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DESIGN OF POWER TRANSFORMERS USING HEURISTIC ALGORITHMS

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Abstract- In this study, meta-heuristic optimization algorithms have been developed. These algorithms are artifical bee algorithm, cuckoo bird algorithm and flower pollination algorithm. The algorithms have been developed to use mixed-integer variables. Pseudo-codes of these algorithms were written by using transformer design variables. MATLAB program was used for transformer design optimization performance tests. A subprogram was developed for each of these three optimization algorithms. Design sub-programs which are common to all algorithm subprograms have been created. A power transformer design program with graphical user interface was prepared in Visual Basic Programming Language by using the obtained results. The lower and upper limit values of the design variables have been extended to include transformers in a wider power range than the three types of transformers examined. In this study, the other parameters of the transformer were calculated from the design variables and the weights of the eight main materials were determined. Thus, the main material costs of the power transformer to be designed are minimized.

Keywords: Power Transformers, Heuristic Algorithms, Transformer Design, Optimization Techniques.

I. INTRODUCTION

The rapid development of technology has increased the need for clean, reliable and continuous energy. Transformers have an important place in the production, transmission, distribution and consumption phases of electrical energy. Transformers, like other electrical machines, are expected to have as high a yield as possible. For an existing problem, algorithms are used to obtain the best solution from all sets of solutions under the given constraint. Especially in multivariate optimization processes, depending on the number of variables and data types, the difficulty levels of the problems may also increase. The solution of these types of problems with classical optimization methods involves difficulties both in modeling and in the solution process depending on the structure of the problem. So, the types of solution methods are rather specific to problems. It has many drawbacks such as the need to define the problem with mathematical functions.

With Particle Swarm Optimization methods, the optimal solution is obtained by using a particle population [1]. In order to overcome these difficulties, heuristic methods based on existing systems and events have been developed. Heuristic algorithms are algorithms capable of providing solutions that are close to the optimum in acceptable time for large-scale optimization problems. These evolutionary-based techniques are intuitive population based search procedures that include random variability and selection operators [2]. Optimization techniques are used to solve many engineering problems. In this study, by using intuitive optimization methods in the design of power transformers, optimum results have been reached.

II. METAHEURISTIC ALGORITHMS

Honey bees live in a social order with the help of instincts. They live their lives by following the rules in this social order. The tasks that each bee in the hive has to fulfill are clear. The bees never leave these duties and responsibilities given to them. Tasks such as searching food, bringing nectar, storing food and communication are among the responsibilities of bees in social order [3]. This tremendous order and balance led the researchers to model the bees' behavior. In the colony of honey bees, a suitable number of individuals should be distributed to jobs for a large number of jobs.

The development of a bee begins with the spawning of the queen bee. The egg turns into larvae and pupae after a while. The hatched bee will begin its life to carry out the designated tasks for itself. While adult bees are located at the nest, young bees and nurse bees perform their duties in the nutrition field [4]. Every time the hatched eggs become adults, each bee has duties such as feeding, storing, collecting and distributing honey and pollen, communicating and searching food. The task of the bee at a given time depends on its current behavioral role, the data it collects from the environment and the response threshold that these data indicate.

Following the separation of the bee from the beehive, the search process first starts with random food research. After the amount of food in the sources is reduced, bees begin to look for new foods or other sources in direction of the information they receive from other bees [5].

The information of the resources found by the bees to be transmitted to each other and found pollen, water and so on. the introduction of resources into the hive is part of this process. The transmission of information between bees is the most important condition for the formation of herd structure and common knowledge. The hive, which is the living space of bees, can be divided into some sections [6]. One of these areas is the so-called dance area where information sharing takes place. Design of transformer using the pseudo-code of created artifical bee algorithm is shown in Figure 1.

Set parameter:, x = (x1 'Winding number of LV winding', x2 'Number of cooling windings of LV winding', x3 'HV winding cooling channel number', x4 'Magnetic induction', x5 'HV winding current density', x6 'LV winding current density', x7 'Core sheet width', x8 'Core window height'),
f(x)= min $DV(x) = min \sum_{i=1}^{8} c_{u(i)}(x).w_{u(i)}(x)$
Generate the initial population
Calculate the best solution in the population
***while** (not termination)*
for each employed bee
find a new solution source according to its strategy
end for
for each onlooker bee
apply local search to the solution source found by its employed bee
if the solution source found by local search is worse than the current solution switch to another strategy
update the current solution and update the best solution if posissible
endif;
endfor;
for each scout bee;
produce a solution source from the best solution;
Choose the best solution g1 ∗ 'High tension winding', g2 ∗ 'Low voltage winding conductor', g3 ∗ 'Core material', g4 ∗ 'Transformer oil', g5 ∗ 'Cooling channel strips', g6 ∗ 'Insulation', g7 ∗ 'Panel sheet', g8 ∗ 'Plate sheet'
endfor;
endhile;
end

