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Synergistic Enhancement of Power System Security using Real Coded BBO based Security Constrained Optimal Generation Dispatch

M. Manoj Kumar[1], Dr.A. Allirani[2*], V. Sundaravazhuthi[3]

[1,3]Assistant Professor, SASTRA Deemed to University
[2]*Professor, SASTRA Deemed to be University
m21052014@gmail.com[1]

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Abstract

A Real Coded Biogeography (RCBBO) integrated Security Constrained Optimal Generation Dispatch (SCOGD) is proposed in this paper as a method to relieve transmission line overloading. Overloading can be related with system security which is the capacity system of the system to stay at ease at some point of atypical conditions. Assessment of system security deals with assessing the secure and insecure operative states, whereas the security improvement offers with the mandatory control motion towards overloads beneath a contingency situation. Through generation rescheduling [1] the overloaded strains are mitigated from the severity. With the planned RCBBO algorithm, to improve the safety vectors, dynamically variable parameters specially the immigration and emigration rateare included as opposed to the mounted values of the parameters. The SCOGD procedure includes programming of generators to minimize the severity index with minimum fuel price. An IEEE-30 bus system is taken into account to check the effectiveness of the proposed approach. Numerical outcomes screen that, for ten iterations the deliberate BBO algorithm out performs the opposite revolutionary algorithms such as cuckoo search (CS), Bat algorithm (BA) and particle swarm optimization (PSO) in getting the minimum fuel charge and therefore the minimal severity index in minimum time. Consequently, the planned BBO set of rules is found to be rapid converging and within economic constraints to arrive at a viable solution for SCOGD problem.

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1. Introduction

Electric power systems are complex network, which faces a by no means-ending growth of energy. Connected loads form the primary part of this growing energy and the operation of power facility has attained sizeable significance in terms of security and reliability. Protection evaluation is the task of ascertaining whether or not or no longer the device working under conventional situation will stand up to the contingenciesor no longer while keeping the limits viable. If the prevailing operative position is observed apprehensive below contingency, then important measures ought to be taken as a way to avoid restriction violations. In this sort of case, power flow averting can relieve the overloading of transmission lines. Using a straightforward homogeneity between overloaded transmission lines flow and the unit generation leads to re-scheduling thepattern of power generation. An economical clear-cut rule has been modeled to examine real-time safety control, with the intention to alleviate the overload [2]. The classical optimization [3] strategies are developed to get the high-quality electricity flow downside, just like the gradient approach, Newton and decoupling ones and add the interior point approach. The above methods have a natural time-consuming converging characteristic and also coincide [4] to local optima. As a consequence, the antique methods be afflicted by many drawbacks to arrive at the most desirable Optimal Power Flow (OPF) Solution.

2. Power System Security

Power network security framework is characterized as the ability of the system to stay safe with no outages when exposed to a contingency. The most essential fault which damages the everyday potential of powersafety is inadequate bus voltages and power circuit overloading because of contingency. Current flow in a power systemrely largely on the connected loads. Loads can be of any rating and each and every component connected to a network must be protected with the aid of switchgear.Overloads [5][6] can be characterized as a phenomenon that implies when the current flowing through the network exceeds the rating of the protective device connected in the system. In a large power system, these overloads lead to a condition of outage due to the excessive electrical stress and these outages can occur in any part of the system such as lines, generators, transformers etc., These outages are called as contingencies and it is regarded as a most important security framework to be addressed.

3. Security Assessment

The security of a power system should be assessed to make certain a particular stage of overall performance. This holds appropriate following any change to the structure of the device or the operational circumstance is changed. Imparting excessivegeneration to boost securitydemands completely different estimation methodologies [7][8] then the only supplying redundant transmission pathways. Thus, security assessment is visible as two methods beneath; one can be the hierarchical exploration of generation, transmission, and distribution security and the other is examiningthe security for the planning, operations and operational time horizons. This approach to security evaluation is applied to a vertically integrated operating structure for the last three decades. Since the system changes from an integrated utility to a disintegrated one, modifications on security assessment is the need of the hour. Modifications in the assessment [9-10] with respect to change in planning & operational aspects are highly regarded since the conventional grid remains unchanged. However, there will be a significant amount of change in maintaining system security byformulating the practices and operational algorithms. based totally on the practices, list the kinds of security assessment as follows.,

