Flower Pollination Algorithm based Optimal Placement of Nano Coolant in Induction Motor

J.Shanmugapriyan, S.Srikrishnakumar, K.R.Sugavanam

Abstract: ***This manuscript describes the best possible placement of nano coolant system by identifying the hotspots through FPA to diminish the harm and losses occurred owing to the high temperature in Induction motor. The important functions of cooling system are to absorb and dissipate the heat spontaneously. The hotspots of the induction motor are spotted with the FPA after thorough analysation of the temperature obtained from a thermal camera. The induction motor's damage due to overheating is reduced with the help of this method. With abnormal temperature conditions, the efficiency of induction motor is reduced. The lifespan is also reduced. The proposed method provides a solution to such problems in induction motor. Experimental results also prove the results obtained from simulation.***

Keywords: Flower pollination optimization (FPA), Particle Swarm Optimization (PSO), induction motor heating, Nano coolant.

I. INTRODUCTION

Induction motors are important for various applications in the industries [1]-[4]. With the advancement in the field of power electronics, different types of converters are used for numerous industrial applications. But thermal considerations convey that there is too much stress on the drives and this is not good for the equipments. The usage of induction motors takes place in a continuous fashion and since there is no rest, heat is produced inside them. The heat is generally produced between the rotor and stator. Since heat is generated within the motor, the metallic parts are influenced because of the property of expansion of metals [5]. The clearance between stator and the rotor is affected. Therefore, friction increases. When there is friction, there is generation of heat in a continuous manner. The copper winding present inside the motor is heated up and due to overheating, there is a resistance built up by the copper winding. This resistance causes a strong opposition to the current flow and hence the losses also increase. With sudden rise in temperature, voltage also is consumed on the higher side leading to shorting of copper winding. The induction motor, now, breaks down and the industrial load demand is failed to be met [6]-[7]. Thus, there arises a need to control the thermal stress occurring in a motor. To reduce the effect of heating and prevent the damages caused due to abnormal temperature, a nano coolant is placed in induction motors.

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This placement requires exact determination of the position at which the coolant must be placed and for doing so an efficient algorithm must be used. Previously, PSO was implemented and in this paper, by using FPA, the exact placement of nano coolant is detected [8].

II. MATERIALS AND METHODOLOGY

The proposed method is used for identifying the hotspots to control the temperature in an induction motor. It is begun by random placements of the coolants. The temperature shows a significant reduction in the location where the coolant is placed and the temperature gradient is observed to be more in other spots. The total temperature is calculated and tracked with the use of a camera which is specially designed to detect heat. By using the FPA the hotspots can be identified and the exact placement of nano tube coolants can be done. An infrared camera helps to identify the hotspots. The image that is feeded into the thermal camera helps to locate the areas of high temperature in a range of numerals that are scalar. It also differentiates the larger heated areas and smaller ones. Fig. 1 shows the image obtained from thermal camera.

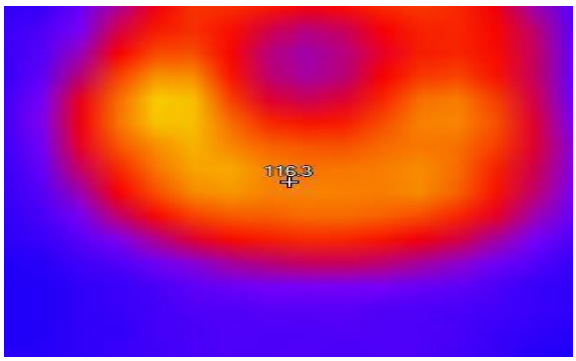


Fig. 1 Induction Motor Hot Spot Image Obtained by Thermal Camera

III. FLOWER POLLINATION ALGORITHM

The FPA is based on the pollination process in the flowers which was developed by yang in the year 2012. It has two processes i.e. biotic and abiotic. In biotic, the pollinators are birds, bees and bats where ninety percentage of pollination are biotic. In abiotic, the pollinator is air [9]-[10]. The flowchart of FPA is explained in the follwing steps:

Step 1: Start the process by setting an initial value for the pollens.

Step 2: The fitness factors should be determined

Step 3: From the obtained fitness factors, determine the least ones.

