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# Reviewed Study on the Performance & Optimization of Power Transformer Using Artificial Intelligence Technique

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***Abstract – Transformers are the core of electrical transmission and conveyance frameworks. The point of transformer design is to acquire the components of all pieces of the transformer so as to gracefully these information to the producer. The transformer ought to be designed in a way with the end goal that it is monetarily suitable, has low weight, little size, great performance and simultaneously it ought to fulfill all the requirements forced by worldwide principles. Numerous scientists have utilized Artificial Intelligence (AI) procedures for transformer design optimization (TDO) and performance investigation. Notwithstanding, the genuine capability of AI methods is yet to be completely investigated for TDO issues. This paper leads a concise survey of innovative work in the field of transformers utilizing ordinary optimization strategies, man-made brainpower based optimization procedures and recommends a portion of the new bio-propelled AI methods that can be utilized for TDO issues***

***Keywords: Transformer, Design, Optimization, Swarm, Intelligence***

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## INTRODUCTION

A transformer has been characterized by ANSI/IEEE as a static electric gadget comprising of at least two windings, with or without an attractive center, for presenting shared coupling between electric circuits. The transformer is an electrical machine that permits the transmission and dissemination of electrical vitality basically and cheaply, as its proficiency is from 95% to 99%, i.e., the transformer works more productively than above all other electrical gadgets. Transformers assume a key job in the interconnection of intensity frameworks at various voltage levels. Without the transformer, it would basically not be conceivable to utilize electric force from numerous points of view today is utilized. Subsequently, transformers possess significant situations in the electric force framework, being the essential connections between power creating stations and purposes of electric force use. There are in excess of 400 distributed articles, 50 books and 65 guidelines in the area of transformers, which have contributed inconceivably in the design improvement and performance of transformers Transformer design is colossal errand in which specialists endeavor to accomplish the similarity with the measures and forced details, while continuing assembling costs low. For nations like India, present day transformer design can assume a huge job in decrease of vitality misfortune. The power division in India had an introduced limit of 249.488 GW as on June 2014.

India presently experiences a significant deficiency of power age limit, despite the fact that it is the world's fourth biggest vitality shopper after United States, China and Russia. India's system misfortunes surpassed 23.65% including non-specialized misfortunes, contrasted with world normal of under 15%. Better transformer design and the utilization of prevalent evaluation electrical steel can definitely lessen no-heap misfortune, one of the prime parts of misfortune in a transformer. No-heap misfortune can be additionally decreased at times if regular electrical steel can be supplanted with nebulous metal. The formless metal sheet that is utilized for center development is a compound comprising of 92% iron, 5% silicon and 3% boron. It has 70% lower no-heap misfortune than silicon steel.

The thickness of indistinct metal sheet is 0.025 mm, i.e., it is around multiple times more slender than the average thickness of silicon sheet steel. With predominant ability in designing combined with broad R&D endeavors, present day transformers are a lot littler in size, lower in cost, and can guarantee a momentous increment in proficiency and lessen lost vitality. With an intend to give the perusers about the different explores that are being led in the territory of transformer design optimization, this paper is composed as follows: Section '2' depicts essential transformer design optimization issue and a portion of the customary techniques embraced by scientists for transformer design. Area '3' depicts the utilization of different man-made brainpower strategies for transformer design optimization and performance investigation. Area '4' talks about different new AI strategies that can be utilized for TDO issues. At long last, area '5' closes this paper

**Transformer Design Optimization Problem**

The issue of transformer design optimization depends on minimization or expansion of a target work which is exposed to a few limitations. Among different target works the generally utilized target capacities are minimization of complete mass, minimization of dynamic part cost, minimization of principle material cost, minimization of assembling cost , minimization of all out possessing cost or boost of transformer evaluated power. With the coming of advanced PCs, there has been extensive decrease in the expense of PC equipment, which has given programming engineers the chance of robotized support in transformer design process. The primary transformer design was made on PC in 1955. In Transformer Design Software bundle was created giving an easy to use transformer design and perception condition, while Jabr limited complete mass of transformer utilizing geometric programming position.

Judd and Kressler proposed a strategy that starts with the accepted center geometry, which at that point finds the estimations of electrical and attractive boundaries which amplify the VA limit or limit misfortune. The transformer design optimization utilizing different design strategy was exhibited in which thought about four destinations: absolute owing cost, mass, all out misfortunes, cost of materials and five requirements: limits on excitation current, impedance, productivity, no heap misfortunes and all out misfortunes. Ideal center choice to limit center and winding misfortunes was completed in in which design model considers high recurrence skin and closeness impacts, shows the impact of number of essential turns on value variety of transformer. Design optimization utilizing MIP procedures was introduced in in which dynamic part cost of transformer has been limited utilizing branch and bound strategies, while exhibited how transformer design optimization can be accomplished utilizing choice trees.