1. Static Security Assessment
2. Dynamic Security Assessment

4. Security Enhancement

Growing call for energy has positioned extreme pressure on system protection. Therefore, this paper concentrates on the problem of a manner to maximize system protection in terms of line loading and voltage stage below conventional operation or even the foremost important one-line contingency situations. Electric energy network security analysis conjointly plays a key role in improving the system safety and to avoid the device crumble circumstance. These days, electric network operation, control, and management emerge as one in every of the hard obligations to ensure continuity and reliability of electric power. Security of the networkhas to be analyzed to keep away from out of control conditions like line overloading's, bus voltage violations and machine disintegrate situations [11]. Dynamic safety assessment is critical which constitutes to the characteristics of swiftly changing running situations. In trendy, the crucial aim of energy facility operation and management is to meet the in no way-finishing call for with zero failures. In the course of this time of operation, failure of generator because of failure of the ancillary system or elimination of line for protection motive or due to hurricane and others, exquisite consequences have to appear. This influences the system frequency and causes load dropping or out of control operation and sooner or later system fall apart state of affairs. This takes place mainly because of the stresson the transmission lines, voltage violation and lack of reactive compensation on the PQ bus. It is ascertained that as a power supply facility, it's essential to ponder a detail that pertains to the networksafety and includes making plans of the system to attend to the protection underneath varied contingencies. In popular, failure of a line or a generator will growthrough the loading on some of the transmission lines [12] and load bus voltage valuehave to violate their minimal or most limits. It is a way important to minimize the network severity and analyze the circumstance to reinforce the security. For this purpose, completely exceptional parameters are referred to extract the maximum excessive lines and generators within the given network throughout a contingency.

5. Contingency Analysis and Selection

Contingency Definition

The contingency is failure of power network components like generator, transformer, transmission line, substation in a grid. Contingency evaluation is executed to see theimpact befell due to the fault.

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Contingency Selection

Each bus in power grid contingency is calculated and they are ranked according totoseverity index. Using Newton Raphson load flow analysis, severity [13] indices are calculated andthe contingency is ranked due to severity index. The contingency for the highest severityindex is chosen to get outage.

Contingency evaluation

The purpose of the contingency plan is to check the change in the functioning of thedevice that occurs after the fault element is removed.

6. Problem Formulation

Optimal Load Dispatch problem

Optimal Load Dispatch is the approach of determination of the output power generated by means of the unit or devices to provide the specified load in a way to approach the minimal fuel cost. Most generating unit includes an exclusive production price mentioned by its fuel value coefficients (a, b, c of a+bp+cp). Optimal load dispatch is likewise mentioned as the coordination of the manufacturing price of all of the units taking part in satisfying the complete load. The aim of optimal load is to work out the optimal generation schedulingof the units taking part in the load supply [14-15]. The sum of the entire power generation ought to adequate to the complete station demand. To be simple, the transmission losses are unnoticed. This converts the solution procedure less complicated. However, in actual exercise, the transmission losses are to be thought-about. The inclusion of transmission losses makes the project of economic dispatch a lot greater complicated. A distinctivesolution procedure method needs to be followed to reach at asolution [16]. This is given mathematically as follows.,

$$Min\ F = \sum_{i=1}^{N} F_i P_i \quad (1)$$

Where $F_i(P_i) = a_i P_i^2 + b_i P_i + c_i$

The minimization function is constrained by following factors:
Equality constraint,

$$\sum_{i=1}^{N} P_i = P_D + P_L \quad (2)$$

Inequality constraint on active power generation $P_i$of each unit I is given by,

$P_i^{min} \le P_i \le P_i^{max}$ in which *i=1,2,3…. N* (3)

Inequality voltage constraint is given by,

$V_i^{min} \le V_i \le V_i^{max}$ in which *i=1,2,3…. N_b* (4)

Power limit on transmission line is given by,

$S_l \le S_l^{max}$ (5)

where,
F is the operating cost
N is the number of generating units
$N_b$is the number of buses
P_i is the power output of i^{th} generating unit
F_i (P_i) is the individual fuel cost function of i^{th}generating unit
P_D is load demand
$P_i^{min}$is the i^{th} generating unit's minimum output
P_i^{max} is the i^{th} generating unit's maximum output
Vi^{min} is the i^{th} bus minimum voltage
V_i^{max} is the ith bus maximum voltage

The fuel cost function of generator in power system is represented as a second-orderpolynomial equation given by,

$$\sum F_i(P_i) = a_i + b_i P_i + c_i P_i^2 + \left| e_i \sin\left(f_i (P_{imin} - P_i)\right)\right| \quad (6)$$

Contingency Problem Formation

Contingency evaluation is a known entity in current power control structures. The aim of this evaluation feature is to present the operator regarding static security. Contingency evaluation of electric facility system is a vital pursuit in planning and operation. In common, outage of 1 conductor or transformer ought to bring about [17] over loads in other branches and/or sharp system voltage push or drop. At some stage in an outage of a single line both the active power flow restriction and also the reactive power flow limit that affects the bus voltage gets altered. Therefore, it is crucial to predict these power glide and also the bus voltages following a contingency. It allows to provoke necessary control moves to hold electricity system protection, reliability and balance.

Contingency Selection

For a huge power network, the quantity of devices employed for operation is more. Therefore, the venture of off linecontingency evaluation will become pretty tedious. Then again, only some of the lines will have results like heavy loadsand low voltages in some parts of the system. Consequently, it is crucial to discover those contingencies and examine them. The technique of figuring out the contingencies that paves way to violation of the operational limits is called contingency selection.

