A Research Paper on Analysis and Solution of Single Area Unit Commitment Problem in Electrical Power System

Ashish Kumar Ashu[1], Mr. Prabodh Khampariya[2]

[1] Department of Electrical Engineering, Sri Satya Sai University of Technology and Medical Sciences, Sehore, MP
[2] Assistant Professor, Department of Electrical Engineering, Sri Satya Sai University of Technology and Medical Sciences, Sehore, MP

ABSTRACT

This paper addresses the Unit Commitment (UC) problem, which is a well-known combinatorial optimization problem arising in operation planning of power systems. In the UC issue, the numerical detailing of Unit Commitment Problem has been produced. The calculation for Unit responsibility issue has been produced utilizing Dynamic Programming Approach and Quadratic Programming based Particle Swarm Optimization (QP-PSO) Approach. The result of QP-PSO calculation is an apparent result of the work. The aftereffects of different IEEE Bus frameworks have been appeared. Additionally, the execution of proposed calculation is contrasted and Heuristic PSO Algorithm, Dynamic programming Algorithm and Genetic Algorithm.

Keywords: unit commitment, scheduling, generation, genetic algorithm, quadratic programming.

I. INTRODUCTION

Electrical power plays a pivotal role in the modern world to satisfy various needs. It is therefore very important that the electrical power generated is transmitted and distributed efficiently in order to satisfy the power requirement. The Economic Load Dispatch (ELD) issue is the most noteworthy issue of streamlining in estimating the age among warm creating units in control framework. The ELD issue is to design the yield control for each committed producing unit to such an extent that the cost of task is limited alongside coordinating force working cutoff points, stack request and satisfying different framework constraints. The ELD issue is a noteworthy issue in the activity of warm/hydro creating station. It is viewed as an advancement issue, and is characterized for limited aggregate age cost, subject to different non-direct and straight imperatives, keeping in mind the end goal to take care of the power demand.

The ELD issue is characterized in two diverse courses, as raised ELD issue and non-curved ELD issue. The raised ELD issue is demonstrated by considering the target work as limiting the generator cost capacities thinking about straight confinements/limitations. In the nonconvex ELD issue the non-straight confinements/imperatives are considered next to direct constraints while lessening cost work. The direct imperatives, that is the age limit and power adjust drives the ELD issue as rough, rearranged issue and the qualities bend is thought to be piecewise straight. A more exact and precise issue is displayed by having the non-straight imperatives, for example, precluded working zones, valve point impacts and slope rate limits. The issue of ELD is typically multimodal, broken and exceedingly nonlinear.

In spite of the fact that the cost bend of warm creating units are by and large displayed as a smooth bend, the inputoutput qualities are nonlinear by nature in light of valve-point stacking impacts, Prohibited Operating Zones (POZ), incline rate breaking points et cetera. Huge steam turbine generators regularly have different valves in steam turbines. These valves are opened and shut to keep the genuine power adjust. Be that as it may, this impact delivers the swells in the cost work. This impact is known as valve-point stacking impact. Disregarding of valve-point impacts prompts erroneous age dispatch. Other than this, the producing units may have positive range where task is relinquished because of the physical constraints of mechanical parts. Such confined districts of stacking arecommonly known as POZ.

At the point when a producing unit has POZ, its working area breaks into remote sub-areas, in this manner framing a non-curved choice space. Besides, the working reach for online units is confined by their incline rate limits. To keep warm changes in the turbine inside safe restricts and to abstain from shortening of life, the rate of increment or abatement of energy yield of producing units is constrained inside a range. Such slope rate imperative makes the ordinary ED issue as a Dynamic Economic Dispatch (DED) issue. The nearness of these nonlinearities in useful generator task makes taking care of the ED issue all the more difficult.

II. PROBLEM FORMULATION

Single Area Unit Commitment Problem

The fundamental goal of unit responsibility is to locate the ideal timetable for working the accessible creating units with a specific end goal to limit the aggregate working expense of the power age. Add up to working expense of energy age incorporates fuel cost, start up and close down expenses. The fuel costs are figured utilizing the information of unit warm rate and fuel value data which is ordinarily a quadratic condition of energy yield of every generator at every hour dictated by Economic Dispatch(ED).

$$F_c(P_i) = a_i + b_i P_i + c_i P_i^2$$

where, a_i, b_i, c_i are the cost coefficients.

