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The effects of steam valve on load economic distribution in steam powerhouse using bats algorithm

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Abstract— Because of the advancement of technology and industry, continued access to electrical energy has become one of the essential requirements of the world. So, continue a large part of manufacturing activity, economic, social and agricultural is not possible without improvement of electrical energy. In this paper, a mutation operator based on three separate corrections is suggested to add to the original Bats Algorithm (BA) with an effective way to improve the algorithm performance. Also, the Bats modified algorithm (MBA) is implemented for solving complex non-convex and uneven RCED by three testing system. Finally, the results of modified algorithm are simulated and the convergence of the MBA is compared with BA to evaluate the accuracy of the proposed algorithm.

Index Terms— voltage control, Renewable energies, distribution networks, distributed generation, photovoltaic.

1 INTRODUCTION

Economic distribution (ED) is the most important part of the system optimization so that it has an effective role in load diffusion, performance and control of the power system [1-3]. By implementing the ED, demanded load and power losses of system have been planned in committed units to the economic performance of the system in a short period of practical constraints [4-5]. For modelling and then applying ED in the real operation power system, it is necessary to consider Statutory Reserve Requirement (SRR) in order to overcome the biggest output error and errors of unwanted load [6-7]. Actually, the change in the output units from time to time is limited because of limitations in up and down of ramp rate [8-9]. In addition, open steam valves of big steam turbine to a large increase in power output cause a Non-convex characteristic in the cost function of the fuel. Therefore, it is needed to a practicing ED include the effects of valves, slope rate limits and SRR, which is limited to find an optimal result of load flow [10-11]. In this paper, ED theory is investigated with three kinds of SRR and slope rate limits [12-13]. Also, an accurate technique based on a BAT algorithm (BA) is implemented to solve the problem of RCED in real-time with power system application and real size that fuel costs of thermal units are minimized [14-15]. Furthermore, a mutation operator based on three separate corrections is proposed to add to the original Bats Algorithm with an effective way to improve the algorithm performance [16].

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2 BATS ALGORITHM

Bats are the only mammals that capable of echoes. Bats emit sound pulses with Low-frequency and then they are waiting for the reflected signal from their surroundings as shown in figure 1 [17-18].

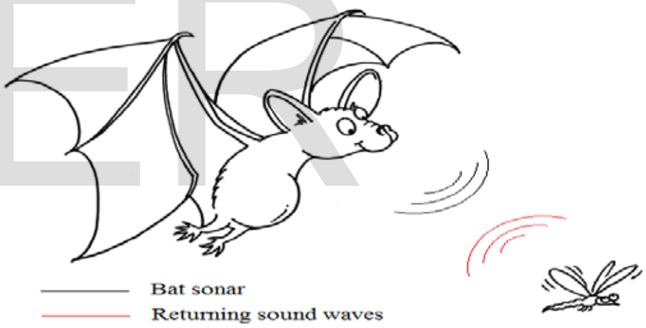

Fig. 1. Use echo to find prey by a bat

Pulses are different in terms of their features and also they are depending on kind of bats [19]. Many bats use short signals with different frequencies are to move around a special site. While the other use the fixed frequency signal for echolocation. Signal bandwidth varies according to the their kinds, in addition they have often increased using more harmonics [20].

3 Load economic distribution by a classic form

The economic distribution of classic load is used to determine the output power of each unit for reduce fuel costs [21]. This model is applied to minimize the total fuel cost function of the circuit units and thus minimize the total cost of production system. In other words, the relationship of this model is as follows:

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$$\min \ C = \sum_{i=1}^{Ng} F_i(P_{gi})$$

Where C is the total of production cost, F_i is the fuel cost function of the i-unit, p_{gi} named output power of i-generator and N_g is the number generators of the operating system.

4 The effect of steam valves

Several steam valves have been used to control the output power units in the powerhouse [22]. These steam valves are causing ripples in the curve of fuel costs . When the steam valves of input unit are opened for the first time, a sudden increase in mortality will be occur and then it causes ripples in the system [23-29]. The conventional methods of mathematical optimization are not capable of responding to this situation due to abrupt changes and discontinuities in the incremental cost function. As shown in figure 2 the effect of the steam valve is exhibited on the fuel cost curve.

