GENETIC ALGORITHM A NOBLE APPROACH FOR ECONOMIC LOAD DISPATCH

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***Abstract*– Economic load dispatch (ELD) is a process of finding optimal generation scheduling of available generators in an interconnected power system to meet the demand on the system, at lowest possible cost, while satisfying various operational constraints on the system. This paper presents an efficient optimization method to solve economic load dispatch problem using Genetic Algorithm (GA), which is a heuristic technique for solving computational problems. Genetic Algorithm is a stochastic searching algorithm which is inspired from the mechanics of genetic and natural selection. The proposed technique is tested and analysed on 3 generating unit system and results are compared with other methods. The comparison shows that the proposed technique has merits in obtaining optimal solution**

Keywords—Economic load dispatch, Genetic Algorithm, Optimization techniques, particle swam optimization.

I: INTRODUCTION

In order to maintain a better economy and reliability of the power system, economic load dispatch is one of the best options for generating companies as the main task for them is to ensure that the electrical energy requirement from the customer is served while minimizing the cost of power generation. Hence, for economic operation of the system, the total demand must be optimally shared among all the generating units with an objective to minimize the total generation cost while satisfying operational constraints on system. Economic load dispatch (ELD) is a process of allocating the optimal combination of generation to all generating units in the power system so that the total generation cost of system is minimized, while satisfying the load demand and system equality and inequality constraints. It is defined as the operation of generation facilities to produce energy at lowest cost to reliably serve consumers, recognizing any operational limits of generation and transmission facilities [1]. ELD is one of the fundamental optimization problems in power system operation and planning. It is therefore of great importance to solve this problem as quickly and accurately as possible. The conventional methods such as Lambda Iteration method, Newton's method, Base Point and Participation factor method etc [1 by thesis] requires the incremental cost curves to be continuous and monotonically increasing [2]. The solution of the ELD using classical methods faces difficulties and has the possibility to be caught at local minima when the cost functions are non convex or piecewise discontinuous. Recently, new heuristic methods likes Genetic Algorithm, Evolutionary algorithm, neural networks etc evade the above difficulties. Genetic algorithms are probabilistic search techniques based on the mechanism of natural selection and survival of the fittest. The search for a global optimum to any optimization problem is conducted by moving from an old population of individuals to a new population using genetics operators. GA searches multiple solutions simultaneously in contrast to conventional optimal algorithms. Particle Swarm Optimization (PSO) is a population-based stochastic optimization technique, inspired by simulation of a social psychological metaphor instead of the survival of the fittest individual. In PSO, the swarm is initialized with a population of random solutions (particles) and searches for optima using cognitive and social factors by updating generation [10].

This paper addresses the use of Genetic Algorithm to solve ELD problem with power balance equation as the equality constraint and limits on the active power generations of the units as the inequality constraints. The proposed algorithm is applied on 3 generating unit system to find optimal allocation of generation on each generating unit and results are compared with other methods.

II: ECONOMIC LOAD DISPATCH FORMULATION

The conventional economic load dispatch (ELD) problem of power generation involves allocation of power generation to different thermal units to minimize the operating cost subject to diverse equality and inequality constraints of the power system. The solution of ELD gives optimal generation of generating units that satisfy the system power balance equation and generation limit constraints. The Economic load dispatch problem can be formulated mathematically as follows

A. Objective Function:

$$\text{Minimize } Ct = \sum_{i}^{Ng} Fi(Pgi) \qquad (1)$$

Where:

Ct is the total cost of generation. Ng is the number of generating units. $F_i(P_{gi})$ is the cost function and P_{gi} is the power output of unit i. $F_i(P_{gi})$ is the generator cost curves usually are modelled with smooth quadratic functions, given by:

$$F_i(P_i) = a_i P_{gi}^2 + b_i P_{gi} + c_i \qquad (2)$$

Where a_i,b_i and c_i are the cost coefficients of unit i.

