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PSO Technique for Solving the Economic Dispatch Problem Considering the Generator Constraints

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ABSTRACT: By economic dispatch means, to find the generation of the different units in a plant so that the total fuel cost is minimum and at same time the total demand and losses at any instant must be met by the total generation. The classical optimizations of continuous functions have been considered. Various factors like optimal dispatch, total cost, incremental cost of delivered power, total system losses, loss coefficients and absolute value of the real power mismatch are evaluated for a simple system by hand calculation. The MATLAB programs were developed to solve Economic Load Dispatch Problem of an n-unit Plant through lambda iterative method and Particle Swarm Optimization

KEYWORDS: frequency hopping sequence (FHS) , optimal power flow (OPF)

I.INTRODUCTION

In a practical power system, the power plants are not located at the same distance from the centre of loads and their fuel costs are different. Also under normal operating conditions, the generating capacity is more than the total load demand and losses. Thus there are many options for scheduling the generation. With large interconnection of electrical networks, the energy crisis in the world and continuous rise in prices, it is very essential to reduce the running charges of electrical energy .i.e. reduce the fuel consumption for meeting a particular demand. In an interconnected power system, the objective is to find the real and reactive power scheduling of each power plant in such a way as to minimize the operating cost. This means that the generators real and reactive powers are allowed to vary within certain limits so as to meet a particular load demand with minimum fuel cost. This is called the optimal power flow (OPF) problem. The OPF is used to optimize the power flow solution of large scale power system. This is done by minimizing selected objective functions. While maintaining an acceptable system performance in terms of generator capability limits and output of the compensating devices. The objective functions, also known as cost functions may present economic costs, system security or other objectives. Efficient reactive power planning enhances operation as well as system security.

In this project our aim was to find optimal solution to the Economic dispatch including losses and generating limits .There are several methods to solve Economic load dispatch problem. Hence we considered one of the conventional methods i.e. lambda iterative method and one of the Artificial Intelligence methods i.e. Particle Swarm Optimization. Lambda iterative method was done by considering a specific lambda value and co-ordination equations were derived. From this equation we got a solution in which inequality constraints imposed on generation of each plant and equality condition were satisfied. Particle Swarm Optimization is also used to solve the same problem. In this method various steps involved are Initialization, Evaluation etc. Through all the above process the optimal solution was derived.The results of both the Lambda iterative method and Particle Swarm Optimization method were compared and the best method was identified as Particle Swarm Optimization method

II.ECONOMIC DISPATCH

It considers a network with N mobile unlicensed nodes that move in an environment according to some stochastic mobility models. It also assumes that entire spectrum is divided into number of M non-overlapping orthogonal channels having different bandwidth. The access to each licensed channel is regulated by fixed duration time slots. Slot timing is assumed to be broadcast by the primary system. Before transmitting its message, each transmitter node, which is a node

DOI: 10.15662/ijareeie.2014.0307009

with the message, first selects a path node and a frequency channel to copy the message. After the path and channel selection, the transmitter node negotiates and handshakes with its path node and declares the selected channel frequency to the path. The communication needed for this coordination is assumed to be accomplished by a fixed length frequency hopping sequence (FHS) that is composed of K distinct licensed channels. In each time slot, each node consecutively hops on FHS within a given order to transmit and receive a coordination packet. The aim of coordination packet that is generated by a node with message is to inform its path about the frequency channel decided for the message copying.Furthermore, the coordination packet is assumed to be small enough to be transmitted within slot duration. Instead of a common control channel, FHS provides a diversity to be able to find a vacant channel that can be used to transmit and receive the coordination packet. If a hop of FHS, i.e., a channel, is used by the primary system, the other hops of FHS can be tried to be used to coordinate. This can allow the nodes to use K channels to coordinate with each other rather than a single control channel. Whenever any two nodes are within their communication radius, they are assumed to meet with each other and they are called as contacted. In order to announce its existence, each node periodically broadcasts a beacon message to its contacts using FHS. Whenever a hop of FHS, i.e., a channel, is vacant, each node is assumed to receive the beacon messages from their contacts that are transiently in its communication radius.

III.EFFICIENT COMMUNICATION

The use of electricity is absolutely necessary in modern day-to-day life. The quality of electricity is stated in terms of constant voltage, constant frequency and uninterrupted power supply at minimum cost. To provide uninterrupted power supply and to return profit on the capital investment we need to cut down the cost of generation of electricity. That means proper operation is very important. There are many factors involved in the successful operation of a power system. The system is expected to supply power instantaneously and continuously to meet customer's demands under all operating conditions. It is also expected that the voltage supplied to the consumers need to be maintained at or near the nominal rated value. For this proper operating procedure must be observed to avoid damage to equipment or other facilities of the system. All of these operating requirements must be achieved simultaneously with minimum cost for production and distribution of power. Economic factors influenced by actions of operating personnel include the loading of generating equipment, particularly of thermal units, where efficiency of unit and fuel costs are major factors in the cost of power production. Purchase power availability, cost and scheduling of overhaul and/or repairs of equipment all affect operating costs. The cost of generation includes the fixed costs (like salaries and capital cost etc) and Variable costs (like fuel cost, maintenance cost and operation cost etc. An engineer is always concerned with cost of Product and Services. For a power system to return a profit on the capital invested, proper operation is very important.

2.1Development of Economic Load Dispatch Methods

The progress of optimal dispatch goes far back as the early 1920's, when engineers were concerned with the problem of economic allocation of generation or the proper division of the load among the generating units available. Prior to 1930, various methods were in use such as: (a) the base load method where the next most efficient unit is loaded to its maximum capability, then the second most efficient unit is loaded, etc., (b). "best point loading," where units are successively loaded to their lowest heat rate point, beginning with the most efficient unit and working down to the least efficient unit, etc. It was recognized as early as 1930, that the incremental method, later known as the "equal incremental method," yielded the most economic results. In 1954, co-ordination equation was developed for solving economic dispatch problem. A breakthrough in the mathematical formulation of the economic dispatch problem was achieved by Carpentier in the early 1960's who treated the entire work in an exact manner. The solution of Carpentier's formulation is a non-linear optimization which has been the subject of much study though the present and its implementation in real time remains a challenge.

