International Journal of Electronics Communication and Computer Engineering
Volume 3, Issue 3, ISSN 2249 –071X

A Comparative Study of GA, PSO and Big Bang-Big Crunch Optimization Techniques for Optimal Placement of SVC's

Dr. H.K. Verma
Department of Electrical Engineering
S.G.S.I.T.S., Indore, INDIA
vermaharishgs@gmail.com

Cheshta Jain
Department of Electrical Engineering
S.G.S.I.T.S., Indore, INDIA
cheshta_jain194@yahoo.co.in

Arun Rathore
Department of Electrical Engineering
S.G.S.I.T.S., Indore, INDIA
arun.rathore4@gmail.com

Priyanka Gupta
Department of Electrical Engineering
S.G.S.I.T.S., Indore, INDIA
priyanka.mits.02@gmail.com

***Abstract* — In a power system, at heavily loaded conditions, there is always a probability of line outage and consequent voltage instability issues. So that the problem of enhancing the voltage profile and decreasing power losses in electrical systems is a task that must be solved in an optimal way. This optimality can be easily achieved by efficient usage of existing facilities along with installing FACTS devices. This paper presents a comparative study of various optimization techniques such as Genetic Algorithm, Particle Swarm Optimization (PSO) and Big Bang-Big Crunch algorithm for optimal placement of Static VAr Compensator (SVC) to improve voltage stability and to considering cost function. The effectiveness of the proposed algorithms have been tested in IEEE-14 Bus test system and it has also been observed that the proposed algorithm can be applied to larger systems and do not suffer with computational difficulties.**

***Keywords* — Big Bang - Big Crunch (BB-BC), Genetic Algorithm(GA), Particle Swarm Optimization(PSO), SVC Placement.**

I. Introduction

The automation of modern industry has increased the expectation level of reliability and therefore to cater the needs, power grid is becoming more and more meshed in a direction of fulfilling the growing demand of power with acceptable quality and costs. This restructuring of power system has uncertainties in system operation resulting in various dynamic issues like uneven line loading, lack of power flow control, voltage stability, and increase in short circuit current etc. In the networked system, the occurrence of contingency can result the sudden increase/decrease in the power flow. This in turn can result in overloading of the line. And the loss of one of the power sources could increase the load demand of any one part of the transmission network, causing voltage depression, leading ultimately to voltage collapse. The problem of the voltage stability and voltage collapse can be effectively solved by introducing the power electronics based power flow controller. To realize a smart and fault tolerant grid Flexible AC transmission system (FACTs) was proposed, which included lumped devices like STATCOM, SSSC and UPFC to improve line capacity, transient stability and angle stability. In order to optimize and obtain the best possible benefits from the use of FACTS devices, it is necessary to consider the following three main issues:

- The types of FACT controllers that should be used.
- The settings of the FACTS controllers.
- The best location of the FACTS controllers in the transmission system [12].

For finding optimal location of different types of FACTS devices in the power system has been reported using different techniques such as simulated annealing (SA) [4], evolutionary programming (EP) [5], genetic algorithms (GA) [6], [7], tabu search (TS) algorithm [8], [9] and particle swarm optimization (PSO) [10],which are probabilistic experimental algorithms. Particle swarm optimization (PSO) is motivated from the simulation of social behaviour. The PSO algorithm was first introduced by Eberhart and Kennedy [16]. Instead of using evolutionary operators to manipulate the individuals, like in other evolutionary computational algorithms, each individual in PSO flies in the search space with a velocity which is dynamically adjusted according to its own flying experience and its mates' flying experience. On the other hand, GA is positively applied to carry out simple and complex problems efficiently and effectively by using evolutionary programming, and evolution strategies. Genetic algorithms were formally introduced in the United States in the 1970s by John Holland at University of Michigan. This lead to Holland's book "Adaption in Natural and Artificial Systems" published in 1975. Genetic algorithm is less sensitive to getting trapped at local optima than gradient search methods. As seen in the nature, most of the population based search approaches are inspired by evolution. They all function in one and the same way that is, the position of the individual can be updated according to the fitness information obtained from the environment by applying some kinds of operators, so that the individuals of the population can be expected to move towards better solution areas. A new technology has been proposed which is similar to GA in respect to creating an initial population randomly, known as Big Bang-Big Crunch (BB-BC) theory. It is introduced by Erol and Eksin which has a low computational time and high convergence speed. According to this theory, in the Big Bang phase energy dissipation produces disorder and randomness is the main feature of this phase; whereas, in the Big Crunch phase, randomly distributed particles are drawn into an order.