B. Constraints :

- Inequality Constraints: This are units operational constraints, each generating units have lower (P_i^{min}) and upper (P_{gi}^{max}) generation limits, as the maximum active power generation is limited thermal consideration and minimum generation is limited by the flame instability of boiler. These bounds can be defined as a pair of inequality constraints, as follows:

$$P_{gi}^{min} \le P_{gi} \le P_{gi}^{max} \qquad i=1 \text{ to } Ng \qquad (3)$$

- Equality Constraints: This is power balance constraint; according to it the total power generated must be equal to total demand plus losses in the system.

$$\sum_{i}^{Ng} Pgi = P_L + P_D \qquad (4)$$

Where P_D is total demand and P_L is losses.

The transmission loss can be calculated by the B coefficients method or power flow analysis.

$$P_L = P^T BP + P^T B_o + B_{oo} \qquad (5)$$

Where PT is an associated matrix of P. B is an Ng X Ng coefficient matrix. Bo is an Ng dimensional coefficient column vector. Boo is a coefficient.

III: GENETIC ALGORITHM OPTIMIZATION

Genetic Algorithms (GAs) are numerical optimization algorithms inspired from the genetic and evolution mechanisms observed in natural systems and population of living being [7]. They are stochastic search techniques based on the mechanism of natural selection and natural genetics. GA starts with an initial set of random solutions called population. Each individual in the population is called chromosome, representing a solution to the problem. A chromosome is a string structure, typically a concatenated list of binary digits representing a coding of control parameter s of a given problem. The chromosomes evolve through successive iterations, called generations. During each generation, the chromosomes are evaluated, using some fitness. To create next generation, new chromosomes called offspring are formed by using genetic operator. A new generation is formed by selecting, according to the value of fitness function, some of the parents and offspring and rejecting others, so as to keep the population size constant. Those chromosomes having higher values of fitness functions have higher probabilities of being selected. GAs are differ and advantageous then other conventional methods in many ways, such as GAs do not require any prior knowledge, space limitation or special properties of the function to be optimized, like smoothness, convexity or existence of derivative. GAs operates on the encoded strings of the problem parameters rather than actual parameters of the problem and it uses probabilistic transaction rules. GAs use a population of points rather than a single point in their search, this allows it to explore several areas of the search space simultaneously, reducing the probability of getting stuck in local minima. Major steps involved in GAs approach are as follows-

A. REPRESENTATION: GA works on a population of strings consisting of a generation. In the present ELD problem, the problem variables correspond to the power generation of various units. The length of each sub string is decided based on the minimum and maximum generation limits and the desired accuracy of solution.

- The number of bits (ni) required representing a solution is given by:

$$2^{ni} \le (Pgi^{max} - Pgi^{min}) \times 10^{(\text{accuracy desired})} \le 2^{ni} \qquad (6)$$

$$\text{Total bits required} = \sum_{i=1}^{Ng} ni \qquad (7)$$

- The actual generation of each generator is calculated by decoding and is given as:

Actual generation = $Pgi^{(min)}$ + {decimal equivalent of binary coded sub string} x $(Pgi^{max} – Pgi^{min}) / (2^n -1)$ (8)

B. INITIALIZATION: An initial population of parent individuals (Pi, i=1,2, ….Ng-1) is generated randomly within a feasible region.

C. FITNESS FUNCTION EVALUATION: Fitness function is derived from the objective function and used in successive genetic operation. The evaluation is the process for establishing the fitness of each chromosome in the population. Those chromosomes having higher value of fitness function have higher probability to get in next generation.

Fitness Function (f ti) = A / Cti (9)

Where A is a very large constant; Cti is the cost corresponding to i^{th} chromosome; f ti is the fitness value of function for i^{th} chromosome.

D. GENETIC OPERATOR: Genetic operators are a set of random transition rules used in genetic algorithm. Genetic operators are used to get a new and improved population from the parent population. These are crossover and mutation. In crossover two parent chromosomes are merged to produce the offspring. Mutation operator changes 1to 0 or 0 to 1 at one place in the whole string with a small probability.

E. GENETIC PARAMETERS: These include Population Size (N), Crossover Probability (Pc), Mutation Probability which influences the performance and efficiency of the genetic algorithm. The population size depends on the nature of the problem, but typically contains several hundreds of possible solutions. The crossover probability is the parameter that affects the rate at which the process of crossover is applied. The number of strings that undergo crossover process is chosen by Pc. Mutation Probability is the probability with which witch each bit position of chromosome in the new population undergoes a random change after the selection process.