Aoki, et al. presented a new Parametric Quadratic Programming method to solve an economic load dispatch problem with dc load flow type network security constraints.

C.E. Lin and G.L. Viviani presented a method to solve the economic power dispatch problem with piecewise quadratic cost functions. The solution approach is hierarchical, which allows for decentralized computations..

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Pereira, et al. described a method for the Economic Dispatch with security-constrained dispatch that can take into account the system rescheduling capabilities. The methodology is based on the Bender's Decomposition principle which allows the iterative solution of a base-case economic dispatch and separate contingency analysis with generation rescheduling.

Lin, et al. presented a real time economic dispatch method by calculating the penalty factors from a base case data base. The basic strategy of the proposed method assumes that a base case data base of economic dispatch solution is established according to statistical average of system operation data of the daily demand curve.

Zi-Xiong Liang presented a zoom feature applied to the dynamic programming method for solving economic dispatch of a system of thermal generating units including transmission line losses.

Gerald B. Sheble, et al. proposed a genetic-based algorithm to solve an economic dispatch problem. The algorithm utilizes payoff information of perspective solutions to evaluate optimality.

K.P. Wong and Y.W. Wong established a hybrid genetic / simulated-annealing approach for solving the thermal generator scheduling problem. It develops a method for encoding generator schedules in the hybrid approach..

T. Yalcinoz and M.J. Short proposed a Neural Networks approach for solving Economic Dispatch problem with transmission capacity constraints.

Allen J. Wood, Bruce F. Wollenberg presented a several classical optimization techniques for solving economic Load dispatch problem. These are Lambda Iteration Method, Gradient method and Dynamic Programming (DP) method, etc.

2.2 Economic Load Dispatch - Thermal Stations

A power system is a mix of different type of generations, out of which thermal, hydro and nuclear power generations contribute the active share. However, economic operation has conveniently been considered by proper scheduling of thermal or hydrogenation only. As for the safety of nuclear station, these types of stations are required to run at its base loads only and there is a little scope for the schedule of nuclear plants in practice.Economy of operation is most significant in case of thermal stations, as the variable costs are much higher compared to other type of generations. This can be considered by looking at various costs of different stations.

Cost	Thermal stations	Hydro stations	Nuclear stations
1. Fixed costs	20%	75%	70%
2. Fuel cost	70%	0	20%
3. Other operational costs	10%	25%	10%

Table 2.1: Various Costs of different Stations

Obviously the cost of fuel form the major portion of all variable costs and the purpose of economic operation is to reduce the cost of fuel. This is a static optimization problem. This project deals with the economic load dispatch of the thermal plants.

2.3 Generator Operating Cost Curves

The major component of the generator operating cost is the fuel input/hour, while maintenance contributes only to a small extent. The fuel cost is meaningful incase of thermal and nuclear stations. But for the hydro station where the energy storage is 'apparently free', the operating cost of such is not meaningful.

The different operating cost curves are:

i. Input output curve.
ii. Incremental fuel cost curve.

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i. Input Output Curve

The input output curve of a unit can be expressed in million kilocalories per hour or directly in terms of Rs./hour versus output in megawatts. The cost curve can be determined experimentally. A typical curve is shown in the fig. Where $(MW)_{min}$ is the minimum-loading limit below which it is uneconomical to operate the unit and $(MW)_{max}$ is the maximum output limit. By fitting a suitable degree polynomial, an expression for operating cost can be written as $F_i(P_{gi})$ Rs/hr at output (P_{gi})

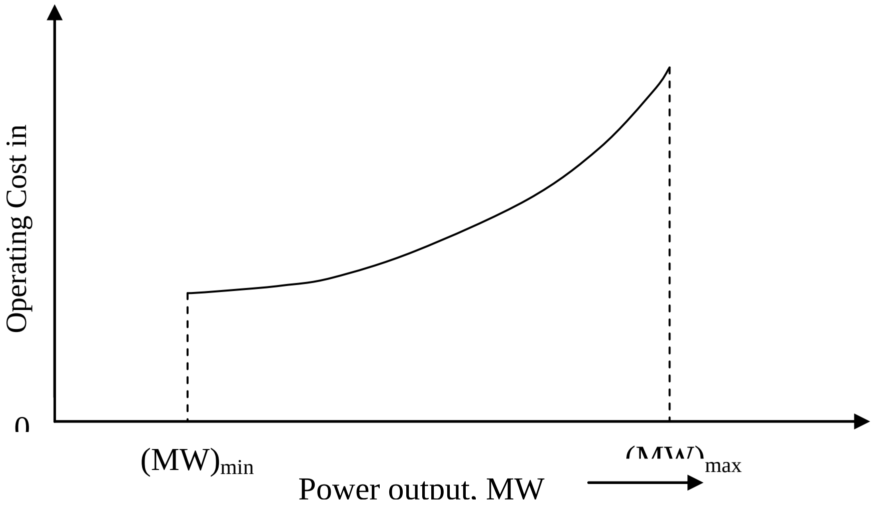

Fig 2.1: Input-Output curve of a generating unit

Where the suffix i stands for the unit number. It is generally sufficient to fit a second-degree polynomial i.e.

$$F_i(P_{gi}) = 1/2\ a_i{*}P^2_{gi} + b_i{*}P_{gi} + c_i$$

Significance: It specifies efficiency and cost of fuel used per hour as a function of power Generation.

