To Improve Performance Response of Economic Load Dispatch by using Optimization Technique

Harmandeep Kaur, Vijay Kumar Joshi

Abstract*: The power systems are grown in complexity of power demands. The focus is shifted to enhance the performance of power system, customer focus, increasing the reliability, clear power and reducing cost. Optimal system includes the economy of operation, fuel costs, system security with the aim of improving the efficiency of electric power system. The Economic load dispatch is the scheduling of power generators with respect to the load to minimize the total cost of transmission and operational costs of generating units while meeting the constraints. The objective of the ELD is to allocate the total transmission loss and total load demand among power plants while satisfying the operational constraints simultaneously. This paper presents solution for improvement of performance response of ELD by using genetic algorithm and fuzzy logic optimization approaches.

Index Terms: Economic load dispatch, optimization, fuzzy logic, genetic algorithm

I. INTRODUCTION

It is necessary to obtain a product at minimum cost as possible by reducing the operating cost or production cost in electrical power systems. The Economic load dispatch is the important function of power system. ELD is the practice of operating the power system in such a way that reduces the cost with respect to load while meeting equality and inequality constraints. To solve ELD problem many traditional techniques were used**.** The traditional deterministic optimization approaches include dynamic programming, gradient method, non-linear programming, lambda iteration method and linear programming. In this paper, the fuzzy logic and genetic algorithm is proposed to solve the ELD problem. In addition, genetic algorithm and fuzzy logic is utilized to verify the efficiency.

II. ECONOMIC DISPATCH BENEFITS

1. If the geological field and electrical range of the area taken under dispatch increases, then economic profit is also increase.

2. Economic dispatch reduces fuel cost and emissions as high-efficiency units frequently expel lower efficiency units using the same or similar fuel. Economic dispatch needs a well maintained balance among economic factors like reliability, efficiency, and some other factors including capacity of a given generating unit to change output at short notice, and scheduling limitations imposed by hydrological conditions, fuel properties and environmental laws.

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III. LITERATURE SURVEY

Liang *et al.* [3] proposed a dynamic programming (DP) technique used to solve economic dispatch including transmission losses. But these classical methods are totally based on assumption values and do not follow converging solution for inappropriate values selected.

Dhillon J.S., Parti S.C. and Kothari et. al [4] formulated the problem as multi objective one. They considered objectives such as operating cost, minimal emission and minimum transmission losses in thermal power dispatch systems, considering uncertainties and inaccuracies in system data. The validity and effectiveness of the method was demonstrated by analyzing a 6-generator case.

Palanichamy and Shrikrishna K., [5] discussed Simple algorithm for economic power dispatch for optimizing the problem while satisfying a set of system operating on strains, including constraints dictated by the electric network. ELD has been widely used in power system operation and planning discussed by Wood and Woolenberg in **[15].** Many approaches **[6]** have been listed to formulate and solve this problem. These approaches include combining emission dispatch with the economic load dispatch **[7]**, includes use of Hopfield Neural Network**[14]**, Fuzzy approach **,**Simulated Annealing **[9].**

Chen Po- Hung & chan hong [8] this paper proposed a genetic approach for solving the economic dispatch problem in large scale system. It is faster than lambda iteration method

Happ [13] reviewed the progress of optimal dispatch, also called economic load dispatch since its inception to the present in chronological sequence. The classic single area as well as multi area cased is summarized, and the important theoretical work in optimal load flows suggested to date reviewed. Approaches to the optimal load flow taken by industry are also reported, as well as an itemization of problems that still remain to be solved.

Bouzeboudja Hamid, Chaker Abdelkader and Alali Ahmed [10] proposed about the economic load dispatch using the real coded genetic algorithm (RCGA).The use of real valued representation in the GAs gives number of advantages in numerical function optimization over binary encoding, the efficiency of GAs is increased as there is no need to convert chromosomes to the binary type, less memory is required.

IV. ELD PROBLEM FORMULATION

The ELD problem assume as an optimization problem of power systems for minimization of the total fuel rate of all generating plants so as to meet the demand while satisfying system constraints.

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The main objective of solving economic dispatch problem is the capability to minimize the fuel rate of electric power systems, while satisfying system equality and inequality constraints. The economic load dispatch problem includes a fuel cost function bounded with power balance and generation capacity constraints. This problem is expressed as follows:

a) Generator Fuel Cost Function: The factor of the rate which is considered in dispatching procedure section is the amount of the burning fuel in the fossil unit because nuclear thermal unit intent to be conducted at consistent output. The total cost of process combines the rates of labour, fuel rate, material and repairs. Generally, Fuel rates incomings includes the fix percentages of material, labour costs and repairs maintenance.

