ISSN: 2278-4632
Vol-11 Issue-01 March 2021

Utilizing Soft Computing Techniques for Economic Load Dispatch Analysis and Optimization

Dr. D. Padmavathi

Assistant professor Department of Electrical Engineering, Raajdhani Engineering college, Bhubaneswar, India

Abstract— **Economic Load Dispatch (ELD) is one of the key concerns in the planning and operation of the power system in the current era. When solving ELD problems, the cost function for each unit is calculated conservatively using mathematical or analytical techniques. Therefore, it can be said that the specific ELD problem is denoted as a nonlinear optimization problem with equality and inequality constraints that cannot be directly addressed by traditional analytical methods. Consequently, many other well-known methodologies, including the numerical method, genetic algorithm, evolutionary programming, neural network strategies, particle swarm optimization, and some other hybrid methods, have been effectively adopted in order to handle this ELD problem. The genetic algorithm is one optimization strategy that has recently proven to be effective. Consequently, we have provided a solution to the economic load dispatch problem of the thermal generator in this study utilising the Genetic Algorithm (GA) method. This recommended technique has been applied to systems with three and six generators, and the system is to be regarded as a lossless system. Finally, despite satisfying a number of equality and inequality restrictions, the result indicates a considerable reduction in generator fuel cost when compared to conventional procedures.**

Keywords—: Economic Load Dispatch, Load Flow, genetic Algorithm, Particle Swarm Optimization.

1. INTRODUCTION

The main goal of economic load dispatch is to optimally allocate the various generating units at the lowest operating cost while still meeting all system requirements. Economic Load Dispatch (ELD) is a tool that programmes the generating unit outputs according to the specific load demands so the power system can be operated most economically. The ELD issue, which has many objectives or distinct types of constraints, has recently been the focus of numerous mathematical programming and optimization research. The Newton-Raphson method, the Lambda Iteration method, and other conventional or orthodox techniques, Base Point and so many others. On the other hand, these typical economic load dispatch (ELD) algorithms have need of incremental cost curves to be piece-wise linear or monotonically increasing. So many standard calculation based techniques failed in solving these types of problems as per the problem is non-linear. By numerous stochastic search algorithms, including the genetic algorithm (GA), evolutionary strategy (ES), evolutionary programming (EP), particle swarm optimization (PSO), and simulated annealing (SA), may prove to be very effective in solving these highly nonlinear ELD problems by taking into account these nonlinear issues. This is because these nonlinear problems are not constrained by the shape of the cost curves. The Genetic Algorithm (GA) is a soft computing technique that finds precise or approximative solutions to optimization and search issues.

2. OBJECTIVE OF THE WORK

The specific goals of this study are as follows:

- It finds a solution to the economic load dispatch problem in order to reduce overall fuel costs while still meeting power generating restrictions.
- Utilizes soft computing methods like GA/PSO to identify the ideal conditions.
- Investigate the effectiveness of these ELD issues, taking into account transmission losses.
- Finally, contrast the outcomes of the two approaches—Genetic Algorithm (GA) and Particle Swarm Optimization (PSO)—with those of the traditional lambda-iteration approach.

3. GENERATOR OPERATING COST

A generator's operational expenses include the cost of fuel, labour, supplies, and maintenance. Typically, set percentages of incoming fuel prices are used to calculate labour, supply, and maintenance expenses. By sequentially opening a series of valves at the steam turbine's inlet, fossil plants can change their output power. When a single valve is only partially opened, throttling losses are very high, but they are very low when the valve is fully open.

