Economic Load Dispatch With Valve Loading Effects Optimize By Bbmo

Nagendra Singh, Anjali Nighoskar, Shiva Ram Krishna

***Abstract*: The Bumble Bees Mating Optimization algorithm is presented in this work for economic load dispatch optimization. Economic dispatch is a method to evaluate the performance of the generating units to fulfill the load demand on minimum fuel cost. The proposed method bumble bees mating optimization work on different three modes namely the queen, the workers and the drones (males). For the evaluation of performance this study consider case study of thirteen and forty generating unit data. The performance of planned methodology is compared with alternative improvement techniques and it's found that minimum operating cost of the thirteen and forty generating unit system with valve loading effect is evaluated by BBMO.**

***Index Terms*: Economic load dispatch, Natural inspired optimization techniques, Bumble Bees Mating Optimization, Valve loading effect.**

I. INTRODUCTION

The main characteristic of the economic load dispatch problem is to share the output power of the running generation sources so as to provide the load demand and satisfying the generator constraints at a minimized fuel cost. Electrical power systems are very large interconnected arrangement. For the effective, economical and reliable operation of large interconnected power system, it requires a proper analysis of operation. Optimization of such large system is possible by using economic load dispatch. Study of economic load dispatch helps us to operate power systems economical and efficient manner, therefore improves supply of energy without any disturbances [2].

The characteristic of classical economic load dispatch (quadratic cost function) problem is linear in nature. Where as if considered the valve loading effects the characteristic of fuel cost function should be non-smooth [3]. Many classical and modern optimization techniques used to solve such a nonlinear problem.

The parametric quadratic programming method was proposed by the authors of [4], for the solution of classical economic load dispatch problem. This method has the ability to increase the convergence rate, but it takes large memory space. Article [5], suggested a QP technique for non-smooth cost function. Similarly the harmony search method proposed by the authors of [6] for the solution of 14 bus data system.

Since the classical optimization techniques has many drawbacks and unable to give the global solution of the problem. Many new procedures are provided in literature used for the solution of financial load dispatch. Authors of [8], suggested PSO technique for ELD with effect of valve loading.

In this work suggest the BBMO algorithm [1-4], for the optimization of linear and nonlinear economic dispatch including the effect of valve loading in the generator and environmental pollution.

II. MATHEMATICAL FORMULATION OF ELD

A. Linear cost function

Linear ELD fuel cost function is formulated as given in Eqn. (1) and eqn. (2).

$$F_T = \text{Min } f(FC) \quad (1)$$

$$f(FC) = \sum_{i=1}^{N} a_i P_i^2 + b_i P_i + c_i \quad (2)$$

Subject to the following limits

Power Generation Limits

The generated power at plant should be lies in the limits of maximum and minimum,

$$P_i^{min} \leq P_i \leq P_i^{max} \quad (3)$$

Generated power balance limits

The total power generated at thermal power plant should be equal to the sum of overall load require and loss of the line and it is represented as in eq. (4).

$$\sum_{i=1}^{n} P_i = P_D \quad (4)$$

Where F_T is the total generation cost, f(FC) is the cost function in terms of power generation, a_i, b_i, & c_i are the cost coefficients, P_i is the power generated by i^{th} generating units, N is the number of generators. P_i is power generated between the limits of maximum and minimum. P_i^{min} & P_i^{max} is the minimum and maximum generated power of i^{th} generator respectively. And P_D is the total system demands.

B. ELD Formulation with valve loading effects

The generators speed is controlled by using valve system at the power plants. Due to presence of these valve ripples are arises at the time of operation. So that the characteristic of obtain fuel cost by ELD method is considered as nonlinear [3,7].

Revised Manuscript Received on May 10, 2019

Nagendra Singh, Department of Electrical Engineering, Trinity College of Engineering & Technology, Karimnagr, Telangana,India.
Anjali Nighoskar, Department of Electrical Engineering, Jagran Lake City University, Bhopal MP, India
Shiva Ram Krishna, Department of Electrical Engineering, Kameshwar Narayan Singh Govt. Polytechnic, Samastipur, Bihar, India

