International Journal of Electronics and Electrical Engineering

Volume 2 | Issue 3 Article 9

January 2014

ECONOMIC DISPATCH - A COMPARATIVE STUDY

APOORVA H.
Department of Electrical & Electronics, Dayananda Sagar College of Engineering,Bangalore, India.,
apoorva@gmail.com

GARIMA SINHA
Department of Electrical & Electronics, Dayananda Sagar College of Engineering,Bangalore, India.,
garima.sinha111@gmail.com

PUNAM DAM
Department of Electrical & Electronics, Dayananda Sagar College of Engineering,Bangalore, India.,
punam.dam@gmail.com

AMRITA PRADHAN
Department of Electrical & Electronics, Dayananda Sagar College of Engineering,Bangalore, India.,
amrita@gmail.com

RRAJENDER REDDY K.
Department of Electrical & Electronics, Dayananda Sagar College of Engineering,Bangalore, India.,
raju.jyothi.siri@gmail.com

Recommended Citation
H., APOORVA; SINHA, GARIMA; DAM, PUNAM; PRADHAN, AMRITA; and REDDY K., RRAJENDER (2014) "ECONOMIC DISPATCH - A COMPARATIVE STUDY," *International Journal of Electronics and Electrical Engineering*: Vol. 2 : Iss. 3 , Article 9.
DOI: 10.47893/IJEEE.2014.1095
Available at: https://www.interscience.in/ijeee/vol2/iss3/9

ECONOMIC DISPATCH - A COMPARATIVE STUDY

APOORVA H.[1], GARIMA SINHA[2], PUNAM DAM[3], AMRITA PRADHAN[4] & RRAJENDER REDDY K.[5]

[1,2,3,4&5]Department of Electrical & Electronics, Dayananda Sagar College of Engineering,Bangalore, India.
E-mail : garima.sinha111@gmail.com, raju.jyothi.siri@gmail.com

Abstract - In this paper we are comparing the widely used Heuristic Method and Genetic Algorithm with a faster and effective non-iterative "λ-Logic Based" algorithm for ED (Economic Dispatch) of Thermal Units. The non-iterative method uses pre-prepared data to obtain the solution for a specified power demand. Genetic Algorithm performs directed random searches through a given set of alternative with the aim of finding the best alternative with respect to the given criteria of goodness. In this paper ED problem is solved using iterative method by Heuristic method , Non-iterative approach by "ƛ-logic Based" technique and genetic Algorithm approach (GA) .The proposed algorithms are tested on 3 and 38 bus system using MATLAB software and the results reported in the paper.

Keywords: *ED = Economic Dispatch, P_D = Power demand on a plant, PPD= Pre- prepared power demand data dF_i/dP_i = Incremental fuel cost of i^{th} unit*

I. INTRODUCTION

Economic dispatch(ED) is the scheduling of generators to minimize the total operating cost depending on equality and inequality constraints. Many techniques have been applied to ED to obtain better solutions [1] to [19]. These include the λ-iteration method, the base point and participation factors method, gradient method, λ-Logic based method and genetic algorithm (GA) method[16]. The λ-Logic based method[19] and GA based method employ pre-prepared data to obtain the solution very fast for a specified power demand (=P_D). The actual support for such fast solution is the pre-prepared data in both λ-Logic based method and GA method. This paper mainly constitutes and compares the three methods and the effectiveness and the best possible method is discussed.

II. PROBLEM FORMULATION

Suppose that we wish to determine the economic operating point for this 3 units when delivered a total of 800 MW before this problem can be solved, the fuel cost of each unit must be specified. Consider the following 3 units

$F1\ (P_1) = 510+7.20\ P_1+0.00142\ P_1^2$

$F2\ (P_2) = 310+7.85\ P_2+0.00194\ P_2^2$

$F3\ (P_3) = 78+7.97\ P_3+0.00482\ P_3^2$

$dF1/dP_1 = 7.2 + 0.00284\ P_1 = \alpha_1 + \beta_1.$

$(150 \leq P_1 \leq 600\ MW)$

$dF2/dP_2 = 7.2 + 0.00388\ P_2 = \alpha_2 + \beta_2.$

$(100 \leq P_2 \leq 400\ MW)$

$dF3/dP_3 = 7.2 + 0.00964\ P_3 = \alpha_3 + \beta_3.$

$(50 \leq P_3 \leq 200\ MW)$

and $P_1 + P_2 + P_3 = 800MW$

solving for ƛ, obtains ƛ=8.66781

And then solving for P_1, P_2 and P_3

$P_1 = 516.834MW$

$P_2 = 210.775MW$

$P_3 = 72.3873MW$

We observe that all constraints are met; i.e., each unit is within its high and low limits and the total output when summed over all three units meets the desired 800MW total.

