An Improved Optimal Economic Dispatch of Wind-Thermal Power Using JAYA Algorithm

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***Abstract*—:In this paper, the use of JAYA algorithm for classical Economic Dispatch problem of thermal power is demonstrated. This method has the advantage of tuning less optimization with consistency. The other competing algorithm, including PSO, has the disadvantage of requirement of parameters tuning for better and consistent result, which itself is an optimization problem. The JAYA algorithm overcomes this problem. Here it is demonstrated using IEEE benchmark systems and also compared with the results of other works.**

***Index Terms*—PSO, Economic Dispatch, Valve Point Effect (VPE), JAYA Algorithm**

I. Introduction

Economic dispatch is process of allocating power generation to available generating unit so that system load is supplied entirely and economically with satisfying all constrains of network and generators [1]. Initially, the objective function of economic dispatch problem was smooth quadratic function [2], but now a days, the economic dispatch problem is become more complicated because of non-smooth cost curve due to inclusion valve point effect [3], prohibited zones [4] or multiple fuels [5] with considering system loss. A practical ED problem is non-convex with non-linear constrains is difficult to solve by classical mathematical methods. Due to this reason, heuristic methods are widely used for solving ED problems. Several such methods have been applied for solving ED problems, such as Newtons method, Dynamic Programming [2], Decomposition method [4], Hierarchical approach based on the Numerical Method (HNUM) [5], decomposition method [4] and many more. These methods are not only time consuming, but produces result far away from optimum point, especially for the large scale system. Researchers have also explored Artificial Intelligence (AI) based methods, for solving non-linear problem with equality and inequality constrains. A non-convex ED problem can be handled by using AI based methods, such a Hopfield neural network (HNN), Genetic Algorithms (GA) [6]-[7], Evolution Programming (EP) [8], Particle Swarm Optimization (PSO) [9]-[10], Biogeography-Based Optimization (BBO) [11], Cuckoo Search Algorithm (CSA) [12]. However, for large scale system and non-convex problem with multiple minima, this methods may suffer from low solution quality and long time for solution. But the main disadvantage is the tuning of controlled variable for obtain global solution. The concept of hybrid methods, which are essentially the combination of Heuristic and AI approach, have also been used to obtain global solution. Though, this methods have high probability to produce better results, but it requires to handle many controlled parameter. In this paper, JAYA algorithm is proposed for solving non smooth ED problem with considering generator and system characteristics including Valve Point Effect (VPE), Prohibited Operating Zone and power loss, calculated by different method. This algorithm is based on the concept that the solution obtained for a given problem should move towards the best solution and should avoid the worst solution [13]. This algorithm requires only the common control parameters and does not require any algorithm-specific control parameters Due to that advantage burden of tuning for obtain best solution of problem is reduced. The JAYA algorithm is tested on several large scale and non-convex system and obtain results are compare to those from many other methods in the literature.

II. Formulation of Economic Dispatch Problem

Economic dispatch is the short-term determination of the optimal output of a number of electricity generation facilities, to meet the system load, at the lowest possible cost, subject to transmission and operational constraints.

A. Objective function

1) Simple Objective Function: Simple thermal cost function represented as smooth quadratic cost function of each generating unit. It can be represented as described in [2]

$$\begin{aligned} F_C &= \sum_{i=1}^{N} F(i) \\ &= \sum_{i=1}^{N} a_i P_i^2 + b_i P_i + c_i \end{aligned} \tag{1}$$

Where,

F_C - Total Fuel Cost

F_i - Cost Function of Generator i

a_i, b_i, c_i - Cost coefficient of Generator i

P_i - Power Output of Generator i

N - Number of Thermal Unit

2) ED Problem Considering Valve Point Effect: In reality objective function is non smooth cost function due to several nonlinear effects. One of such non-linearity is Valve Point Effect [3]. Due to presence of valve point loading effect, non-linearity and discontinuity of the Economic Load Dispatch (ELD) increases. To include VPE, basic objective function is required to modify. Valve-point loading affects the input-output characteristics of generating units, making the fuel costs function non-linear and non-smooth. This has been considered in the solution of load dispatch problems, but not in the planning phase of unit commitment. In a simple approach, a quadratic function with sine term, representing valve point effect is considered. A Multivalve steam turbine has very different input-output curve compare to simple thermal cost function. In thermal power plant, steam valve operation produces ripples. To consider this periodicity, cost equation is modified. Higher order of non-linearity in a cost equation counts the ripple effect. A commonly used fuel cost function with VPE is give here.