Step 4: For the incremental fitness value, check the value of rand.
Step 5: When the value exceeds P, global pollination is done and if does not exceed, local pollination is done.

$x_i^{t+1} = x_i^t + \gamma L(\lambda)(gbest - x_i^t)$ (1)

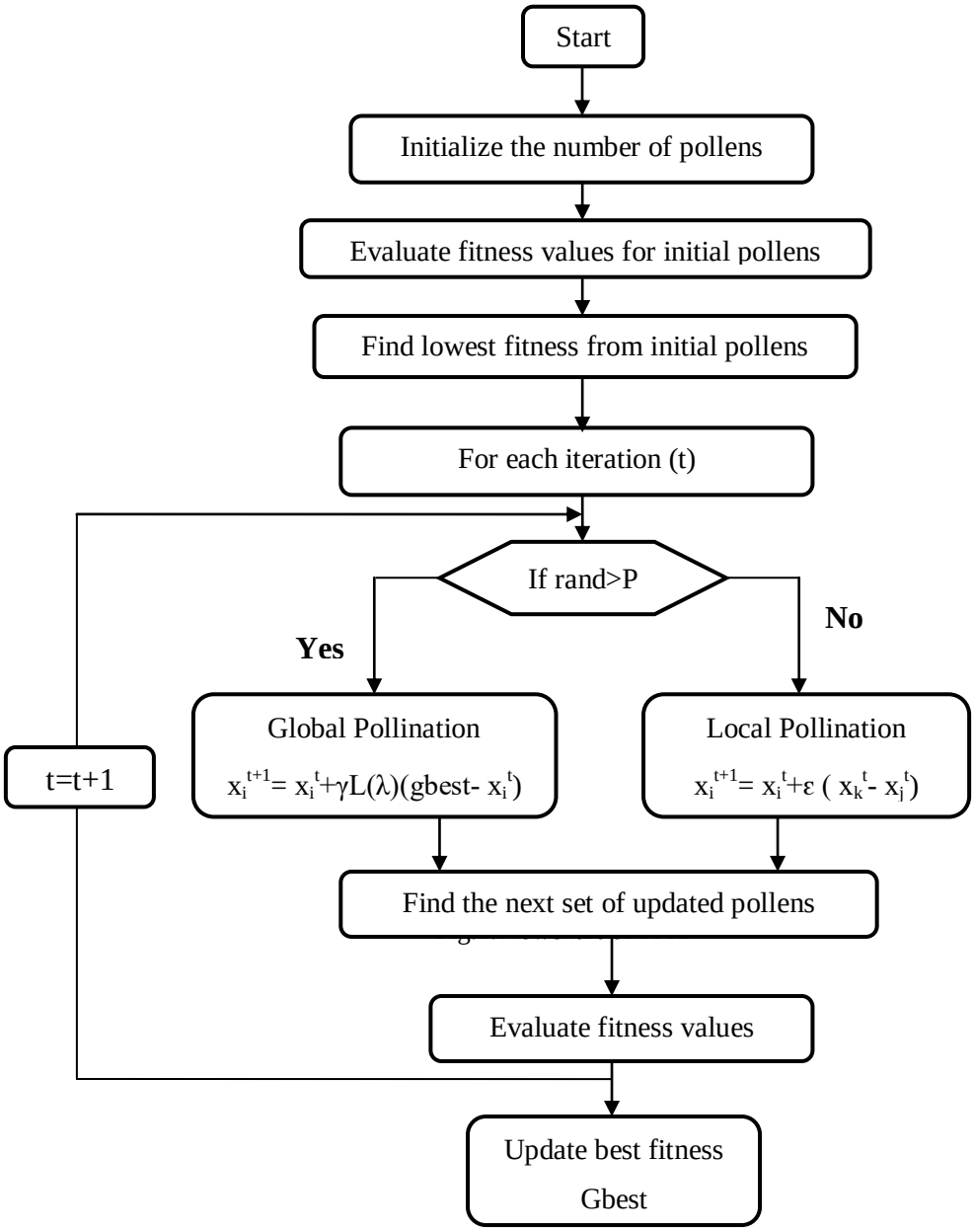
Where L(λ) depicts levy distribution which is accountable for the movement of pollens between different species of plants. The levy factor is given in equation