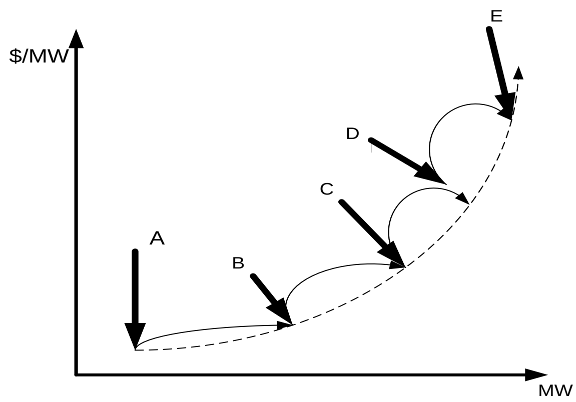

Fig.1.Characteristic of fuel cost curve including valve effect

The operation of valves beginning and remaining to hold the smooth speed of the generator is shown in fig.1The ELD function with valve effect is given as follows,

$$F_T(P_i) = f(FC) + \left|(e_i \sin(f_i(P_i^{min} - P_i)\right| \quad (5)$$

Where $F_T(P_i)$ shows the cost function including valve loading effect, e_i and f_i are the valve coefficients.

III. BUMBLE BEES MATING OPTIMIZATION

A. Bumble Bees Behavior

Bumble bees are social insects that form colonies consisting of the queen, workers (females) and the drones (males). The queens search the flowers and collect the pollen and nectar. After getting a suitable site for the nest, prepares pots of wax for the store food and wax cells into which eggs are laid [1–4].

After the emergence of the primary people, the queen now not for ages as the people take over the obligations of collecting meals (foragers) and the queen stays inside the nest laying eggs and tending to her young. Some workers, also, remain in the nest and help raise the brood (household workers). Males do not contribute in collecting food. Bumble bee workers are able to lay eggs when the queen's ability to suppress the workers reproduction diminishes. These eggs are developed into feasible male bumble bees [2,4].

The founder queens top laying eggs and grows weak from old age while the remaining workers continue to forage for food but only for them. Away from the colony, the new queens and men stay off nectar and pollen and spend the night on plants or in holes. The queens are subsequently mated (often more than once), the sperm from the mating is saved in spermatheca and she searches for a suitable place for diapauses[8].

The election of brood is given as follows

$$b_{ij}(t) = \begin{cases} q_j(t), & \text{if } \mathrm{rand}(0,1) \le C_{r1} \\ d_{kj}(t), & \text{otherwise} \end{cases} \quad (6)$$

The fittest of the broods are selected as new queens at the same time as the rest are the people. Initially, the new queens are fed from the old queen and afterwards from the workers. The new queens is selected as follows,

$$nq_{ij} = nq_{ij} + (P_{max} - \frac{(P_{max} - P_{min})*Iter_i}{Iter_{max}} * \left(nq_{ij} - q_j\right) + \frac{1}{M} * \sum_{k=1}^{M}(P_{min} - \frac{(P_{min} - P_{max})*Iter_{initial}}{Iter_{max}} * \left(nq_{ij} - w_{kj}\right) \quad (7)$$

Where nq_{ij} presents the new queen, q_j presents old queens, w_{kj} shows the worker, M is the number of the workers, P_{max}, P_{min} are maximum power, minimum power respectively, $Iter_i$ is the current local search iteration and $Iter_{max}$ is the maximum number of local search iterations. The movement calculation of drones away from the hive is given as follows,

$$d_{ij} = d_{ij} + \alpha(d_{kj} - d_{lj}) \quad (8)$$

Where dij, dkj and dlj are the solutions of the drones i, k, and l respectively, and α shows the percentage of affects of drone k and l by the drone i.

The new queen selects the drones which can be used for mating via the manner defined formerly. In the next generation, the best fertilized queens survive and all the other members of the population die.

IV. ALGORITHM OF BBMO

It's have mainly two phases, initial phase and main phase so according to phases we have to set the parameters:

Step 1: Select the parameters for the algorithm.
Step 2: Take the maximum iterations.
Step 3: Take maximum mating.
Step 4: Define the maximum number of queens.

Initial Phase

Step 5: Creates the initial population for the bumblebees.
Step 6: Evaluate the bumble bees fitness function.
Step 7: From the best fit function select the queens.
Step 8: consider remaining bees are as the drones.
Step 9: Sorting the drones according to their fitness' functions
Step 10: For the mating by queens select the number of drones.
Step 11: Arrange the drones genotype for queen's mating.