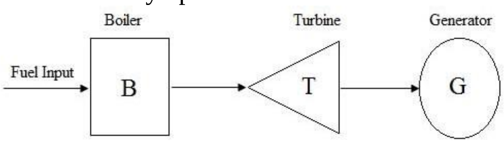

Fig. 1 Simple model of a conventional fossil Plant

Figure 1 shows the simple model of a fossil plant for transmitting purposes. The cost of plant is typically estimated

ISSN: 2278-4632
Vol-11 Issue-01 March 2021

by a quadratic portion or sections. The curve in Figure 2 displays the plant's operating cost. This cost is often computed using one or more quadratic sections for transmission resolutions. The fuel cost curve for active power generation assumes a quadratic form and is given as follows:

$$F(P_{gi}) = a_i P_{gi}^2 + b_i P_{gi} + c_i \; Rs/hr \quad (1)$$

Where a_i , b_i , c_i are cost coefficients for i^{th} unit;
$F(Pgi)$ is the total cost of generation; and
Pgi is the generation ofi^{th} plant

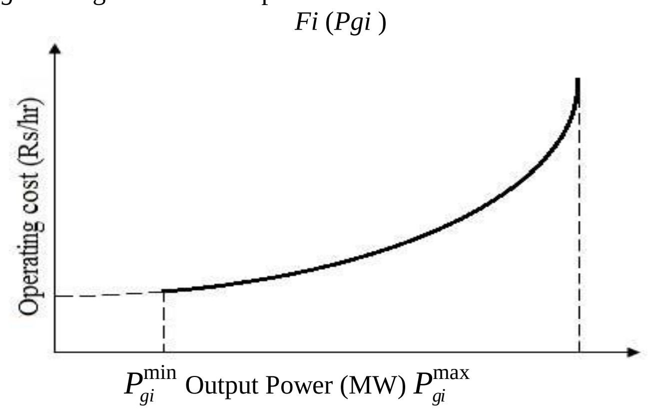

Figure.2 Operating costs curve of a fossil fired generator

4. PROPOSED SOFT COMPUTING METHODOLOGY OUTLINE

In order to tackle an Economic Load Dispatch (ELD) problem, the two primary types of soft computing techniques—Genetic Algorithm (GA) and Particle Swarm Optimization (PSO), also known as generic population-based probabilistic search optimization algorithms—are discussed in this section.

A. GENETIC ALGORITHM

On behalf of many optimization applications, the Genetic Algorithm is also known as a global optimization technique has arisen as an aspirant due to its efficiency and flexibility. This algorithm is based on stochastic searching. This approach was proposed by John Holland in1975.

B. PARTICLE SWARM OPTIMIZATION

The Particle Swarm Optimization (PSO) technique can be described as a population-based stochastic optimization method that is motivated by the simulation of a social psychological metaphor rather than the presence of the ideal individual. In this approach, the system is modified using a population of haphazard solutions, and it is then examined for optimum conditions by informing successive generations of cognitive and social factors. The particles are compressed stochastically close to the location of each particle's current velocity, their best performance in the past, and the best performance of their neighbours. PSO has been successfully used for a variety of applications, primarily in solving the continuous nonlinear

5. RESULTS AND DISCUSSION

In this segment, the results obtained of ELD after implementation of proposed soft computing techniques i.e. GA and PSO are discussed& compared. The programs are executed in MATLAB 7.12.0.635. The developed algorithms based on GA and PSO for ELD problem, have been talk over in chapter -4. The main objective is to minimize the cost of generation of plants using GA and PSO methods. The performance is evaluated considering losses using two generator test systems, i.e. three generator test system and six generator test system, whose input data is given in Table 1 and table 6 respectively.

CASE STUDY 1: 3 GENERATOR TEST SYSTEM

The coefficients (a_i,b_i,c_i) of fuel cost, minimum and maximum power limits are given in Table 1 [20].The power demand is considered to be 150 (MW). The results corresponding to lambda method, GA and PSO are detailed in section 2, 3 and 4 respectively and the comparison of results of these methods is shown in table 5.

Unit no.	a_i	b_i	c_i	p_i^{min}	p_i^{max}
1	0.008	7.00	200	10	85
2	0.009	6.3	180	10	80
3	0.007	6.8	140	10	70

Table 1 Features of power plant with three generator test system

And loss coefficient matrix are given as

$$B = \begin{bmatrix} 0.0218 & 0.0093 & 0.0028 \\ 0.0093 & 0.0228 & 0.0017 \\ 0.0028 & 0.0017 & 0.0179 \end{bmatrix}$$

$$B_0 = \begin{bmatrix} 0.0003 & 0.0031 & 0.0015 \end{bmatrix}$$

$$B_{00} = 0.00030523$$

Optimum Solution Using conventional lambda method for Case Study 1

The description of the results obtained by utilizing conventional lambda method considering losses is shown below in Table 2.