Figure 1. Design of transformer using the pseudo-code of created artifical bee algorithm

Information sharing between bees happens by the dance of bees. New and quality food sources are discovered with shared knowledge. Bees that bring food from sources need to share the location information with the source to send the other bees to these sources. The bee, who gets the information about the location, uses sunlight to find this target. They can measure the angle between their orbits and the sun. According to the energy consumption, the bees determine their energy by flying at different heights. The figure of the figure shows the direction of the nutrient source at the center of the figure, the length of the straight line, the distance from the hive, and the quality of the nectar when the line is taken. The Bee Algorithm is based on the modeling of bees' food search behavior.

A new heuristic algorithm inspired by the lifestyle of the cuckoo birds, the cuckoo bird optimization algorithm is based on the location and reproduction of birds. Cuckoo birds come from where the bird, the real owner of a bird's nest, walks away and leave its egg between the host bird and its eggs. This event lasts only 10 seconds.

The nest owner takes one of his eggs with his beak and moves away from the nest. Later, the baby cuckoo continues to be fed by the stepmother, although it becomes larger than the nesting bird [7]. Design of transformer using the pseudo-code of created cuckoo bird algorithm is shown in Figure 2.

Purpose function:, x = (x1 'Winding number of LV winding', x2 'Number of cooling windings of LV winding', x3 'HV winding cooling channel number', x4 'Magnetic induction', x5 'HV winding current density', x6 'LV winding current density', x7 'Core sheet width', x8 'Core window height'),
n piece host slot transformer parameter generate the starting population
while (stop criterion)
Get a random cuckoo parameter with a Levy flight
Find transformer cost f(x)= min $DV(x) = min \sum_{i=1}^{8} c_{u(i)}(x).w_{u(i)}(x)$
n Choose the random parameter slot for the socket
if $(F_i > F_j)$
end
replace with new solution
The worst parameter is to drop the p_o *rate of the nests*
Build new ones
Keep good solution parameter values
Sort solutions
Find the best solution g1 ∗ 'High tension winding', g2 ∗ 'Low voltage winding conductor', g3 ∗ 'Core material', g4 ∗ 'Transformer oil', g5 ∗ 'Cooling channel strips', g6 ∗ 'Insulation', g7 ∗ 'Panel sheet', g8 ∗ 'Plate sheet'
end while

Figure 2. Design of transformer using the pseudo-code of created cuckoo bird algorithm

Eggs that are not recognized by the stepmother hatch before their half-sisters during the incubation period. Although he hasn't opened his eyes in the first 4 days, he starts to take out his half brothers from the nest by various movements. The eggs are randomly placed around the egg centers taking into consideration the spawning radius. After the eggs are placed, the eggs that are noticed by the host bird are removed from the nest. 10% of the unwanted eggs are removed. The parameter defined in the algorithm controls the number of cuckoo birds living in the environment. Therefore, in each iteration, the cuckoo will survive as much as the best cost value. The group, which has the best costs after forming a group of cuckoo birds in different areas, is selected as the target point for the migration of other cuckoo birds.

Average Clustering Algorithm is used to determine cuckoo groups. The first starting environment is generated in the cuckoo algorithm. Each bird is assigned a random number of eggs. The maximum spawning radius is determined for each bird. Specify the spawning radius of the eggs into the space is released. The eggs recognized by the host birds are destroyed. Chickens are allowed to hatch and grow. The habitat of each growing bird is evaluated. The number of birds that can live in the area is limited. Unwanted areas are destroyed. The best group of birds is identified and the target habitat is selected. New cuckoo population migrates to the target habitat. If the required condition is met, the optimization is stopped and the first step is continued [8].

The Flower Pollination Algorithm is one of intuitive methods of the metal inspired by the nature of the process. Design of transformer using the pseudo-code of created flower pollination algorithm is shown in Figure 3.

