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Using HBMO Algorithm to Optimal Sizing & Sitting of Distributed Generation in Power System

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Abstract

This paper analyzes of HBMO placement method efficiency in comparison with PSO and GA in order to sizing and sitting of distributed generation in distribution power system. These algorithms for optimization in this paper is tested on IEEE 33 bus reconfigured test system. The proposed objective function considers active power losses and the voltage profile in nominal load of system. In order to use of optimization algorithms, at first, placement problem is written as an optimization problem which includes the objective function and constraints, and then to achieve the most desirable results, Optimization methods is applied to solve the problem. High performance of the proposed algorithm in mention system is verified by simulations in MATLAB software and in order to illustrate of feasibility of proposed method will accomplish.

Keywords: Distributed Generation- DG Placement- Optimization Methods- Multiobjective function- Optimization

1. Introduction

Worldwide demand for energy is rapidly growing, threatening price stability and causing concerns over the security of supply. Moreover, there are serious worries about global warming and climate changes due to the increase of greenhouse effect caused by combustion of fossil fuels. Thus, it looks clear that a strong deployment of renewable energy and distributed generations is needed [1].

Growing of Distributed Generation can be has influence in voltage profile, stability, power loses at power system both in distribution and transmission side. In order to improvement of power system situation such as correction of voltage profile, addition of stability, decrease of loses power and etc, it is necessary that the installation of DGs in power system become systematically **Error! Reference source not found.**.

In some papers, the optimum location and size of a single DG unit is determined [3][4] In Refs. [5–7], the authors determined the optimum location of the DG in the distribution network. The work was directed towards studying several factors related to the network and the DG itself such as the overall system efficiency, the system reliability, the voltage profile, the load variation, network losses, and the DG loss adjustment factors. A TS search method to find the optimal solution of their problem was explained in [8], but the TS is known to be time consuming algorithm also it is may be trapped in a local minimum.

In order to minimization of real power losses of power system in ref [9], a PSO algorithm was developed to specify the optimum size and location of a single DG unit. The problem was converted to an optimization program and the real power loss of the system was the only aspect considered in this study in order to determine of optimally location and size of only one DG unit.
P-V curves in ref [10] have been used for analyzing voltage stability in electric power system to determine the optimum size and location of multiple DG units to minimize the system losses under limits of the voltage at each node of the system.

A new multiobjective index (IMO)-based analytical approach to determine the optimal size and power factor of DG unit for reducing power losses and enhancing loadability is presented in [11]. This index is defined as a combination of active and reactive power loss indices by optimally assigning a weight to each index such that the IMO can reach a minimum level. a multi-objective approach is used to minimization of power losses and maximization of

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voltage stability due to finding weakest voltage bus as well as due to weakest link in the system are considered in [12].Particle Swarm Optimization (PSO) algorithm is applied to solve the multi-objective problem. The effect of bilateral contract between Disco and upstream network and between Disco-Customers in supplying demand power of customers based on hybrid power market rules is investigated in [13]. The costs include capital cost, replacement cost, operation and maintenance cost, fuel cost, production cost, and reliability improvement cost.

In this paper, HBMO optimization techniques in comparison with PSO and GA which is capable of finding global or near global optimum solution is used for optimal size and site of distributed generation in 33-bus of IEEE test system with tie line that present in [14][10]. Objective functions are gathered to form a multi objective optimization problem. The objective function is formed by combining on real power losses and voltage profile of the mention system.

2. Problem Formulation

For obtaining the maximum benefit from the placement of DG, it is necessary to consider the impact of DG on a power system. The factors including line losses reduction and voltage profile improvement are considered in the placement and sizing of DG.

2.1 Objective Functions Formulation

The objective function combined from two components. One part is Real Power Loss (RPL) that is 70 percent of mention objective function and Voltage Profile Improvement (VPI) with 30 percent weight of objective function.

