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A Review On Improved Partical Swarm Optimization For Multi-Ojective Optical Power Flow Considering The Cost,Loss, Emission And Voltage Stability Index

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Abstract

Traditional Economic Load Dispatch deals with minimizing generation cost while maintaining set of equality and equality constraints. On the other hand, the fossil fuel plants pollutes environment by emitting some toxic gases. Thus conventional minimum cost operation can not be the only basis for generation dispatch; emission minimization must also be taken care of. Power system must be operated in such a way that both real and reactive powers are optimized simultaneously. Reactive powers should be optimized to provide better voltage profile as well as to reduce system losses. Thus the objective of reactive power optimization problem can be seen as minimization of real power loss over the transmission lines. Now a days large integrated power systems are being operated under heavily stressed conditions which imposes threat to voltage stability. Voltage collapse occurs when a very low voltage profile or collapses. All these four objectives are to be met for efficient operation and control. The results of all the four objectives are conflicting and noncommensurable. Hence an efficient control which meets all the specified objectives is required.

In this project an attempt has been made to optimize each objective individually using Particle Swarm Optimization. The so developed algorithm for Optimization of each objective is tested on two systems i.e. on IEEE 30 and IEEE 57 bus system. In this work a method has been proposed to solve multiobjective optimization method using fuzzy decision satisfaction method while the objectives are minimized individually using Particle Swarm Optimization. Simulation results of IEEE 30 bus and IEEE 57 bus network are presented to show the effectiveness of the proposed method.

Key Words:*PSO, Economic dispatch control*

1. Introduction

Power system should be operated in such a fashion that simultaneously real and reactive power is optimized. Real power optimization problem is the traditional economic

dispatch which minimizes the real power generation cost. Reactive power should be optimized to provide better voltage profile as well as to reduce total system transmission loss. Thus the objective of reactive power optimization problem can be seen as minimization of real power loss over the transmission lines. Traditional Economic Dispatch [1] aims at scheduling committed generating unit's outputs to meet the load demand at minimum fuel cost while satisfying equality and inequality constraints. On the other hand thermal power plants (which contribute major part of electric power generation) create environmental pollution by emitting toxic gases such as carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen oxides (NOx). Increasing public awareness against environment pollution and Kyoto agreement has forced thermal power plants to limit these emissions. Several strategies for minimizing these emissions have been proposed among which dispatch of generating units to minimize emissions as well as fuel cost is the most attractive approach as this can be applied to the traditional economic dispatch algorithm with slight modification.

Initially Economic/Environmental dispatch (EED) problem was solved by minimizing fuel cost considering emission as one of the constraints. Different methods have been reported in literature for solving the multiobjective EED problem such as weighting factor approach, ε-constraint method, classical Newton - Raphson method, goal programming approach etc.

PARTICLE SWARM OPTIMIZATION

Particle swarm optimization (PSO) is a population based stochastic optimization technique developed by Dr. Eberhart and Dr. Kennedy in 1995, inspired by social behavior of bird flocking or fish schooling. [3]

PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithms (GA). The system is initialized with a population of random solutions and searches for optima by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum particles.

In past several years, PSO has been successfully applied in many research and application areas. It is demonstrated that PSO gets better results in a faster, cheaper way compared with other methods. [4]

Compared to GA, the advantages of PSO are that PSO is easy to implement and there are few parameters to adjust. One version, with slight variations, works well in a wide variety of applications. Particle swarm optimization has been used for approaches that can be used across a wide range of applications, as well as for specific applications focused on a specific requirement. PSO has been successfully applied in areas like, function optimization, artificial neural network training, fuzzy system control, and other areas where GA can be applied.

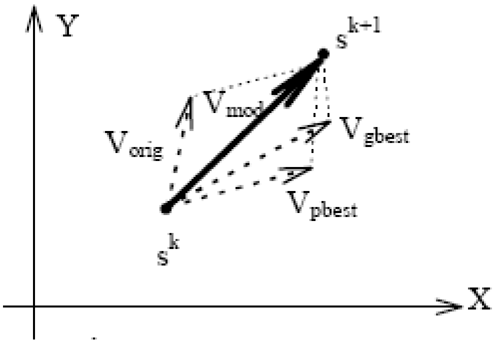

Fig 1.1.Concept of modification of a searching point.

S^k	Current Position
S^{k+1}	Modified Position
V_{orig}	Current Velocity
V_{mod}	Modified Velocity
V_{pbest}	Velocity base on $pbest$
V_{gbest}	Velocity based on $gbest$

2. ECONOMIC DISPATCH USING PSO

The use of electricity is indispensable in modern age. The quality of electricity is stated in terms of constant voltage, constant frequency and uninterrupted power supply at minimum cost For arriving at minimum cost we consider the case of thermal power plants. The quantity of coal and the cost of coal used in the generation of power in a thermal plant is directly dependant on the power output produced. Therefore in order to deliver the power at minimum cost, we need to reduce the amount of fuel used. This simple solution for this is the use of more efficient generating units. But there is certain maximum limit for the efficiency of the generating units. So for a particular power output the operating schedule with the distribution of load among the various units, which results in minimum generating cost is required. Preparation of such appropriate schedule is nothing but our economic dispatch problem.

In this chapter PSO algorithm is proposed to determine the optimal dispatch of generators, such that total fuel cost incurred is reduced. This algorithm has been tested on IEEE 30 bus and IEEE 57 bus system .

3. PROBLEM FORMULATION

The ED problem is to determine the optimal combination of power outputs of all generating units to minimize the total fuel cost while satisfying the load demand and operational constraints. Since the total cost of generation is a function of the individual generation of the sources which can take values within certain constraints, the cost of generation will depend upon the system constraint for a particular load demand. This means the cost of generation is not fixed for a particular load demand but depends upon the operational constraints of the sources.

Broadly speaking there are two types of system constraints: (1) Equality constraints, and (2) Inequality constraints. Inequality constraints are two types: (a) Hard type and (b) Soft type. The hard type are those which are definite and specific like the tapping range of an on-load tap changing transformer whereas soft type are those which have some flexibility associated with them like the nodal voltages and phase angle between the nodal voltages, etc. Soft inequality constraints have been very efficiently handled by the penalty function.

Objective Function

The economic dispatch problem is a constrained optimization problem and it can be mathematically expressed as follows:

$$\text{Minimize} \qquad F_T=\sum_{i=1}^{n} F_i\left(P_i\right) \tag{3.1}$$

Where F_T = Total cost of generation (Rs/hr)

n = Number of generators

P_i = Real power generation of ith generator

f_i = Fuel cost function of ith generator

subject to a number of power systems network equality and inequality constraints.

Each generator cost function establishes the relationship between the power injected to the system by the generator and the incurred costs to load the machine to that capacity. Typically, generators are modeled by smooth quadratic functions such as to simplify y the optimization problem and facilitate the application of classical techniques

$$F_T=\sum_{i=1}^{n} F_i(P_i)=\sum_{i=1}^{n} a_i+b_iP_i+c_iP_i^2 \tag{3.2}$$

where, a_i , $b_i$and c_i are fuel cost coefficients

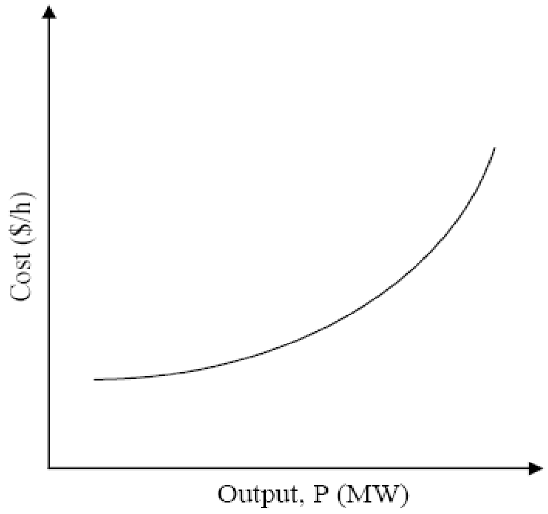

Fig. 3.1 Typical Fuel Cost Function of a Thermal generation Unit

Equality Constraint:

The power balance constraint is an equality constraint that reduces the power system to a basic principle of equilibrium between total system generation and total system loads. Equilibrium is only met when the total system generation ($\sum P_i$) equals to the total system load (P_D) plus the system losses(P_{Loss})

$$\sum_{i=1}^{n} P_i = P_D + P_L \tag{3.3}$$

4. EMISSION DISPATCH USING PSO

NO_X emission is taken into account, since it is more harmful than other pollutants. The NO_X emission can be approximated as shown in fig 4.1, a quadratic function of the active power output from the generating units.

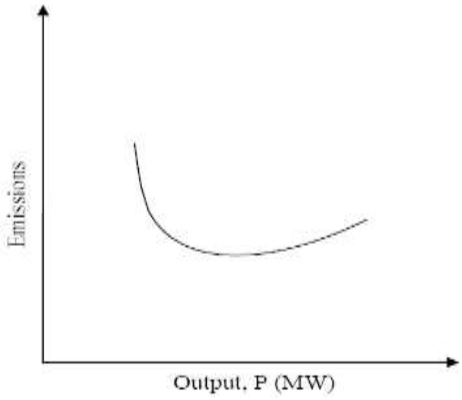

Fig.4.1(a)NO_x Emission Function

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

$$Minimize\ E = \sum_{i=1}^{n} \alpha_i + \beta_i P_i + \gamma_i P_i^2 \tag{4.1}$$

where

E : total emission release (Kg/hr)

α_i, β_i, γ_i : emission coefficients of the i^{th} generating unit

Subject to demand constraint (4.2) and generating capacity limits (4.3).

$$\sum_{i=1}^{n} P_i = P_D + P_L$$

(4.2)

$$P_{imin} \le P_i \le P_{imax}$$

(4.3)

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

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

(4.4)

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

$=b_i+2c_i$ (4.5)

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.

4.1RESULTS

25 independent runs are made and results are given in Table 4.1(a)

Table 4.1(a)independent run results

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**

Minimum of all the 25 results:

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

System generation =287.804039MW

Graphs of emission release, fuel cost, and total system losses are shown in Fig 4.1(b), 4.1(c), 4.1(d) respectively

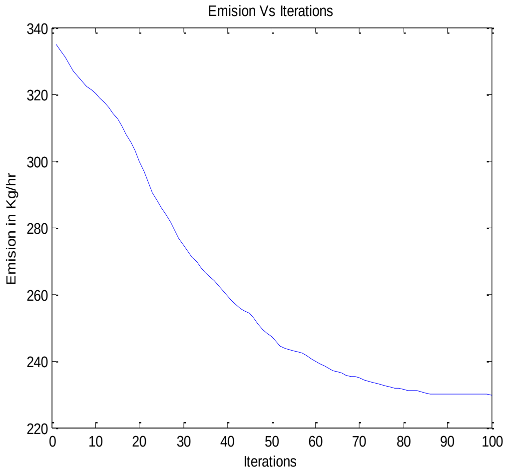

Fig 4.(b) Total Emission release versus iterations

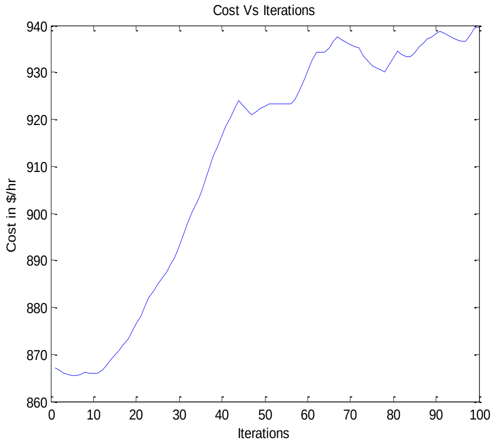

Fig 4.1(c) Total cost losses

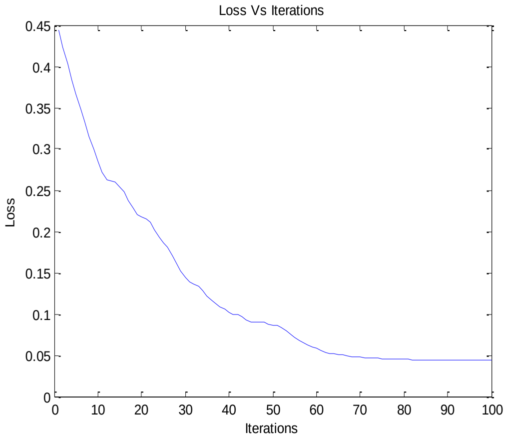

Fig 4.1(d) total system losses

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 4.2(b)

Table 4.2(b) Results of FDC Load flow

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

4.2 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 4.2(c)

Table 4.2(a) Minimum of all 25 independent runs

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

Total System generation = 1440.025670MW

Graph of emission release is shown in Fig 4.2(d)

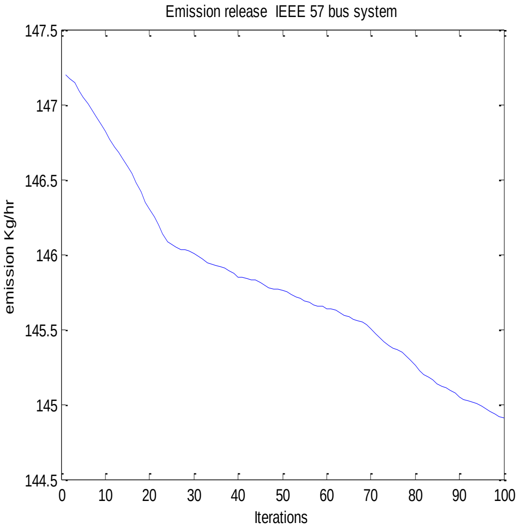

Figure 4.2(a) total emission release

5 CONCLUSION

In this work an approach to solve multiobjective problem which aims at minimizing fuel cost, real power loss, emission release and improving stability index of the system simultaneously has been proposed. Several system constraints (namely limits on generator real and reactive powers output, limits on bus voltage magnitude and angles) are taken care off.

We have successfully implemented Particle Swarm Optimization solution for Economic Dispatch Problem. The so algorithm has been tested on IEEE 30 bus system and IEEE 57 bus system. An attempt has been made to determine the optimum dispatch of generators, when emission release is taken as objective. The algorithm has been tested on IEEE 30 bus and IEEE 57 bus system. Reactive power optimization is taken as another objective and the algorithm has been developed for minimizing the total system losses using PSO. Improving stability index of the system is taken as another independent objective and this improvement is done using PSO. Thus all the four objectives are solved individually and the results from these individual optimizations are fuzzified and final trade off solution is thus obtained. In this work basic assumption made is that the decision maker (DM) has imprecise or fuzzy goals of satisfying each of the objectives, the multiobjective problem is thus formulated as a fuzzy satisfaction maximization problem which is basically a min-max problem.

Our proposed approach satisfactorily finds global optimal solution within a small number of iterations. The algorithm is fast and can be applied online. The multiobjective problem is handled using the fuzzy decision satisfaction maximization technique which is an efficient technique to obtain trade off solution in multiobjective problems. But as the evolutionary methods PSO also has the drawback of not converging to exactly same value all the times due to stochastic nature. But in this case PSO has almost returned the same value for most of the cases.

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