Optimal Congestion Management: Strength Pareto Gravitational Search Algorithm

Hossein Ghadimi[1], Adel Akbarimajd[2], Noradin Ghadimi[3]

[1]Ardebil Province Electricity Distribution Co, Ardabil, Iran

[2]Electrical Engineering Department, Faculty of Engineering, University of Mohaghegh Ardabili, Ardabil, Iran

[3]Young Researchers and Elite club, Ardabil Branch, Islamic Azad University, Ardabil, Iran

Abstract— Congestion management is one of the basic tasks performed by system operators to ensure the operation of transmission system within operating limits. In this research, Strength Pareto Gravitational Search Algorithm (SPGSA) is used to optimum management of a distributed network congestion for raise efficiency, increase safety margins and reduce cost of distribution network unit production regarding to practical constraints such as maximum network voltage, maximum transmission line current, power balance and load level. Actually nowadays, violations of distribution network constraints as; limit of power transmission lines, bus voltages and other practical constraints, are one of the most important issues in electrical energy in reconstruction systems contract. The effectiveness of the proposed technique which is based on collective intelligence is applied on 30 and 118 bus IEEE standard power system in comparison with CPSO, PSO-TVAC and PSO-TVIW. The numerical results demonstrate that the proposed technique is better and superior than other compared methods.

Keywords*; Optimum congestion management, SPGSA, Operating limits.*

I. INTRODUCTION

Managing dispatch is one of the important control activities in a power system. Optimal power flow (OPF) has maybe been the most significant technique for obtaining minimum cost generation patterns in a power system with existing transmission and operational constraints [1].

The dispatch problem has been formulated with two different objective functions: cost minimization and minimization of transaction deviations. Congestion charges can be evaluated in both the cases. In a pool market mode, the sellers (competitive generators) may submit their incremental and decremental bid prices in a real-time balancing market. These can then be combined in the OPF problem to yield the incremental/decremental change in the generator outputs. In the same, the case of the bilateral market mode, each transaction contract may include a compensation price that the buyer-seller pair is willing to accept should its transaction be curtailed. This can then be modeled as prioritize of the transactions through the latter’s sensitivities to the violated constraint in case congestion occurs [2-3].

Consequently, there are two broad paradigms that may be employed for congestion management which called cost-free means and the not-cost-free means [4]. The former include actions like out aging of congested lines or operation of transformer taps. These means are termed as cost-free only because the marginal costs (and not the capital costs) involved in their usage are nominal. The not-cost-free means is classified in two main concepts as:

- Rescheduling generation: For this concept, system operator re-dispatches power generation in such a way, as a result power flows does not overload any line. Every units of generation can bid an increase or reduce its production in a similar way as this is done on a balancing market, whereas the responsibility of system operator is to select bids in efficient way. Someway, countertrade approach based congestion management can be viewed as simplified OPF problem, where optimization variables are re-dispatch of the active power production and criteria function is minimum of the costs related to this active power re-dispatch.
- Prioritization and curtailment of loads/transactions: A parameter termed as willingness-to-pay-to-avoid-curtailment was introduced in [5]. It can be an appropriate technique for setting the transaction curtailment strategies which will be able to exposure in the OPF framework.

In Irregular electrical environment, Independent System Operators (ISO) managed system line congestion. Temperature, voltage and stability are system limitations. Selective method for congestion management should be accepted from economical aspect and the necessary incentive to increase investment to provide network capacity for transmission network and generation division [6].

Several OPF based congestion management schemes for multiple transactions have been proposed. In [7] a number of Congestion management approaches are presented. In [8], [9], describe technique which is called congestion factor of distribution network. Ranking zone categorized by sensitivity index is divided to active and reactive power. This technique in computational aspect is complex. An approach using the minimum total modification to the desired transactions for relieving congestion is presented in [10]. A variant of this least modification approach [11] used a weighting scheme with the weights being the surcharges paid by the transactions for transmission usage in the congestion-relieved network. In [6], an OPF based approach that minimizes cost of congestion and service costs is proposed. In [5], a new mechanism of congestion management in multilateral transaction networks has been developed based on physical flows. In [10], the concept of Relative Electrical Distance (RED) to alleviate overloaded lines by the timing of active power is described. This method minimized system Loss and improved voltage profile. However, in this paper has been not raised schedule cost.