$$F_C = \sum_{i=1}^{N} a_i P_i^2 + b_i P_i + c_i + \mid e_i \times \sin((P_{imin} - P_i)) \mid \quad (2)$$

Where,
e_i & f_i - Cost coefficient of Generator i
P_i-Power Produced by Generator i

B. Equality & Inequality Constraints

1) Power Balance equation: For power balance, equality criterion must be satisfied. The total power generation must be equal to total load demand and the system losses.

$$F_C = \sum_{i=1}^{N_g} P_i - P_d - P_{Loss} = 0 \quad (3)$$

Where,
N_g - Total Number of Generators
P_d - Total Demand
P_{Loss} - Transmission Loss

In this work, P_{Loss} calculated by two different method and results are compared. The first method is *N-R Flow method*, where the load flow is run in each iteration for calculation of power loss in the network. This method is comparatively more accurate method, but it is slow as it requires computation time for running the load flow. The second method is *B coefficient* method [2], which is an approximate method. But it has an advantage of faster processing time. The formula for calculation of loss from *B coefficient* is given here.

$$P_{Loss} = \sum_{i=1}^{m} \sum_{j=1}^{m} P_i B_{ij} P_j + \sum_{i=1}^{m} B_{oi} P_i + B_{oo} \quad (4)$$

Finally the comparison of results of both the methods is given in test case.

2) Minimum & Maximum Power limit: Real power output of i^{th} generator P_i must lie between maximum and minimum power limit of that generator. It is given by

$$P_{i,min} \le P_i \le P_{i,max} \quad (5)$$

Where,
P_i, min - Minimum limit of Generator i
P_i, max - Maximum limit of Generator i

3) Ramp Rate Limit: The power output of any turbine-generator system cannot be changed suddenly. How fast power output of generator can be changed is depends on the ramp rate limit of the generator. The actual operating range of all running generating unit is restricted by their corresponding ramp limits [9]. The ramp up and ramp down constrain is described by,

$$P_i - P_i^o \le UR_i P_i^o - P_i \le DR_i \quad (6)$$

Where,
P_i^o - Previous output power of the Generator i
UR_i - Upper Ramp limit of Generator i
DR_i - Lower Ramp limit of Generator i

To consider the ramp rate limit and power output constrain, at the same time, the equation is rewritten in inequality constraint form.

$$max\{P_{i,min}, P_i^o - DR_i\} \le P_i \le min\{P_{i,max}, P_i^o + UR_i\} \quad (7)$$

4) ED Problem Considering Prohibited Operating Zones: In real system, entire operating range of a generating unit is not always available due to physical operating limitations. Unit may have restricted operating zones, due to faults in machines or associated auxiliaries. Such faults may lead to system instability for certain range of generator power output [4]. Therefore, unit with prohibited zone have few additional inequality constraints in the operating range as follows

$$P_i \in \begin{cases} P_{i,min} \le P_i \le P_{i,1}^l & i = 1, 2, ..., npz \\ P_{i,k-1}^u \le P_i \le P_{i,k}^l & k = 2, 3, ..., pzi \\ P_{i,pzi}^u \ leq P_i \le P_{i,max} \end{cases} \quad (8)$$

Where,
$P_{i,k}^l$ - Minimum limit of Generator i
$P_{i,k}^u$ - Maximum limit of Generator i
pzi - number of prohibited zones of unit i
npz - number of unit which have prohibited zones