In this paper a comparative study of various optimization techniques such as Particle Swarm Optimization (PSO), Genetic Algorithm and Big Bang-Big

International Journal of Electronics Communication and Computer Engineering
Volume 3, Issue 3, ISSN 2249 –071X

Crunch algorithm is done for optimal placement of Static VAr Compensator (SVC) to improve voltage stability and to considering cost function.

II. Problem Formulation

A. SVC Model

An SVC is a shunt-connected static generator and/ or absorber of reactive power in which the output is varied to maintain or control specific parameters of an electrical power system. Basically an SVC consists of a combination of a fixed capacitors or reactors, Thyristor switched capacitors and Thyristor controlled reactors connected in parallel with the electrical system. However, from steady state point of view, this can be represented by an equivalent FC-TCR circuit .In this study, SVC is modelled as a variable susceptance. The steady state model of the SVC is shown in fig. 1.

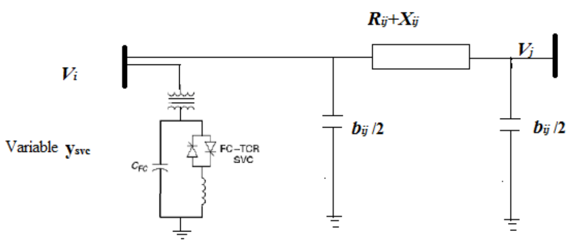

Fig.1 Equivalent circuit of an SVC connected to a bus terminal [10]

B. Objective Function

Mainly objective function consists two objectives out of which one is technical and one economical aspect.

- Minimize the voltage deviations:

The bus voltages must be maintained around the nominal value. Practically, the accepted deviations can reach up to 10% of the nominal values.

$V_{i(min)} \leq V_i \leq V_{i(max)}$ (1)

- Minimize the installation costs:

The installation cost of the SVC device can be calculated by following cost function.

$C_{svc} = 0.0003S^2 - 0.3051S + 127.3$ (2)

C_{SVC}= the cost of SVC devices in [US$/KVar]

S= Operating range of SVC in [MVar]

The unit for generation cost is *US$/Hour* and for the investment costs of SVC devices are *US$*. They must be unified into *US$/Hour*.

Therefore the average value of the investment costs is calculated using the following equation.

$IC = Csvc/(8760 * 5)\ \$/hr$ (3)

Where *IC* is the total investment costs of SVC devices.

C. SVC reference value

The size of an SVC is expressed as an amount of reactive power connected to a bus of voltage of 1 p.u.. The relationship between injected Var or absorbed Var and bus voltage may be described as follow [12].

$Q_{svc} = -V_K^2 \times B_{svc}$ (4)

$B_{SVC\,(min)} \leq B_{SVC} \leq B_{SVC\,(max)}$ (5)

D. Fitness function

The goal of this paper to find the optimal location and size that minimizes the voltage deviations, and installation costs. The constraints of this particular problem do not openly contain the variables and therefore the effect of the constraints must be included in the value of the fitness function [14]. The fitness function of this problem according to the above mentioned conditions is as follow.

$F(x) = W_1 \times V_i + W_2 \times IC$ (6)

In which

W_1 & W_2 = Weight factor such that $W_1+W_2=1$

IC= Installation cost of SVC devices that can be find out by equation (2) & (3).

V_i= voltage contribution at bus *i*

III. Solution Using Genetic Algorithm

Genetic algorithms are stochastic global search technique based on the mechanism of natural selection and genetics [18].Genetic algorithms were formally introduced in the United States in the 1970s by John Holland at University of Michigan. This lead to Holland's book "Adaption in Natural and Artificial Systems" published in 1975.Algorithm is initiated with a set of solutions (represented by chromosomes) called population. A new population is formed using the solutions of the previous population. The new population so obtained is considered to be better than the old one. Selection of solutions to form new solutions (offspring) is done according to their fitness - the more suitable they are the more chances they have to reproduce. This is repeated until, for example, number of populations or improvement of the best solution is satisfied. In particular, genetic algorithms works extremely well on mixed (continuous and discrete), combinatorial problems. They are less sensitive to getting trapped at local optima than gradient search methods. Working of GAs is completed by performing the three tasks coding, fitness function and GA operators. GAs is suitable for solving maximization problems. Minimization problems are transformed into maximization problem by suitable transformation. For maximization problems, the fitness function can be considered to be the same as the objective function or F (i) = O (i). in case of minimization problems, the fitness function is an equivalent maximization problem chosen such that the optimum point remains unchanged .The following fitness function is often used:

$F(X) = \frac{1}{1+f(x)}$ (7)

There are mainly three operators in genetic algorithm which are following[24].

1) Reproduction: Reproduction selects good strings in a population and forms a mating pool. The commonly-used reproduction operator is the proportionate reproduction operator where a string is selected for the mating pool with a probability proportional to its fitness. Therefore the probability for selecting the i[th] string is given by:

$Pi = \frac{Fi}{\sum_{i=1}^{n} Fi}$ (8)

Where n is the population size.

2) *Crossover operation:* In the crossover operation, new strings are generated by exchanging information among strings of the mating pool. There are two types of crossover operation, one point and two point crossover operation. In case of one point crossover a single crossover point on both parents' organism strings is selected. All data beyond that point in either organism string is swapped between the two parent organisms. The resulting organisms are the children and in case of two point crossover two points to be selected on the parent organism strings. Everything between the two points is swapped between the parent organisms.

3) *Mutation*: A crossover operator is mainly responsible for the search of new strings, even though a mutation operator is also used for this purpose sparingly. The mutation operator changes 1 to 0 and vice versa with a small mutation probability, Pm .The need for the mutation is to achieving a local search around the current solution. The mutation is also used to maintain diversity in the population.

For optimal placement and sizing of SVC using GA an algorithm is given below.

1. Run the load flow and determine voltage for all the buses.
2. Identify the weak buses for placement of SVC using voltage nominal value ($V_{imin} \le V_i \le V_{imax}$)
3. Generate randomly 'n' number of particles, where each particles represents as particle[i] =[bsvc1,bsvc2………..bsvcj] where j represents number of weak buses.
4. Set GEN = 1
5. Run the load flows by placing a particle 'i' at the weak bus for reactive power compensation and store the voltage.
6. For each population, evaluate the cost function and the fitness value by using eq. (3) & (6)
7. Select the solutions in pool from initial population
8. Perform Crossover on the solutions selected randomly from the pool
9. Perform Mutation on the offspring generated by the crossover operation
10. Combine the solutions of the pool and the offsprings and refer them as new population.
11. Replace new population with initial population for next generation
12. if Gen ≤ MAXGEN, Go to step 5
13. Stop

IV. Solution Using Particle Swarm Optimization

PSO is an evolutionary computation technique developed by Eberhart and Kennedy in 1995, and was inspired by the social behavior of bird flocking and fish schooling [16]. PSO has its roots in artificial life and social psychology as well as in engineering and computer science. It uses a population of individuals, called particles, which fly through the problem hyperspace with some given initial velocities [2]. In each iteration, the velocities of the particles are adjusted considering the previous best position of the particles and their neighbourhood best position. And these positions are determined by some predefined fitness function. After that the movement of each particle naturally reaches to an optimal or near-optimal solution. It requires only primitive mathematical operators, and is computationally inexpensive in terms of both memory requirements and speed [2].

There is a problem space in which each particle keeps track of its coordinates and they are associated with the best solution (fitness). This value is called Pbest. When a particle takes all the population as its topological neighbours, the best value is a global best and is called Gbest [2]. After finding the two best values; the particle updates its velocity and positions with following equation (9) and (10).

$$V_{ij}^{K+1} = w * V_{ij}^{K} + C1 * rand(\ ) * [pbest_{ij}^{K} - X_{ij}^{K}] + C2 * rand() * [gbest_{ij}^{K} - X_{ij}^{K}] \quad (9)$$

$$X_{ij}^{K+1} = X_{ij}^{K} + V_{ij}^{K+1} \quad (10)$$

Where,

V_{ij}^{k+1} - Velocity of i[th] individual at (k + 1) [th] iteration;

