A Multi objective function Based Optimization for minimal Cost, Emission and Voltage Stability using Fuzzified PSO

K.SWETHA, K.CHANDRA SEKHAR

PG student, Dept of electrical engineering, A.U College of Engg, A.P. ,INDIA swethakaryampudi99@gmail.com
Associate professor,Deptofelectricalengineering,A.U College of Engg,A.P.,Indiakona.chandrasekhar699@gmail.com

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Abstract: *This paper presents a brief study on economic dispatch problem using particle swarm optimization as a tool for finding the minimal fuel cost, emission and maintaining stable voltage. When problems are formulated individually it is found that there is a conflict among the results of the three problems. So in order to obtain balanced solution multi objective function is formulated using fuzzy combined with PSO is tested on 30 bus system and the efficiency of the PSO method results are also presented here.*

***Key Words*: Particle swarm optimization PSO, Fuzzy, Emission, Voltage Stability, Thermal power plant (tpp)**

1. INTRODUCTION

One of the objectives in the operation of today's complex electric power systems is to meet the demand for power at the lowest possible cost, while provides consumers with adequate and secure electricity.[1].Eberhart and Kennedy are the two persons who got inspired by the social behavior of bird flocking led to the evolution of particle swarm optimization which is a continuous non linear optimization techniques. It is a population based heuristic technique.

2. Overview of particle swarm optimization

The basic principles in "classical" PSO are very simple. A set of moving particles (the swarm) will be set into the search area.

Each particle has a position vector of *Xi* and a velocity vector *Vi*.The position vector *Xi* and the velocity vector *Vi* of the *i* th particle in the *n*-dimensional search area could be represented as $Xi= (xi1, xi2, xin)$ and $Vi= (vi_1, vi_2, v_{in})$ respectively. The memory with which each particle finds the best position is called Pbest and best location is known as Gbest. Assume $Pbest = (xi1Pbest, xi2Pbest, ..., xin(Pbest)$) and $Gbest = (x1Gbest, x2Gbest, ...,xn(Gbest))$ be the best positions of the individual *i* and all the individuals. At each level, the velocity of the *i* th particle will be updated according to the following equation in the PSO algorithm.

$Vik+1=\omega Vik+c1r1\times Pbestik-Xik+c2r2\times Gbestk-Xik$ ……….. (1)

In this velocity updating process, the acceleration coefficients $c1$, $c2$ and the inertia weight ω are predefined and $r1$, $r2$ are uniformly generated random numbers in the range of [0, 1]. In general, the inertia weight ω is set according to the following equation:

$\omega= \omega max-\omega max-\omega minitermax\times iter$……… (2)

The approach used by Eq (2) is called the "inertia weight approach .With the help of above equation diversification characteristic is gradually decreased and a specific velocity, which gradually moves through the current searching point close to *Pbest* and *Gbest,* can be calculated .Each individual moves from the present position to the next one by the modified velocity in Eq (1) using the following equation: $Xik+1=Xik+Vik+1$……… (3) [1]

2.1Pseudo code for pso

Initialize particle;
End;
Do For each particle;
Calculate fitness value;
If the fitness value is better than the best fitness value (*pbest*) ;
Set current value as the new *pbest;*
End;
Choose the particle with the best fitness value of all the particles as the *gbest;*
For each particle;
Calculate particle velocity according equation;
Update particle position according equation;
End;
While maximum iterations or minimum error criteria are not attained;

End;

3. Problem formulation

Each particle consists of power generations of all units excluding taps, shunts and slack bus voltage. The size of each particle is equal to sum of active power generations, no of voltages excluding slack bus, number of voltage, taps, and shunts.

3.1 Fuel minimization problem:

The use of electricity is like "can't live without" in modern age. The quality of electricity is estimated in terms of voltage, frequency and power supply at low cost. For reducing the cost thermal power plants play a major role. The quantity of raw material used in the generation of power in a tpp is directly dependant on the output power. For the delivery of the power at low cost, the quantity of fuel used must be minimized for this purpose efficient generating units must be identified and scheduled. Load must be scheduled properly for minimizing cost this is called economic dispatch.

Minimize: $F_T = \sum_{i=1}^{n} F_i(P_i)$

$$F_T = \sum_{i=1}^{n} F_i(P_i) = \sum_{i=1}^{n} a_i + b_i P_i + c_i P_i^2$$

Where F_T = Total cost of generation ($/hr) P_i = Real power generation of ith generator, F_i=Fuel cost function of ith generator, n = Number of generators, a_i, b_i and c_i are fuel cost coefficients [5]

3.2 Emission minimization problem:

The emissions from the thermal plants are dangerous effluents like smoke, ash, Co2, No2, So_2etc

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

E: total emission release (Kg/hr)

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

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

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

3.3 Stability problem:

Voltage stability is concerned with the ability of a power system to maintain acceptable voltages at all nodes in the system under normal condition and after being subject to a disturbance [4].A power system is said to have a situation of voltage instability when a disturbance causes a continuous and uncontrollable rise and fall in voltage level.