In this research, SPGSA is proposed for re-dispatching system with congestion management to minimize cost, congestion lines for overload condition and satisfied production constraints and generator loads. The proposed SPGSA is based on collective intelligence and is appropriate for multi objective functions too [12]. The effectiveness of the proposed technique is applied on 30 and 118 bus IEEE standard power system in comparison with classic particle swarm optimization (CPSO), PSO with time varying acceleration coefficient and PSO-time varying inertia weight [13]. Proposed method has a high convergence rate and placed in local areas.

II. Problem Expression

The optimal congestion management minimizing re-dispatch cost can be expressed as [9].

$$Min \sum_{g=1}^{Ng} Ic_g(\Delta P_g)\Delta P_g \tag{1}$$

Where *ICg* and *ΔPg* are incremental and decremental cost respectively and active power adjustment is of generator g, respectively. *Ng* is Number of participating generators.

Subject to:

- Power balance constraint:

$$\sum_{g=1}^{Ng}(GS_g^{ij}.\Delta P_g) + F_l^0 \le F_l^{\max} \tag{2}$$

- Operating limit constraints:

$$\Delta P_g^{\min} \le \Delta P_g \le \Delta P_g^{\max}; g = 1,2,...,Ng \tag{3}$$

Where,

$$\Delta P_g^{\min} = P_g^{\min} - P_g ; \Delta P_g^{\min} = P_g^{\min} - P_g$$

- Line flow constraints:

$$\sum_{g=1}^{Ng}(GS_g^{ij}.\Delta P_g) + F_l^0 \le F_l^{\max} \tag{4}$$

A. Selecting Re-dispatched Generators

The Generator Sensitivity (GS) technique indicates the change of active power flow due to change in active power generation. The GS value of generator *g* on the line connected between buses *i* and *j* can be written as [8].

$$GS_g^{ij} = \frac{\Delta P_{ij}}{\Delta P_{Gg}} = \frac{\partial P_{ij}}{\partial \theta_i}.\frac{\partial \theta_i}{\partial P_{Gg}} + \frac{\partial P_{ji}}{\partial \theta_j}.\frac{\partial \theta_j}{\partial P_{Gg}} \tag{5}$$

The power flow equation on congested lines can be calculated by:

$$\frac{\partial P_{ij}}{\partial \theta_i} = -V_i V_j.G_{ij}.\sin(\theta_i - \theta_j) + V_i V_j.B_{ij}.\sin(\theta_j - \theta_i) \tag{6}$$

$$\frac{\partial P_{ij}}{\partial \theta_i} = +V_i V_j.G_{ij}.\sin(\theta_i - \theta_j) - V_i V_j.B_{ij}.\sin(\theta_j - \theta_i) = -\frac{\partial P_{ij}}{\partial \theta_i} \tag{7}$$

The relation between the change in active power at each bus and voltage phase angles can be written as:

$$[\Delta P]_{n\times 1} = [\mathrm{H}]_{n\times n} \times [\Delta\theta]_{n\times 1} \tag{8}$$

$$[\mathrm{H}]_{n\times n} = \begin{bmatrix} \frac{\partial P_1}{\partial \theta_1} & \frac{\partial P_1}{\partial \theta_2} & \cdots & \frac{\partial P_1}{\partial \theta_n} \\ \frac{\partial P_2}{\partial \theta_1} & \frac{\partial P_2}{\partial \theta_1} & \cdots & \frac{\partial P_2}{\partial \theta_n} \\ \vdots & \vdots & & \vdots \\ . & . & & . \\ \frac{\partial P_n}{\partial \theta_1} & \frac{\partial P_n}{\partial \theta_2} & \cdots & \frac{\partial P_n}{\partial \theta_n} \end{bmatrix}_{n\times n} \tag{9}$$

Where, $[M] = [\mathrm{H}]^{-1}$ therefore $[\Delta\theta]_{n\times 1} = [M]_{n\times n} \times [\Delta P]_{n\times 1}$. Since bus 1 is the reference bus, the first row and first column of [M] can be eliminated. Therefore, the modified [M] is written as:

$$[\Delta\theta]_{n\times 1} = \begin{bmatrix} 0 & 0 \\ 0 & [\mathrm{M}-1] \end{bmatrix}_{n\times n} \times [\Delta P]_{n\times 1} \tag{10}$$

In (10), the modified [M] represents the values of $\frac{\partial \theta_i}{\partial P_{Gg}}$ and $\frac{\partial \theta_j}{\partial P_{Gg}}$ in (5) to calculate GS values. Large GS generators will be selected for re-dispatched since they are more influential on the congested line.