ii. Incremental Fuel Cost Curve

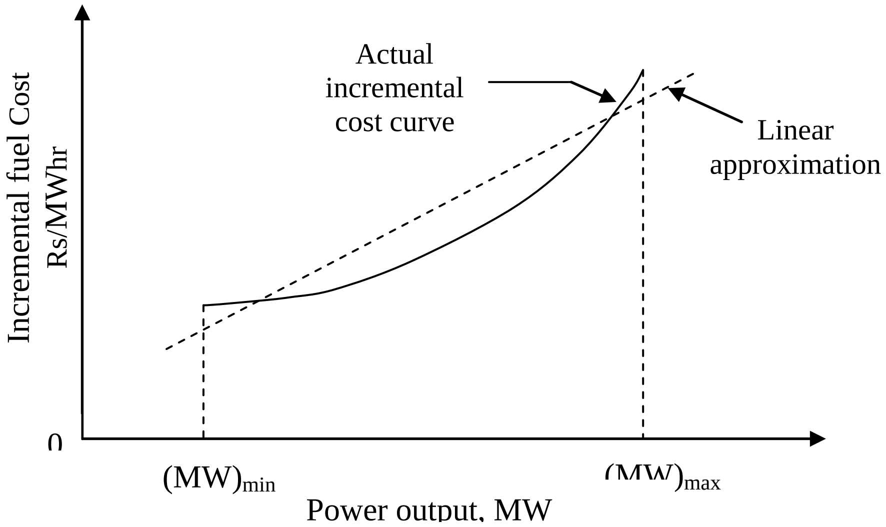

Fig 2.2: Incremental fuel cost vs. power out put

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We know that the operating cost of the thermal plant is

$$F_i(P_{gi}) = 1/2\ a_i{*}P^2_{gi} + b_i{*}P_{gi} + c_i$$

The slope of the cost curve is called the incremental fuel cost curve

$$(IC)_i = dF_i/dP_{gi} = a_i{*}P_{gi} + b_i$$

It is expressed in terms of Rs/MWhr. A typical plot of this curve is shown above.For better accuracy incremental fuel cost may be expressed by a number of short line segments (piecewise linearization) alternatively we can fit a polynomial of suitable degree to represent IC curve in the inverse form equation.

$$P_{gi} = \alpha_i + \beta_i(IC)_i + \gamma_i(IC)^2_i + \ldots\ldots$$

Significance: The curve represents the increase in cost rate per increase in one mega watt output.

2.6 Economic Load Dispatch Problem

2.6.1 Economic Dispatch

The objective of economic load dispatch of electric power generation is to schedule the committed generating unit outputs so as to meet the load demand at minimum operating cost while satisfying all units and operational constraints of the power system.

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

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

Where, F_T : total generation cost (*Rs/hr*)
n : number of generators
P_i : real power generation of i^{th} generator (*MW*)
$F_i(P_i)$: generation cost for P_i

Subject to a number of power systems network equality and inequality constraints. These constraints include:

2.6.2 System Active Power Balance

For power balance, an equality constraint should be satisfied. The total power generated should be the same as total load demand plus the total line losses

$$P_D + P_L - \sum_{i=1}^{n} P_i = 0$$

Where, P_D : total system demand (*MW*)
P_L : transmission loss of the system (*MW*)

2.6.3 Generation Limits

Generation output of each generator should be laid between maximum and minimum limits. The corresponding inequality constraints for each generator are

$$P_{n,min} \leq P_n \leq P_{n,max}$$

Where, $P_{n,min}$: minimum power output limit of n^{th} generator (*MW*)
$P_{n,max}$: maximum power output limit of n^{th} generator (*MW*)

The generation cost function $F_n(P_n)$ is usually expressed as a quadratic polynomial:

$$F_n(P_n) = a_nP_n^2 + b_nP_n + c_i$$

Where, a_n , b_n and c_n are fuel cost coefficients.

2.6.4 Network Losses

Since the power stations are usually spread out geographically, the transmission network losses must be taken into account to achieve true economic dispatch. Network loss is a function of unit generation. To calculate network losses, two methods are in general use. One is the penalty factors method and the other is the *B* coefficients method.

The latter is commonly used by the power utility industry. In the *B* coefficients method, network losses are expressed as a quadratic function:

$$P_L = P_m B_{mn} P_n$$

Where, B_{mn} are constants called *B* coefficients or loss coefficients.

III. ECONOMIC LOAD DISPATCH USING LAMBDA ITERATION METHOD

The detailed Algorithm for solving the economic load dispatch problem using lambda iteration method is given below

Step 1: Read data namely cost-coefficients, B-coefficients, P limits and power demand.
Step 2: Make an initial guess λ and Δλ for the Lagrange multiplier.
Step 3: Calculate the generations based on equal incremental production cost.
Step 4: Calculate the generations at all buses using the equation

$$P_n = \frac{1 - (f_n/\lambda) - \square\ \square\ \square\ \square_{mn} P_m \atop m \neq n}{(F_{nn}/\lambda) + 2B_{nn}}$$

Step 5: For each unit, check the generation limits and impose the limits in case of violation.
If $P_n > P_{nmax}$, set $P_n = P_{nmax}$
If $P_n < P_{nmin}$, set $P_n = P_{nmin}$
Step 6: Check if the difference in power at all generator buses between two Consecutive iterations is less than a prespecified value. If not, go back to step 3.
Step 7: Calculate the loss using the relation

