Economic Load dispatch with Heat and Power by Proposed Convex Optimizer

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Abstract - The modern power system around the world has grown in complexity of interconnection and power demand. The focus has shifted towards enhanced performance, increased customer focus, low cost, reliable and clean power. In this changed perspective, scarcity of energy resources, increasing power generation cost, environmental concern necessitates optimal economic dispatch. In reality power stations neither are at equal distances from load nor have similar fuel cost functions. Hence for providing cheaper power, load has to be distributed among various power stations in a way which results in lowest cost for generation. Practical economic dispatch (ED) problems have highly non-linear objective function with rigid equality and inequality constraints. Particle swarm optimization (PSO) is applied to allot the active power among the generating stations satisfying the system constraints and minimizing the cost of power generated. The viability of the method is analyzed for its accuracy and rate of convergence

Keywords *- PSO, ELD, Optimization*

1. INTRODUCTION

Generation of electricity is done by using heat engines which are used to convert heat energy into electrical energy and this heat is produced from combustion of fossil fuel, coal etc. This combustion induces pollution in the environment by releasing harmful gases like SO_2, CO etc. In the previous stage, we used to generate electricity from a heat engine, power plant. With the development of the technology the methods for generation is integrated, now we used to combine heat and power process for better efficiency [5]. The combined heat and power unit is also termed as co-generation and termed as CHP. As it is a combination of heat and power it classifies as a most fruitful form of power generations because the combined form of heat and power gives fuel efficiency and also helps to reduce the transmission losses. CHP has the capability to change single fuel into electricity as well as heat energy in a single process. CHP has a special place in the utility industries. CHP gives more efficiency with fuel rather than by electricity generation. The waste electrical energy declared from the individual production is also utilizes by CHP for a different kind of work. CHP can use this wasted energy in the form of combined heat and power district heating (CHPDH). The efficiency of the individual process for generation is up to 55 % whereas; this efficiency is increased to 90% by applying CHP or implementing CHP. If we talk about the environmental effect of CHP there is a reduction in the pollutant gaseous like SO_2, CO etc. up to 13 to 15 %.

AS every positive element has some negative part, this method also has some drawbacks which are termed as an Economic dispatch (ED). ED is the most important optimization problem in the CHP. CHP dispatch deals with the distribution of power to the consumer. The main problem arises in the case of distribution because 13- 16 % of energy is wasted during transmission of energy from one place to another. As CHP is the combination of heat and power demand gets double for heat as well as power and more complex its distribution. The main goal of any organization is to utilize maximum to maximum energy and there is a minimum amount of loss of the energy. The economic dispatch problem in CHP is termed as CHPED.

There are many economic dispatch problems like in valve point, multiple areas for load dispatch, economic-environment dispatch or cubic cost function ED etc. The author used to research the solution to the given problem and they provide many solutions to resolve the CHPED. The below literature survey gives the highlight on the various techniques represented by the author's to resolve the dispatch problems.

II. LITERATURE REVIEW

Gazijahani,et al. [1]: In this paper, there is a study on the effect of DRP on the operation of SDS and author also used to investigate the optimal scheduling of DER units from economic and decisive. It is assumed in this investigation that network is supplied with renewable energy resources and ESS. The main purpose of optimization is to reduce all over cost. To reduce the objective function ACO is implemented. The results demonstrate that the proposed framework is efficient and significant in terms of optimal operations.

Jayakumar, et al. [2]: In this paper, to solve the dispatch problems author gives an algorithm called as grey wolf optimization. The significance of GWO is examined by applying it to the problems of static, economic, and dynamic economic dispatch. These three are the main problems of combined heat and power dispatch and used to assume the practical aspects like effects of valve point, emission, loss during transmission etc. The proposed approach is used to reduce the fuel cost and fuel emission simultaneously. The outcomes obtain from GWO is then used to compare with the algorithm or result from the literature survey on state-of-art. The comparative result demonstrates the quality performance of GWO

Ghorbani, et al. [3]: In this paper, to resolve the problems of CHPED author used to introduce exchange market algorithm (EMA).This is a quite strong algorithm which contains 2 strong absorbing operators and 2 active searching operators with help of which EMA is capable to conclude optimum point from optimization problem. To verify the working of the proposed algorithm on the problem of CHPED various factors are used to optimize like valve-point effect, power loss and system constraints. The outcome demonstrates the quality of EMA to solve the problems.

Mellal, et al. [4]: In this paper**,** there is an investigation on the problems or major issues in combined heat and power economic dispatch. The author gives an introduction to Cuckoo optimization algorithm co-powered by penalty functions to resolve investigated problems. In this paper, two case studies on CHPED is investigated and solve the problems by using proposed approach. The outcome obtains from the proposed method is used to compare with another examined results in terms of optimizations. The result after comparison demonstrates the quality of proposed method.

Chen, et al. [5]: The paper gives analysis on the integration of the flexibility of combined heat and power by using electrical boiler and heat storage tanks. In this paper, to upgrade the energy system on heat and power a linear model is introduced by the author. The model is presented with a complete description of charging process in the heat storage tanks. The model used to stabilize the demands of heat and power from multiple areas in different-different duration with energy sources like CHP, wind power etc. The result demonstrates the effectiveness and significance of electrical boiler and heat storage tanks. They are able to integrate the flexibility of CHP and very important they can reduce curtailment of wind and save energy in energy system respectively.