III. Gravitational Search Algorithm Technique

The Gravitational Search Algorithm (GSA) is constructed based on the law of gravity and the notion of mass interactions. GSA is one of the newest heuristic algorithms which have been inspired by the Newtonian laws of gravity and motion. In GSA a set of agents called masses are introduced to find the optimum solution by simulation of Newtonian laws of gravity and motion [15]. Also, each mass agent has four specifications: location, inertia mass, active gravitational mass, and passive gravitational mass. The location of the mass corresponds to a solution of the problem, and its gravitational and inertial masses are determined using a fitness function. In other words, each mass shows a solution, and the algorithm is navigated by properly adjusting the gravitational and inertia masses. By lapse of time, we expect that masses be attracted by the heaviest mass. This mass will show an optimum solution in the search space [16]. “Figure 1”, shows the entrance of mutual forces on each mass.

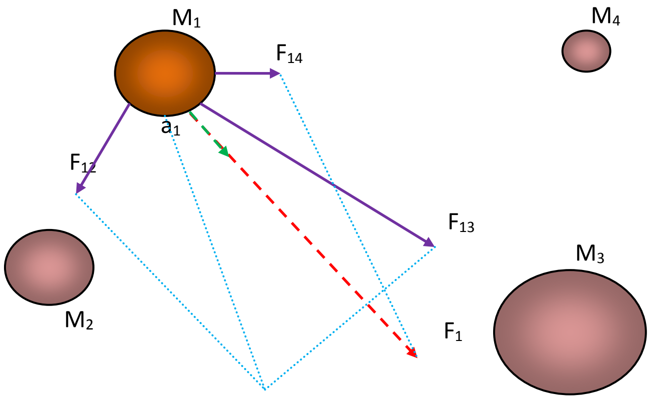

Figure 1. The entrance mutual forces on each mass

The GSA could be considered as an isolated system of masses. It is like a small artificial world of masses obeying the Newtonian laws of gravitation and motion [17].

More precisely, masses obey the following laws:

- Law of gravity: Every particle attracts each other particle and the gravitational force between two particles is directly proportional to the product of their masses and inversely proportional to the distance between them, R.
- Law of motion: The current velocity of any mass is equal to the sum of the fraction of its previous velocity and the variation in the velocity. Changing in the velocity or acceleration of any mass is equal to the force acted on the system divided by mass of inertia.

To describe the GSA consider a system with s masses in which position of the i_{th} mass is defined as:

$$X_i = (x_i^1, \dots, x_i^d, \dots, x_i^n), i = 1, 2, \dots, s \tag{11}$$

Where, x_i^d is position of the i_{th} mass in the d_{th} dimension and n is the dimension of the search space. According to [18] mass of each agent is computed after calculating current population's fitness as:

$$M_i(t) = \frac{q_i(t)}{\sum_{j=1}^{s} q_i(t)} \tag{12}$$

Where, $M_i(t)$ is the mass value of the agent i at t.

$$q_i(t) = \frac{fit_i(t) - worst(t)}{best(t) - worst(t)} \tag{13}$$

Where, $fit_i(t)$ is the fitness value of the agent *i* at *t*, and worst (t) and best (t) are defined as follows for the minimization problem:

$$best(t) = \underset{j \in \{1,\ldots,s\}}{Min} \; fit_i(t) \tag{14}$$

$$worst(t) = \underset{j \in \{1,\ldots,s\}}{Max} \; fit_i(t) \tag{15}$$

To compute acceleration of an agent, total forces from a set of heavier masses that apply on it should be considered based on the law of gravity, which is followed by calculation of agent acceleration using the law of motion. Afterwards, next velocity of an agent is calculated as a fraction of its current velocity added to its acceleration. Then, its next position can be calculated using:

$$F_i^d(t) = \sum_{j \in kbest, j \neq i} rand_i G(t) \frac{M_j(t) M_i(t)}{R_{ij}(t) + \varepsilon} (x_j^d(t) - x_i^d(t)) \tag{16}$$

$$a_i^d(t) = \frac{F_i^d(t)}{M_i(t)} = \sum_{j \in kbest, j \neq i} rand_j G(t) \frac{M_j(t)}{R_{ij}(t) + \varepsilon} (x_j^d(t) - x_i^d(t)) \tag{17}$$

$$V_i^d(t+1) = rand_i \times v_i^d(t) + a_i^d(t) \tag{18}$$

$$x_i^d(t+1) = x_i^d(t) + v_i^d(t+1) \tag{19}$$

Where, $rand_i$ and $rand_j$ are two uniformly distributed random numbers in the interval [0, 1], ε is a small value, $R_{ij}(t)$ is the Euclidean distance between two agents *i* and *j*, defined as $R_{ij}(t)=||X_i(t), X_j(t)||_2$, *kbest* is the set of first *K* agents with the best fitness value and biggest mass, which is a function of time, initialized to K_0 at the beginning and decreasing with time. Here K_0 is set to s (total number of agents) and is decreased linearly to1.