V_{ij}^{k} - Velocity of i[th] individual at k[th] iteration;

w - Inertial weight;

c1, c2 - Positive constants called acceleration constants;

rand () - Generates random numbers distributed within the interval [0, 1].

p_{best}^{ij} - Best position of the i[th] individual;

g_{best}^{ij} - Best position among the individuals (group best);

X_{ij} - Position of ith individual at kth iteration;

k - Position of i[th] individual at k[th] iteration;

i - Particles index;

j - Particles dimension;

Inertia weight

The inertia weight is linearly decreased. The purpose is to improve the speed of convergence of the results by reducing the inertia weight from an initial value of 0.9 to 0.1 in even steps over the maximum number of iterations as shown in [15].

$$W_i = 0.9 - 0.8\left(\frac{iter - 1}{maxiter - 1}\right) \quad (11)$$

Where,

W_i = The inertia weight at iteration *i*.

iter= the iteration number.

maxiter= The maximum number of iterations.

An algorithm for optimal SVC placement and sizing using PSO is given below.

1. Set the loading
2. Run the load flow and determine voltage for all the buses.
3. Identify the weak buses for placement of SVC using voltage nominal value ($V_{imin} \le V_i \le V_{imax}$)
4. Generate randomly 'n' number of particles, where each particles represents as particle [i] = [bsvc1, bsvc2………..bsvcj], where j represents number of weak buses.
5. Generate the particle velocity V[i] =0.4*rand*Vmax

6. Run the load flows by placing a particle ‘i’ at the weak bus for reactive power compensation and store the voltage.
7. Evaluate the fitness function.
8. Determine *pbest* value and then identify *gbest* value.
9. Update the velocities and position of particle by using equations (9) & (10).
10. If maximum iteration number is reached ,then go to next step else go to step6.
11. Stop

V. Solution Using Big Bang-Big Crunch Algorithm

The BB-BC algorithm is an optimization algorithm developed by Erol and Eksin in 2006.They viewed Randomness to be equivalent to Energy Dissipation in nature, while Convergence to a local or global optimum point as Gravitational Attraction. Since energy dissipation creates disorder from ordered particles, randomness was used as a transformation from a converged solution (order) to the birth of totally new solution candidates (disorder or chaos)].

Based on this perspective Erol and Eksin divided the algorithm into two phases namely: Big Bang phase and the Big Crunch Phase. In respect to creating random initial population the proposed method is similar to the Genetic Algorithm. In the Big Bang phase, the candidate solutions are randomly distributed all over the search space in a uniform manner. This is followed by Big Crunch Phase which converges these points to a single representative point via a centre of mass, wherein the term mass refers to the inverse of the merit function value. The point representing the centre of mass that is denoted by ‘X_C’ is calculated according to:

$$Xc = \frac{\sum_{i=1}^{N}\left(\frac{1}{fi}\right)xi}{\sum_{i=1}^{N}\left(\frac{1}{fi}\right)} \qquad (12)$$

Where

x_i: A point within an n-dimensional search space generated.

f_i: A fitness function value of this point.

N: The population size in Big Bang phase.

After a number of sequential Big Bangs and Big Crunches the algorithm converges to a solution by using centre of mass knowledge from the previous Big Bang phase. This can be achieved by using a normal distribution operation in every direction in which new offspring’s are spread around the centre of mass. The positions of new candidate solutions at the beginning of each Big Bang are normally distributed around a new point located between the center of mass and the best solution [25],

$$X^{new}\beta.X_C + (1-\beta).X_{BEST} + \frac{r\propto(X_{max} - X_{\min})}{k} \qquad (13)$$

where β is the parameter controlling the influence of the global best solution X_{BEST} on the location of new candidate solutions, here value of $\propto$ and β lie between 0 and 1.

r: A normal random number

k:The iteration step.

A step by step algorithm for optimal placement and sizing of SVC using Big Bang-Big Crunch Theory is given below.