Contingency Ranking

Stereotype power flow techniques may be used comprehensively to compute the overall performance indications by means of simulating everycontingencies not during the online. Ordering of the contingencies is handled primarily based at the values of the performance indications. The contingency along with maximum cost of overall performance indications is ranked preliminary. The analysis is then distributed for higher order contingencies. The performance indices can be categorized into two types calledactive power performance index (PIP) and reactive power performance index (PIV). The contingency ranking is especially based totally on severity index given bySeverity index, $I_{sl} = \sum_{l\in 0_l}^{n} (S_l / S_l^{max})^{2m}$ (7)

Real power performance index (PIP)

Real power performance index (PIP) reflects the active power flow violation [18].

$$PIP = M_p \sum_{i=1}^{L} \frac{P_i}{P_{imax}} \quad (8)$$

The value of PIP will be a small if all flows are within limit, and it will be large if one or more lines are overloaded.
Consequently, the value of maximum power flowing through the line can be calculated by,

$$P_{imax} = \frac{V_i * V_j}{X} \quad (9)$$

Reactive power performance index (PIV)

Reactive power performance index (PIV) represents the bus voltage violations. It is given by the equation,

$$PIV = M_V \sum_{i}^{N_{pq}} \left[\frac{2(V_i - V_{inom})}{V_{imax} - V_{imin}}\right]^2 \quad (10)$$

7. Formation of SCOGD Problem

The key goal of the security improvement is to schedule the generating unitsin a way to reduce severity with minimum fuel value underneath a contingency system state [19]. To attain this objective, it's necessary to develop a system which combines the features of contingency and economic load dispatch called Security Constrained Optimal Generation Dispatch (SCOGD). Fig.1.shows the SCOGD system. The bus and the line information are treated as system inputs. After that N-1-line outage contingency integrated Newton RaphsonLoad Flow (NRLF) technique is carried out. Performing contingency analysis computes the severity index and hence the critical contingencies. It is then fed as input toSCOGDprogram. During the execution, the system inputs the generator information and cost. Also, the generators are scheduled optimally so as to compute both the fuel price and severity index. The active powers of the rescheduled generatorsare fed back to the security analysis program to attain both minimum fuel price and severity index. The designof SCOGDarchitecture for IEEE 30-bus is shown in Fig.1.

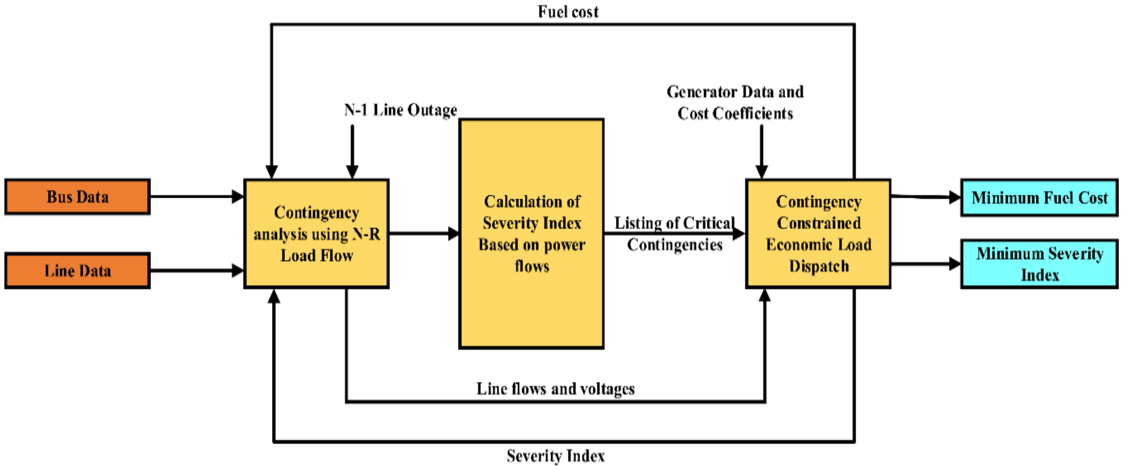

Figure 1: SCOGD Architecture

8. Bbo based Optimization

The BBO algorithm [20] is based on an historic principle of island biogeography which explains the geographical distribution of organic organisms. This become installed through MacArthur and Edward O. Wilson for the duration of the exploration examine in the period between 1960 and1967. Island, in biogeography, is a place of appropriate habitat, which is neighborhood environment occupied by way of an organism surrounded with the aid of an rate of mistaken habitat and is full of actual reservoirs of endemic, exclusive, peculiar, and relict species. Every island has its own features as easy biotas, various mixtures of biotic and abiotic elements and variability in isolation, form and size. The unique BBO has a weak point in migration and mutation degrees that impacts its performance. In BBO [18] the islands are the structured variables and the capabilities availability on the ones islands represents the impartial variables. This is a new biogeography stimulated global optimization algorithm that's similar to the island version-primarily based on GA's. In this, each species has peculiar immigration proportion λ and emigration proportion μ. The immigrationand emigration proportion are features of the number of species within the habitat. They may be calculated as follows:

$$\lambda_k = I\left(1 - \frac{k}{n}\right) \quad (11)$$

$$\mu_k = E\left(\frac{k}{n}\right) \quad (12)$$

Where,
$I$is the immigration proportion possible,
E is the emigration proportion possible,
k is the number of species of habitat,
n is the maximum number of species.