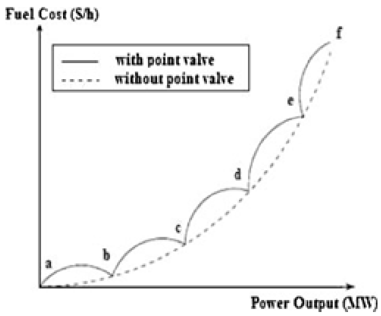

Fig. 1. Fuel cost curve of unit with and without valve point effect

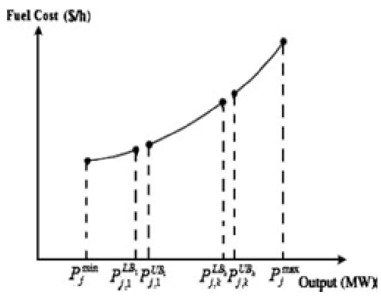

Fig. 2. Fuel cost curve of unit with prohibited zones

III. JAYA FOR ECONOMIC DISPATCH PROBLEM

A. Overview of JAYA Algorithm

JAYA is a new population based optimization method introduced by Rao [13] for optimal solution for constrained and unconstrained optimization problems. Unlike other population based heuristics algorithms, JAYA has no algorithm specific controlling parameter. In this method, only two ordinary controlling parameter, population size and number of generation, is used. In JAYA optimization technique, the solution determined for a specific problem is shifted toward the optimum solution and avoid the inferior solution [13]. Let $f(x)$ is the objective function to be minimized or maximized. At any iteration i, assume that there are m number of generation $(j = 1, 2, , m)$ and n number of population (k = 1,2,,n).

Let $f(x)$ is the objective function to be minimized or maximized. At any iteration i, assume that there are m number of generation $(j = 1, 2, , m)$ and n number of population $(k = 1, 2, , n)$. $f(x)_{best}$ is the best candidate solution obtain from entire candidate solution and $f(x)_{worst}$ is the worst candidate solution obtain from entire candidate solution.

If $X_{j,k,i}$ is the value of the j^{th} variable for the k^{th} candidate during the i^{th} iteration, than this value is modified as per equation 9.

$$X_{j,k,i}^{'} = X_{j,k,i} + r_{1,j,i}[(X_{j,best,i}) - (X_{j,k,i})] - r_{2,j,i}[(X_{j,worst,i}) - (X_{j,k,i})] \quad (9)$$

Where,

$X_{j,best,i}$ - Value of variable j for best candidate

$X_{j,worst,i}$ - Value of variable j for worst candidate

$X_{j,k,i}^{'}$ - New updated value of $X_{j,k,i}$

$r_{1,j,i}$ & $r_{2,j,i}$ - Random numbers

In the equation (9), second term indicates the tendency of solution to move closer to best solution and third term indicates the tendency of the solution to avoid the worst solution. From this, updated parameter is accepted, if current value is better than previous value. The accepted value at the end of iteration is considered as an input for next iteration. Figure(3) shows the flow chart of JAYA algorithm.

B. Implementation of JAYA Algorithm for Economic Dispatch Problem

A step-by-step procedure is given here for implementation of JAYA algorithm to solve the Economic Dispatch Problem.

1) Initialize each generator unit capacity, cost coefficient, power demand of system.
2) Initialize B coefficient $(B_0, B_1, B_2....)$, if *B coefficient method* is used, else initialize data for *N-R load flow* method (branch data, bus data, generator data etc.)
3) Initialize no of population, variable size, iteration.
4) Generate random active power in limit of respective maximum and minimum power for all population.
5) Calculate P_{Loss} either by B coefficient method or by *N-R load flow* method.
6) Find the cost value of all generation
7) Find the best and worst solution among all cost
8) Update new value of generation by using Eq. (9).
9) Check new value generation is in limit. If any generation inequalities limit violate, then set corresponding limit.
10) Modified cost solution is obtained by using new value.
11) If modified solution of particulate generation is better than previous solution. Accept new solution and generation, otherwise previous solution and generation continued in the next iteration.
12) Repeat process up to all iteration complete or stopping criterion is satisfied.

13) Display results and plot graph.

