MODIFIED BEE SWARMING ALGORITM TO EMISSION CONSTRAINED ECONOMIC DISPATCH PROBLEM

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Abstract - *The generation of electricity from fossil fuel releases several contaminants, such as sulfur oxides, nitrogen oxides and carbon dioxide, into the atmosphere. Recently the problem which has attracted much attention is pollution minimization due to the pressing public demand for clean air. In this paper modified version of a Bee swarming (MBS) has been proposed to solve environmental economic dispatch problem. The feasibility of the proposed MBS algorithm has been tested with six generating unit test system. The simulation results are compared with existing techniques and the results demonstrates that the proposed MBS algorithm attain the competitive results than existing algorithms.*

Key Words: **Emission, carbon dioxide, sulfur dioxide, nitrogen oxide, MBS algorithm.**

1. INTRODUCTION

Since the text of the Clean Air Act Amendments of 1990 several power industries reduces their emissions from fossil fuel fired power plants. The main objective of Economic Load Dispatch (ELD) of electric power generation is to schedule the committed generating units so as to meet the load demand at minimum operating cost while satisfying all unit and system equality and inequality constraints [1]. There is a growing need from the society for adequate and secure supply of electricity not only at the cheapest rate, but also at minimum level of emission [2-4].

Several methods to reduce the atmospheric emissions have been proposed and discussed by many researchers [5-18]. They include switching to fuels with low emission potential, installing post-combustion cleaning system e.g. electrostatic precipitators, replacement of the aged fuel-burners with cleaner ones, and reallocation of loads to generators with low emission coefficients. The first two methods involve considerable amount of capital investment and hence, can be termed as long term options. The third method is an attractive short- term alternative and requires only minor modification of dispatching programs to include emissions. By proper load allocation among the various generating units of the plants, the harmful effects of the emission of particulate and gaseous pollutants from power stations, particularly from thermal power stations, can be reduced. Based on the shallow water theory named water evaporation optimization algorithm [19] have been applied to solve environmental economic dispatch problems.

Recently, inspired by the foraging behavior of honeybees, researchers have developed Modified Bee Swarming (MBS) algorithm [20] for solving various optimization problems. In this paper modified Bee Swarming (MBS) algorithm is proposed to solve emission constrained economic dispatch problem.

2. PROBLEM FORMULATION

The reduction emission from fossil fuel fired power plants is essential for power industries due to clean Air Act Amendments of 1990 and the problem can be formulated as

The total emission of generation E_i can be

$$E_i = \alpha_i P_i^2 + \beta_i P_i + \gamma_i \qquad (2.1)$$

Ei is the function of emissions in (Kg/h) and αi, βi and γi are the co-efficient of emission characteristics specific to each production unit.

3. BEES SWARMING OPTIMIZATION ALGORITHM

The foraging bees are classified into three categories; employed bees, onlookers and scout bees. All bees that are currently exploiting a food source are known as employed. The employed bees exploit the food source and they carry the information about food source back to the hive and share this information with onlooker bees. Onlookers bees are waiting in the hive for the information to be shared by the employed bees about their discovered food sources and scouts bees will always be searching for new food sources near the hive. Employed bees share information about food sources by dancing in the designated dance area inside the hive. The nature of dance is proportional to the nectar content of food source just exploited by the dancing bee. Onlooker bees watch the dance and choose a food source according to the probability proportional to the quality of that food source. Therefore, good food sources attract more onlooker bees compared to bad ones. Whenever a food source is exploited fully, all the employed bees associated with it abandon the food source, and become scout. Scout bees can be visualized as performing the job of exploration, whereas employed and onlooker bees can be visualized as performing the job of exploitation.

In the ABC algorithm, each food source is a possible solution for the problem under consideration and the nectar amount of a food source represents the quality of the solution represented by the fitness value. The number of food sources is same as the number of employed bees and there is exactly one employed bee for every food source. This algorithm starts by associating all employed bees with randomly generated food sources (solution). In each iteration, every employed bee determines a food source in the neighbor- hood of its current food source and evaluates its nectar amount (fitness). The i[th] food source position is represented as X_i where i=1, 2, ..., N is a D-dimensional vector. The nectar amount of the food source located at X_i is calculated by using the Eq. (7). After watching the dancing of employed bees, an onlooker bee goes to the region of food source at X_i by the probability p_i defined in Eq. (8).

$$fit_i = \frac{1}{1+f_i} \quad (7)$$

$$p_i = \frac{fit_i}{\sum_{n=1}^{N} fit_n} \quad (8)$$

The onlooker finds a neighborhood food source in the vicinity of X_i by using the Eq. (9)

$$v_{ij} = x_{ij} + \phi_{ij}(x_{ij} - x_{kj}) \quad (9)$$

Where k∈{1,2,...N} and j∈{1,2,...D} are randomly chosen indexes. Although k is determined randomly, it has to be different from i. ϕ_{ij} is a random number between [-1, 1]. If its new fitness value is better than the best fitness value achieved so far, then the bee moves to this new food source abandoning the old one, otherwise it remains in its old food source. When all employed bees have finished this process, they share the fitness information with the onlookers, each of which selects a food source according to probability given in Eq. (8). With this scheme, good food sources will get more onlookers than the bad ones. Each bee will search for better food source around neighborhood patch for a certain number of cycles (limit), and if the fitness value will not improve then that bee becomes scout bee.