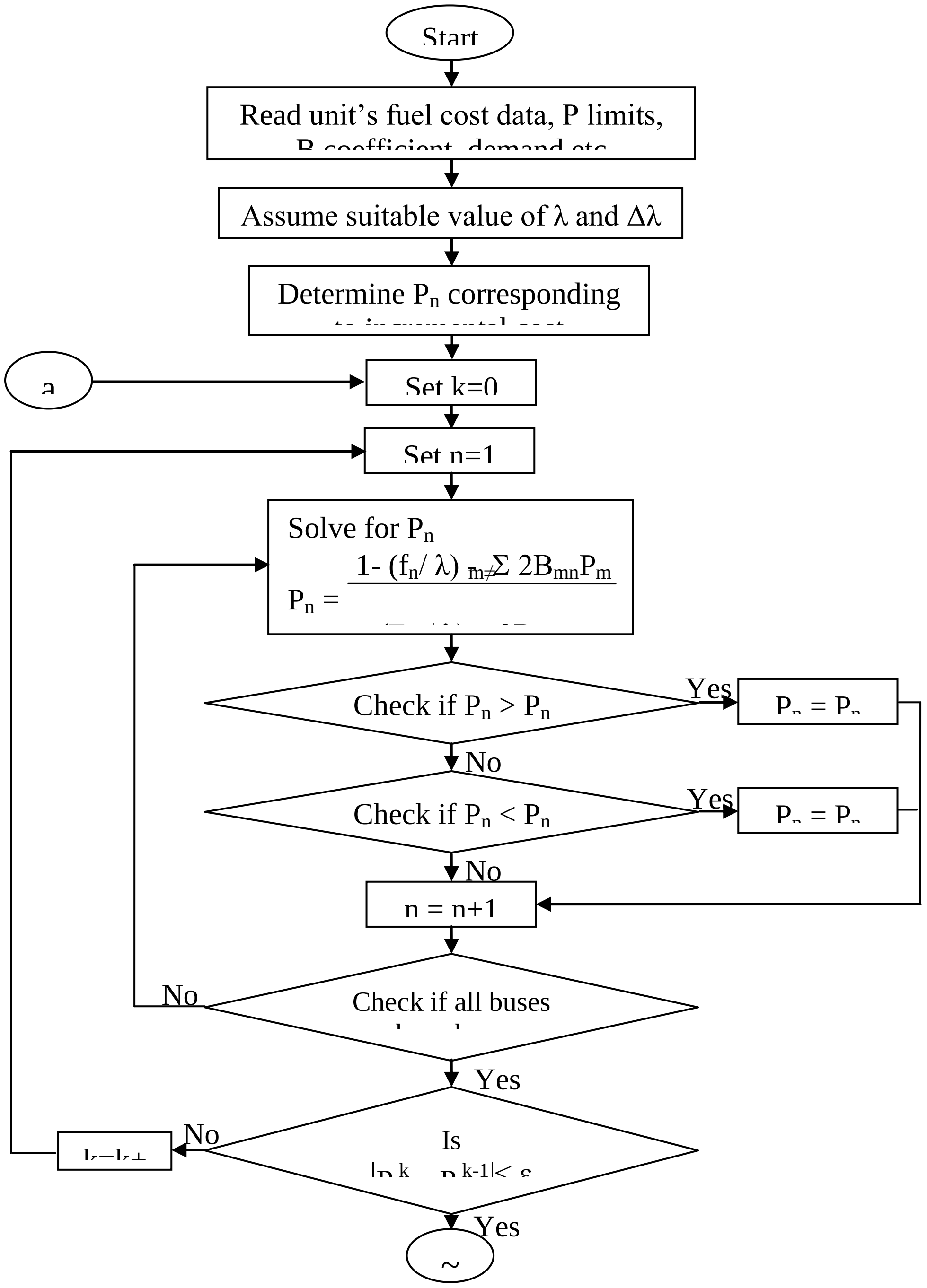
$$P_L = \square\ \square\ \square\ \square_{m} P B_{mn} P_n$$

And calculate mismatch between generator power and demand plu losses.

$$\Delta P = |\Sigma P_G - P_L - P_D|$$

Step 8: Check if ΔP is less than ϵ (a specified value)
If yes, stop calculation and calculate cost of generation with these values of powers. Otherwise, go to step 9.
Step 9: Increase λ by Δλ (a suitable step size); if $\Delta P < 0$ or
Decrease λ by Δλ (a suitable step size); if $\Delta P > 0$
and repeat from step 4.

Flow Chart


Start
Read unit's fuel cost data, P limits,
Assume suitable value of λ and Δλ
Determine P_n corresponding
a
Set k=0
Set n=1
Solve for P_n
$P_n = \frac{1-(f_n/\lambda)\ \sum_{m\neq n} 2B_{mn}P_m}{}$
Check if $P_n > P_n$
Yes
$P_n = P_n$
No
Check if $P_n < P_n$
Yes
$P_n = P_n$
No
n = n+1
Check if all buses
No
Yes
Is
No
k=k+
Yes

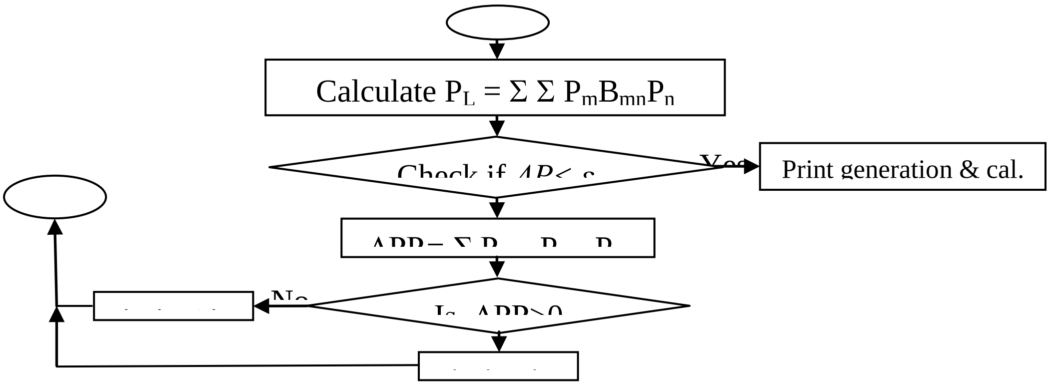


Fig. 3.1 Flow Chart of Lambda Iteration Method for Economic Load Dispatch

VI. PARTICLE SWARM OPTIMIZATION

4.1Outline of the Basic Particle Swarm Optimization:

This project presents a quick solution to the constrained ED problem using the PSO algorithm to search for optimal or near optimal generation quantity of each unit. The search procedures of the proposed method were as shown below.

