SOLUTION TO ECONOMIC LOAD DISPATCH USING PSO

A Project report submitted in partial fulfilment

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By

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CERTIFICATE

<u>To whom it may concern</u>

This is to certify that the project work entitled **Solution of economic load dispatch using pso** is the bona fide work carried out by **Shubham kumar rai,(11701615049**),**Pritam mondal(11701616007)** a student of B.Tech in the Dept. of Electrical Engineering, RCC Institute of Information Technology (RCCIIT), Canal South Road, Beliaghata, Kolkata-700015, affiliated to Maulana Abul Kalam Azad University of Technology (MAKAUT), West Bengal, India, during the academic year **2018-19**, in partial fulfillment of the requirements for the degree of Bachelor of Technology in Electrical Engineering and that this project has not submitted previously for the award of any other degree, diploma and fellowship.

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ABSTRACT

The modern power system around the world has grown in complexity of interconnection and power demand. The focus has shifted towards enhanced performance, increased customer focus, low cost, reliable and clean power. In this changed perspective, scarcity of energy resources, increasing power generation cost, environmental concern necessitates optimal economic dispatch. In reality power stations neither are at equal distances from load nor have similar fuel cost functions. Hence for providing cheaper power, load has to be distributed among various power stations in a way which results in lowest cost for generation. Practical economic dispatch (ED) problems have highly non-linear objective function with rigid equality and inequality constraints. Particle swarm optimization (PSO) is applied to allot the active power among the generating stations satisfying the system constraints and minimizing the cost of power generated. The viability of the method is analyzed for its accuracy and rate of convergence. The economic load dispatch problem is solved for three and six unit system using PSO and conventional method for both cases of neglecting and including transmission losses. The results of PSO method were compared with conventional method and were found to be superior. The conventional optimization methods are unable to solve such problems due to local optimum solution convergence. Particle Swarm Optimization (PSO) since its initiation in the last 15 years has been a potential solution to the practical constrained economic load dispatch (ELD) problem. The optimization technique is constantly evolving to provide better and faster results.

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CHAPTER 1:

INTRODUCTION

With large interconnection of the electric networks, the energy crisis in the world and continuous rise in prices, it is very essential to reduce the running costs of electric energy. A saving in the operation of the power system brings about a significant reduction in the operating cost as well as in the quantity of fuel consumed. The main aim of modern electric power utilities is to provide high-quality reliable power supply to the consumers at the lowest possible cost while operating to meet the limits and constraints imposed on the generating units and environmental considerations. These constraints formulates the economic load dispatch **(ELD)** problem for finding the optimal combination of the output power of all the online generating units that minimizes the total fuel cost, while satisfying an equality constraint and a set of inequality constraints. Traditional algorithms like lambda iteration, base point participation factor, gradient method, and Newton method can solve this ELD problems effectively if and only if the fuel-cost curves of the generating units are piece-wise linear and monotonically increasing . Practically the input to output characteristics of the generating units are highly non-linear, non-smooth and discrete in nature owing to prohibited operating zones, ramp rate limits and multifuel effects. Thus the resultant ELD becomes a challenging non-convex optimization problem, which is difficult to solve using the traditional methods.Methods like dynamic programming, genetic algorithm, evolutionary programming, artificial intelligence, and particle swarm optimization solve non-convex optimization problems efficiently and often achieve a fast and near global optimal solution. Among them PSO was developed through simulation of a simplified social system, and has been found to be robust in solving continuous non-linear optimization problems. The PSO technique can generate high-quality solutions within shorter calculation time and stable convergence characteristics.

CHAPTER 2:

BACKGROUND & LITERATURE REVIEW

2.1 THERMAL POWER PLANT

A thermal power plant is a power plant in which its prime-mover is driven by steam. Water is the working fluid. It is heated at the boiler and circulated with energy to be expanded at the steam turbine to give work to the rotor shaft of the generator. After it passes through the turbine, it is condensed in a condenser and then pumped to feed the boiler where it is heated up.