In GSA, the gravitational constant, *G*, will take an initial value, G_0, and it will be reduced with time:

$$G(t) = G(G_0, t) \tag{20}$$

Also some differences and advantages of this technique are consisting of [19]:

- In GSA, the agent direction is calculated based on the overall force obtained by all other agents.
- In GSA the force is proportional to fitness value and so agents see the search space around themselves in the influence of force.
- GSA is memory-less and only current position of the agents plays a role in the updating procedure.
- In GSA the force is inversely proportional to the distance between solutions.

"Figure 2" shows the flowchart of the proposed intelligent algorithm.

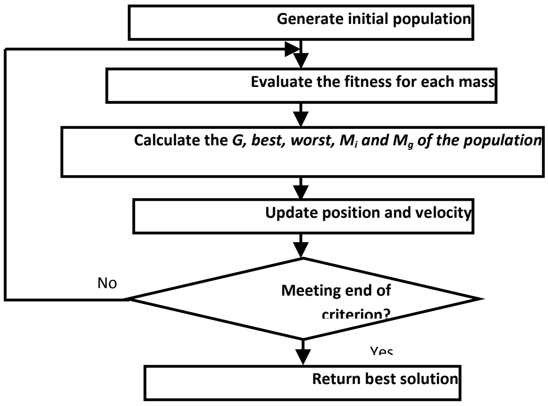

Figure 2. Flowchart of GSA

A. Strength Pareto GSA

Strength Pareto GSA in an improved GSA which can deal with multi objective function. Accordingly, the concept of this technique is based on pareto dominance and defined as:

Decision vector of X_1 dominates X_2 if;

$$X_1 \prec X_2 \Leftrightarrow (\forall_i \in \{1,2,\ldots,n\} : f_i(X_1) \leq f_i(X_2)) \wedge (\exists_i \in \{1,2,\ldots,n\} : f_i(X_1) \leq f_i(X_2)) \quad (21)$$

Also the decision vector of X € X_i is non-beaten if

$$\exists_a \in A : X \prec a \quad (22)$$

Therefore, the *X* is the optimum pare to if be non-beaten rather than X_F. In terms of this point that, the goals of *X* cannot improve, without another goal could worse it. This point is called optimum pareto or non-inferior [19].

IV. Numerical Results

Actually several techniques are applied to find out the minimum cost for any demand for 30 and 118 bus power systems [13]. Results of proposed SPGSA are compared with Particle Swarm Optimization (CPSO [14], PSO-TVAC [14] and PSO-TVIW [14]). All the calculation has been calculated on MATLAB 7.6 environment.

A. IEEE 30-bus system

In this part the IEEE 30-bus power system with six generators and forty one lines is tested as a first case study. The system configuration of the proposed case study is shown in "Figure 3" [12]. For this study, Bus 1 is considered as the reference bus/slack. A congested line between buses 1 and 2 exists as shown in "Table 1".

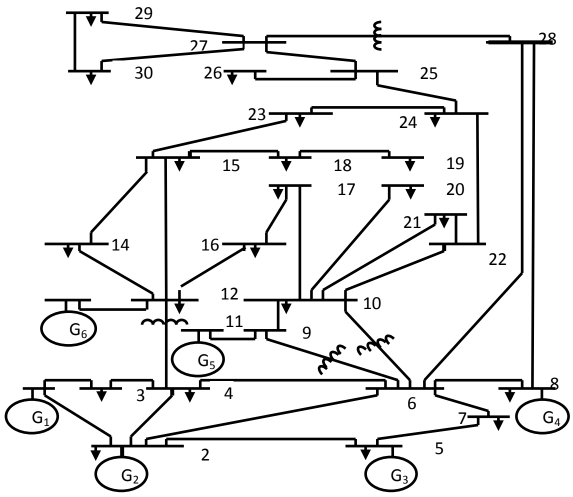

Figure 3. The IEEE 30-bus system configuration

TABLE I. A CONGESTED LINE ON THE IEEE 30-BUS SYSTEM

Congested line	*Active power flow (MW)*	*Line limit (MVA)*	*Overload (MW)*

1 to 2	170	130	40

"Table 2" shows the GS values of 6 generation units. Considering GS values, all generators are selected for re-dispatched.

