Scientific Journal Impact Factor (SJIF) : 3.518
International Journal of Modern Trends in Engineering and Research
ISSN (ONLINE) : 2349 - 9745
ISSN (PRINT) : 2393 - 8161

Environmental Emission Reduction of Thermal Power Plant by using Intelligence Technique of Artificial Bee Colony

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Abstract: In recent years increasing of thermal power plants air pollution and concentration of carbon dioxide emission leads to the global warming. Due to the harmful effects of the emission released by fossil fueled electric power plants, Emission Dispatch plays an important role in power industry. This paper proposed an artificial bee colony approach for solving the Emission Dispatch problem considering the power limits. The numerical results have shown the performance and applicability of the proposed artificial bee colony method.

Keywords- Global Warming, Emission Dispatch, SOx gas emission, artificial bee colony and Evolutionary Method

I. INTRODUCTION

Development of country and population growth needs more and more electric power at a reasonable price and pollution less power. But this electric power demand is supplied mainly by thermal power plants, which produce harmful gases like Sulfur Oxides SOx, Nitrogen Oxides NOx and Cox [1]. Scheduling of power plant generation is gives a great importance in electric power utility systems. One of the prime concerns from social and environment aspects is that both human and non-human life forms are severely affected by the atmospheric pollution caused during generation of electricity from fossil fuels. This may give rise to the problem of global warming [2]. In recent years the economic dispatch problem has taken a suitable twist as the public has become increasingly concerned with environmental matters. The absolute minimum cost is not anymore the only criterion to be met in the electric power generation and dispatching problems. The generation of electricity from the fossil fuel releases several contaminants such as sulfur oxides (SOx) and oxides of nitrogen (NOx) into the atmosphere. These gaseous pollutants cause harmful effects on human beings as well as on plants and animals [3]. The problem that has attracted much attention is pollution minimization due to the pressing public demand for clean air [4].Recently, different heuristic approaches have been proved to be effective with promising performance, such as Tabu search (TS) [5], Differential evolution (DE) [6], Evolutionary programming (EP) [7], Genetic algorithm (GA) [8], Artificial Immune System [9] and Particle swarm optimization (PSO) [10].

Artificial bee colony (ABC) algorithm invented by Karaboga has been proved to be more effective than some conventional biological-inspired algorithms like genetic algorithm (GA), differential evolution (DE) and particle swarm optimization (PSO). But, ABC is superior at exploration.This paper presents a recently developed optimization method, where ABC algorithm is to guide the search of candidate solution towards the global optima [11] and the reduction of SO2 gas emission from the thermal power plant.

The proposed artificial bee colony method focuses on solving the emission load dispatch constraint. The feasibility of the proposed method was demonstrated for three systems. The results obtained through the proposed approach and compared with those reported in recent literatures.

II. LITERATURE SURVEY

S. R. Vyas, Dr. Rajeev Gupta presented Emission Reduction Technique from Thermal Power Plant By Load Dispatch, Reduction in the emission of the SO2 gases from power system operation is the very giant task of pollution control system. There are so many methods are used for the reduction of the SO2 emission from the power plant. All the methods require so many equipment and additional arrangement for the reduction in SO2 emission from the power plant. On the other hand if we reduce the emission with arraigning load in proper schedule than there are no additional arrangement and equipment require. In this method we can use the optimum output in terms of emission from the different power plant. Overall emissions reduce for the given output of power with same equipment by load dispatch scheduling [12].