Main Phase

Step 12: take logic do while the maximum number of iterations has not been reached
Step 13: Use the crossover operator and creates the broods.
Step 14: Evaluate the fitness function of each brood.
Step 15: Sortout the broods as per their fitness value.
Step 16: Select the best broods as the new queens
Step 17: Select the rest broods as the workers
Step 18: the queen's position is updated by updating the position of old queens and the workers
Step 19: By mating of the queens can generate the number of drones.
Step 20: Similarly can creates the workers by using drones.
Step 21: For each drone evaluate the fitness function.
Step 22: Now evaluate the movement of the drones when they are away from the hive.
Step 23: Sorting the drones according to their fitness' functions
Step 24: The system is repeated until the most range of mating for every new queen has not been reached.
Step 25: For the mating with queens select the suitable drones.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Step 26: Stop repetition of process
Step 27: find out the new queens which will survive for the next iteration.

V. RESULTS EVALUATION

In this work considered two cases, in the first test case a 13 generating unit system with valve point loading effect is considered. Capacity, cost coefficients and valve point loading of 13 generator systems [11], for the load demand of 1800 MW are shown in table1.

In the second case evaluated generation cost of 40 generating unit system with considering of vale loading effects with the load demand of 10500MW shown in table 3. For obtain best results of the test data shown in table I, take 200 trials and number of iteration takes 100. Optimum results obtained by BBMO and techniques proposed in various study shown in the table 4.

Table 1: Cost coefficient and capacity limit of 13 unit system for the load of 1800 MW load

Gen. Units	a_i	b_i	c_i	e_i	f_i	P_i^{min}	P_i^{max}
	Cost coefficients			Valve loading coefficients		Generation limits	
1	0.00028	8.10	550	300	0.035	0	680
2	0.00056	8.10	309	200	0.042	0	360
3	0.00056	8.10	307	150	0.042	0	360
4	0.00324	7.74	240	150	0.063	60	180
5	0.00324	7.74	240	150	0.063	60	180
6	0.00324	7.74	240	150	0.063	60	180
7	0.00324	7.74	240	150	0.063	60	180
8	0.00324	7.74	240	150	0.063	60	180
9	0.00324	7.74	240	150	0.063	60	180
10	0.00284	8.60	126	100	0.084	40	120
11	0.00284	8.60	126	100	0.084	40	120
12	0.00284	8.60	126	100	0.084	55	120
13	0.00284	8.60	126	100	0.084	55	120

Optimum results obtained by BBMO and other methods used by various article is presented in the table 2.

Table 2: Convergence results of 13 generating units system for the demand of 1800 MW with valve loading effects

Power Output	**HS [14]**	**DE [15]**	**DEC-SQP [10]**	**NN-EPS [12]**	**EP-EPSO [12]**	**BBMO**
P1(MW)	628.31	628.31	526.182	490	505.4731	521.45
P2(MW)	149.59	149.24	252.185	189	254.1686	194.02
P3(MW)	222.74	223.16	257.92	214	253.8022	223.07
P4(MW)	109.86	109.85	78.2586	160	99.835	82.034
P5(MW)	60	109.86	84.4892	90	99.3296	116
P6(MW)	109.87	109.86	89.6198	120	99.3035	100.23
P7(MW)	109.87	109.82	88.088	103	99.7772	93.034
P8(MW)	109.86	109.82	101.157	88	99.0317	105.03
P9(MW)	109.68	60	132.098	104	99.2788	151.52
P10(MW)	40	40	40.0007	13	40	41
P11(MW)	40	40	40	58	40	59.920
P12(MW)	55	55	55	66	55	56.2
P13(MW)	55	55	55	55	55	56.44
Power output (MW)	1800	1800	1800	1800	1800	1800
Total fuel cost with valve loading ($/h)	17963.83	17963.94	17938.9	18442.593	17932.4766	17928.3

The comparative results for 13 and 40 generating units with other proposed techniques in the research articles, shown in the table 5. Results obtained by BBMO is compare with other techniques shown in the literature,

VI. CONCLUSIONS

In this work the Bumble Bees Mating Optimization algorithm proposed for the solution of a constrained optimization issues. This algorithm was analytically presented and tested using test data of 13 and forty generating units. The results of the proposed method are compared with the results of other admired techniques. The results obtained by the BBMO for the test data of 13 and 40 generating units as compare to other admired methods is better and its cost of fuel obtained by BBMO is minimum. Its shows the proposed method is more effective than other methods

Table 3: coefficients and generation limits for forty generating units, load demand of 10500MW