TABLE II. GENERATION SENSITIVITY OF 6 UNITS ON THE IEEE 30-BUS SYSTEM

Gen no	*1*	*3*	*5*	*8*	*11*	*13*
GS 1_2	0	-0.8908	-0.8527	-0.7394	-0.7258	-0.6869

The GS values of all six generators in the IEEE 30-bus system are high therefore it is needed to use all generators for redispatch to relieve the congested line. To achieve this goal, selected group of generators having the largest GS values may be used to save the computational effort.

The GS values and generation redispatch on the IEEE 30-bus system have been shown in "Figure 4". Comparison of SPGSA solutions on the IEEE 30-bus system with other techniques are presented in "Table 3". There is no doubt that the proposed method provide minimum redispatch cost solution of $ 231.4679, whereas PSO-TVAC $ 237.9/h, CPSO and PSO-TVIW provide $ 240.3/h and $ 239.2/h, respectively. In addition, the solutions of SPGSA optimization have the lowest standard deviation as 1.24. The convergence characteristic of SPGSA schemes on the IEEE 30-bus system is presented in "Figure 5".

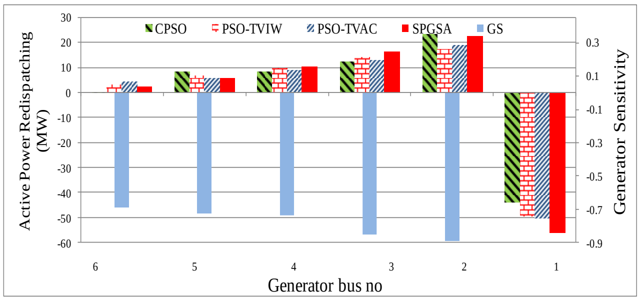

Figure 4. GS values and generation re-dispatch on the IEEE 30-bus system

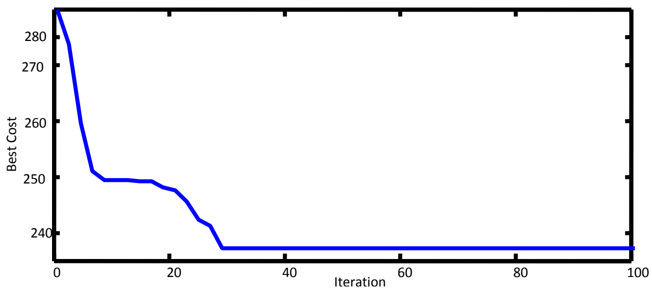

Figure 5. Convergence characteristics of SPGSA schemes on the IEEE 30-bus system. ”

B. IEEE 118-bus system

The system configuration of the IEEE 118-bus system with 54 generators and 186 lines [14] is used as second case study. Bus 1 is assigned as the reference bus. The congested line data is shown in “Table 4”.

“Figure 7”, shows the GS values and the results of GS values for all generator buses are presented in “Table 5”.

TABLE III. COMPARISON OF IGSA SOLUTIONS ON THE IEEE 30-BUS SYSTEM

Algorithm	MW	ΔP_1	ΔP_2	ΔP_5	ΔP_8	ΔP_{11}	ΔP_{13}	Total ΔP	Cost ($ /h)
CPSO	Max	-66.1	28.9	23.3	18.1	6.2	3.7	146.3	403.1
	Min	-47.9	18.6	16.5	11.3	2.8	0.1	97.2	240.3
	Mean	-55.9	22.6	16.2	10.5	5.6	2.6	113.2	287.1
	SD	8.3	7.6	3.5	3.3	3.2	3.3	15.9	48.2
PSO-TVIW	Max	-58.5	16.7	13.0	11.8	8.6	5.7	114.2	288.0
	Min	-47.3	20.1	14.5	10.5	4.8	0.5	97.7	239.2
	Mean	-50.1	18.9	13.2	9.2	5.9	4.1	101.4	253.1
	SD	2.8	3.5	5.4	3.3	3.5	6.1	13.3	3.8
PSO-TVAC	Max	-51.1	22.0	14.7	8.8	6.2	1.0	103.8	254.9
	Min	-47.3	25.1	16.0	7.6	0.6	0.0	96.7	237.9
	Mean	-49.3	17.5	14.0	9.9	6.8	3.0	100.5	247.5
	SD	0.8	2.1	2.1	2.2	2.3	2.4	4.6	1.6
SPGSA	Max	-45.42	24.32	12.21	8.33	8.23	0.34	98.8500	242.5395
	Min	-43.30	20.10	13.40	8.50	8.70	0.70	94.7000	231.4679
	Mean	-44.16	23.34	12.32	8.44	8.13	0.24	96.6300	235.9852