Step 1: Specify the upper and lower bound generation power of each unit, ancalculate F_{max} and F_{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 solution that satisfies the practical operation constraints.

Step 2: To each individual Pg of the population, employ the B-coefficient lossformula to calculate the transmission loss P_L.

Step 3: Calculate the evaluation value of each individual Pg_i in the population using the evaluation function f given by (4).

Step 4: Compare each individual's evaluation value with its pbest. The bestevaluation value among the pbests is denoted as gbest.

Step 5: Modify the member velocity v of each individual Pg_i according to $(5V_{id}^{(t+1)} = \omega.\ V_i^{(t)} + C_1*\text{rand}\ ()*(\text{pbest}_{id} - Pg_{id}^{(t)}) + C_2*\text{Rand}\ ()*(\text{gbest}_d - Pg_{id}^{(t)})$

i = 1, 2. . . n; d=1, 2 . . . m Where n is the population size, m is the number of units, and the ω value is set by (3).

Step 6: If $V_{id}^{(t+1)} > V_d^{max}$, then $V_{id}^{(t+1)} = V_d^{max}$.
If $V_{id}^{(t+1)} < V_d^{min}$, then $V_{id}^{(t+1)} = V_d^{min}$.

Step 7: Modify the member position of each individual Pg_i according to (6)

$$Pg_{id}^{(t+1)} = Pg_{id}^{(t)} + v_{id}^{(t+1)} \quad \rightarrow (6)$$

$Pg_{id}^{(t+1)}$ must satisfy the constraints, namely the prohibited operating Zones and ramp rate limits. If $Pg_{id}^{(t+1)}$ violates the constraints the $Pg_{id}^{(t+1)}$ must be modified toward the near margin of the feasible solution.

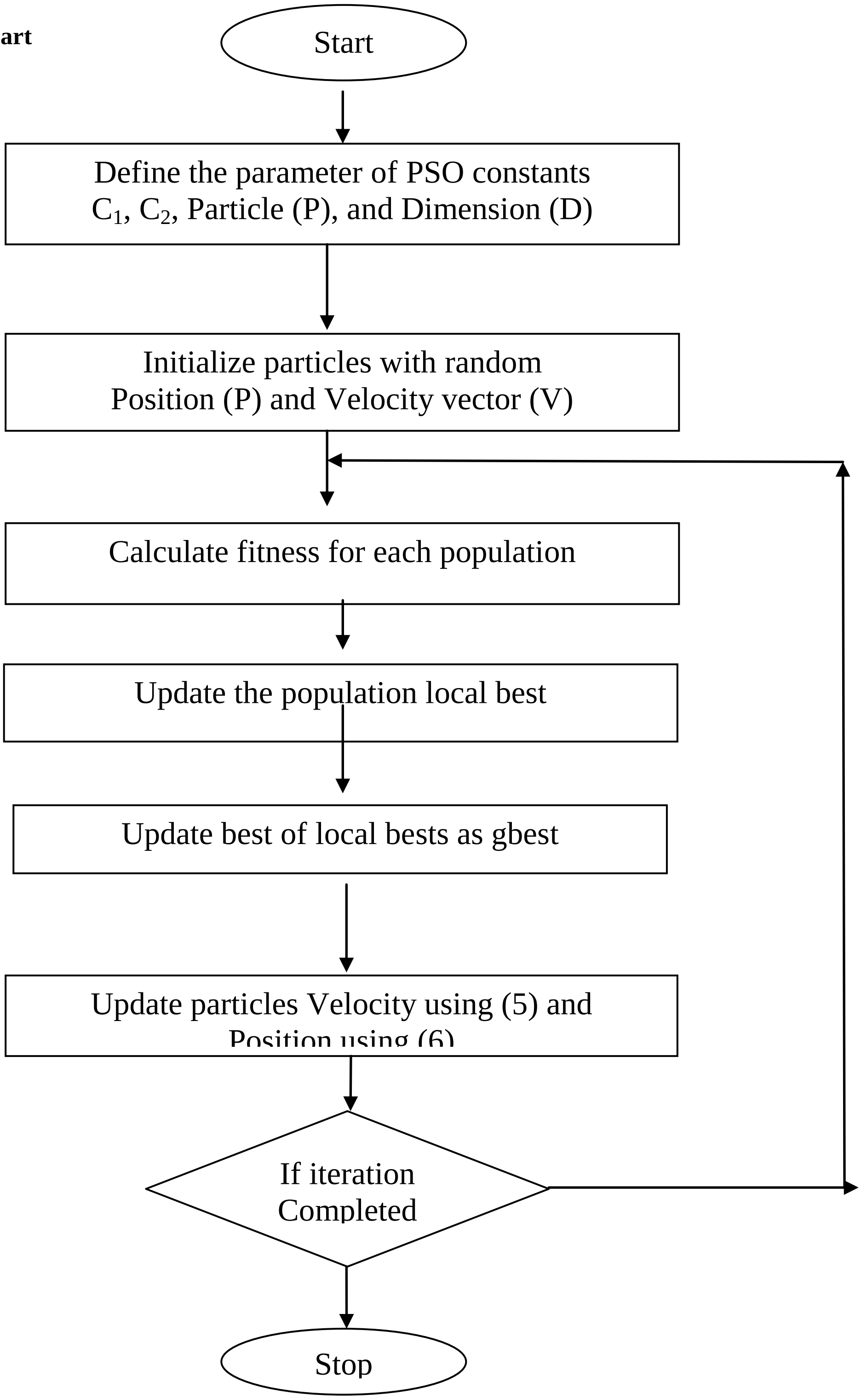
Step 8: If the evaluation value of each individuals is better than the previouspbest, the current value is set to be pbest. If the best pbest is better than gbest, the value is set to be best.