Purpose function:, x = (x1 'Winding number of LV winding', x2 'Number of cooling windings of LV winding', x3 'HV winding cooling channel number', x4 'Magnetic induction', x5 'HV winding current density', x6 'LV winding current density', x7 'Core sheet width', x8 'Core window height'),

f(x)= $\min DV(x) = \min \sum_{i=1}^{8} c_{u(i)}(x).w_{u(i)}(x)$

Generate a random start population. (n: Number of pollen)

*Calculate the best solution for the initial population g * Probability switch p ∈ [0, 1]*

while(*t< Max Iteration*)

  for i=1: n

   if *rand < p (uniform distribution)*

  Levy *distribution* ***L*** *(Up to the number of parameters)*

Biotic growth $x_i^{t+1} = x_i^t + a\,L(b).(g*x_i^t)$

   Else

  Draw ε *(Uniform distribution [0,1])*

   Choose random j and k solutions

Abiotic reproduction $x_i^{t+1} = x_i^t + \mathcal{E}(x_j^t - x_k^t)$

   end if

Take the new solution and check it out. Update the population if the new solution is good

   end for

   Choose the best solution g1 ∗ 'High tension winding', g2 ∗ 'Low voltage winding conductor', g3 ∗ 'Core material', g4 ∗ 'Transformer oil', g5 ∗ 'Cooling channel strips', g6 ∗ 'Insulation', g7 ∗ 'Panel sheet', g8 ∗ 'Plate sheet'

end while

Figure 3. Design of transformer using the pseudo-code of created flower pollination algorithm

The Flower Pollination Algorithm is mainly inspired by the flowering process of flowering plants. The main aim of the flower pollination is to provide the optimum viability and optimum biological reproduction stage. Pollination and other factors interact best for the propagation of plants [9]. There are two important forms of pollination, biotic and abiotic. While 90% of the flowering plants perform biotic pollination, they perform abiotic reproduction at 10%. While pollinators such as flies and insects carry pollen in biotic form, no pollinator is available in abiotic form [10].

Flower Pollination Algorithm works according to the four basic rules. Global pollination processes are carried out biologically, and pollinators carry pollen according to Levy flights. Abiotic and self-pollination are noted local pollination. Like insects, pollinators may improve the likelihood of proliferation, which is proportional to the similarity of the two flowers. A key possibility of regional and universal pollination may be checked by p ∈ (0, 1). Since insects may fly for a long time, pollen can be carried long distance [11]. This guarantees the best reproduction. Levy distribution is used to meet the pollination force. While insects trip long distances, the action of the insects may be shown according to the Levy distribution [12].

The most important feature of this algorithm for optimization is to use the Levy distribution to search for many solution points in search space. As in flowers, biotic pollination model to determine the solution points at long distances and abiotic pollination model of the solution points to investigate the neighboring of the algorithm is the logic of optimization [13].

III. DESIGN OF POWER TRANSFORMERS USING HEURISTIC ALGORITHMS

Power transformer design has been made by using three metamorphic optimization algorithms. In order to see the stringent needs of the transformer industry, algorithms for optimization problems have been proposed.

The common basic technical characteristics of the transformers are three-phase oil type distribution transformers, the winding core construction, the low voltage winding conductor is copper foil and the high voltage winding indicator is round enameled copper wire [14, 15].

Purpose functions used for transformer design optimization; minimization of the active part weight, minimization of the cost of the active part, minimization of the main material cost, minimization of the cost of production, maximization of the efficiency, maximization of the nominal power and minimization of the total cost [16-18]. Total transformer cost is generated at Equation (1).

$$TTC = PT + c_{il}P_0 + c_{ll}P_{ll} \quad (1)$$

where, c_{il} (Dollars/Watt) is the cost of idle loss, P_0 is idle losses, c_{ll} (Dollars/Watt) is the cost of load loss, P_{ll} is load losses and PT is the price of transformer. In the total cost of ownership method, the operating costs incurred due to losses during the lifetime of the transformer are brought to the current costs and added to the purchase price. For transformer efficiency, it is the minimum cost to minimize the investment required to achieve the greatest energy savings. This results in the selection of transformers that are most economically optimal for the given need. The transformer design constraints that must be met by national standards and customer specifications are indicated below.

- The calculated idle losses of transformer should be less than maximum idle losses. The calculated load losses of transformer should be less than the maximum load losses. The calculated total losses of transformer should be less than the maximum total losses. The calculated short-circuit impedance of transformer should be between the minimum and maximum short-circuit impedance values.
- The temperature rise due to the total losses of the transformer should be less than the maximum temperature rise value. Total heat generated by the total losses of the transformer; be combined with the combined effects of conduction, convection and radiation.
- The calculated efficiency of transformer should be higher than the minimum yield value. The impact voltage in the windings of transformer must be less than the maximum impact voltage value that the insulation paper between the coils of winding can withstand.
- The induced voltage in the windings must be less than the maximum induced voltage value between the winding layers of the insulation paper. Transformer boiler sizes should be less than maximum boiler sizes.