For simplification, thermal power plants can be modelled as a transfer function of energy conversion from fossil fuel to electricity as described .

g.1 Energy conversion diagram of a thermal power plant.

The thermal unit system generally consists of the boiler, the steam turbine, and the generator. The input of the boiler is fuel, and the output is the volume of steam. The relationship of the input and output can be expressed as a convex curve .The input of the turbine-generator unit is the volume of steam and the output is electrical power, the overall input-output characteristic of the whole generation unit can be obtained by combining directly the input-output characteristic of the boiler and the input-output characteristic of the turbine-generator unit. It is a convex curve.

2.2 OPERATING COST OF A THERMAL POWER PLANT:

The factors influencing power generation are operating efficiencies of generators, fuel cost and transmission losses. The total cost of generation is a function of the individual generation of the sources which can take values within certain constraints. The problem is to determine the

generation of different plants such that total operating cost is minimum. The input to the thermal

plant is generally measured in Btu/hr and the output power is the active power in MW. A

simplified input-output curve of a thermal unit known as heat-rate.

Fig 2. Input Output characteristics of generator unit P_G (MW)

In all practical cases, the fuel cost of any generator unit 'i' can be represented as a quadratic

function of the real power generation.

$C_i = A_i * P_i^2 + B_i * P_i + C_i$

The incremental fuel-cost curve is a measure of how costly it will be to produce the next

increment of power.

$dC_i/dP_i = 2A_i * P_i + B_i$

2.3 CALCULATION OF INPUT-OUTPUT CHARACTERISTIC PARAMETERS:

The parameters of the input-output characteristic of any generating unit can be determined by the

following approaches

1. Based on the experiments of the generating unit efficiency.

2. Based on the historic records of the generating unit operation.

3. Based on the design data of the generating unit provided by manufacturer.

In the Practical power systems, we can easily obtain the fuel statistic data and power output statistics data. Through analyzing and computing data set (Fk, Pk), we can determine the shape of the input-output characteristic and the corresponding parameters.

2.4 SYSTEM CONSTRAINTS:

Generally there are two types of constraints [3]

i)   Equality constraints

ii)   Inequality constraints

2.4.1 EQUALITY CONSTRAINTS

The equality constraints are the basic load flow equations of active and reactive power[3].

$$\sum_{i=1}^{N} P - P - P = 0$$

2.4.2 INEQUALITY CONSTRAINTS:

 i) Generator Constraints:

The KVA loading of a generator can be represented as $P^2 + Q^2$. The KVA loading should not exceed a pre-specified value to limit the temperature rise. The   maximum   active   power

generated 'P' from a source is also limited by thermal consideration to keep the temperature rise within limits. The minimum power generated is limited by the flame instability of the boiler. If the power generated out of a generator falls below a pre-specified value Pmin, the unit is not put on the bus bar.

$$P_{min} \leq P \leq P_{max}$$

• The maximum reactive power is limited by overheating of rotor and minimum reactive power is limited by the stability limit of machine. Hence the generator reactive powers Q should not be outside the range stated by inequality for its stable operation.

$$Q_{min} \leq Q \leq Q_{max}$$

ii) Voltage Constraints:

The voltage magnitudes and phase angles at various nodes should vary within certain limits. The normal operating angle of transmission shoul lie between 30 to 45 degrees for transient stability reasons. A higher operating angle reduces the stability during faults and lower limit of delta assures proper utilization of the available transmission capacity.

iii) Running Spare Capacity Constraints:

These constraints are required to meet

a) The forced outages of one or more alternators on the system &

b) The unexpected load on the system.

The total generation should be such that in addition to meeting load demand and various losses a minimum spare capacity should be available i.e.

$$G \geq P_p + P_{so}$$

Where G is the total generation and P_{so} is some pre-specified power. A well planned system has minimum P_{so}. [3]

iv) Transmission Line Constraints:

The flow of active and reactive power through the transmission line circuit is limited by the thermal capability of the circuit and is expressed as.