	SD	0.65	1.87	1.98	2.11	2.21	2.34	3.25	1.24

TABLE IV. A congested LINE on the IEEE 118-bus system

Congested line	Active power flow (MW)	Line limit (MVA)	Overload (MW)
89 to 90	260	200	60

Table IV shows, the generator buses 85, 87, 89, 90, and 91 are among the largest magnitude of GS. This implies that these generators could significantly affect to the congested line. Thus, they are chosen as re-dispatched generators. Using the largest GS values, only 6 generators out of 54 are used for re-dispatching by SPGSA algorithm, requiring a much less computational effort.

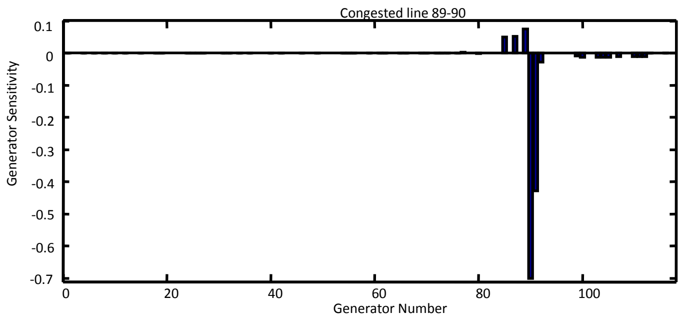

Figure 6. GS values of 54 units on the IEEE 118-bus system

TABLE V. GS VALUES OF 54 GENERATORS ON THE IEEE 118-BUS SYSTEM

Gen no.	*GS(10^-3)*	*Gen no.*	*GS(10^-3)*	*Gen no.*	*GS(10^-3)*
1	0	42	-0.0375	80	-0.9250
4	-0.0005	46	-0.0242	85	50.068
6	-0.0001	49	-0.0460	87	50.654
8	-0.0014	54	-0.0838	89	74.455
10	-0.0014	55	-0.0871	90	-701.15
12	0.0004	56	-0.0854	91	-427.90
15	0.0021	59	-0.1100	92	-28.411
18	0.0051	61	-0.1160	99	-9.391
19	0.0046	62	-0.1130	100	-12.915
24	0.1350	65	-0.1350	103	-12.737
25	0.0484	66	-0.0983	104	-12.854

26	0.0337	69	0.2120	105	-12.772
27	0.0451	70	0.3690	107	-12.202
31	0.0339	72	0.2326	110	-12.274
32	0.0477	73	0.3400	111	-12.07
34	-0.0323	74	0.5410	112	-11.747
36	-0.0329	76	0.8650	113	0.0110
40	-0.0343	77	0.0012	116	-0.1750

Comparison of SPGSA solutions on the IEEE 118-bus system with other techniques are presented in "Table 6". This is clear that, the proposed SPGSA provide minimum re-dispatch cost solution of $ 821.8283. The convergence characteristic of SPGSA schemes on the IEEE 118-bus system is presented in "Figure 7".

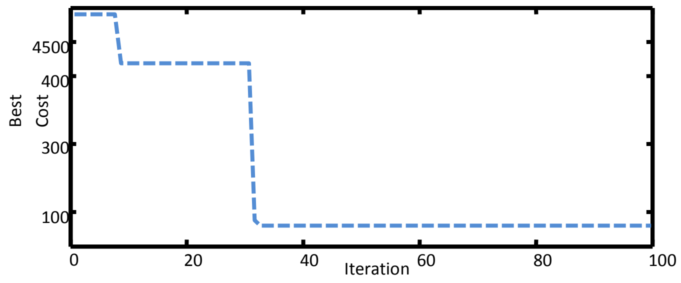

Figure 7. Convergence characteristics of SPGSA schemes on the IEEE 118-bus system

As the GS at bus 85, 87, and 89 are positive, the generation output at these buses is reduced. By contrast, the generators at bus 90 and 91 have negative GS values, thus the generation is increased. Moreover, the GS magnitude affects the amount of active power adjustment. The reference bus is used to maintain the power balance. The relationship between GS values and power re-dispatch shown in the "Figure 8".

