ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 9, Issue 3, March 2022

Simulated Annealing (SA) Algorithm based Economic Load Dispatch with Optimal Power Flow

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Abstract**:** The Economic dispatch with optimal power flow is allocated for generator production. We must consider all limitations and economical mode and network constraints. The Power users are organized in their efforts towards networks with high generation and minimum fuel costs. In large scale system, non-linear problems are solved with the help of optimization methods. In this paper simulated annealing (SA) method is used to solving the non linear problems. The validity and effectiveness of the proposed integrated algorithm has been tested with IEEE 30 bus system. Numerical results show that the proposed integrated Algorithm can provide accurate solutions with reasonable time for any type of fuel cost functions.

Keywords: Economic Load dispatch, Optimal Power Flow, Simulated Annealing.

I. Introduction

In this paper Economic Load dispatch with optimal power flow problem played a vital role in large networks. To improve its formulation and adopt efficient techniques in the economic dispatch problem. Economic dispatch is aimed at determining the Power output combination of on line generating units that minimizes fuel costs while simultaneously satisfying all unit and system equality and inequality constraints. Economic load dispatch has been utilized for this purpose and widely accepted by most of the utilities and implemented in the dispatch centres. Economical operation is very important for a power system to return a optimal generation on the invested fuel cost. Operational economics involving power generation and delivery can be divided in to two parts, one dealing with minimum cost of power production called economic load dispatch and the other dealing with minimum loss delivery of generated power to the loads. The economic dispatch problem can be solved by means of the optimal power flow. The optimal power flow is used determine the optimal output of the generators in view of minimizing fuel cost and transmission losses.

Simulated Annealing (SA) is the general purpose stochastic search technique to solve hard constrained optimization problems. The technique has many features but it takes long time. It is easy to find optimal solution with a high probability. The simulated Annealing optimization technique begins with a randomly generated solution and then making successive random modifications until a end process is satisfied. A survey of existing Literature [1-20], on the problem reveals that various numerical optimizations techniques have been employed to approach the complicated economic dispatch problem. The dynamic programming (DO) methods, Linear Programming (LP) methods, Newton Raphson Method (NR) Hop Field (HF) Method, Genetic Algorithm (GA), Particle Swam Optimization (PSO) and non-convex economic dispatch.

Economic load dispatch is one of the main functions of the modern energy management system which determines the optimal real power settings of generating units with an objective to minimize the total fuel cost of economic dispatch. From the Literature review, a need for evolving simple and effective methods for obtaining an optimal solution for the Economic load dispatch. An attempt has be made with simulated Annealing is used to solve these ELD

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problems, which eliminates the above mentioned drawback. In SA, the fuel cost and demand are taken as control parameters. The Algorithm is based on the Annealing neural network. Classical optimization methods are a direct means for solving this problem. SA has the great advantage of good convergence property and the execution time is considerably reduced. It has good solution quality for ELD problems. It is the capable of determining the global or nearest global solutions. It is based on the basic genetic operation of human chromosomes. It operates with the stochastic mechanics, which combine off spring creation based on the performance of solution. In this proposed work the parents are obtained from a predefined set of solutions to meet the requirements. The selection process is done by using Evolutionary strategy. The validity and effectiveness of the proposed Algorithm has been tested with IEEE 30 bus system.
Acquiring primary energy and storing it via a DC bank with subsequent processing with AC rectifier is carried out [21]. In [22], efficient power factor is derived with "Flyback converter" for providing high efficiency.

II. Optimal Power Flow Problem

A. Mathematical Formulation

The optimization of production cost function F of generation has been formulated based on classical OPF problem without violating system constraints. For a given power system network, the optimization of production cost of generation is given by the following equation.

a) **Base case** (Optimal generation without any wheeling transaction)

For a given power system network, the optimization cost of generation is given by the following equation.

$$C = \min \sum_{i=1}^{Ng} fi(P_{Gi})\,\$/hr \qquad (1)$$

Where,

C = Optimal cost of generation when the utility supplying its own load.

$fi(P_{Gi})$ = Generation cost function of the generator for P_{Gi} generation.

N_g = Number of generator connected network.

b) The operating cost function of the power producer is optimized with the following power system constraint

$$C = \min \sum_{i=1}^{Ng} P_{Gi} = P_d + P_l \qquad (2)$$

Where,

P_d = Total load of the system.