Step 9: If the number of iterations reaches the maximum, then go to step 10. Otherwise, go to step 2.

DOI: 10.15662/ijareeie.2014.0307009

Step 10: The individual that generates the latest gbest is the optimal generatiopower of each unit with the minimum total generation cost.

Flow chart



DOI: 10.15662/ijareeie.2014.0307009

V. MATLAB

```
% PURE ECONOMIC DISPATCH PROBLEM USING LAMBDA ITERATION METHOD
clear all
clc
opf=fopen('lamb_eco.doc','w+');
no_units=6;
Pd=1450;
a=[0.0070 0.0095 0.0090 0.0090 0.0080 0.0075];
b=[7 10 8.5 11 10.5 12];
c=[240 200 300 150 200 120];
Pmax=[500 200 300 150 200 120];
Pmin=[100 50 80 50 50 50];

B=[  0.000017  0.000012  0.000007 -0.000001 -0.000005 -0.000002
     0.000012  0.000014  0.000009  0.000001 -0.000006 -0.000001
     0.000007  0.000009  0.000031  0.000000 -0.000010 -0.000006
    -0.000001  0.000001  0.000000  0.000024 -0.000006 -0.000008
    -0.000005 -0.000006 -0.000010 -0.000006  0.000129 -0.000002
    -0.000002 -0.000001 -0.000006 -0.000008 -0.000002  0.000150  ];

itermax=1000;
epsilon=0.1;
alpha=2*a;
clc
Pg=zeros(no_units,1);
del_lambda=0.010;
tic;deltaP=10;iter=0;
EPd=Pd/no_units;
while  abs(deltaP)>epsilon && iter< itermax
  iter=iter+1;
  for i=1:no_units
    sigma=B(i,:)*Pg-B(i,i)*Pg(i);
    Pg(i)=(1-(b(i)/lambda)-(2*sigma))/(alpha(i)/lambda+2*B(i,i));
    if Pg(i)<Pmin(i)
      Pg(i)=Pmin(i);
    end
    if Pg(i)>Pmax(i)
      Pg(i)=Pmax(i);
    end
  end
  P_loss=Pg'*B*Pg;
  Pt=sum(Pg);
  deltaP=Pt-Pd-P_loss;
  error(iter)=deltaP;

  if deltaP>0
    lambda=lambda-del_lambda;
  end
  if deltaP<0
    lambda=lambda+del_lambda;
  end
```

DOI: 10.15662/ijareeie.2014.0307009

```
end
fprintf(opf,'\n ECONOMIC DISPATCH USING LAMBDA ITERATION METHOD\n');
if iter<itermax
   fprintf(opf,'\n Problem converged in %d iterations\n',iter);
else
   fprintf(opf,'\n Problem diverged in %d iterations\n',iter);
end
fprintf(opf,'\n Optimal Lambda = %g\n',lambda);
for i=1:no_units
   fprintf(opf,'\n Pgen(%d)=%g MW',i,Pg(i));
end
fprintf(opf,'\n Total Power Generation, P_total = %g MW\n',Pt);
fprintf(opf,'\n Total Power Demand             = %g MW',Pd);
fprintf(opf,'\n Total Power Loss               = %g MW',P_loss);
fprintf(opf,'\n\n Error= %g\n',deltaP);
Ft=0.0;
for i=1:no_units
   F(i)=c(i)+b(i)*Pg(i)+a(i)*Pg(i)*Pg(i);
      fprintf(opf,'\n Fuel cost of Gen.(%d)= %g Rs/Hr',i,F(i));
Ft=Ft+F(i);
end
fprintf(opf,'\n Total fuel cost= %g Rs/Hr\n',Ft);
runtime=toc;
fprintf(opf,'\n CPU time = %g sec.\n\n',runtime);
fclose('all')
```

5.1 Code for particle swarm optimization

```
% Particle swarm optimization
clear all;
clc;
opf=fopen('pso_eco.doc','w+');
no_units=6;
Pd=1200;
a=[240 200 300 150 200 120];
b=[7 10 8.5 11 10.5 12];
c=[0.0070 0.0095 0.0090 0.0090 0.0080 0.0075];
pmax=[500 200 300 150 200 120];
pmin=[100 50 80 50 50 50];

B=[  0.000017  0.000012  0.000007 -0.000001 -0.000005 -0.000002
     0.000012  0.000014  0.000009  0.000001 -0.000006 -0.000001
     0.000007  0.000009  0.000031  0.000000 -0.000010 -0.000006
    -0.000001  0.000001  0.000000  0.000024 -0.000006 -0.000008
    -0.000005 -0.000006 -0.000010 -0.000006  0.000129 -0.000002
    -0.000002 -0.000001 -0.000006 -0.000008 -0.000002  0.000150  ];

no_part=60;
itermax=1000;
alpha=b;
beta=2*c;
for i=1:no_units
   Lambda_min(i)=alpha(i)+beta(i)*pmin(i);
```