R. Gopalakrishnan, Dr.A. Krishnan et.al has proposed Intelligence Technique to Solve Combined Economic and Emission Dispatch, A power system operation at minimum cost is no longer the only measure for electrical power dispatch. Combined Economic Emission Dispatch (CEED) problem is attained by considering both the economy and emission objectives with necessary constraints. The stability of the power system is also considered as an important factor in the performance of the power system. Several optimization techniques are slow for such complex optimization tasks and are not suitable for on-line use. This paper presents an effective optimization algorithm, for solving security constrained combined economic emission dispatch problem. Also, the power system stability plays an important role in power system. Power system stability criteria are also considered in this paper for better performance of the entire power system. In this paper, an efficient optimization technique called Modified Artificial Bee Colony Optimization is used to solve the CEED problem. The performance of the proposed approach is compared with the other optimization techniques. The experimental result shows that the proposed system results in better solution for CEED problem with the maintenance of system stability [13].

Dimple Singla, Sanjay K. Jain have proposed A Review on Combined Economic and Emission Dispatch using Evolutionary Methods, Economic load dispatch is an important optimization problem in power system. Due to the harmful effects of the emission released by fossil fueled electric power plants, Emission Dispatch plays an important role in power industry. This leads to the formulation of combined economic and emission dispatch (CEED) problem. This paper presents a review on evolutionary methods for solving combined economic and emission dispatch problems [14].

Naveen Kumar, K. P. Singh Parmar et.al has proposed Optimal Solution of Combined Economic Emission Load Dispatch using Genetic Algorithm, in this paper, a genetic algorithm (GA) approach is presented for optimal solution of combined economic emission load dispatch (CEELD) problem. Fuel cost and emission are considered to formulate the multi-objective optimization problem. An optimal trade-off between fuel cost and emission is obtained using genetic algorithm [15].

III.PROBLEM DESCRIPTION

The emission dispatching strategies developed in the 1970s are (a) to minimize the emissions and (b) to minimize power production cost subject to the emission constraints. In strategy (b), the level of emissions is to be restricted. According to this strategy the emission and economic dispatch problem is known as environmentally constrained economic. The emission of pollutants is harmful to all types of life forms such as human beings, animals, tree etc. It also causes global warming, hence damaging many more things. The summation of all effects may be interpreted as cost, as they degrade the environment in one or other form. Therefore, the objective of emission dispatch is to minimize the total environmental degradation or the total pollutant emission due to the burning of fuels for production of electrical power to meet the load demand. However, the economic dispatch problem provides the amount of power to be generated by various generating units of a power system for a minimum total fuel cost without constraints of emission release. The emission function includes sum of all types of emissions as SOx, NOx, particulate materials and thermal radiation with suitable pricing for each pollutant released. But in this only SO and NO emissions are taken into account, since they are more harmful than other pollutants [16].

Emission Dispatch:-. A three-generator system has been considered for the load dispatch for the reduction in Sox emission. For the above there are so proposed artificial bee colony method has been used. Emission dispatch problem for SO2 emission calculation for the individual power plant unit is as per given below [17].

The total (kg/hr) emission can be expressed as

$$E(P) = \sum_{i=1}^{n} E_i(P_i)$$

$$E_i(P_i) = \sum_{i=1}^{n} d_i + e_i P_i + f_i P_i^2 \quad Rs/hr$$

Where, $E_i(P_i)$ -Total fuel cost $(Kg \quad /hr)$,Pi - generating unit i^{th} , d_i, e_i, f_i Emission coefficients of i^{th} unit, n- Number of generating units

Power balance constraint The total power generated must supply total load demand and transmission losses.

$$\sum_{i=1}^{n} P_i = P_d + P_l \text{ MW}$$

Where, P_d- total load demand (MW), P_l- Total transmission losses (MW)

Unit capacity constraint

The power generated, Pi by each generator is constrained between its minimum and maximum limits, i.e.

