Received March 2, 2019, accepted May 4, 2019, date of publication May 7, 2019, date of current version May 21, 2019.

Digital Object Identifier 10.1109/ACCESS.2019.2915343

Temperature Analysis in Power Transformer Windings Using Created Artificial Bee Algorithm and Computer Program

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This work was supported by the Turkish Chamber of Electrical Engineers.

ABSTRACT The transformers used in certain stages of electricity production and distribution are the most important element due to their high costs and long service life. The most important parameter that reduces the useful life of the transformers is the high-temperature level which causes the fastening of the insulation material. The complexity of the temperature analysis in the power transformer windings makes it necessary to use an optimal resolution algorithm. It has been preferred to develop an artificial bee algorithm to solve complex temperature optimization problems in power transformer windings realistically and quickly. In this paper, the power transformer detection panel has been developed. The data required for the algorithm have been obtained by performing experiments in different power transformers. A microcontroller-based data acquisition circuit has been created to monitor the operating conditions of the power transformers. Variables such as the temperature of the environment and the temperature of the transformer have been transferred to the computer by sampling. The analysis of winding temperatures of power transformers has been determined by using the developed Artificial Bee Algorithm and computer program. The generated algorithm has been coded using the C # programming language. The temperature analysis of the power transformer windings has been created using the Microsoft SQL Server 2017 database. The data obtained from experimental studies have been compared with the data obtained from the developed algorithm and computer program. Using the computer program based on this algorithm, the loss, and temperature data of the transformer have been accurately estimated according to the variable states of the load and its harmonic content.

INDEX TERMS Animal behavior, bee algorithm, power transformers, temperature analysis, transformers.

I. INTRODUCTION

The main criterion that limits the useful life of the transformer and limits the transformer loading is the thermal performance of the transformer [1]–[3]. The most important parameter of thermal performance is the hot spot temperature. The hot spot temperature is the maximum temperature observed in the region of the transformer's current-carrying elements, insulating material or insulating fluid, usually in the region close to the top of the windings. This parameter is considered to represent the temperature limit associated with the loading of the transformer [4]–[6]. The best way to be informed by the hot spot temperature is by placing sensors in the actual hot zone and transferring the measured values with the sensors to the outside of the transformer tank. However, this situation is impossible for the transformers already used. The sensors must be placed inside the transformer in design phase. It is impossible to place these sensors in existing transformers. Therefore, an algorithm has been developed to calculate and estimate the temperature parameters of the transformers. The flying behavior of birds and their flying patterns, food search behaviors of ants, swim and grouping of fish herds, the communication of honey bees with dances have been investigated in the study. The results of the interaction of animal communities such as bees, ants, birds, termites and fish flocks have been investigated and artificial intelligence techniques have been developed to find solutions to scientific problems [7]–[11]. These studies have led to the development of approaches that adapt the behavior of herds to systems and models.

The associate editor coordinating the review of this manuscript and approving it for publication was Fuhui Zhou.

II. THE IMPROVED ARTIFICIAL BEE ALGORITHM

Bee colonies around the hive with the swing movement share information with each other. Self-organization of individuals within the herd is the main feature of the system [12]. It carries out its tasks on its own by using the information received from other individuals in the system [13]. Positive feedback is generated through behavioral rules that support the occurrence of suitable situations. The bees who receive information about the location benefit from sunlight to achieve this goal. They calculate the angle between the orbits and the sun. Bees that determine the distance according to the energy consumption, the energy of different height flies by adjusting their energy. The flight behavior of bees was investigated and a flight map was created. The flight map of bees is given in Figure 1.

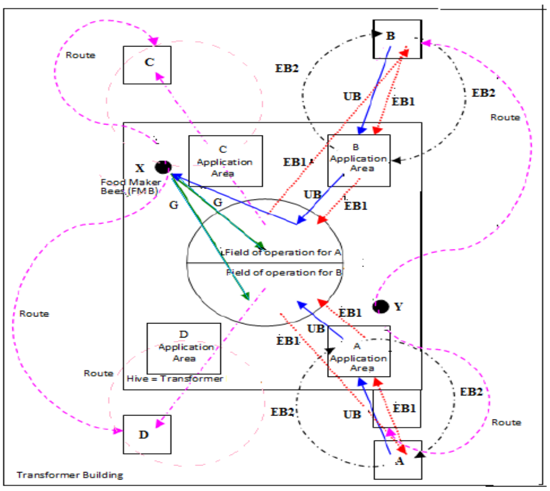

FIGURE 1. The created flight map of bees.