S. no.	c_i	b_i	a_i	P_i^{min}	P_i^{max}	e_i	f_i
	Cost coefficients			Generation limits		Valve Coefficients	
1	94.705	6.73	0.0069	36	114	100	0.084
2	94.705	6.73	0.0069	36	114	100	0.084
3	309.54	7.07	0.02028	60	120	100	0.084
4	369.03	8.18	0.00942	80	190	150	0.063
5	148.89	5.35	0.0114	47	97	120	0.077
6	222.33	8.05	0.01142	68	140	100	0.084
7	287.71	8.03	0.00357	110	300	200	0.042
8	391.98	6.99	0.00492	135	300	200	0.042
9	455.76	6.6	0.00573	135	300	200	0.042
10	722.82	12.9	0.00605	130	300	200	0.042
11	635.2	12.9	0.00515	94	375	200	0.042
12	654.69	12.8	0.00569	94	375	200	0.042
13	913.4	12.5	0.00421	125	500	300	0.035
14	1760.4	8.84	0.00752	125	500	300	0.035
15	1728.3	9.15	0.00708	125	500	300	0.035
16	1728.3	9.15	0.00708	125	500	300	0.035
17	647.85	7.97	0.00313	220	500	300	0.035
18	649.69	7.95	0.00313	220	500	300	0.035
19	647.83	7.97	0.00313	242	550	300	0.035
20	647.81	7.97	0.00313	242	550	300	0.035
21	785.96	6.63	0.00298	254	550	300	0.035
22	785.96	6.63	0.00298	254	550	300	0.035
23	794.53	6.66	0.00284	254	550	300	0.035
24	794.53	6.66	0.00284	254	550	300	0.035
25	801.32	7.1	0.00277	254	550	300	0.035
26	801.32	7.1	0.00277	254	550	300	0.035
27	1055.1	3.33	0.52124	10	150	120	0.077
28	1055.1	3.33	0.52124	10	150	120	0.077
29	1055.1	3.33	0.52124	10	150	120	0.077
30	148.89	5.35	0.0114	47	97	120	0.077
31	222.92	6.43	0.0016	60	190	150	0.063
32	222.92	6.43	0.0016	60	190	150	0.063
33	222.92	6.43	0.0016	60	190	150	0.063
34	107.87	8.95	0.0001	90	200	200	0.042
35	116.58	8.62	0.0001	90	200	200	0.042
36	116.58	8.62	0.0001	90	200	200	0.042
37	307.45	5.88	0.0161	25	110	80	0.098
38	307.45	5.88	0.0161	25	110	80	0.098
39	307.45	5.88	0.0161	25	110	80	0.098
40	647.83	7.97	0.00313	242	550	300	0.035

Table 5: Comparative results of the proposed methods with other techniques listed in the literature for ELD with valve-point loading

Optimization Techniques	Results for 13 thermal units ($/h)	Results for 40 thermal units ($/h)
MPSO[9]	-	122252.26
DEC-SQP[10]	17938.9	121741.97
DE/BBO[11]	-	121420.89
ICA-PSO[11]	-	121413.20
NN-EPSO[12]	18442.593	130328.325
NPSO-LRS[13]	-	121664.4308
EP-EPSO[12]	17932.4766	
HS[14]	17963.83	
DE[15]	17963.94	
BBMO	17928.3	121410.9

REFERENCES

1. http://www.bumblebee.org
2. http://www.everythingabout.net/articles/biology/animals/arthropods/insects/bees/bumble_bee
3. http://bumbleboosters.unl.edu/biology.shtml
4. http://www.colostate.edu/Depts/Entomology/courses/en570/papers_1998/walter.htm
5. N. Sinha, "Evolutionary programming techniques for economic load dispatch", IEEE Trans. Evolut. Comput. 7, 2003, pp.83–94.
6. Selvakumar, "A new particle swarm optimization solution to nonconvex economic dispatch problems", IEEE Transaction Power System, 2007, 22, 42–51.
7. Alsumait, "A hybrid GA-PS-SQP method to solve power system valve point economic dispatch problems", Applied Energy, 2010, pp.1773-1781.
8. Lixiang Li, "A hybrid CPSO–SQP method for economic dispatch considering the valve-point effects", Energy Conversion and Management 53, 2012, pp.175–181.
9. Park J.B., "A particle swarm optimization for economic dispatch with non-smooth cost functions", IEEE Transaction Power systems,Vol. 20, 2005, pp. 34-49.
10. Leandro dos Santos Coelho, "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, 2006, pp. 989-995.
11. Aniruddha Bhattacharya, "Hybrid Differential Evolution With Biogeography Based Optimization for Solution of Economic Load Dispatch," IEEE Transactions on Power systems, Vol. 25, No. 4, 2010, pp. 1955-1964.
12. S. Muthu Vijaya Pandian, "An Evolutionary Programming Based Efficient Particle Swarm Optimization for Economic Dispatch Problem with Valve-Point Loading", European Journal of Scientific Research, Vol.52 No.3, 2011, pp.385-397.