Equations (11) & (12) are just one method for calculating λ and μ. There are other differentoptions to assign them based on different species models.BBO translates the herbal distribution species into a widespread common solution. Each island represents ansolutionwherein the good approach is that the island has masses of true biotic and abiotic elements which draws more species than different islands. Every characteristic is known as Suitability Index Variable (SIV) [21] which represents the independent variable of this type of problem in BBO. As those functions changes the Island Suitability Index (ISI) adjustments too, hence in BBO, ISI is the structured variable.

A problem with n-independent variables and k-islands or individuals can be expressed

$$ISI_i = f(SIV_1, SIV_2, \ldots\ldots\ldots\ldots\ldots .. SIV_n) \quad (13)$$

where*i*= 1,2……. k

RCBBO Based Optimization

Real-coded BBO method known as RCBBO, is implemented for global optimization issues in the continuous domain. Every species is represented with the aid of a D-dimensional actual parameter vector. Right here, the mutation operator is integrated into RCBBO to improve exploration [22] ability and to improve variety of the population. The algorithm of Real Coded BBO is defined beneath where generation counter is given by means of t and the populace length is NP.

Real Coded BBO (RCBBO) Algorithm

Step-1: Randomly generate the initial population, *P*
Step-2: Computer fitness for every individual *X* in *P*
Step-3: Initialize the generation counter to 1
Step-4: **while** The fitness criterion is not satisfied **do**
Step-5: Sort the population in descending order
Step-6: For every individual, map the HSI to the number ofspecies
Step-7: Compute the immigration rate $\lambda_i$and the emigration rate $\mu_i$for each individual X_i
Step-8: Modify the population utilizing the migration operator
Step-9: Update the probability for each individual
Step-10: Increase the population with the mutation operator
Step-11: Evaluate the population, *P*
Step-12: Increment the generation counter to 2
Step-13:**end while**

RCBBO based SCOGD

This section demonstrates the procedure of integrating RCBBO [23-26] algorithm with the SCOGD problem. The target feature is to schedule the generators with optimal fuel price, specified the severity index is reduced below essential contingencies, subjected to various constraints.

Procedure of RCBBO algorithm for SCOGD problem

Step-1. Population initialization and initialization of iterations & problem dimensions
Step.2. Perform N-1 line outage integrated NRLF and computation of losses, line flows and swing bus power
(3) Form a new objective function considering the penalty function, since during N-1 line outage transmission line voltage violations, violations at load bus and swing bus are to be considered. The objective function with penalty factor is given by,

$$F^*(P_i) = F_i(P) + K_v \times \sum_{i-1}^{N_b}(V_i - V_i^{max})^2 + K_s \times \sum_{i=1}^{N_l}(S_{li} - S_{li}^{max})^2 + K_p \times (P_s - P_s^{max})^2 \quad (14)$$

where, K_v, K_s&K_p are positive penalty coefficients of voltage & power.
(4) Asses thefuelprice and active powers of the generators using the augmented objective and calculate the severity index using NRLF method. The results of this is taken as prior solutions
(5) Set t_i = 1, $\lambda_{min} = 0.05$,$\lambda_{max} = 1$, $\mu_{min} = 0.05$ and $\mu_{max} = 0.5$
(6) Calculate λ and μ for the particular generation by using (10)& (11)
(7) Calculatefuelprice, voltages on thebus, power flows and swing bus power using N-1 security integrated NRLF to arrive at a severity index.
(8) Compare the iterative solution with the previous ones
(9) If $NS \leq NS_{max}$, terminate program and return the amplified fuel cost, severity index of the population,
else, fix $t_i = t_i + 1$ and go to step 4.
(10) If $t_i = t_{imax}$, go to step 11
(11) Return the values of the rescheduled generation along with minimum fuel price and minimum severity index