Here; A, B, C and D refer to nutrient sources. X is the explorer bee. G refers to the dancing bee. EB1 refers to the bees that transmit information about the location and amount of the nectar source to other bees. EB2 refers to the bee which brings the nectar to the hive. UB refers to the researcher bee in the field of dance which abandons the food source. In the beginning, the bee starts to look for food supply. There are two cases for this bee. X begins to search for food. There may be a scout bee to the sources described by following dancing bees. Bees from sources begin to bring nectar from the sources they find. Thus, these bees become a duty bee. EB2 continues to bring nectar from the source without sharing the information. EB1 dances with other bees by transferring information to other bees about the location and amount of the nectar source by dancing before returning to the source. UB leaves the source and comes to the dance area. With bees dancing, other bees are directed to a job. Negative feedback in bees is generated by working rules. That balance positive feedback to ensure consistent movement of the flock together [14], [15]. Information exchange between some individuals in any herd provides information exchange within the herd and multiple communications occur [16]–[18]. The value of a food source depends on many factors, such as the type of the source, the distance to the hive, the amount of nutrients, or the difficulty of reaching the nectar. Worker bees have been assigned to bring the nutrient collected from previously identified sources [19]–[22]. Another task is to transfer the position and quality information of the source to the other bees in the hive. The bees that bring the food from the source need to share the location information with the source to send the bees to these resources with other bees [23]–[26]. The bee that gets the information about the location uses sunlight to find this target. Bees that determine the distance according to the energy consumption, the energy of different height flies by adjusting their energy. The rocking dance similar to the eight figures provides the transmission of important information to the bees in the hive [27]–[29]. These parameter values have been automatically selected by the proposed mechanism instead of the user to determine the bee parameters by the temperature analysis algorithm in the developed power transformer windings. In this algorithm, mutation, creep, crossover, interpolation and external valuation operators perform superior search by completing random search. With this mechanism, the average of the conformity values obtained in the transformer test has been used instead of the suitability value for each bee in a single experiment. A solution in the created Bee Algorithm has been replaced with a new randomly generated solution when it cannot be developed during a particular repetition. Almost all of the test problems of the transformer, this algorithm have been developed to achieve optimum results. Accuracy, learning speed and robustness of this algorithm has been proven by the results obtained from transformer experiments.

III. DETERMINATION OF WINDING TEMPERATURES IN POWER TRANSFORMERS

The relationship between the useful life of the transformer and temperature is given in Equation (1). According to Equation (1), the useful life of the transformer isolation is inversely proportional to the temperature at which the transformer operates, and therefore on the transformer losses. UL is useful life. X and Y are constant numbers. ΘH is the hot spot temperature change.

$$\%UL = X.e^{\frac{Y}{\Theta H+273}}.100 \tag{1}$$

The temperature distribution inside the transformer is not homogeneous [30]–[32]. The insulating material in the hotter parts ages faster. Therefore the temperature of the hot spot zone must be taken into account [33]–[36]. The hot spot temperature cannot be measured by an after-installed device in the transformers being used [37]–[42]. When the transformer is in the design phase, temperature sensors can be installed in the appropriate parts of the windings. They can be transferred to the outside of the transformer tank. Therefore, it is necessary to accurately estimate the temperature of the non-measurable hotspot using its relation with the upper oil temperature. When generating the algorithm, the data in the certified test reports of the transformer manufacturer have been used. Measured values are three phase current information of transformer, temperature information of the environment where the transformer is located and transformer upper oil temperature information. Transformer idle losses (P_{IL}), transformer load losses (P_{LL}), base currents (I_b) and HV and LV side resistance values (r_{ave}, R_{ave}) have been obtained from load losses and short circuit voltage test. Nominal upper oil temperature rise value ($\Delta\Theta_{TRV}$) and nominal winding temperature rise value ($\Delta\Theta_H$) have been obtained from the heat increase test. Transformer nominal capacity (Cn), transformer connection type (Y/Δ), transformer active part, oil, boiler and equipment weights (kg, lt) have been learned from transformer label. The temperature of the hot spot (Θ_H) shown in Equation (2) is composed of the winding temperature change value ($\Delta\Theta_H$), the ambient temperature (Θ_A) according to the oil temperature, and the upper oil temperature change value ($\Delta\Theta_{TRV}$) according to the ambient temperature.

$$\Theta_H = \Theta_A + \Delta\Theta_H + \Delta\Theta_{TRV} \quad (2)$$

The upper oil temperature value (Θ_{TRV}) according to the ambient temperature is as in Equation (3).