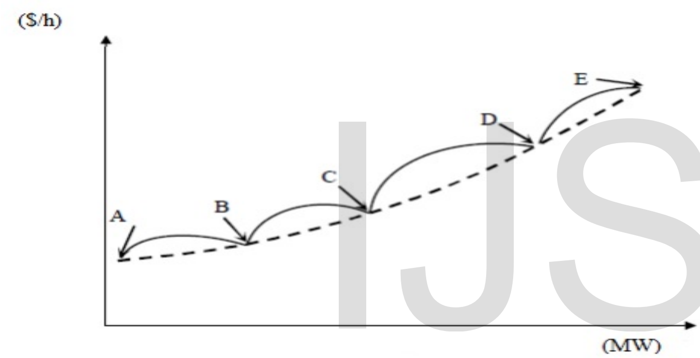

Fig. 2. Illustration of Fuel cost curves for generators with 5steam valves.

5 Economic distribution model based on steam valves effect

A mathematical model is a explanation of a system based on mathematical definitions and language. This model has been used to predict the behavior of original device and element specially nanomaterials in engineering [24-27-28]. Mathematical model of the objective function for load economic distribution problem need to modify with the effect of the steam valves in the powerhouse thermal. The fuel cost function is modified with respect to this effect as the sum of two parts so that the first and the second term is a quadratic function and absolute value of the sine function respectively.

$$F_i(P_{gi}) = a_i P_{gi}^2 + b_i P_{gi} + c_i + \left| e_i \times \sin(f_i \times (P_{gi_{(\min)}} - P_{gi})) \right| \quad (1)$$

where ei and fi are the the valve position parameters of i-generator, Ai ,Bi, Ci are the fuel cost function factors of i-unit. Recently, the steam valve effect has been considered to solve ED problems by many researchers.

6 Results and discussion of EED

1-6 Simulation results on a test network

In this part ED with the objective function of total cost and also, the objective function of the total pollution is investigated. In addition, the results of single-objective optimization and multi-objective optimization results is presented.

1-1-6 Load Distribution Economic

Network test: System with 10 units

This test system includes 10 power units with valve-point effects and fuel multiple choice for demanding 2700 MW load. Information about the system is shown in Table 1.

Table 1 The first test system with 10 power plant units

Unit	Generation Min P_1 P_2 Max / F1 F2 F3	Fuel type	Cost coefficients a_i	b_i	c_i	e_i	f_i
1	100 196 250	1	.2697e2	-.3975e0	.2176e-2	.2697e-1	-.3975e1
	1 2	2	.2113e2	-.3059e0	.1861e-2	.2113e-1	-.3059e1
2	50 114 157 230	1	.1184e3	-.1269e1	.4194e-2	.1184e0	-.1269e2
	2 3 1	2	.1865e1	-.3988e-1	.1138e-2	.1865e-2	-.3988e0
		3	.1365e2	-.1980e0	.1620e-2	.1365e-1	-.1980e1
3	200 332 388 500	1	.3979e2	-.3116e0	.1457e-2	.3979e-1	-.3116e1
	1 3 2	2	-.5914e2	.4864e0	.1176e-4	-.5914e-1	.4864e1
		3	-.2875e1	.3389e-1	.8035e-3	-.2876e-2	.3389e0
4	99 138 200 265	1	.1983e1	-.3114e-1	.1049e-2	.1983e-2	-.3114e0
	1 2 3	2	.5285e2	-.6348e0	.2758e-2	.5285e-1	-.6348e1
		3	.2668e3	-.2338e1	.5935e-2	.2668e0	-.2338e2
5	190 338 407 490	1	.1392e2	-.8733e-1	.1066e-2	.1392e-1	-.8733e0
	1 2 3	2	.9976e2	-.5206e0	.1597e-2	.9976e-1	-.5206e1
		3	-.5399e2	.4462e0	.1498e-3	-.5399e-1	.4462e1
6	85 138 200 265	1	.5285e2	-.6348e0	.2758e-2	.5285e-1	-.6348e1
	2 1 3	2	.1983e1	-.3114e-1	.1049e-2	.1983e-2	-.3114e0
		3	.2668e3	-.2338e1	.5935e-2	.2668e0	-.2338e2
7	200 331 391 500	1	.1893e2	-.1325e0	.1107e-2	.1893e-1	-.1325e1
	1 2 3	2	.4377e2	-.2267e0	.1165e-2	.4377e-1	-.2267e1
		3	-.4335e2	.3559e0	.2454e-3	-.4335e-1	.3559e1
8	99 138 200 265	1	.1983e1	-.3114e-1	.1049e-2	.1983e-2	-.3114e0
	1 2 3	2	.5285e2	-.6348e0	.2758e-2	.5285e-1	-.6348e1
		3	.2668e3	-.2338e1	.5935e-2	.2668e0	-.2338e2
9	130 213 370 440	1	.8853e2	-.5675e0	.1554e-2	.8853e-1	-.5675e1
	3 1 3	2	.1530e2	-.4514e-1	.7033e-2	.1423e-1	-.1817e0
		3	.1423e2	-.1817e-1	.6121e-3	.1423e-1	-.1817e0
10	200 362 407 490	1	.1397e2	-.9938e-1	.1102e-2	.1397e-1	-.9938e0
	1 3 2	2	-.6113e2	.5084e0	.4164e-4	-.6113e-1	.5084e1
		3	.4671e2	-.2024e0	.1137e-2	.4671e-1	-.2024e1

