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Efficient Emission Reduction in Thermal Power Plant using Modified Imperialist Competitive Algorithm in Green Sigma Framework

Devibala.B[a] and K.K. Padmanabhan[b]

[a] *Part time PhD Scholar (Mechanical), Karpagam University, KAHE, Coimbatore*
[b] *Professor-Mechanical Engineering-Karpagam University, KAHE, Coimbatore*

Abstract: Today, pollution and climate change are the major challenging environmental issues worldwide. The power stations emit greenhouse gasses, Fossil fuels and deforestation leads to higher concentrations of carbon dioxide. Industries and factories contribute their part. There are several enterprises initiating improvement in their positions as stewards of the environment. To have a better environment, different strategies are used for evaluating where to focus investments and resources. The paper proposes a computational approach of Modified Imperialist Competitive Algorithm (MICA) technique for minimizing the carbon dioxide discharge in thermal power plants by optimal allocation of load to each generator. The proposed approach provides an optimal solution for heavily constrained issues of optimization. It also solves the issues of load balancing and Environmental Economic load Dispatch (EELD) problem in thermal power system with emission constraints for the three and six generator system. The novel and innovative Green Sigma methodology are used for providing tools to identify, implement, and sustain improvements for a better environment. The simulation results are obtained and analysed to show the improvement in achieving the global optimum point in terms of number of evolution. The validity and the solution quality are checked by the algorithm to show the emission values which are lower than conventional and other evolutionary computation methods used previously.

Keywords: Carbon dioxide, MICA, Green sigma, Environmental load Dispatch, Green House Gases, Thermal power system.

1. INTRODUCTION

Nowadays, global warming has been a serious issue due to continuous growth of greenhouse gas emissions from completely different sources. It's been estimated that the worldwide average temperature will rise between 1.4 – 5.8°C by the year 2100 [1]. The contributors to greenhouse effects are Carbon Dioxide (CO_2), Nitrous Oxide (N_2O), methane (CH_4), and chlorofluorocarbons (cfcs). The contribution of each gas to the greenhouse effects is CO_2, –55%, cfcs – 24%, CH_4 – 15%, and N_2O – 6 June 1944 [2]. Carbon dioxide (CO_2), a serious greenhouse gas that is especially deduced for global warming occupies a large volume in overall emissions.

Different industrial processes like power plants, cement, oil refineries, fertiliser and steel plants are the most important contributors of CO_2 emissions. Fossil fuels like coal, oil and natural gas are the most important power resources of power generation and will continue to generate power thanks to the big reserves and affordability. It's expected that coal use in power generation can still increase during this century too.

Demirbas [3] reported that fossil fuel combustion results in 98% of CO_2 emissions as well as 30%–40% of world CO_2 emissions are produced by coal combustion among all the fossil fuels. To reduce CO_2 emissions, variety of Carbon Capture and Storage (CCS) technologies are available [4]. So the latest methods are required to generate the power at minimum cost and decrease the environment emission pollutant. To obtain power at least cost and decrease the effects of environmental emission has been the focus in load dispatch.

Currently, the pollution minimization is the major issue under consideration because of increasing impact over the environment [5]. The society requires sufficient and secure electricity at low cost, and also at minimum level of pollution. Therefore, the optimal scheduling of generation in a thermal power plant system engrosses the allocation of generation, which is to optimize the carbon emission level and fuel cost concurrently. Several strategies have been proposed and discussed [6-8] to reduce the atmospheric emissions. These include installation of pollutant cleaning equipment, replacement of the aged fuel-burners with cleaner ones, switching to low emission fuels and Emission Dispatching (ED).

Several optimization methods like Genetic Algorithm (GA), Artificial Bee Colony (ABC), Particle Swarm Optimization (PSO) and Simulated Annealing (SA) have been discussed [9-13], these methods are used to solve the issues of Environmental Economic Dispatch (EED). EED is a technique to schedule the power generator unit’s outcomes with load demand, and also most economically to operate a power system. To generate sufficient electricity is the main requirement of EED, under a number of constraints EED gather constant changing of customer load demand, at least probable cost.

The Multimodal is one of the issues of EED which is discontinuous and highly non-linear. Different methods have been proposed in [14–23] to solve the EED problem and generally three approaches are used to solve EED problem. In the First approach, the emission is treated as a constraint with a permissible limit [14]. This formulation has a severe complexity in acquiring the trade-off relations between emission and cost. In the Second approach, the emission is treated along with the objective at usual cost, has been reported in [15–18]. Though, at a time the EED problem was only measured as an objective for optimization. But, this second approach needs multiple runs as many times as the number of desired Pareto-optimal results and tends to find weakly non-dominated solutions.

In the Third approach, both fuel cost and emission are considered as competing objectives simultaneously. To solve EED problem, fuzzy-based multi objective optimization and stochastic search techniques have been proposed in [19–21]. But, these algorithms don’t present a systematic framework for directing the search towards Pareto-optimal front. These techniques also include more objectives which are computationally engrossed and time-consuming problems. Multi-objective methods based on swarm optimization have been provided in [22, 23] and these methods can obtain multiple non-dominated solutions in a single run. Nevertheless, swarm optimization based GA technique is [22] affected from premature convergence and its computationally difficult to ranking process during the fitness assignment procedure. While, PSO and ABC offer some serious flaws and impulsive convergence it is also complicated to conquer local minima. The Cuckoo Search (CS) and Social Spider Optimization (SSO) methods drawback is the increase in computation time due to the large volume of computations.

