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Economic Load Dispatch Problem With Valve - Point Effect using Cuckoo Search Algorithm

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Abstract— This paper proposes application of cuckoo search algorithm for solving economic load dispatch problem. cuckoo search algorithm is based on aggressive reproduction strategy of fascinating birds, cuckoos. The proposed approach has been examined and tested with the numerical results of economic load dispatch problems with three and five generating units with valve point loading without considering prohibited operating zones and ramp rate limits. The results of the proposed cuckoo search algorithm are compared with that of other techniques such as lambda iteration, and ABC. For both the cases, the proposed algorithm outperforms the solution reported for the existing algorithms. In addition, the promising results show the robustness, fast convergence and efficiency of the proposed technique.

I. INTRODUCTION

Economic load dispatch (ED) is an important task in the power plants operation which aims to allocate power generations to match load demand at minimal possible cost while satisfying all the power units and system constraints [3]. The complexity of the problem is due to the nonlinear and non-smooth characteristics of the input-output curves of the generators, because of valve-point effect, ramp rate limits and prohibited operating zones. The mathematical programming based optimization methods such as lambda iteration, base point participation method, Gradient and Newton's methods can solve successfully the convex ED problems [4]. But unfortunately, these methods are ineffective to handle the non convex ED problems with non-differentiable characteristics due to high complexity. Dynamic programming can solve such type of problem, but it suffers from curse of dimensionality. Hence for optimal solution this problem needs a fast, robust and accurate solution methodology. Now days heuristic search methods such as simulated annealing (SA)[3]-[4], genetic algorithm (GA) [7], evolutionary programming (EP) [8], particle swarm optimization (PSO) [9]-[12], Bacteria foraging optimization (BFO) [13], differential evolution (DE) [14] and chaotic ant swarm optimization [17] are employed to solve the ED problems All the approaches have achieved success to a certain extent.

This paper presents the application of proposed cuckoo search algorithm to economic load dispatch problem with valve point loading.

II ECONOMIC LOAD DISPATCH PROBLEM

The economic load dispatch problem is defined as to minimize the total operating cost of a power system while meeting the total load plus transmission losses with in the generator limits. Mathematically, the problem is defined as to minimize equation (1) subjected to the energy balance equation given by (2) and the inequality constraints given by equation (3).

$$F_i(P_i) = \sum_{i=1}^{NG} (a_i P_i^2 + a_i P_i + c_i) \quad (1)$$

$$\sum_{i=1}^{NG} P_i = P_D + P_1 \quad (2)$$

$$P_{imin} \text{ Ç } P_i \text{ Ç } P_{imas} \quad (i=1, 2, 3 \ldots NG) \quad (3)$$

Where ai , ai and ci are cost coefficients
PD is load demand
Pi is real power generation
P1 is power transmission loss
NG is number of generators
One of the important, simple but approximate methods of expressing transmission loss as a function of generator powers is through B-coefficients. The general form of the loss formula using B-coefficients is

$${}_{i=1} \quad {}_{j=1} \qquad \text{MW} \quad (4)$$

Where Pi , Pj are real power injections at the ith, jth buses Bij are loss coefficients The above loss formula (4) is known as George's formula.
In normal economic load dispatch problem the input – output characteristics of a generator are approximated using quadratic functions, under the assumption that the

incremental cost curves of the units are monotonically increasing piecewise-linear functions. However, real input-output characteristics display higher – order nonlinearities and discontinuities due to valve – point loading in fossil fuel burning plants.

The generating units with multi – valve steam turbines exhibit a greater variation in the fuel cost functions. The valve – point effects introduces ripples in the heat – rate curves. Mathematically operating cost is defined as:

$$F_i(P_i) = \sum_{i=1}^{NG} (a_i P_i^{2} + a_i P_i + c_i + |d_i \times \sin\{e_i \times (P_i^{min} - P_i)\}|) \qquad (5)$$

Where ai , ai , ci , di and ei are cost coefficients of ith unit. Mathematically, economic dispatch problem considering valve point loading is defined as minimizing operating cost given by equation (5) subjected to energy balance equation and inequality constraints given by equations (2) and (3) respectively.