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```
    Lambda_max(i)=alpha(i)+beta(i)*pmax(i);
end
lambda_min=min(Lambda_min);
lambda_max=max(Lambda_max);
lambda_min=lambda_min';
lambda_max=lambda_max';
for i=1:no_part
    part(i)= unifrnd(lambda_min,lambda_max);
end
Pbest=zeros(1,no_part);
vel_max=(lambda_max-lambda_min)/10;
for i=1:no_part
    vel(i)= unifrnd(-vel_max,vel_max);
end
c1=2;
c2=2;
psi=c1+c2;
K=2/abs(2-psi-sqrt(psi*psi-4*psi));
Gbest=0.0;
P=zeros(no_part,no_units);
tic;
for iter=1:itermax
    for i=1:no_part
        for k=1:no_units
            temp=0;
            for j=1:no_units
                if j~=k
                    temp=temp+B(k,j)*P(i,j);
                end
            end
        end
        temp=2*temp;
        for j=1:no_units
            Nr(j)=1-(alpha(j)/part(i))-temp;
            Dr(j)=(beta(j)/part(i))+(2*B(j,j));
            if P(i,j)>pmax(j)
                P(i,j)=pmax(j);
            end
            if P(i,j)<pmin(j)
                P(i,j)=pmin(j);
            end
        end
        P_loss=0;
        for k=1:no_units
            for j=1:no_units
                P_loss=P_loss+(P(i,k)*B(k,j)*P(i,j));
            end
        end
        Pgen(i)=0.0;
        for j=1:no_units
            Pgen(i)=Pgen(i)+P(i,j);
        end
```

DOI: 10.15662/ijareeie.2014.0307009

```
error(i)=Pgen(i)-Pd-P_loss;
fit(i)= 1.0/(100.0+abs(error(i))/Pd);
if Pbest(i)<fit(i)
   Pbest(i)=fit(i);
   Pbest_part(i)=part(i);
end
if Gbest<Pbest(i)
   Gbest=Pbest(i);
   Gbest_part=Pbest_part(i);
end
Wmin=0.4;
Wmax=0.9;
W=Wmax-((Wmax-Wmin)*iter/itermax);
vel(i)=K*(W*vel(i)+c1*rand()*(Pbest_part(i)-part(i))+c2*rand()*(Gbest_part-part(i)));
if abs(vel(i))>vel_max
   if vel(i)<0.0
      vel(i)=-vel_max;
   end
   if vel(i)>0.0
      vel(i)=vel_max;
   end
end
tpart=part(i)+vel(i);
for k=1:no_units
   ttemp=0;
   for j=1:no_units
      if j~=k
         ttemp=ttemp+B(k,j)*P(i,j);
      end
   end
end
ttemp=2*ttemp;
for j=1:no_units
   Nr(j)=1-(alpha(j)/tpart)-ttemp;
   Dr(j)=(beta(j)/tpart)+2*B(j,j);
   if tp(j)>pmax(j)
      tp(j)=pmax(j);
   end
   if tp(j)<pmin(j)
      tp(j)=pmin(j);
   end
end
tP_loss=0;
for k=1:no_units
   for j=1:no_units
      tP_loss=tP_loss+(tp(k)*B(k,j)*tp(j));
   end
end
tpgen=0.0;
for j=1:no_units, tpgen=tpgen+tp(j);
end
terror=tpgen-Pd-tP_loss;
```