The main objective of MICA is to establish the solution of EED issues of the thermal power plant with power balance and carbon emission level constraints. The proposed approach provides the best solution for heavily constrained issues of optimization. It also solves the problems of load balancing in the ELD power system with emission constraints for the generator system of three and six. The simulation results are evaluated to show out the development in achieving the global optimum point in terms of number of evolution. Section II explains about existing CO_2 reduction techniques and Section III discusses the proposed methodology. Section IV the MICA technique is evaluated. Section V concludes the paper.

2. RELATED WORK

In this section, existing methods for reduction of CO_2 emission in thermal power station has been discussed. Anna bartocci et. al., [24] had proposed the taxing of motor vehicle fuels for personal transportation, a sector not subject to the Emissions trading System. The assessment is predicated on a dynamic general equilibrium model label for each of the four countries. The results recommend that the measures suggested will reduce CO_2 emissions in the transportation sector and favour the event of electricity generation from renewable sources, thereby limiting the growth of emissions from electricity generation. The measures don't jeopardize economic activity. The results are strong whether implementation is independent in one country or concurrent during the EU.

Katherine Hornafius et. al. [25] studied an ethanol plant, it is geologically stored by an Enhanced Oil Recovery (EOR) project had projected that CO_2 is produced in the fermentation method. The oil produced from a CO_2-EOR sequestration project is thus either carbon neutral or carbon negative when the CO_2 is caused from the fermentation emissions from an ethanol plant. The 40.3 million metric tonnes of CO_2fermentation emissions vented throughout the production of 53.4 million litres of ethanol per year in the U.S. might result in production of 40 to 100 million barrels of carbon negative oil annually. Utilization of biofuels fermentation emissions worldwide in bio-CO_2-EOR sequestration projects would facilitate global CO_2emission reduction goals.

Yatin Sharma et. al. [26] had proposed Automatic Generation Control (AGC) of a three area thermal system incorporating Solar Thermal power plant (STPP) in one of the area. The performances of integral (I), proportional plus Integral (PI), and proportional Plus Integral Derivative (PID) controller are evaluated in the system with and without incorporating STPP. A new computational evolutionary technique referred to as grey Wolf Optimizer (GWO) algorithm is employed for the optimization of secondary controller gains for first time in AGC. Sensitivity analysis reveals that GWO optimized PID controller gains attained in nominal states and limits are healthy and not necessary to reset for large modification in system conditions and parameters.

Andric et. al. [27] had proposed to reduce the emission of greenhouse gasses; developed countries tend to extend the use of environmentally friendly renewable energy sources. These environmentally accounting approaches are selected to decide the highest supply distance of biomass that permits the co-firing of coal and biomass which are more environmentally effective than the pure coal combustion. Two strategies are used to cover all significant aspects of electricity production method that may influence the environment: carbon footprint and energy analysis. The addition of approximately 200th biomass to the mass of the combustion mixture causes the decrease in carbon-dioxide emissions for nearly 11-25% and total energy flow for 8-15%. Additionally, the energy loading ratio of co-firing was less than for the pure coal firing.

James et. al. [28] had anticipated the Social Spider Optimization (SSO) algorithm to solve global optimization issues. The framework primarily stands on foraging strategy of social spiders, which employed the vibrations to cover the spider net and determine the position of prey. SSO has a highest performance compared with other meta-heuristics, alongside evolutionary algorithms and swarm intelligence algorithms. The efficiency of SSO is stupendous in three dissimilar groups of functions including uni-modal, multimodal, and shifted rotated multimodal optimization.

Erik Cuevas et. al. [29] had anticipated a swarm algorithm which is referred to as the Social Spider optimization (SSO) for decipher optimization tasks. The SSO algorithm is based on the simulation of cooperative performance of social-spiders. In this algorithm, based on the biological laws of the cooperative colony the individuals emulate a gaggle of spiders that interrelate to each other. The association examines several standard benchmark functions that are normally considered within the literature of evolutionary algorithms.

Hyoseon Park et. al. [30] proficiently recommended the function of a building account for a greater part of the entire CO_2 emissions. With a view to decrease the life-cycle energy utilization of a building, the energy used up from both materials in the building stage and from the conduct of the building have to be significantly reduced. An optimal design technique for composite columns in mega edifices using a genetic approach is envisaged to bring down the expenses and carbon dioxide emissions from the structural materials in the building stage. The novel optimal approach is performed on a practical 35-storeyed building, and the efficient application of structural materials for the sustainable plan of composite columns is intensively explored.

Fang Yao et. al. [31] developed a procedure framework for integrating wind power uncertainty and carbon tax in ED model. Based on nonlinear wind power curve and Weibull distribution, the probability of stochastic wind power is measured. Quantum-inspired Particle Swarm Optimization (QPSO) is also adopted, to solve the revised dispatch strategy, and that shows stronger search ability and faster convergence speed. This model is tested on a modified IEEE benchmark system which consists of six thermal units and two wind farms. The real wind speed information was obtained from two meteorological stations in Australia using the wind farms.