P_1 (MW)	33.4701
P_2 (MW)	64.0974
P_3 (MW)	55.1011

ISSN: 2278-4632
Vol-11 Issue-01 March 2021

Total Power Output	152.6686
Total Demand (MW)	150.00
Transmission losses P_L(MW)	2.6686
Total Cost of Power Output($/h)	1599.98

Table 2 Optimal Result of lambda method for Case Study

Optimum Solution Using Genetic Algorithm for Case Study 1

Here is a full summary of the outcomes from applying GA while accounting for losses. 50 people are considered to be the population size. Three 16-bit substrings are represented by a single string. As a result, the population we used is 50 x 48 in binary. The cross-over probability is assumed to be 0.9 and the mutation probability is assumed to be 0.1. The points of crossover and mutation are selected at random. A series of steps were created and are covered in Chapter 4 in order to simulate the suggested GA method to solve ELD. Table 2 below displays the best GA outcome.

P1 (MW)	34.4895
P2 (MW)	64.0299
P3 (MW)	54.1534
Total Power Output(MW)	152.2678
Total Load Demand (MW)	150.00
Transmission losses P_L(MW)	2.6728
Total Cost($/h)	1600.00

Table 3 Optimal Result of GA for Case Study 1

Optimum Solution Using Particle Swarm Optimization for Case Study 1

In order to simulate the proposed PSO method to solve ELD. The execution parameters for proposed PSO methodology are: swarm size 50, No. of iteration 1000, population size 10, acceleration constant $c_1 = c_2 = 2.0$, initial inertia weigh factor 0.9, final inertia weight factor 0.4 and error gradient taken as 10^{-6}. The optimal result of PSO is shown below in Table3.

P1 (MW)	32.8101
P2 (MW)	64.5950
P3 (MW)	54.9369
Total Power Output (MW)	152.342
Total Load Demand (MW)	150
Transmission losses P_L(MW)	2.342
Total Cost($/h)	1597.48

Table 4 Optimal Result of PSO for Case Study 1

Comparison of Case Study 1

Table 5 shows the comparison of optimum scheduling and total cost ($/hr) of three generator test system for different methods. This shows that particle Swarm Optimization results minimum operating cost in three methods listed below.

Method ology	Generator Wise Optimum Scheduling (MW)			Total cost($/hr)
	P1	P2	P3	
Lambda Method	33.4701	64.0974	55.1011	1599.98
Genetic Algorithm Method	34.4895	64.0299	54.1534	1600.00
Particle Swarm Optimization	32.8101	64.595	54.9369	1597.48

Table 5 Comparison for Case Study 1

CASE STUDY 2: 6 GENERATOR TEST SYSTEM

The coefficients of fuel cost and maximum and minimum power limits are given in Table 6.The power demand is considered to be 700 (MW). The results corresponding to Conventional Lambda, GA and PSO are detailed in section 7, 8 and 9 respectively, and the comparison of results of these methods is shown in Table 10.

Unit No.	a_i	b_i	c_i	min P_i	max P_i
1	0.15247	38.53973	756.79886	10	125

2	0.10587	46.15916	451.32513	10	150
3	0.02803	40.3965	1049.9977	35	225
4	0.03546	38.30553	1243.5311	35	210
5	0.02111	36.32782	1658.569	130	325
6	0.01799	38.27041	1356.6592	125	315

Table 6Features of power plant with six generator test system

And loss coefficient matrix is given as

$$B_{mn} = 10^{-4} \times \begin{bmatrix} 1.4 & 0.17 & 0.15 & 0.19 & 0.26 & 0.22 \\ 0.17 & 0.60 & 0.13 & 0.16 & 0.15 & 0.20 \\ 0.15 & 0.13 & 0.65 & 0.17 & 0.24 & 0.19 \\ 0.19 & 0.16 & 0.17 & 0.71 & 0.30 & 0.25 \\ 0.26 & 0.15 & 0.24 & 0.30 & 0.69 & 0.32 \\ 0.22 & 0.20 & 0.19 & 0.25 & 0.32 & 0.85 \end{bmatrix}$$