Table 2 Simulation results of the optimization of economic distri-

bution of the load on first test network

Method	Best	Average	Worst
CGA_MU [29]	624.7193	627.6093	633.8652
IGA_MU [9]	624.5178	625.8692	630.8705
DE [30]	624.5146	624.5246	624.5458
RGA [30]	624.5081	624.5079	624.5088
PSO [30]	624.5074	624.5074	624.5074
PSO-LRS [31]	624.2297	624.7887	628.3214
NPSO[31]	624.1624	625.218	627.4237
NPSO-LRS [31]	624.1273	625.9985	626.9981
The proposed Method	623.8839	623.9346	623.9873

Table 3 The amount of generating power for generating power units in the first test network

Unit	P (MW)
1	216.0511
2	211.9071
3	280.6642
4	240.7613
5	279.6583
6	239.7953
7	292.2220
8	240.4926
9	424.2447
10	274.2035

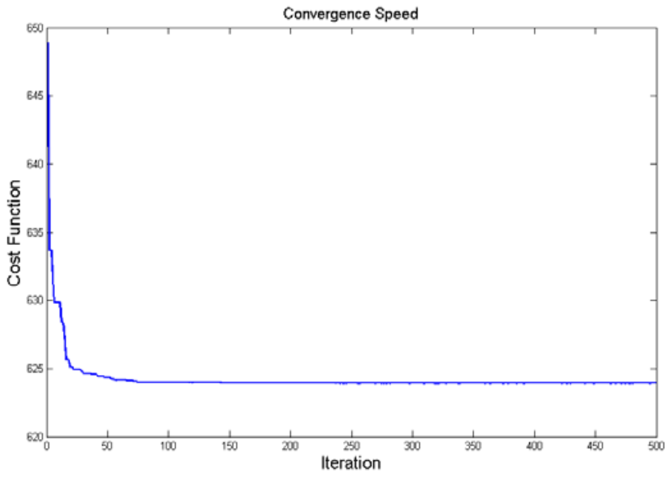

Fig. 3 .The convergence speed of the proposed algorithm in the first test

2-1-6 Load Economic distribution and pollution simultaneously

Test system: System with 6 units

This test system consists of six units that be required to give an appropriate response for 2.834 MW demanded load. Information about pollution and cost functions of the proposed system are given in the table 4. The objective function of pollution includes the amount of produced both sulfur dioxide and nitrogen oxide pollution. The nominal power of 100 MW is used to per-unit the values of the maxima and minima of production. It should be noted that these values have been prepared based on the IEEE Standard.