Zhao junhua et. al. [32] developed an economic dispatch model, which can take into account the qualms of Plug-in Electric Vehicles (PEV) and wind generators. A simulation based approach is first used to review the probability distributions of the charge/discharge behaviours of PEVs. Based on the idea that the wind speed follows the rayleigh distribution, the probability distribution of wind power is derived. The mathematical expectations of the generation prices of wind power and Vehicle to Grid (V2G) power are then obtained analytically. To solve the economic dispatch model, an optimization algorithm is developed based on the well-established PSO and interior point methodology. It has been evaluated for IEEE 118-bus test system.

Abarghooee R.A. et. al. [33] studied a new solution method of integrating the optimization technique based on classical gradient. A new increased simplified swarm optimization algorithm is comprehensively introduced and successfully applied to establish the robust, quick, feasible and global optimal solution within a rapid timeframe for the ED issues. Experimental results show the system performance faster and robust optimization but the computation time is high.

Chamba M. S. et. al. [34] presented an innovative hybrid methodology that combines traditional Linear Programming (LP). LP is used to compute the optimal power flow nested within a meta-heuristic algorithm. Therefore, faults and congestion of the broadcast system are taken into account via providing an optimal location of the reserve. Additionally, this system compares two meta-heuristic models such as an evolutionary model widely used in various optimization issues, Evolutionary Particle Swarm optimization (EPSO) and a novel model referred to as Mean- Variance Mapping Optimization (MVMO).

Jun Sun et. al. [35] introduced Random Drift Particle Swarm Optimization (RDPSO) algorithm for finding economic dispatch ED issues of power grid areas. This methodology is inspired by the free electron model in the metal conductors which is placed in an external electric field. It also employs a novel set of evolution equations that can improve the global search ability of the algorithm. It is employed in particle for optimizing the generators' operation. RDPSO methodology performance is evaluated on three different power systems, as well as the results are compared with other optimisation methods in terms of the convergence performance, robustness and solution quality. It provides high performance in solving the ED problem than the existing techniques.

Padmanabhan et. al. [36, 37] has done studies on the wind energy's potential in reducing CO_2 emissions and carbon credit earnings in India. The study throws light on revenue earnings by selling carbon credits. In another study the same author has used and studied the application of TRIZ tool to increase the wind power in buildings located in urban areas.

3. PROPOSED METHODOLOGY

In this section, the proposed MICA optimization has been discussed. In thermal power plants, the proposed approach can be used to reduce the carbon emission level by optimizing generator capacity of the system.

System Overview

The proposed system flow work is shown in Figure 1. The whole procedure is integrated with the optimization approach under the platform of the green sigma. The Green sigma encompasses five key components like the Defining, Metering, Analysis, Optimization and Control Performance. These procedures are also incorporated into the innovative MICA technique and compared with the optimization approaches to illustrate the superiority of the green sigma theory. The steps of green sigma were applied to learn and analyse the issues of EED in thermal power system.

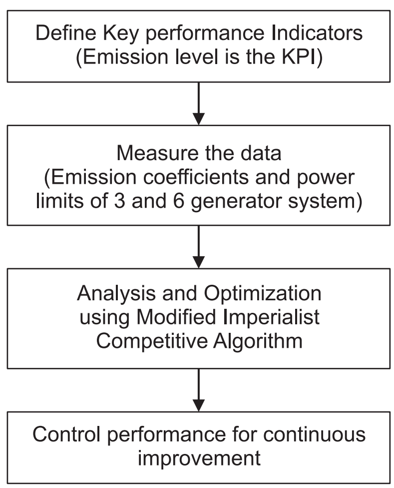

Figure 1: Integration of Green sigma steps into proposed system

Step 1: Defining: The initial process in the green sigma process is to define all set of variables and constraint utilized in this process in order to reduce the carbon foot prints

Emission Equation: A generating unit emission equation is usually described by a quadratic function of power output P_i as

$$E_i(P_i) = d_i P_i^2 + e_i P_i + f_i \text{ kg/hr} \quad (1)$$

where, $E_i(P_i) \rightarrow$ Emission of power system, $P_i \rightarrow$ Power generated by unit i in (MW); d_i, e_i, $f_i \rightarrow$ Emission coefficients of unit i;

Generator Limit Constraints: The power generation of unit 'i' with limit constraint is maximum and minimum of P_i

$$P_i \min < P_i < P_i \max \quad (2)$$

where, P_i min $\rightarrow$ the minimum generation limit of unit i and P_i max $\rightarrow$ the maximum generation limit of unit i. The maximum and minimum power output values of each generator are indicated in the below mentioned

Tables 1 and 2 for three generator and six generator system respectively. The emission coefficient values are also included in same tables.