$C_p \leq C_{pmax}$; Where C_{pmax} is the maximum loading capacity of the Pth line. [3]

v) Transformer tap settings:

If an auto-transformer is used, the minimum tap setting could be zero and maximum one, i.e. $0 \leq t \leq 1.0$

Similarly for a two winding transformer if tapping are provided on the secondary side,

$0 \leq t \leq$ n where n is the ratio of transformation. [3]

vi) Network security constraints:

If initially a system is operating satisfactorily and there is an outage, may be scheduled or forced one, it is natural that some of the constraints of the system will be violated. The complexity of these constraints (in terms of number of constraints) is enhanced when a large system is being analyzed. In this a study is to be made with outage of one branch at a time and then more than one branch at a time. The natures of the constraints are same as voltage and transmission line constraints. [3]

2.5 OPTIMUM LOAD DISPATCH:

The optimum load dispatch problem involves the solution of two different problems. The first of these is the unit commitment or pre dispatch problem wherein it is required to select optimally out of the available generating sources to meet the expected load and provide a specified margin of operating reserve over a specified period time .The second aspect of economic dispatch is the on-line economic dispatch wherein it is required to distribute the load among the generating units paralleled with the system in such manner so as to minimize the total cost of operation.

2.6 COST FUNCTION

Let C_i represent the cost, expressed in Rs per hour, of producing energy in the ith generator. $C = \sum_{i=1}^{N} C_i$ Rs/hrs. The generated real power P_{Gi} has a major influence on the cost function. The individual real power generation can be raised by increasing the prime mover torque which requires an increased expenditure of fuel. The reactive generations Q_{Gi} do not have any significant influence on Ci because they are controlled by controlling the field excitation. The individual production cost Ci of generator units is therefore for all practical purposes considered a function only of P_{Gi} , and for the overall production cost C, we thus have

$$C = \sum_{i=1}^{N} C_i(P_i)$$

2.7 PARTICLE SWARM OPTIMIZATION:

Most of the conventional computing algorithms are not effective in solving real-world problems because of having an inflexible structure mainly due to incomplete or noisy data and some multi-dimensional problems. Natural computing methods are best suited for solving such problems. In general Natural computing methods can be divided into three categories:

1) Epigenesis

2) Phylogeny

3) Ontogeny.

PSO belongs to the Ontogeny category in which the adaptation of a special organism to its environment is considered.

2.8 DESCRIPTION OF PSO:

Particle Swarm Optimization (PSO) is a biologically inspired computational search and optimization method developed by Eberhart and Kennedy in 1995 based on the social behaviours of birds flocking and fish schooling.

Particle (X): It is a candidate solution represented by an m-dimensional vector, where m is the number of optimized parameters. At time t, the ith particle $X_i(t)$ can be described as $X_i(t)=[X_{i1}(t), X_{i2}(t),..,X_{in}(t)]$, where X_s are the optimized parameters and $X_{ik}(t)$ is the position of the ith particle with respect to the kth dimension; i.e. the value of the kth optimized parameter in the ith candidate solution.

Population, Pop (t): It is a set of n particle at time t, i.e. Pop (t) $=[X_1(t), X_2(t),.., X_n(t)]$.

Swarm: It is an apparently disorganized population of moving particles that tend to cluster together towards a common optimum while each particle seems to be moving in a random direction.

Personal best (Pbest): The personal best position associated with i[th] particle is the best position that the particle has visited yielding the highest fitness value for that particle.

Global best (Gbest): The best position associated with i[th] particle that any particle in the swarm has visited yielding the highest fitness value for that particle. This represents the best fitness of all the particles of a swarm at any point of time.