The total fuel cost over the given time period 'T' is

$$TFC = \sum_{t-1}^{T} \sum_{i=1}^{N} F_c P_i * X_i(t)$$

where, X_i (t) is the position or status of i^{th} unit at t^{th} hour.

Start up cost is that cost which occurs while bringing the thermal generating unit online. It is expressed in terms of the time (in hours) for which the units have been shut down. On the other hand, shut down cost is a fixed amount for each unit which is shut down. A start up cost can be expressed as :

$$SUC_i = \begin{Bmatrix} HSC_i, if MDT_i \le DT_i < MDT_i + CSH_i \\ CSC_i, if DT_i > MDT_i + CSH_i \end{Bmatrix}$$

where,

DT_i- shut down time,

MDT_i- Minimum down time,

HSC_i- Hot start up cost,

CSC_i- Cold start up cost,

CSH_i- Cold start hour of i^{th} unit.

Algorithm of Proposed Hybrid Particle Swarm Optimization :

The Proposed Algorithm consists of Hybrid combination of Quadratic Programming and Particle Swarm optimization (QP-PSO). The procedure of the proposed hybrid algorithm is as follows:

Step-1: Initialize the Generating Units parameters i.e. Pmin, Pmax, MDT, MUT, a, b,c, SUC, SUH, Tcold, Init State, NG,T, Pload etc.

Step-2: Initialize the PSO parameters i.e**.** NP, ITERmax, Zmax, Zmin etc.

Step-3: Initialize the swarm. and sort Pmax in decending order w.r.t. time.

Step-4: Satisfy the load demand constraints and Reserve constraints using the equation () and () respectively. The Pseudo Code for constraints is mentioned below.

Step-5: Satisfy Minimum Up Time and Down Time constraints using the equation () and () respectively.

Step-6: Again Check the load demand constraints and Reserve constraints for updated population using the equation () and () respectively.

Step-7. Solve the Economic load Dispatch Problem without considering valve-point effects incorporating wind power using Quadratic Programming.

Step-8: Update the Swarm Position and Velocity using equation () and () respectively.

Step-9: Calculate the updated constraints using ( ) and randomly generate initial population around the solution obtained from **Quadratic Programming** for PSO.

Step-10. Again Solve the Economic Load Dispatch problem with valve-point effects and calculate Gfitness using Particle Swarm optimization. The Pseudo code for updating the status of swarm is mentioned below.

Step-12: Display the final status of the Generating units and Minimum Cost.

Step-13: Save the final results.

III. RESULTS AND DISCUSSIONS

Modern Soft Computing Technique: QP-PSO Algorithm

The Hybrid QP-PSO calculation has been produced as Modern enhancement calculation to explain the Single Area Unit Commitment issue. The comparing consequences of previously mentioned IEEE Bus frameworks utilizing Hybrid QP-PSO calculation are demonstrated as follows:

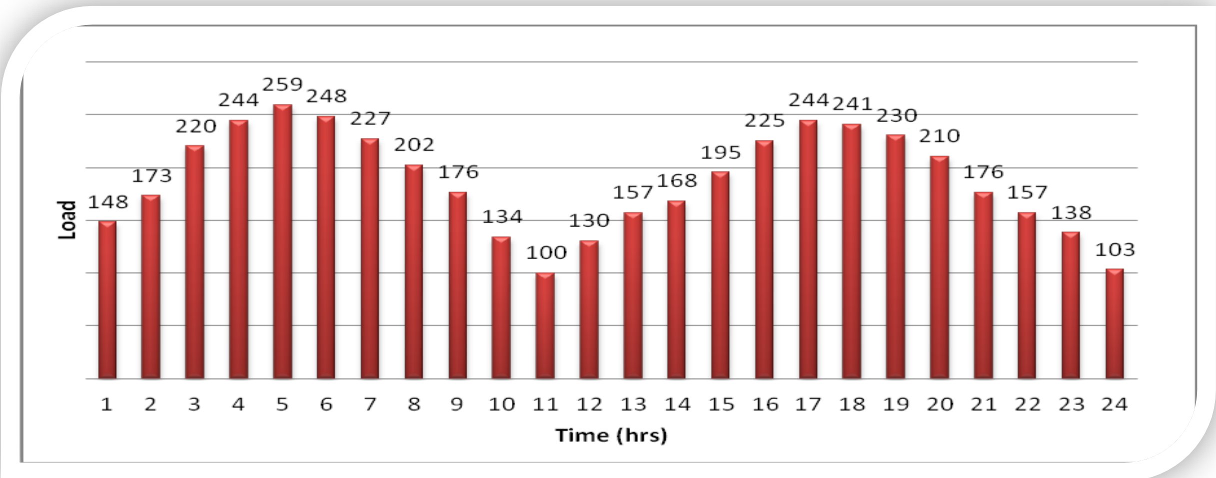

Fig. 1: Load Demand pattern for 24-hours for 14-Bus System

Table 1: Results for 14-Bus System Using QP-PSO

Time	1	2	3	4	5	6	7	8	9	10	11	12
G1	148	173	220	144	159	148	227	202	176	134	100	130
G2	0	0	0	0	0	0	0	0	0	0	0	0
G3	0	0	0	100	100	100	0	0	0	0	0	0
G4	0	0	0	0	0	0	0	0	0	0	0	0
G5	0	0	0	0	0	0	0	0	0	0	0	0
Time	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
G1	157	168	195	225	234	121	220	210	176	157	0	0
G2	0	0	0	0	0	0	0	0	0	0	38	103

G3	0	0	0	0	0	0	0	0	0	0	100	0
G4	0	0	0	0	0	120	10	0	0	0	0	0
G5	0	0	0	0	10	0	0	0	0	0	0	0
TOTAL COST=12886												

Table 2: Results of 30-Bus System Using QP-PSO

Time (hrs)	1	2	3	4	5	6	7	8	9	10	11	12
G1	166	116	149	200	200	142	166	133	112	81	147	160
G2	0	80	80	37	38	80	0	0	80	80	0	0
G3	0	0	0	0	15	50	50	50	0	0	0	0
G4	0	0	0	0	0	0	0	0	0	0	0	0
G5	0	0	0	30	30	0	30	30	0	0	0	0
G6	0	0	0	0	0	0	0	0	0	0	0	0
Time (hrs)	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
G1	170	105	128	152	166	161	156	145	124	102	161	131
G2	0	80	80	80	80	80	80	80	80	80	0	0
G3	0	0	0	0	0	0	0	0	0	0	0	0
G4	0	0	0	0	0	0	0	0	0	0	0	0
G5	0	0	0	0	0	0	0	0	0	0	0	0
G6	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COST=13733												

Table 3: Compared Results

Optimization Algorithm	No. of Generating Units	Total Operating Cost
Heuristic PSO Algorithm	10	557183
Shuffled Frog Leaping Algorithm	10	564769
Dynamic Programming Algorithm	10	**553837**
Hybrid QP-PSO Algorithm [Proposed Algorithm]	10	**566960**

CONCLUSIONS

In this work, the detailing and usage of arrangements techniques to acquire the ideal arrangement of Single Area unit Commitment Problem utilizing Dynamic Programming Approach and Hybrid QP-PSO calculation is completed. The accompanying critical focuses have been watched all through the work:

- Particle Swarm streamlining calculation can be utilized to illuminate a significant number of an indistinguishable sorts of issues from Genetic Algorithms.
- Particle Swarm framework has memory which the Dynamic Programming calculation and Lagrangian Relaxation Algorithm does not have.
- In molecule Swarm enhancement, person that fly past optima are pulled to return toward them, learning of good arrangements is held by all particles.
- Particle Swarm Optimization has likewise been exhibited to perform well on Heuristics PSO calculation test capacities and it has all the earmarks of being a promising methodology for robot undertaking learning.

The viability of the created calculation is tried for IEEE-14 Bus System, IEEE-30 System, IEEE-56 Bus System and IEEE Bus framework comprising of 10 Generating Units. The outcomes got by QP-PSO calculation is additionally contrasted and Dynamic Programming calculation, Heuristics PSO calculation and Shuffled Frog Leaping Algorithm. It is discovered that QP-PSO is giving better outcomes when contrasted with Heuristics PSO calculation. Working Cost utilizing Dynamic Programming calculation is superior to Classical PSO calculation.