Impact of natural limitations on dissemination transformer cost assessment was delineated in while showed least cost decision of a circulation transformer in decentralized electric markets. Whatever the picked optimization technique is, the colossal errand of accomplishing the ideal harmony between transformer performance and cost is entangled, and it is ridiculous to expect that the ideal cost design would fulfill all the mechanical, warm and electrical requirements. Along these lines, the specialists have turned to Artificial Intelligence methods in quest for the equivalent.

**Artificial Intelligence Techniques for Transformer Design Optimization**

Artificial Intelligence techniques have been extensively used in order to cope with the complex problem of transformer design optimization. This section describes the use of various AI techniques employed by researchers for TDO problems.

**Genetic Algorithms**

Genetic Algorithms (GAs) are based on Darwin's theory of survival of fittest. The basic concepts of GAs were developed while the practicality of using GAs for complex problems was demonstrated by DeJong (1975) and David Goldberg (1989). Genetic algorithms have been widely for optimization in various domains including science, commerce and engineering. The primary reasons for their success are broad applicability, ease of use and global perspective. GAs have been employed for transformer construction cost minimization as well as construction and operating cost minimization. GAs have also employed for the optimization of distribution transformers cooling system design. Parameter identification of power transformer was suggested in in which evolutionary computational model was developed using GA. Genetic Algorithms have also been used for performance optimization of cast-resin type distribution transformers or toroidal core transformers Optimal design of rectifier power transformer using genetic algorithm and simulated annealing was carried out in which showed effectiveness of GA as an efficient search technique for design optimization of rectifier power transformer. Georgilakis dealt with transformer cost minimization problem by combining genetic algorithms with finite element method using external elitism strategy. Hybrid optimal design of a distribution transformer was presented in which combined 2-D finite element, genetic algorithm and a deterministic algorithm to find the final solution. Optimal transformer design based on total owning cost using simple genetic algorithm was demonstrated in which adopted penalty function approach to process objective functions with weighted coefficients.

Demonstrated in while bushing fault diagnosis using ANN was carried out. Application of artificial neural networks for interpreting and classifying different types of faults was envisaged in which employed separate neural network model to classify each type of fault. Detection of internal winding faults using neural networks have also been discussed in while Ahadpour employed electronic nose and neural networks for diagnosis of power transformers with internal faults.

**Artificial Bee Colony (ABC) Algorithm**

Artificial Bee Colony simulates the intelligent foraging behavior of a honeybee swarm. In ABC model, the colony consists of three groups of bees: employed bees, onlookers and scouts. It is assumed that there is only one artificial employed bee for each food source. Hence, the number of employed bees in the colony is equal to the number of food sources around the hive. Employed bees go to their food source and come back to hive and dance on this area. The employed bee whose food source has been abandoned becomes a scout and starts to search for finding a new food source. Onlookers watch the dances of employed bees and choose food sources depending on dances. The performance of ABC algorithm is better or similar to other population based algorithms such as genetic algorithm, particle swarm optimization, and differential evolution algorithm and evolution strategy. ABC algorithm has been successfully applied for structural optimization problem and real parameter optimization.

## OBJECTIVE

1. Multi-objective optimization also known as multi-criteria or multi-attribute optimization, is the process of simultaneously optimizing two or more conflicting objectives subject to certain constraints.

## REVIEW OF LITERATURE

In order to attain global optimal or quasioptimal solution for power transformers design, some inter related key techniques such as Genetic Algorithm and Artificial neural networks.

S.B. Vasutinsky [2012] provides a detailed design procedure of power transformer including all basic parameters and deals with transient phenomena in transformer, mechanical forces and thermal characteristics and also the design of core. Sufficient material for transformer design is also provided in the book.

V.N. Mittle and Mittal [2013] provides a general introduction to design of transformer including a discussion on choice of design variables, dimensions, and mechanical forces in transformers and mentioning the performance characteristics of the designed transformer. This book also includes the computer aided design of the transformer.

A.K. Sawhney and A Chakraborti [2014] provides a detailed procedure for designing the transformers, also describes the optimum designs such as design for minimum cost or design for maximum efficiency. This book describes all the necessary components of transformer as well as the design requirements.

Geromel, Luiz H and Souza, Carlos R [2015] presents a novel power transformer design methodology using intelligent systems. The methodology describes in this paper allows the application of the artificial neural networks in some specific stages of the design. The novel metedology is an important tool, not only for optimizing the projects, but also for minimizing substantially the necessary for their execution, as it simplifies the design procedure.

Pavlos S. Georgilakis, Marina A. Tsili and Athanassios T Souflaris [2016] discusses that the aim of the transformer design is to completely obtain the dimensions of all the parts of the transformer based on the given specifications, using available material economically in order to achieve lower cost, lower weight, reduced size and better operating performance. In this paper, a transformer design optimization method is proposed aiming at designing the transformer so as to meet the specification with the minimum cost.

