Novel Approach of Economic Load Dispatch for Combined Heat and Power using Artificial Bee Colony Approach

Ritesh Arora[1], Shavet Sharma[2]
Research Scholar[1], Assistant Professor
Department of Electrical Engineering, SSCET, Badhani

Abstract - The economic load dispatch is an integral part of power system. The leading purpose is to minimize the fuel cost of power plant without violating any system constraints. Many conventional methods are applied to elucidate economic load dispatch through mathematical programming and optimization technique. The popular traditional method is the lambda-iteration method. Many heuristic approaches applied to the ELD problems such as dynamic programming, evolutionary programming, genetic algorithm, artificial intelligence, particle swarm optimization etc. In this study, two cases are taken named as three unit system and six unit system. The fuel cost for both systems compared using conventional lambda-iteration method and PSO and ABC method. These calculations are done for without transmission losses as well as with transmission losses. In the end, the fuel cost for both methods compared to analyze the better one from them. All the analyses are executed in MATLAB environment.

Keywords *- PSO, ABC, intelligence, ELD*

I. INTRODUCTION

The traditional methods of generating electricity are unsuitable because the loss of the heat energy is high in this process. The principle of combined power and heat generation is also called as cogeneration which recovers the heat and power from the single fuel. In this paper, the author mainly focused on the problem of combined heat and power economic dispatch. It is a complex optimization issues in the generation of power. The main objective of this paper is to reduce the cost of heat and power cogeneration. This problem is solved by using the different type of optimization methods. Mainly these are divided into three types: Non-linear optimization method, evolutionary methods and gradient descent methods [3].

Economic dispatch is one of the leading issues in the field of power system. In the optimization of process electric power is allocated to the different power generating unit for reducing the total cost of the power generation. The other solution of this problem is to divide it into two parts that are heat dispatch and power dispatch. Two layer algorithms is used in this method of solving the dispatch problem [2]. Artificial Immune System is another method which is used to solve the problem of CHPED. This method provides the effective result in minimizing the cost [6]. PSO algorithm is applied with time-varying acceleration coefficients. Non-convex problems are solved by using the proposed method of optimization. The results of this paper show that the proposed method works very effectively and provides the good solution to the CHPED problem [10].

WOA is whale optimization algorithm which is used to solve the CHPED problem. It is a meta-heuristic technique which is used for the effective optimization. It solves the non-convex problem of CHPED. The advent of stochastic search algorithms has provided alternative approaches for solving the CHPED problem. Improved ant colony search algorithm, evolutionary programming (EP) [4], the genetic algorithm, the harmonic search algorithm, and multi-objective particle swarm optimization (PSO) have been successfully applied to solve the CHPED problem.

Another method which is used for the optimization is PSO. Particle swarm optimization (PSO) is a population-based stochastic algorithm driven by the reenactment of a social mental representation rather than the survival of the fittest person. Roused by the swarm insight and probabilities speculations, this work shows the utilization of consolidating of PSO, Gaussian probability distribution functions and additionally turbulent groupings. In this specific circumstance, this paper proposes enhanced PSO approaches for settling EDPs that considers nonlinear generator components, for example, incline rate constrains and restricted working zones in the power framework operation [11].

II. LITERATURE REVIEW

Kim et al. [1] in this paper, the author case study the combined cooling power and heat problem. In this study, the author uses the HOMER software to solve the problem. This study is based on the buildings of the residential area. It shows the energy improvements in the residential and commercial area building. The main objective of this study is to analyze the energy efficiency using photovoltaic systems and absorption chillers. HOMER software is a program which is used for modeling the renewable micro-grid systems. The result shows that it is an energy efficient system.

Haji, V et al. [2] proposed a PSO algorithm which is based on the dynamic control parameters. This algorithm enhances the convergence rate and reduces the fitness function. It selects the coefficient which is based on the weight and population size. A controller which is based on the fuzzy id is also used with the PSO for the optimization. The proposed algorithm improves the performance of the single shaft. The proposed controller is used to control the loop and improve the response to the frequency drop and changing the load. The result of simulation shows that the proposed method works very effectively.