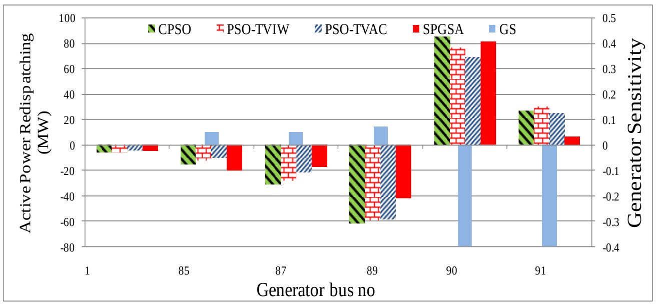

Figure 8. GS values and power re-dispatch on the IEEE 118-bus system

According to the numerical results, it is clear that the proposed technique is superior and better than the other techniques. That is regarding to distribution network constraints, to reduce cost and increase efficiency and security of power system distribution network.

TABLE VI. COMPARISON OF SPGSA SOLUTIONS ON THE IEEE 118-BUS SYSTEM

Algorithm	MW	ΔP_1	ΔP_2	ΔP_5	ΔP_8	ΔP_{11}	ΔP_{13}	Total ΔP	Cost ($ /h)
CPSO	Max	-5.1	-6.4	-8.6	-122.9	117.8	18.9	279.8	1604.5
	Min	-5.1	-27.3	-27.5	-28.9	68.1	25.9	182.7	875.0
	Mean	-5.9	-15.3	-31.5	-62.0	85.1	26.8	226.6	1183.8
	SD	4.4	8.4	11.4	17.5	23.2	14.6	30.5	196.4
PSO-TVIW	Max	-2.7	-13.8	-23.4	-97.7	121.4	10.4	269.4	1497.8
	Min	-6.8	-18.2	-28.2	-33.1	78.3	8.9	173.5	853.8
	Mean	-5.5	-12.1	-28.2	-59.8	76.4	29.8	211.7	1088.4
	SD	4.3	6.7	10.7	16.9	21.1	13.5	26.3	165.8
PSO-TVAC	Max	-5.9	-6.2	-6.5	-96.2	80.1	30.5	225.5	1229.6
	Min	-0.8	-12.1	-13.9	-52.3	81.6	3.3	163.8	829.5
	Mean	-4.4	-10.3	-22.0	-58.5	69.4	24.7	189.3	970.7

	SD	2.9	5.0	10.0	15.1	9.8	16.1	16.5	94.5
SPGSA	Max	-8.54	-21.21	-13.24	-41.35	87.87	6.54	178.761	878.2295
	Min	-7.04	-19.26	-12.65	-40.73	80.86	7.58	168.143	821.8283
	Mean	-4.65	-20.21	-17.21	-42.33	81.42	6.65	172.483	856.8244
	SD	1.12	4.36	8.26	14.24	8.72	15.25	15.42	75.363

V. Conclusions

The operational aspects of power systems pose some of the most challenging problems encountered in the restructuring of the electric power industry. In this research Strength Pareto Gravitational Search Algorithm is used in optimization problem of congestion management in electricity market regarding to distribution network constraints to reduce cost and increase efficiency and security of power system distribution network. Purposed algorithm had an appropriate convergence rate compared with other techniques. The proposed technique convergence rate is really less than in comparison other methods in solving complex mathematical problems. The approach is validated through numerical results and demonstrates that it has better ability in finding optimal answers and possibility of particle placed in local zone.

Appendix

g: Participating generator

N_g: Number of participating generators

IC_g: Incremental and decremented cost of generator g

ΔP_g Active power adjustment at bus g.

ΔP_g^{min}: Minimum adjustment limit of generator g.

ΔP_g^{max}: Maximum adjustment limit of generator g.

P_g: Active power output.

P_g^{min}: Minimum generation limit of generator g.

P_g^{min}: Maximum generation limit of generator g.

F_l^0: Power flow caused by all contracts requesting the transmission service.

F_l^{max}: Power flow limit of line l.

n_l: Number of transmission lines in the system.

ΔP_{ij}: Changed in active power flow on the line connected between buses i and j.

ΔPG$_g$: Changed in active power of generator *g*.

n: Number of all the buses in the system.

V_i, V_j: Voltage magnitude at buses *i* and *j*.

ϑ_i, ϑ_j: Phase angle at buses *i* and *j*.

