OPPOSITIONAL TLBO ALGORITHM FOR OPTIMUM GENERATING SCHEDULING OF POWER SYSTEM NETWORK WITH VALVE POINT LOADING EFFECT

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https://doi.org/10.26782/jmcms.2019.12.00063

Abstract

This paper discusses about ELD Problem is modelled by non-convex constrained based cost function. This paper discusses the nonconvex cost function based ELD problem. Actually, these problems are not solvable using a convex optimization techniques. Normally convex-conventional techniques are not solvable to ELD problems. So there is a need for using a meta-heuristic optimization methods. So in order to solve the non-convex cost function problems, a new meta-heuristic optimization techniques are required. Out of all optimization techniques, Oppositional Teaching and Learning Based Optimization (OTLBO) is introduced to solve the ELD problems and which will give better promising results. In this paper, OTLBO algorithm is used to solve the load dispatch problems economically to solutions economically with valve point loading effect. In this paper, Oppositional Teaching and Learning Based Optimization (OTLBO) compares with other standard standard algorithms like TLBO and lambda iteration method. The OTLBO feasibility and effectiveness is demonstrated on 6, 10, and 14 units test systems along with the other optimization algorithms. The Comparison results enhance the global best solution for economic load dispatch solutions.

Keywords: Valve point loading effect, Economic load dispatch, Non-convex cost function, Oppositional T & L Based Optimization (OTLBO), Teaching and Learning Based Optimization (TLBO).

I. Introduction

Now a days, generator scheduling is a big problem for power engineers. Since from the past few decades, number of techniques are practiced for economic
load dispatch problems. The ELD tells that optimal generator scheduling of loads so that supplying power must be equal to power demanding and power losses as a decreasing fuel cost[II]. Actually the power generation cost is very high. In India the major power is generated from thermal power plants where the running cost is too high. So it is necessary to minimize the power generation cost as well as transmission losses for ELD problems [III,VI,VIII]. Many researchers implemented to number of algorithms to solution of economic load dispatch problems. This paper explores the new meta-heuristic algorithm i.e. oppositional teaching and learning based optimization technique. Previously many mathematical programming methods are developed for solving ELD problems in order to get convergence solution. Linear programming techniques are effective but it will applicable only for piecewise linear cost functions. So nonlinear programming approaches have to be implement for solution of non-linear cost functions. NR based methods cannot solve the equality constraints problems [I]. This paper tells the solution of ELD problem with valve point loading effect by OTLBO algorithm with consideration of transmission losses. In this paper, we also implemented OTLBO algorithm for 6, 10 and 14 unit test system and also compared with TLBO algorithm. Finally, OTLBO algorithm gives high quality solution for global minimization.

II. Problem Formulation

Load dispatch solutions defines reducing the fuel cost, real power balancing and satisfying the demand of active power. The ELD problem is represented by [X].

\[ FC(P_i) = \sum_{i=1}^{N} F_i(P_i) \]  

(1)

Here \( FC(P_i) \) = overall fuel cost,

\( P_i \) = Power generation of \( i^{th} \) thermal generating unit

The fuel cost is quadratic function so it is,

\[ F_i(P_i) = a_i P_{gi}^2 + b_i P_{gi} + c_i \]  

(2)

Subjected to

\[ \sum_{i=1}^{N} P_i = P_D + P_L \]  

(3)

\[ P_{i,\text{min}} \leq P_i \leq P_{i,\text{max}} \]  

(4)

A. Economic dispatch problem with valve-point loading effect

Here valve point effect means sum of quadratic function function plus sinusoidal cost function which is represented as [IX].
\[ F_i(P_i) = a_i + b_i P_i + c_i P_i^2 + \left| e_i \sin(f_i \cdot (P_i^{\min} - P_i)) \right| \]  

(5)

Here \( e_i \) and \( f_i \) are generating units reflecting coefficients.

The line losses are represented by

\[ P_L = \sum_{i=1}^{n} \sum_{j=1}^{n} P_i B_{ij} P_j + \sum_{i=1}^{n} P_i B_{0i} + B_{00} \]  

(6)

Here \( B_{ij}, B_{0i}, \) and \( B_{00} \) are coefficients of line loss

### III. Simulation Results & Discussion

The OTLBO algorithm effectiveness and feasibility is tested on standard test systems like 6, 10, 14 and results are also compared with TLBO algorithm as well as Lambda iteration method.