1. Real Power Loss formulation (RPL):

Buses voltage, line currents and real power loss in system lines calculates from the output results of power-flow in this paper. For a simple two bus network, the losses that occurs in the line is given by,

$$P_e + jQ_e = (r + jx)|I|^2 \tag{1}$$

where P_e is the active power loss; Q_e the reactive power loss; and I is the line current, given by:

$$I = \frac{V_s\angle\delta_s - V_r\angle\delta_r}{r + jx} \tag{2}$$

Where,

$$V_s\angle\delta_s = V_s\cos\delta_s + jV_s\sin\delta_s \tag{3}$$

$$V_r\angle\delta_r = V_r\cos\delta_r + jV_r\sin\delta_r \tag{4}$$

From (3), (4) and (2) results in,

$$[V_s\angle\delta_s - V_r\angle\delta_r]^2 = (P_e + jQ_e)(r + jx) \tag{5}$$

From Eq. (2) ,(3) and (4), we can conclude that the line resistance and reactance play a very crucial role for voltage stability and the line losses (or current) should be reduced for stable and improved voltages, which is only possible by providing active and reactive power support to the system. Economically it is not possible to provide support on each bus. Therefore the most suitable site and size of DG should be selected from where the maximum benefits could be achieved. Total loss power in power system is defined by:

$$P_{Loss}^{Total} = \sum_{i=1}^{N} r_i |I_i|^2 \tag{6}$$

Where, N is the number of lines in power system and RPL is given by:

$$RPL = \frac{P_{Loss}^{Total}}{P_{Loss}^{no\min al}} \tag{7}$$

Where, $P_{Loss}^{no\min al}$ is the real power loss in nominal condition of study system.

2. Voltage Profile Improvement (VPI):

One of the avails of optimizes location and size of the DG is the improvement in voltage profile. This index penalizes the size-location pair which gives higher voltage deviations from the nominal value (Vnom). In this way, closer the index to zero better is the network performance. The VPI can be defined as.

$$VPI = \frac{1}{\Delta V_{nom}} \max_{i=2}^{n} \left(\frac{|V_{nom}| - |V_i|}{|V_{nom}|} \right) \tag{8}$$

The Multi Objective Function (MOF) in this paper in order to achieve the performance calculation of distribution systems for DG size and location is given by:

$$MOF = \sigma_1 IVD + \sigma_2 ILP \tag{9}$$

Where σ_1 and σ_2 consider in this paper 0.7 and 0.3 respectively.

2.2 Constrains Formulation

The multi objective function (11) is minimized subjected to various operational constraints to satisfy the electrical requirements for distribution network. These constraints are the following.

1) Power-Conservation Limits.

The algebraic sum of all incoming and outgoing power including line losses over the whole distribution network and power generated from DG unit should be equal to zero.

$$P_{Gen} + P_{DG} - \sum_{i=1}^{n} P_D - P_{total}^{Loss} = 0 \tag{10}$$

2) Distribution Line Capacity Limits.

Power flow through any distribution line must not exceed the thermal capacity of the line.

$$S_{ij} < S_{ij}^{\max} \tag{11}$$

3) Voltage Limits.

The voltage limits depend on the voltage regulation limits should be satisfied.

$$V_i^{\min} \le V_i \le V_i^{\max} \tag{12}$$

This paper employs Particle Swarm Optimization technique to solve the above optimization problem and search for optimal or near optimal set of problem. Typical ranges of the optimized parameters are [0.01 100] MW for PDG and [0.95-1.05] for voltage of buses.

3. Honey Bee Mating Optimization

The honey bee is a social insect that can survive only as a member of a community, or colony. The colony inhabits an enclosed cavity. A colony of honey bees consist of a queen, several hundred drones, 30,000 to 80,000 workers and broods during the active season. A colony of bees is a large family of bees living in one bee-hive. The queen is the most important member of the hive because she is the one that keeps the hive going by producing new queen and worker bees [16]. Drones' role is to mate with the queen. Tasks of worker bees are several such as: rearing brood, tending the queen and drones, cleaning, regulating temperature, gather nectar, pollen, water, etc. Broods arise either from fertilized (represents queen or worker) or unfertilized (represents drones) eggs. The HBMO Algorithm is the combination of several different methods corresponded to a different phase of the mating process of the queen. In the marriage process, the queen(s) mate during their mating flights far from the nest. A mating flight starts with a dance performed by the queen who then starts a mating flight during which the drones follow the queen and mate with her in the air. In each mating, sperm reaches the spermatheca and accumulates there to form the genetic pool of the colony. The queen's size of spermatheca number equals to the maximum number of mating of the queen in a single mating flight is determined. When the queen mates successfully, the genotype of the drone is stored. At the start of the flight, the queen is initialized with some energy content and returns to her nest when her energy is within some threshold from zero or when her spermatheca is full. In developing the algorithm, the functionality of workers is restricted to brood care, and therefore, each worker may be represented as a heuristic which acts to improve and/or take care of a set of broods. A drone mates with a queen probabilistically using an annealing function as [17].