Beigvand et al. [3] the author proposed gravitational search algorithm to solve the CPHED problem. This algorithm is used to solve the non-convex problems. This algorithm is based on the gravitational law and law of particles motion. To check the effectiveness of the proposed algorithm it is applied on the different cases. The performance can be measure by checking the loading effect and transmission losses. The results show that this method is also operating at lower fuel cost.

Schmidla et al. [4] the aim of this paper is to integrate the renewable energies using the CHP with thermal storages. In the proposed approach the operation schedule of the system is calculated by using the linear optimization method. This method is proposed to expand the use of the renewable resources in the electrical power supply. The implementation results of the proposed approach show that it works effectively and efficiently.

Perea, E., et al. [5] proposed a new algorithm of optimization for the economic dispatch of combined power and heat. This method of optimization reduces the operating cost of the system. Hot water storage tanks are used to schedule the daily operations of the CHP device. It maximizes the benefits of the electricity that is generated and it covers the heat demand. The value of target function is minimized by the proposed optimization algorithm. The output of the optimization algorithm defines the operating set points of the CHP units. The results of the proposed methodology show that it is very cost effective.

Buonomano, Annamaria, et al. [6] the author reviewed the different method of solid oxide fuel gas and turbine technologies. The author investigated the power plants of the SOFG/ GT. Most of the system is fed by the methane which is easier to maintain and cheaper. In this type of system reforming process is required to convert the methane into hydrogen. In reforming process steam is the main constituent which is required. In this analysis author also analyze the configuration of the different layouts. The efficiency of the proposed system is very high. It is very flexible regarding the type of the fuel. The resulting analysis presents the SOFC/GT power plants can also be fed by alternative fuels like coal and biomass.

Mellal et al. [7] introduced the cuckoo algorithm of optimization with penalty function. This method of optimization is used to solve the problem of combined heat and power economic dispatch problem. In this paper, the author considers the two case studies. These two problems are solved by using the proposed method. The result of the paper shows that the PFCOA method works very effectively on both the cases and gives the better result than the existing method.

Mertzis, Dimitrios, et al. [8] in this paper the author discussed about the gasification of agricultural residue in CHP. The gasification process is combined with internal combustion engine which is operated as an electricity generator. This paper presents the unit performance of the operational stability. The results of the paper show the effect of the different type of biomass, parameters of gasification and engine intake.

Hagh, Mehrdad Tarafdar, et al. [9] proposed an improved group search optimization algorithm. In the existing method of search it only gives the near optimal solution. In IGSO it provides the optimal solution for the run time period. It used sinusoidal term and considers the effects of the valve and Kron formula is used to measure the transmission losses. This method solves the non-convex and non-linear problems. The results of the simulation show that it performs better than the existing GSO method and provides very effective results.

Jayabarathi, T., et al. [10] the author proposed an invasive weed algorithm which solves the problem of the economic power and heat dispatch problem. It is based on the weed colonization and distribution method. It solves the problem of the industries in which heat is consumed directly with the power. The cogeneration unit produced the heat and power and operates in the feasible zone. Each feasible zone as a specific value of the power and heat. The proposed method optimizes the fuel cost and provides the high improvement in results.

Behnam et al. [11] in this paper, the author proposed the solution for the combined power and heat problem by using the Particle Swarm Optimization (PSO) algorithm. In this work, it considers the valve-point effects. PSO algorithm is applied with time-varying acceleration coefficients. Non-convex problems are solved by using the proposed method of optimization. The results of this paper show that the proposed method works very effectively and provides the good solution to the CHPED problem.

III. PROPOSED METHODOLOGY

In PSO algorithm, every bird is denoted as a particle and have their own intelligence and some social behavior which coordinate their activities toward food or a destination. Initally, the process is started from swarm of particles. Each particle contains a solution to the related problem that is generated randomly and in every iteration it generates an optimal solution. The i[th] particle is bounded with a position in an s-dimensional space, in which s is the no. of particles involved in the problem. Position is determined by the values of s variables and possible solution to the problem after optimization. Ach particle i is determined by three vectors that are Current position L_i, its best position in the previous cycles, M_i, and its velocity by N_i.