G_{ij}: Conductance of the line connected between buses *i* and *j*.

B_{ij}: Susceptance of the line connected between buses *i* and *j*.

K: Current iteration number

References

[1] O. Abedinia, N. Amjady, H.A. Shayanfar, A. Ghasemi, Optimal Congest Management Based VEPSO on Electricity Market, “Technical and Physical Problems of Engineering” (IJTPE), Issue. 11, Vol. 4, No. 2, pp: 56-62, Jun 2012.

[2] O. Abedinia, N. Amjady, Mohammad S. Naderi, Optimal congestion management in an electricity market using Modified Invasive Weed Optimization, Environment and Electrical Engineering (EEEIC), 2012 11th, pp: 467 – 472, 2012 ,

[3] D. Grgič and F. Gubina, "Congestion management approach after deregulation of the slovenian power system", IEEE Transactions on Power Systems, 0-7803-7519-X/02, pp. 1661-1665, 2002.

[4] A. Kumar, S.C. Srivastava, S. N. Singh, "Congestion management in competitive power market: a bibliographical survey", Electric Power Systems Research, vol. 76, pp. 153-164, 2005.

[5] F. Capitanescu, T. V. Cutsem, "A unified management of congestions due to voltage instability and thermal overloads", Electric Power Systems Research, vol. 77, pp. 1274-1283, 2007.

[6] T. Meena, K. Selvi, "Cluster based congestion management in deregulated electricity market using PSO", Proceeding of IEEE Indicon Conference, December Vol.11, No.13, pp. 627-630, 2005.

[7] J. Fu, J. W. Lamont, "A combined framework for service identification and congestion management", IEEE Transactions on Power Systems. vol.16, pp. 56-61, 2001.

[8] G. Yesuratnam, D. Thukaram, "Congestion management in open access based on relative electrical distances using voltage stability criteria", Electric Power Systems Research, vol.77, pp. 1608-1618, 2007.

[9] P. Boonyaritdachochai, "Optimal congestion management in an electricity market using particle swarm optimization with time-varying acceleration coefficients", Computers and Mathematics with Applications, 201008.

[10] C. N. Yu, M. Ilic, "Congestion clusters-based markets for transmission management", Proceeding of IEEE PES Winter Meeting, vol. 2, pp. 821-832, 1999.

[11] A. R. Mehrabian and C. Lucas, "A novel numerical optimization algorithm inspired from invasive weed colonization," Ecological Informatics, vol. 1, pp. 355-366, 2006.

[12] H. Sepehri-Rad and C. Lucas, "A recommender system based on invasive weed optimization algorithm," in Proc. IEEE Congress on Evolutionary Computation, 2007, pp. 4297–4304.

[13] A. R. Mehrabian and A. Yousefi-Koma, "Optimal positioning of piezoelectric actuators of smart fin using bio-inspired algorithms,"Aerospace Science and Technology, vol. 11, pp. 174–182, 2007.

[14] B. Panida, B. Chanwit, O. Weerakorn, "Optimal congestion management in an electricity market using particle swarm optimization with time-varying acceleration coefficients", Computers and Mathematics with Applications, Vol. 3, pp. 1-10, 2010.

[15] H.A. Shayanfar, O. Abedinia, Mohammad. S. Naderi, A. Ghasemi, GSA to Tune Fuzzy Controller for Damping Power System Oscillation, In: Proceedings of the international conference on artificial intelligence, Las Vegas, Nevada, pp: 713-719, USA, 2011.

[16] O. Abedinia, A. Ghasemi, R. Bazyar, A. Yousefi, Multi-objective GSA for solve the EED problem based fuzzy method, 17th Electric Power Distribution Conference, Tehran, Iran, pp:1-9, 2012. (In Persian)

[17] HA. Shayanfar, A. Ghasemi, N. Amjady, O. Abedinia, Economic Load Dispatch Using Strength Pareto Gravitational Search Algorithm with Valve Point Effect, In: Proceedings of the international conference on artificial intelligence, Las Vegas, Nevada, USA, pp: 545-551, 2012.

[18] O. Abedinia, A. Ghasemi, Wind power effect over unit commitment generating via gravitational search algorithm, The 27th International Power System Conference (PSC2012), Under publish.

[19] R. Bazyar, A. Ghasemi, O. Abedinia, A. Yousefi, The economic distribution of power and CHPED heat using improved SPGSA, International Power System Conference (PSC), Tehran, Iran, pp:1-9, 2011. (In Persian).