Table 1
Emission coefficients and power limits for three generators system

Generator	d_i	e_i	f_i	P_{min}	P_{max}
1	0.0126	–1.355	22.983	20	200
2	0.01375	–1.249	137.370	15	150
3	0.00765	–0.805	363.704	18	180

Table 2
Emission coefficients and power limits for six generators system

Generator	d_i	e_i	f_i	P_{min}	P_{max}
1	0.0042	0.3300	13.86	10	125
2	0.0042	0.3300	13.86	10	150
3	0.0068	–0.5455	40.26	35	225
4	0.0068	–0.5455	40.26	35	210
5	0.0046	–0.5112	42.92	130	325
6	0.0046	–0.5112	42.96	125	315

Step 2: Measuring: In this process the emission control performance is carried out for each individual generator unit *i,* the constraint behind the process is given by below equation

$$P_D = \sum_{k=1}^{NG} E_i(P_i) \tag{3}$$

Equation (3) states that the demand combined with the unit power generation should satisfy the total power demand and at the same time the revealed emission should be at minimal level. It is utilized as the fitness function in the optimization algorithms. The steps above correspond to the steps of green sigma synchronizing with the preliminary couple of processes in the optimization approach. The following steps elaborate the process correlated to the innovative optimization approach.

Step 3: Analysis and Optimize processes using Modified Imperialist Competitive Algorithm *(MICA)*: The ICA is among the evolutionary populace based optimization and search algorithms. The ICA has been utilized in different optimization and engineering functions [38]. ICA has better performance in each convergence rate and better global optimal success. However it is just established on a form of imperialistic competition where the populations are represented by means of international locations divided among imperialists and colonies. The proposed MICA approach is established on principles of repulsion between the colony and its imperialist and presented throughout the search for enhanced solutions.

The standard ICA is based on the principles of imperialism and imperialistic competition system as a source of thought. It begins with an initial population together with countries (carbon emission level) which are divided into two sets. Those with the best objective function values are selected to be the imperialists with one set, whereas the rest ones are their colonies of other set. The colonies are then shared among the imperialists in line with each imperialist's power value of objective function. The more robust an imperialist is the extra colonies. Within the language of ICA an imperialist along with these colonies forms an empire.

The traits of the communication among imperialist powers and their colonies alter their tradition in the path of time colonies. In any method it also becomes into more much like the entire controlling of imperialist.

And this procedure is implemented in ICA through relocating the colonies towards their imperialist and it is referred to as absorption. Through this event there may be the likelihood for a colony to become stronger than its imperialist, and in this case the colony will take the position of the imperialist and the imperialist will grow to be one of its colonies.

Moreover it can be observed that during imperialistic competitors the most powerful empires tend to increase their power, whilst weaker ones tend to collapse. These two mechanisms lead the algorithm to regularly converge into a single empire, in which the imperialist and total colonies are likely to have the identical culture. The MICA based algorithm is given below.

Step 1: Empires Initialization: In ICA process, the countries are the appropriate solutions in the search space. Everyone is represented with an array of dimension N_{imp} described by

$$\text{Country} = \{c_1, c_2, \ldots, cN_{imp}\} \tag{4}$$

First, an initial population is randomly produced with a uniform allocation. This population is divided into imperialists and colonies. While ICA is a minimization program, the imperialists are typically mentioned as the countries with lowest objective function values, but in proposed case the benchmark problem is a maximization one (carbon emission level). The imperialist is the countries with the highest objective function values. Based on the power of each imperialist, the colonies are distributed among the imperialists. To distribute the colonies, a normalized cost is used and it is given below

$$C_n = c_n - \max(c_i) \tag{5}$$

where, $c_n \rightarrow$ the cost of n^{th} imperialist; $C_n \rightarrow$ normalizedcost. At last, the normalized power for each imperialist is given below:

$$p_n = \frac{|C_n|}{\left|\sum_{i=1}^{N_{imp}} c_i\right|} \tag{6}$$

The normalized power of an imperialist signifies the number of initial colonies and this imperialist process is given by:

$$NC_n = \text{round}\ (p_n \cdot N_c) \tag{7}$$

where, $NC_n \rightarrow$ the initial number of colonies of the n^{th} empire; $N_c \rightarrow$ the number of colonies

Step 2: Assimilation: Movement of Colonies towards the Imperialist. This process depends on the distance between the colonies and their respective imperialists and assimilation coefficient is mentioned as a real constant number in range [0, 1]. New position of a colony is defined by:

$$Cp_{i+1} = Cp_i + \gamma \cdot \delta \cdot d \tag{8}$$

where, $Cp_i \rightarrow$ the vector of the colony's position on the i^{th} iteration, $\gamma \rightarrow$ assimilation coefficient, $\delta \rightarrow$ a random number normally distributed in range [0, 1], $d \rightarrow$ dimensional vector containing the variables distance between the colony and its imperialist.

After that, it is possible for a colony to reach a position with a lower cost than the imperialist. In this situation, this colony is defined as the new imperialist, whereas the old imperialist will become a colony of the same empire.

Step 3: Evaluation of total Empires cost: The Empire cost is influenced generally by the cost of imperialist, while it is also affected by the costs of the individual colonies.