$$P_i^{min} \le P_i \le P_i^{max}$$

Where, P_i^{min}- minimum generation limit, P_i^{max}- Maximum generation limit

IV. ARTIFICIAL BEE COLONY ALGORITHM

Artificial bee colony is one of the most recently defined algorithms by Karaboga in 2005, motivated by the intelligent behaviour of honey bees. In the ABC system, artificial bees fly around in the search space, and some (employed and onlooker bees) choose food sources depending on the experience of themselves and their nest mates, and adjust their positions. Some (scouts) fly and choose the food sources randomly without using experience. If the nectar amount of a new source is higher than that of the previous one in their memory, they memorize the new position and forget the previous on .Thus; the ABC system combines local search methods, carried out by employed and onlooker bees, with global search methods, managed by onlookers and scouts, attempting to balance exploration and exploitation process

In the ABC algorithm, the colony of artificial bees consists of three groups of bees: employed bees, onlooker bees, and scout bees. It is population-based search procedure and the foraging behavior of real bees in finding food sources is shown in Fig 1-A, Fig 2-B, Fig 3-C and Fig 4-D.The model consists of 3 essential components: employed bees, unemployed bees, and food sources. Fig 1-A clearly shows the essential parts of the model: employed bees, unemployed bees, food sources, and a dancing area. Employed bees y around in a multidimensional search space and choose their food sources depending on their own experience, which is shown in Fig 1-B.

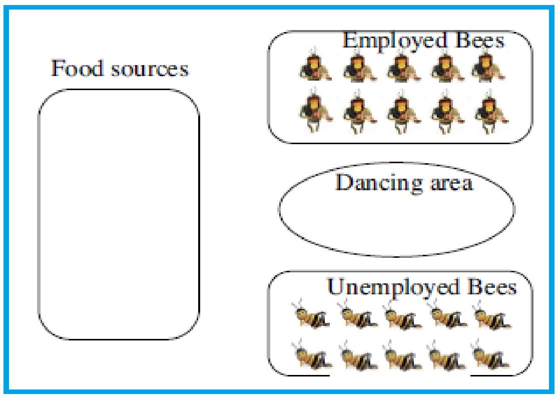


Fig 1 Behaviors of artificial bee colonies-A

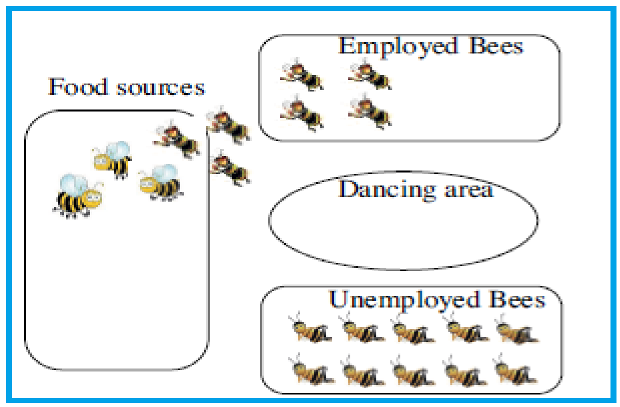


Fig 2 Behaviors of artificial bee colonies-B

Once the employed bees complete their search Process, they share their food source information with unemployed bees or onlooker bees waiting in the hive by dancing in the dancing area, which is shown in Fig 1-C. Onlooker bees probabilistically choose their food sources depending on this information gained from the Employed bees, which is shown in Fig1-D. If there is no improvement in the food source (Fitness), then the scout bees y and choose the food sources randomly without using experience, which is also shown in Fig 1-D [17].