Current position $L_i = (l_{i1}, l_{i2}, l_{i3} \dots \dots . . l_{is})$ (1)

Best position in previous cycle $M_i = (m_{i1}, m_{i2} \dots \dots \dots m_{is})$ (2)

Flight velocity $N_i = (n_{i1}, n_{i2}, n_{i3 \dots \dots \dots}, n_{is})$ (3)

This algorithm is based on the communication between the birds during the search of the food. Eacg bird look at the specific direction (its best ever attained position M_i) and later, when they communicate themselves thy go to the bird which is in the best position from the food. All the birds move towards the best position bird with a velocity that depends on the present velocity. Search space is examine by each bird from its current position.

Artificial Bee Colony Algorithm

Artificial bee colony algorithm is a Meta heuristic algorithm which is used for the optimization and solves the numerical problems. The idea behind the algorithm was developed by inspiring from the foraging behavior of bees. The model of ABC consists of three main parts: employed bees, unemployment bees and food sources. The first two parts s, looking for a rich source of food, this is the third part, which is close to their hive. To apply ABC, optimization problems under consideration are first converted to the problem of minimizing the objective function to find the optimal parameter vector. Then, artificial bee randomly found the first solution vector populations, and then iteratively improve them by using the different techniques: move to a better solution through a mechanism neighbor search, while giving up bad solution.

Algorithm

Initialization Phase

The initial food sources are randomly produced by the equation

$$x_m = l_i + rand(0,1) * (u_i - l_i) \dots \dots \dots \dots (i)$$

Where u_i and l_i are the upper bond and lower bond of the solution space of objective function, rand (0, 1) is a random number with in the range [0, 1].

Employed Bee Phase

The neighbor food source v_{mi} is determined and calculated by the following equation.

$$v_{mi} = x_{mi} + \Phi_{mi}(x_{mi} - x_{ki}) \dots \dots \dots \dots (ii)$$

Where i is a randomly selected parameter index, x_k is a randomly selected food source, ϕ_{mi} is a random number within the range [-1, 1]. The fitness is calculated by the following formula (3), after that a greedy selection is applied between x_m *and* v_m.

$$fit_m(x_m) = \frac{1}{1+f_m(x_m)}, f_m(x_m) > 0 \text{ and } fit_m(x_m) = 1 + |f_m(x_m)|, f_m(x_m) < 0 \dots \dots . . (iii)$$

Where, $f_m, (x_m)$ is the objective function value of x_m.

Onlooker Bee Phase

The quantity of food source is evaluated by its profitability and the profitability of all food source. P_m is determined by the formula

$$P_m = \frac{fit_m(x_m)}{\sum_{m=1}^{SN} fit_m(x_m)} \dots \dots \dots \dots (iv)$$

Where, $fit_m(x_m)$ is the fitness of x_m. Onlooker bees search the neighborhoods of food source according to the expression

$$v_{mi} = x_{mi} + \phi_{mi}(x_{mi} - x_{ki}) \dots \dots \dots \text{(v)}$$

Scout Phase

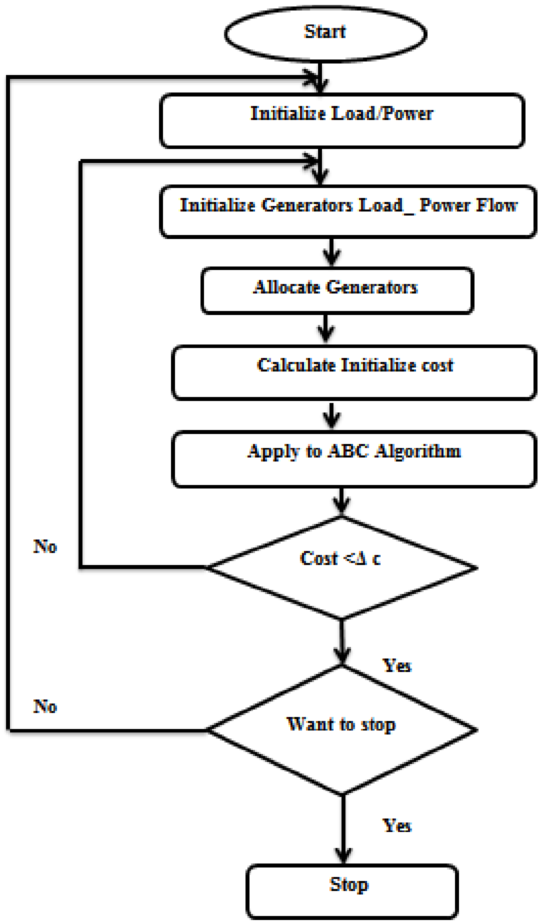
The new solutions are randomly search by the scout bees.