$$\Theta_{TRV} = \Theta_A + \Delta\Theta_{TRV} \quad (3)$$

After a change in load, the upper oil temperature change value has been expressed as the function in Equation (4), which includes an oil time constant. τ_{TRV} is the time constant of the oil temperature. $\Delta\Theta_{TRV,i}$ is the oil temperature change first value. $\Delta\Theta_{TRV,F}$ is the oil temperature change final value.

$$\Delta\Theta_{TRV} = \Delta\Theta_{TRV,i} + \left(\Delta\Theta_{TRV,F} - \Delta\Theta_{TRV,i}\right) \cdot \left[1 - e^{(-t/\tau TRV)}\right] \quad (4)$$

The initial value of the upper oil temperature change has been calculated as in Equation (5). $\Delta\Theta_{TRV,R}$ is the oil temperature change value at rated load. K_i is the first ratio of instant load to rated load. R is the ratio of loss of load to idle losses. n is number of cycles.

$$\Delta\Theta_{TRV,i} = \Delta\Theta_{TRV,R}.[(K_i^2.R + 1)/(R + 1)]^n \quad (5)$$

In Equation 6, the upper oil temperature change final value ($\Delta\Theta_{TRV,F}$) has been calculated separately for each digit. K_F is ratio of instantaneous current to rated current.

$$\Delta\Theta_{TRV,F} = \Delta\Theta_{TRV,R}.[(K_F^2.R + 1)/(R + 1)]^n \quad (6)$$

The upper oil temperature change value ($\Delta\Theta_{TRV}$) obtained as a result of the calculation made in the previous step is equal to the oil temperature change first value ($\Delta\Theta_{TRV,i}$) in the next step. The time constant of the oil temperature is indicated by τ_{TRV}. When the transformer load or the required cooling intensity is changed, the temperatures of the winding and the oil follow this in a delayed manner. This is explained by an oil time constant for oil. The oil time constant is calculated using the calorimetric thermal capacity of the transformer. $\tau_{TRV,R}$ is the time constant of the oil temperature at rated load. C is defined as thermal capacity. $P_{T,R}$ is defined as thermal power.

The time constant of the oil temperature at rated load is as in Equation (7).

$$\tau_{TRV,R} = \left(C \cdot \Delta\Theta_{TRV,R}/P_{T,R}\right) \quad (7)$$

C takes variable values according to transformer cooling type. The thermal capacity has been calculated by multiplying the corresponding parts of the transformer by weight in kilograms. The basis of the exponential warming equation is based on the average temperature increase of the entire transformer mass. However, the upper oil temperature change is a variable that can be measured by temperature indicators or thermocouples during thermal tests. The time constant of the oil temperature is calculated as given in Equation (8).

$$\tau_{TRV} = \tau_{TRV,R} \cdot \frac{(\Delta\Theta_{TRV,F}/\Delta\Theta_{TRV,R}) - (\Delta\Theta_{TRV,i}/\Delta\Theta_{TRV,R})}{(\Delta\Theta_{TRV,F}/\Delta\Theta_{TRV,R})^{1/n} - (\Delta\Theta_{TRV,i}/\Delta\Theta_{TRV,R})^{1/n}} \quad (8)$$

The hot spot temperature change is indicated by the oil temperature. The hot spot temperature is the maximum temperature that the winding temperature can reach. Hot spot temperature change according to the upper oil temperature value has been calculated as given in Equation (9). $\Delta\Theta_{H,i}$ is hot spot temperature change first value. $\Delta\Theta_{H,F}$ is hot spot temperature change final value.

$$\Delta\Theta_H = \Delta\Theta_{H,i} + (\Delta\Theta_{H,F} - \Delta\Theta_{H,i}).(1 - e^{-t/\tau w}) \quad (9)$$

The first value of the hot spot temperature change according to the upper oil temperature has been calculated as given in Equation (10). m is defined as experimental variable to calculate $\Delta\Theta_H$. $\Delta\Theta_{H,R}$ is winding hot spot temperature change at rated load.

$$\Delta\Theta_{H,i} = K_i^{2m}.\Delta\Theta_{H,R} \quad (10)$$

The temperature value of the hot spot temperature change according to the upper oil temperature has been calculated as given in Equation (11).

$$\Delta\Theta_{H,F} = K_F^{2m}.\Delta\Theta_{H,R} \quad (11)$$

The nominal hot spot temperature change value according to the upper oil temperature has been calculated as given in Equation (12). $\Delta\Theta_{H/A,R}$ is nominal value of the hot spot temperature according to the ambient temperature.