Azizipanah-Abarghooee, et al. [6]: In this paper, to manage the CHPELD which stands for combined heat power economic load dispatch a multi-objective indeterminate framework on the basis of CCP stands for chance-constrained programming is proposed by the author. This proposed approach was taken following characteristics into consideration like wind outputs, PV outputs, consumer's heat and electrical demand. Here we used to formulate SMCPED is the proposed approach and utilizes CCP in the concept of a jointly distributed random variable (JDRV). The author also used to develop a new algorithm by combining CSA and DE. The author used to evaluate the Pareto optimal solution by using hybridized cuckoo search algorithm for risk over cost minimization. This framework is verified by implementing this on 5-40 test system for attaining minimum cost and maximum probability to obtain targeted cost.

Adhvaryyu, et al. [7]: In this paper, to resolve the optimization task in combined heat and power economic dispatch (CHPED) the author represent the bio-inspired new krill herd (KH) algorithm. This prosed algorithm is significant for the determination of global optima in short duration and is based on the individual behavior of krill herding. The main goal of this function is to identify the distance between individual krill. The position of krill depends upon the motion generated by surrounded krill, its foraging motion and diffusion motion. The working of this proposed algorithm is examined by simulation process and the outcome is used to compare with other optimization technique like PSO, EP, and DE. The comparative results show that solution attains by KH is quite better than other methods.

Cho, et al. [8]: In this paper, the author used to give a review of combined cooling, heating and power system that is termed as (CCHP). This paper gives a summary of the improvement in the performance of energetic and energetic analysis. There is also a review of the optimization algorithm and approach which can be used to improve the working of CCHP. This paper presents most illustrious research and emanating trends in CCHP technologies. It is declared that the information given in this review is quite beneficial and valuable. In term of research, design, and guidance for further work. The distance in the present CCHP research and its development is discussed by the author.

Gu, et al. [9]: In this paper, the authors used to give a discussion on the modeling, planning and energy management of the CCHP microgrid. The working of CCHP microgrid depends upon the design and energy management of microgrids. For planning and management of energy, the essential step is model accurately therefore, this paper gives a discussion about the modeling of CCHP microgrid. There are many evaluating and indicating methods for the planning of CCHP microgrid. At last, there is a discussion on energy management of the CCHP microgrid from different aspects like cogeneration decoupling, control approaches etc.

Zhao, et al. [10]: In this paper, there is a brief discussion on the historical development of thermoelectric cooling and its material and the attainment of the thermoelectric materials. Various techniques are represented for thermoelectric element modeling and thermoelectric cooler to enhance the thermoelectric cooling system performance. Finally there is a discussion on the application of cooling application like domestic refrigeration, electronic cooling etc. It is assumed that the given discussion is fruitful to the thermoelectric cooling system in terms of design, simulation, and analysis.

Liu, et al. [11]: In this paper, a survey is held on the approach of CCHP like state-of-the-art in four parts. In the first part, enhancement and execution approach of CCHP is given by the authors and analysis on the merits of CCHP and detail discussion on the introduction of the related component is given. In the second part, illustration is done to introduce prime mover and thermally activated facilities. In the third part, there is a discussion on the current progress in terms of management, control, optimization etc. In the last part, there is in the enhancement of CCHP system and discussion about their problems in listed countries.

Karami, et al. [12]: In this paper, the author deals with the residential hybrid thermal, electrical-connected homes energy system which contains a fuel cell with CHP and a battery as ESS stands for energy storage system. In this paper, to generate the efficient table which indicates the optimal operational schedule there is an enhancement of day-ahead scheduling algorithm to maintain different resources. The main purpose of this generation is for the distribution of energy resources at an individual time interval to reduce the operational cost of a smart house. While optimization the effect of electricity tariff and the efficiency of the energy storage system are taken into consideration.

III. PROPOSED WORK

A. The PSO Algorithm

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 itsvelocity by N_i.

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

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

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

In each iteration,eq 4 calculate the current position and velocity

$$l_i' = l_i + N_i' \quad (4)$$

The new velocity is given by the euation 5.

$$N_i' = \omega N_i + a_i rand(\quad)(M_i - L_i) + a_2\, rand(\quad)(M^* - L_i) \quad (5)$$

Here,

- a_1, a_2 are two positive elements which shows the learning factors.
- Rand () function gerenrates the random number in eq 5
- ω is factor of interia. Local and global search vconbgtrols by it and it changes in every iteration of serach.
- $M_i$best present solution among all.

Algorithm

Step 1: Generate random solutions.

Step 2: Search the best solution from the random solutions.

Step 3: Repeat the following step until the condition is not stopped.

3.1 Calulate the ω .

3.2 Loop i =1,2…..n

Begin

- Compute the value of objective function for solution i.
- If particle I gives the better value for the objective function, let I is the best solution.

- Compute new velocity for particle i using equation 5.
- Compute the new position for particle i using equation 4.

END

B. 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

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

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.

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

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 betweenx_m and v_m.

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

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

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

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

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

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

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

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.

III. CONCLUSION

PSO method is proposed to be employed to solve the ELD problem for two cases one three unit system and another six unit system. The PSO algorithm is expected to show superior features including high quality solution, stable convergence characteristics. The solution is close to that of the conventional method but is expected to give better solution in case of higher order systems. The comparison of results for the test cases of three unit and six unit system are expected to clearly show that the proposed method is indeed capable of obtaining higher quality solution efficiently for higher degree ELD problems. The convergence tends to be improving as the system complexity increases. Thus solution for higher order systems can be obtained in much less time duration than the conventional method

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