The new solutions x_m will be discovered by the scout by using the following expression

$$x_m = l_i + rand(0, 1) * (u_i - l_i) \dots \dots \dots \text{(vi)}$$

Where, $rand(0, 1)$ is a random number within the range [0, 1], u_i *and* l_i are the upper and lower bound of the solution space of objective function.

Check whether the solution is optimized or not if optimized follows the next step. If not optimized again sent back to the optimizer.



Methodology Explanation:
Step 1: Start
Step 2: In this step initialize the load/power.
Step3: In this step initialize the generator load_ Power flow.
Step4: In this step allocate the generator.
Step5: After allocation the generator calculate the initial cost.
Step6: When cost is initialized then apply the ABC algorithm.
Step7: After applying the ABC algorithm get the cost value.
Step8: If cost is less than Δc then go the next step. If cost is not less than the Δc then go the step3.
Step9: In this step if want to stop then stop, if don't want stop then go to the step2.
Step10: Stop.

IV. RESULTS

By using ABC for solving CHPED problem this research work has been performed in FORTRAN-90. Within a feasible operating region in order to obtain an optimal solution, different values of ABC parameters are taken. PSO and ABC parameters include inertia weight, Acceleration constant. Optimally for best solution these parameters have been set.

Table 4.1: Comparing different techniques results obtained in 5000 iteration:

Generators value	PSO	ABC
P1	49.1180	25.6793
P2	79.7093	52.2061
P3	75.8260	16.3984
H1	50.6900	3.4936
H2	79.7093	36.4806
H3	42.2454	76.5153

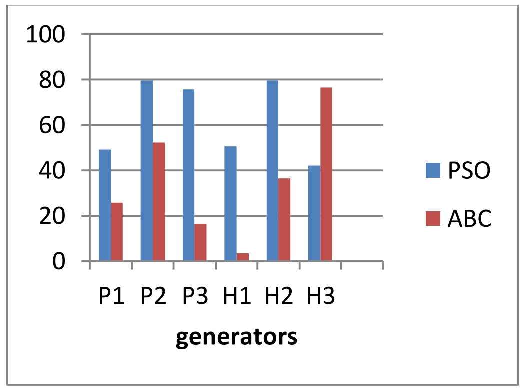


Figure 4.3: Comparison of PSO and ABC With 5000 Iterations

Table 4.4: Comparing different techniques results obtained in 10000 iterations:

Generators value	PSO	ABC
P1	46.7656	71.3459
P2	80.4038	71.3878
P3	76.9527	61.3878
H1	28.2632	36.4756
H2	51.7430	49.1842
H3	36.4096	30.8018

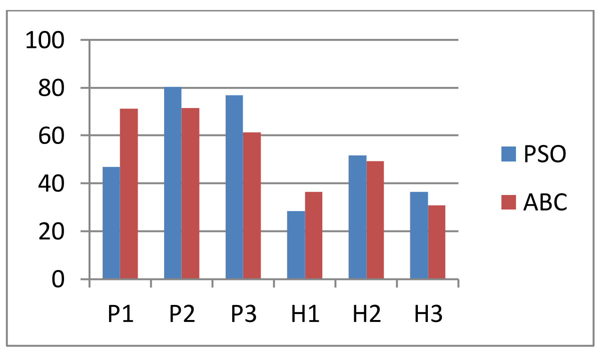


Figure 4.4: Comparison of PSO and ABC With 10000 Iteration

Table 4.5: Comparing different techniques results obtained in 15000 iterations:

Generators value	PSO	ABC
P1	47.7377	45.2936
P2	81.3814	81.1570
P3	75.8260	77.6773
H1	19.7110	25.9807
H2	54.9481	53.5801
H3	42.2454	36.8061