REFERENCES

[1]. Hardiansyah, Junaidi and Yohannes MS, "Application of Soft Computing Methods for Economic Load Dispatch Problems", *International Journal of Computer Applications (0975 – 8887),* Vol. 58, No. 13, Nov. 2012, pp. 32-37.

[2]. Lee K. S. and Geem Z. W., "A new meta-heuristic algorithm for continuous engineering optimization: harmony search theory and practice", *ELSEVIER Journal Computer Methods Applied Mechanical Engineering 194*, 2005, pp. 3902–3933.

[3]. Coelho L.S. and Mariani V.C., "An improved harmony search algorithm for power economic load dispatch", *ELSEVIER Journal Energy Conversion and Manage.50*, 2009, pp. 2522–2526.

[4]. Coelho L.S., Bernert D. L. A., and Mariani V. C., "Chaotic Differential Harmony Search Algorithm Applied to Power Economic Dispatch of Generators with Multiple Fuel Options", *Evolutionary Computation (CEC), 2010 IEEE Congress,* Barcelona, 18- 23 July 2010, pp. 1- 5.

[5]. Singh, Lakhwinder, and J. S. Dhillon. "Cardinal priority ranking based decision making for economic-emission dispatch problem." International Journal of Engineering, Science and Technology,vol. 1, no. 1, pp: 272-282, 2009.

[6]. VK Kamboj, A Bhardwaj, HS Bhullar, K Arora, K Kaur, Mathematical model of reliability assessment for generation system, Power Engineering and Optimization Conference (PEDCO) Melaka, Malaysia, 2012 IEEE.

[7]. Duman, S., U. Güvenç, and N. Yörükeren. "Gravitational search algorithm for economic dispatch with valve-point effects." International Review of Electrical Engineering,vol. 5, no. 6, pp:2890-2895, 2010.

[8]. Bhattacharya, Aniruddha, and Pranab Kumar Chattopadhyay. "Solving complex economic load dispatch problems using biogeography-based optimization." Expert Systems with Applications vol. 37, no. 5, pp: 3605-3615, 2010.

[9]. Navpreet Singh Tung, Amit Bhardwaj, Tarun Mittal, Vijay Shukla, Dynamics of IGBT based PWM Converter A Case Study, International Journal of Engineering Science and Technology (IJEST), ISSN: 0975-5462, 2012.

[10]. Gaing, Zwe-Lee. "Particle swarm optimization to solving the economic dispatch considering the generator constraints." IEEE Transactions on Power Systems,vol. 18 , no. 3, pp: 1187-1195, 2003.

[11]. R. T. F. Ah King and H. C. S. Rughooputh, "Elitist Multi-objective Evolutionary Algorithm for Environmental/Economic Dispatch," Congress on Evolutionary computation, vol. 2, pp. 1108-14, 8-12 Dec.2003.

[12]. T. Aruldoss Albert Victoire and A. Ebenezer Jeyakumar ,"Hybrid PSO-SQP for economic dispatch with valve-point effect" Electric Power Systems Research; 71,pp: 51-9, 2004.

[13]. Bilolikar V.S., Jain K. and Sharma M. R., "An Annealed Genetic Algorithm for Multi Mode Resource Constrained Project Scheduling Problem", *International Journal of Computer Applications (0975 – 8887),* Vol. 60, No.1, Dec. 2012, pp. 36-42.

[14]. Valenzuela J. and Smith A. E., "A Seeded Memetic Algorithm for Large Unit Commitment Problems", *Journal of Heuristics,* Sep. 1999.

[15]. Mafteiu- Scai L. O. and Mafteiu- Scai E. J., "Solving Linear Systems of Equations using a Memetic Algorithm", *International Journal of Computer Applications (0975 – 8887*), Vol. 58, No.13, Nov. 2012, pp. 16-22.

[16]. Mafteiu-Scai L. O., "Improved the Convergence of Iterative Methods for Solving Systems of Equations by Memetics Techniques", *International Journal of Computer Applications (0975 – 8887),* Vol. 64, No.17, Feb. 2013, pp. 33-38.