1. Run the load flow and determine voltage for all the buses.
2. Identify the weak buses for placement of SVC using voltage nominal value ($V_{imin} \leq V_i \leq V_{imax}$).
3. Form an initial generation of N candidates in a random manner. Respect the limits of the search space. Where each candidates represents as candidate[i] = [bsvc1, bsvc2……….bsvcj] where j represents number of weak buses.
4. Set GEN = 1
5. Run the load flows by placing a particle ‘i’ at the weak bus for reactive power compensation and store the voltage.
6. Calculate the fitness function values of all the candidate solutions.
7. Find the centre of mass according to (12). Best fitness individual can be chosen as the centre of mass.
8. Calculate new candidates around the centre of mass by adding or subtracting a normal random number whose value decreases as the iterations elapse of using equation (13).
9. Return to Step 2 until stopping criteria has been met.

VI. Comparative Study

The merits and the limitations of above discussed methods are tabulated in the following manner.

	Particle Swam Optimization	**Genetic Algorithm**	**Big Bang-Big Crunch**
Merits	1) It is easy in its concept and coding implementation compared to other heuristic optimization techniques. 2) It is less sensitive to the nature of the objective function compared to the conventional mathematical approaches. 3) It seems to be somewhat less dependent of a set of initial points compared to other evolutionary methods. 4)PSO techniques can generate high-quality solutions within shorter calculation time and stable	1) It can solve every optimization problem which can be described with the chromosome encoding. 2) It solves problem with multiple solution. 3)Easy to discover global optimum. 4) Since the genetic algorithm execution technique is not dependent on the error surface. We can solve multidimensional,	1) It has a low computational Time and high convergence speed. 2) Most Significantly, a numerically simple algorithm with relatively few control parameters. 3) Less memory is required in case of Big Bang-Big Crunch theory. 4) It can maintain the diversity of the search, in which it may avoid being trapped in local optimum.

International Journal of Electronics Communication and Computer Engineering
Volume 3, Issue 3, ISSN 2249 –071X

	convergence characteristics.	non-differential, and non-continuous problem.	
Limitations	1) It has the problems of dependency on initial coefficients and parameters i.e. difficulty in finding their optimal design Parameters.	1)Genetic algorithm use a coding of the parameters used to calculate the objective function in guiding the search, not the parameters themselves. 2) It searches through many points in the solution space at one time, not a single point. 3) Limited information about solution's components	1) Limited information about solution's components.

Table.1 Comparative study of PSO, GA & BB-BC.

VII. Results

The effectiveness of the proposed algorithms has been illustrated using the IEEE-14 bus test system. Initially, the system was heavily loaded; it has 5 generator buses 9 load buses and 20 branches. Consequently, all the voltages of the load buses as shown in table.1 were low and bus voltages of 3, 10,11,12,13 and 14 even out of the limit, which is below 0.95p.u. By considering minimization of voltage deviation and cost function and applying PSO, GA &BB-BC separately all the bus voltages come within limit. The bus data without SVC & after optimal placement of SVC using PSO, GA & BB-BC algorithm separately is given in table.2, 3, 4 & 5 below.

Bus NO	Volt Mag.	Angle Degree	Load MW	Load MVAR	Injected MVAR
1	1.0600	0	0.000	0.000	0
2	1.0450	-0.053	0.217	0.127	0
3	0.9692	-0.197	0.942	0.190	0
4	0.9287	-0.315	0.112	0.075	0
5	1.0000	-0.249	0.000	0.000	0
6	0.9847	-0.167	0.478	0.039	0
7	1.0000	-0.249	0.000	0.000	0
8	0.9894	-0.142	0.076	0.018	0
9	0.9709	-0.283	0.295	0.166	0
10	0.8945	-0.389	0.090	0.058	0
11	0.8897	-0.394	0.350	0.018	0
12	0.9153	-0.331	0.061	0.016	0
13	0.9148	-0.329	0.135	0.058	0
14	0.9249	-0.324	0.149	0.058	0

Table.2 BusData 14 IEEE buses system without SVC installation

Bus NO	Volt Mag.	Angle Degree	Load MW	Load MVAR	Injected MVAR
1	1.0600	0	0.000	0.000	0
2	1.0450	-0.053	0.217	0.127	0
3	1.0100	-0.197	0.942	0.190	0
4	1.0700	-0.311	0.112	0.075	0
5	1.0900	-0.246	0.000	0.000	0
6	1.0106	-0.171	0.478	0.039	0
7	1.0000	-0.245	0.000	0.000	0
8	1.0273	-0.151	0.076	0.018	43
9	0.9882	-0.276	0.295	0.166	0
10	0.9899	-0.388	0.090	0.058	0
11	1.0056	-0.412	0.350	0.018	0
12	1.0457	-0.323	0.061	0.016	0
13	1.0357	-0.321	0.135	0.058	0
14	0.9833	-0.314	0.149	0.058	0

Table.3 Bus Data 14 IEEE buses system with SVC installation using PSO.