$$P_{rob}(Q,D) = e^{-\frac{\Delta(f)}{s(t)}} \quad (13)$$

Where Prob (Q, D) is the probability of adding the sperm of drone D to the spermatheca of queen Q (that is, the probability of a successful mating); Δ (f) is the absolute difference between the fitness of D (i.e., f (D)) and the fitness of Q (i.e., f (Q)); and S (t) is the speed of the queen at time t. It is apparent that this function acts as an annealing function, where the probability of mating is high when both the queen is still in the start of her mating–flight and therefore her speed is high, or when the fitness of the drone is as good as the queen's. After each transition in space, the queen's speed, S(t), and energy, E(t), decay using the following equations.

$$S(t+1) = \alpha \times s(t)(2) \quad (14)$$

$$E(t+1) = E(t) - \gamma \quad (15)$$

Where α is a factor and γ is the amount of energy reduction after each transition. Also, Algorithm and computational flowchart of HBMO method to optimize the PEM controller parameters is presented in Figure 2.

Thus, HBMO algorithm may be constructed with the following five main stages:

a) The algorithm starts with the mating–flight, where a queen (best solution) selects drones probabilistically to form the spermatheca (list of drones). A drone is then selected from the list at random for the creation of broods.
b) Creation of new broods by crossoverring the drones' genotypes with the queen's.
c) Use of workers (heuristics) to conduct local search on broods (trial solutions).
d) Adaptation of workers' fitness based on the amount of improvement achieved on broods.
e) Replacement of weaker queens by fitter broods.

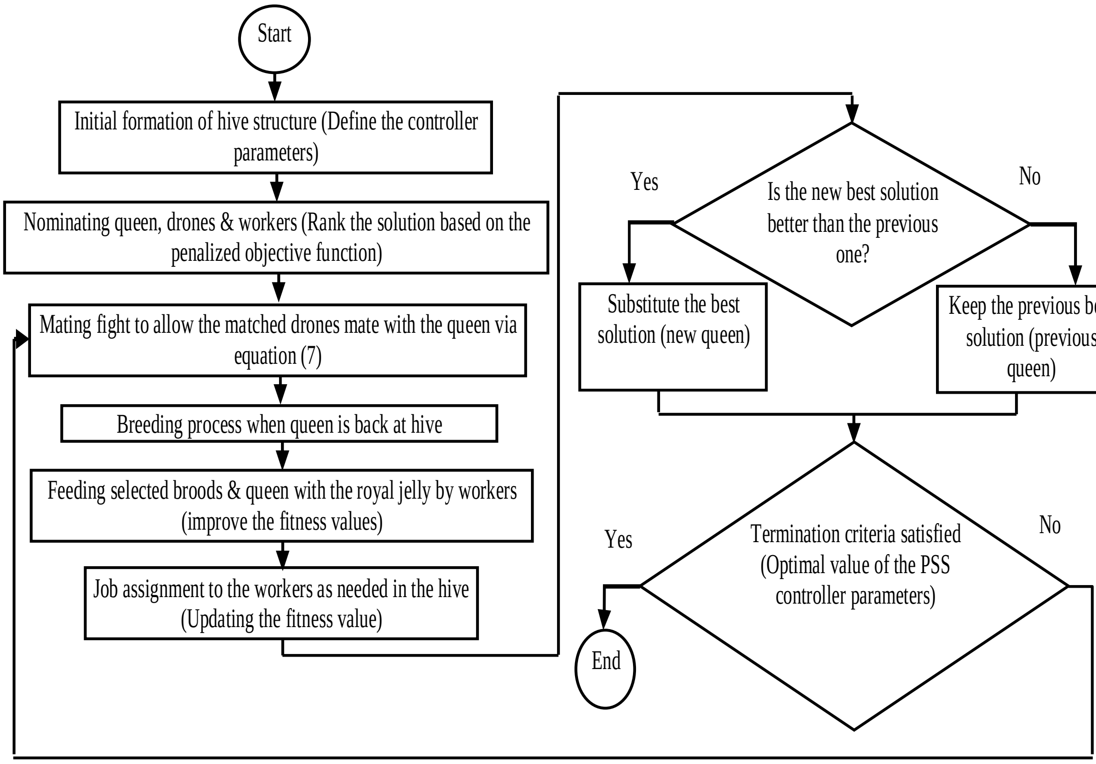

Figure 2. Algorithm and computational flowchart of HBMO

4. Case Study and Placement Results

In the case study presented in this section, we investigate how optimization algorithms affects DG placement, system power loss reduction and voltage profile enhancement. The placement of two DGs and Three DGs are considered using various algorithms. To demonstrate the utility of the placement algorithms, a 33-bus test system with tie lines that present in ref [14] and shown in Figure 1 is considered and the system details are given in Table 1.