**Test system 1: Six unit test system**

This case, a non-convex cost function based 6 thermal units are considered. The proposed method effectiveness is tested on two different load demands 800 and 1263 MW that can be meet by 6 thermal units. The test system data taken from [V]. In this case population size is assumed as 60. The TLBO & OTLBO load dispatch results are formulated in table 1. In this case, 25 independent trails have been made with 200 iterations per trail. Based on the performance, three different methods results are compared shown in below table 1.

**Table 1. Comparisional results for 6-unit system**

| Unit | \( P_D = 800 \text{ MW} \) | \( P_D = 1263 \text{ MW} \) |
|------|----------------|----------------|
|      | Lambda | TLBO | OTLBO | Lambda | TLBO | OTLBO |
| 1    | 342.2421 | 343.4325 | 339.6431 | 447.5038 | 444.4068 | 447.5038 |
| 2    | 95.4819  | 96.5919  | 96.5813  | 173.3182 | 170.8177 | 173.3182 |
| 3    | 181.9937 | 183.1756 | 183.2407 | 263.4628 | 263.9355 | 263.4628 |
| 4    | 53.6758  | 50     | 53.9589  | 139.0653 | 146.5230 | 139.0652 |
| 5    | 82.5707  | 82.8179 | 82.5354  | 165.4734 | 166.4267 | 165.4733 |
| 6    | 50.0000  | 50     | 50      | 87.1347  | 83.7436  | 87.1347  |

| Generatio n cost in $/hr | 9528.722 2 | 9528.884 4 | 9528.796 9 | 15449.899 5 | 15450.675 3 | 15449.899 5 |
|--------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Power loss in MW         | 5.9642      | 6.0179      | 5.9597      | 12.9582     | 12.8536     | 12.9582     |

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From the Table 1, at load demand of 800MW, the obtained minimum cost by Lambda iteration is 9528.7222$/hr with the power loss of 5.9642MW. The obtained minimum cost by OTLBO method is 9528.7969$/hr with the power loss of 5.9597 MW. The cost obtained by TLBO is 9528.8844$/hr with power loss of 6.0179 MW. From the records, its clearly shows that the obtained minimum cost by all the methods is almost same as the global solution at the load demand of 800 MW. Now the power demand of 1263MW, the obtained minimum cost by Lambda iteration method and OTLBO is 15449.8995$/hr with the power loss of 12.9582MW. The minimum cost obtained by TLBO is 15450.6753$/hr with the power loss of 12.8536MW. The cost obtained by Lambda iteration method and OTLBO is same as the global solution.

Fig.1 shows the comparison of convergence characteristics at different populations for different methods. As shown fig x axis represents iterations and y axis represents minimum cost in $/hr.

![Comparison of convergence characteristics for different populations](image)

**Test system2: 10-unit system**

This case, anon-convex cost function based 10 thermal units are considered. The performance of the proposed methods was demonstrated at two different load demands and that load demands meet by ten thermal units are 1500 and 2000MW. The test data taken from [VII]. Here 100 population size is taken. The dispatch results of 10-unit system using the proposed methods are given in Table 2. For this test system, trails of 25 independent are made with 300 iterations/trail. Based on data obtained, the comparisons of six thermal units test by different methods are presented in Table 2.
Table 2. Comparisional results for 10-unit system

| Unit | \(P_D=1500\text{MW}\) | \(P_D=2000\text{MW}\) |
|------|----------------|----------------|
|      | Lambda | TLBO | OTLBO | Lambda | TLBO | OTLBO |
| 1    | 43.5706 | 45.6086 | 55.0000 | 55.0000 | 55.0000 |
| 2    | 60.8157 | 61.7683 | 80.0000 | 80.0000 | 80.0000 |
| 3    | 72.1301 | 67.6629 | 107.0165 | 120.0000 | 107.0151 |
| 4    | 60.3987 | 55.5074 | 99.9004 | 95.5547 | 99.9007 |
| 5    | 51.3367 | 51.4848 | 81.9005 | 77.8408 | 81.9024 |
| 6    | 71.3367 | 71.4848 | 83.2229 | 78.7297 | 83.2221 |
| 7    | 207.1676 | 209.5249 | 300.0000 | 300.0000 | 300.0000 |
| 8    | 222.2243 | 232.5880 | 340.0000 | 340.0000 | 340.0000 |
| 9    | 372.1789 | 375.2049 | 470.0000 | 470.0000 | 470.0000 |
| 10   | 387.8631 | 378.1727 | 470.0000 | 470.0000 | 470.0000 |
| Genratn cost in $/hr | 81130.0325 | 81129.7603 | 111261.5057 | 111289.9482 | 111261.5051 |
| Power loss in MW | 49.0223 | 49.0223 | 87.0403 | 87.1252 | 87.0403 |