```
      Error(iter)=terror;
      tfit= 1.0/(1.0+abs(terror)/Pd);
      if tfit>fit(i)
         part(i)=tpart;
         Pbest(i)=tfit;
         Pbest_part(i)=part(i);
      end
      if Gbest<Pbest(i)
         Gbest=Pbest(i);
         Gbest_part=Pbest_part(i);
      end
   end
   if abs(terror)<0.01
      break;
   end
end
runtime=toc;
fprintf(opf,'\n ECONOMIC DISPATCH USING PSO\n');
fprintf(opf,'\n Problem converged in %d iterations\n',iter);
fprintf(opf,'\n Optimal Lambda= %g\n',Gbest_part);
for j=1:no_units
 fprintf(opf,'\n Pgen(%d)= %g MW',j,tp(j));
end
fprintf(opf,'\n Total Power Generation        = %g MW\n',sum(tp));
fprintf(opf,'\n Total Power Demand            = %g MW',Pd);
fprintf(opf,'\n Total Power Loss          = %g MW\n',tP_loss);
fprintf(opf,'\n Error= %g\n',terror);
total_cost=0.0;
for j=1:no_units
 Fuel_cost(j)=a(j)+b(j)*tp(j)+c(j)*tp(j)*tp(j); total_cost=total_cost+Fuel_cost(j);
end
for j=1:no_unitsfprintf(opf,'\n Fuel cost of Gen.(%d)= %g Rs/Hr',j,Fuel_cost(j));
end
fprintf(opf,'\n Total fuel cost= %g Rs/Hr\n',total_cost);
fprintf(opf,'\n cpu time = %g sec.',runtime);
fclose('all');
```

Using the Trust-Worthy algorithm it defines a threshold value to the SUs to overcome the PUE attacks. It enables CR-Networks nodes to efficiently utilize the available spectrum channels. Nodes, which can easily find various licensed channel opportunities without interfering the primary system increases. This reveals that it has a potential to be able to convert the various network conditions into a performance improvement.

VI .RESULTS

The effectiveness of the proposed method is tested with six generating units system. There are two methods used for solving the Economic load Dispatch. Firstly the problem is solved by conventional Lambda iterative method. Then a proposed PSO method is applied to solve the problem. A reasonable loss coefficients matrix of power system network was employed to draw the transmission line loss and satisfy the transmission capacity constraints. The program is written in MATLAB software.The generator cost coefficients; generation limits and B- coefficient matrix of six units system are taken from [4].These Parameters are shown in Appendix-I. The Economic Load Dispatch solution for the six-unit system is solved using conventional technique (lambda-iteration) and PSO technique and then results are compared. The results of Economic Load dispatch using Conventional method and PSO are shown in Table 1. and Table 2. for 500MW, 700MW, 1000MW, 1200 MW, 1350MW and 1450MW

S.No	Load demand(MW)	P_1 (MW)	P_2 (MW)	P_3 (MW)	P_4 (MW)	P_5 (MW)	P_6 (MW)	P_L (MW)	Fuel cost (Rs./Hr)
1.	500	216.388	50	85.702	50	50	50	1.991	6106.21
2.	700	312.282	73.420	159.487	50	59.14	50	4.164	8288.81
3.	1000	391.557	132.135	220.812	93.182	122.043	50	8.127	11957.20
4.	1200	434.380	163.796	254.043	128.659	155.661	76.594	11.307	14559.00
5.	1350	466.385	187.465	278.916	150	180.562	101.657	14.212	16586.10
6.	1450	497.113	200	300	150	200	120	16.739	17980.10

Table .1. Test results of Lambda-iteration method for 6- unit system

S.No	Load demand(MW)	P_1 (MW)	P_2 (MW)	P_3 (MW)	P_4 (MW)	P_5 (MW)	P_6 (MW)	P_L (MW)	Fuel cost (Rs./Hr)
1.	500	216.106	50	85.880	50	50	50	1.991	6105.02
2.	700	312.957	77.806	160.516	50	52.928	50	4.199	8287.55
3.	1000	393.634	138.455	222.537	90.271	113.217	50	8.123	11930.40
4.	1200	438.852	172.501	257.243	125.645	146.350	70.708	11.293	14538.10
5.	1350	470.988	196.721	281.878	150	169.617	94.887	14.086	16575.50
6.	1450	500	200	300	150	196.687	120	16.688	17975.20

TABLE .2.TEST RESULTS OF PSO METHOD FOR 6- UNIT SYSTEM

VII. CONCLUSIONS AND FUTURE SCOPE

By economic dispatch means, to find the generation of the different units in a plant so that the total fuel cost is minimum and at same time the total demand and losses at any instant must be met by the total generation. The classical optimizations of continuous functions have been considered. Various factors like optimal dispatch, total cost, incremental cost of delivered power, total system losses, loss coefficients and absolute value of the real power mismatch are evaluated for a simple system by hand calculation. The MATLAB programs were developed to solve Economic Load Dispatch Problem of an n-unit Plant through lambda iterative method and Particle Swarm Optimization. The results for the individual methods are tabulated in the previous section. From the results it can be concluded that, the lambda iterative method heavily depends on the selection of initial value. If the initial guess value is far from the actual value, it takes much time to provide converged solution. Sometimes, the solution may not converge. In other words, the convergence of lambda iteration method depends on initial guess of lambda. Whereas PSO method always provides converged solution which does not require initial value of lambda. In this work, the ramp rate constraints are not included. Also the concept of prohibited zones is not incorporated. In future work, this can be extended by incorporating prohibited zones along with ramp rate constraints

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REFERENCES

[1] Lin Lu, Qi Luo, Jun-yong Liu, Chuan Long, "An Improved Particle Swarm Optimization Algorithm", IEEE International Conference On Granular Computing, pp. 486-490, 2008.

[2] A. Immanuel Selvakumar, Member, IEEE, and K. Thanushkodi, "A New Particle Swarm Optimization Solution to Nonconvex Economic M Dispatch Problems", IEEE TRANSACTIONS ON POWER SYSTEMS, VOL. 22, NO. 1, pp. 42-51, FEBRUARY 2007.

[3] T. O. Ting, Student Member, IEEE, M. V. C. Rao, and C. K. Loo, Member, IEEE, "A Novel Approach for Unit Commitment Problem via an Effective Hybrid Particle Swarm Optimization", IEEE TRANSACTIONS ON POWER SYSTEMS, VOL. 21, NO. 1,pp. 411-418, FEBRUARY 2006.

[4] Zwe-Lee Gaing, "Particle Swarm Optimization to solving the EconomicDispatch Considering the Generator Constraints", IEEE Trans. On Power Systems, Vol.18, No.3, pp. 1187-1195, August 2003.

[5] P. Venkatesh, R. Gnanadass, and Narayana Prasad Padhy, "Comparison and application of evolutionary Programming techniques to combined economic Emission dispatch with line flow constraints", IEEE Trans, on Power Syst., Vol. 18, No. 2, pp. 688-697, May 2003.

[6] Hirotaka Yoshida, Kenichi Kawata, Yoshikazu Fukuyama, Member, IEEE, Shinichi Takayama, and Yosuke Nakanishi, Member, IEEE, "A Particle Swarm Optimization for Reactive Power and Voltage Control Considering Voltage Security Assessment", IEEE TRANSACTIONS ON POWER SYSTEMS, VOL. 15, NO. 4, pp. 1232-1239, NOVEMBER 2000.

[7] Angeline, P. J. "Using selection to improve particle swarm optimization",Proceedings of IEEE Congress on Evolutionary Computation 1998 Anchorage,Alaska, USA, 1998b.

[8] H. T. Yang, P. C. Yang, and C. L. Huang, "Evolutionary programming based economic dispatch for units with non-smooth fuel cost functions", IEEE Trans. on Power Systems, Vol. 11, No. 1, pp. 112-118, Feb. 1996.

[9] J. Kennedy and R. C. Eberhart, "Particle swarm optimization," Proceedings of IEEE International Conference on Neural Networks (ICNN'95), Vol. IV, pp. 1942-1948, Perth, Australia, 1995.

[10]B H Chowdhury and S Rahman, "A Review of Recent Advances in Economic Dispatch", IEEE Transactions on Power System, Vol 5, no 4, pp. 1248-1259, 1990.

[11]D W Ross and S Kim, "Dynamic Economic Dispatch of Generation", IEEE Transactions on Power Apparatus and Systems, pp. 2060, November/December1980.

[12]HAPP, H.H, "Optimal power dispatch", IEEE Trans., PAS-93, pp. 820- 830, 1974.

[13]T.E. Bechert and H.G. Kwatny, "On the Optimal Dynamic Dispatch of Real Power", IEEE Transactions on Power Apparatus and Systems, pp. 889,May/June 1972.

[14] I.J. Nagrath, D.P. Kothari, "Modern Power System Analysis", 2nd Edition, Tata McGraw-Hill Co, 1989.

[15] C.L. Wadhwa, " Electric Power Systems", New Age International (P) Ltd. Publishers, New Delhi, India, 2001.