The optimization process uses a number of particles constituting a swarm that moves around a pre-defined search space looking for the best solution. Each particle is treated as a point in the D-dimensional space in which the particle adjusts its "flying" according to its own flying experience as well as the flying experience of other neighbouring particles of the swarm. Each particle keeps track of its coordinates in the pre-defined space which are associated with the best solution (fitness) that it has achieved so far. This value is called pbest. Another best value that is tracked by the PSO is the best value obtained so far by any particle in the whole swarm. This value is called gbest. The concept consists of changing the velocity of each particle toward its pbest and the gbest position at the end of every iteration. Each particle tries to modify its current position and velocity according to the distance between its current position and pbest, and the distance between its current position and gbest.[6]

CHAPTER 3:

METHODOLOGY

PROBLEM FORMULATION
ECONOMIC LOAD DISPATCH NEGLECTING LOSSES
ELD WITH LOSS
FORMULATION OF PSO
APPLICATION OF PSO METHOD TO ECONOMIC LOAD DISPATCH

3.1 PROBLEM FORMULATION:

The objective of the economic load dispatch problem is to minimize the total fuel cost.

$$\text{Min } F_T = \sum$$

$$\text{Subject to } P_D + P_L = \sum$$

3.2 ECONOMIC LOAD DISPATCH NEGLECTING LOSSES[3]

LAGRANGIAN MULTIPLIER (LAMBDA-ITERATION) METHOD:

$$F = F_T + \lambda (P - \sum_{n=1}^{N} Pn)$$

Where λ is the Lagrangian Multiplier.

Differentiating F with respect to the generation P_n and equating to zero gives the condition for optimal operation of the system.

$$\partial F / \partial P = \partial F / \partial P + \lambda(0-1) = 0$$

$$= \partial F / \partial P - \lambda = 0$$

Since $F_T = F_1 + F_2 \ldots \ldots .. + F_N$

$$\partial F / \partial P = dF_n / dP = \lambda$$

Therefore the condition for optimum operation is

$dF_1/dP_1 = dF_2/dP_2 = \ldots \ldots \ldots = dF_n/dP_n$

The incremental production cost of a given plant over a limited range is represented by

$dF_n/dP_n = F_{nn}P_n + f_n$

F_{nn}= slope of incremental production cost curve

f_n= intercept of incremental production cost curve

The active power generation constraints are taken into account while solving the equations which are derived above. If these constraints are violated for any generator it is limited to the corresponding limit and the rest of the load is distributed among the remaining generator units according to the equal incremental cost of production.

3.3 ELD WITH LOSS:[3]

The optimal load dispatch problem including transmission losses is defined as

$$\text{Min } F_T = \sum$$

$$\text{Subject to } P_D + P_L - \sum$$

Where P_L is the total system loss which is assumed to be a function of generation

Making use of the Lagrangian multiplier λ, the auxiliary function is given by

$$F = F_T + \lambda (P_D + P_L - \sum \quad)$$

The partial differential of this expression when equated to zero gives the condition for optimal

Load dispatch, i.e.

$$\partial F / \partial P = \partial F + \lambda \left(\partial P / \partial P - 1 \right)$$

$$dF/dP_n + \lambda * \partial P / \partial P = \lambda$$

Here the term $\partial P / \partial P$ is known as the incremental transmission loss at plant n and λ is known as the incremental cost of received power in Rs.per MWhr. The above equation is a set of n equations with (n+1) unknowns ie. 'n' generations are unknown and λ is unknown. These equations are also known as coordination equations because they coordinate the incremental transmission losses with the incremental cost of production.

To solve these equations the loss formula is expressed in terms of generations as

$$P_L = \sum_m \sum_n {}_m B_{mn} {}_n$$

Where P_m and P_n are the source loadings, B_{mn} the transmission loss coefficient.

$$\partial P / \partial P = 2 \sum_m B_{mn} P$$

Also $dF_n/dP_n = F_{nn}P_n + f_n$

$\therefore$ The coordination equation can be rewritten as

$$F_{mn} {}_n + f_n + \lambda \sum 2 B_{mn} {}_m = \lambda$$

Solving for P_n we obtain

$$P_n = (1 - f_n / \lambda * \sum_{m!=n} 2 B_{mn} P) / (F_n / \lambda + 2 B_{nn})$$

When transmission losses are included and coordinated, the following points must be kept in mind for economic load dispatch solution

1. Whereas incremental transmission cost of production of a plant is always positive, the incremental transmission losses can be both positive and negative.