$L(\lambda) = \lambda\Gamma(\lambda) \sin(\pi\lambda/2)/(\pi * s^{1+\lambda})(s >> s_0 > 0)$ (2)

If random value is not less than the probability, then the local pollination is performed using equation

$x_i^{t+1} = x_i^t + \varepsilon (x_k^t - x_j^t)$ (3)

The dissimilar pollens of same species represented by x^t_k and x^t_j and ε defines the local search which is also in the range [0 1].
Step 6: A new set of updated pollens are obtained.
Step 7: Fitness factors for this new set are obtained.
Step 8: The best fitness value is chosen as the optimized value.
Step 9: These steps are repeated until all the fitness values in the iteration are obtained.



IV. RESULTS AND DISCUSSION

The convergence curve (shown in fig. 3) is drawn through MATLAB simulation software considering both the FPA and PSO. From the curve, it is observed that the iterations required for FPA is 400 and for that of PSO is 600 which is around 200 iterations higher. Thus, the time taken by the proposed algorithm is lesser and also the efficiency in extracting the heat spots is appreciable and reliable. Hence this algorithm can be preferred.

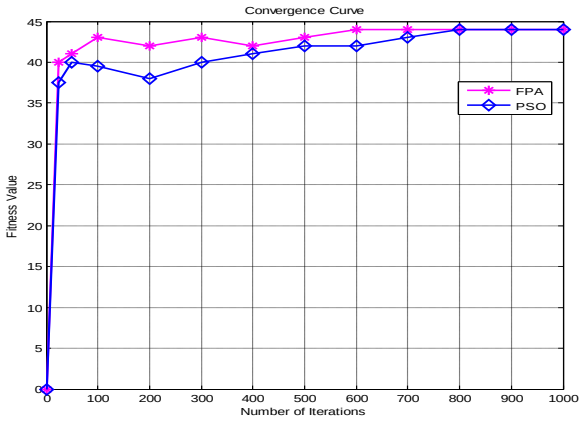


Fig. 3 Comparison between PSO and FPA algorithm

The algorithmic results shown measure the hotspots and place nanocoolants there in order to mitigate the heat dissipated during the usage of the induction motor thereby increasing the lifespan of the equipment and also placing the nano coolant at optimal location. The fig. shows the setup where a temperature sensor measures 44 degrees celcius temperature at the induction machine and placement of the coolant is done at that point. There is less complexity involved in applying the FPA algorithm.

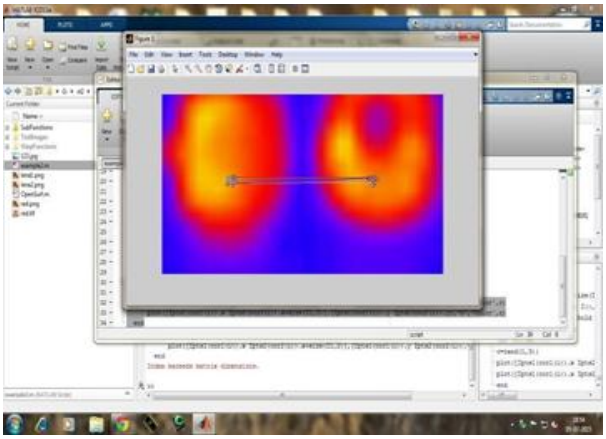


Fig. 4 Simulation result

V. EXPERIMENTAL VERIFICATION OF RESULTS

With the help of flower pollination algorithm, optimal location for placing the nano coolant has been identified successfully and experimental implementation of nano coolant on the induction motor is depicted in the figure 5.

Fig. 5 Optimal Placement of Nano Coolant in Induction Motor

VI. CONCLUSION

The FPA has been identified hotspot for the placement of nano coolant in the location of overheated point in induction motor. From the simulation results and the experimental verification done, one can conclude that the flower pollination algorithm shows superiority in terms of increasing the life span of induction motor and also increasing the efficiency. Also a comparison between PSO algorithm and FPA algorithm has been done and a conclusion that the iterations required is lesser in FPA has been made.

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