The above procedure is explained in the flowchart shown in Fig.2.,

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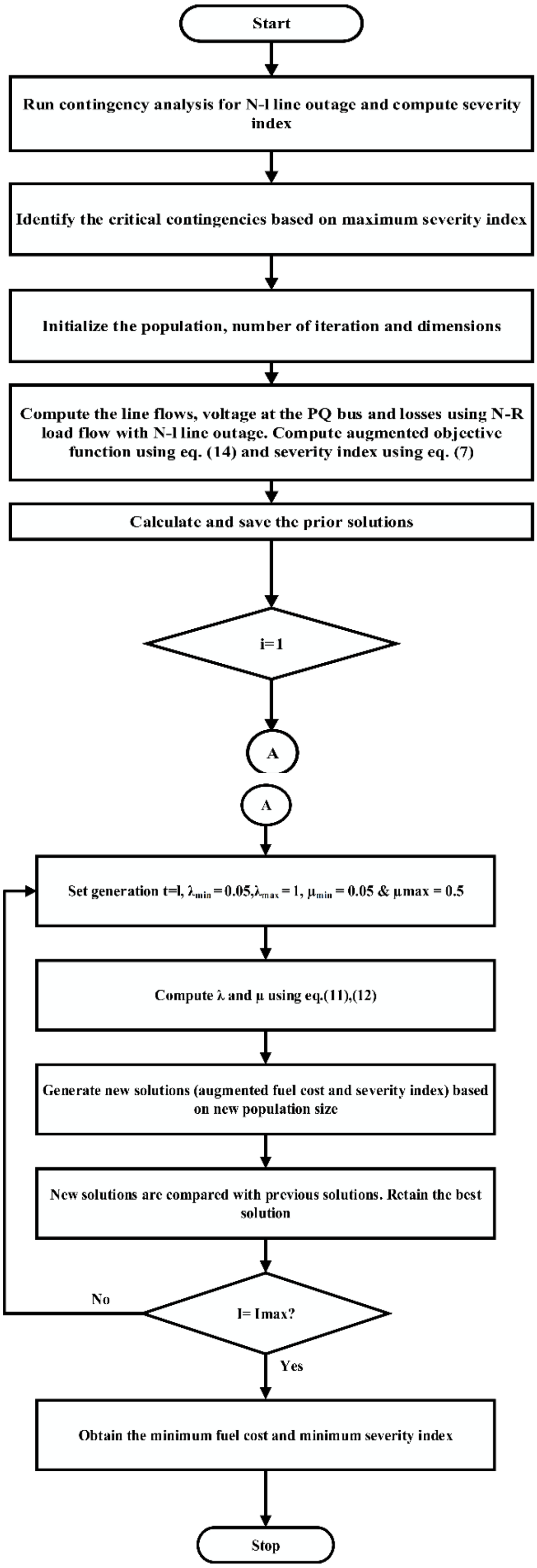
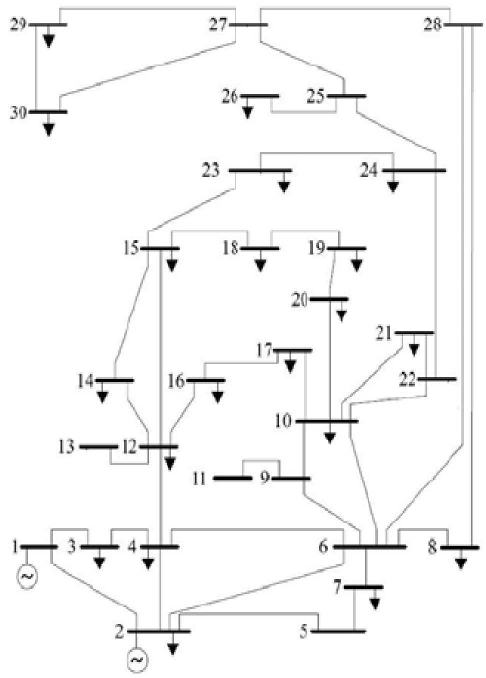


Figure 2: Flowchart for RCBBO based SCOGD

9. Results & Discussion

IEEE 30-Bus System One Line Diagram



The contingency analysis is carried out on the IEEE 30 bus system in-order to assess the potentialoverloads. From the results it is identified that theoutagesare caused in the lines 1–2, 1–3, 3–4 and 2–5 which causes overloading in other lines. For thecontingencies stated above, the power flow of the heavily loaded lines along with severity index is given inTable.1

Simulation results of the proposed method, shows that severity index before rescheduling is low for the proposed RCBBO based optimization and also the minimum fuel cost is achieved through this algorithm. Therefore, it will be easy to reschedule the generations based on the results provided by the algorithm. On the other hand, this method of generation rescheduling involves no extra cost for compensating the line losses due to overloads, since the internal characteristics of the power facility system is exploited and no external components are involved. So, it is prudent that in addition to minimizing the fuel cost, the operational cost is also reduced, leading to optimal operating system. Results obtained are tabulated and are shown as figures in the following sections.

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Table 1: IEEE30 Bus System Contingency Analysis
without Rescheduling

Line Outage	Line Overloaded	Power Flow (MVA)	Power Flow Limit (MVA)	Severity Index
1-3	1-3	199.94	130	5.8036
3-4	3-4	181.35	130	
4-6	4-6	111.75	90	
1-2	1-2	187.41	130	4.3732
2-6	2-6	67.62	65	
1-2	1-2	185.13	130	4.0101
2-6	2-6	68.89	65	
2-6	2-6	80.37	65	2.7779
5-7	5-7	78.229	70	

Table 2: Optimal Generation Dispatch using RCBBO under severecontingencies (before rescheduling)