The objective function used is to minimize the cost of main material of transformer. The cost of materials used in transformer design is calculated in Equation (2).

$$\min DV(x) = \min \sum_{i=1}^{8} c_{u(i)}(x).w_{u(i)}(x) \quad (2)$$

where, $DV(x)$ is the design vector consisting of eight variables, $c_{u(i)}(x)$ is the unit cost of each element of transformer (USD/kg) and $w_{u(i)}(x)$ is the weight of each element of transformer (kg). Constraints are described as the following:

$$z_{sc(\min)} \le z_{sc} \le z_{sc(\max)} \quad (3)$$

$$\Delta T_{r,c} \le \Delta T_{r\max,g} \quad (4)$$

$$(P_{cll} + P_{il}) \le h_t \quad (5)$$

$$P_{cll} - (1 + \frac{t_{ll}}{100}) P_{cll,g} \le 0 \quad (6)$$

$$P_{il} - (1 + \frac{t_{il}}{100}) P_{il,g} \le 0 \quad (7)$$

$$(P_{cll} + P_{il}) - (1 + \frac{t_{tl}}{100})(P_{cll,g} + P_{il,g}) \le 0 \quad (8)$$

where, P_{il} is calculated idle losses, $P_{il,g}$ is guaranteed idle losses, P_{cll} is calculated load losses, $P_{ll,g}$ is guaranteed load losses, t_{il} is idle losses percentage tolerance, t_{ll} is load losses percentage tolerance, t_{tl} is total losses percentage tolerance, z_{sc} is calculated short circuit impedance, $z_{sc(\min)}$ is guaranteed minimum short circuit impedance value, $z_{sc(\max)}$ is guaranteed maximum short circuit impedance value, h_t is thrown heat by conduction, convection and radiation, $\Delta T_{r,c}$ is calculated temperature rise and $\Delta T_{r\max,g}$ is the guaranteed maximum temperature rise.

Main materials of transformer and unit costs are given in Table 1. The variables of transformer design optimization are given in Table 2.

Table 1. Main materials of transformer and unit costs

Material	Unit cost (USD/kg)
High tension winding	13.03
Low voltage winding conductor	13.03
Core material	7.08
Transformer oil	2.63
Cooling channel strips	9.85
Insulation	8.76
Panel sheet	2.54
Plate sheet	2.25

Table 2. The variables of transformer design optimization

Design variable	Unit	Type	Lower limit	Upper limit
Winding number of LV winding	-	Integer	15	60
Number of cooling windings of LV winding	-	Integer	0	15
HV winding cooling channel number	-	Integer	0	15
Magnetic induction	Gauss	Real number	13500	18000
HV winding current density	A/mm^2	Real number	0.9	5.5
LV winding current density	A/mm^2	Real number	0.9	5.5
Core sheet width	mm	Real number	90	550
Core window height	mm	Real number	90	550

The other parameters of the transformer were calculated from the design variables by using the generated algorithms and the weights of the eight main materials were found. The goal is to achieve the result of a run rather than a separate optimization run for different combinations of these variables.

In this study, the results of optimization studies of theoretical and practical design for three distribution transformers with 1000, 1250 and 1600 kVA powers are given. The common basic technical characteristics of transformers made in design optimizations are given below.

- Three-phase, oil-type distribution transformers, Primary voltages is 40 kV and secondary voltages is 0.8 kV.
- Winding core construction, AG winding conductor copper foil, HV winding conductor round enameled copper wire.
- Loss voltage values and short circuit voltage values of the transformers given in Table 3.
- Average winding temperature rise 65K, peak oil temperature rise 50K.
- Unit costs for the given material in order to calculate the total material costs of the transformers given in Table 1.

The limits and tolerances of transformers examined are given in Table 3. The Comparison of control parameters used in Table 4. The Best reliability score for each algorithm are given in Table 5.