Thus, the fuel cost function for individual generating plant is assumed as a quadratic function and is stated as:

$$\mathbf{F(P_g) = \sum_{i=1}^{n} F_i(P_{gi})}$$

Where F_i is fuel cost of each generator with power generation output i.e P_{gi}. Operating Fuel cost equation of a generator is stated by a quadratic polynomial of power output P_{gi} as:

$$\boldsymbol{F_i(P_{gi}) = \sum_{i=1}^{n}(a_i P_{gi^2} + bP_{gi} + c_i)\frac{Rs}{hr}}$$

Where, F_i (P_{gi}) is the fuel rate expressed in Rupees per hour (Rs/hr),

P_{gi} is the power generated (MW) ,

a_i,b_i ,c_i is the fuel rate coefficients of i^{th} unit.

i^{th} Unit fuel rate coefficients are a_i,b_i ,c_i.

n is number of generating plants.

b) System Constraints: It has two types.

i. Equality Constraint
ii. Inequality Constraint

Equality constraints

Power balance equation: The total generating power is equal to the transmission lines power loss P_L plus the total demand P_D . Hence, equality equation should be expressed as:

$$\sum_{i=1}^{n} P_{gi} = P_D + P_L \text{ MW}$$

Inequality constraints:

Generating unit capacity equation: Generated power output of individual generating unit is limited by minimum and maximum generation boundaries based on the output values and operational limits is needed to obtain the stable operation of electric power systems, as follows:

$$P_{gi}^{min} \le P_{gi} \le P_{gi}^{max}, \text{ for gi=1, 2… n}$$

c) Problem Statement

Aggregating the equality, inequality constraints and objective function, the problem is evaluated mathematically as a non linear emission and objective optimization problem as follows:

Minimization: $[F_i\ (P_{gi})]$

Subject to : $g_{gi}(P) = 0$

$h_{gi}\ (P) \le 0$

Where,

g_{gi} = equality constraint which describes equation of power balance.

h_{gi} = inequality constraint which describes equation of generating unit capacity.

V. PROPOSED METHODOLOGY

A. Genetic Algorithm (GA):

John Holland fashioned Genetic Algorithm in the 1960s. Genetic Algorithm is the numerical optimization algorithm based on the principle of the genetic and evolution algorithms observed in natural systems and population of living being [16]. In Genetic algorithms, Binary encoding deals with 0 or 1 bit strings, in which bit values of individual string performs simulation of genes of each chromosome and collection of individuals forms the population . Binary Bit is formed by the string of fixed length symbols by encoding individual parameter series, and then they are integrated into a complete bit of strings known as chromosomes. From the concatenated bit strings, substrings of specific length are derived and decoding and mapping into values is performed. Generally, Genetic Algorithm optimization technique combines the steps of initialization of population(combination of chromosomes) generation, evolution of fitness function and creating the new population generation by using selection methods, crossover and mutation operators.

For the maximization problem, the fitness function is described as:

$$g(f(X)) = F(X)$$

And Fitness function for the minimization problem is

$$g(f(X)) = \frac{1}{1+F(X)}$$

Where g (f(X)) describes the fitness function and F(X) describes the objective function.

Genetic Algorithms are capable of finding an optimal solution to solve the optimization problem within a modest time. One of the characteristic that differentiate GAs from other traditional deterministic optimization approaches include dynamic programming, gradient method, non-linear programming, quadratic programming , lambda iteration method and linear programming search methods is the ability of dealing with a population of solutions simultaneously, without any requirements of large number of function evaluations.

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Genetic Algorithm for ELD Problem

Step 1 Initialization of Population: Firstly specify the parameters for genetic algorithm and initialize the population size, time limit, maximum generation, and read the cost coefficients of units.

Step 2 Formulation of population: The initial formation of population for each generator can be obtained by

$P^{j}_{gi} = P^{min}_{gi} + \{(P^{max}_{gi} - P^{min}_{gi}) / (2^{1} - 1)\} * b^{j}_{1}$

Where, gi = number of generator

gj = number of generation

Step 3 Calculate the fitness function: Determines the maximum and average Fitness function of population members

Step 4 Reproduce: Choose the Parent entity using 'Roulette Wheel' selection method and then perform the single point crossover and in last perform the mutation operator to recover the lost characteristics throughout the operation.

Step 5 Exit: Rerun above steps until the action has been encounter or it fulfills the specified criteria.

B. Fuzzy Logic (FL)

Fuzzy Set theory first advanced in their current form by Lotfi Zadeh in 1960s. Fuzzy logic is a problem-solving procedure which allows itself to implement in a structure varies from small, simple, microcontroller and embedded systems into networked, large, workstations and control systems. It can be performed in software, hardware, or in a combination of both[1]. Fuzzy logic produces definite results by following a simple approach based on uncertainty, estimation and lost data input values. FL is distinct to typical Boolean logic and is installed to sort and hold the considerations of multi value logic whose values lie between 0 and 1. Fuzzy logic is used to command nonlinear systems which are not easy to build mathematically. Fuzzy logic method includes the membership function which describes a curve representation of individual input participant. Fuzzy Logic can be developed further by stating fuzzy sets and fuzzy relations. The logic starts with the fuzzification in which all input data are fuzzifies into fuzzy membership functions. Then, execution of fuzzy rules is performed and finally defuzzification of fuzzy output functions takes place to get crisp output data.