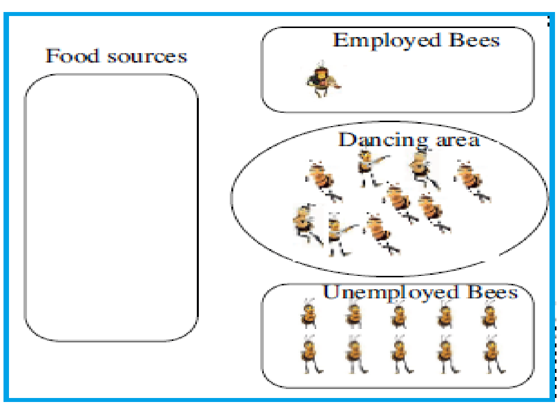


Fig 3 Behaviors of artificial bee colonies-C

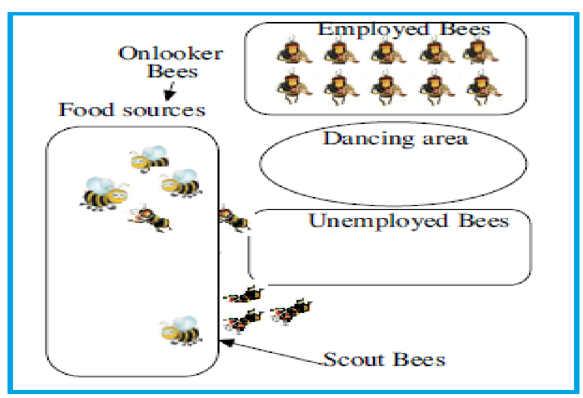


Fig 4 Behaviors of artificial bee colonies-D

V.METHODOLOGY OF PROPOSED ARTIFICIAL BEE COLONY ALGORITHM

This paper uses Artificial Bee Colony (ABC) algorithm [13] for the Economic and Emission dispatch problem and the stabilization of the power system. This paper uses an optimization algorithm that

utilizes the bee behavior in food forging. ABC algorithm is used for the stabilization and Economic and Emission dispatch problem of the power system. In order to overcome the limitations (such as, slow convergence features and easily gets stuck on local solutions) in the ABC approach, ABC algorithm has to be improved which would enhance the overall performance of the system. ABC consists of three groups of bees namely employed bees, onlooker bees and scout bees and three actions namely searching food source, recruiting bees for the food source and discarding the food source. Employed bees makes use of food source and share the data about the food source with onlookers. Onlooker bees remain in the hive for the data offered by the employed bees. Scout bees look for the new food source. Employed bees contribute to information about food sources by dancing in the dance area and the nature of dance is Proportional to the nectar content of food source just used by the dancing bees. Onlooker bees study the dance and a food source is chosen based on the probability proportional to the value of that food source. Therefore, several onlooker bees are attracted towards good food sources. A bee, whether it is scout or onlooker, becomes employed whenever it identifies a food source. Whenever a food source is utilized wholly, all the employed bees interconnected with it eliminate it and may become scouts or onlookers.
In the ABC algorithm, the position of the food source denotes a probable solution of the problem to be optimized which is represented by a d-dimension real-valued vector. The amount of nectar in a food source is correspondent to the quality (fitness) of the connected solution. The number of employed bees or the onlookers is same as the number of the food sources (solutions) in the population. On the other hand, there is only one employed bee for every food source. The algorithm of ABC method is described in step by step [18].

Step In Artificial Bee Colony (ABC) Algorithm

Step I: Initialization of the ABC algorithm parameters.

In this step, Specify generator emission coefficients, generation power limits for each unit and B-loss coefficients. Initialize the four control parameters of ABC algorithm and maximum cycle for termination process. the parameters of the ABC algorithm, such as the colony dimension, maximum cycle number (MCN), number of variables, and limit parameter, are initialized.

Step II: Initialization of the population with a random solution.

In this step, a set of food sources (initial population of S solutions xi (i = 1, 2,......S)) is generated randomly by the bees and their nectar amounts are determined, where S corresponds to size of the employed bees. Each solution xi is represented by a D-dimensional vector, where D corresponds to the number of parameters to be optimized.

Step III: Evaluation of the fitness.

In this step, evaluation of the fitness function of each food source position corresponding to the employed bee in the colony.