Table 4 Pollution information about systems with 6 power plant units

Nitrogen		Solfide Di-Oxide			
λ	Ξ	γ	β	α	Unit
2.857	0.0002	6.490	-5.554	4.091	1
3.333	0.0005	5.638	-6.047	2.543	2
8.000	0.000001	4.586	-5.094	4.258	3
2.000	0.002	3.380	-3.550	5.326	4
8.000	0.000001	4.586	-5.094	4.258	5
6.667	0.00001	5.151	-5.555	6.131	6

Table 5 Cost Information of System with 6 power plant units (100 MW Base Case)

c	B	a	P_{Max} (pu)	P_{Min} (pu)	Unit
10	200	100	0.5	0.05	1
10	150	120	0.6	0.05	2
30	180	40	1.0	0.05	3
10	100	60	1.2	0.05	4
20	180	40	1.0	0.05	5
10	150	100	0.6	0.05	6

Table 6 Simulation results for the distribution optimization of

economic pollution on First Test networks

	Optimizing Emission		Optimizing Emission	
Method	Pollution (kg/hr)	Cost ($/hr)	Pollution (kg/hr)	Cost ($/hr)
MPSO [44]	0.1943	639.32	0.2229	600.572
FAPSO [50]	0.19421	639.42	0.2231	600.721
PSO [39]	0.194371	642.86	0.2219	605.219
LP [38]	0.194227	639.600	0.2233	606.314
MOSST [44]	0.1942	644.112	0.2222	605.889
SPEA[41]	0.194210	638.507	0.22151	600.150
FCPSO[41]	0.194207	638.358	0.22226	600.132
NSSA [36]	0.194356	639.209	0.22282	600.572
NSSA-II[50]	0.194204	638.249	0.22188	600.155
MO-DE/PSO [44]	0.194203	638.270	0.22201	600.115
NPSA [43]	0.194327	639.180	0.22116	600.259
The proposed Method	0.194202	638.2736	0.22219	600.1116

Table 7 Amount of production power of generating units in the first test network

	Emission Target	Cost Target
Unit	P (MW)	P (MW)
1	0,406074	0,109719
2	0,459069	0,299766
3	0,537939	0,524299
4	0,382953	1,016198
5	0,537539	0,524298
6	0,510027	0,359719

The nominal power of 100 MW is used to per-unit the values of the maxima and minima of production.

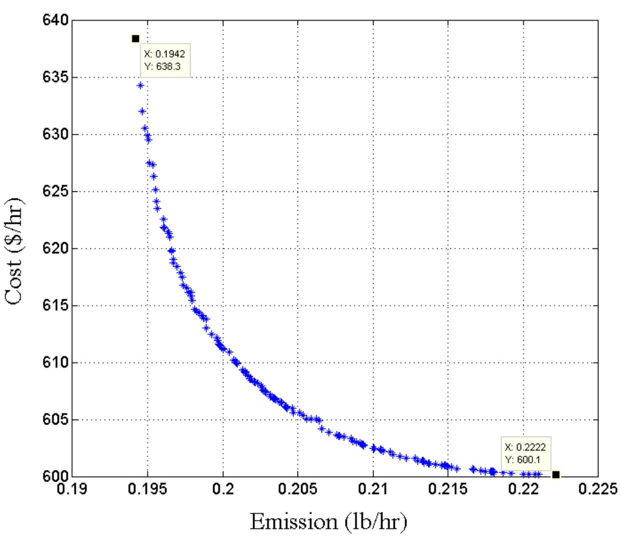

Fig. 4. Results of multi-objective optimization and flung points in the first test network

It should be noted that these values have been prepared based on the IEEE Standard.

7 Conclusion

In this research a new evolutionary optimization algorithm called MBA is suggested to solve the non-smooth convex optimization problems of ED. The proposed method is implemented to set the parameters and mutation strategies for improving the performance of the algorithm BA. The main idea of this improved method is increasing the Crossover and Mutation operators to raise the distribution of the bat population. Furthermore, this correction method is presented to overcome the shortcomings of premature convergence. In this work not only the cost objective function at the traditional distribution of economic load is considered, but also, objective function of pollution is focused. This function is especially interesting from the perspective of environmental resources. Also, the flung points idea is presented to solve multi-objective structure that, it offers a set of appropriate responses instead of an optimal solution. This method can give permission to the operator to select an optimal operating point based on the needs and preferences of the network.

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