F. TERMINATION: The generation process is repeated until the termination criteria i.e generation maximum (gen_max) is achieved.

IV: ALGORITHM FOR ELD USING GA

Step1. Read system data, namely ai,bi,ci and assume suitably population size (N), Crossover Probability (Pc), Mutation Probability (Pm), Maximum generation (gen_max).

Step2.Calculate the number of bits required representing the solution and total bits required using Eq.6 and 7.

Step3. Create the initial population randomly of size N.

Step4. Check the constraints (both equality and inequality), evaluate fitness function and store the total cost of generation and corresponding variables.

Step5. Construct a roulette wheel for selection process, as follows:

- Calculate the total fitness value

  $Ft = \sum_{i=1}^{N} fti$ (10)
- Calculate the probability of selection using formula

  Pi = f ti / Ft for i=1 to N (11)
- Find the cumulative probabilities for each chromosome

  $q_i = \sum_{j=1}^{i} Pi$ for i= 1to N (12)
- Generate random number ri (for i= 1,N) in the range {0,1}.
- If $r_i < q_i$ then select the first chromosome; otherwise select the mth chromosome such that
  $q_{m-1} < r_i < q_m$ (13)

Step6. Apply the recombination operator, crossover to the individuals in the selected population as follows:

- Generate random number r_i in the range {0,1}.
- If r_i <Pc for i = 1 to N, select the ith chromosome for crossover.
- If the numbers of selected chromosomes are odd, add or remove one selected chromosome randomly.
- For each pair of coupled chromosome, generate a random integer number posi in the range [1, k-1], where k is the number of bits in the chromosome. The number posi indicate the position of crossing point.

Step7. Update the population, check the constraints and Evaluate fitness function for the new population, store minimum cost and its corresponding variables, if it is better then in step 4.

Step8. The mutation operator is performed on bit-by bit basis as follows:

- Generate random number r in between {0,1}.
- If r < Pm then mutate the bit, counting from starting bit of first chromosome and then go to step 7.

Step9. If the number of generation reaches the maximum (gen_max) then go to step 10, otherwise go to step 4.

Step10. The fitness that generates the minimum total generation cost is the solution of the problem.

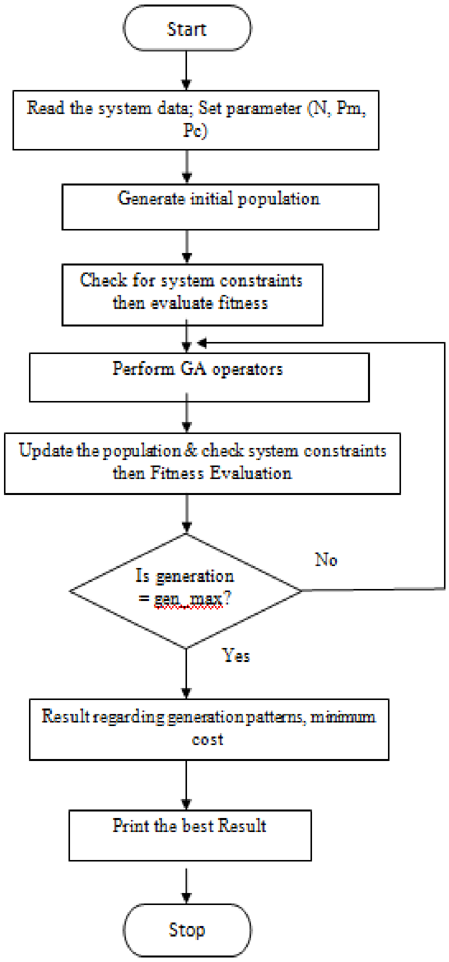


Fig.1 Flow Chart of GA

V: SIMULATION RESULTS

A matlab program implementing the proposed algorithm was first prepared and run for a 3 generator system. A comparison with Lambda method and Ant colony algorithm (ACO) is provided in table.