Method I:

In this method, the problem is solved using the iterative Heuristic Method [11]. Here, the initial value of λ is assumed.

Method II:

In this method, the problem is solved using the Genetic Algorithm[16]. The Genetic principles "Natural Selection" and "Evolution Theory" are main guiding principles. Here, the initial value of λ is assumed and a search space is specified. The three most important aspects of Genetic Algorithm are:

1. Definition of Objective function
2. Definition and implementation of Genetic Representation
3. Definition and implementation of Genetic Operators

ALGORITHM

STEP 1.a) Read no. of units (K), Power Demand (P_d), a_i, b_i, c_i, P_{imin}, P_{imax} where i=1 to K, itermax, String length (SL), population size (NC), Crossover probability, Elitism probability, Mutation probability.

b) Initialize the guess value λ_{imin} and $\lambda_{imax.}$

STEP 2. Generate the initial population of chromosomes of binary bits with random number generation technique.

STEP 3. Set iteration count i=1.

STEP 4. Set the chromosome count j=1.

STEP 5. Decode binary bits of this of population (λ*) and calculated the λ_{act} from λ*.

$$\lambda^* = \sum_{i=1}^{SL} \{ d_i * 2^{-i} \} \qquad (1)$$

$\lambda_{act} = \lambda_{min} + \lambda^*(\lambda_{max} - \lambda_{min})$

STEP 6. Calculated powers of all the units using this value of λ_{act}.

STEP 7. Check power limits of all units

If $P_i > P_{imax}$ then set $P_i = P_{imax}$

If $P_i \geq P_{imin}$ then set $P_i = P_{imin}$

STEP 8. Calculate

$$Err[i] = \left| \sum_{i=1}^{k} P_i - P_d \right| \qquad (2)$$

$Fit[i] = 1/\{1+Err[i]) / P_d\}$

STEP 9. Increment the iteration count i, if i<NC go to step 5.

STEP 10. Sort the chromosomes and all their related data in the descending order according to their fitness.

STEP 11. Checks Err [0] < $(0.0001*P_d)$

STEP 12. If the step 11 is satisfied then print the result of P_i, λ_{act}, Total Fuel Cost.

STEP 13. Check if Fit [0] =Fit [NC]

STEP 14. If the step 13 is satisfied then print "All chromosomes have identical data, problem converged".

STEP 15. Perform the crossover on the two selected parents and generate new child Chromosomes.

STEP 16.Repeat step 15, for required number of times.

STEP 17. Now, copy the P_e % of chromosomes of old population to new population starting from the top.

STEP 18. Add all the generated child chromosomes.

STEP 19. Perform mutation on all the chromosomes.

STEP 20. Now replace old population with new Population.

STEP 21. Increment iteration count.

STEP 22. If i<itermax, go to step 4.

STEP 23. If iterations count is greater than maximum number of iterations initialized, then say that Maximum number of iterations is reached, problem not converged".

STEP 24. STOP

Method III

ALGORITHM

STEP 1 a) Read no. of units k, a_i, b_i, P_{min}, P_{max} for i =1 to k.

b) Calculate $\alpha_i = b_i$ and $\beta_i = 2^* c_i$ for i= 1 to k.

STEP 2. Calculate $\lambda_{min} = \alpha_i + \beta_i * P_i$ at $P_i = P_{imin}$ and $\lambda_{imax} = \alpha_i + \beta_i * Pi$ at $Pi = P_{imax}$.

STEP 3. Arrange all λ values in ascending order.

STEP 4. j =1 i.e. λ_j is the least value.

STEP 5. Calculate P_i For i=1 to K and check

a. If $\lambda j \leq \lambda_{imin}$ then set $Pi = P_{imin}$,

b. If $\lambda j \geq \lambda_{imax}$ then set $Pi = P_{imax}$

c. If $\lambda_{imin} < \lambda_j < \lambda_{imax}$ then calculate

$Pi = (\lambda_j - \alpha_i)/\beta_i$

STEP *6. Calculate Pre-Prepared Demand (PPD) =*

$$\sum_{i=1}^{k} Pi \qquad (3)$$

STEP *7. Check j=2*k i.e. all λ values are considered if yes go to step 9.*

STEP *8. j = j+1 i.e., consider next higher λ value and go to step 5.*

STEP *9. Calculate slope m_j for two successive λ values $m_j = (\lambda_{j+1} - \lambda_j) / (PPD_{j+1} - PPD_j)$ for j=1 to 2k.*

STEP *10. Read Power Demand Pd value.*

STEP 11. If it lies within the limits goto step 12 otherwise go to step 18.

STEP 12. Find j and j+1 such that $PPD_j < P_d < PPD_{j+1}$.

STEP 13. Calculate $\Delta P = P_d - PPD_j$.

STEP 14. Calculate $\lambda_{new} = m_j * \Delta P + \lambda_j$.

