Comparison of Classical Method and Soft Computing Optimization Algorithm applied to Economic load Dispatch Problem

Anil K Jain
Department of Electrical and Electronics Engineering
SVITS, Indore, M.P., India

Toshi Mandloi
Department of Electrical and Electronics Engineering
SVITS, Indore, M.P., India

Abstract- This paper presents a comparative study of classical method and soft computing optimization algorithm applied to solve Economic Load Dispatch problem with non-smooth fuel cost curves considering transmission losses, power balance and capacity constraints. The soft computing algorithm varies from the classical method in terms of the following basic factors. The genetic algorithm based approach produces significantly better solutions compared against those obtained using the standard economic dispatch approach. It also proves the robustness of this algorithm in solving this type of optimization problem. GA differs from Classical optimization techniques in that it works on a population of solutions and searching is on a bit string encoding of the real parameters rather than the parameters themselves. Also GA uses probabilistic transition rules. The performance of the soft computing algorithm is investigated and tested with a three generator power system. Simulation results are presented to show the comparative performance of these methods.

Keywords – Lambda iteration Method, Economic Load Dispatch, Genetic Algorithm.

I. INTRODUCTION

In a practical power system, the power plants are not located at the same distance from the centre of loads and their fuel costs are different. Also, under normal operating conditions, the generation capacity is more than the total load demand and losses. Thus, there are many options for scheduling generation. In an interconnected power system, the objective is to find the real and reactive power scheduling of each power plant in such a way as to minimize the operating cost. This means that the generators real and reactive power is allowed to vary within certain limits so as to meet a particular load demand with minimum fuel cost. This is called the optimal power flow (OPF) or economic load dispatch problem (ELD). The ELD is used to optimize the power flow solution of large scale power system. This is done by minimizing selected objective functions, the objective functions also known as cost functions, may present economic costs, system security, or other objectives. Economic load dispatch problem is an optimization problem where objective function is highly non linear, non-convex, non differentiable and may have multiple local minima. Therefore, classical optimization methods may not converge or get trapped to any local minima. This paper presents a comparative study of Classical Method and Soft Computing Optimization Algorithm to solve Economic load Dispatch Problem. The methods are tested on three generator power system.

The classical approach to the Economic Load Dispatch Problem (ELD) seeks to minimize the cost of generation subject to the certain constraints. Economic load dispatch (ELD) problem is one of the most important in power system operation and planning. So many models by using different techniques have been used to solve these problems. Lambda iteration method (LIM) offers a suitable and classical approach to meet the objectives of to determine the optimal combination of power outputs of all generating units so as to meet the required demand at minimum cost while satisfying the generator constraint. This paper presents an improved fast and reliable technique to solve ELD Problem using Lambda iteration method (LIM) in MATLAB environment for three generator units. The ELD problem has been solved by the Lambda iteration method. The technique is quite effective, but has some limitations. For example, it is pointing out the fuel cost curve of the ELD which is not necessarily quadratic. This implies that the mathematical programming cannot be applied to such a problem. In recent years, genetic algorithms (GAs) have been studied to solve the combinatorial problems. GA is a kind of the probabilistic heuristic algorithm that is able to find the global minima. The basic idea is analogous to the natural selection of the biology. GA has an advantage that the cost function does not necessarily require the gradient. In that sense, the method is more flexible in solving the combinatorial problems. Also, GA is based on finding the global maxima with a group of solution candidates.

II. ELD Problem Formulation:

When the distances of generating plants from the loads are different, the cost of different transmission losses will affect the economic distribution. The economic dispatch problem is to simultaneously minimize the overall cost rate and meet the load demand of a power system. For a power system model consisting of NG generating units, let C1, C2, …. Cn, represents the fuel cost of individual plants, and P1, P2, ….. Pn, represents the power output respectively. P_D is total power received by the load and P_L the total transmission losses. The ELD problem considering transmission losses can be stated as follows.

Minimize $C = \sum_{i=1}^{NG} C_i$ (1)

Where $C_i = \alpha_i + \beta_i P_i + \gamma_i P_i^2$, and

Subject to the constraint

$P_D + P_L - \sum_{i=1}^{NG} P_{gi} = 0$ (2)

Eq.(2) is the active power balance equation.

The output power of each generation unit is bounded between two limitations is,

$P_{gi}(min) < P_{gi} < P_{gi}(max)$

For i= 1 to NG.
Where P_{gi} (min) , P_{gi} (max), denote the minimum and maximum output power generation of unit i.

