energy consumers in the manufacturing sector, even though many improvements in the energy efficiency have already been introduced in the Electric Arc Furnace (EAF) process. Consequently, further developments in the energy performance are still requested. However, additional technical and technological progresses are now uneconomical, i.e. high costs for few benefits. The main opportunity consists, thus, in the improvement of the EAF transformer's performance, as its relevance due to the fact that all the melting energy passes trough it. Recent EAF transformers have become indistinctly well performing in terms of rated performances. As a consequence, the basis of the competition has been shifted from the single product to a customized solution, consisting of tangible products and intangible services designed and combined to fulfill specific customer needs in an economical and sustainable manner (PSS). The intangible value is currently the key to obtain competitive advantages and to overcome the competitors' performances. These extra services take into account the real energy losses obtained during the operation of the furnace in order to design a tailor-made transformer, the provider consultancy on the efficient operation of the product and the integration of maintenance initiatives. To perform the economical analysis of the solution, it is thus necessary to calculate the EAF transformer's life cycle cost (LCC) taking into account the purchasing price, the costs of energy losses (no load, load, LV terminals and auxiliary losses) and the cost due to maintenance. At the present, no works have been conducted on the EAF transformers, which are exposed to more critical conditions than power/distribution transformers.**[01]**

Zakeri, B., & Syri, S. (2015) The LCC of different grid-scale EES technologies were analyzed by conducting an extensive review of the existing literature, considering uncertainties in cost data and technical parameters. The results reveal that the cost estimations/projections of the EES systems are rather dispersed and inconsistent among different references. The cost estimations rely on assumptions and scaling the size, the case for most of battery systems, which reduces the consistency among different sources of data. Most of the EES systems are in formative stages of commercialization and those commercial plants are mainly site-specific resulting in more inconsistency in the cost data. Hence, a robust LCC analysis should account for the uncertainties.**[02]**

Lazari, A. L., & Charalambous, C. A. (2015) This paper has introduced a method for evaluating the losses of transformers serving large-scale PV applications. The method is proposed separately for IPPs and for RUs. Under each of the two cases, the capitalization of losses accounts for the appropriate capital and future operating costs of the transformer over its lifetime brought back into a present day cost. The specific operational characteristics of a PV plant have been integrated in the proposed method through two operating states (GS and NGS). A further element that influences the proposed loss evaluation method is the fact that the losses in these transformers will be served locally by the PV plant, rather than remotely by any other generation facilities. Hence the LCOE for PV generation is utilised to estimate the cost value of the energy that will be used by the losses of the transformer. Furthermore, it is clearly demonstrated that under certain conditions, the TOC of the transformer serving a PV system can vary depending on which method of loss evaluation is employed. Finally, it is shown that the annual solar potential has an impact on the loss factors calculation. This is a feature that should be properly accounted for, as it may affect the tender evaluation processes to select the transformer that has the lowest TOC over its lifetime.**[03]**

III. TECHNO ECONOMICAL COST AND OBJECT FUNCTION

The Life-Cycle-Cost Method The Method for Life-Cycle Cost calculation in this paper is performed in accordance to IEC 60300-3-3 "Dependability management Part 3-3: Application guide – Life cycle costing. According to IEC 60300-3-3, the life cycle of an element will be sub-divided into the following six cost-causing phases:

a) concept and definition;
b) design and development;
c) manufacturing;
d) installation;
e) operation and maintenance;
f) disposal.

In many cases it makes sense to combine the fore mentioned different elements of costs into: *f*

- investment, *f*
- operating, *f*
- recycling costs.

The investment costs (concept/definition, design/development, manufacturing, installation) are in return to the operating costs (operation, maintenance), costs, whose level is visible before the investment is made. In case of the installation costs these costs can be counted to the investment or the operating costs. For a more precise cost assessment, a further distinction between operational and maintenance costs has to be made. Such a distinction allows an easier benchmarking of different maintenance strategies, as these turn out to be the main cost drivers for the analysis.

IV. ALGORITHM

FORMULATION OF OBJECTIVE FUNCTION

We need to formulate objective functions to validate above said points. And a comparative study of results obtained will be considered in this work.