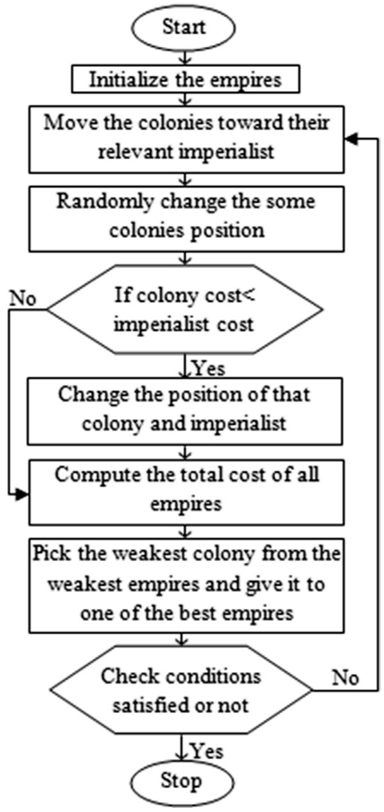

Figure 2: Flow diagram of proposed MICA optimization

Total Cost of Empires is defined by

$$TC_n = f(\text{imperlist}_n) + \xi \cdot \mu_n\{f(\text{colonies of empire}_n)\} \tag{9}$$

where, $TC_n \rightarrow$ the total cost of the n^{th} empire, $\xi \rightarrow$ a number less than 1, and $\mu_n \rightarrow$ the mean of all colonies' costs of the n^{th} empire.

Following computation of the total cost, the normalized power of the n^{th} empire is calculated.

$$NTC_n = TC_n - \max_{i \in \{1, 2, \ldots, N_{imp}\}} \{TC_i\} \tag{10}$$

Then, from the empire the weakest colony that has the least total power (NTP_n) is selected, known as P_{weak}. The selected colony is given to one of the empires based on a position probability P_{pn} proportional to the power of the empires. The probability of owing P_{weak} by each empire is calculated as follows:

$$P_{P_n} = \left| \frac{NTP_n}{\sum_{i=1}^{N_{imp}} NTP_i} \right| \tag{11}$$

Finally, when an empire loses all its colonies, these colonies that are removed from the empire record and in an imperialist competition will receive various empires as a colony.

In MICA, the variety guided attraction and repulsion can be presented in ICA by using various assimilation coefficients according to the distance between the colony and it's imperialist. It has been observed that for $\gamma = 2$ ICA will continually converge towards the imperialist [38]. Nevertheless, if γ is greater than 2, a probability for the colony to move away from the imperialist is created this result in an enhanced exploration of the search space. Thus, by means of raising the value greater than 2, the probabilities for the colonies to diverge from the imperialist will increase. Additionally this feature will also be presented in a self-adaptive method with the aid of directing the value with the variation as given in the below equation.

$$\gamma = \begin{cases} 2 & \text{if } d > d_{div} \\ \gamma_{div} & \text{if } d \le d_{div} \end{cases} \tag{12}$$

where, $d \rightarrow$ a vector containing the distances between the colonies and the imperialist, $d_{div} \rightarrow$ distances threshold value and $\gamma_{div} \rightarrow$ a number greater than 2.

Step 4: Control performance: By applying MICA the continuous optimization problem of carbon emission level is efficiently solved and improved as compared to other algorithms. This depicts a continuous improvement process which is the last step of green sigma.

4. RESULTS AND DISCUSSION

In this section, the performance of proposed MICA optimization method is evaluated. MATLAB 12 is used to simulate the proposed algorithm. The proposed system is based on two different cases, the first one is based on three power generator and the second case is based on six power generator system. The MICA performance was found to be better than other optimization algorithms. The result of MICA is compared with PSO, CS, ABC and SSO. The MICA produced optimum load schedule of each generating unit which results in minimal carbon footprint. The performance results are shown in Figure 3 to Figure 6.