The fuel cost characteristics of 3 generator system ($/hr)

$F(P_1)=200+7.0P_1+0.008P_1^2 \quad 10 \le P_1 \le 85$

$F(P_2)=180+6.3P_2+0.009P_2^2 \quad 10 \le P_2 \le 80$

$F(P_3)=140+6.8P_3+0.007P_3^2 \quad 10 \le P_3 \le 70$

B=[.021 .0093 .0028;.0093 .0228 .0017;.0028 .0017 .0179]

Bo= [.0003 .0031 .0015] ; Boo=.00030523

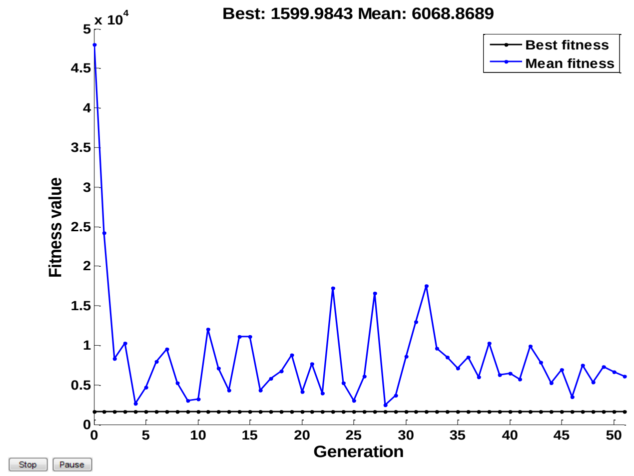
Load demand= 150 MW

Table1. GA parameter

S. No	GA parameter	Value
1.	Population size	50
2.	Probability of crossover, (Pc)	0.5
3.	Probability of mutation ,(Pm)	0.02
4.	Maximum generation (gen_max)	50

Table2. Result of ELD

Case study	P1 (MW)	P2 (MW)	P3 (MW)	Cost ($/h)	Time (sec)
Lambda iteration	33.47	64.09	55.10	1599.985	-
GA	33.31	64.21	55.13	1599.984	2.91
PSO	33.32	64.12	55.20	1599.983	3.74



The minimum cost of generation obtained by GA is 1599.984 ($/Hr) and the loss is 2.65 (MW).

VI: CONCLUSION

In this paper, we have studied the Economic Load Dispatch problem (ELD) and a recent approach, Genetic Algorithm has been proposed to solve it. From the above result analysis we see proposed algorithm has better ability to save total cost and computational time as compared to other conventional methods. GA method can overcome the disadvantage of premature convergence of conventional methods and can obtain better solution with better efficiency and convergence. Hence it can be concluded that proposed method is easier and computational efficiency is better as compared to conventional methods.

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REFRENCES

[1] Economic Dispatch: Concepts, practices and Issues FERC staff Palm Spring, California November 13, 2005.

[2] Sinha Nidul, Chakrabarthi R. And Chattopadhyay P.K, "Evolutionary Programming techniques for economic load dispatch", IEEE Transaction on evolutionary computation, Vol. 7,pp.83-94,2003

[3] Chiang C.L, "Genetic based algorithm for power economic load dispatch", IET Gener.Transm.Distrib,1,(2),pp.261-269,2007.

[4] Mori Hiroyuki and Horiguchi Takuya, "Genetic algorithm based approach to economic load dispatching", IEEE Transactions on power system, Vol.1,pp.145-150,1993.

[5] David C. Walter et al, "Genetic algorithm solution of economic dispatch with valve point loading", IEEE Transactions on power systems, Vol. 8,No.3,August 1993.

[6] Hadi Saadat, "Power system Analysis",McGraw-Hill,1999.

[7] D.E. Goldberg, "Genetic Algorithm in search, optimization and Machine learning", Addison-Wesley, 1989.

[8] Achayuthakan Chira and Srivastava S.C, " A Genetic algorithm based economic dispatch solution for eastern region of egat system having combined cycle and generation plants", IEEE Transactions on power systems, Vol. 1,pp.165-170, 1998.

[9] YOUNES Mimoun and Rahli Mostafa, "Economic power dispatch using the combination of tow genetic algorithms", Journal of Electrical and Electronics Engineering, Vol. 6,pp.175-181,2006.

[10] Kennedy J. and Eberhart R.C., "Particle swarm optimization", Proceedings of IEEE International conference on Neural Network (ICNN'95), Vol. 4, pp.1942-1948,perth, Australia, 1995.