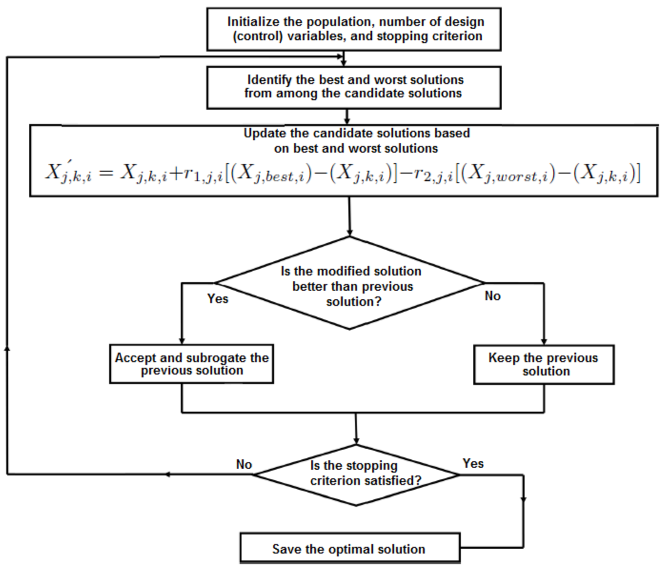

Fig. 3. Flow Chart of JAYA Algorithm

IV. Numerical Example and Simulation Results

In this work, the proposed JAYA algorithm is applied to ELD problem for four different cases of power system: 1) 3-generators and 40-generators system with valve point loading; 2) 40-generating units with valve point loading and prohibited operating zones; 3) 6-generators unit with ramp rate limit and prohibited zone with power loss calculated by *B coefficient*; 4) IEEE-30 bus system with 6 generator units, 41 transmission lines, four tap-changing transformers and two injected VAR sources. In all this cases, power loss is calculated by *B coefficient* and *N-R load flow*. The proposed method is coded in MATLAB platform and run 100 independent trials for each case on a 2.1 GHz PC with 2 GB of RAM.

A. Case-1:System with Valve Point Effect (VPE)

The JAYA algorithm is applied to two ED problems one with 3-generators and another is 40-generators with VPE . In this case the system power loss is neglected. The input data for 3-generators and 40-generator system are given in [8]. Here total load demand for 3-generators and 40-generators system is 850MW and 10500 MW respectively. The minimum, maximum and average cost of 3- generators system obtained with JAYA method is given in Table-I. The same system is evaluated with different optimization methods (MPSO [14], EP [8], IEP [15] and GA [16]) and the results are compared in Table-II. Also the convergence characteristic is shown in figure (4) In this case, JAYA method is also tested on another system of 40-generators. The results obtained from JAYA method is compared with ten other methods, MSL [12], Improved Fast Evolutionary Programming (IFEP) [8], New PSO with Local Random Search (NPSO-LRS) [17], Self Organizing Hierarchical PSO (SOH-PSO) [10], Quantum Inspired PSO (QPSO) [12], SA-PSO [18], BBO [11], and Cuckoo Search Algorithm (CSA) [12], and the results are tabulated in Table-III. The optimum cost obtain by JAYA algorithm is less than the costs obtained by other methods. Moreover JAYA method gives better solution in lesser time as compared to many other methods except MSL and BBO methods. The convergence of JAYA algorithm for 40 generators system is given in figure 5.

TABLE I
Result of 3-Generators (Case-1)

Evolution Method	Mean Time (Sec)	Mean Cost ($)	Min Cost ($)	Max Cost ($)
JAYA	3.458	8237.30	8234.07	8241.54

TABLE II
Result of 3-Generators With Different Optimization Methods (Case-1)

Unit	GA[15]	IEP[15]	EP[8]	MPSO[14]	JAYA
P_1	300	300.23	300.26	300.27	300.27
P_2	400.00	400.00	400.00	400.00	400.00
P_3	150	149.77	149.74	149.73	149.73
P_{Load}	850	850	850	850	850
Cost ($)	8237.6	8234.09	8234.07	8234.07	8234.07

TABLE III
Comparison of Cost & Processing time with Different Optimization Methods (Case-1, 40-Generators)

Methods	Max Cost (k$)	Min Cost (k$)	Avg Cost (k$)	CPU Time (s)
JAYA	122.36	120.72	121.29	2.109
CSA[12]	121.81	121.41	121.52	3.03
BBO[11]	121.69	121.42	121.50	1.17
SA-PSO [18]	-	121.43	-	23.89
SOH-PSO [10]	122.45	121.50	121.85	-
NPSO-LRS [17]	122.98	121.66	122.20	-
PC-PSO[11]	122.86	121.77	122.46	-
PSO-LRS[17]	123.46	122.03	122.56	-
SPSO [11]	124.1	122.05	122.33	-
MSL [12]	-	122.40	-	0.047
IFEP [8]	125.74	122.62	123.38	1167.3

B. Case-2:System with Valve Point Effect (VPE) And Prohibited Operating Zones (POZ)

In this case, Valve Point Effect with prohibited zones are considered. A 40-Generators test system having unit 10-14 with prohibited operating zones, as given in [19], is taken to study the response of JAYA algorithm. The total load demand taken is 10500MW. The results obtained from JAYA algorithm is compared with four other optimization methods (CSA [12],

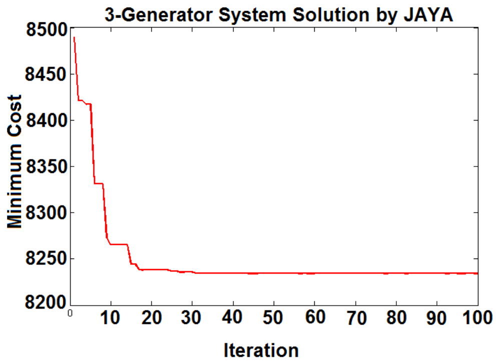

Fig. 4. Convergence of JAYA algorithm with 3-Generator

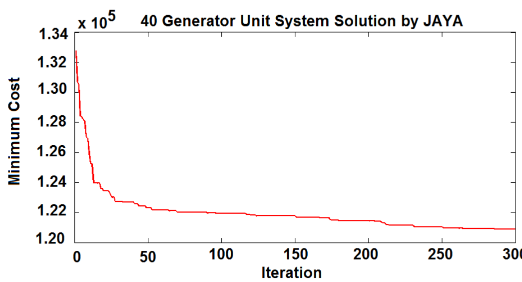

Fig. 5. Convergence of JAYA algorithm with 40-Generator

fuzzy adaptive PSO (FAPSO) and NAPSO), given in [19], is compared with respect to four attributes, namely minimum cost, maximum cost, average cost and CPU time. The results are tabulated in Table-III. Also the convergence of JAYA algorithm is plotted in figure 6. The comparative study of 40 Bus system with VPE (Case-I) and VPE with POZ (Case-II) is given in APPENDIX-A.

TABLE IV
COMPARISON OF SIMULATION RESULTS FOR CASE-2

Methods	Max Cost (k$)	Min Cost (k$)	Avg Cost (k$)	CPU Time (s)
JAYA	122.15	121.07	121.45	10.613
CSA [12]	121.89	121.49	121.55	14.71
NAPSO [19]	121.49	121.49	121.49	12.7
FAPSO [19]	122.60	122.26	122.47	19.6
PSO [19]	125.37	124.88	125.16	35.87

C. Case-3:System with Prohibited Operating Zones (POZ), Ramp Rate Limit And Losses

In this case, 6-Generators System is considered, with Ramp Rate Limit and Prohibited Operating Zone, to study the response of JAYA Algorithm. The input data for this case is been taken from [9]. Total load demand considered is 1263MW. Results obtain from JAYA algorithms is compared with four other methods(BBO [11], PSO [9], New Coding-Based Modified PSO [20], and GA [9]). The cost statistics

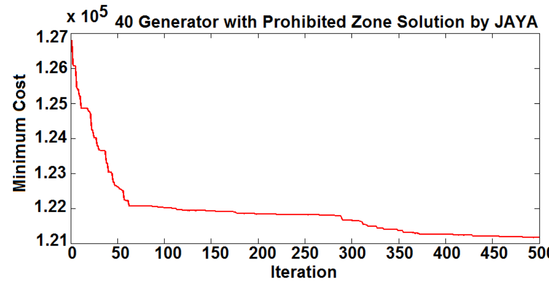

Fig. 6. Convergence with 40-Generator with VPE and POZ

of results obtained with different methods is given in Table-IV. The optimum result obtained from different methods are tabulated in Table-V. The convergence characteristic of JAYA algorithms is shown in figure 7.

TABLE V
COMPARISON OF SIMULATION RESULTS FOR CASE-3

Methods	Avg Cost (k$)	Min Cost (k$)	Max Cost (k$)	CPU Time (s)
JAYA	15.44	15.44	15.44	1.068
BBO [11]	15.44	15.44	15.44	1.08
SOH-PSO[10]	15.50	15.45	15.61	2.32
MPSO [20]	15.45	15.45	15.46	5.46
PSO[9]	15.45	15.45	15.49	12.78
PSO-LRS[17]	15.45	15.45	15.46	-
NPSO[17]	15.45	15.45	15.45	23.68
GA[9]	15.47	15.46	15.52	10.8

TABLE VI
COMPARISON OF BEST RESULTS OF CASE-3

Unit Power	JAYA	BBO [11]	SOH-PSO [10]	MPSO [20]	PSO [9]	GA [9]
P_1	447.05	447.39	438.21	446.71	447.50	474.80
P_2	172.24	173.23	172.58	173.01	173.32	178.64
P_3	263.93	263.31	257.42	265.00	263.47	262.21
P_4	140.39	138.00	141.09	139.00	139.06	134.28
P_5	165.76	165.41	179.37	165.23	165.48	151.90
P_6	86.012	87.08	86.88	86.78	87.13	74.1
Power O/P (MW)	1275.39	1275.45	1275.55	1275.7	1276.01	1276.03
Loss (MW)	12.40	12.44	12.55	12.73	12.958	13.022
Cost (k$/hr)	15.442	15.444	15.446	15.447	15.450	15.459
time(S)/itr	0.01644	0.032	0.0632	0.0379	0.006	0.22

D. Case-IV: IEEE 30 Bus System with different methods of Loss Calculation

The purpose of studying this case is to evaluate JAYA Algorithm with two different loss calculation methods, namely, B coefficient and N-R load flow. For power loss calculation

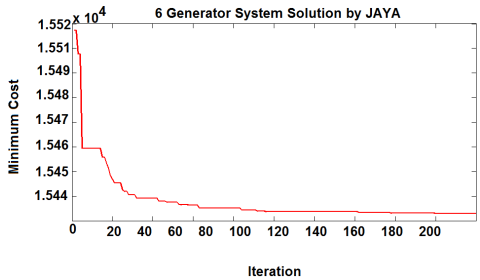

Fig. 7. Convergence of 6-Generator System

with B-coefficient, equation (4) is used, and for N-R load flow MATPOWER-Ver.6 is used as given in [21]-[22]. The cost coefficient and B-coefficient data of IEEE-30 bus system are given in APPENDIX-A. Branch and bus data are taken from [23]. In this case, JAYA algorithm is applied to IEEE-30 bus system with 6-generators, 41 transmission lines, 4 tap-changing transformers and 2 injected VAR sources. This case is studied in two parts. In the first part, the optimum results of JAYA algorithm with two different loss calculation methods, B coefficient and N-R load flow, are compared. The results are tabulated in Table-VI and the convergence characteristic of JAYA algorithm with B-Coefficient and N-R Load Flow is given in Fig 8 & 9. In the second part, the results obtained from JAYA algorithm is compared with two other methods, MODE [23] and ABC [23]. The results are tabulated in Table-VII

TABLE VII
COMPARISON OF RESULTS OF CASE-3 WITH DIFFERENT LOSS METHODS

Method	Mean Time (sec)	Mean Cost ($)	Minimum Cost ($)	Maximum Cost ($)
N-R load flow	29.27	803.30	802.59	804.26
B-coefficient	04.45	801.85	801.72	802.25

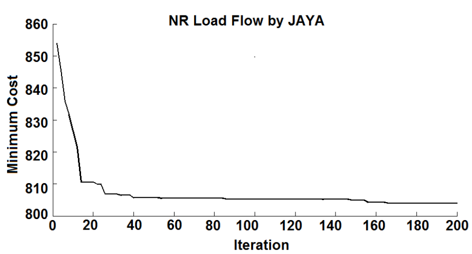

Fig. 8. Convergence of IEEE 30 Bus System with NR Method

E. Case-V: IEEE 6 Bus System with 5% Wind Penetration

In this case, JAYA method is tested with Hybrid power system. The IEEE-6 bus system with 95% thermal and 5% wind is studied. The cost function is modified to include the wind power in the system. The wind power has three cost related with under-estimation of wind, Over-estimation of wind and the direct running cost. It is given in Eq.(10). The detail explanation of each of this cost is not in the scope of this work.

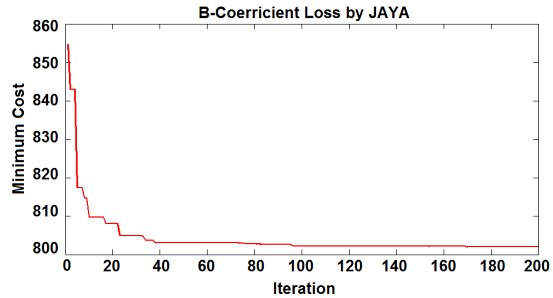

Fig. 9. Convergence of IEEE 30 Bus System with B-Coefficient

TABLE VIII
COMPARISON OF SIMULATION RESULTS FOR CASE-3

UNIT POWER(MW)	JAYA-B Coeff.	JAYA-NR	ACO [23]	MODE [23]
P_1	175.20	174.17	151.39	151.94
P_2	48.10	50.30	52.78	55.56
P_3	20.97	22.41	21.79	22.06
P_4	23.15	23.19	37.27	29.5
P_5	13.14	10.68	13.7	16.95
P_6	12	12	14.54	15.58
LOSS	9.21	9.35	8.07	8.2
TOTAL COST($/hr)	801.72	802.59	808.71	808.18

$$C_t = \sum_{i=1}^{n_t} C_i(P_i) + \sum_{j=1}^{n_w} [(C_{oe,j}(W_j) + (C_{ue,j}(W_j) + (C_{dir,j}(W_j)] \quad (10)$$