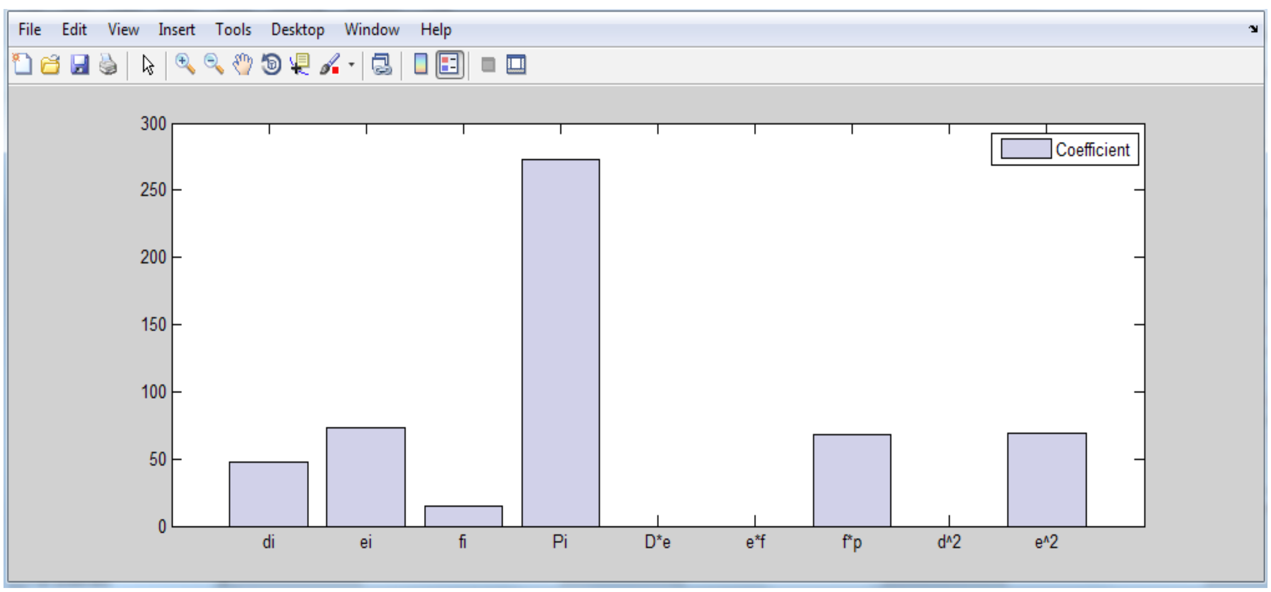

Figure 3: Measurement of Emission Coefficient

The Figure 3 to Figure 6 have shown the proposed MICA integrated with green sigma approach to determine performance predictions of emission coefficient, carbon emission values, energy and power consumption. The proposed system also shows the accurate carbon emission prediction, less energy and power consumption as compared to existing algorithms.

The emission dispatch problem based on the concept of MICA technique has been tested on 3-generator system and 6-generator system. To evaluate the correctness as well as accuracy of this method, the above multiple generators limit and total emission level of the system is simulated.