It is clear from the above explanation that there are three control parameters used in the basic ABC: The number of the food sources which is equal to the number of employed or onlooker bees (N), the value of limit and the maximum cycle number (MCN).

Parameter-tuning, in meta-heuristic optimization algorithms influences the performance of the algorithm significantly. Divergence, becoming trapped in local extrema and time-consumption are such consequences of setting the parameters improperly. The ABC, algorithm, as an advantage has few controlled parameters. Since initializing a population "randomly" with a feasible region is sometimes cumbersome, the ABC algorithm does not depend on the initial population to be in a feasible region. Instead, its performance directs the population to the feasible region sufficiently [13].

3.1 MODIFIED BEES SWARMING (MBS) OPTIMIZATION ALGORITHM FOR EED PROBLEM

Though the ABC algorithm described in the preceding Section provides the optimal schedule for GMS problem it does not guarantee the constraint satisfaction. Therefore it should be included with the suitable penalty factor during the fitness evaluation. Hence modifications are carried out at the initialization steps in the main ABC algorithm to efficiently deal the various equality and inequality constraints. The subsequent sections describe in detail the implementation strategies of improved ABC.

Initialization

The following modifications are carried out in the initialization process.

- The elements of an individual are selected at random satisfying the inequality constraints such as maintenance window, maintenance area and crew constraints.
- The generating units to be committed are identified based on their maximum generation capacity and should satisfy the spinning reserve constraint.
- The preceding steps are repeated until the individual satisfies these constraints.

The initial population of N individuals thus created satisfies the equality and inequality constraints. The fitness values of the individuals are computed using Eq. (7).

Limit

The controlled parameter (limit) is important in the ABC algorithm because it prevents the algorithm from trapped in local extrema. The limit is taken as 0.5 * N * D [13-16], however assume that one of the initial solutions was "fortunately" the optimal or near the optimal one, then after a predetermined number of trails this solution, intuitively, will never be improved; consequently the ABC algorithm will abandon this (presumed optimal) solution, if it is discovered, is memorized at least once before releasing it, the proposed limit value is set equal to $1+O_b^2$.

4. BEES SWARMING OPTIMIZATION

The proposed algorithm for solving EED problem is summarized as follows.

Step1: Read the system data.

Step2: Initialize the control parameters of the algorithm.

Step3: An initial population of N solution is generated for each solution X_i (i=1, 2 ... N) is represented by a D-dimensional vector.

Step4: Evaluate the fitness value of each individual in the colony.

Step5: Produce neighbor solutions for the employed bees and evaluate them.

Step6: Apply the selection process.

Step7: If all onlooker bees are distributed, go to step 10 Otherwise, go to the next step.

Step8: Calculate the probability values p_i for the solutions X_i.

Step9: Produce neighbor solutions for the selected onlooker bee, depending on the p_i value and evaluate them.

Step10: Determine the abandoned solution for the scout bees, if it exists and replace it with a completely new randomly generated solution and evaluate them.

Step11: Memorize the best solution attained so far.

Step12: Stop the process if the termination criterion is satisfied. Otherwise go to step3.

5. RESULTS AND DISCUSSION

Software package implementing the new proposed technique is developed using Intel(R) Core(TM)² Duo CPU, 2.10 GHz processor. To illustrate the validity and effectiveness of the proposed technique, the 6 generating units test system given in [19] is studied and solved. The control parameters of SI algorithm are chosen as colony size 200, maximum cycle/generation number (MCN) 50, and limit value 40.

Software package implementing the new proposed technique is developed using Intel(R) Core(TM)² Duo CPU, 2.10 GHz processor. To illustrate the validity and effectiveness of the proposed technique, the 6 generating units test system given in [19] is studied and solved. The control parameters of SI algorithm are chosen as colony size 100, maximum cycle/generation number (MCN) 100, and limit value 30.

