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Research Article

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Development of intelligent algorithm for minimization of sulphur oxides carbon oxides and nitrogen oxides in flue gases

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ABSTRACT

Pollution control is a challenging task in the modern era. The major cause of air pollution is the flue gas from the thermal power stations. It is the primary pollutant which is directly emitted to the atmosphere causes severe health hazards. The major pollutant present in the flue gases are sulphur oxides, carbon oxides and the nitrogen oxides. Power generation from thermal power plants without air pollution is impossible, but it can be minimized. The objective function of this approach is minimization of pollutants in the flue gases subjected to equality and inequality constraints. In this proposed work a hybrid intelligent technique Genetic Algorithm based Artificial Bee Colony algorithm is implemented in IEEE 30 bus system.

Key words: Genetic Algorithm, Artificial Bee Colony, Newton Raphson load flow, Flue gas, Emission Coefficient.

INTRODUCTION

The atmosphere is mainly affected by air pollution because of the formation of green house gases by different ways. Large amount of green house gases are emitted in to atmosphere because of burning the fossil fuels. In most of the power plants the fossil fuels are used for the production of power generation. Nowadays the requirement of electrical energy is more in that most of the requirement can be satisfied by the thermal power plants. In thermal power plants the coal is used as a fuel. The power can be generated by burning the coal in the furnace. At the time of burning the coal more amount of flue gases are formed that can be used in several places in the plant and the remaining gases can be emitted to the atmosphere through chimney. The flue gas consists of large amount of sulphur oxides, nitrogen oxides, carbon oxides and other gases. When it is directly emitted to the atmosphere air can be polluted due to the effect of toxicity of the pollutant present in the gas. More production of flue gases leads to serious hazardous conditions.

Impact of Sulphur Oxides

When the sulphur content present in the flue gas is react with air sulphur oxides are formed. It is a color less gas but it is having strong odor. Due to the reaction acid precipitations are formed in the cloud .When it is react with water acid rains are formed. It is very harmful to living beings and plants. Continuous affecting of sulphur oxides can leads to respiratory system failure.

Impact of Nitrogen Oxides

Nitrogen content in the flue gas is react with the oxygen present in the air nitrogen oxides are formed which is reddish brown in color. The nitrogen oxides are nitric acid and nitrogen dioxide Due to nitrogen oxides irritations are formed in eyes, breathing of nitrogen oxides can cause irritation in throats which can leads to asthma and severe bronchitis. Formation nitric acid leads to acid rain.

Impact of Carbon oxides

In flue gases large amount of carbon content is present when it is react with air carbon monoxides and carbon dioxides are formed. It is a colorless and odorless gas. Carbon monoxide is a very dangerous gas. It is a colorless and odorless gas. It can react directly react with the iron content present in the hemoglobin of the blood. Due to this it can remove all the oxygen content in the blood finally it leads to death. But carbon dioxide is very useful to plants for photosynthesis and it emits oxygen to human beings.

Due to these impacts, controlling of emission gases present in flue gas is very essential. But controlling the sulphur oxide content, nitrogen oxide content and carbon oxide content in the flue gas at chimney increases the generation cost of the plant as well as it can deviate the limits of real power, reactive power and voltage levels. Without affecting the generation costs and limits, minimization of emission gas control is very difficult. This can be remedied by optimization technique. Several conventional techniques [1-2] are converged in local optimal solution. To overcome these effects intelligent techniques are introduced. In [3] Genetic algorithm based CEED problem is explained. In [4] Differential Evolution based CEED approach is developed. To increase the effectiveness the best features of Genetic algorithm and Differential Evolution are hybridized and applied in [5]. To get the optimal solution the best feature of Genetic Algorithm is combined with Artificial Bee Colony algorithm.

EXPERIMENTAL SECTION

Objective Function

The objective function of this problem is minimization of emission of sulphur oxides, nitrogen oxides and carbon oxides present in flue gas. This can be calculated by

Minimize Emission =

$$\sum_{i=1}^{NG}(A_i+B_iP_{gi}+C_iP^2gi) \qquad \text{tons/hr} \qquad (1)$$

Subjected to equality constraints from the power balance equation

$$\sum_{i=1}^{NG}P_{gi} = P_D+P_L \qquad (2)$$

$$\sum_{i=1}^{NG}Q_{gi} = Q_D+Q_L \qquad (3)$$

Inequality constraints of control and dependant variables

$$P_{gi}^{min} \le P_{gi} \le P_{gi}^{max} \qquad \text{for i=1to Ng} \qquad (4)$$

$$Q_{gi}^{min} \le Q_{gi} \le Q_{gi}^{max} \qquad \text{for i=1to NG} \qquad (5)$$

$$V_i^{min} \le V_i \le V_i^{max} \qquad \text{for i=1to NB} \qquad (6)$$

$$T_i^{min} \le T_i \le T_i^{max} \qquad \text{for i=1to NT} \qquad (7)$$

$$MVA_i \le MVA_i^{max} \qquad \text{for i=1to NL} \qquad (8)$$

Where,
P_{gi} & Q_{gi} – i^{th} generator real and reactive power generation
P_D & Q_D – total real and reactive power demand
P_L & Q_L – total real and reactive power loss
V_i – i^{th} bus voltage magnitude
T_i – i^{th} transformer tap position
MVA_i – i^{th} transmission line MVA flow
NG – number of generators
NB – number of bus
NT – number of transformer
NL – number of lines
A, B, &C – Emission coefficients