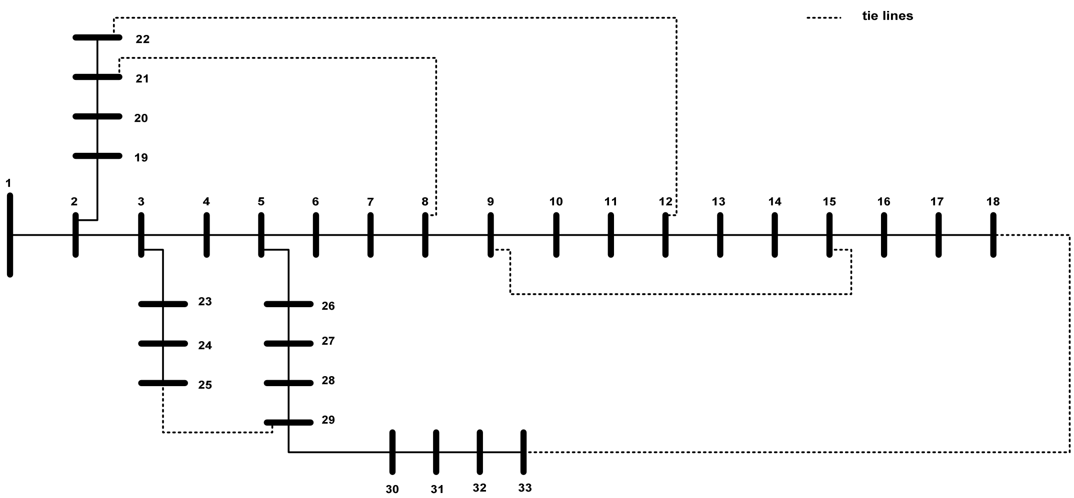

Figure 1. IEEE 33 bus study system with tie lines in ref [14]

Table 1. Lines, active and reactive power details in study system

Branch nom.	Sen Node	Rec. node	P of Rec . node KW	Q of Rec . node KVAr	Resistance ohms	Reactance ohms
1	1	2	100	60	0.0922	0.0470
2	2	3	90	40	0.4930	0.251 1
3	3	4	120	80	0.3660	0.1 864
4	4	5	60	30	0.3811	0.1941
5	5	6	60	20	0.8190	0.7070
6	6	7	200	100	0.1872	0.6188
7	7	8	200	100	1.7114	1.2351
8	8	9	60	20	1.0300	0.7400
9	9	10	60	20	1.0440	0.7400
10	10	11	45	30	0.1966	0.0650
11	11	12	60	35	0.3744	0.1238
12	12	13	60	35	1.4680	1.1550
13	13	14	120	80	0.5416	0.7129
14	14	15	60	10	0.5910	0.5260
15	15	16	60	20	0.7463	0.5450
16	16	17	60	20	1.2890	1.7210
17	17	18	90	40	0.7320	0.5740
18	18	19	90	40	0.1640	0.1565
19	19	20	90	40	1.5042	1.3554
20	20	21	90	40	0.4095	0.4784
21	21	22	90	40	0.7089	0.9373
22	22	23	90	50	0.4512	0.3083
23	23	24	420	200	0.8980	0.7091
24	24	25	420	200	0.8960	0.7011
25	25	26	60	25	0.2030	0.1034
26	26	27	60	25	0.2842	0.1447
27	27	28	60	20	1.0590	0.9337
28	28	29	120	70	0.8042	0.7006
29	29	30	200	600	0.5075	0.2585
30	30	31	150	70	0.9744	0.9630
31	31	32	210	100	0.3105	0.3619
32	32	33	60	40	0.3410	0.5302
33*	21	8			2.0000	2.0000
34*	22	12			2.0000	2.0000
35*	9	15			2.0000	2.0000
36*	25	29			0.5000	0.5000
37*	33	18			0.5000	0.5000

We assume that two DG units that size of them between 25KW-10MW are considered to locate in 33-bus tie line system. Results of this case using various algorithms present in table (2) and Fig (2).