2. The individual generators will operate at different incremental costs of production.

3. The generation with highest positive incremental transmission loss will operate at the lowest incremental cost of production.

3.4 FORMULATION OF PSO:

PSO is initialized with a group of random particles (solutions) and then searches for optima by updating generations. In every iteration, each particle is updated by following two "best" values. The first one is the best solution (fitness) it has achieved so far. This value is called pbest. Another "best" value that is tracked by the particle swarm optimizer is the best value, obtained so far by any particle in the population. This best value is a global best and called g-best. After finding the two best values, the particle updates its velocity and positions according to the following equations.[2]

$$V_i^{(u+1)} = w*V_i^{(u)} + C_1*rand(\ )*(pbest_i - P^{(u)}) + C_2*rand(\ )*(gbest_i - P^{(u)})$$
$$P^{(u+1)} = P^{(u)} + V_i^{(u+1)}$$

In the above equation,The term rand ( )*(pbest_i - $P_i^{(u)}$) is called particle memory influence

The term rand ( )*(gbest_i -$P_i^{(u)}$) is called swarm influence.

In the above equation, C1 generally has a range (1.5,2) which is called as the self-confidence range and C2 generally has a range (2, 2.5) which is known as the swarm range. $V_i^{(t)}$ which is the velocity of the ith particle at iteration 'i' should lie in the pre-specified range (Vmin,Vmax). The parameter Vmax determines the resolution with which regions are to be searched between the present position and the target position. If Vmax is too high, particles may fly past good solutions. If Vmax is too small particles may not explore sufficiently beyond local solutions. Vmax is often set at 10-20% of the dynamic range on each dimension.

The constants C1 and C2 pull each particle towards pbest and gbest positions. Low values allow particles to roam far from the target regions before being tugged back. On the other hand, high values result in abrupt movement towards, or past, target regions. Hence the acceleration constants C1 and C2 are often set to be 2.0 according to past experiences.

The inertia constant can be either implemented as a fixed value or can be dynamically changing. This parameter controls the exploration of the search space. Suitable selection of inertia weight 'ω' provides a balance between global and local explorations, thus requiring less iteration on average to find a sufficiently optimal solution. As originally developed, ω often decreases linearly from about 0.9 to 0.4 during a run. In general, the inertia weight *w* is set according to the following equation,

$$W = W_{max} - \left\lceil \frac{W_{max} \quad W_{min}}{R} \right\rceil * ITER$$

Where W -is the inertia weighting factor

W$_{max}$ - maximum value of weighting factor

W_{min} - minimum value of weighting factor

ITER – Current iteration number

$ITER_{max}$-Maximum iteration number.

3.5 APPLICATION OF PSO METHOD TO ECONOMIC LOAD DISPATCH

STEPS OF IMPLEMENTATION:

1. Initialize the Fitness Function ie. Total cost function from the individual cost function of the various generating stations.

2. Initialize the PSO parameters Population size, C1, C2, W_{MAX}, W_{MIN}, error gradient etc.

3. Input the Fuel cost Functions, MW limits of the generating stations along with the B-coefficient matrix and the total power demand.

4. At the first step of the execution of the program a large no(equal to the population size) of vectors of active power satisfying the MW limits are randomly allocated.

5. For each vector of active power the value of the fitness function is calculated. All values obtained in an iteration are compared to obtain Pbest. At each iteration all values of the whole population till then are compared to obtain the Gbest. At each step these values are updated.

6. At each step error gradient is checked and the value of Gbest is plotted till it comes within the pre-specified range.

7. This final value of Gbest is the minimum cost and the active power vector represents the economic load dispatch solution.