P_l = Transmission losses of the system (when the utility supplying its own load)

c) The power flow equation of the power network,

$$g(|v|, \phi) = 0 \qquad (3)$$

Where

|v| and ϕ is a voltage magnitude and phase angle of different buses

d) The in-equality constraint on real power generation P_{Gi} of each generation i

$$P_{Gi}^{min} \le P_{Gi} \le P_{Gi}^{min} \qquad (4)$$

e) The in quality constraint on voltage of each PQ bus

$$V_i^{min} \le V_i \le V_i^{max} \qquad (5)$$

Where,

V_i^{min} and V_i^{max} are respectively minimum and maximum voltage at bus i.

f) Power Limit on transmission Line

$$MVAf_{p,q} \le MVAf_{p,q} \qquad (6)$$

Where,

$MVAf_{p,q}$ is the maximum rating transmission line connecting BVS P and q.

III. SIMULATED ANNEALING

The simulated Annealing technique is an algorithm, which exerts the resemblance between the annealing of a metal and a minimization process. A metal is a system of many atoms. The total internal energy of the metal depends on its state in the form of relative position, orientation and

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motion of the atoms in the metal. Although the prediction of a specific state is almost impossible due to the extremely rapid microscopic movement of the atoms, the statistical properties of many replica systems of atoms in their equilibrium can be characterized. It has been observed that when a metal is annealed or cooled slowly. The energy of the metal tends to assume the global minimal value.

Simulated Annealing generates feasible solutions of a minimization problem which correspond to the states of metal, with the cost of a feasible solution corresponding to the energy of the metal in a state. By moving among the feasible solutions the way the states of a metal under the annealing would evolve, the global optimum of the problem can be approached with high probabilities. Simulated Annealing has been successfully applied to many difficult combinational optimization problems. The method assumes no special problem structure and is highly flexible with expect to various constraints.

III.A. Simulated annealing Algorithm to solve Economic load dispatch

The Algorithm are as follows:

1. Initialize the power loadings or parent vectors $P=[P_1, P_2, \ldots\ldots P_n]$, $i = 1,2,\ldots.N_p$
2. Evaluate the fuel cost F objective function, using the trial vector P_i and find the minimum of F.
3. Initialize the temperature T and local loop counter M.
4. Generate neighbourhood solutions P^1 for the initial power loadings by adding the Gaussian random variables to the current solution.

4a. Calculate the standard deviation
$\sigma i = \beta * f_{pi}/f_{min} (P_{i,max} – P_{i,min})$

4b. Add a Gaussian random variable, N (O, σi^2) to all the component of P_i, to get P^1_i

5. Evaluate the objective function using P^1. Find the difference ΔF is F and F^1.
6. Evaluate the probability of acceptance ρ as $\rho=1/(1+\exp(\Delta F/T))$
7. Accept P^1 as the new solution if ρ = random (0, 1) , otherwise go to the initial power loadings.
8. Increment the counter m and repeat from step 3 until m reaches its maximum value.
9. If m reaches its maximum value increase T by $T= \rho T$, Where $\rho<1$, is the scaling factor and repeat from step 3 until T reaches its minimum limit.

IV. CONCLUSION

The simulated Annealing algorithm is used to solve the economic load dispatch in a dynamic manner, the proposed technique, which aims at minimizing fuel cost with several constraints. Our proposed approach satisfactory finds global optimal solution within a small no off iteration. But as the other evolutionary methods like SA-OPF, almost better results for most of the cases. Simulated Annealing is known to converge to the global minimum with a probability of unity and thus improves any given solution in computation time.

VI. SIMULATION RESULTS

The SA-OPF Algorithm was applied to the IEEE 30 bus standard test system.

a. Base Case
(Optimal generation of 6 – Generating Plants)

For the base case optimal generation (MW) of the generation, unit of the utility is presented in Table 1.

The total cost of generation for base case optimal schedule is C = 759.89 $ / hr.

Table 1 Base Case

Output		
Total Power Demand		299 MW
Power Generated	P_1	175 MW
	P_2	23 MW
	P_5	26MW
	P_8	27MW
	P_{11}	21MW
	P_{13}	27MW
Total Fuel Cost		759.89 $ / hr
No. of Iterations		100
Execution Time		1.222 sec

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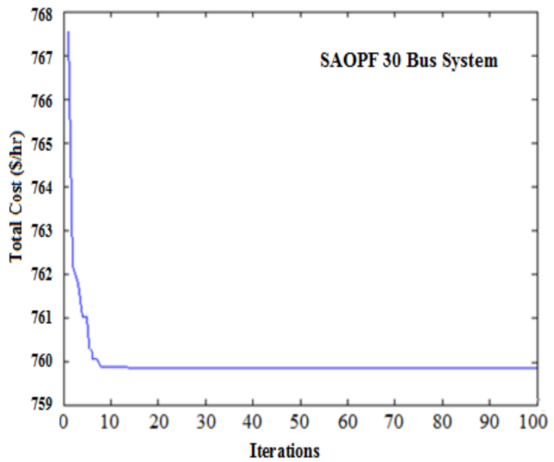

REFERENCES

[1]. Ross DW, Kim S. Dynamic economic dispatch of generation. IEEE Trans Power Apparatus Syst 1980;99(1):2060–88.