III CUCKOO SEARCH ALGORITHM

The Cuckoo search (CS) [2] algorithm is a Meta heuristic developed by Xin-She yang and Suash Deb in 2009.This algorithm is a nature inspired algorithm which is based on aggressive reproduction strategy of fascinating birds, cuckoos. These cuckoos spread their species by replacing other bird's eggs in their nests with cuckoo's eggs to increase the hatching probability. Some bird species are able to discover the alien eggs and they throw off them or build new nests for their own eggs. Assumptions Some of the assumptions utilized for describing the Cuckoo Search algorithm are

1. Only one egg is laid at a time by each cuckoo and this egg is dumped in a nest which is chosen randomly.
2. Eggs with high quality in the best nests are carried to next generations.
3. The probability of discovering the cuckoo's eggs by other birds is defined by pa in the range [0, 1] and the number of host nests available is assumed to be constant.

For further simplification of the algorithm, each egg in a nest is treated as one solution and cuckoo egg is treated as a new solution. The fitness is determined by the difference in solutions based on the rate of discovery of alien eggs by other birds. Solutions with best fitness replace the existing solutions. Before the initialization of the number of nests, both upper Ub and lower Lb bounds for each egg. Once initialization bounds have been specified, each egg of every nest is assigned a value from within the prescribed range by a random generator as shown in equation. Nest (i,:)=Lb+(Ub-Lb).*rand(size(Lb)) (13) The fitness of the solutions is determined and the current best solution is stored. New solutions are generated based on step size chosen randomly by keeping the current best using the equations (14) and (15)

stepsize=rand*(nest(rand(n),:)-nest(rand(n),:))
(14)

s=s + stepsize.*randn (size(s)) (15)

where n is the number of nests and s represents the new solutions

Probability of discovery of eggs is defined by pa chosen randomly and the next set of new nests is generated using equations (16) and (17).

K=rand (size(nest))>pa (16)

IV RESULTS

The applicability and efficiency of cuckoo search algorithm for practical applications has been tested on two test cases. The Parameters for cuckoo search algorithm considered here are: n=20; Pa=0.5. The proposed cuckoo search algorithm stopping criteria I based on maximum- generation=100.

Test case 1: The system consists of three thermal units[1]. The cost coefficients of all thermal generating units with valve point effect are listed in table (1). The transmission losses, prohibited zones and ramp rate limits are not considered. The economic load dispatch problem is solved to meet a load demand of 850 MW and 1050 MW.

Table: 2 show the summarized result of all the existing algorithms along with cuckoo search algorithm for test case 1. Form Table: 2, it is clear that cuckoo search algorithm gives optimum result in terms of minimum fuel cost compared to other existing algorithms shown.

Test case 2: The system consists of five thermal units [1]. The cost coefficients of all thermal generating units with valve point effect are listed in table (3). The transmission losses, prohibited zones and ramp rate limits are not

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considered. The economic load dispatch problem is solved to meet a load demand of 730 MW.

Table: 1 Cost coefficients for Three Generating units

Unit	Fuel cost coefficients					$P_{G\,min}$ (MW)	$P_{G\,mas}$ (MW)
	a_i	a_i	c_i	d_i	e_i		
G1	0.0016	7.92	561.0	300	0.032	100	600
G2	0.0048	7.92	78.0	150	0.063	50	200
G3	0.0019	7.85	310.0	200	0.042	100	400

Table: 2 Comparison of results for test case 1.

Load demand	Parameter	Lambda	ABC	cuckoo search
850 MW	P1,MW	382.258	300.266	384.4
	P2,MW	127.419	149.733	151.6
	P3,MW	340.323	400.000	313.9
	Total cost, Rs/h	8575.68	8253.10	8253.1
1050 MW	P1, MW	487.500	492.6991	492.6993
	P2, MW	162.500	157.301	158.1006
	P3, MW	400.000	400.00	399.2001
	Total cost, Rs/h	10212.459	10123.73	10123.6954

Table: 3 Cost coefficients for Three Generating units

Unit	Fuel cost coefficients					$P_{G\,min}$ (MW)	$P_{G\,mas}$ (MW)
	a_i	a_i	c_i	d_i	e_i		
G1	0.0015	1.8	40.0	200.0	0.035	50	300
G2	0.0030	1.8	60.0	140.0	0.040	20	125
G3	0.0012	2.1	100.0	160.0	0.038	30	175
G4	0.0080	2.0	25.0	100.0	0.042	10	75
G5	0.0010	2.0	120.0	180.0	0.037	40	250

Table: 4 Comparison of results for test case 2.