$$\Delta\Theta_{H,R} = \Delta\Theta_{H/A,R} - \Delta\Theta_{TRV,R} \quad (12)$$

The time constant (τw) of the winding temperature is indicated by. The rated value of the winding temperature time constant has been calculated as given in Equation (13).

$$\tau_{TW,R} = \left(C.\Delta\Theta_{H,R}/P_{T,R}\right) \quad (13)$$

The time constant of the winding temperature has been calculated as given in Equation (14).

$$\tau_W = \tau_{W,R} \cdot \frac{(\Delta\Theta_{H,F}/\Delta\Theta_{H,R}) - (\Delta\Theta_{H,i}/\Delta\Theta_{H,R})}{(\Delta\Theta_{H,F}/\Delta\Theta_{H,R})^{1/n} - (\Delta\Theta_{H,i}/\Delta\Theta_{H,R})^{1/n}} \quad (14)$$

The resistances R1 and R2 in Equation (15) have been calculated according to the connection type of the high voltage and low voltage side of the transformer. I_{1R} is primary current of the transformer. I_{2R} is secondary current of the transformer. K is rate of instantaneous load to rated load.

$$P_{\text{Total lose}} = P_{\text{LoadLose}} - K \cdot \left[R_1 \cdot (I_{1R})^2 + R_2 \cdot (I_{2R})^2 \right] \quad (15)$$

Equation (16) has been used to make normalization, taking into account the actual values of the current. h refers to the harmonic number. I_h is harmonic current. I is nominal current of the transformer. I_{rated} is maximum current in which the transformer cannot be operated.

$$P_{LoadLose}(pu) = [\sum_{h=1}^{h=h\max} (I_h/I_1)^2].(I/I_{rated})^2 \quad (16)$$

The upper oil temperature increase value (Θ_{TRV}) has been calculated as given in Equation (17). The winding temperature values have been calculated as given in Equation (18), Equation (19) and Equation (20). $P_{LoadLose}(pu)$ is the per unit value of the load losses. n is an experimental variable. Θ_{HTO} is hot spot temperature according to upper oil. P_{ec} is defined as loss of eddy currents.

$$\Theta_{TRV} = \Delta\Theta_{TRV,R}.[(P_{TotalLose})^n / P_{TotalLose}]^n + \Theta_A \quad (17)$$

$$R.I_{2,R}^2 = 1,5.R_2.I_{b(LV)}^2 \quad (18)$$

$$R.I_2^2 = P_{LoadLose}(pu).R.I_{2,R}^2 \quad (19)$$

$$\Theta_{HTO} = (\Delta\Theta_{H,R} - \Lambda\Theta_{TRV,R}).[\frac{R.I_2^2 + P_{ec}^{adj}.2,4}{(K.R_2.I_{2,R}^2) + P_{ec}.2,4}]^{0,8} \quad (20)$$

IV. TEMPERATURE ANALYSIS OF TRANSFORMER WRAP BY USING BEE ARTIFICIAL ALGORITHM

According to the need for defining the temperature of the transformer, there are some limitations for the optimum solution. In the initial case, some pre-definitions have been made to save time and narrow down the search space. The basic steps of the Bee Algorithm for finding and analyzing the transformer temperature are as follows.

Step 1: The problem of transformer is assigned to the problem to solve the problem.

Step 2: The problem of transformer is assigned to the class defined.

Step 3: The problems of transformer are assigned to their class according to the problem type.

Step 4: Different methods of analysis should not be assigned to the same timeperiod.

Step 5: Different problems should not be assigned to the same timeframe.

Step 6: If the problem is solved by specific solutions, the problem should be assigned to common solutions.

The basic bee algorithm parameter is given in Table 1.

'n' solution research space is shown in Figure 2.

The Created Bee Algorithm for finding and analyzing the transformer temperature is given in Figure 3. Algorithm begins with the random placement of n solution

TABLE 1. The bee algorithm parameters.

