Scrutiny of Phenomena of Voltage Black out Criteria on Power System Transmission Line

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Abstract— Most of the research work summarized aims at reducing oxides of Sulphur (SO_x) and oxides of nitrogen (NOx).A major effort has been devoted in reducing one type of pollutants or a mixture of pollutants. The approaches are designed either to reduce the total production of emissions or to reduce the concentration of pollution at ground level at certain areas which depends on both emissions and meteorological factors. In this chapter a PSO algorithm is proposed to determine the optimal dispatch of generators, such that total fuel cost incurred and emissions are reduced. This algorithm has been tested on IEEE 30 bus and IEEE 57 bus system and the results obtained are comparable to that of conventional method.

Key words: PSO, Optimal Dispatch, Voltage Stability, Stability Criteria, Transmission Line, 30 Bus System

I. INTRODUCTION

Fossil-fuel fired electric power plants use coal, gas or combinations thereof as the primary energy resource, and produce atmospheric emissions whose nature and quantity depend on the fuel type and its quality. Coal produces particulate matter such as ash, and gaseous pollutants such as carbon oxides, sulfur oxides and oxides of nitrogen. The thermal energy dissipated in cooling water raises its temperature and may be considered as a pollutant. Hydro-plants produce no such emissions.[2] Nuclear power produces radiation emissions, which are well contained. The major part of electric power generation is due to fossil-fuel plants and their emissions contribution cannot be neglected. Pollution affects not only human beings, but also other life-forms such animals, buds, fish, and plants. It also causes damage to materials, reducing visibility, as well as causing global warming. [4]These effects may be interpreted as costs because they damage our life in one way or another. The damage caused by a pollutant depends on its type, meteorological conditions and on our exposure to it. This suggests that each pollutant should be treated on its own merit in assigning cost values usually referred to as valuing environmental externalities.

A. Motivation and Objective

This represents the harmfulness or damage created.

Emissions may be reduced through the following means:[7]

1) Post-combustion cleaning systems such as electrostatic precipitators (SOx emissions can be reduced by installing stack gas scrubbers).This requires not only considerable time for design, testing and installation, but also considerable capital outlay.[3]
2) Switching to fuels with low emission potential **(**Sox emissions may be reduced by switching permanently to low sulfur fuel). Fuel switching depends on the price and availability of low sulfur fuel such as oil, gas and coal of low sulfur contents. Switch from one type of fuel to another may result in losses of jobs in coal mining areas.
3) Dispatch the power generation to minimize emissions instead of the usual cost objective of economic dispatch.

The first method requires designing and installing of new equipment, while the second method requires modifying existing equipment and controls to suit the new fuel mix. The third method requires only minor modification of dispatching program to include emissions. Method 3 is economic and easy in operation compared to other.[5]

II. EMISSION DISPATCH USING PSO

A. Problem Formulation

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 power to meet the load demand. The emission function can be expressed as the sum of all types of emissions such as NO_X, SO_2, particulate materials and thermal radiation with suitable pricing for each pollutant emitted. In this project only NO_X emission is taken into account, since it is more harmful than other pollutants.[7]The NO_X emission can be approximated as shown in fig ., a quadratic function of the active power output from the generating units.

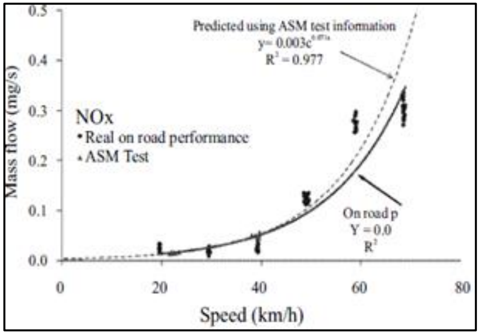

Fig. 1: NO_x Emission Function

The emission dispatch problem can be defined as the following optimization problem, [9]

$$Minimize\ E = \sum_{i=1}^{n} \alpha_i + \beta_i P_i + \gamma_i P_i^2 \qquad (1)$$

Where

E: total emission release (Kg/hr)

α_i, β_i, γ_i: emission coefficients of the ith generating unit Subject to demand constraint (4.2) and generating capacity limits (4.3).

$$\sum_{i=1}^{n} P_i = P_D + P_L \qquad (2)$$

$$P_{imin} \le P_i \le P_{imax} \qquad (3)$$

The well know solution method to this problem using the coordination equation is

$$PF_i \frac{dF_i(P_i)}{dP_i} = ... = PF_n \frac{dF_n(P_n)}{dP_n} \qquad (4)$$

Where $\frac{dF_i(P_i)}{dP_i}$ is the incremental cost denoted by

$$\lambda = b_i + 2c_i \qquad (5)$$

PF_i is the penalty factor of unit i given by

$$PF_i = \frac{1}{1 - \partial P_L / \partial P_i},$$

And $\partial P_L / \partial P_i$ is the incremental loss of unit i.