Step IV: ***Reproduction and Modification***

Modification of the food source position and local selection by the employed bee. In this step, an employed bee modifies the food source position, finds a new position (solution) using her visual information belonging to that
source in her memory, and tests the nectar amount of the new source. In the ABC algorithm, the new food source found by the employed bee is described as follows:

$$v_{ij} = x_{ij} + \phi_{ij}(x_{ij} - x_{kj}) \quad \text{.............................} \mathbf{(1)}$$

Where, k (1, 2, 3…..S) and j (1, 2…..D) are randomly chosen indices and ϕ is a random number in the interval of
[-1, 1]. In fact ϕij gives a comparison between 2 sources found, the new and the old. After vij is produced and its fitness is evaluated, the comparison is done by the employed bees. According to the comparison, if the fitness value of the new food source is better than that of the old one, the new food source is kept in the memory and the old one is discarded; otherwise, the new one is discarded from the memory and the old one is kept. This selection is called local searching or greedy selection process in the ABC algorithm. In this process, if the new food source is selected instead of the old one, a limit count is set.

Step V: Employ the onlookers for the selected sources and evaluate the fitness.
After completion of the local search process in Step 5 by the employed bees, they come back into the hive and share the nectar amount information of the sources with the onlooker bees waiting at the dancing area. In fact, these onlooker bees were called employed bees before going to the food source that they visited. In this step, onlooker bees make a new food source choice according to the information they took from the employed bees and the nectar amount is calculated. This process of choosing a food source depends on the probability value Pi associated with the fitness of that food source and is formulated as follows:

$$\boldsymbol{P_i = \frac{f_i t_i}{\sum_{n=1}^{N} f_i t_n}} \text{……………….…………….. } \mathbf{(2)}$$

Where, $\boldsymbol{f_i t_i}$ is the fitness value of the *i* th solution and *N* is the total number of food sources which is equal to the number of employed bees.

Step VI: Modification of the food source position by the onlookers.
In this step, the onlookers modify the food source position to find a new position (solution) using the visual information belonging to that source in their memory and check the nectar amount of the new source, just as in the case of the employed bee in Step 5. The greedy selection process is done again for the onlookers in this step. That is, if the fitness value of the new food source is better than that of the old one, the new food source is kept in the memory and old one is discarded; otherwise, the new one is discarded from the memory and the old one is kept.

Step VII: Abandon the exploited food sources.
This step is done according to the `limit' parameter, which is a predetermined number of cycles for releasing the food source. In the ABC algorithm, a solution is abandoned when that solution can not improve further for the determined limit value. In this step, when the nectar amount is abandoned in this way, one of the employer bees is determined randomly as a scout bee to find a new food source. This process is described as follows:

$$\boldsymbol{x_{ij} = x_{jmin} + \delta\,(0,1) * (x_{jmax} - x_{jmin})} \text{……………….… } \mathbf{(3)}$$

j (1,2………D)

Where, δ is a random value in the interval of [0,1], and x_{jmax} and x_{jmin} are the minimum and maximum limits of the parameter to be optimized and Keep the position achieved so far and increase the counter of the cycle.

Step VIII: Stopping of the global searching process.

In the ABC algorithm, steps V through IX are repeated until the criterion is met. Next, this global searching process stops.

V. CASE STUDY AND RESULTS

The proposed method for emission dispatch problem is evaluated using the 3- generator system which is tested on the standard IEEE system [12]. The simulation was performed using MATLAB 12 (R2009a), Data for the generator is as per the given below in appendix section. Here we consider three units for the calculation and their maximum and minimum capacity is as per table1. SOx emission coefficient for the each three plants are as per given in table 2 and Loss coefficient of plant is as per given in table 3.in this section 2 cases studies

Case 1 population size Effect for 3 unit emission problem

The Parameter of ABC algorithm considered here are: N=10; Food-Number=N/2; and limit=100, max Cycle 500, run time 50 and PD 500MW.