Fuzzy Logic Method:

1) First describes the criteria and objectives to control the system and also determines the situation responsible for system failure.

2) Describe relationships among input and output values and selects a least number of values for providing input into fuzzy inference engine.

3) Use the Fuzzy logic Rules model, and divide the problem into a set of rules which describes the required output value process to a given input value system. The fuzzy rules counting and complexities rely on the input variable numbers which are processing in the system and on the fuzzy variable numbers connected to individual input value. If achievable, purpose at least one variable with its time derivative.

4) Construct Fuzzy logic MF (membership functions) which describes the input values and output values purposed in the fuzzy rules.

5) In last, system testing and computation of results is performed, operate membership functions and rules, and then again test the system until the desired output is not obtained.

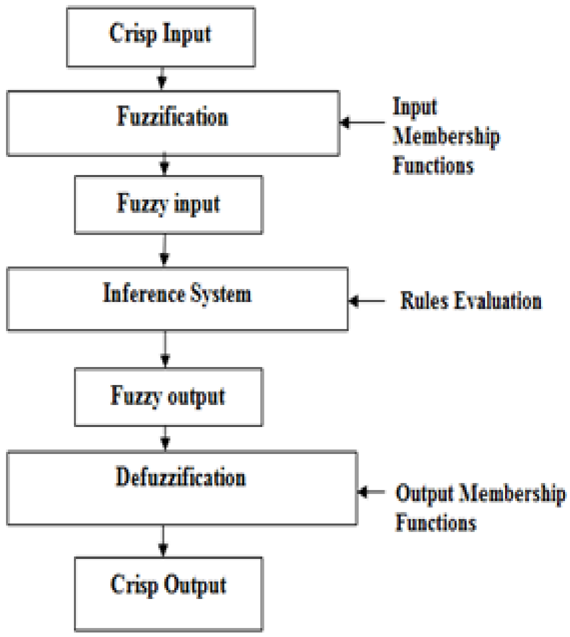

Fig 4.1 Flow Chart of Proposed Algorithm

VI. RESULTS AND DISCUSSION

The results to improve performance response of ELD after the implementation of proposed genetic algorithm and fuzzy logic are discussed and compared with the Lambda iteration and PSO (Particle Swarm Optimization) The algorithms are implemented in MATLAB to solve problem of Economic load dispatch. The main focus shifts on reducing the rates of generation of plants using GA and FL optimization methods. The performance analysis is evaluated as:

Problem I: Three generator test systems

The specifications of three generator test system are given in table1. The coefficients of fuel rate with maximum and minimum power limits are given table1.

Table 1: 3 Generator Test System Fuel Rate Coefficients

Unit no.	a_i	b_i	c_i	P^{min}_{gi}	P^{max}_{gi}
1	0.00662	7.95	363	15	95
2	0.00940	7.82	212	15	85
3	0.00484	7.68	150	15	75

Table 2: For 3 generators test system obtained Optimal Result using GA are

P_1 (MW)	42.0103
P_2 (MW)	62.2256
P_3 (MW)	54.7642

Total Power(MW)	**155.00**
Total Cost(Rs/MWh)	**95863.978**

Time Comparison of GA with PSO and lambda iteration

Table3. Comparison of GA with the Lambda iteration method (LIM) and PSO (Particle Swarm Optimization)

Case study	P1 (MW)	P2 (MW)	P3 (MW)	Cost (Rs. /h)	Time (sec)
LIM	34.58	64.29	56.13	1599.985	4.03
GA	**33.29**	**64.19**	**55.10**	**1599.982**	**2.85**
PSO	33.38	64.13	55.22	1599.984	3.83

Results obtained with Fuzzy logic for Economic load dispatch

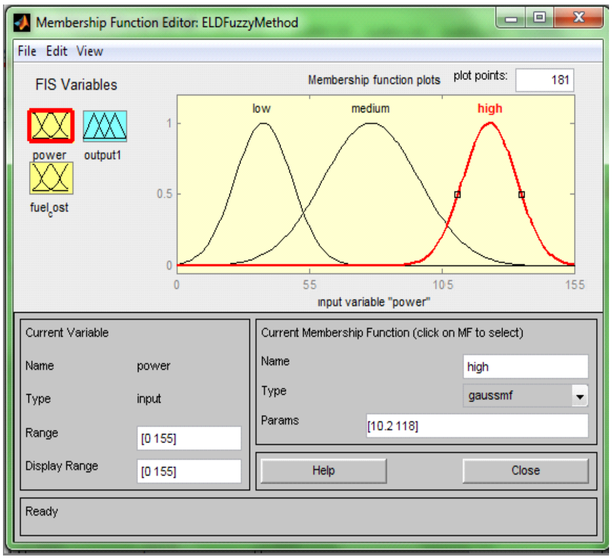

Fig.5.1 Fuzzy Input Power Membership Function

Fig.5.1 shows fuzzy input membership functions. "gaussmf" is the name of current membership function The graph field displays linguistic variables low, medium, high for input variables. Figure given below shows the curves of these variables.[10.2 118] is the numerical parameters for current membership functions.