From the Table 2, at load demand of 1500MW the obtained minimum cost by Lambda iteration technique and TLBO is \(81130.0325\$/hr\) with the power loss of \(49.0223\text{MW}\). The obtained minimum cost by OTLBO technique is \(81129.7603\$/hr\) with the power loss of \(49.007\text{MW}\). From the above records it says clearly that the obtained minimum cost by the OTLBO is the global solution at the load demand of 1500MW. Now power demand of 2000MW the obtained minimum cost by Lambda iteration method is \(111261.5057\$/hr\) with the power loss of \(87.0403\text{MW}\). The obtained minimum cost by OTLBO method is \(11261.5051\$/hr\) with the power loss of \(87.0403\text{MW}\). The TLBO obtained cost is \(111289.9482\$/hr\) with power loss of \(87.1252\text{MW}\). Therefore the cost obtained by Lambda iteration method and OTLBO is almost same but the cost obtained by OTLBO method is global minimum.
Fig. 2 Comparison of convergence characteristics of obtained minimum cost for 20 runs

Fig. 2 shows, the graphical representation of comparison convergence characteristics of obtained minimum cost for 20 runs at load demand 2000 MW. As shown in fig the cost obtained by Lambda iteration method is constant for all runs while the other methods are varying.

Test system 3: 14-unit system

This case, a non-convex cost function based 14 thermal units are considered. The performance of the proposed methods is demonstrated at two different load demands and that load demands meet by 14 thermal units are 1500 and 2000 MW. The data taken from [IV]. Here population is 140. The dispatch results of 14-unit system using the proposed methods are given in Table 3. For this test system, 500 iterations per trail are made with 25 independent trails. From the data, six thermal units’ comparisons shown by different methods are presented in Table 3.

Table 3. Comparisional results for 14-unit system

| Unit | $P_D=1500$[MW] | $P_D=2000$[MW] |
|------|----------------|----------------|
|      | Lambda | TLBO | OTLBO | Lambda | TLBO | OTLBO | Lambda | TLBO | OTLBO |
| 1    | 221.3101 | 220.1858 | 218.5729 | 310.6826 | 308.1352 | 312.1435 |
| 2    | 189.0354 | 192.2743 | 190.7673 | 269.8385 | 276.6890 | 271.6552 |
| 3    | 50.5688  | 49.1485  | 53.1257  | 120.5517 | 117.5742 | 116.8470 |
| 4    | 88.2294  | 86.0241  | 88.1582  | 129.9985 | 130.0000 | 130.0000 |
| 5    | 150.0000 | 150.0258 | 150.0026 | 192.9272 | 192.3146 | 193.8548 |
| 6    | 135.0000 | 135.0258 | 135.0026 | 163.3757 | 162.2258 | 163.2621 |
| 7    | 135.0000 | 135.0258 | 135.0026 | 136.9125 | 136.0410 | 136.1677 |
| 8    | 60.0000  | 60.0258  | 60.0026  | 84.6855  | 86.0736  | 82.8410  |

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From the Table 3.3, power demand of 1500MW, obtained minimum cost by Lambda iteration method is 6612.5868$/hr with the power loss of 17.9213MW. The obtained minimum cost by OTLBO technique is 6612.5089$/hr with the power loss of 18.1087MW. TLBO produced the cost of 6612.5120$/hr with power loss of 18.1655MW. It has been showed that the minimum cost obtained by all the methods is almost same but the cost obtained by OTLBO is the global solution at the load demand of 1500MW. Now at the power demand of 2000MW the obtained cost from all the methods is almost same but the cost obtained by OTLBO method is global minimum and it is 8895.4566$/hr with power loss of 30.7713MW.

Fig. 3 Distribution of generation conceded by ten generators at $P_D=1500$ MW

Fig 3.3 shows how the generation shared by fourteen generators with respect to their minimum and maximum limits. Which means it satisfies the inequality
constraint. From the equality constraint, the fourteen generators generation should meet to given load demand.

IV. Conclusion

In this paper, standard ELD problem can be solved in different cases with different methods. In first case ELD problem is represented with non-convex cost-function, already present there in network. The algorithms TLBO & OTLBO are successfully used to minimize the ELD problem considering 6,10 and 14-unit test systems and also distinguished with lambda technique to test the performance of the proposed algorithm. The proposed algorithm OTLBO found better solution for all test systems than TLBO. This investigation results certainly says that the proposed method can be utilised as effective optimization providing better satisfactory solutions for ELD problems.

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