There is a number of system black-outs caused by voltage instabilities so far. Most of the network problems are caused due to sudden raise in load, loss of transmission line, a transformer or a generator. As power systems become more complex and heavily loaded, voltage instability becomes a great problem.[5]

$$voltage\ stability(i) = 1 - \left| \frac{\sum FLG(j\ no\ of\ units, i) * E(i)}{E(j)} \right|$$

Where FLG =-$[Y_{LL}]^{-1}$* $[Y_{LG}]$

4. Observation

From the results it is observed that in the process of fuel minimization stability, emissions are violating the limits. When emission as an objective function is formulated the other two values are high similarly while stability problem is solved results shows that the other two are high. In order to avoid this problem multi objective function is formed with fuel, emission and stability as constraints. These constraints are fuzzified using fuzzy min-max logic along with particle swarm optimization. Our objective is to determine an optimal solution for all the three optimization sub problems. Our goal is to minimize
G(X) = {G1(X1), G2(X2),G3(X3)}.
While satisfying the set of constraints AX Where G1(X) is Fuel cost minimization problem. G2(X) is emission minimization problem. G3(X) is stability index minimization problem. Let F1 (Xi) be the fuel cost in $/hr for ith control vector, F2 (Xi) be the Emission release in kg/hr for ith control vector, F3 (Xi) be the index for ith control vector.

4.1 Proposed code for multi objective Function:

i. Load the values of fixed cost, loss, index, emission for each problem.

ii. Form admittance matrix and FLG matrix for Lindex calculation.

iii. Form B1 sub matrix. Decompose B1.

iv. Initialize population and velocities

v. Set Pbest=0 and itercount=1,Set particle count=1

vi. The values of power generations, voltage, magnitudes, tap values and shunts are obtained

vii. Form the Ybus and B2 sub matrix. Decompose B2

viii. Run FDC load flow and calculate cost, emission, and index values.

ix.Fuzzify fuel cost emission and index obtained.

x. Compute the value of each individual in the population and compare it with each its P_{best} value. If the obtained value is better than the previous value, the present value is set to be P_{best}.

xi. Increment individual count by +1. If count < size of population go to step vi.

x. The best value among the P_{best} is denoted as g_{best}.

xi. Update the velocity V of each individual according to
$v_i^{k+1} = k*(w*v_i^k + c_1*rand_1*(pbest_i - x_i) + c_2*rand_2*(gbest_i - x_i)), x_i^{k+1} = x_i + v_i^{k+1}$

xii. Update the member position of each individual P_i according to $P_i^{(k+1)} = P_i^{(k)} + V_i^{(k+1)}$

xiii. The individual that generates the g_{best}, is the required for the solution. [4],[5]

5. Results and Discussion:

The above proposed system when tested on 30 bus system following results are obtained

When fuel as objective function

System demand =283.400000MW

Total cost =807.340978$/hr

Total emission =381.574334Kg/hr

Voltage Stability of the system =0.470460

The line losses of the system =10.830509 MW

When emission is taken as objective function:

Total emission =229.730456Kg/hr

Total cost =935.242976$/hr

Voltage Stability of the system =0.390901 p.u

The line losses of the system =5.088603 MW

When voltage stability is taken as objective function

Voltage stability of the system =0.171782

Total cost =898.024280$/hr

Total emission =318.430656Kg/hr

The line losses of the system =22.536161 MW

The lower voltage magnitude limits of all the buses are 0.95 p.u. and the upper limits are 1.1 for all the PV buses and 1.05 p.u. for all the PQ buses and the reference bus [6].We can understand that when the problems are formulated independently results indicate there is either rise or fall the cost, emission and voltage stability. So with the help of fuzzy min max approach combined with particle swarm optimization is formulated and solved

When multi objective function is formulated with the three constraints

Total cost =951.710855$/hr

Total emission =234.204773Kg/hr

Voltage Stability of the system =0.267629

The line losses of the system =4.325734

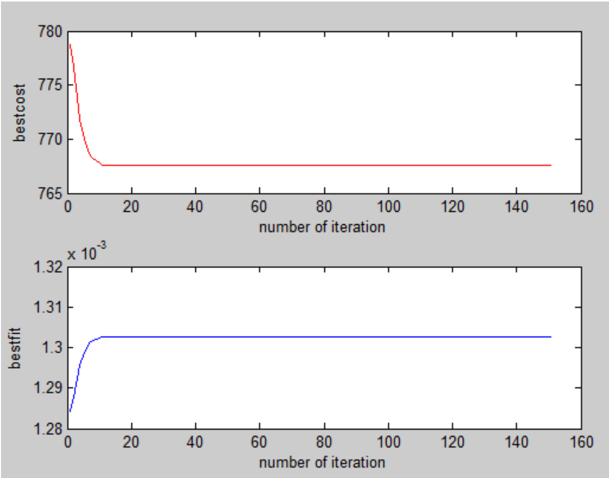

Figure 1: best cost and best fit vs no of iterations.

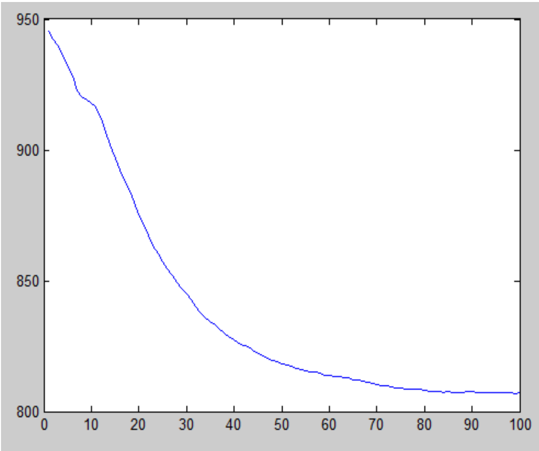

Figure 2: Cost vs Iterations

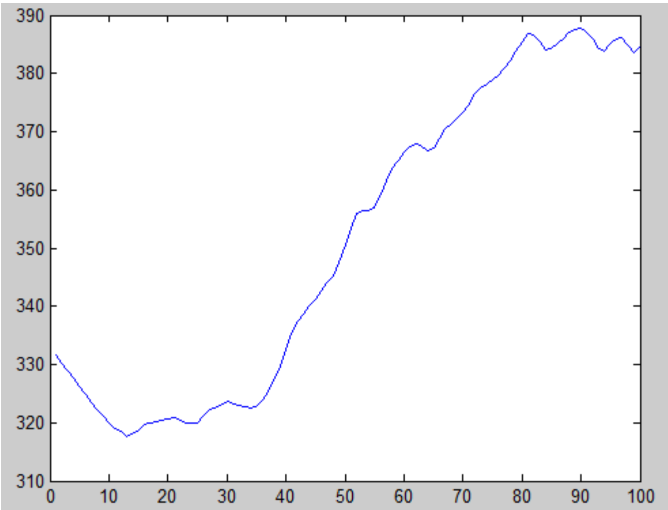

Figure 3: Emission vs Iteration

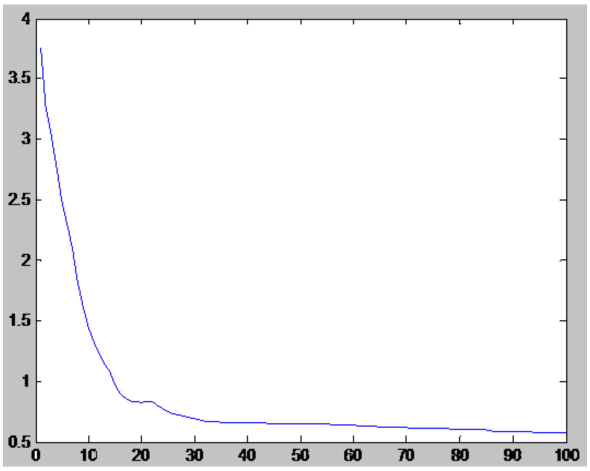

Figure 4: Voltage stability vs Iteration

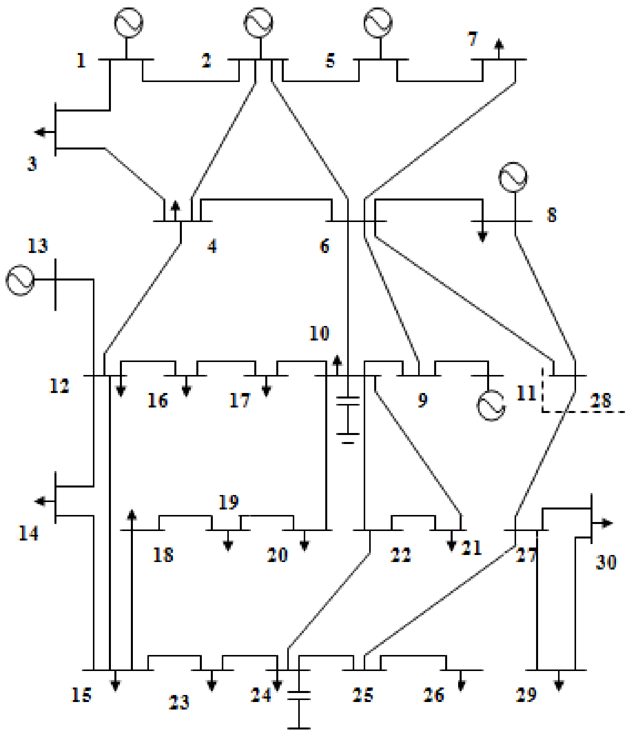

Figure 5: 30 bus system

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