The objective function for the Techno-Economic Evaluation of useful life of Transformer will includes

$$OF = C_{TO} + C_M + C_{NSE} \qquad [1]$$

OF = Objective Function.
CTO = Cost of Total Owning
CNSE = *Cost of Interruption.*
CM = Cost of Annual Repair & Maintenance.

Step 1 Calculation of Total Owning Cost (C_{TO})

The total owning cost (*CTO*) method provides an effective way to evaluate various transformer initial purchase prices and cost of losses. The goal is to choose a transformer that meets specifications and simultaneously has the lowest CTO. The A and B values include the cost of no-load and load losses in the CTO formula:

$$C_{TO} = IC + A\times (P_0 + P_{00}) + B\times (P_k + P_{cs} - P_{00}) \quad [2]$$

Where,
P0 = No Load Losses (NLL)
Pco = Power Consumption of cooling equipment at no load operation
Pk = Load Losses (LL)
Pcs = Rated Power Operation
IC = Initial Cost

$$A = t\times \frac{Cn}{2}\times \frac{1\left(\frac{1}{1+i}\right)^n}{i} \qquad [3]$$

$$B = K^2\times \frac{Cn}{2}\times t\times \qquad [4]$$

$$\frac{Cn}{2} = \frac{c+(cx(1+j)n)}{2} \qquad [5]$$

Where,

t = Operating Time in Hour per year
i = Discount factor for investment (Cost of Money in percentage)
n = No. of Year for lifetime of the transformer in Year

2 /C= Cost of Energy at the mid-life of the transformer
C = Initial Cost of Energy (in Rs/kWh)
j = Annual Increases of Energy Price (in Percentage)
k = Average Loading of the Transformer during its Life time

Step 2 Calculation of Interruption Cost

The interruption cost [30] can be measured in terms of non-supplied energy cost. Thus

the objective is to formulate the annual cost of interruption which depends upon

failure rate of transformer in its three different life stages (infant, normal and wear out

region). Mathematically the cost of non supplied energy can be modeled as follows:

$$C_{NSE}\ AIC = \lambda \times P \times r \qquad [6]$$

Where,
λ: Variable Failure rate of transformer
P: Average load on the transformer
r: Average outage time

Step 3 Calculation of Maintenance Cost

$$C_M = 0.03 \times \text{Initial Investment cost (IC)} \qquad [7]$$

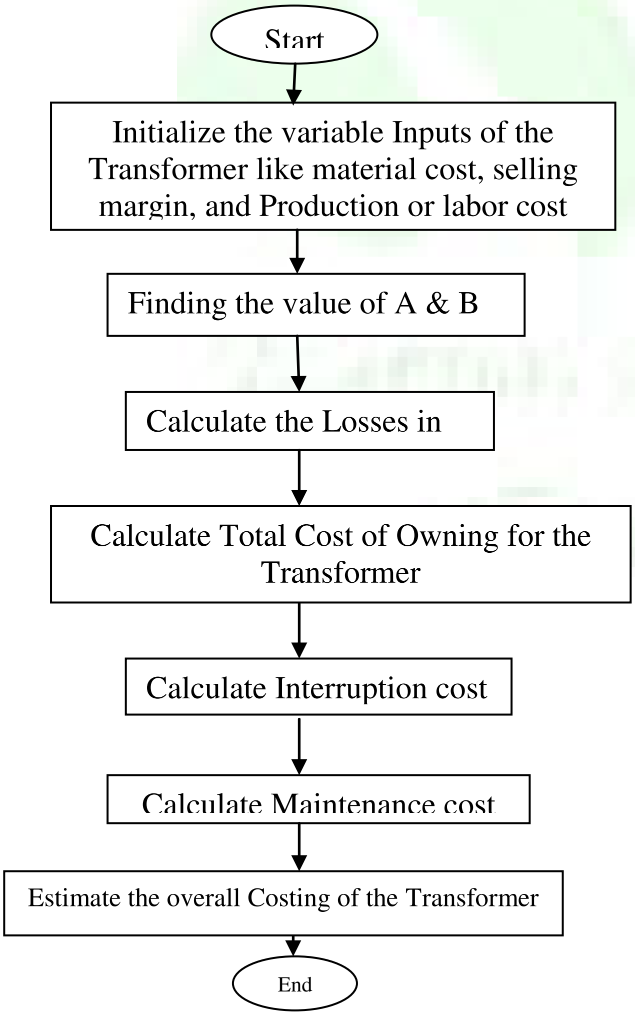

Fig. .1 Flow Chart of the Estimated Cost of the Power Transformer

V. SIMULATION AND RESULT

For the simulation of proposed objective function use MATLAB (R2015a) software. That is shown in below figure 2.