Table 3. Limits and tolerances of transformers examined

Power	P_{il}(W)	P_{ll}	U_{sc}(%)
1000 kVA	1850	10000	5
1250 kVA	2200	12000	5
1600 kVA	2600	14500	6
Tolerances	10%	10%	10%

Table 4. Comparison of control parameters used in this study

Algorithm type	1000 kVA		1250 kVA		1600 kVA	
	$t_{Accuracy}$ %	$t_{Precision}$ %	$t_{Accuracy}$ %	$t_{Precision}$ %	$t_{Accuracy}$ %	$t_{Precision}$ %
Artifical bee	0.24	0.60	0.34	0.98	0.39	1.05
Cuckoo bird	0.25	0.62	0.36	1	0.45	1.20
Flower polli.	0.25	0.61	0.35	0.99	0.43	1.12

Table 5. Best reliability score for each algorithm

Algorithm type	Loop	Pop	$t_{Ac.}$% - $t_{Pre.}$%	Speed	Confidence
Artifical bee	1400	80	0.25-0.60	67	71
Cuckoo bird	2000	70	0.08-0.15	32	92
Flower polli.	2000	60	0.19-0.39	58	85

The Matlab program for transformer design optimization performance testing consists of a subprogram for each of the artifical bee algorithm, cuckoo bird algorithm and flower pollination algorithm and a design calculation subprogram, which is commonly used by all algorithm subprograms. The original algorithms are developed to use mixed-integer variables with three algorithms that can only use continuous design variables. The lower and upper limit values of the design variables have been extended to include transformers in a wider power range than the three types of transformers examined. The maximum number of cycles is 1400 and 2000. The population size is 60, 70 and 80. Algorithm control parameters are given in Table 4. The stop criterion of the algorithms was not used. The tests were iterated 15 times for each transformer type and algorithms.

As the combination of the maximum number of cycles and population size that each algorithm would give the best results, performance tests were performed for a different combination of these values. The Artificial Bee Algorithm and the Flower Pollination Algorithm are faster than the Cuckoo Bird Algorithm. The speed of these two algorithms is close to each other. Reliability score The Cuckoo bird algorithm is the most reliable one. As a result, the most suitable algorithm for the design of the theoretical power transformer is the Cuckoo bird algorithm.

However, it is understood that other algorithms are not suitable for this purpose. The results obtained here are based on the graphical user interface, a power transformer design program. Based on the results obtained from this, a power transformer design program has been prepared with the graphical user interface in Figure 4.

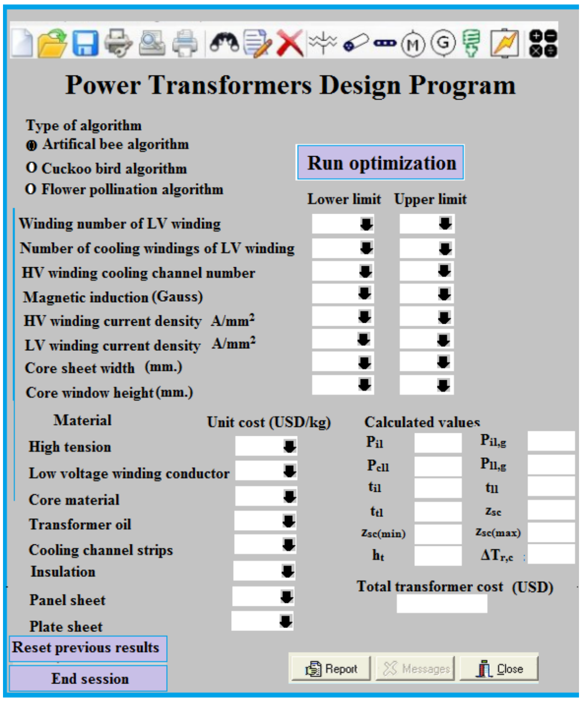

Figure 4. The Interface of power transformers design program

The program is capable of theoretical and practical optimization. Artificial bee algorithm, flower pollination algorithm and cuckoo bird algorithm were used for practical optimization. The maximum number of loops is 1400 for artificial bee algorithm, 2000 for cuckoo bird algorithm and flower pollination algorithm. Population size values were chosen as 80 for artificial bee algorithm, 70 for cuckoo bird algorithm and 60 for flower pollination algorithm. The program can list the best solution during the incremental purpose function value and all applicable practical solutions can be transferred to the Excel table.

IV. CONCLUSIONS

Power transformers are an indispensable element of today's energy systems. Power transformers are the most widely studied electrical machines in electrical machinery.

Since the logic of transformer design is essentially an established issue, it has continued for decades. New studies on this subject, rather than producing new theories to increase the efficiency of transformers, to reduce the cost of high-density composite magnetic material, to improve working conditions, to increase the design speed, and so on concentrated on topics.