[2]. Liang ZX, Glover JD. A zoom feature for a dynamic programming solution to economic dispatch including transmission losses. IEEE Trans Power Syst 1992;7:544–50.

[3]. Sheble GB, Brittig K. Refined genetic algorithm economic dispatch example. IEEE Trans Power Syst 1995;10:117–24.

[4]. Nanda J, Kothari DP, Srivastava SC. New optimal power dispatch algorithm using Fletcher's quadratic programming method. ProcInstElectrEng C 1989;136(3):153–61.

[5]. Hota PK, Chakrabarti R, Chattopadhyay PK. Economic emission load dispatch with line flow constraints using sequential quadratic programming technique. J InstEng (India) 2000;81:39–43.

[6]. Chen JF, Chen SD. Multi objective power dispatch with line flow constraints using the fast Newton–Raphson method. IEEE Trans Energy Convers 1996;12:86–93.

[7]. Park JH, Kim YS, Lee KY. Economic load dispatch for piecewise quadratic cost function using Hopfield neural network. IEEE Trans Power Syst 1993;8:1030–8.

[8]. Lee KY, Yome AS, Park JH. Adaptive Hopfield networks for economic load dispatch. IEEE Trans Power Syst 1998;13:519–26.

[9]. Srinivasan D, Chang CS, Liew AC. Multi objective generation schedule using fuzzy optimal search technique. ProcInstElectrEng – Gen Trans Dist 1994;141:231–41.

[10]. Wang KP, Fung CC. Simulated annealing based economic dispatch algorithm. ProcInstElectrEng C 1993;140:509–15.

[11]. Whei-Min Lin, Fu-Sheng Cheng, Ming-Tong Tsay. An improved tabu search for economic dispatch with multiple minima. IEEE Trans Power Syst 2002;17(1):108–12.

[12]. JaruroteTippayachai, WeerakornOngsakul, IssarachaiNgamroo. Parallel micro genetic algorithm for constrained economic dispatch. IEEE Trans Power Syst 2002;17(3):790–7.

[13]. Fukuyama Y, Chiang HD. A parallel genetic algorithm for generation expansion planning. IEEE Trans Power Syst 1996;11:955–61.

[14]. Dakuo He, Fuli Wang, Zhizhong Mao. A hybrid genetic algorithm approach based on differential evolution for economic dispatch with valve-point effect. Int J Electr Power Energy Syst 2008;30:31–8.

[15]. Krishna TeerthChaturvedi, ManjareePandit, LaxmiSrivastava. Particle swarm optimization with time varying acceleration coefficients for non-convex economic power dispatch. Int J Electr Power Energy Syst 2009;31:249–57.

[16]. Baskar G, Mohan MR. Security constrained economic load dispatch using improved particle swarm optimization suitable for utility system. Int J Electr Power Energy Syst 2008;30:608–13.

[17]. Coelho Leandro dos Santos, Lee Chu-Sheng. Solving economic load dispatch problems in power systems using chaotic and Gaussian particle swarm optimization approaches. Int J Electr Power Energy Syst 2008;30:297–307.

[18]. Ranjit Roy, Ghoshal SP. A novel crazy swarm optimized economic load dispatch for various types of cost functions. Int J Electr Power Energy Syst 2008;30:242–53.

[19]. Wang Lingfeng, Singh Chanan. Stochastic combined heat and power dispatch based on multi-objective

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particle swarm optimization. Int J Electr Power Energy Syst 2008;30:226–34.

[20]. Basu M. Dynamic economic emission dispatch using non dominated sorting genetic algorithm-II. Int J Electr Power Energy Syst 2008;30:140–9.

[21]. Simon, J., Monika, V., Santhiya, V. N. S., & Evangeline, E. S. (2017, September). Multisource energy harvesting architecture for electrical applications. In 2017 IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI) (pp. 1812-1816). IEEE.

[22]. Shyni, S. M., Simon, J., Memala, W. A., & Bhuvaneswari, C. (2020, November). Implementation of Integrated SEPIC-Flyback Converter for LED Drive with Efficient Power Factor. In 2020 4th International Conference on Electronics, Communication and Aerospace Technology (ICECA) (pp. 385-389). IEEE.