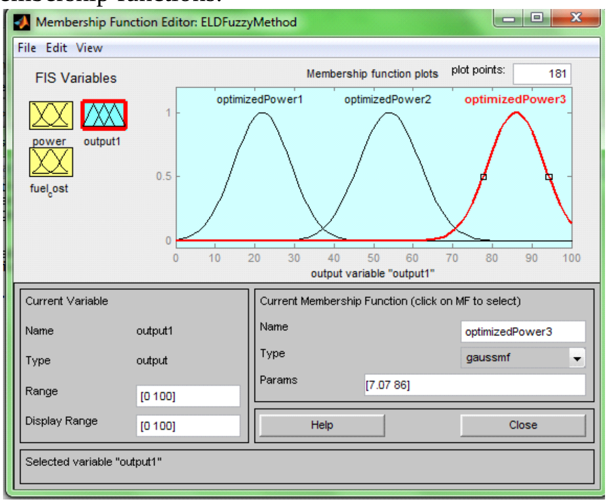

Fig.5.2 Fuzzy Output Power Membership Function

Fig.5.2 shows fuzzy output membership functions. "gaussmf" is the name of current membership function. The graph field displays linguistic variables optimizedPower1, optimizedPower2, optimizedPower3 for output variables. Figure shows the curves of these variables. [7.07 86] is the numerical parameters for current membership functions. [0 100] is the range and display range of current membership function.

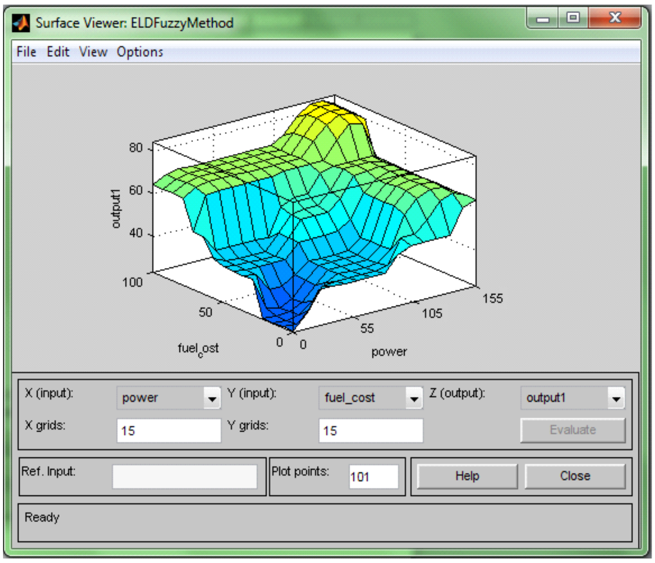

Fig.5.3. Surface Viewer

Fig.5.3 shows surface viewer. It is a Graphical user interface tool used creates fuzzy inference systems and generates 3-D view. It shows the results of ELD obtained after the successful implementation of proposed Fuzzy logic in which two input values are allotted to Y & X axis, while output value allotted to Z-axis. To create smoother plot, a field named plot point is used to describe the points on which MF is performed in input/ output values. It specifies 101 as a default plot field. In fig 4, input axis shows as power & fuel cost and output axis Z is shown as optimized power.

Table 4: Optimal Result Obtained using FL

P_{min} (MW)	P_{max} (MW)	Power generated (MW)	Fuel cost (Rs)	Error (%)
55 80	150 200	70.31 82.332	772 1001	0.101 0.137

VII. CONCLUSION

In this paper, Genetic Algorithm method and Fuzzy logic technique have been successfully presented to obtain the optimum solution to ELD problem. The load at the electric power generating system varies from time to time so it in not possible to load dispatch for every load demand. This is where Fuzzy logic and genetic algorithms plays an important role to improve the performance response of ELD by providing highly optimal solutions to reduce the computational time. For the testing of GA and fuzzy logic, three generators test systems are used.

The results of fuzzy logic and genetic algorithms are compared with traditional methods.

It is found that fuzzy logic is giving better results than GA. Fuzzy logic proves itself as fast optimization method and provides true optimum generations of both operating costs and transmission line losses of the power system.

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