The population size is another important issue in heuristic techniques. Too large a population makes an algorithm slow and computationally inefficient, while a very small population may not be capable of searching a minimum, particularly in complex problems. The optimal population size depends on problem dimension. Larger the dimension, larger is the population size required to achieve good results. Tests were carried out for 100,250,500 and 1000 populations. With increase in population, a steady improvement in minimum emission, Mean emission and Maximum emission and standard deviation was noticed in the given in the Table 1 and fig 1,fig 2,fig 3and fig 4 show Effect of population size.

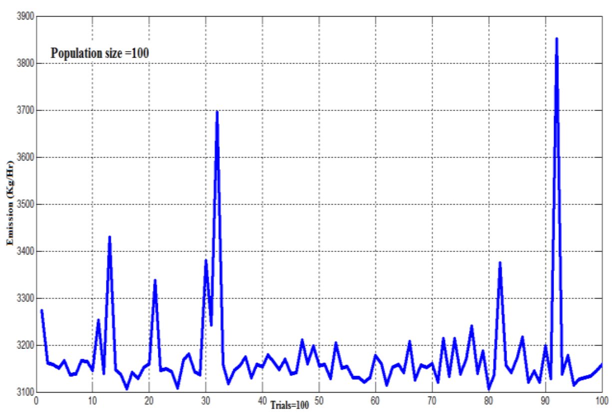


Fig 1- Population Size 100

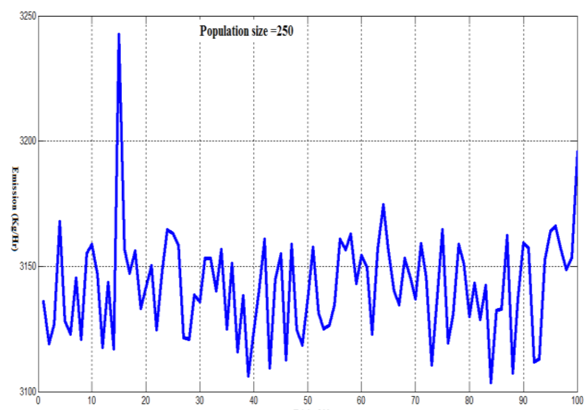


Fig 2-Population Size 250

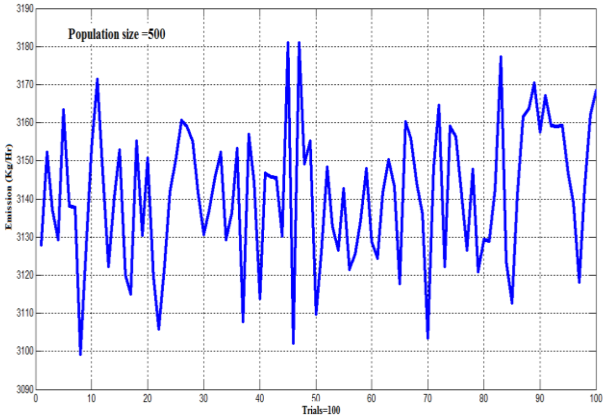


Fig 3-Population Size 500

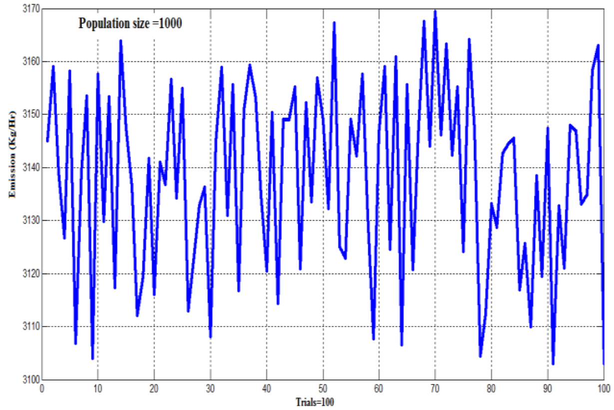


Fig 4-Population Size 1000

Table 1 population size Effect for best emission solution (50 Trial)