	1-2	1-3	3-4	2-5
P1(MW)	199.803	187.36	187.015	190.9889
P2(MW)	49.9144	44.87	44.556	47.655
P3(MW)	21.7742	18.88	19.8625	25.7101
P4(MW)	16.8462	21.88	18.4406	15
P5(MW)	10	11.74	13	10
P6(MW)	12	13.20	14.7356	12
MIN FUEL COST($/HR)	860.887	819.092	818.0476	831.6541
MAX FUEL COST($/HR)	862.746	821.874	820.8384	835.0198
MEAN FUEL COST($/HR)	861.705	820.0227	819.4585	833.1506

Table 3: Optimal Generation Dispatch using RCBBO (after rescheduling)

	1-2	1-3	3-4	2-5
P1(MW)	129.92	125.73	126.24	129.97
P2(MW)	75	73.46	75.68	72.30
P3(MW)	25.2709	29.18	26.91	32.92
P4(MW)	32.1833	35	29.60	35
P5(MW)	22	15.29	22	10.99
P6(MW)	12	14	12.17	14.91
MIN FUEL COST($/HR)	848.05	838.76	838.00	852.30
MAX FUEL COST($/HR)	861.59	850.66	842.98	857.53
MEAN FUEL COST($/HR)	853.28	843.59	848.13	854.90

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Table 4: Line flow calculations after generator rescheduling

Line Outage	Line Overloaded	Power Flow (MVA)	Power Flow Limit (MVA)	Index
1-3	1-3	129.87	130	0
3-4	3-4	120.68	130	
4-6	4-6	72.98	90	
1-2	1-2	126.69	130	0
2-6	2-6	58.65	65	
1-2	1-2	123.98	130	0
2-6	2-6	57.13	65	
2-6	2-6	63.62	65	0
5-7	5-7	64.84	70	

From Table.4, it can be understoodthat under outage 1-2,the new line flows obtained aftergenerator rescheduling for the lines 1–3, 3–4 and 2–5, are below the line flowlimit, relieves the overloaded lines and thus the severity index obtained is zero.

Comparative Analysis of Algorithm Performance

The results of BBO algorithm is compared with otherheuristic algorithms such as PSO, GA & BBO and the results are tabulated for 10 iterations as shown in Table.5

Case-1 shows the values before rescheduling and Case-2 shows the values after rescheduling

Algorithms	Line Outage	Fuel Cost ($/H)	Severity Index	
			Case-1	Case-2
RCBBO	1-2	848.0513	5.8036	0
BBO		848.9419	5.8081	0
GA		849.0639	5.8116	0
PSO		852.7211	5.8654	0
RCBBO	1-3	838.7619	4.3732	0
BBO		839.2668	4.4185	0
GA		838.5927	4.382	0
PSO		841.2035	4.4386	0
RCBBO	3-4	838.0044	4.0101	0
BBO		838.448	4.2432	0
GA		839.8933	4.1683	0
PSO		843.011	4.1683	0
RCBBO	2-5	852.3098	2.7779	0
BBO		852.9106	3.8294	0
GA		853.1307	3.9221	0
PSO		855.0447	3.7907	0

Line Flow Analysis

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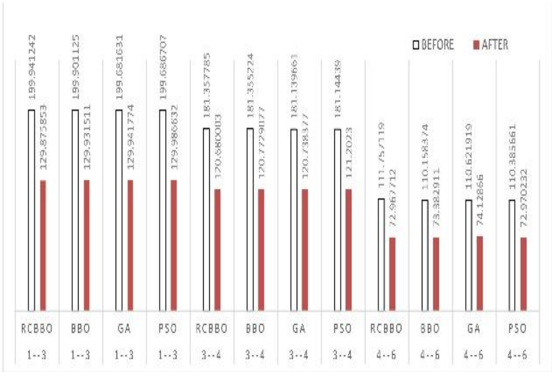

Figure 3: Comparative analysis of power flows before and after rescheduling fortheoutage of line 1-2

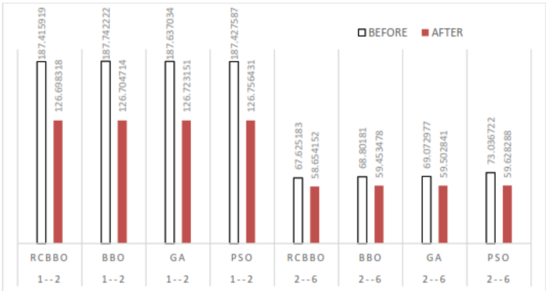

Figure 4: Comparative analysis of power flows before and after rescheduling fortheoutage of line 1-3

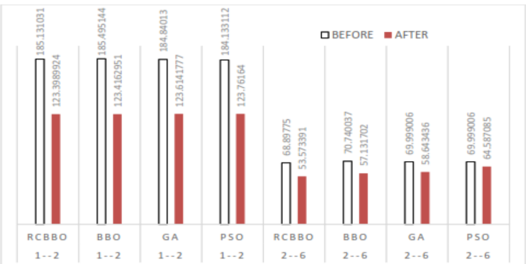

Figure 5: Comparative analysis of power flows before and after rescheduling forthe outage of line 3-4