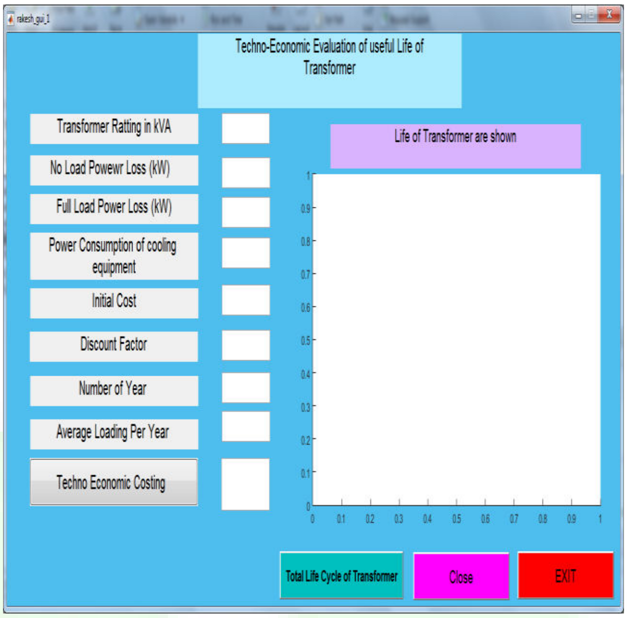

Fig. 2. Shows MATLAB GUI Window

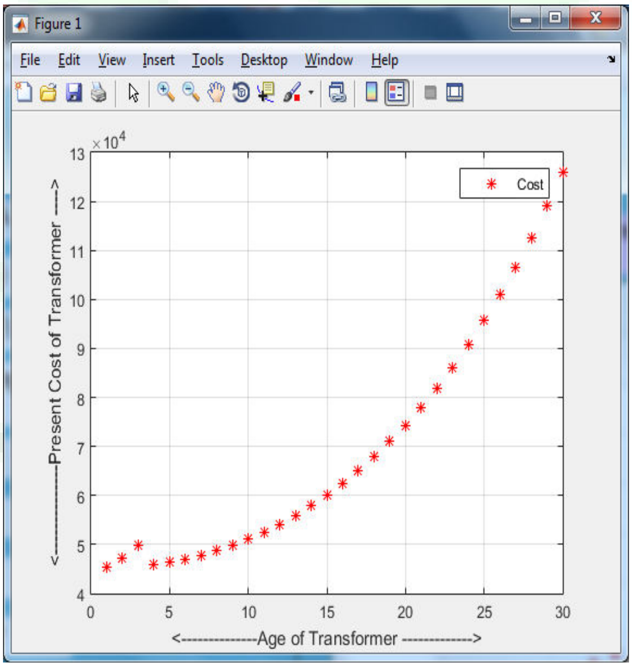

Fig. 3 Transformer Cost Analysis

VI. CONCLUSION

Finally it can be summarized, that the Life-Cycle-Cost Analysis is a useful instrument to identify the main cost drivers of a network and to take up there appropriate actions to reduce the costs. Because it is possible to examine the present value of each component, these set screws still can be refined. The calculation of the outage costs plays a crucial part, if the system operator intends to change the maintenance strategy, for example a transition from a time based to a condition based maintenance strategy. Due to the low failure rate of modern system components the benefit for additional condition assessment devices has to be calculated very carefully.

REFRENCES

[1] Marchi, B., et al. "Product-service system for sustainable EAF transformers: real operation conditions and maintenance impacts on the life-cycle cost." Procedia CIRP 47 (2016): 72-77.

[2] Zakeri, Behnam, and Sanna Syri. "Electrical energy storage systems: A comparative life cycle cost analysis." *Renewable and sustainable energy reviews* 42 (2015): 569-596.