Population size	100	250	500	1000
P1	240.000000	216.756694	233.459722	162.204260
P2	179.720110	188.385752	209.369794	238.000000
P3	80.281306	94.891827	57.186784	99.804889
Minimum Emission (Kg./Hr.)	3207.1	3113.6	3109.2	3103.0
Mean Emission (Kg./Hr.)	3377.1	3142.4	3141.1	3138.1
Maximum Emission (Kg./Hr.)	3851.4	3242.4	3181.0	3169.4
SD	51.2402	25.7458	19.7843	15.0826

Case 2 Comparison of Best Results for 3 unit emission

The Parameter of ABC algorithm considered here are: N=20; Food-Number=N/2; and limit=100, max Cycle 1000, run time 100 and different (300 MW, 350MW, 400 MW, 450 MW) power demand.

The Emission dispatch problem solution for the 3-unit system is solved using proposed artificial bee colony method for different power demands. Table 2 show Minimum pure emission results and Minimum pure emission are show in the Fig 5, Fig 6.Fig 7, Fig 7 and Fig 8for different power load.

Table 2 Minimum pure emission result for different Power Demand

Power Demand (MW)	PD-300	PD-350	PD-400	PD-450
P1 (MW)	121.173821	123.787581	102.469864	187.058825
P2 (MW)	115.138076	176.031188	199.765069	205.968258
P3(MW)	63.689697	50.179865	97.763943	89.526239
Minimum Emission (Kg./Hr.)	**2108.2**	**2339.5**	**2577.2**	**2833.0**

Mean Emission (Kg./Hr.)	**2133.3**	**2368.9**	**2612.7**	**2876.4**
Maximum Emission (Kg./Hr.)	**2190.5**	**2421.6**	**2671.7**	**2930.0**
SD	15.5498	16.6905	18.6871	20.1136