Optimum Solution Using conventional lambda method for Case Study 2

The description of the results obtained by utilizing conventional lambda method considering losses is shown below in Table 5.7

P_1 (MW)	25.7526
P_2 (MW)	10.00
P_3 (MW)	106.9487
P_4 (MW)	113.9719
P_5 (MW)	238.1334
P_6 (MW)	225.3922
Total Power Output (MW)	720.1988
Total Load Demand (MW)	700
Transmission losses P_L(MW)	20.1988
Total Cost(Rs/hr)	36937.75

Table 7 Optimal Result of lambda method for Case Study 2

Genetic Algorithm-Based Optimum Resolution for Case Study 2 Here is a full summary of the outcomes from applying GA while accounting for losses. The population size is 50, and the length of string in the population is supposed to be 96. Three 16-bit substrings are represented by a single string. As a result, the population we used is 50 x 96 in binary. The cross-over probability is assumed to be 0.9 and the mutation probability is assumed to be 0.1. The points of crossover and mutation are selected at random. Table 8 below displays the best GA outcome.

P_1 (MW)	27.2960
P_2 (MW)	14.3795
P_3 (MW)	109.5430
P_4 (MW)	128.7011
P_5 (MW)	224.5443
P_6 (MW)	214.9074
Total Power Output (MW)	219.3714
Total Load Demand (MW)	700
Transmission losses P_L(MW)	19.3714
Total Cost (Rs/hr)	36924

Table 8 Optimal Result of GA for Case Study 2

Optimum Solution Using Particle Swarm Optimization for Case Study 2

A series of actions were created and are covered in Chapter 4 in order to emulate the suggested PSO strategy to solve ELD. The execution parameters taken into account in a system with six generators are the same as those in a system with three generators. The following Table 9 displays the PSO's ideal outcome.

P1 (MW)	28.8101
P2 (MW)	10.0000
P3 (MW)	118.9583
P4 (MW)	118.6747
P5 (MW)	230.7630

P6 (MW)	212.7449
Total Power Output (MW)	719.4318
Total Load Demand (MW)	700.00000
Transmission Losses P_L(MW)	19.4318
Total Cost(Rs/hr)	36912.20

Table 9 Optimal Result of PSO for Case Study 2
Comparison of Case Study 2

Table 10 compares the overall cost (Rs/hr) and optimal scheduling for various techniques. This demonstrates that the three approaches below have the lowest operational costs when using particle swarm optimization.

Methodology	Total cost		
	P1	P6	Total cost
Lambda Method	25.7526	225.3922	(Rs/hr) 36937.75
Genetic Algorithm Method	27.296	214.9074	36924
Particle Swarm Optimization	28.8101	212.7449	36912.2

6. CONCLUSIONS

This work involves the creation and application of strategies for solving the Economic Load Dispatch problem utilising the Genetic Algorithm and Particle Swarm Optimization. Three generator and six generator test systems are used to evaluate the performance of the designed software. The outcomes of various techniques are also contrasted with one another. PSO is discovered to produce superior outcomes than GA and the traditional lambda technique. The genetic technique we used to solve the economic load dispatch optimization problem has been implemented effectively. Compared to analytical and traditional algorithms, the findings were better and more effective. This approach works well with changing power demands and any n number of generators. Additionally, the outcome can be improved by using hybrid optimization techniques and more real world constraints so as to get optimum and accurate solution.