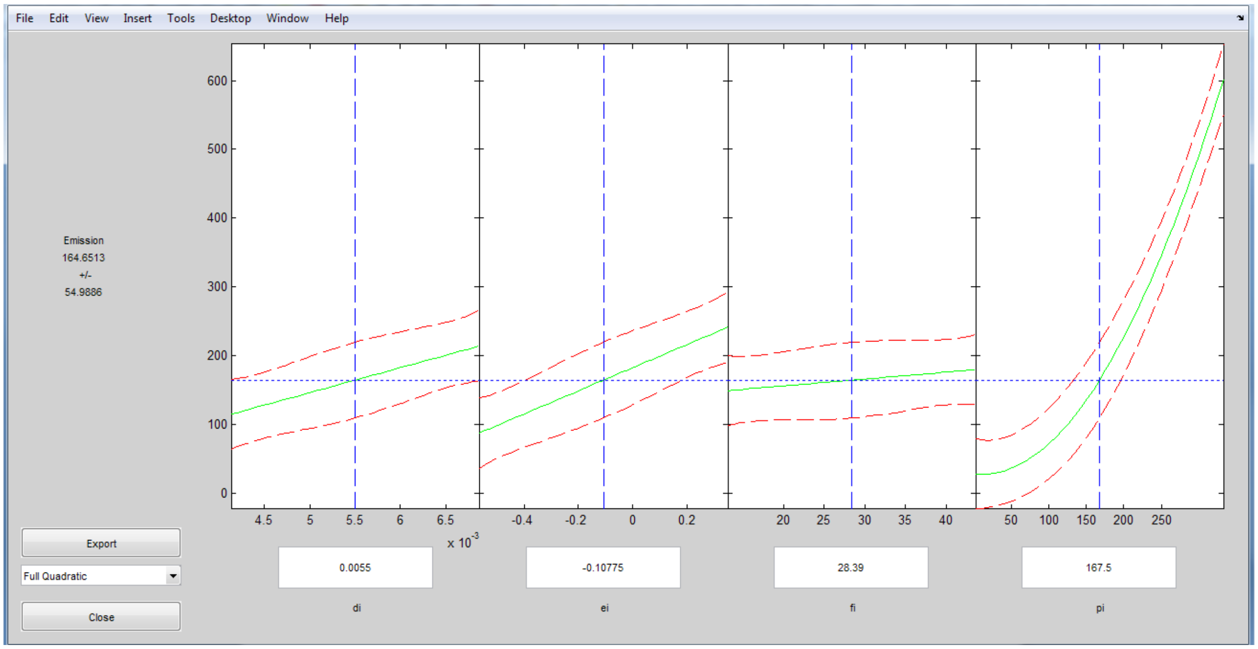

Figure 4: Interactive plot showing carbon emission values

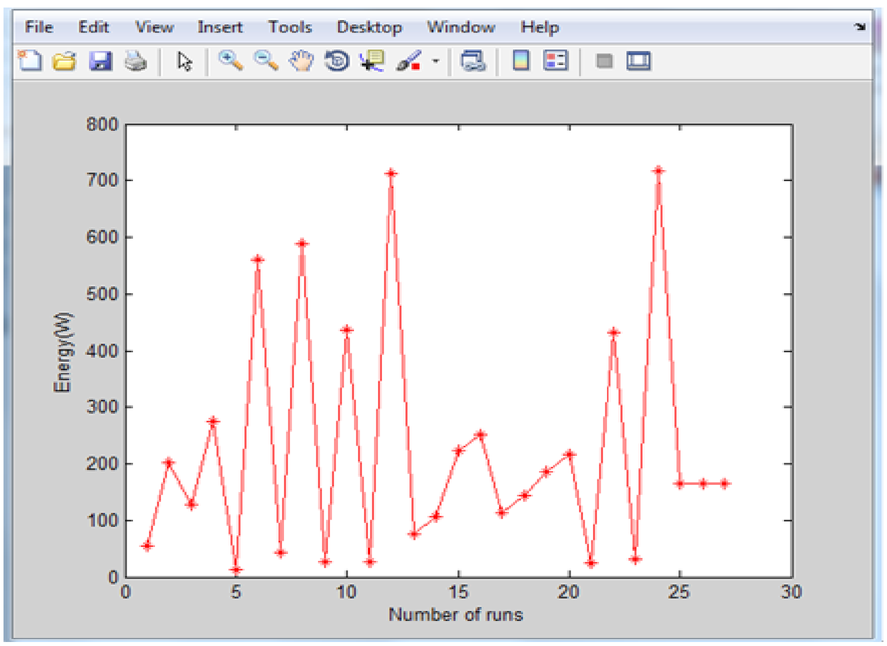

Figure 5: Energy prediction for proposed system

Initially, 3-generating units based test is simulated for various demands in the range of 200-400 MW. The carbon emission under variable load for various power demands in a 3-generator system is shown in Table 3. Second test system consists of 6-generating units with demand range of 500-1100 MW. The carbon emission under variable load of 6-generator system is shown in table 4.

Figure 7 shows the percentage deviation of all the optimization algorithms such as the Conventional, PSO, CS, ABC and SSO techniques from MICA method from three to six generator system, under existing methods from MICA are illustrated. Thus the graph depicts the proposed algorithm has best optimization performance

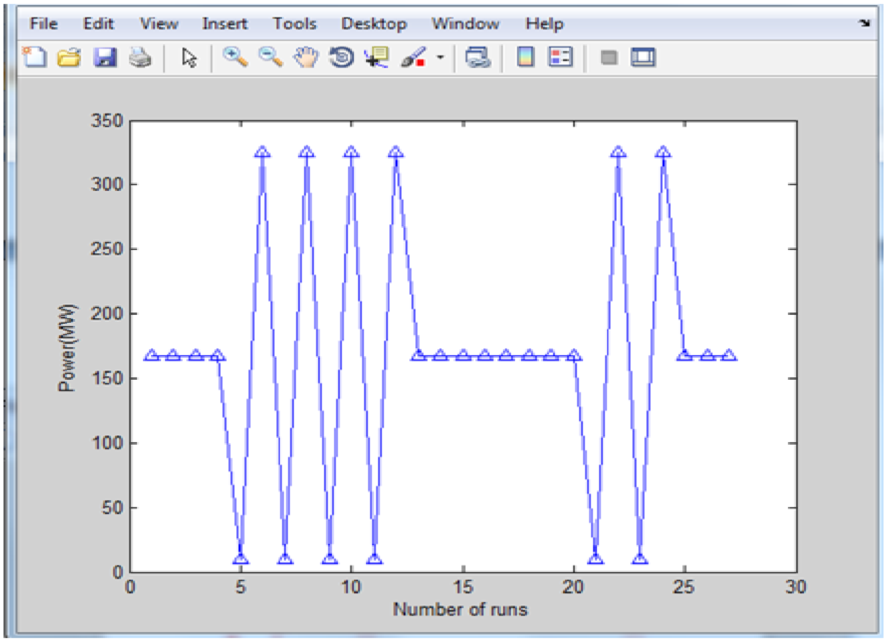

Figure 6: Power prediction for proposed system

compared with the existing algorithms. Figure 8 shows the percentage deviation of all the optimization algorithms such as the Conventional, PSO, CS, ABC and SSO methods from MICA method. In the three generator system the percentage deviation achieved by existing methods from MICA are shown in Figure 8. Thus the graph depicts the proposed algorithm has best optimization performance when compare to existing algorithms.

Table 3
Carbon emission under variable load for three generators system

Power Demand (MW)	*Conventional (kg/hr)*	*PSO (kg/hr)*	*CS (kg/hr)*	*ABC (kg/hr)*	*SSO (kg/hr)*	*MICA (kg/hr)*
200	529.26	447.3847	457.3364	446.8093	445.454	443.34
250	597.499	474.2944	500.6522	472.2116	471.656	470.99
300	684.826	516	526.44	512.75	509.56	507.33
350	791.24	579.2368	579.2368	577.709	573.64	571.23
400	916.742	664.9562	681.9939	656.3968	655.32	654.02

Table 4
Carbon emission under variable load for six generators system

Power Demand (MW)	*Conventional (kg/hr)*	*PSO (kg/hr)*	*CS (kg/hr)*	*ABC (kg/hr)*	*SSO (kg/hr)*	*MICA (kg/hr)*
500	261.634	275.0969	287.3355	259.2496	257.56	256.6
600	338.992	336.1699	337.5002	328.8721	325.36	323.45
700	434.38	423.7861	425.0213	421.5496	420.32	418.8
800	547.796	531.234	531.234	529.2357	525.654	523.5
900	679.24	650.0425	673.7841	645.7846	641.354	640.123
1000	828.72	792.4867	806.1682	790.3046	785.694	783.521
1100	996.224	958.1743	963.3274	949.3912	945.685	943.873