Bee Algorithm Parameters	Explanation
n	Number of solutions
f	Number of wrong zones selected from problematic n number of errors
b	Selected "f" is the best number of zones in the wrong region
nbp	Number of solutions applied to the best solution b zone faulty region
nrp	Remaining number of solutions (f-b)
nss	Neighbor solution search size
itn	Stop criterion (number of iterations)

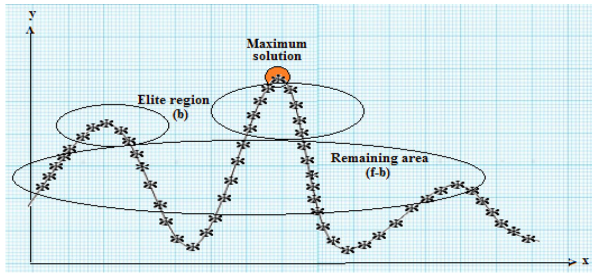

FIGURE 2. 'n' solution research space.

research space. n solutions are examined according to each other according to the conformity of the points examined by selecting the more appropriate regions (f) are selected. The elite regions (b) and the remaining regions (f-b) with the best conformity value are selected. The neighborhood search size (nss) of these zones is determined. For the search of more appropriate points in the selected regions, the better solution (nbp) than the other selected regions (nbp) representing the better solutions, and the remaining solutions (nrp) to the other regions are applied. For the new population, the solution with the most appropriate value in each region is selected. Other solutions in the regions are separated from the research space. Other solutions (f-b) in the population are randomly placed in the research space to obtain new potential solutions. At the end of iteration, the new population consists of two parts. Solutions for each selected region and random search solutions have been maintained until optimization criterion is achieved. Winding losses due to current harmonics have been considered. It also includes the increase in core losses due to voltage harmonics. The maximum load rate has been determined using the measurement data. In the study, software has been developed in which the temperature analysis of power transformer windings is defined.

The flow chart of the program is given in Figure 4.

The measurement and control panel in the diagram given in Figure 5 has been installed in the control building of Mersin-Yenisehir Substation.

Conventional current and voltage transformer information of the measurement point has been connected to the measurement system. The information on the upper oil temperature sensors and the ambient temperature sensors installed in the power transformers located outside the control building