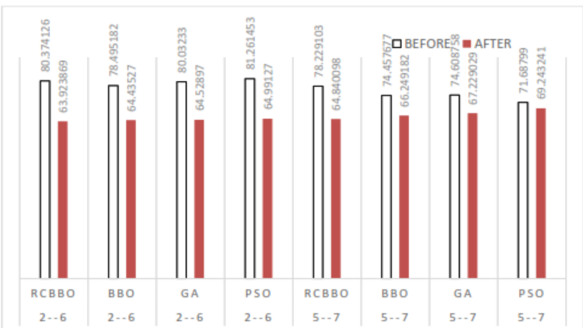

Figure 6: Comparative analysis of power flows before and after rescheduling forthe outage of line 2-5

Fuel Price Analysis

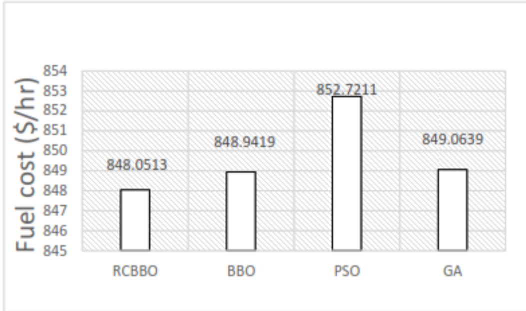

Figure 7: Fuel price comparison of different algorithms for the line outage 1-2

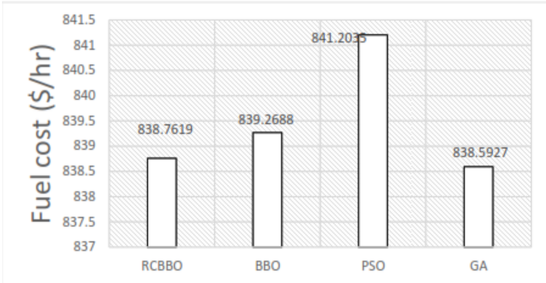

Figure 8: Fuel price comparison of different algorithms for the line outage 1-3

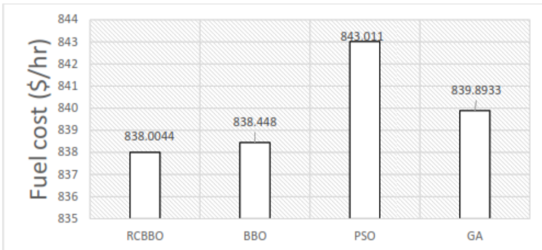

Figure 9: Fuel price comparison of different algorithms for the line outage 3-4

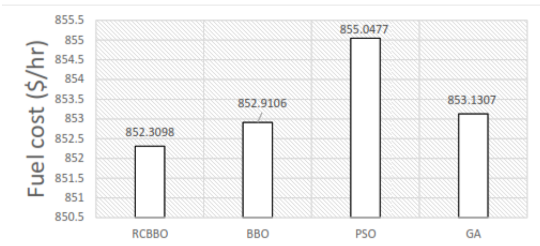

Figure 10: Fuel price comparison of different algorithms for the line outage 2-5

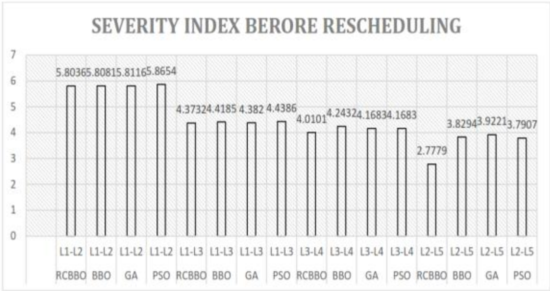

Figure 11: Chart for severity index of critical contingencies estimated by different algorithms

10. Conclusion

This paper approaches the Security Constrained Optimal Generation Dispatch problem with RCBBO based optimization which utilizes immigration and emigration rates to mitigate the line stress. This became possible since the metaheuristic technique utilizes dynamically variable values λ & μ to obtain a best solution, rather than utilizing fixed values. This study concentrated on performing contingency analysis to list out the critical contingencies in the first step. Then the proposed RCBBO algorithm is applied to reschedule the generations in a way to achieve minimum fuel price and severity index. Simulation results reveals that RCBBO algorithm rendered minimum severity index with minimum fuel price under environments of line overloads. Also, the RCBBO algorithm outlawed the other algorithms such as GA, PSO and BBO implemented for SCOGD problem. Thus, the proposed algorithm is effective enough to arrive at a solution for Security Constrained Optimal Generation Dispatch problem.

References

[1] A. Y. M. Abbas, S. E. G. M. Hassan, and Y. Abdelrahim,“Transmission lines overload alleviation by generation rescheduling and load shedding,” J. Infrastruct. Syst., 2016.