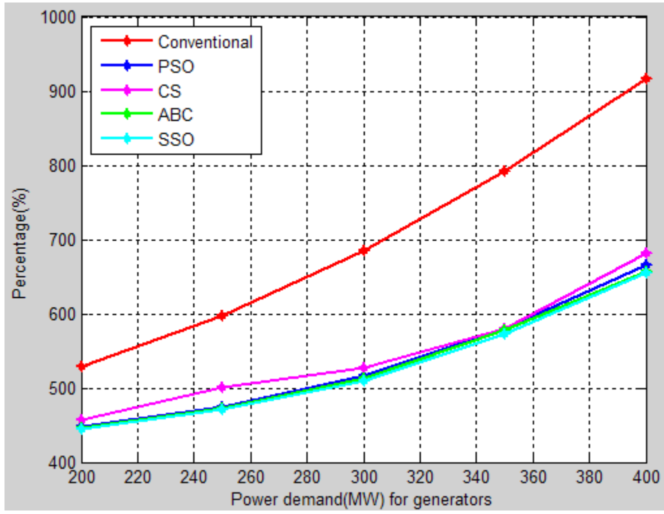

Figure 7: Deviation between each optimization techniques for three generator system of MICA

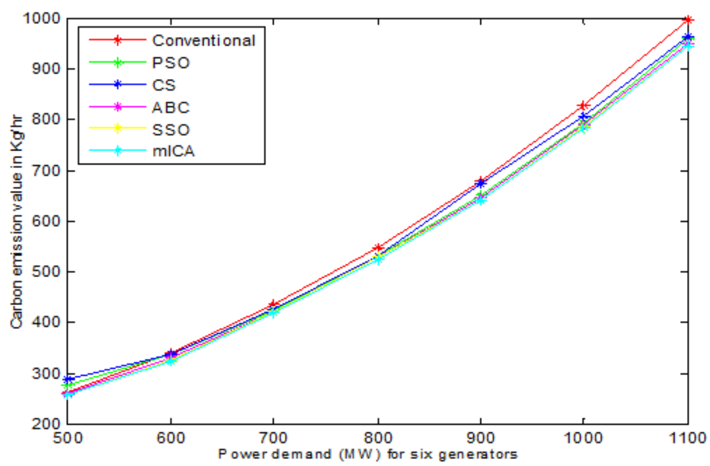

Figure 8: Deviation between each optimization techniques from MICA for six generator system

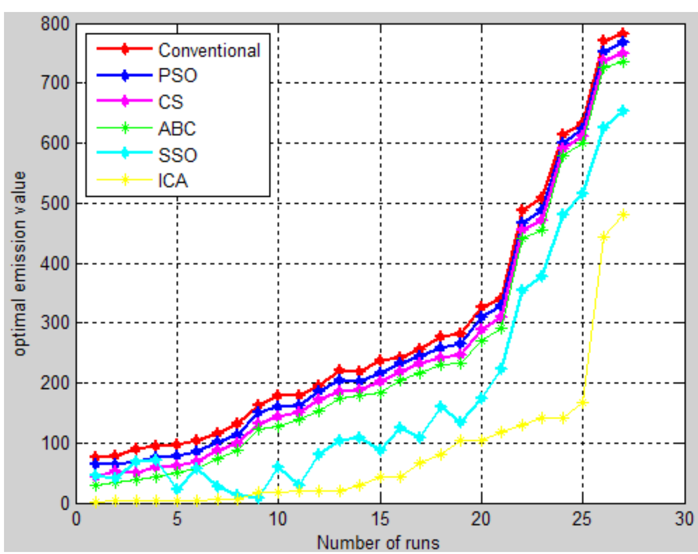

Figure 9: Optimal Carbon Emission Comparison

Figure 9 shows the optimal carbon emission value comparison of all the optimization algorithms such as the Conventional, PSO, CS, ABC and SSO techniques from MICA method. Thus the graph depicts the proposed algorithm with better optimal emission value when compared with the existing algorithms, and prediction accuracy is high in MICA.

5. CONCLUSION

This research paper has presented MICA based green sigma process applied to solve the environmental economic load dispatch problem to determine the optimal schedule of each generator and thereby contribute to reduction of emissions in a thermal power plant. Green sigma facilitates to determine the highest-priority opportunities to pursue, give the information to quantify the advantages, and provide the analysis and coverage tools needed to optimize operations, sustain advantages, and institutionalize continuous process improvement. It's seen from the simulation results that the proposed method reduces the effect of global warming by minimizing the amount of CO_2 level in fossil burning of fuels for each generator. The standard solution shows the promising feasible approach for solving the economic thermal power dispatch issue using MICA. The simulation results show the best optimal carbon emission values. The numerical results have shown the performance and pertinence of the proposed method. In future, various other optimization algorithms are proposed for the same system to yield better results.

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