STEP 15. Calculate P_i by using step 5 for λ_{new} i=1.

STEP 16. Print the result Pi λ_{new}, Total Fuel Cost.

STEP 17. Want to change Power Demand go to step 10.

STEP 18. Print that the "demand is not in between the limits".

STEP 19. Stop.

III. RESULTS AND DISCUSSIONS:

The effectiveness of proposed methods are tested with two different test data. The data consists of 3 generators and 38 generator systems. Considering 3 units systems, the data of the system is given in [19] and results are given in the table (3.1). Considering 38 units systems, the data of the system is given in [19] and results are given in the table (3.2)

	Heuristic Method	Genetic Algorithm	NON-Iterative
Number of Iterations	8	10	1
Initial Guess Value (λ0)	8	λmin=8 λmax=10	No need
Final Value (λ actual)	8.66781	8.667725	8.66781
P1	516.834	516.8045	516.836
P2	210.775	210.7538	210.777
P3	72.3873	72.3781	72.3873
Pgen	800	799.94	800
Total Fuel Cost ($/Hr.)	7341.49	7340.94	7341.49

TABLE 3.2: Comparison of test results for 38 units (Power values are in MW)

	Heuristic Method	Genetic Algorithm	Non-Iterative
Number of iterations	3999	5	1
Initial Guess Value(λ_{actual})	1060	$\lambda_{min} \rightarrow 1060$ $\lambda_{max} \rightarrow 1070$	No need
Final value(λ_{actaul})	1064.211	1064.216	1064.21
P_1	426.605	426.613	426.606
P_2	426.605	426.613	426.606
P_3	429.663	429.67	429.663
P_4	429.663	429.67	429.663
P_5	429.663	429.67	429.663
P_6	429.663	429.67	429.663
P_7	429.663	429.67	429.663
P_8	429.663	429.67	429.663
P_9	114	114	114
P_{10}	114	114	114
P_{11}	119.767	119.771	119.768
P_{12}	127.072	127.076	127.073
P_{13}	110	110	110
P_{14}	90	90	90
P_{15}	82	82	82
P_{16}	120	120	120
P_{17}	159.598	159.598	159.598
P_{18}	65	65	65
P_{19}	65	65	65
P_{20}	272	272	272
P_{21}	272	272	272
P_{22}	260	260	260
P_{23}	130.648	130.651	130.649
P_{24}	10	10	10
P_{25}	113.304	113.307	113.305
P_{26}	88.066	88.068	88.0666
P_{27}	37.505	37.505	37.505
P_{28}	20	20	20
P_{29}	20	20	20
P_{30}	20	20	20
P_{31}	20	20	20
P_{32}	20	20	20
P_{33}	25	25	25
P_{34}	18	18	18
P_{35}	8	8	8
P_{36}	25	25	25
P_{37}	21.7782	21.782	21.062
P_{38}	21.062	21.062	21.062
P_{gen}	5999.999	6000.077	6000.001
Total fuel cost($/Hr)	91417234	9417317	9417236.9

From the results of table 3.1 reveals the followings observations. All the three proposed methods give λ_{actual} value same but number of iterations taken to converge the solution is different. For a guess value of (λ^0) 8 for ED (ECONOMIC DISPATCH) of units for power demand 800MW,The Heuristic method has taken 8 iterations, Genetic Algorithm has taken 10 iterations and Non-Iterative method though it is not given any initial guess value (λ^0).It is converged in one iteration only. Here the power demand must be specified in pre-prepared data (PPD_1 to PPDj) limits only. If we assume the worst guess value of (λ^0), Heuristic and Genetic Methods may take more number of iterations to converge into solution. Sometimes this may lead to divergence of the solution. If we observe, the total power generation and the Fuel cost, there is no considerable difference in results. As the λ_{actual} value is same for all proposed methods, load sharing among 3 units for 3 methods are almost same.

From the results of table 3.2 reveals the followings observations.

All the three proposed methods give λ_{actual} value same but number of iterations taken to converge the solution is different. For a guess value of (λ^0) 1060 for ED (ECONOMIC DISPATCH) of units for power demand 6000MW,The Heuristic method has taken 3999 iterations, Genetic Algorithm has taken 5 iterations and Non-Iterative method though it is not given any initial guess value (λ^0).It is converged in one iteration only. If we assume the worst guess value of (λ^0), Heuristic and Genetic Methods may take more number of iterations and sometimes divergence of the solution may take place. As calculations are more in 38 unit system, the computation time is very large. By using Genetic Algorithm, to converge the solution very fastly and to reduce the number of iteration. The search space(λ limits),search points,mutation,cross-over and elitism probabilities must be appropriately selected.Therefore,an expert is needed to use GA method. By using non-iterative method, though it is initially calculating all the necessary data(Pre-Prepared),it is calculating only once If we specify the power demand within the pre-prepared data limits(i.e.PPD_1 to PPDj),the problem is converged into solution in only one iteration.Finally,we can observe the total power and total fuel cost that there is no considerable difference in results. As the λ_{actual} value is same for all proposed methods, therefore load sharing among 38 generators for 3 methods are almost same.