From Eq. (4.4) and (4.5) power output of i^{th} unit is given as

$$P_i = \frac{1 - \frac{\alpha_i}{\lambda_{emission}} - \sum_{j=1}^{n} 2B_{ij}P_j}{\frac{2\beta_i}{\lambda_{emission}} + 2B_{ii}} \qquad (6)$$

Network losses are expressed as a quadratic function:

$$P_L = \sum_{i=1}^{n}\sum_{i=1}^{n} P_i B_{ij} P_j + \sum_{i} P_i B_{i0} + B_{00} \qquad (7)$$

Where, B_{ij},B_{i0},B_{00} are constants called **B** coefficients or loss coefficients.

1) Representation of Individual

The proposed approach uses the equal system incremental emission release ($\lambda_{emission}$) as individual (particles) of PSO. Each individual within the population represents a candidate solution for solving the emission dispatch problem.

2) Evaluation Function

The evaluation function adopted is

$$f = \frac{1}{1 + k\left(\frac{\sum_{i=1}^{n} P_i - P_D - P_{loss}}{P_D}\right)} \qquad (8)$$

Where, *k* is a scaling constant (*k* = 50 in this study).

B. Algorithm

1) Specify the lower and upper bound generation power of each unit, and calculate λ_{max} and λ_{min}. Initialize randomly the individuals of the population according to the limit of each unit including individual dimensions, searching points, and Velocities. These initial individuals must be feasible candidate solutions that satisfy the practical operation constraints.
2) Set iteration count=1
3) Set population count=1
4) To each individual in the population (i.e at each $\lambda_{emision}$) compute power output of all generators using Eq. (6). Employ the B-coefficient loss formula Eq. (7) to calculate the transmission loss $P_{L.}$
5) Calculate the evaluation value of each individual in the population using Eq.(8)

   Compare each individual's evaluation value with its P_{best}. If the evaluation value of each individual is better than the previous P_{best}, the current value is set to be P_{best}.
6) Increment individual count by 1. If count < population size goto step (4).
7) The best evaluation value among the P_{best} is denoted as g_{best}
8) Modify the member velocity V of each individual according to

$$v_i^{k+1} = k*(w*v_i^k + c_1*rand_1*(pbest_i - x_i) + c_2*r\ and_2*(gbest_i - x_i))$$

$$x_i^{k+1} = x_i + v_i^{k+1}$$

   Where
   v_i^k: velocity of particle i at iteration k
   w: inertia weight factor
   c_1, c_2: learning factor
   $rand_1$, $rand_2$: random number between 0 and 1
   x_i^k: position of particle i at iteration k
9) If $v_i^{k+1} > V_{max}$, then $v_i^{k+1} = V_{max}$ and if $v_i^{k+1} < -V_{max}$, then $v_i^{k+1} = -V_{max}$).
10) Modify the member position of each individual Pi according to $Pi^{(k+1)} = Pi^{(k)} + Vi^{(k+1)}$ and $Pi^{(k+1)}$ must satisfy the constraints.
11) Increment iteration count by 1.If the number of iterations reaches the maximum, then go to Step 13.Otherwise, go to Step 3.
12) The individual that generates the latest g_{best} is the optimal generation power of each unit with the minimum emission release.
13) At this power generation compute total fuel cost. Run FDC load flow to determine system losses and stability index.