Load demand	Parameter	Lambda	ABC	cuckoo search
730 MW	P1, MW	218.028	229.5247	229.52
	P2, MW	109.014	102.0669	102.98
	P3, MW	147.535	113.4005	112.67
	P4,MW	28.380	75.000	75.0
	P5,MW	272.042	210.0079	209.81
	Total cost, Rs/h	2412.709	2030.259	2029.67

Table: 4 show the summarized result of all the existing algorithms along with CUCKOO SEARCH algorithm for test case 2. Form Table: 4, it is clear that CUCKOO SEARCH algorithm gives optimum result in terms of minimum fuel cost compared to other existing algorithms shown.

V CONCLUSION

In this paper, a new cuckoo search algorithm has been proposed. In order to prove the effectiveness of algorithm it is applied to economic load dispatch problem with three and five generating units. The results obtained by proposed method were compared to those obtained by lambda iteration method and ABC. The comparison shows that cuckoo search algorithm performs better than above mentioned methods. The cuckoo search algorithm has superior features, including quality of solution, stable convergence characteristics and good computational efficiency. Therefore, this results shows that cuckoo search optimization is a promising technique for solving complicated problems in power system.

REFERENCES

[1] D.P. Kothari, J.S. Dhillon , power system optimization, second edition, PHI learning private limited,2011, pp 536-591

[2] Xin-She Yang, A new metaheuristic cuckoo search algorithm, luniver press, 2008

[3] M.E. EI-Hawary and G.S.Christensen:Optimal Economic Operation of Electric Power System. New York Academic (1979).

[4] A. J., Wood & B. F. Wollenberg, Power Generation, Operation, and Control, New York: Wile 1996.

[5] K. P. Wang and , C.C.Fung, "Simulate annealing base economic dispatch algorithm", IEE Proeeding - C, vol.140,no.6, pp.509-515, 1993.

[6] K.P. Wong and Y.W.Wong, "Genetic and genetic/simulated-annealing approaches to economic dispatch. Inst. Elect Eng Proceedings - C,vol.141,no.5, pp.507-513, 1994.

[7] C-L.Chiang, "Genetic–based algorithm for power economic load dispatch", IEE Proceeding on Generation, Transmission and Distribution, vol.1,no.2,pp.261-269, 2007.

[8] N.Sinha, R.Chakrabarti and P.K. Chattopadhyay, "Evolutionary programming techniques for economic load dispatch", IEEE Transactions on Evolutionary Computation, vol.7,no.1, pp.83-94, 2003.

[9] A.I Selvakumar and K.Thanuskodi, "A new particle swarm optimization solution to non-convex economic dispatch problem", IEEE Transactions on Power System, vol.22,no.1, pp.42-50, 2007.

[10] Zwe-Lee Gaing, Particle swarm optimization to solving the economic dispatch considering the generator

constraints. IEEE Transactions on Power System,vol.18,no.3. pp.1187-1195, 2003.

[11] Krishna Teerth Chaturvedi, Manjaree Pandit, Laxmi Srivastava, “Particle swarm optimization with crazy particles for nonconvex economic dispatch” Appl. Soft Comput. Vol.9,no.3, pp.962- 969, 2009.

[12] A.I Selvakumar, K Thanuskodi, “ Anti- predatory particle swarm optimization:solution to nonconvex economic dispatch problems” Electrical Power System and Research, vol.78,no.1, pp.2-10, 2008.

[13] S.P Ghoshal, A.Chatterjee, V.Mukherjee, “Bio-inspired fuzzy logic based tuning of power system stabilizer”, Expert System with Applications, vol.36, no.5. pp. 9281- 9292, 2009.

[14] R. Storn, and K. Price, “Differential Evolution –a simple and Efficient Adaptive Scheme for Global Optimization over Continuous Spaces,” Technical Report TR-95-012, ICSI, March 1995.

[15] R. Storn, and K.Price, "Differential Evolution - a Simple and Efficient Heuristic for Global Optimization over Continuous Spaces", Journal of Global Optimization, Kluwer Academic Publishers, Vol. 11 ,pp. 341 – 359, 1997.

[16] P.K.Roy, S.P.Ghoshal, S.S.Thakur,“Biogeography based optimization for multi-constraint optimal power flow with emission and non-smooth cost function, “Expert Systems with Applications,” vol.37,no.12, pp.8221-8228, 2010.

[17] J Cai, X Ma, Li-Xiang LI, Y Yang, H Peng, X Wang,“Chaotic ant swarm optimization to Economic dispatch”,Electrical Power System and Research, The Journal of China Universities of Post Telecommunications, vol.77.no10, pp.1373-1380, 2007.