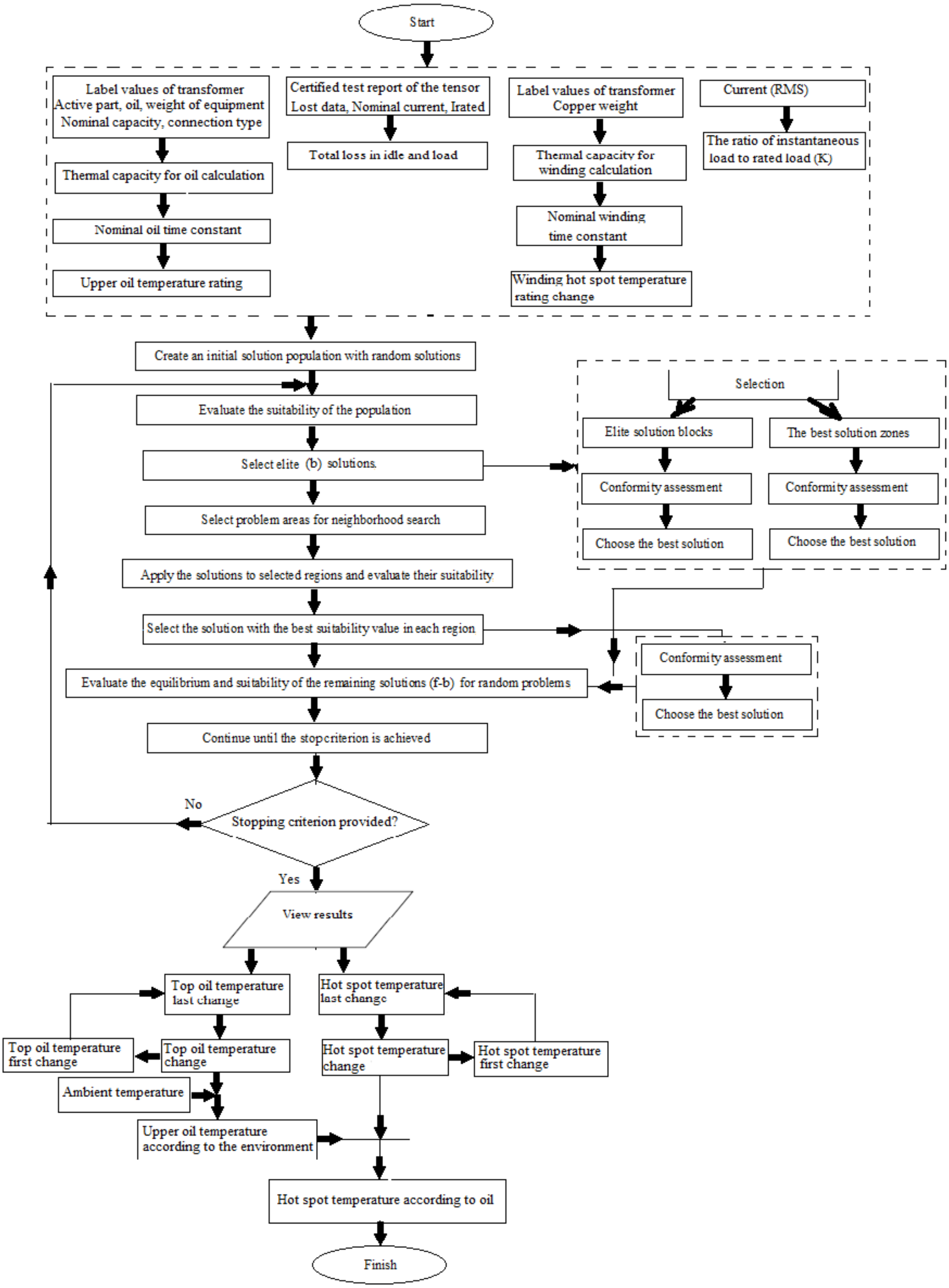

FIGURE 3. The Created Bee Algorithm for finding and analyzing the transformer temperature.

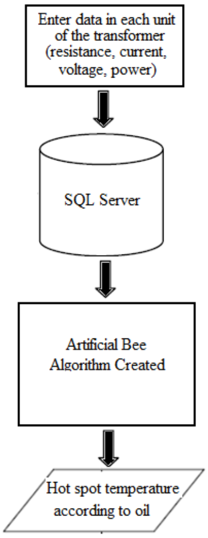

FIGURE 4. The flow chart of the transformer temperature analysis program.

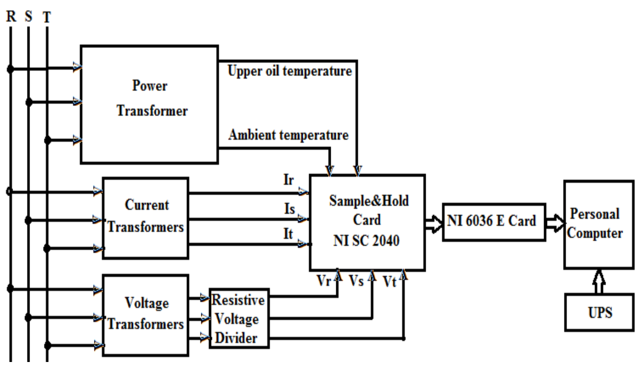

FIGURE 5. The diagram of measurement system.

have been connected to the measuring system using a signal converter. The personal computer, the signal transducer and the uninterruptible power supply of the sensors have been used in the measurement system. One-minute data record has been created with data taken in seconds. The data in the measurement taken using the Lab-view program have been processed through the codes written in the M-file extension in Matlab Program. During the data processing, the conventional current and voltage transformer conversion ratios and the corresponding coefficients of the temperature sensors have been written in the appropriate places in the M-file. Thus, the actual values have been obtained. Thanks to the eight channels in the National Instruments' SC2040 card, current and voltage information as well as ambient and upper oil temperatures have been taken. The 6036E Card enables an analog/digital signal conversion between the SC2040 and the computer. It was also used to sample analog signals from the output of the SC2040 inserted in the PCMCIA slot. The voltage divider card has been used to obtain voltage information. Magnetic circuit open able cable type current clamps

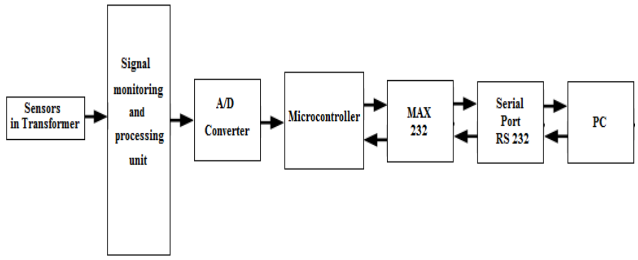

FIGURE 6. Hardware of the transformer temperature analysis program.

have been used to receive current information. In order to convert the clamp output current to the voltage, it was terminated on the resistor and connected to the SC2040 channels. Resistance thermometers have been used for temperature measurements. Signal transducers have been used to provide a constant current that the resistive thermometer's variable resistor must go through. 6036E and SC2040 sampling and holding card to communicate with each other in a healthy way to record data is used in the Lab-view program. The Matlab program has been used to process the recorded raw data. The hardware of the transformer temperature analysis program is shown in Figure 6.