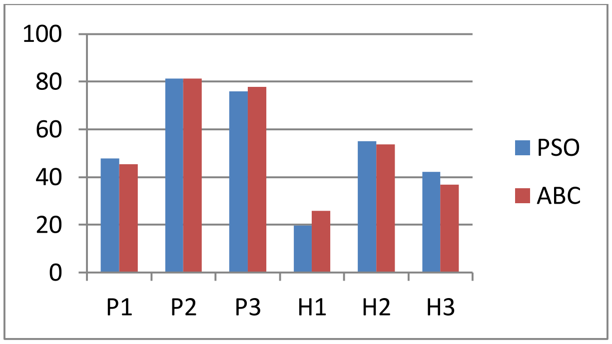


Figure 4.5: Comparison of PSO and ABC with 15000 Iterations

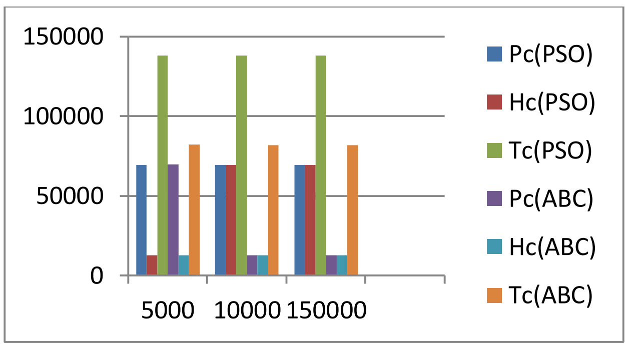


Figure 4.5: Comparing different techniques results obtained in iterations

V. CONCLUSION

In this study, two methods (lambda iteration method and ABC) are implemented to examine the superiority between them. Lambda iteration method is conventional method but ABC is population based search algorithm. ABC displayed high quality solution along with convergence characteristics. The plotted graphs for both three unit system and six unit systems showed the property of convergence characteristic of ABC . The reliability of ABC is also superior. The faster convergence in ABC approach is due to the employment of inertia weight factor which is set to be at 0.9 to 0.4(In fact, it decreases linearly in one run). As far as the fuel cost is concerned, it is small for three unit system but it is reasonably good for six unit system.

VI. REFERENCES

[1]. Kim, Insu, Jean-Ann James, and John Crittenden. "The case study of combined cooling heat and power and photovoltaic systems for building customers using HOMER software." *Electric Power Systems Research* 143 (2017): 490-502.

[2]. Haji, V. Haji, and Concepción A. Monje. "Fractional order fuzzy-PID control of a combined cycle power plant using Particle Swarm Optimization algorithm with an improved dynamic parameters selection." *Applied Soft Computing* 58 (2017): 256-264.

[3]. Beigvand, Soheil Derafshi, Hamdi Abdi, and Massimo La Scala. "Combined heat and power economic dispatch problem using gravitational search algorithm." *Electric Power Systems Research* 133 (2016): 160-172.

[4]. Schmidla, Tim, and Ingo Stadler. "Prospective Integration of Renewable Energies with High Capacities Using Combined Heat and Power Plants (CHP) with Thermal Storages." *Energy Procedia* 99 (2016): 292-297.

[5]. Perea, E., et al. "A novel optimization algorithm for efficient economic dispatch of Combined Heat and Power devices." *Energy and Buildings* 111 (2016): 507-514.

[6]. Buonomano, Annamaria, et al. "Hybrid solid oxide fuel cells–gas turbine systems for combined heat and power: a review." *Applied Energy* 156 (2015): 32-85.

[7]. Mellal, Mohamed Arezki, and Edward J. Williams. "Cuckoo optimization algorithm with penalty function for combined heat and power economic dispatch problem." *Energy* 93 (2015): 1711-1718.

[8]. Mertzis, Dimitrios, et al. "Performance analysis of a small-scale combined heat and power system using agricultural biomass residues: The SMARt-CHP demonstration project." *Energy* 64 (2014): 367-374.

[9]. Hagh, Mehrdad Tarafdar, et al. "Improved group search optimization method for solving CHPED in large scale power systems." *Energy Conversion and Management* 80 (2014): 446-456.

[10]. Jayabarathi, T., et al. "Combined heat and power economic dispatch problem using the invasive weed optimization algorithm." *Frontiers in Energy* 8.1 (2014): 25.

[11]. Mohammadi-Ivatloo, Behnam, Mohammad Moradi-Dalvand, and Abbas Rabiee. "Combined heat and power economic dispatch problem solution using particle swarm optimization with time varying acceleration coefficients." *Electric Power Systems Research* 95 (2013): 9-18.