In 33 bus IEEE system without any DG, the network loss is 70.2kW and the minimum voltage in bus 14 is 0.974 pu. As can be seen, that is obvious the two DG placement results in line power losses and voltage profile is better than without DG in study system. After placement the total of system is achieved 34.8, 35 and 36.8 kW using HBMO, PSO and GA algorithm, respectively. Voltage profile for all of mentioned algorithms and without any DG are presented in Fig 2. From of this figure, it can be say that the placement of DGs in system improved the all of bus voltage. In comparison with without DG condition, the voltage of three placement cases is very better.

Table 2. Results of sizing and sitting with various algorithm

Optimization algorithm	DG Size	DG Site	Network Loss
Without DG	------	------	70.2KW
HBMO	1584.1 1627.3	15 25	34.8KW
PSO	1626.6 1606.2	14 25	35KW
Genetic Algorithm	1548.0 1798.1	25 9	36.8KW

In three algorithms, using the HBMO the minimum value of bus voltage is achieved 0.9925 pu. Using the PSO and GA this value is achieved 0.991 pu.

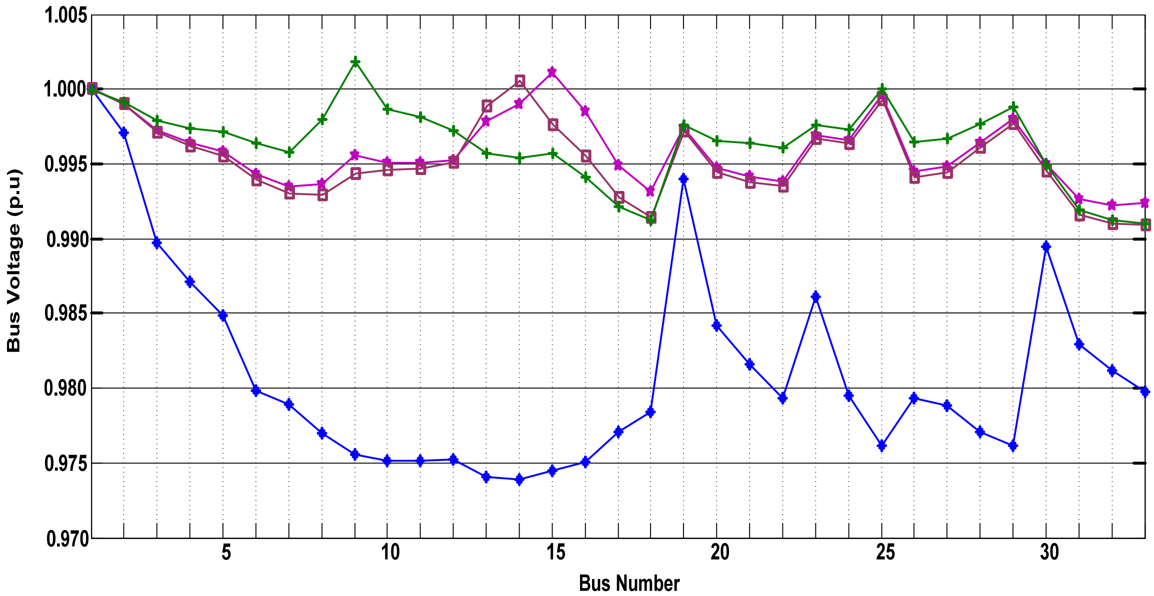

Figure 2. voltage profile of study system with various placement results

5. Conclusion

In this paper, a various approaches based on HBMO, PSO and GA in order to Multiobjective optimization analysis, including two DG units, for size-site planning of distributed generation in distribution system was presented. In solving this problem, at first problem was written in the form of the optimization problem which its objective function was defined and written in time domain and then the problem has been solved using three methods. The proposed optimization algorithm was applied to the 33-bus test system with tie lines. Using the results, the efficiency of these algorithms for improvement of voltage profile and reduction of power losses in study system is analyzed. The results of this methods are shown the effeciency of HBMO algorithm for mentioned test system.

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