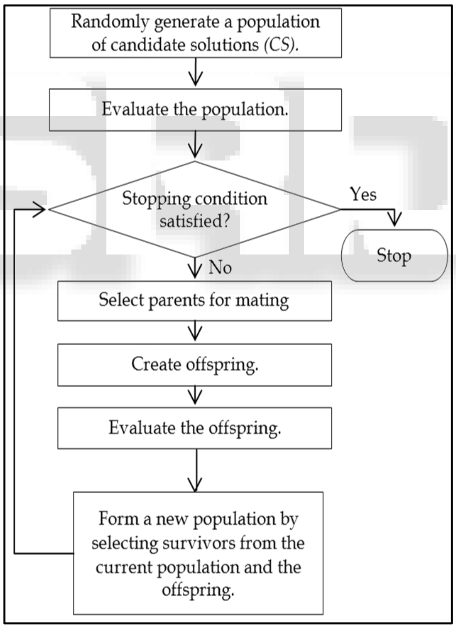

Fig. 2: Flow chart

III. CASE STUDIES AND RESULTS

A. IEEE 30 bus system

The IEEE 30 bus system data is presented at appendix A. The PSO parameters used in this case study are: No of particles 60, learning factors c_1=2.05, c_2=2.05, weight factor w=1.2, constriction factor K=0.7925. Maximum number of iterations=100.

IV. RESULTS

25 independent runs are made and results are given in Table-

S. No	Fuel Cost ($/hr)	Emission (kg/hr)	Loss (MW)	Stability Index

1	935.716224	229.830261	5.206237	0.286704
2	936.740038	229.914310	5.178947	0.241042
3	934.716287	232.397552	5.490850	0.378935
4	936.406602	230.038230	5.431610	0.234593
5	933.048693	230.972685	6.190436	0.567414
6	933.291444	229.623982	4.978802	0.288559
7	934.911517	230.363464	5.776981	0.361696
8	923.680543	231.267412	5.977318	0.567225
9	934.869489	229.879392	5.267346	0.278989
10	941.838934	230.886463	6.350915	0.826250
11	934.492880	231.711469	5.799568	0.892337
12	939.979565	232.431421	5.872153	0.944405
13	937.165226	230.561047	6.035668	0.258353
14	933.256176	229.241600	4.502957	0.260216
15	935.562217	229.879379	5.262585	0.975758
16	939.705526	230.073516	5.068460	0.250473
17	935.696315	231.200970	4.970010	0.249642
18	937.643584	230.205955	5.623568	0.456873
19	935.036720	229.813272	5.190821	0.269874
20	934.190655	231.079826	4.393658	0.268167
21	933.213469	229.220726	4.477311	0.265723
22	932.094511	229.144834	4.404039	0.267070
23	938.736354	230.877748	6.382204	0.226367
24	940.631650	230.657277	6.109790	0.411644
25	934.197496	229.230332	4.476639	0.261995
Min	932.094511	229.144834	4.404039	0.267070

Fuel Cost ($/hr)	Emission (kg/hr)	Loss (MW)	Stability Index
932.094511	229.144834	4.404039	0.267070

Table 1: 25 independent runs are made and results

System generation =287.804039MW

Graphs of emission release, fuel cost, and total system losses are shown in Fig. as followings

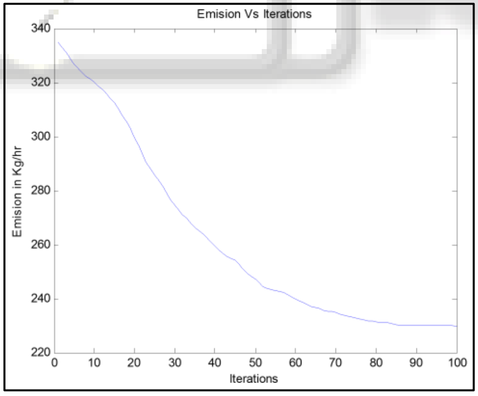

Fig. 3: Total Emission release versus iterations

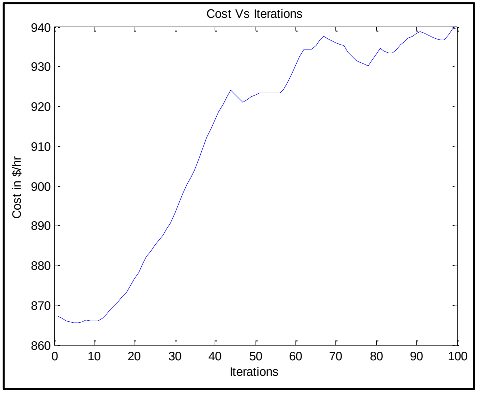

Fig. 4: Total fuel cost

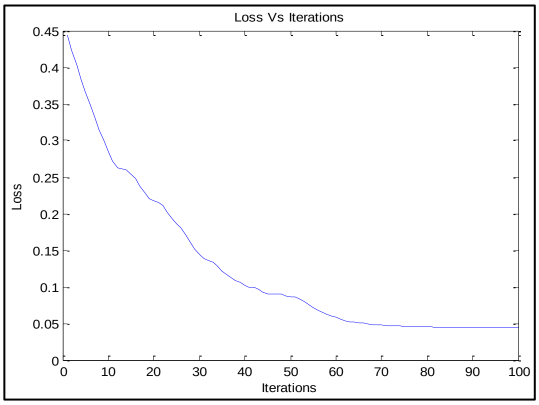

Fig. 5: Total system losses

Using PSO, we get optimal dispatch of generators for minimizing total emission release. Using these power outputs of generators FDC load flow is made. The converged voltages, reactive power generations at all buses and Lindex at each bus are then obtained. Those values are shown in table-

S. No	Voltage	Pgen	Qgen	Lindex
1	1.000000	0.662716	-0.287728	0.000000
2	1.006944	0.665546	0.110742	0.000000
3	0.992035	0.500037	0.153665	0.000000
4	0.995768	0.349773	0.582340	0.000000
5	1.013996	0.300004	-0.024995	0.000000
6	1.000000	0.399767	0.645928	0.000000
7	1.004308	-0.000000	-0.000000	0.001359
8	0.998311	-0.000001	-0.000000	0.004968
9	1.064750	0.000116	0.000000	0.091635
10	1.042402	0.000509	-0.000003	0.111095
11	1.064750	0.000000	0.000000	0.091635
12	1.055635	-0.000685	-0.000005	0.114302
13	1.045484	-0.000016	-0.000006	0.122688
14	1.040805	-0.000013	0.000001	0.120771
15	1.036691	-0.000014	0.000001	0.118803
16	1.027732	0.000727	0.000003	0.110176
17	1.032669	0.000006	0.000001	0.113114
18	1.025757	-0.000003	0.000000	0.126995
19	1.023140	-0.000003	-0.000000	0.128013
20	1.027181	0.000003	-0.000001	0.124293
21	1.027099	0.000014	-0.000005	0.115161
22	1.026731	-0.000432	-0.000000	0.114760
23	1.027049	-0.000003	-0.000000	0.118745
24	1.022552	0.000002	-0.000002	0.115662
25	1.044043	-0.000002	0.000000	0.100204
26	1.026834	-0.000002	-0.000000	0.105702
27	1.065632	0.000065	-0.000003	0.089553
28	0.992489	-0.000058	0.000000	0.012563
29	1.046661	-0.000002	0.000000	0.104591
30	1.035686	-0.000008	0.000001	0.118118

Table 2: The converged voltages, reactive power generations at all buses and Lindex at each bus

A. IEEE 57 Bus System

The IEEE 57 bus system data is presented at appendix B. The PSO parameters used in this case study are: No of particles 60, learning factors c_1=2.05, c_2=2.05, weight factor w=1.2, constriction factor K=0.7925. Maximum number of iterations = 100. Minimum of all 25 independent runs is given in table 4.3

Fuel Cost ($/hr)	Emission (kg/hr)	Loss (MW)	Stability Index
767.669895	144.904969	23.525670	6.67085

Table 3: Minimum of all 25 independent runs

Total System generation = 1440.025670MW

Graph of emission release is shown in Fig.

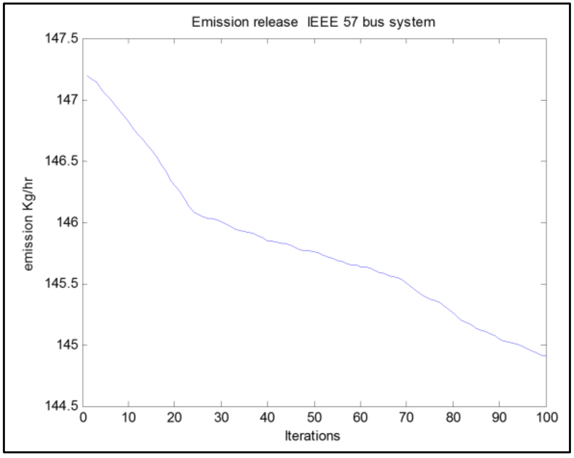

Fig. 6: Total emission release

V. CONCLUSION

Transmission line is very sensitive for the voltage collapse .so if any small variation is occur in it that will responsible for the huge effect in their performance analysis. If voltage changes then the current changes which cause to the variation the transmission losses, just like copper losses, corona loss, skin effects, proximity effects. Etc.

In this way there is essential to identify the criteria up to which they gives better performance and enhance the efficiency and reliability of the power system.

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