Economic Load Dispatch Optimization of Six Interconnected Generating Units Using Particle Swarm
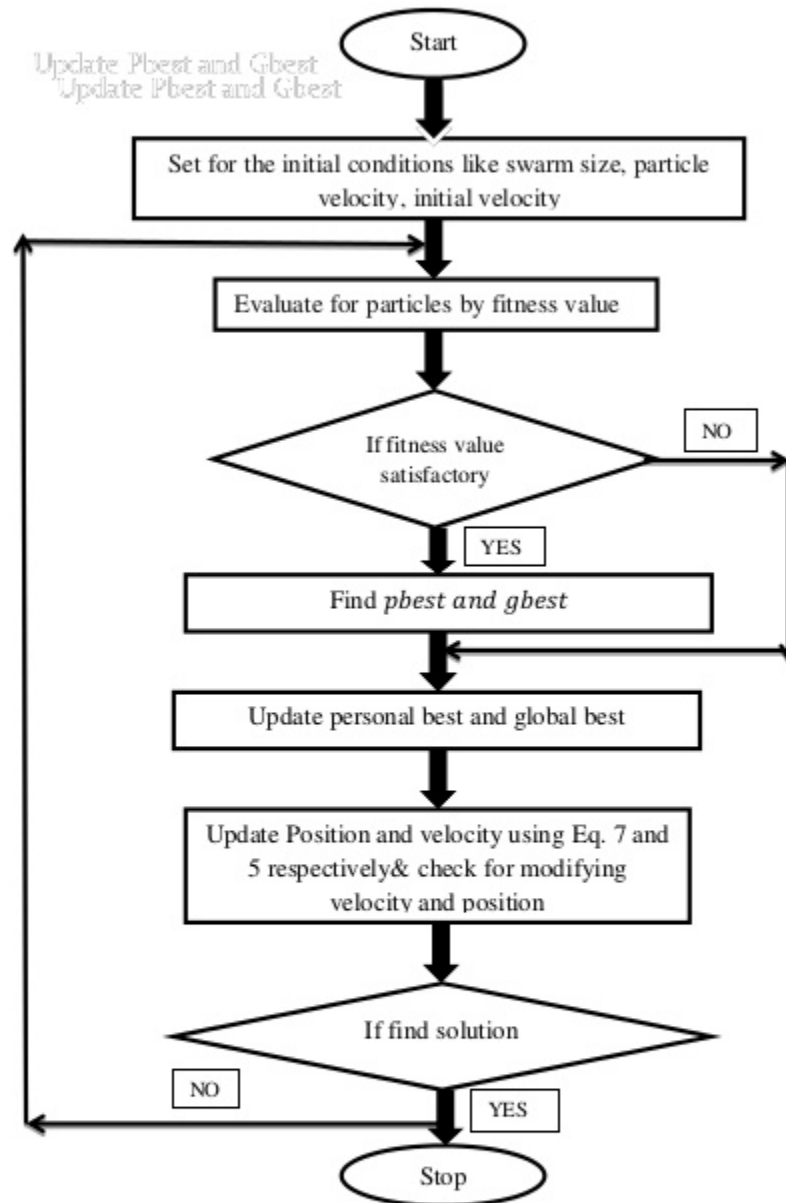

Fig. 2. Flow Chart of Proposed Algorithm for ELD Optimization using PSO

V. SIMULATION RESULTS AND DISCUSSION

The six unit test system consisting of six thermal units, 26 buses, and 46 transmission lines is used for simulation of proposed problem of economic load dispatch. This system is simulated for 50 iterations. The characteristics of the six thermal units are given in Table 2.

SOLUTION TO ECONOMIC LOAD DISPATCH USING PSO

```
%Code for particle swarm optimization
clear all
clc
no_units=6;
Pd=284.3;
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=50;
itermax=1000;
alpha=b;
beta=2*c;
for i=1:no_units
Lambda_min(i)=alpha(i)+beta(i)*pmin(i);
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=1.5;
c2=1.5;
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:iter
```

CHAPTER 4

RESULT

SIX UNIT THERMAL SYSTEM

CASE STUDY 1: SIX UNIT THERMAL SYSTEM CONVENTIONAL (LAGRANGE MULTIPLIER) METHOD

The cost characteristics of the three units in Rs/hr are given as:

$F1 = 0.15240P1^2 + 38.53973P1 + 756.79886$

$F4 = 0.03546P4^2 + 38.30553P4 + 1243.5311$

$F2 = 0.10587P2^2 + 46.15916P2 + 451.32513$

$F5 = 0.02111P5^2 + 36.32782P5 + 1658.5596$

$F3 = 0.02803P3^2 + 40.39655P3 + 1049.9977$

$F6 = 0.01799P6^2 + 38.27041P6 + 1356.6592$

The unit operating constraints are:

$100 \text{ MW} \le P1 \le 500 \text{ MW};$ $50 \text{ MW} \le P2 \le 200 \text{ MW};$

$50 \text{ MW} \le P4 \le 150 \text{ MW};$

$80 \text{ MW} \le P3 \le 300 \text{MW};$

$50 \text{ MW} \le P6 \le 120 \text{ MW}$

$50 \text{ MW} \le P5 \le 200 \text{MW};$

B-Coefficient Matrix:

B=[0.000140 0.000017 0.000015 0.000019 0.000026 0.000022

   0.000017 0.000060 0.000013 0.000016 0.000015 0.000020

   0.000015 0.000013 0.000065 0.000017 0.000024 0.000019

   0.000019 0.000016 0.000017 0.000071 0.000030 0.000025

   0.000026 0.000015 0.000024 0.000030 0.000069 0.000032

   0.000022 0.000020 0.000019 0.000025 0.000032 0.000085];

Table : Comparison of results between Conventional method and PSO method for Six-unit system (Loss included Case).

SI.No.	Power Demand (MW)	Conventional Method (Rs/Hr)	PSO Method (Rs/Hr)
1	284.3	4977.65	4977.6
2	300	5230.7	5230.76
3	350	5490.78	5490.796

Table 14: Reliability Evaluation of PSO method.

Sl No.	Power Demand (MW)	Min(MW)	Mean(MW)	Std Deviation(MW)
1	284.3	4977.65	4977.64	0.001005049
2	300	5230.7	5230.70318	0.000318944
3	350	5490.78	5490.7810	0.000106356

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CHAPTER 5:

CONCLUSION

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FUTURE SCOPE

PSO method was employed to solve the ELD problem for two cases one three unit system and another six unit system. The PSO algorithm showed superior features including high quality solution, stable convergence characteristics. The solution was close to that of the conventional method but tends to give better solution in case of higher order systems. The comparison of results for the test cases of three unit and six unit system clearly shows that the proposed method is indeed capable of obtaining higher quality solution efficiently for higher degree ELD problems. The convergence characteristic of the proposed algorithm for the three unit system and six unit system is plotted. The convergence tends to be improving as the system complexity increases. Thus solution for higher order systems can be obtained in much less time duration than the conventional method. The reliability of the proposed algorithm for different runs of the program is pretty good, which shows that irrespective of the run of the program it is capable of obtaining same result for the problem. Many non-linear characteristics of the generators can be handled efficiently by the method. The PSO technique employed uses a inertia weight factor for faster convergence. The inertia weight is taken as a dynamically decreasing value from Wmax to Wmin at and beyond ITER max. The convergence characteristic of the method for varying ITERmax was analyzed. Values of ITERmax between 1000-2000 give better convergence characteristic, so the value of 1500 is used for optimum results.

Advantages of PSO:

1. It only requires a fitness function to measure the 'quality' of a solution instead of complex mathematical operation like gradient or matrix inversion. This reduces the computational

complexity and relieves some of the restrictions that are usually imposed on the objective function like differentiability, continuity, or convexity.

2. It is less sensitive to a good initial solution since it is a population-based method.

3. It can be easily incorporated with other optimization tools to form hybrid ones.

4. It has the ability to escape local minima since it follows probabilistic transition rules

5. It can be easily programmed and modified with basic mathematical and logical operations

6. It is in-expensive in terms of computation time and memory.

7. It requires less parameter tuning.

.

FUTURE SCOPE:

1. PSO algorithm can be combined with other simple optimization techniques to improve their performance when applied to ELD problems and obtain better results.

2. Bus Data and Line Data of the system can be taken as input along with the load demand to obtain the minimization function with constraints on voltage and reactive power at various points of the system.

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