In this study, an interface program for the design of power transformers has been developed by using artificial bee algorithm, cuckoo algorithm and flower pollination algorithm. The interface program has a very easy to use format that includes windows components. Power transformer design is a preferred interface for a designer with knowledge of design. With the interface created, a flexible design was possible by taking all the necessary inputs for the design. All necessary calculations were made and numerical results were presented to the designer. The interface created has reduced the loss of parameters and design costs.

REFERENCES

[1] H. Shayeghi, H.A. Shayanfar, G. Azimi, "A Hybrid Particle Swarm Optimization Back Propagation Algorithm for Short Term Load Forecasting", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 4, Vol. 2, No. 3, pp. 12-22, September 2010.

[2] H. Shayeghi, H.A. Shayanfar, A. Ghasemi, "A Robust ABC Based PSS Design for a SMIB Power System", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 8, Vol. 3, No. 3, pp. 86-92, September 2011.

[3] T. Davidovic, D. Teodorovic, M. Selmic, "Bee Colony Optimization Part I: The Algorithm Overview", Yugoslav Journal of Operations Research, Vol. 25, pp. 33-56, 2015.

[4] D. Karaboga, "An Idea Based on Honey Bee Swarm for Numerical Optimization", Tech. Rep. TR06, Erciyes University, Kayseri, Turkey, 2005.

[5] W. Gao, S. Liu, "A Modified Artificial Bee Colony Algorithm", Comput. Oper. Res., No. 39, pp. 687-697, 2012.

[6] N. Imanian, M.E. Shiri, P. Moradi "Based Artificial Bee Colony Algorithm for High Dimensional Continuous Optimization Problems", Eng. Appl. Artif. Intell., No. 36, pp. 148-163, 2014.

[7] R. Rajabioun, "Cuckoo Optimization Algorithm, Applied Soft Computing", No. 11, pp. 5508-5518, 2011.

[8] S. Mahmoudi, S. Lotfi, "Modified Cuckoo Optimization Algorithm (MCOA) to Solve Graph Coloring Problem", Applied Soft Computing, No. 33, pp. 48-64, 2015.

[9] X.S.Yang, "Flower Pollination Algorithm for Global Optimization", International Conference on Unconventional Computing and Natural Computation, pp. 240-249, 2012.

[10] S. Pant, A. Kumar, M. Ram, "Flower Pollination Algorithm Development: A State of Art Review", Int. J. Syst. Assur. Eng. Manag., pp. 1-9, 2017.

[11] D. Rodrigues, X.S. Yang, A.N. De Souza, J.P. Papa, "Binary Flower Pollination Algorithm and Its Application to Feature Selection", Recent Advances in Swarm Intelligence and Evolutionary Computation, pp. 85-100, 2015.
[12] M. Abdel-Baset, I. Hezam, "A Hybrid Flower Pollination Algorithm for Engineering Optimization Problems", Int. J. Comput. Appl., Vol. 140, No. 12, 2016.
[13] L. Valenzuela, F. Valdez, P. Melin, , "Flower Pollination Algorithm with Fuzzy Approach for Solving Optimization Problems", Nature-Inspired Design of Hybrid Intelligent Systems, pp. 357-369, 2017.
[14] F.D. Samirmi, W.H. Tang, Q.H. Wu, "Power Transformer Condition Monitoring and Fault Diagnosis with Multi-Agent System Based on Ontology Reasoning", IEEE PES Asia-Pacific Power and Energy Engineering Conference, pp. 1-6, 2013.
[15] H.C. Sun, Y.C. Huang, C.M. Huang, "Fault Diagnosis of Power Transformers Using Computational Intelligence: A Review", Energy Procedia, Vol. 14, pp. 1226-1231, 2012.
[16] A. Koochaki, S.M. Kouhsari, G. Ghanavati, "Transformer Internal Faults Simulation", Advances in Electrical and Computer Engineering, Vol. 8, No. 2, pp. 23-28, 2008.
[17] J. Mikulovic, M. Savic, "Calculation of Transients in Transformer Winding and Determination of Winding Parameters", Advances in Electrical and Computer Engineering, Vol. 89, No. 4, pp. 293-300, 2007.
[18] A. Koochaki, S.M. Kouhsari, G. Ghanavati, "Transformer Internal Faults Simulation", Advances in Electrical and Computer Engineering, Vol. 8, No. 2, pp. 23-28, 2008.

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