Bus NO	Volt Mag.	Angle Degree	Load MW	Load MVAR	Injected MVAR
1	1.0600	0	0.000	0.000	0
2	1.0450	-0.053	0.217	0.127	0
3	1.0100	-0.270	0.942	0.190	0
4	1.0700	-0.404	0.112	0.075	0
5	1.0900	-0.316	0.000	0.000	0
6	1.0113	-0.228	0.478	0.039	0
7	1.0000	-0.316	0.000	0.000	0
8	1.0285	-0.203	0.076	0.018	46
9	0.9883	-0.353	0.295	0.166	0
10	0.9900	-0.463	0.090	0.058	0
11	1.0056	-0.472	0.350	0.018	0
12	1.0457	-0.419	0.061	0.016	0
13	1.0357	-0.415	0.135	0.058	0
14	0.9834	-0.404	0.149	0.058	0

Table.4: Bus Data 14 IEEE buses system with SVC installation using GA.

Bus NO	Volt Mag.	Angle Degree	Load MW	Load MVAR	Injected MVAR
1	1.0600	0	0.000	0.000	0
2	1.0450	-0.054	0.217	0.127	0
3	1.0100	-0.271	0.942	0.190	0
4	1.0700	-0.404	0.112	0.075	0
5	1.0900	-0.316	0.000	0.000	0
6	0.9759	-0.228	0.478	0.039	0
7	1.0000	-0.316	0.000	0.000	0
8	0.9882	-0.203	0.076	0.018	40
9	0.9670	-0.356	0.295	0.166	0
10	0.9820	-0.463	0.090	0.058	0
11	0.9637	-0.473	0.350	0.018	0
12	1.0324	-0.419	0.061	0.016	0
13	1.0179	-0.415	0.135	0.058	0
14	0.9833	-0.404	0.149	0.058	0

Table.5 Bus Data 14 IEEE buses system with SVC installation using BB-BC.

Fig.2, 3 & 4 show the best fitness values of 50 generation using PSO, GA & 10 generation for BB-BC respectively.