Implementation

Hybrid GA-ABC algorithm is used to solve emission minimization problem. In this problem IEEE 30 bus system is taken for implementation. The control variables considered in this approach are 5 real power generator bus, 6 generators voltage magnitude and 4 transformers tap position totally 15 control variables. All these control variables lies between lower and upper limits. The number of the employed bees is equal to the number of solutions in the population. First randomly distributed initial population is generated. The initial values are taken from the Newton Raphson load flow analysis. After initialization, calculate the fitness function and set as the solution of initial food source. The population is subjected to repeat the cycles of the search processes of the employed, onlooker, and scout bees, respectively. An employed bee produces a modification on the source position in her memory and searching a new food source position. To identify the source effectively the crossover operator of GA is introduced. This population is evolving iteration by iteration to find global optimal solution. The maximum number of iteration it may evolve is taken as 200 iterations and the population selected is 30.In this work single point cross over is used and cross over constant value 0.7 is considered. Hybrid GA-ABC algorithm gives good optimal solution as compared to all other developed algorithm.

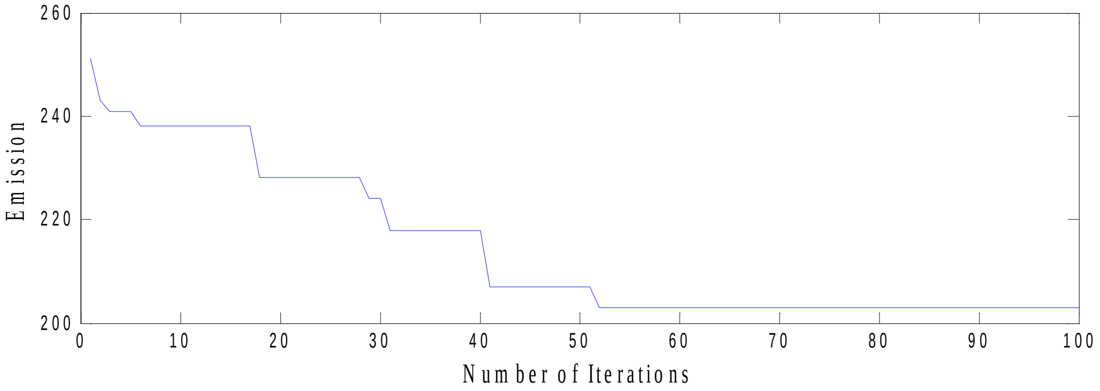
RESULTS AND DISCUSSION

The developed algorithm is implemented in IEEE 30 bus system. The line data and bus data are taken from [6]. In this bus only 6 generators are present. The emission coefficients of 6 generators are shown in Table-1.

Table-1 Generator emission coefficients

Gen. No	a (ton/hr)	b (ton/Mw hr)	c (ton/Mw^{2}hr)
1	4.091	-5.554	6.490
2	2.543	-6.047	5.638
3	4.258	-5.094	4.586
4	5.426	-3.550	3.380
5	4.258	-5.094	4.586
6	6.131	-5.555	5.151

Hybrid GA-ABC is iterated for 100 iterations the convergence characteristics is shown Figure-1 and converged around 41st iteration. By this approach a minimum emission of 0.203 ton/hr. is obtained.



Figue-1 Convergence Characteristics

Table-2 shows the control variables minimum and maximum limits and the optimal emission of this approach. The results of this approach are compared with DE-GA approach in [6]. The emission is reduced from 0.2045 ton/hr to 0.203 ton/hr.

Table - 2 Control variable limits and optimal solution

Sl. No.	Control variables	Min limit	Max limit	GA-ABC
1	P_{g1}	50	200	176
2	P_{g2}	20	80	56.3
3	P_{g3}	15	50	36.78
4	P_{g4}	10	35	22.37
5	P_{g5}	10	30	16.78
6	P_{g6}	12	40	22.8
7	V_{g1}	0.95	1.05	1.05

Sl. No.	**Control variables**	**Min limit**	**Max limit**	**GA-ABC**
8	V_{g2}	0.95	1.05	1.004
9	V_{g3}	0.95	1.05	1.036
10	V_{g4}	0.95	1.05	0.993
11	V_{g5}	0.95	1.05	1.011
12	V_{g6}	0.95	1.05	1.023
13	T_1	0.9	1.1	1.015
14	T_2	0.9	1.1	1.026
15	T_3	0.9	1.1	0.98
16	T_4	0.9	1.1	1.016
Emission (ton/hr)				**0.203**

CONCLUSION

This hybrid algorithm GA-ABC provides better solution for this emission minimization problem. ABC has no cross over operator and the solution may improved by adding cross over with it, since GA has better cross over ABC is hybrid with GA. The hybrid GA-ABC approach has faster convergence compared to other algorithm the number of iteration is less and also attains a better solution. This hybrid algorithm gives best results compared to other algorithms and satisfies all the equality and inequality constraints for the same test case IEEE 30 bus system with same constraints.

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