Table 4: Convergence results of 40 generating units system, for the demand of 10500MW with valve loading effects.

Generating Units	DE/BBO [11]	NN-EPSO [12]	DEC-SQP [10]	MPSO [9]	ICA-PSO [11]	NPSO-LRS [13]	BBMO
P1(MW)	110.7998	114	111.7576	114	110.8	113.98	110.9
P2(MW)	110.7998	114	111.5584	114	110.8	114	110.88
P3(MW)	97.3999	120	97.3999	120	97.41	97.424	97.4003
P4(MW)	179.7331	190	179.7331	182.2222	179.74	179.73	179.7336
P5(MW)	87.9576	97	91.6560	97	88.52	89.651	87.889
P6(MW)	140	140	140.0000	140	140	105.4	140
P7(MW)	259.5997	300	300.0000	300	259.6	259.75	259.5996
P8(MW)	284.5997	300	300.0000	299.021	284.6	288.45	284.57
P9(MW)	284.5997	300	284.5997	300	284.6	284.65	284.57
P10(MW)	130	300	130.0000	130	130	204.81	130
P11(MW)	168.7998	375	168.7998	94	168.8	168.83	94
P12(MW)	94.00	375	94.00	94.00	94.00	94.00	94.00
P13(MW)	214.7598	500	214.7598	125	214.76	214.77	214.852
P14(MW)	394.2794	500	394.2794	304.485	394.28	394.29	394.2924
P15(MW)	394.2794	500	304.5196	394.607	394.28	304.52	394.2924
P16(MW)	304.5196	500	304.5196	305.323	304.52	394.28	394.2924
P17(MW)	489.2794	402.6	489.2794	490.272	489.28	489.28	489.281
P18(MW)	489.4188	225	489.2794	500	489.28	489.28	489.281
P19(MW)	5112.3	508	511.2794	511.404	511.28	511.28	511.267
P20(MW)	511.3073	458	511.2794	512.174	511.28	511.3	511.267
P21(MW)	523.2794	356	523.2794	550	523.28	523.29	523.198
P22(MW)	523.2794	394	523.2853	523.655	523.28	523.29	523.198
P23(MW)	523.2794	355	523.2847	534.661	523.28	523.28	523.198
P24(MW)	523.2794	525	523.2794	550	523.28	523.3	523.198
P25(MW)	523.2794	310	523.2794	525.057	523.28	523.29	523.198
P26(MW)	523.2794	448	523.2794	549.155	523.28	523.29	523.198
P27(MW)	10.00	72	10.00	10.00	10.00	10.00	10.00
P28(MW)	10.00	131	10.00	10.00	10.00	10.00	10.00
P29 (MW)	10.00	75	10.00	10.00	10.00	10.00	10.00
P30(MW)	97	67	90.3329	97	96.39	89.014	87.7999
P31(MW)	190.00	151.00	190.00	190.00	190.00	190.00	190.00
P32(MW)	190.00	112	190.00	190.00	190.00	19.00	190.00
P33(MW)	190.00	139	190.00	190.00	190.00	190.00	190.00
P34(MW)	164.7998	90	200.00	200	164.28	200	164.8025
P35(MW)	200	129	200.00	200	200	165.14	195.627
P36(MW)	200	104	200.00	200	200	172.03	200
P37(MW)	110	36	110	110	110	110	110
P38(MW)	110	89	110	110	110	110	110
P39(MW)	110	104	110	110	110	93.096	110
P40(MW)	511.2794	550	511.2794	512.964	511.28	511.3	510.2794
Total power generation(MW)	10500	10500	10500	10500	10499.46	10500	10500
Total cost with Vale Effect($/hr)	121420.89	130328.325	121741.97	122252.26	121413.20	121664.4308	121410.9

AUTHORS PROFILE

Dr. Nagendra Singh, Completed his BE from RGPV, Bhopal, MP, India, in Electrical Engineering. HE completed M.Tech in Power Electronics from NIIST, Bhopal, MP, India. He awarded Ph.D in Electrical Engineering from Mewar University, Rajasthan, India. Currently he is working as principal and Associate professor in Trinity College of Engineering & Technology, Karimnagar, Telangana, India.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication