JAYA ALGORITHMOPTIMISEDCONGESTION MANAGEMENT IN A COMPETITIVE POWER MARKET

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Abstract:*Transmission clog is the significant test in the activity of serious force market. Adequate transmission hallway is fundamental for acknowledgment of intensity exchange. This paper proposes a proficient methodology for transmission blockage the executives utilizing the Black Hole Algorithm (JAYA). Blockage is eased by rescheduling of genuine force from the market clearing plan. JAYA is an as of late presented nature roused calculation with less number of boundaries. The calculation is simple for usage, takes less number of cycles and tuning for a specific application. The quality of the calculation is approved by contrasting its exhibition and that of Particle Swarm Optimization (PSO) and Big Bang Big Crunch (BBBC) calculations accessible in the writing. Changed IEEE-30 and Modified IEEE-57 transport frameworks are taken for the recreation reason. General Terms Competitive force market, dark opening calculation. Watchwords Rescheduling, line blackout, over-burden reciprocal/multilateral transaction*

General Terms: Competitive power market, black hole algorithm.

Keywords: Rescheduling, line outage, overloaded bilateral / multilateral transaction.

1. INTRODUCTION

In a liberated force market, creating organizations (GENCOs) are delivering force and offer it to the appropriating organizations (DISCOs). The free framework administrator (ISO) is encouraging force move between concurred GENCO and DISCO. All concurred exchanges are not generally achievable because of warm constraint of lines and voltage solidness limit. An exchange might be conservative yet ridiculous when there is no adequate transmission passageway. Transmission blockage might be characterized as a portion of the lines arriving at their warm breaking point during exchange among GENCOs and DISCOs. Transmission blockage influences the security of a force framework as it prompts fell blackout of lines in the framework. Transmission clog should be overseen by a few unique ways and they are characterized dependent on if cost is included

I. Cost-free techniques:
   a. By outraging the clogged lines
   b. By the utilization of transformer taps or stage shifters.
   c. Activity of FACTS gadgets especially arrangement gadgets
II. Non-cost free techniques
   a. By re-planning of age from generators.
   b. Through shortening of burdens.

In rebuilt power markets impediments of intensity transmission networks because of ecological, option to proceed (ROW) and financial issues is a major test. 3Optimal age comparing to least-cost brings about expanded misfortunes and compromises the soundness and security of the influence frameworks [1], [2]. Distinctive clog the executive's strategies reasonable for various power markets are accounted for in the literary works [3]. In any case, the hunger for still productive and solid technique to tackle this clog the board issue is perpetual [4]. 1In [5], an effective zonal blockage the board approach utilizing Power Transfer Distribution Factors (PTDF) is talked about. Hogan follows the agreement way and nodal valuing approach [6] utilizing spot evaluating hypothesis [7] for the pool-based market. An elective methodology dependent on equal business sectors for interface based bandwidth rights is utilized by Chao and Peck [8]. 5A planning approach between producing organizations and framework administrator for blockage the board utilizing Benders cuts is examined by H.Y.Yamina and Shahidehpour [9].

Willingness-to-pay premium is suggested for staying away from reduction of the concurred exchanges [10]. Locational Marginal Price (LMP) signals are additionally utilized [11] for generators to mitigate transmission blockage. The method talked about in [12] consolidates the blockage cost and the minor expense at each transport in a pool power model and cost minimization is accomplished. For clog help, better use of existing transmission line is an appropriate other option. In that capacity, 16Flexible AC Transmission Systems (FACTS) gadgets are likewise utilized [13]. Applications 5of FACTS gadgets, for example, Thyristor-Controlled Series Compensator (TCSC) and Thyristor Controlled Phase Angle Regulator (TCPAR) are proposed to oversee clog quickly and effectively.

Work [14] proposes an OPF issue for least expenses for both clog and administration. Mitigating clogs brought about by voltage unsteadiness and warm over-burdens is taken in [15]. This additionally utilizes OPF which is comprehended by standard solvers. Line over-burden lightening by rescheduling of genuine force age dependent on relative electrical separation (RED) is presented in [16]. Be that as it may, the rescheduling cost isn't advanced when the generators have diverse cost capacities. Blockage the board by load shortening [17] is finished by B.K. Talukdar et al

Clog the executives by ideal genuine force rescheduling is recommended through streamlining methods. Transformative Programming (EP) approach is utilized to reschedule the genuine force age for blockage the board in [18]. Ideal blockage the board in a power market utilizing molecule swarm streamlining with time-differing quickening coefficients (PSO-TVAC) is finished by PanidaBoonyaritdachochai, ChanwitBoonchuay, WeerakornOngsakul in [19]. Tulika JAYA Bhattacharjee and Ajoy Kumar Chakraborty have recommended the NSGAII calculation for blockage the board in a pool-based power market Incorporating voltage and transient security [20].

Multi-Objective Particle Swarm Optimization (MOPSO) technique is utilized by J. Hazra and Sinha for cost proficient age rescheduling or potentially load shedding as a mean for clog the board [21]. S. Dutta and Singh [22] utilized PSO calculation for recognizing the contributing generators and ideal rescheduling of genuine force for overseeing clog in a pool at least rescheduling cost. Versatile bacterial scrounging calculation is abused for blockage the board by B.K. Panigrahi and V. RavikumarPandi in [23]. Venkaiah and Vinod Kumar [24] investigated fluffy versatile bacterial searching (FABF) calculation for blockage the board by ideal rescheduling of forces.

In this paper, the as of late created, straightforward and proficient JAYA calculation is taken for ideal rescheduling of genuine force for clog the executives in a pool based force market. The calculation utilized is simple for execution, with less number of boundaries and productive in getting the worldwide best outcomes.

2. JAYA Algorithm

Jaya Algorithm is created by people manufactured consolidation technique for settling various sorts of enhancement issues, including the obliged and unconstrained issues created by Rao in 2016 [35]. The vital target of the JAYA calculation is that once the arrangement is accomplished for a specific issue, the ideal outcome must be reached, in this manner all the while evading the most noticeably terrible outcome. JAYA is a Sanskrit word meaning triumph. The JAYA calculation constantly tries triumph by accomplishing achievements for finding an ideal arrangement and endeavors to neglect discontent by moving far from the most exceedingly awful arrangement. The JAYA Algorithm endeavors phenomenal undertakings to effectively find the certified outcome and arrangement, so it is named the JAYA calculation. This advancement procedure is extremely self-absorbed in an application point of view. Moreover, it contains no calculation explicit boundaries and assembles to ideal explanation insensibly less number of capacity assessments. The principle bit of leeway of the JAYA Algorithm contrasted with additional transformative calculations is that it is unlimited to calculation explicit boundaries and uses just two regular boundaries, that is, populace size and the quantity of cycles. In instances of other enhancement methods, which require a scaling component and hybrid possibility, for instance, when a molecule swarm streamlining needs a latency weight, the learning element and increasing speed coefficient are utilized for the underlying introduction. Along these lines, a basic bit of leeway of the JAYA figuring is its master capacities, to the extent disregarding the undertaking of changing limitations and lessening the time needed for the improvement cycle. Thereare numerous uses of the JAYA calculation in various exploration territory

2.1 Steps involved for JAYA Algorithm

1. *Instate* populace size (IPZ), number of plan factors and meeting measures, number of wellness work assessments (FFE)
2. Investigate the wellness work an incentive for every competitor;
3. Function Evaluation value =NP;
4. While FEE <Max_FEE do
5. Select the .home applicant Xbest and the most noticeably awful up-and-comer Xworst from the populace;
6. For I = 1 to NP do
7. Select the wellness work an incentive for the refreshed applicant;
8. Expense = FEE + 1;
9. Accept a better solution
10. End For
11. End while

3. MATHEMATICAL PROBLEM FORMULATION

The main objective of the proposed work is to find the optimal rescheduled values of active power generations from the generators so as to minimize the total congestion while satisfying the generators equality and inequality constraints. When the generation bids are submitted, congestion cost is computed using the following mathematical equations. The objective function of this congestion management problem can be written mathematically as:

$$\min TC = \sum_{j=1}^{ng} (C_k \Delta P_{Gj}^{+} + D_k \Delta P_{Gj}^{-}) \quad \$/hr \tag{4}$$

Where,

TC is the total congestion cost in $/hr

C_k is the incremental biding cost

D_k is the decremented biding cost

ΔP_{Gj}^{+} is the amount of active power increment in the generator j.

ΔP_{Gj}^{-} isthe amount of active power decrement in the generator j.

3.1 Equality constraints:

3.1.1 Real power balance:

$$P_{gi} - P_{di} - \sum_{j=1}^{N} |V_i||V_j||Y_{ji}| \cos(\delta_i - \delta_j - \theta_{ij}) = 0 \tag{5}$$

3.1.2 Reactivepower balance:

$$Q_{gi} - Q_{di} - \sum_{j=1}^{N} |V_i||V_j||Y_{ji}| \sin(\delta_i - \delta_j - \theta_{ij}) = 0 \tag{6}$$

$$P_{gi} = P_{gi}^{c} + \Delta P_{gi}^{+} - \Delta P_{gi}^{-} \,; i = 1,2,3 \ldots ng \tag{7}$$

$$P_{dk} = P_{dk}^{c} \,; k = 1,2,3 \ldots. Nd \tag{8}$$

3.2 Inequality constraints:

3.2.1 Real power generation output:

$$P_{Gi}^{\min} \le P_{Gi} \le P_{Gi}^{\max} \quad i = 1, \ldots. ng \tag{9}$$

3.2.2 Reactive power generation output:

$$Q_{Gi}^{\min} \le Q_{Gi} \le Q_{Gi}^{\max} \quad i = 1, \ldots. ng \tag{10}$$

3.2.3 Incremented or decremented real limit:

$$(P_{gi} - P_{gi}^{\min}) = \Delta P_{gi}^{\min} \le \Delta P_{gi} \le \Delta P_{gi}^{\max} = (P_{gi}^{\max} - P_{gi}) \tag{11}$$

$$\Delta P_{gi}^{+} \geq 0; \Delta P_{gi}^{-} \geq 0 \quad (12)$$

4. RESULTSAND DISCUSSION

An appropriate code has been created in MATLAB programming to locate the ideal estimation of the OCR in a solitary and multi-circle Distribution network utilizing JAYA. The proficiency and execution of JAYA were tried for the distinctive single-and Multi-circle frameworks, and it was discovered that JAYA gave the most good and far and away superior outcomes for all situation examines. Three contextual investigations were utilized, and the framework subtleties of all the contextual investigations can be found in references [23, 29, 47, and 48]. For each situation study, the accompanying JAYA factors were utilized. · Populace size = 50. · A most extreme number of cycles = 200. The extensive explanation of the issue plan and the utilization of JAYA to find the ideal goal are exhibited for all contextual analyses. execution of JAYA calculation 5in blockage the board issue is tried in the adjusted IEEE-30 transport . The modified IEEE-30 bus system consists of 41 transmission lines, 24 load buses, 6 Generator buses with a base load of 283.4 MW active power and 126.2 MVAR reactive power. In the modified IEEE-57 bus system there are 50 load buses, 80 transmission lines, and 7 generator buses with a total load of 1250.8 MW real power and 336.4 MVAR reactive power. Line data and bus data for both the test case systems are taken from the [27]. Here, four cases have been taken as shown in the table.

The different operating conditions considered for congestion management are as in table Evaluated conditions in the test case.

Table 1. Different cases considered

Sl.No	Case	Conditions applied in the system	Test System
1	Case A	Outage of line 1-2	Modified IEEE-30 bus
2	Case B	Load at all the buses are raised by 20%	Modified IEEE-30 bus
3	Case C	2 bilateral transactions T1- 20 MW from bus 9 to bus 13 T2- 10 MW from bus 3 to bus 41	Modified IEEE-57 bus
4	Case D	2 multilateral transactions T1-50 MW from bus 4 to bus 15 as20 MW & bus 19 as 30 MW. T2-25MW from bus 10 bus 47 as10 MW &bus 56 as 15 MW	Modified IEEE-57 bus

4.1 Case A

The primary cause of transmission congestion is taken in this case. Line outage contingency screening and ranking shows that line 1-2 is the most critical one in IEEE-30 bus system. Congestion due to the outage of the line is relieved by rescheduling the power output from the generators. Performance wise JAYA is better than the other two algorithms. Total congestion cost suggested by JAYA is only 476.983$ while it is 665.4502$ by PSO and 586.2415$ by BBBC. The cost shown by JAYA is much low and it is proving the strength of the algorithm.

Table 2. Optimal rescheduling power for case A

Rescheduled power	**BBBC Technique**	**PSO Technique**	**JAYA Technique**
P_{G1}	129.632	129.992	129.815
P_{G2}	67.5414	62.4440	71.7032
P_{G3}	24.7957	28.1494	24.6738
P_{G4}	35.2147	37.8556	34.0030
P_{G5}	21.6808	18.0638	18.0318
P_{G6}	17.7766	20.0729	17.8388
Congestion Cost	586.789	665.4502	490.783
Loss	13.2415	13.1784	13.2660

It is clear from table 3 PSO recommends for decremental change in all the generators except at generator 1 for relieving congestion. JAYA and BBBC are behaving in a similar way in managing congestion as both the methods taking same pattern of incremental or decremental change. For minimum congestion cost, JAYA shows relatively large change than PSO and BBBC methods at generator 2.

Table 3. Optimal change of real power for case A

Technique	UP/DOWN adjustment of participating generators (MW)					
	ΔP_{G1}	ΔP_{G2}	ΔP_{G3}	ΔP_{G4}	ΔP_{G5}	ΔP_{G6}
BBC	-8.9577	9.9814	0.2357	0.2147	-0.1534	1.1666
PSO	-8.5973	4.8840	3.5894	2.8556	2.1429	3.4629
JAYA	-8.6746	14.3432	0.1338	0.0047	-0.7999	0.5201

Power flow in the lines of the system under different conditions are compared in figure 1. Outage of line 1-2 results in overflow in lines 2 and 4. The congested flow in these two lines are removed by rescheduling of generator powers. It is obvious from the figure that all the three algorithms are succeeded in congestion management.

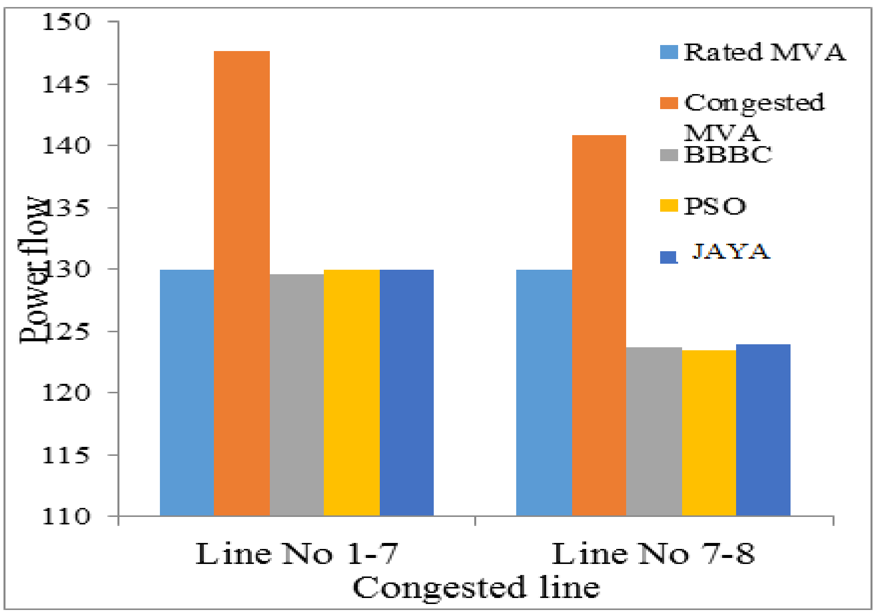

Figure 1. Power flow through the lines (Case A)

Strength of an optimization algorithm is generally analyzed by the number of times the algorithm is run for finding the global best solution. The algorithm maintains the best solution at different iterations and converged to the global best solution at the 60th iteration. Within 100 iterations best solution is reached.

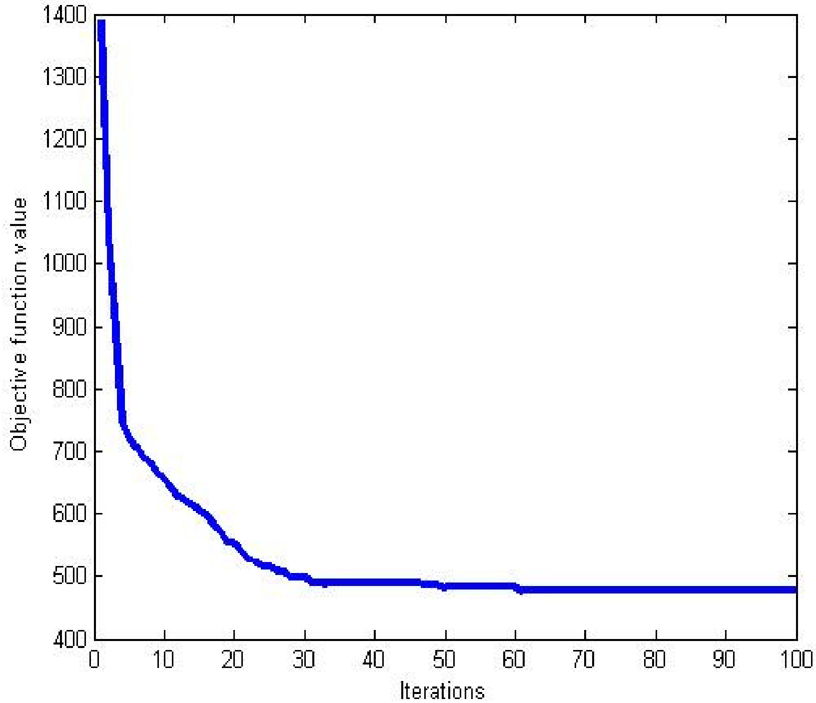

Figure 2. Convergence behaviour of JAYA in case A

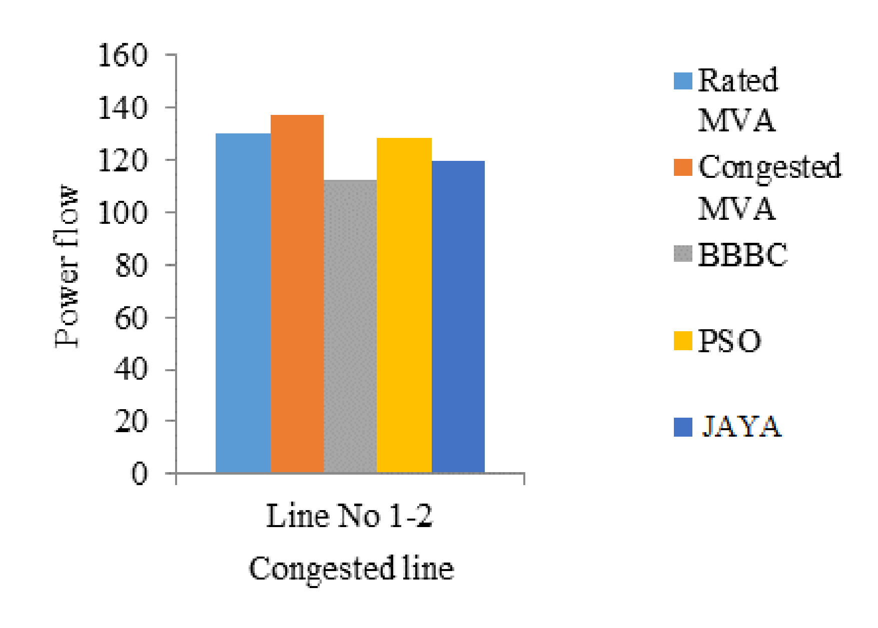

Figure 3. Comparison between Power flow and Congested line

4.2 Case B

Increase in load causes transmission congestion. In this case, load at all the 24 load buses are increased by 20%. The total real and reactive power demands are 340.08 MW and151.44 MVAR respectively. As a result, line 1 gets congested. Congestion cost occurring inrescheduling of real power by the three methods are compared in table 4. Congestion cost found by JAYA algorithm is better than the costs reported by PSO and BBBC algorithms.

Table 4. Optimal rescheduling for case B

Rescheduled power	**BBBC Technique**	**PSO Technique**	**JAYATechnique**
P_{G1}	172.5337	190.2066	181.6946
P_{G2}	81.0509	61.3884	73.8379
P_{G3}	24.7049	28.6971	26.0898
P_{G4}	37.0619	35.5828	34.9799
P_{G5}	18.3775	18.9187	18.1488
P_{G6}	18.3373	17.6376	17.7019
Congestion Cost	1412.6	1487.1	1396.9
Loss	11.9862	12.3512	12.3699

In rescheduling of real power, all the three algorithms are behaving in the same manner to get an absolute result. The change in power is decremental at all the generator buses.

Table 5. Change in power for case B

Technique	**UP/DOWN adjustment of participating generators (MW)**					
	ΔP_{G1}	ΔP_{G2}	ΔP_{G3}	ΔP_{G4}	ΔP_{G5}	ΔP_{G6}
BBBC	33.9437	23.4909	0.1449	2.0619	0.4475	1.7273
PSO	51.6166	3.8284	4.1371	0.5828	0.9887	1.0276
JAYA	43.1046	16.2779	1.5298	-0.0201	0.2188	1.0916

For clear understanding of the congestion relief, line flow through the congested line 1-2 is depicted in figure 3. BBBC outperforms the other two algorithms of PSO and JAYA in relieving the line. However, the objective of minimum cost for removing congestion is achieved only by the proposed JAYA algorithm.

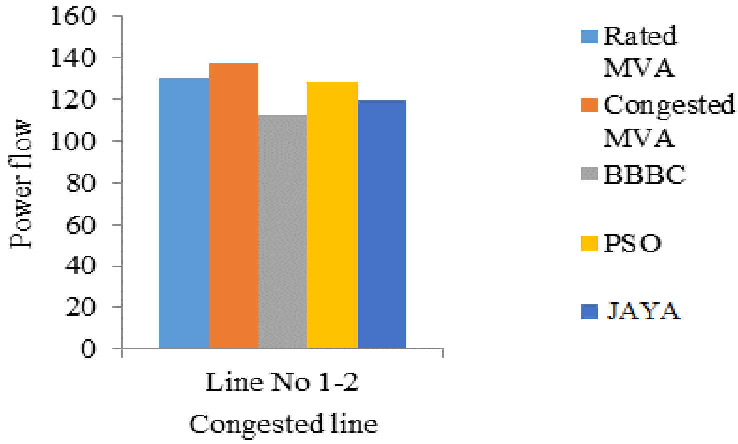

Figure 3. Power flow through the lines (Case B)

Convergence characteristic of JAYA in this case is shown in figure 4. The number of iterations taken to reach the best result is only 25. The number of iterations taken is much encouraging and proves the efficiency of the algorithm

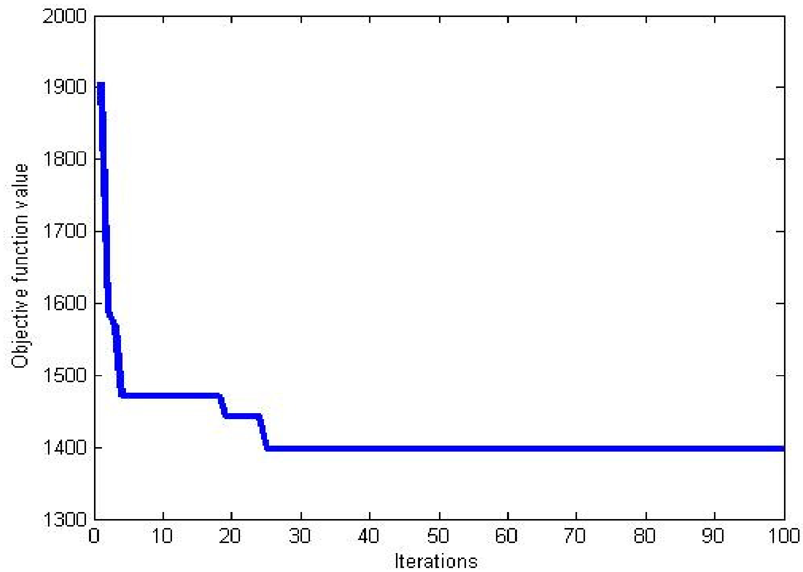

Figure 4. Convergence behavior of JAYA in case B

4.3 Case C

In a liberated force market, there are respective exchanges among GENCOs and DISCOscausing overload in lines connecting them. Here, two bilateral transactions, one between buses 9 and 13 and the other one between buses 3 and 41 are taken. The farmer transaction is for 20 MW and the later is for 10 MW. Congestion cost reported by the three algorithms is compared in table 6. In this case also the cost suggested by the JAYA algorithm is the minimum one. The saving in cost by JAYA is 10054.8 $ when compared to PSO and 437.9 $ to BBBC

Table 6. Optimal rescheduled power for case C

Rescheduled power	BBBC Technique	PSO Technique	JAYA Technique
P_{G1}	156.026	174.831	151.785
P_{G2}	100.000	99.9855	94.1063
P_{G3}	45.3448	46.3399	42.7881
P_{G4}	89.7372	79.2741	90.0794
P_{G5}	435.662	447.775	449.767
P_{G6}	89.0122	85.4515	80.5799
P_{G7}	356.719	339.720	363.709
Congestion Cost	3277.70	3894.60	2839.80
Loss	21.7026	22.5781	22.0171

The ups and downs in the rescheduled pattern of real power are illustrated in figure 5. The three algorithms follow different change in line flow pattern in congested lines after adjustment of power generation from different generators is compared in figure 6. All the three algorithms are succeeded in relieving congestion in the lines. However the algorithms are so tuned that the total congestion cost is minimal and that is why the level of relief is different for different algorithms.

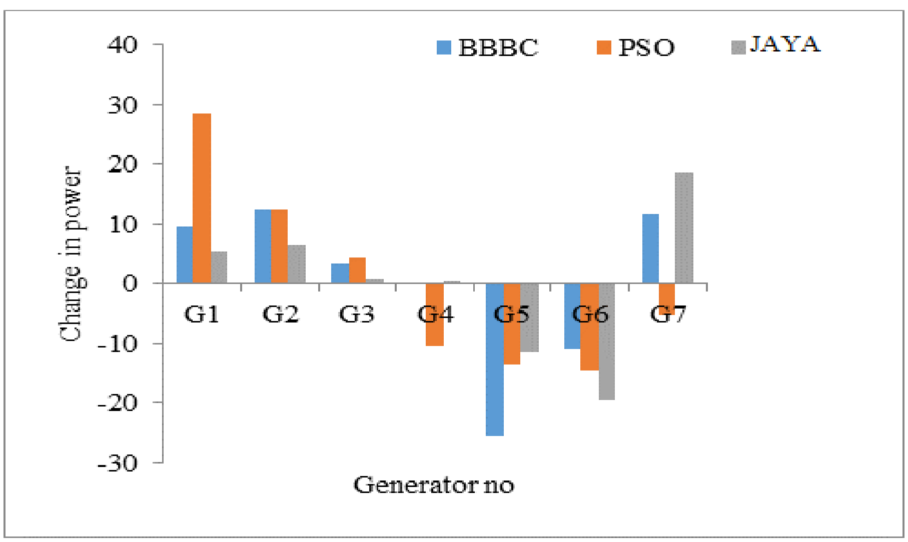

Figure 5. Amount of change in power (Case C)

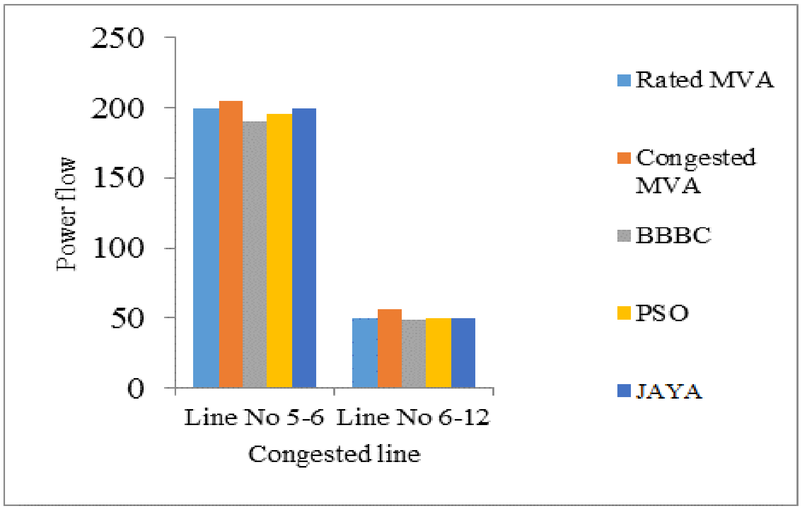

Figure 6. Amount of change in power (Case C)

Convergence quality of JAYA in case C is plotted in figure 7. The algorithm takes about 60 iterations to establish the global best results.

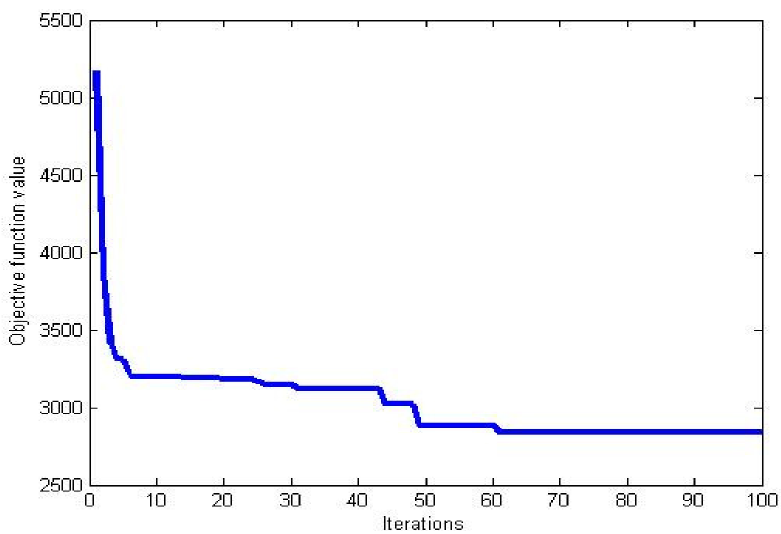

Figure 7. Convergence behavior of JAYA in case C

4.4 Case D

According to this case,, a multilateral transaction as shown in table 1 is introduced and this results in congestion of lines 8-4, 5-6 and 6-12. Real power settings corresponding to market clearing price is rescheduled for relieving congestion. The three algorithms are attempted in this task. It is clear from the table 7 that the total congestion cost achieved by the JAYA is less than that by BBBC and PSO algorithms

Table 7. Optimal rescheduled power for case D

Rescheduled power	BBBC Technique	PSO Technique	JAYA Technique
P_{G1}	136.2373	184.762	154.6814
P_{G2}	100.0000	92.6939	100.0000
P_{G3}	87.4114	44.0997	43.6182
P_{G4}	89.3565	79.7630	89.5093
P_{G5}	424.5687	450.6397	444.1082
P_{G6}	89.2517	73.3911	76.6197
P_{G7}	354.6537	357.1931	373.3758
Congestion Cost	6494.7	6580.9	6028.3
Loss	30.6793	31.7425	31.1126

Change in real power schedule for congestion management by the three algorithms is shown in figure 8. For relieving the congestion in the transmission line all the algorithms are suggesting same type of change

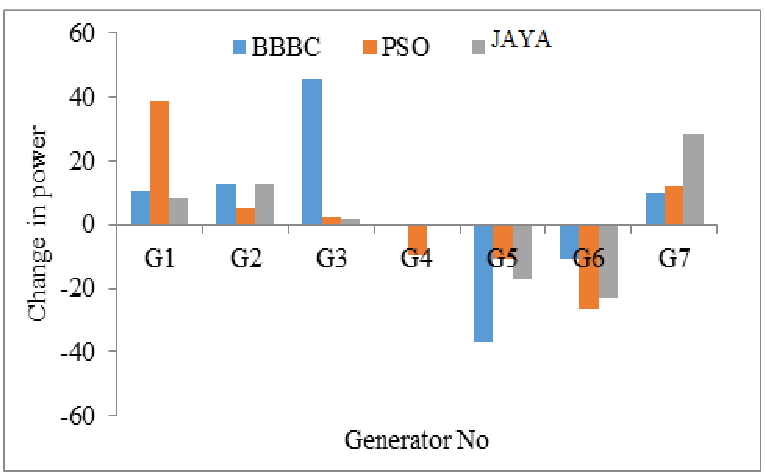

Figure 8. Amount of change in power (Case D)

A multilateral transaction as given in table 1 is considered in case D. As a result of the transaction, three lines out of 80 lines in the Modified IEEE-57 are congested. Real power generation pattern is adjusted for relieving congestion in line 8-4, line 5-6 and line 6-12. Figure 9 shows the line flows through the congested lines before and after the congestion management. All the three algorithms are performing almost equally in the congestion management.Congestion due to the multilateral transaction is relieved by using the three algorithms.

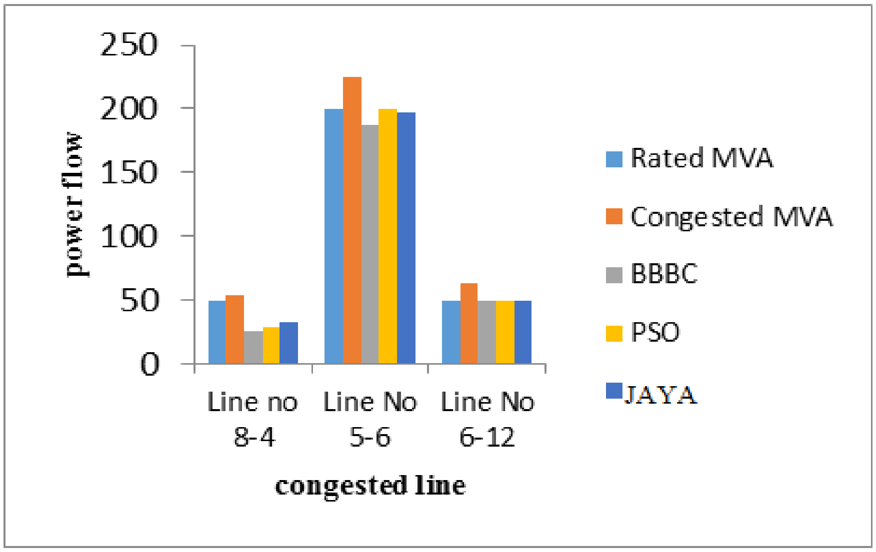

Figure 9. Power flow through the lines (Case D)

IEEE-57 bus system is a large sized power system moreover a multilateral transaction is taken as the cause for congestion. However, the JAYA algorithm performs in a better manner with regard to convergence to the global best results. It is evident from the figure 10 that the algorithm is independent of the system size and is a reliable one.

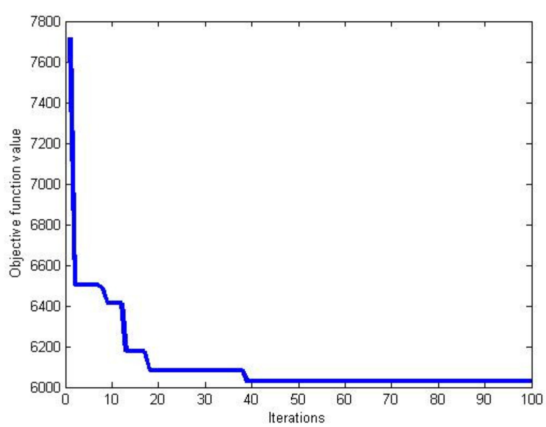

Figure 10. Convergence behavior of JAYA in case D

5. CONCLUSION

In this work a new nature inspired algorithm, the JAYA is suggested for a power system problem. The algorithm is simple, with less number of parameters to be tuned and can be easily coded in Matlab language. Transmission congestion and availability of transmission capacity are the two key issues in operation of restructured power markets and are to be addressed. Rescheduling of power generation is followed in this work for congestion management. Three different algorithms, namely BBBC, PSO and JAYA are used for congestion management through real power rescheduling. It is obvious from the numerical results that the JAYA algorithm outperforms the other two algorithms in the congestion management. The performance of the JAYA is tested on two test cases of Modified IEEE-30 bus system and Modified IEEE-57 bus system. Further, four different cases of congestion are taken. The JAYA algorithm performs better in all the four cases and optimizes the total congestion cost. This JAYA algorithm can be of use inother power system optimizations like economic load dispatch, optimal power flow etc.

6. ACKNOWLEDGMENTS

The authors gratefully thank and recognize the specialists of Annamalai University for the offices offered to complete this work

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