A. Lambda Iteration Method

Lambda iteration method is more conventional to deal with the minimization of cost of generating the power at any demand. Lambda iteration method is one of the methods used in solving the system lambda and ELD problem. The problem may be expressed as the Lagrange function which consists of the cost function and constraints. A typical approach is to augment the constraints into objective function by using the Langrangian multipliers. Lambda is the variable introduced in solving constraint optimization problem and called a Lagrange multiplier. Lambda iteration is mostly used for the sake of computing lambda and other associated variables using a computer. Flow Chart of Lambda iteration method for ELD is given below in fig 1:

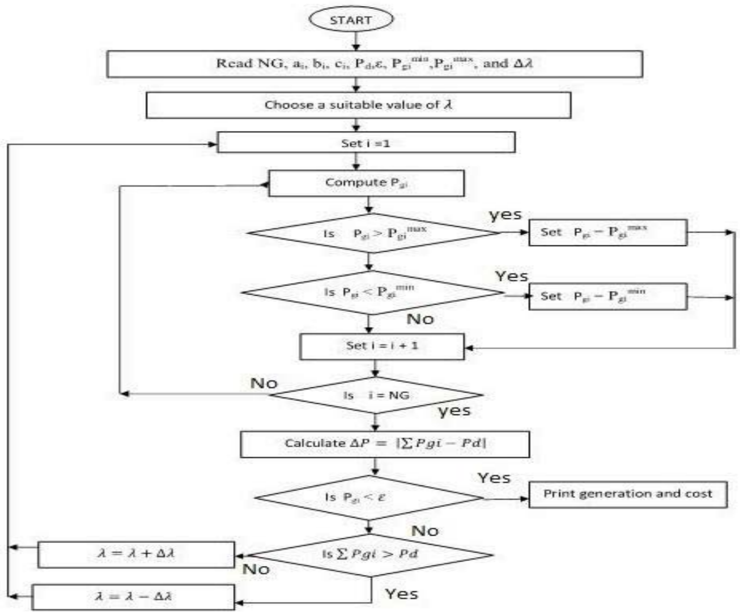

Fig.1 Flowchart of LIM

B. Genetic Algorithm

Genetic Algorithms (GA) are direct, parallel, stochastic method for global search and optimization, which imitates the evolution of the living beings, described by Charles Darwin. GA are part of the group of Evolutionary Algorithms (EA). The evolutionary algorithms use the three main principles of the natural evolution: reproduction, natural selection and diversity of the species, maintained by the differences of each generation with the previous. Genetic Algorithms works on a set of individuals, representing possible solutions of the task. The selection principle is applied by using a criterion, giving an evaluation for the individual with respect to the desired solution. The best-suited individuals create the next generation. The large variety of problems in the engineering sphere, as well as in other fields, requires the usage of algorithms from different type, with different characteristics and settings.

Genetic algorithm is one of the most developed paradigms in evolutionary computation. It basically implements the theory of evolution as an algorithm. The method of selecting or picking parents and method of inserting offspring's back into population taken together is called model of evolution. The following steps are performed while applying GA to practical problems:

1. Coding
2. Generation of Population
3. Reproduction Operators
4. Crossover and Mutation Operators

Coding

GA may be binary coded or real coded depending upon the representation of problem variable. In binary coded GA, problem variables are coded in the form {0, 1} bits whereas in real coded variables are represented by floating point number.

Generation of Population**s**

Populations are generated by random numbers. The larger population size does not provide better results and vice visa. So, depending on problems, we have to select the appropriate size carefully

Reproduction Operators

Reproduction operator is usually the first operator applied on the population. The Chromosomes are selected based on the Darwin's evolution theory of survival of the fittest. Best are selected for crossover. There are number of GA reproduction operators in the literature but the main idea in them is that the above average strings are picked from the current population and their multiple copies are inserted in the mating pool in a probabilistic manner. The selection method used in this work is Roulette Wheel Selection.

Crossover and Mutation Operators

The crossover operation is used to create new individual with a pair of parents. A part of parents is exchanged with each other. Crossover operator is applied to the mating pool with a hope that it will produce good offspring's. The aim of this operator is to search the parameter space in such a way that the information stored in the parents is preserved to maximum extent. Number of crossover operators exists in the GA literature. Single point to five point crossover, uniform crossover with & without mask has been investigated for economic dispatch problem. The newly created by means of selection and crossover population can be further applied to mutation. Mutation means, that some elements of the DNA are changed. Those changes are caused mainly by mistakes during the copy process of the parent's genes. In the terms of GA, mutation means random change of the value of a gene in the population.