The results are of this study is tabulated in table (IX)

V. CONCLUSION

Different cases is of economic load dispatch is studied with different method. From the studied cases, it is visible that the JAYA Method is very consistent and gives overall good results. The JAYA methid is also tested with wind energy in the system and found working satisfactorily.There are methods, which gives optimum cost but lack in computation times, whereas performance of JAYA Algorithm is good with respect to cost as well as computation time. Also, the biggest advantage of JAYA Algorithm is that it is a tuning-less algorithm, which is a one of the disadvantage with other heuristic methods.

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TABLE IX
COMPARISON OF RESULTS OF ED WITH 5% WIND PENETRATION WITH JAYA AND PSO

UNIT POWER(MW)	JAYA	PSO
PG_1	450.52	440.77
PG_2	174.95	168.46
PG_3	264.81	300
PG_4	142.12	135.4
PG_5	174.52	163.4
PG_6		
Wind Generation (MW)	74.517	67.57
Wind Scheduled (MW)	63.15	63.15
Total Loss (MW)	12.44	12.66
Reserve Cost ($)	0	0
Penalty Cost($)	83.22	56.54
Overall Cost ($)	14745.36	14818.487

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APPENDIX A

TABLE X
COMPARISON OF SIMULATION RESULTS FOR CASE-3

Unit	P_{imin}	P_{imax}	a_i	b_i	c_i
1	50	200	0.00375	2	0
2	20	80	0.0175	1.75	0
3	15	50	0.0625	1	0
4	10	35	0.00834	3.25	0
5	10	30	0.025	3	0
6	12	40	0.025	3	0

$$B_{i,j} = 10^{-5} \begin{vmatrix} 21.8 & 10.3 & 0.9 & -1.0 & 0.2 & 2.7 \\ 10.3 & 18.1 & 0.4 & -1.5 & 0.2 & 3.0 \\ 0.9 & 0.4 & 41.7 & -13.1 & -15.3 & -10.7 \\ -1.0 & -1.5 & -13.1 & 22.1 & 9.4 & 5.0 \\ 0.2 & 0.2 & -15.3 & 9.4 & 24.3 & 0 \\ 2.7 & 3.0 & -10.7 & 5.0 & 0 & 35.8 \end{vmatrix}.$$

$$B_{0,i} = 10^{-5} \begin{vmatrix} 0.3 & 21 & 5.6 & 3.4 & 1.5 & 7.8 \end{vmatrix}.$$

$$B_{0,0} = 10^{-5} \begin{vmatrix} 1.4 \end{vmatrix}.$$

TABLE XI
COMPARISON OF OPTIMAL SOLUTION OF CASE-I & CASE-II

UNIT	Case I (MW)	Case II (MW)	UNIT	Case I (MW)	Case II (MW)
1.00	113.98	114.00	21.00	530.98	522.91
2.00	114.00	113.41	22.00	550.00	523.57
3.00	120.00	120.00	23.00	550.00	527.12
4.00	179.80	183.43	24.00	523.19	521.54
5.00	88.32	97.00	25.00	522.94	523.47
6.00	140.00	139.88	26.00	521.57	525.98
7.00	299.20	300.00	27.00	150.00	150.00
8.00	287.46	292.74	28.00	10.01	10.05
9.00	283.83	300.00	29.00	11.69	10.11
10.00	131.75	130.00	30.00	87.49	97.00
11.00	94.00	94.00	31.00	190.00	190.00
12.00	94.99	94.00	32.00	190.00	188.68
13.00	125.00	125.00	33.00	189.69	190.00
14.00	305.72	400.73	34.00	179.87	198.41
15.00	392.00	483.48	35.00	200.00	200.00
16.00	303.21	125.00	36.00	167.01	165.05
17.00	495.96	493.93	37.00	110.00	110.00
18.00	496.18	488.55	38.00	110.00	110.00
19.00	511.90	509.21	39.00	109.81	110.00
20.00	509.56	510.10	40.00	509.79	511.99