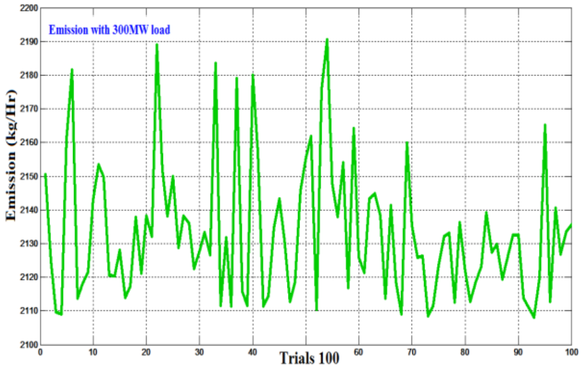


Fig 5- Minimum pure emission for 300MW

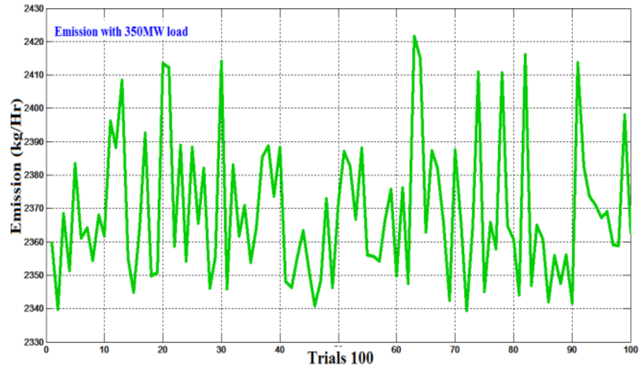


Fig 6- Minimum pure emission for 350MW

Fig 7- Minimum pure emission for 400MW

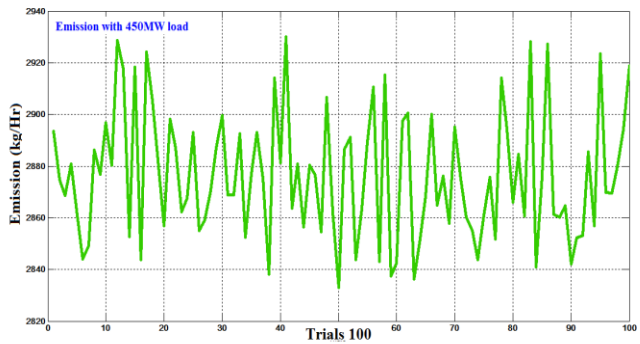
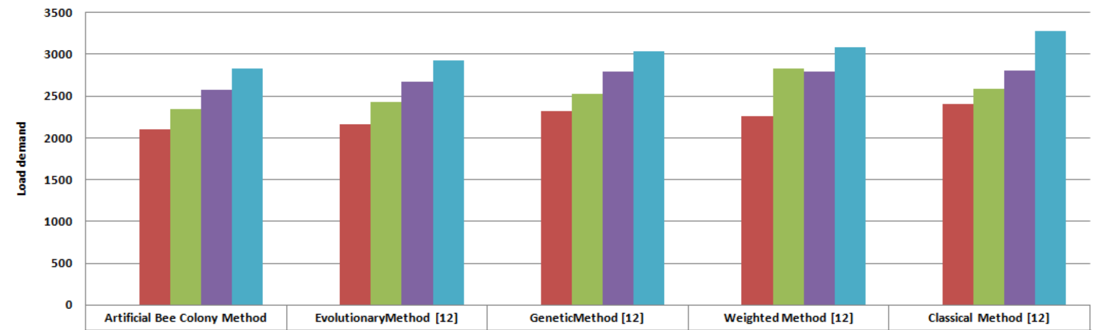


Fig 8-Minimum pure emission for 450M

The comparison of result for the proposed artificial bee colony method with Evolutionary Method, Genetic Method (GA), Weighted Method and Classical Method with minimum emission is presented in table 3 and minimum emission release is presented by Fig 9 .it is explicit that ABC algorithm has succeeded in finding the global optimum solution.

Table 3 Comparison of Artificial Bee Colony Solution of Emission under Various Loads Conditions for Three Generator System

Generation MW	**Minimum released Emission (Kg/Hr)**				
	Artificial Bee Colony Method	Evolutionary Method [12]	Genetic Method[12]	Weighted Method [12]	Classical Method [12]
300 MW	**2108.2**	2166	2317	2263	2408
350 MW	**2339.5**	2433	2528	2829	2585
400 MW	**2577.2**	2678	2790	2801	2812
450 MW	**2833.0**	2931	3034	3084	3285



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300 MW	2108.2	2166	2317	2263	2408
350 MW	2339.5	2433	2528	2829	2585
400 MW	2577.2	2678	2790	2801	2812
450 MW	2833	2931	3034	3084	3285

Fig 9 Comparison of Artificial Bee Colony Solution of Emission under Various Loads

VI. CONCLUSION

Power systems have some serious Emission environmental problems, in this paper have formulated and implemented artificial bee colony algorithms and have been shown to improve the optimization of emission dispatch problem. The artificial bee colony algorithms have been tested for test system with 3 generating units. The comparison shows that artificial bee colony algorithms perform better then above mentioned methods. The artificial bee colony algorithm has superior features, stable convergence characteristics, quality of solution and good computational efficiency. Therefore, this result shows that artificial bee colony algorithms optimization is a promising technique for solving complicated problems in power system environment.

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APPENDIX SECTION

Table A1: SO_2 emission coefficient of 3units

Emission Coefficients				**Minimum Value in Mw.**	**Maximum Value in Mw.**
Unit	di	ei	fi		
P1	51.3778	5.05928	0.001206	90	240
P2	182.2605	3.84624	0.002320	85	238
P3	508.5207	4.45647	0.001284	20	100

Table A2 loss Coefficients of 3 units

Bij	1	2	3
1	0.000134	0.0000176	0.000183
2	0.0000176	0.000153	0.000282
3	0.000183	0.000282	0.00162