REFERENCES

[1] *Koustav Dasgupta and Sumit Banerjee, "An Analysis of Economic Load Dispatch using Different Algorithms", Proceedings of 2014 1st International Conference on Non Conventional Energy (ICONCE 2014)*

[2] *Raul Silva Barros, Omar Andres Carmona Cortes at el., "A Hybrid Algorithm for Solving the Economic Dispatch Problem", BRICS Congress on Computational Intelligence & 11th Brazilian Congress on Computational Intelligence 2013*

[3] *Shaik Affijulla and Sushil Chauhan, "A New Intelligence Solution for Power System Economic Load Dispatch", IEEE Conference 2011*

[4] *Aniruddha Bhattacharya, Member, IEEE and Pranab Kumar Chattopadhyay, "Biogeography-Based Optimization for Different Economic Load Dispatch Problems" IEEE Transactions on Power Systems, VOL. 25, NO. 2, MAY 2010*

[5] *YU Ting-Fang and PENG Chun-Hua," Application of An Improved Particle Swarm Optimization to Economic Load Dispatch in Power Plant", 3rd International Conference on Advanced Computer Theory and Engineering (ICACTE) 2010*

[6] *Meng Xin, Gao junru and Li Lei, "Load Distribution of Thermal Power Plant Based on Adaptive Genetic Algorithm", International Forum on Computer Science-Technology and Applications 2009*

[7] *Abolfazl Zaraki and Mohd Fauzi Bin Othman, "Implementing Particle Swarm Optimization to Solve Economic Load Dispatch Problem", International Conference of Soft Computing and Pattern Recognition 2009*

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

[9] *Sai H. Ling, Herbert H. C. Iu, Kit Y. Chan and Shu K. Ki, "Economic Load Dispatch: A New Hybrid Particle Swarm Optimization Approach", Manuscript received September 11, 2007.*

[10] *Warsono, D. J. King, C. S. Özveren and D.A. Bradley, "Economic Load Dispatch Optimization of Renewable Energy in Power System Using Genetic Algorithm", Manuscript received April 14, 2007.*

[11] *Leandro dos Santos Coelho and Viviana Cocco Mariani, "Combining of Chaotic Differential Evolution and Quadratic Programming for Economic Dispatch Optimization With Valve-Point Effect", IEEE Transactions on Power Systems, VOL. 21, NO. 2, May 2006.*

[12] *Guo-li zhang, et al., " Dynamic economic load dispatch using hybrid genetic algorithm and the method of fuzzy number ranking", Proceedings of the Fourth International Conference on Machine Learning and Cybernetics, Guangzhou, 18-21 August 2005.*

[13] *Nidul Sinha, R. Chakrabarti, and P. K. Chattopadhyay, "Evolutionary Programming Techniques for Economic Load Dispatch", IEEE Transactions on Evolutionary Computation, VOL. 7, NO. 1, February 2003.*

[14] *Ling S. H., Lam H. K., Leung H. F. and Lee Y. S., "Improved genetic algorithm for economic load dispatch with valve- point loadings", IEEE Transactions on power systems, Vol. 1, pp. 442 – 447, 2003.*

[15] *Xian Wang, Yu-Zeng Li and Shao-Wazhang, "A New Neural Network Approach To Economic Emission Load Dispatch", Proceedings of the First International Conference on Machine Learning and Cybernetics, Beijing, 4-5 November 2002.*

[16] *Giridhar Kumaran and V.S.R.K. Mouly, "Using Evolutionary Computation to Solve the Economic Load Dispatch Problem", IEEE Conference 2001.*

[17] *Abido M. A, "Particle swarm optimization for multi machine power system stabilizer design", Proceedings of IEEE Power Engineering Society Summer Meeting IEEE Press, 2001.*

[18] *Kothari D. P. and Dhillon J. S., "Power System Optimization", Second Edition, PHI learning Private limited, 2011*

[19] *Kothari D. P. and Nagrath I. J., "Modern Power System Analysis", Tata McGraw - Hill, Third Edition, 2003.*

[20] *Hadi Saadat, "Power System Analysis", Tata McGraw- Hill, 2002.*

[21] *Eberhart R. C. and Kennedy J., "A new optimizer using particle swarm theory", Proceedings of the 6th. International Symposium on Micro Machine and Human Science, Nagoya, Japan, pp. 39-43, 1995.*