The software was developed in the Microsoft Visual Studio 2017 development environment, using the C# programming language. Microsoft SQL Server 2017 database has been used for the environment where the information is stored. The data obtained as a result of the operation of the information and the created program has been stored in the database. General definitions and information to be used in the algorithm transformer unit information to the unit table, transformer failures are defined information is entered into the transformer fault table. After the algorithm runs and ends, the transformer failure has been automatically displayed. Electronic hardware has been realized for transferring data from 30 sensors connected to different units of transformer to computer. An interface card was designed using the microcontroller to communicate the computer via sensors, microcontroller and serial port in the designed system. The program of this card has been written in PICC. The voltage values obtained from the sensors using the RS-232 serial port have been displayed on the program screen created on the computer screen. The interface program has been written in the Visual Basic programming language. The microcontroller and the MAX232 interface have been used to exchange data over the serial port. The created transformer temperature analysis program is shown in Figure 7.

Developed power transformer detection panel and experiment connection diagram is given in Figure 8. Power transformer detection panel developed in Mersin University Laboratory is given in Figure 9.

The panel hardware consists of one personal computer, one uninterruptible power supply, one sampling & holding card, one data acquisition card, one resistive voltage divider card, three current and voltage transformer, three resistive

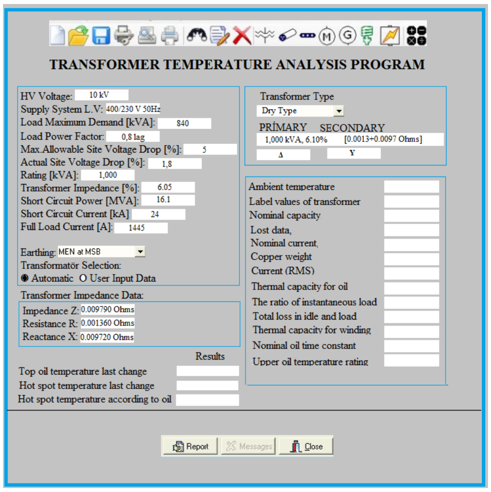

FIGURE 7. The transformer temperature analysis program created by artificial bee algorithm.

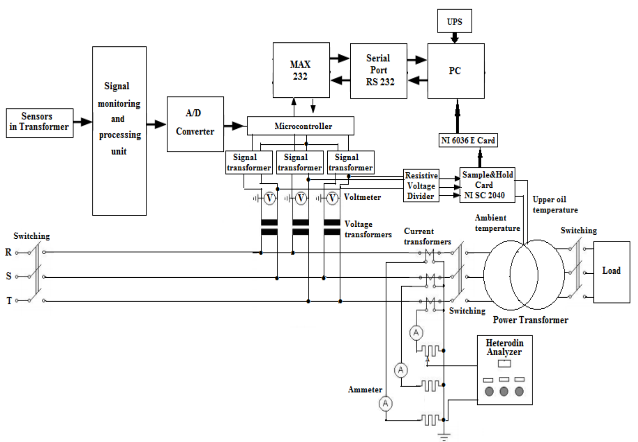

FIGURE 8. Developed power transformer detection panel and experiment connection diagram.

FIGURE 9. Power transformer detection panel developed in Mersin University Laboratory.

voltage divider. There are many ambient temperature sensors, one upper oil temperature sensor, many sensors to different units of the transformer, analog/digital signal converters for sensors and many serial ports. This panel has been installed within the control building of Yenisehir Transformer Center. Hot spot temperature changes from the algorithm are shown in Figure 10.

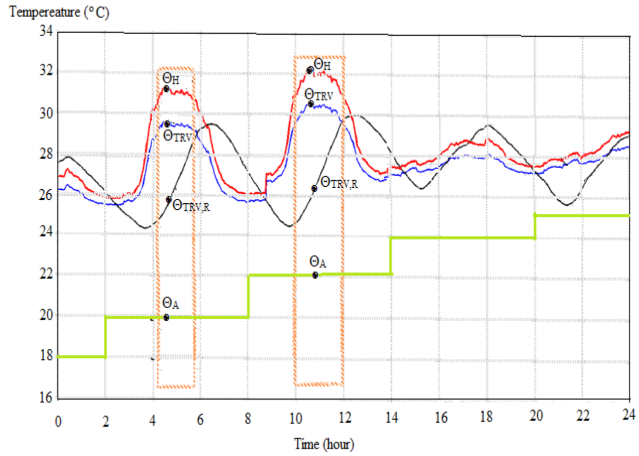

FIGURE 10. Hot spot temperature changes from the algorithm.