IV. CONCLUSION

The paper has been an attempt to solve the Economic Dispatch problems using Iterative technique, Genetic Algorithm and Non-Iterative Technique.

Using any conventional method such as λ-updation method the disadvantages are a worst initial guess value which leads to divergence of the solution, slow convergence with large number of iterations and experienced persons are required to choose a good guess value. The paper then deals with Genetic Algorithm technique which is better than Heuristic method. The final stage of paper as explained the "Non- Iterative λ- based" method.

The paper has compared the results obtained by using the above three methods and views out the superiority of "Non-Iterative λ – logic based" method and it was the best method when compared with conventional and GA methods.

REFERENCES

[1] T.Yalcinoz, M.J.Short, "Large Scale Economic Dispatch using an improved Hopfield Neural Network".IEE Proc.Gener. Tran .Disturb Vol.144 No.2. March 1997,PP 181-185.

[2] Hong-Tzer Yang Pai-Chuan yang, Ching-Lien Haang. "A Parallel Genetic Algorithm Approach to solving the unit commitment problem : Implementation on the Transpoter Networks,"IEEE transactions on Power Systems,Vol 12 No 2,May 1997.

[3] Kumar .J.and Sheble,G.B "Clamped State Solution of Artificial Neural Network for Real-Time Economic Dispatch", IEEE Transactions on Power Systems,1995,10 (2),PP 925-931.

[4] Park J.H.KIM,Y.S, ECM.I.K, and LEE, K.Y.,"Economic Load Dispatch for Piecewise Quadratic Cost Function using Hopfield Neural Network", IEEE Transaction on Power Systems,1993,8(3),PP 1030-1038.

[5] Sendaula M.H., Biswas,.S.K., Eltom.A, Parten.C. and Kazibwe W., "Simulatneous Solution of Unit Commitment and Economic Dispatch Problems using Artificial Neural Networks". Electrical Power Energy and Systems. 1993,15(3), PP 193-199.

[6] Luis Vargas. Victor H. Quintana,Anthony Vanneli. "A Tutorial Description of an Interior Point method and its application to Sevurity Constrained Economic Dispatch", IEEE Transactions on Power Systems. Vol.8, No.3, August 1993,PP 1315-1324.

[7] Chowdhury, B.H. and Rahman, S., "A Review of Recent Advances in Economic Dispatch", IEEE Transactions on Power Systems. Vol. , No.4,PP 248-1259,Nov 1990.

[8] Aoki.K and Satoh T., "New Algorithm for classic Economic Dispatch", IEEE Transactions on Power Apparatus and Systems. Vol. PAS-103. No.6. PP 1423-1431 , June 1984

[9] Mota-Palomino,R., and Quintana, V .II., "A Penalty Function Linear Programming Method for Solving Power System Constrained Economic Operation Problems", IEEE Transactions on Power Apparatus and Systems, Vol. PAS-103, No-6, Ppp.1414-14222. June 1984.

[10] Happ M.M "Optical Power Dispatch –A Comprehensive Survey", IEEE Transactions on Power Apparatus and Systems. Vol. PAS-91, No3.PP.841-854, May/June 1977.

[11] Wood A.J and Wollenberg . B.F. "Power Generation Operation and Control".(John Wiley and Sons ,New York,1984).

[12] C.L. Wadhwa, "Generation,Distribution and Utilisation of Electrical Energy", New Age International Publishers.

[13] M.L. Soni, P.V. Gupta, U.S Bhatnagar and A.Chakrabarti. "A Text Book On Power Systems Engineering",Dhanpat Rai and Sons (P) Ltd.

[14] J.B Gupta. "Course in Power Systems".S.K Kataria and Sons (P) Ltd.

[15] D.P. Kothari and I.J.Nagarath. "Modern Power System Analysis" Tata McGraw-Hill Publishing Company Ltd.

[16] S.Rajashekharan and G.A Vijayalaxmi Pai. "Neural Networks, Fuzzy Logic and Genetic Algorithm(Synthesis and Application)". Prentice-Hall of India(P) Ltd.

[17] John J.Grainger and William D. Stevenso, JR. "Power System Analysis".McGraw-Hill International Editions.

[18] Arthor R.Bergen and Vijay Vittal. "Power System Analysis".Pearson Education.

[19] Maheswarapu Sydulu. "A Very Fast and Effective Nom-Iterative λ-Logic Based Algorithm for Economic Dispatch of Thermal Units". IEEE Transactions on Power Systems. June 1999,PP 1434-1437.

◈◈◈