III. EXPERIMENTAL ANALYSIS AND RESULTS

The two methods discussed above have been applied to a three- generator power system to meet a demand of 300MW. The cost characteristics of generator are given as below.

$C1=0.00525\ P_1^2 + 8.663P_1 + 328.13$ Rs. /Hr

$C2=0.00609\ P_2^2 + 10.040P_2 + 136.91$ Rs. /Hr

$C3=0.00592\ P_3^2 + 9.760P_3 + 59.16$ Rs. /Hr

The cost characteristics are valid for the following minimum and maximum limit of power generation.

$P_1^{min}=50$ MW, $P_1^{max}= 250$ MW

$P_2^{min}=5$ MW, $P_2^{max}= 150$ MW

$P_3^{min}=15$ MW, $P_3^{max}= 100$ MW

The transmission loss coefficients are given as:

B= [0.00136 0.0000175 0.000184
0.0000175 0.000154 0.000283
0.000184 0.000283 0.000161] MW^{-1}

To implement GA in above problem, real power generation of generators is considered as variable to be searched.
Here

Length of the string, l = 16 bits

Population size, L = 20

Crossover Probability, $P_C = 0.8$

Mutation Probability, $P_m = 0.01$

Table -1 Experiment Result

Method	P1	P2	P3	Total Cost
LIM	202.3987	80.8899	27.05987	3614.349
GA	202.4288	80.94910	27.06991	3614.148

Table 1 shows the comparative result of the above mentioned two methods, and it has been observed that GA method gives more positive approach towards optimizing the overall cost of generation.

IV. CONCLUSION

The comparison of results for the test cases of three units clearly shows that the GA 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. The reliability of the GA method for different runs of the program is pretty good, which shows that irrespective of the run of the program it is capable of obtaining same result for the problem. Many non-linear characteristics of the generators can be handled efficiently by the method.

REFERENCES

[1] D. P. Kothari, J.S.Dhillon, “Power System optimization”, PHI, Second Edition (2010).
[2] Ashfaq Husain, “Electrical Power System”, CBS Publishers and Distributors, Fifth Edition (2007).
[3] Hadi Saadat, “Power system Analysis”, Tata Mc Graw-Hill Edition.(2002)
[4] Classical Approach to Solve Economic Load Dispatch Problem of Thermal Generating Unit in MATLAB Programming, International Journal of Engineering Research & Technology (IJERT), Vol. 2 Issue 10, October 2013, ISSN: 2278-0181.
[5] Y.H. Song and C.S.V. Chou, "Advanced engineered- conditioning genetic approach to power economic dispatch," IEE Proc. Gener.Transm. Distrib., vol. 144, pp. 285-292, May 1997.
[6] H.H. Happ, "Optimal power dispatch - A comprehensive survey," IEEE Trans. Power App. Syst., vol. PAS-96, pp. 841-854, 1977.
[7] A.H. Wright, Genetic algorithms for real parameter optimization*,* in Foundations of Genetic Algorithms, J.E. Rawlins (Ed.), Morgan Kaufmann, pp. 205-218, 1991.
[8] A. J. Wood and B. F. Wollenberg, *Power* Generation, Operation, and Control*,* John Wiley & Sons, N. Y.
[9] P.H. Chen and H.C. Chang, "Large-scale economic dispatch approachby genetic algorithm," IEEE Trans. on Power Systems, vol. 10, no. 4,pp. 1919-1926, November 1995.
[10] Goldberg David E. Genetic algorithms in search, optimisation and machine learning. Reading, MA: Addison-Wesley, 1989.
[11] P.-H. Chen and H.-C Chang, “Large-scale economic dispatch by genetic algorithm,” IEEE Trans. Power Syst., vol.10, pp.1919-1926, Nov.1995.
[12] Bakirtzis A, Petridis V, Kazarlis SA. Genetic algorithm solution to the economic dispatch problem. IEE Proc C 1994; 141 (4).
[13] Liu guohua, Bao hong & Li wenchao. (2001). The genetic algorithm programming in MATLAB. Research of Computer Aapplication,2001(8):80-82.
[14] Yin ming, Zhang xinghua & Dai xianzhong. (2000). The programming of genetic algorithm in MATLAB. Application of Electronic Technology, 2000(1):9-11
[15] M. Rahli and P. Pirotte, “Optimal load flow using sequential unconstrained method (SUMT) under power transmission losses minimization,” Electric Power Systems Research Journal, 1999, pp. 61-64.
[16] D. Walters and G.B. Sheble, "Genetic algorithm solution of economic dispatch with valve point loading," IEEE Trans. on Power Systems, vol 8, no. 3,pp. 1325-1331, 1993.