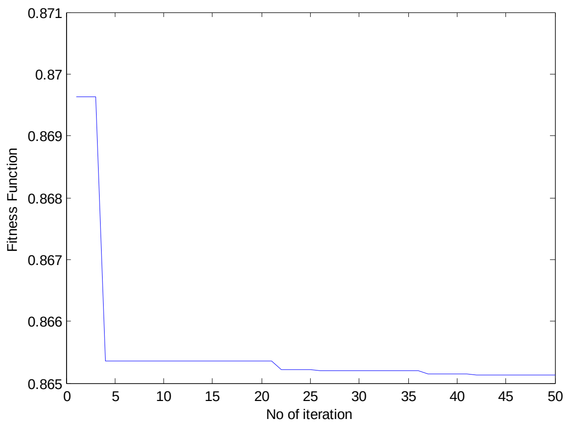

Fig.2 Result for GA

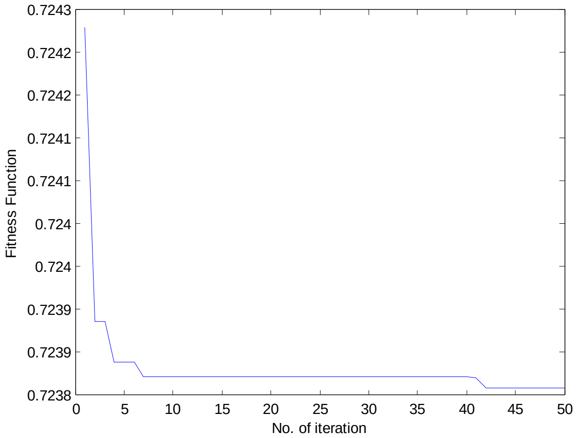

Fig.3 Result for PSO

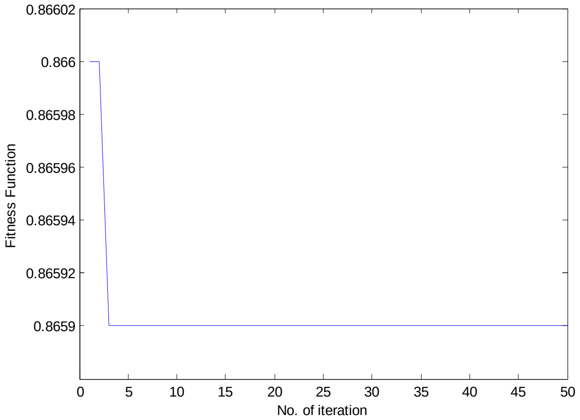

Fig.4 Result for BB-BC

VIII. Conclusion

In this paper a comparative study of PSO, GA & BB-BC has done for finding the optimal location & size of an SVC within IEEE-14 Bus system with the objective function of reducing voltage deviations and installation cost. BB-BC is numerically simple algorithm with relatively few control parameters & it gives better convergence results and also it requires less memory for storage as compare to PSO & GA. BB-BC may avoid being trapped in local optimum by maintaining the diversity of search. It is also proof that PSO techniques can generate high-quality solutions within shorter calculation time and stable convergence characteristics as compare to GA but it has the problems of dependency on initial coefficients and parameters. Genetic Algorithm can solve every optimization problem which is described with the chromosome encoding but it doesn't provide whole information about solution's components & it searches through many points in the solution space at one time, not a single point. So that from the above discussion it is clear that BB-BC algorithm is better than as compare to PSO & GA in several factors and PSO is better than GA. The effectiveness of the proposed work will be tested on IEEE-30 & IEEE-68 Bus system which does not suffer with computational difficulties.

References

[1] A Mohammadi, M Jazaeri, "A Hybrid Particle Swarm Optimization-genetic Algorithm for Optimal Location of SVC Devices in Power System Planning" , *in Proc. of Universities Power Engineering conference* 2007, pp:1175-1181.

[2] S.Sakthivel , M. Mary, R.Vetrivel, V. Senthamarai Kananan, "Optimal Location of SVC for Voltage Stability Enhancement under Contingency Condition through PSO Algorithm", *International Journal of Conference Application* April 2011, vol:20-No.1.

[3] N G. Hingorani, L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, *IEEE Press, New- York*, 2000.

[4] KP. Wang, CC. Fung, "Simulate annealing base economic dispatch algorithm*", IEE Proc C* 1993, 140(6), pp. 507–13.

[5] HT. Yang, PC. Yang, CL. Huang. , " Evolution programming based Economic dispatch for units with non-smooth fuel cost functions*", IEEE Trans Power System* 1996, 11(1), pp. 112–8.

[6] DC. Walters, GB. Sheble, "Genetic algorithm solution of economic Dispatch with valve point loading", *IEEE Trans Power System* 1993, 8, 99, pp. 1325–32.

[7] P-H. Chen, H-C. Chang, "Large-scale economic dispatch by genetic algorithm", *IEEE Trans Power System* 1995, 10, pp. 1919–26.

[8] W. Ongsakul, Dechanupaprittha S, Ngamroo I, "Tabu search algorithm for constrained economic dispatch", *In: Proceedings of the international conference on power system* September 2001, Wuhan, China, pp.428–33.

[9] W. Ongsakul, Dechanupaprittha S, Ngamroo I, "Parallel tabu search Algorithm for constrained economic dispatch", *IEE Proc-Gener Transm Distrib* 2004, 151(2), pp.157–66.

[10] Gaing Zwe-Lee, "Particle swarm optimization to solving the economic Dispatch considering the generator constraints", *IEEE Trans Power Syst* 2003 18 (3), pp. 1187–95.

[11] K. Prakash , M. Sydulu, " Particle Swarm optimization Based Capacitor Placement on Radial Distribution Syatems", *in Proc. of Power Engineering Society General Meeting*2007,pp:1-5.

[12] K. Sundareswaran , B. Hariharan, F.P. parasseri, D.S. Antony, B. Subair " Optimal Placement of Static VAr Compensators(SVC's) using Particle Swarm Optimization", *in Proc. of Power, Control and Embedded Systems International Conference*2010 ,pp:1-4.