[3] Lazari, Antonis L., and Charalambos A. Charalambous. "Life-cycle loss evaluation of power transformers serving large photovoltaic plants in vertically integrated and decentralised systems." *IET Generation, Transmission & Distribution* 9.8 (2015): 759-766.

[4] Amoiralis, Eleftherios I., et al. "Energy efficient transformer selection implementing life cycle costs and environmental externalities." *2007 9th International Conference on Electrical Power Quality and Utilisation*. IEEE, 2007.

[5] Charalambous, Charalambos A., et al. "Loss evaluation and total ownership cost of power transformers—Part I: A comprehensive method." *IEEE Transactions on Power Delivery* 28.3 (2013).

[6] Nilsson, Julia, and Lina Bertling. "Maintenance management of wind power systems using condition monitoring systems—life cycle cost analysis for two case studies." *IEEE Transactions on energy conversion* 22.1 (2007).

[7] Marchi, B., et al. "Product-service system for sustainable EAF transformers: real operation conditions and maintenance impacts on the life-cycle cost." *Procedia CIRP* 47 (2016).

[8] Degraeve, Zeger, Eva Labro, and Filip Roodhooft. "Constructing a total cost of ownership supplier selection methodology based on activity-based costing and mathematical programming." *Accounting and Business Research* 35.1 (2005): 3-27.

[9] Georgilakis, P. S., et al. "Environmental cost of transformer losses for industrial and commercial users of transformers." *2011 North American Power Symposium*. IEEE, 2011.

[10] Bian, Jianpeng, et al. "Probabilistic analysis of life cycle cost for power transformer." *Journal of Power and Energy Engineering*2.04 (2014): 489.

[11] Draber, S., et al. *How operation data helps manage life-cycle costs*. No. CONF. 2000.

[12] Huber, Jonas E., and Johann W. Kolar. "Volume/weight/cost comparison of a 1MVA 10 kV/400 V solid-state against a conventional low-frequency distribution transformer." *2014 IEEE Energy Conversion Congress and Exposition (ECCE)*. IEEE, 2014.

[13] Wilcox, Melissa, et al. "Electric motor drive reliability review and life cycle cost analysis." *Proc. Gas Electric Partnership*. 2013.

[14] Hinow, Martin, et al. "Substation life cycle cost management supported by stochastic optimization algorithm." *Heinz Aeschbach, Karsten Pohlink AREVA T&D AG* (2008).

[15] Zhang, Yiyi, et al. "A cost-effectiveness assessment model using grey correlation analysis for power transformer selection based on life cycle cost." *Kybernetes* 43.1 (2014): 5-23.

[16] Lee, Sung Hun, An Kyu Lee, and Jin O. Kim. "Determining economic life cycle for power transformer based on life cycle cost analysis." *2012 IEEE International Power Modulator and High Voltage Conference (IPMHVC)*. IEEE, 2012.

[17] Lazari, Antonis L., and Charalambos A. Charalambous. "Life-cycle loss evaluation of power transformers serving large photovoltaic plants in vertically integrated and decentralised systems." *IET Generation, Transmission & Distribution* 9.8 (2015): 759-766.

[18] Yilmaz, Murat, and Philip T. Krein. "Review of the impact of vehicle-to-grid technologies on distribution systems and utility interfaces." *IEEE Transactions on power electronics* 28.12 (2012): 5673-5689.

[19] Zakeri, Behnam, and Sanna Syri. "Electrical energy storage systems: A comparative life cycle cost analysis." *Renewable and sustainable energy reviews* 42 (2015): 569-596.

[20] Bailey, Paul E. "Life-cycle costing and pollution prevention." *Pollution Prevention Review* 1 (1990): 27-39.

[21] McKeever, John W., et al. *Life-cycle cost sensitivity to battery-pack voltage of an HEV*. No. 2000-01-1556. SAE Technical Paper, 2000.

[22] Farmer, Chris, et al. "Modeling the impact of increasing PHEV loads on the distribution infrastructure." *2010 43rd Hawaii International Conference on System Sciences*. IEEE, 2010.

[23] Zeinoddini-Meymand, Hamed, and Behrooz Vahidi. "Health index calculation for power transformers using technical and economical parameters." *IET Science, Measurement & Technology* 10.7 (2016): 823-830.