In order to show the effectiveness of the proposed MBS algorithm it has been tested on six generating unit system for the load demand of 700 MW, 800 MW, 900 MW, 1000 MW. The system particulars are available in the literature [19]. The simulation results obtained by the proposed as well as existing algorithms are presented in Table 5.1 and 5.2.The results shows that the proposed MBS algorithm achieves the minimized emission of NO_x for all load demands.

Table 5.1 simulation results of proposed MBS algorithm

Power Demand	Techniques	Cost ($/hr)	Emission (Kg/h)
700 MW	FA	38101.09	434.13
	BA	38100.95	434.13
	HYB	38101.13	434.13
	WEO [19]	38100.72	434.12
	ABC	38100.65	434.09
	MBS	**38100**	**434**
800 MW	FA	43719.20	548.70
	BA	43719.15	548.70
	HYB	43719.14	548.70
	WEO [19]	43718.39	548.69
	ABC	43718.21	548.54
	MBS	**43718.10**	**548.12**
900 MW	FA	49650.29	682.62
	BA	49650.14	682.62
	HYB	49649.97	682.62
	WEO [19]	49649.53	682.61
	ABC	49649.34	682.45
	MBS	**49649**	**682.13**
1000 MW	FA	55456.64	837.77
	BA	55456.49	837.77
	HYB	55456.24	837.77
	WEO [19]	55456.12	837.76
	ABC	55456.08	837.45
	MBS	**554556**	**837**

In all cases the proposed MBS algorithm achieves the competitive results with fully satisfies the system and problem constraints. The total production cost obtained by the proposed algorithm is also compared with existing techniques is also presented in Table 5.1. The comparison also shows that feasibility of the proposed algorithm reach better results in terms of least production cost. The proposed algorithm have capability of online implementation for reduction of emission and production cost. From the comparison it is clear that MBS algorithm outperforms the existing algorithms.

6. CONCLUSION

The increase of production activities globally as well as demand of electric energy, numerous investments have been done on thermal generation. Based on current statistics 42% of total global electric generation is from coal, which is the main source of pollutants gases which are NOx, COx and SOx. As a result of increase of pollutants gases from electric power generation activities, the concept of environmental economic dispatch is the major concern whereby the generation of electric energy is no longer focused on reduction of cost of fuel alone but also the issue of reducing pollutant emissions has become the major concern. In this paper modified bee swarming algorithm is proposed to solve emission constrained economic dispatch problem. The simulations are carried out on matlab environment and results are presented. The comparison of results shows that the efficiency of proposed algorithm.

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Power Demand MW	Techniques	P_1 (MW)	P_2 (MW)	P_3 (MW)	P_4 (MW)	P_5(MW)	P_6 (MW)	Pl (MW)
700	FA	80.1523	82.4019	113.9655	113.4758	163.4493	163.0944	16.53
	BA	80.1431	82.4033	113.9684	113.4763	163.4530	163.0950	16.53
	HYB	80.1506	82.4054	113.9570	113.4851	163.4436	163.0975	16.53
	WEO[19]	80.1439	82.4043	113.9657	113.4772	163.4471	163.0951	16.53
	MBS	**81.1326**	**82.1762**	**113.6542**	**114.2367**	**163.1121**	**163.0327**	**17.34**
800	FA	100.5399	103.7475	127.0118	126.3499	182.1959	181.7376	21.58
	BA	100.5295	103.7579	127.0076	126.3466	182.2088	181.7321	21.58
	HYB	100.5207	103.7662	127.0024	126.3547	182.1999	181.7385	21.58
	WEO[19]	100.5211	103.7511	127.0032	126.3518	182.2081	181.7382	21.57
	MBS	**100.2123**	**104.2341**	**127.0019**	**128.1254**	**182.0876**	**181.2354**	**22.89**
900	FA	120.9389	125.3301	140.1958	139.3394	201.0812	200.4822	27.36
	BA	120.9330	125.3313	140.1994	139.3392	201.0855	200.4791	27.36
	HYB	120.9357	125.3202	140.1992	139.3479	201.0706	200.4940	27.36
	WEO[19]	120.9362	125.3211	140.1993	139.3393	201.0808	200.4812	27.36
	MBS	**121.2341**	**125.1253**	**140.0862**	**139.1210**	**201.0201**	**201.1251**	**27.71**
1000	FA	125.0000	150.0000	156.2191	155.2644	224.0618	223.1839	33.73
	BA	125.0000	150.0000	156.2704	155.1559	224.0577	223.2458	33.73
	HYB	125.0000	150.0000	156.0719	155.2412	224.2263	223.1934	33.73
	WEO[19]	125.0000	150.0000	156.0792	155.2183	224.2173	223.2163	33.73
	MBS	**125.0000**	**150.000**	**156.0523**	**154.1232**	**225.3542**	**223.6543**	**34.18**

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