[13] "Proposed terms and definitions for flexible AC transmission system(FACTS)", *IEEE Transactions on Power Delivery* , October 1997, Volume 12, Issue 4, Pages 1848-1853.

[14] Betram Koh Lin Hon "Accelerated Genetic Algorithm in Power System Planning" *Electrical Engineering thesis* 2003

[15] MaysamJafari,Saeed Afsharnia,"Voltage Stability Enhancement in Contingency Conditions using Shunt FACTS Devices,"*EUROCON The international conference on "computer as a tool"*Warsaw,9-12 Sept. 2007,IEEE.

[16] J. Kennedy, R. Eberhart, "Particle swarm optimization" *Proceedings of the IEEE International Conference on Neural Networks* 1995, pp. 1942- 1948 .

[17] M.H.Haque, "Determination of Steady state voltage stability limit of a power system in the presence of SVC", *in proceedings of 2001 Power Tech*, 10-13 Sept.2001, Portugal: IEEE

[18] K.F.Man, K.S.Tang and S.Kwong, "Genetic Algorithm concepts and application", *IEEE Trans. On Industrial Electronics* ,Oct 1996, vol 43 no.5, pp.519-534.

[19] M. K. Verma, S. C. Srivastava, "Optimal placement of SVC for static and dynamic voltage security enhancement," *International Journal of Emerging Electric Power Systems* 2005, vol. 2, no. 2, Article 1050.

[20] S.A. Jummat, I.musirin, M.M. Othman, " Transmission loss Minimization using SVC based on Particle Swarm optimization*", in Proc. of Industrial Electronics and Applications (ISIEA)*2011,pp:419-424.

[21] I.Pisica , C. Bulac, L. Toma, M. Eramia " Optimal SVC Placement in Electric Power Systems using a Genetic based method", *in Proc. of PowerTech* 2009,pp:1-6.

[22] H.F.Wang, F.J.Swift, and M.Li, "Selection of installing locations and feedback signals of FACTS-based stabilizers in multimachine power systems by reduced order modal analysis", *IEEE Proceedings - Generation, Transmission and Distribution*, 1997. 144(3): pp 263-9.

[23] A. Kaveha, S. Talataharib, "Size optimization of space trusses using Big Bang–Big Crunch algorithm", *Elsevier, Computers and Structures* 87 (2009), pp. 1129–1140.

[24] kalyanmoy Deb ,*Optimization for Engineering Design, Algorithms and Examples.*

[25] Engin Yesil, Leon Urbas, "Big Bang – Big Crunch Learning Method forFuzzy Cognitive Maps", World Academy of Science, Engineering and Technology 71 (2010),pp.815-824

AUTHOR'S PROFILE

Dr. H. K. Verma

is a professor in the Department of Electrical Engineering, Shri G.S.I.T.S Indore, India. He has more than 20 years of experience in teaching and research. His current area of research includes Power system, control system, Drives, Optimization and Neural Networks. He has published more than fifteen papers in referred international journals. He has also presented more than fifty research articles in national and international conferences. He is a member of ISTE and IE (India).

Ms. Cheshta Jain

received M.E from Shri G.S.I.T.S, Indore India in 2007. She is a Asst. Professor in the Department of Electrical and Electronics, MITM, Indore, India. Presently she is pursing PhD from S.G.S.I.T.S. Indore, India. Her research interests include power system restructuring, power system optimization & control.

Mr. Arun Rathore

S/O Mr. M.L Rathore was bron at Dewas city, M.P., INDIA on 10 April 1988. He is pursuing his M.E degree in Power Electronics from SGSITS College, Indore [M.P.]. He did his B.E in Electrical and Electronics from MIT College, Indore [M.P] in 2009. He did his Diploma in Electrical Engineering from SVP College, Indore [M.P.] in 2006. He has one year teaching experience as a lecturer from 2009-2010.His area of interest include Power system, Power electronics, Electrical Machines.

Ms. Priyanka Gupta

D/O of Mr. Rajendra Gupta was born at Rewa city, M.P., India on 2nd April 1987. She is pursuing her M.E. degree in Power electronics from SGSITS College, Indore [M.P.]. She did her B.E. in Electrical Engineering from MITS College, Gwalior, [M.P] in 2009. She has one year teaching experience as a lecturer from 2009-2010. Her area of interest includes Power system, Power electronics and Drives