[2] D. Simon, “Biogeography-based optimization,” IEEE Trans. Evol. Comput., 2008.

[3] W. Gong, Z. Cai, C. X. Ling, and H. Li, “A real-coded biogeography-based optimization with mutation,” Appl. Math. Comput., 2010.

[4] W. Guo, L. Wang, and Q. Wu, “An analysis of the migration rates for biogeography-based optimization,” Inf. Sci. (Ny)., 2014.

[5] O. Abedinia, A. Ghasemi, and N. Ojaroudi, “Improved time varying inertia weight PSO for solved economic load dispatch with subsidies and wind power effects,” Complexity, 2016.

[6] A. Amsavalli, D. Vigneshwaran, M. Lavanya, and S. Vijayaraj, “Study of Multi-Area Economic Dispatch on Soft Computing Techniques,” Int. J. Multidiscip. Res. Mod. Educ. ISSN Vol. II, Issue II, 2016.

[7] Bansilal, D. Thukaram, and K. Parthasarathy, “An expert system for alleviation of network overloads,” Electr. Power Syst. Res., 1997.

[8] G. Baskar and M. R. Mohan, “Security constrained economic load dispatch using improved particle swarm optimization suitable for utility system,” Int. J. Electr. Power Energy Syst., 2008.

[9] G. Baskar and M. R. Mohan, “Security Constrained Optimal Generation Dispatch using improved particle swarm optimization for security enhancement,” Electr. Power Syst. Res., 2009.

[10] A. Hoballah and I. Erlich, “A framework for enhancement of power system dynamic behavior,” in IEEE PES General Meeting, PES 2010, 2010.

[11] U. Kiliç, K. Ayan, and U. Arifoğlu, “Optimizing reactive power flow of HVDC systems using genetic algorithm,” Int. J. Electr. Power Energy Syst., 2014.

[12] M. S. Kumari and S. Maheswarapu, “Enhanced Genetic Algorithm based computation technique for multi-objective Optimal Power Flow solution,” Int. J. Electr. Power Energy Syst., 2010.

[13] T. K. P. Medicherla, R. Billinton, and M. S. Sachdev, “Generation rescheduling and load shedding to alleviate line overloads-analysis,” IEEE Trans. Power Appar. Syst., 1979.

[14] K. Muthulakshmi, R. M. Sasiraja, and V. S. Kumar, “The Phenomenal Alleviation of Transmission Congestion by Optimally Placed Multiple Distributed Generators Using PSO,” Circuits Syst., 2016.

[15] K. Pandiarajan and C. K. Babulal, “An anfis approach for overload alleviation in electric power system,” J. Electr. Syst., 2014.

[16] K. Pandiarajan and C. K. Babulal, “Fuzzy ranking based non-dominated sorting genetic algorithm-II for network overload alleviation,” Arch. Electr. Eng., 2014.

[17] Pradeepa H., T. Ananthapadmanabha, S. Rani D.N., and Bandhavya C., “Optimal Allocation of Combined DG and Capacitor Units for Voltage Stability Enhancement,” Procedia Technol., 2015.

[18] P. K. Roy, S. P. Ghoshal, and S. S. Thakur, “Biogeography based optimization for multi-constraint optimal power flow with emission and non-smooth cost function,” Expert Syst. Appl., 2010.

[19] P. T. S and Somasundaram P, “Multi-Area Security Constrained Economic Dispatch by Fuzzy-Stochastic Algorithms,” J. Theor. Appl. Inf. Technol., 2009.

[20] A. Shandilya, H. Gupta, and J. Sharma, “Method for generation rescheduling and load shedding to alleviate line overloads using local

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ISSN: 0193 - 4120 Page No. 6611 - 6621

optimization," IEE Proc. C Gener. Transm.Distrib., 1993.

[21] A. Bhattacharya and P. K. Chattopadhyay, "Hybrid differential evolution with biogeography-based optimization algorithm for solution of economic emission load dispatch problems," Expert Syst. Appl., 2011.

[22] A. Bhattacharya and P. K. Chattopadhyay, "Hybrid differential evolution with biogeography-based optimization for solution of economic load dispatch," IEEE Trans. Power Syst., 2010.

[23] D. Devaraj and B. Yegnanarayana, "Genetic-algorithm-based optimal power flow for security enhancement," in IEE Proceedings: Generation, Transmission and Distribution, 2005.

[24] R. A. El-Sehiemy, M. B. Shafiq, and A. M. Azmy, "Multi-phase search optimisation algorithm for constrained optimal power flow problem," Int. J. Bio-Inspired Comput., 2014.

[25] O. B. Haddad, S. M. Hosseini-Moghari, and H. A. Loáiciga, "Biogeography-Based Optimization Algorithm for Optimal Operation of Reservoir Systems," J. Water Resour. Plan.Manag., 2016.

[26] P. Somasundaram and K. Kuppusamy, "Application of evolutionary programming to security constrained economic dispatch," Int. J. Electr. Power Energy Syst., 2005.