Pavlos S. Georgilakis and Eleftherios I. Amoiralis [2017] proposes an integrated artificial intelligence technique to achieve an optimum design of a transformer. AI is used to reach an optimum transformer design solution for the winding material selection problem with the aim of selecting the appropriate winding material Cu or Al.

J.G. Breslin and W.G. Hurley [2018] feels that despite the recent use of computer software to aid in the design of power supply components such as transformers and inductors, little work has been done on investigating the usefiilness of a web-based environment for their design. This paper presents a web-based transformer design system which can create new optimized transformer designs.

T.H.Putman [2013] describes the constraints which economics places on the design of power transformers. The mathematical analysis shows how the size, losses, reactances and power output are related when the transformer is optimally designed. Because of the number of simplifying assumptions, which have been made, this paper is not a treatise on how to design power transformers. On the contrary, it is a broad view of the design Problem, which yields findings which are new and which seem to be borne out by the experience of transformer design engineers. The paper confirms the validity of propositions, which previously had only empirical backing Rabih A.

Jabr [2014] considers that the design problem requires minimizing the total mass of the core and wire material while ensuring the satisfaction of the transformer ratings and a number of design constraints. This paper shows that the design problem can be formulated in geometric programming GP format as GP provides an efficient and reliable solution for the design optimization problem with several variables and it guarantees that the obtained solution is global optimum.

Farrukh Shahzad, M.H. Shwehdi, [2013] analysis that availability of personal computers in laboratories have offered new possibilities in power engineering education. With this software, lab instructors can demonstrate and explain the transformer design concept on this screen and quickly respond to students queries with on-line explanation. The students can learn more by using the program and exchanging the ideas and question with fellow students. The engineering intuition of the students is greatly developed by moving the emphasis from the numerical analysis and computer programming to the comprehension of fundamental principles of transformer design.

Paul H. Odessey, [2015] describes blending of traditional transformer design practice with the phenomenal speed and logic adaptability of a modem computer has lead to a greater insight into transformer design procedures. This is due in part to the ability of the computer to execute many cumbersome and reiterative calculations in a logical and stepwise procedure leading to a design that satisfies all input specifications. Several empirical relationships are used to provide a good starting point in a generalized design procedureas well as means to handle subsequent changes. In addition , the interaction of temperature rise , voltage regulation , and losses upon the various parameters is analyzed and treated in a logical order to achieve design objective.

R AUcock. R McClelland, S A Holland and A Roue [2016] proposes the Finite Element Methods for transformer Design and analysis. To be more precise FEM is used to make more efficient use of materials

S. Padma, R Bhuvaneswari and S. Subramanian [2017] proposed Simulating Aimealing SA technique for optimization of three phases Power Transformer Design. The initial cost of transformer viz., material cost of stampings and the cost of copper used for windings is chosen as the objective that is to be minimized.

S. Hosimin Thilagar and G. Sridhara Rao [2018] present an in situ parameter estimation method to determine the equivalent circuit parameters of three-winding transformer. The suggested method also estimates geometrically a complex parameter that is mutual leakage between secondary and tertiary windings, which would be useful in transient studies.

## RESEARCH METHODOLOGY

Transformers used nowadays are extremely various in their purpose, arrangement and sizes. In addition to power transformers serving for the transmission and distribution of electrical energy there are many special transformers, namely rectifying, welding, furnace, measuring etc. A modem transformer of high voltage represents a complicated electromagnetic apparatus. The design of such a transformer without taking into account the experience of modem transformer-consumption had been far from reality. That is why emphasis is given not only to the theoretical consideration of the phenomena in transformer, but also the practical aspects, expressed in empirical formulae, tables and curves.

**Table 1: Typical numbers of steps and space factor for transformer cores**

| Type of core | Ducts | Core diameter in mm | Number of steps | Space factor |
|---|---|---|---|---|
| Single framed | Without ducts | < 100 | 1 | 0.64 |
| | | | 2 | 0.79 |
| | | | 3 | 0.84 |
| | | | 4 | 0.87 |
| | | 100 - 150 | 5 | 0.88 |
| | | 250 - 300 | 6 | 0.89 |
| | Longitudnal ducts | 350 - 750 | 6 to 8 | 0.86 |
| Double framed | Longitudnal and cross ducts | 550 -1000 | 7 to 10 | 0.88 |

## DATA ANALYSIS

The design of transformer has been carried out using AI techniques. Conductor thickness and width has been selected using Artificial Neural Network (ANN) while the different design parameter has been found using Genetic Algorithm (GA) for different objective function as shown in Chapter-4.

## CONCLUSION

This paper gives an overview of the literature regarding transformer design optimization using artificial intelligence techniques. Publications from various international journals and conference proceedings have been included to cover wide range of engineering methods and design considerations. A brief review of modern, bio-inspired artificial intelligence techniques that can be employed for TDO problems is also discussed. This survey provides significant information about the future trends in the field of transformer design optimization.

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