[17]. Sanusi H. A., Zubair A., and Oladele R., "Comparative Assessment of Genetic and Memetic Algorithms", *Journal of Emerging Trends in Computing and Information Science,* Vol. 2, No. 10, Oct. 2011, pp. 498-508.

[18]. Yare Y., Venayagamoorthy G. K., and Saber A. Y., "Economic Dispatch of a Differential Evolution Based Generator Maintenance Scheduling of a Power System", in *Power & Energy Society General Meeting, 2009(PES '09) IEEE,* Calgary, Alberta, 26-30 July 2009, pp. 1-8.

[19]. Navpreet Singh Tung, Amit Bhardwaj, Ashutosh Bhadoria, Kiranpreet Kaur, Simmi Bhadauria, Dynamic programming model based on cost minimization algorithms for thermal generating units, International Journal of Enhanced Research in Science Technology & Engineering, Volume 1, Issue 3, ISSN: 2319-7463, 2012.

[20]. M. Sudhakaran, S.M.R Slochanal, R. Sreeram and N Chandrasekhar, "Application of Refined genetic Algorithm to Combined Economic and Emission Dispatch" J. Institute Of Engg. (India) ,vol. 85, pp: 115-119, Sep. 2004.

[21]. M. Sudhakaran and S.M.R Slochanal, "Integrating Genetic Algorithm and Tabu Search for Emission and Economic Dispatch Problem" J. Institute of Engg. (India) ,vol. 86, pp: 22- 27, June.2005

[22]. Swain, R. K., N. C. Sahu, and P. K. Hota. "Gravitational search algorithm for optimal economic dispatch." Procedia Technology ,vol. 6, pp: 411-419, 2012.

[23]. Yang, Xin-She, Seyyed Soheil Sadat Hosseini, and Amir Hossein Gandomi. "Firefly algorithm for solving non-convex economic dispatch problems with valve loading effect." Applied Soft Computing ,vol.12, no. 3 pp: 1180-1186, 2012.

[24]. Gupta, Tripti, and Manjaree Pandit. "PSO-ANN for Economic Load Dispatch with Valve Point Loading Effects." International Journal of Emerging Technology and Advanced Engineering; ISSN 2250-2459, vol. 2, no. 5, 2012.

[25]. Ravi C.N. and Rajan C. C. A., "Emission Constraint Optimal Power Flow using Differential Evolution", *International Journal of Computer Applications (0975 – 8887*), Vol. 61, No.13, Jan. 2013, pp. 12- 15.

[26]. EA Bhardwaj, RK Sharma, EA Bhadoria, A Case Study of Various Constraints Affecting Unit Commitment in Power System Planning, International Journal of Enhanced Research in Science Technology & Engineering, 2013.

[27]. Rajasomashekar, S., and P. Aravindhababu. "Biogeography based optimization technique for best compromise solution of economic emission dispatch." Swarm and Evolutionary Computation,vol. 7, pp: 47-57, 2012.

[28]. Güvenç, U., Y. Sönmez, S. Duman, and N. Yörükeren. "Combined economic and emission dispatch solution using gravitational search algorithm." Scientia Iranica ,vol.19, no. 6 , pp: 1754-1762, 2012.

[29]. Kushwaha N., Bisht V.S. and Shah G., "Genetic Algorithm based Bacterial Foraging Approach for Optimization", *National Conference on Future Aspects of Artificial intelligence in Industrial Automation (NCFAAIIA 2012),* Proceedings published by International Journal of Computer Applications, 2012, pp. 11- 14.

[30]. Chakraborty S., Senjyu T., Yona A., Saber A. Y. and Funabashi T., "Generation Scheduling of Thermal Units Integrated with Wind-Battery System Using a Fuzzy Modified Differential Evolution Approach", *Intelligent System Applications to Power Systems, 2009 (ISAP '09), 15th International Conference,* Curitiba, Brazil, 8-12 Nov. 2009, pp. 1-6.

[31]. Sharma R., Panigrahi B. K., Rout P. K. and Krishnanand K.R., "A Solution to Economic Load Dispatch Problem with Non-smooth Cost Function using Self-Realized Differential Evolution Optimization Algorithm", *Energy, Automation, and Signal (ICEAS), 2011 International Conf.*, 28- 30 Dec. 2011, pp. 1-6.