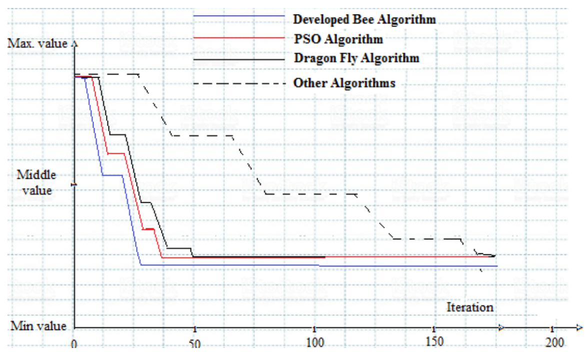

FIGURE 11. Iteration change of the created bee algorithm and other algorithm.

Conventional current and voltage transformer data information of the measurement point have been brought to the measurement system with the help of cables and connections. Information on the upper oil temperature sensors and ambient temperature sensors placed in the power transformers located outside the control building have been brought to the side of the measuring system using a signal converter and connections have been made. The data obtained have been processed in Matlab environment. All parameters of the transformer have been estimated by the generated algorithm and computer program. Iteration change of the created bee algorithm and other algorithm are shown in Figure 11.

The data obtained from the developed algorithm and the experimental results obtained from the transformer have been compared. It is understood that the error in the optimum data obtained from the developed algorithm is between $\pm 1\%$ and $\pm 2\%$ and the results are reached faster. Comparison of control parameters used is given in Table 2.

The best reliability score for each algorithm is given in Table 3.

28th iteration in the developed Bee Algorithm has reached the conclusion. 38th iteration in the Particle Swarm Optimization Algorithm has reached the conclusion. 50th iteration in the Dragon Fly Algorithm has reached the

TABLE 2. Comparison of control parameters used in this study parameters.

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

TABLE 3. The best reliability score for each algorithm.

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

conclusion. In other algorithms, the result has been reached in the 170th iteration. Artificial bee algorithm has been compared with other algorithms. According to other algorithms, this improved algorithm is the most reliable and fastest.

V. CONCLUSION

The biggest problem encountered in power transformers during operation is the heating caused by losses in cores and windings. It should be used without exceeding the useful life of the transformers which are the most expensive and important element of the electrical transmission and distribution chain. We need to know the temperature value of hot spot. It is possible to determine the temperatures in the transformers by performing detailed thermal analysis during the winding height. The heuristic method has been developed to determine the temperatures in transformers. Thus, the best result has been tried to be reached. An algorithm which automatically identifies the temperatures in power transformers was created. This algorithm based on herd intelligence has been used to describe transformer temperatures based on the behaviors of bees moving in herd to find food. The loading method of the transformers is based on the hot-spot temperature calculation. The hot-spot temperature has been calculated to provide the expected useful life of the insulating solid material under normal conditions. The data obtained by the algorithm will enable us to have information about the healthy operation of the transformers. The measurements have been evaluated separately in order to obtain both power quality parameters and the upper oil, hot spot temperature values of the transformers. After the algorithm runs and ends, the transformer temperatures have been automatically displayed. The software has been developed in C# programming language by using the improved artificial bee colony algorithm. Electronic equipment has been created to transfer data from sensors connected to different units of transformer to computer. An interface card has been designed using the microcontroller to communicate the computer via sensors, microcontroller and serial port in the designed system. The program of this card has been written in PICC. The voltage values obtained from the sensors using the serial port have been displayed on the program screen created on the computer screen. In addition to the electronic circuit designed to communicate with the computer, an interface program has been written in the Visual Basic Programming Language. The data transmission has been transferred to the microcontroller via a serial port. The data obtained from the developed algorithm and the experimental results obtained from the temperatures of transformer have been compared. It is understood that the error in the data obtained from the developed algorithm is between ± 1% and 3%. The hottest point of the transformer winding has been determined. Thus, it has been possible to increase the overload times and limits of the transformers. In this study, it has been possible to know the upper oil and hot spot temperature values according to the loading capacities of the transformers by the developed algorithms and panel. In addition, the transformer overrides some of its loads, so that overheating has been able to be prevented. By using the improved algorithm, the computer program and the control panel in electrical transmission and distribution, the power transformers will be operated in a healthy manner and thus will not exceed their useful life.

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