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A Dispatching of Load for Conventional Generator by Using a Particle Swarm Optimization Technique

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***Abstract:** In solving the electrical power system economic dispatch problem, the main aim is to find the optimal output power among the various generators available to serve the load. Economic Load Dispatch (ELD) is one of the important issues in Power system operation. The goal of ELD is to obtain the optimal allocation of various generating units available to meet the system load. The validation is done for thermal system by particle swarm optimization. The analytical methods suffer from slow convergence and particle swarm optimization is efficient alternative to solve large scale non linear optimization problem. This paper presents an overview of basic particle swarm optimization to provide a survey on the problem of economic load dispatch as an optimization problem. The study is carried out for a test system without loss case.*
***Index Terms:** Economic load dispatch, particle swarm optimization.*

I. INTRODUCTION

Electrical power systems are having the capacity of producing sufficient power to meet the load demand and losses.Since electricity is cannot be stored so it is necessary to start and shutdown a number of generating units at various power stations each day. Hence an Economic Load Dispatch (ELD) problem plays an important role in electrical power system. The use of alternate sources of energy, the economic load dispatch (ELD) problem involves only conventional thermal energy which use non resources such as fossil fuels. Renewable energy sources are more popular due to their reduced cost, improved reliability and lower green house gas emissions, more and more researches have been investigated into power systems incorporating wind power. The Economic Load dispatch problem has been handled by many researchers in past years ago. Economic Load Dispatch has been widely used in power system operation and planning. There are various mathematical programming methods used to solve this kind of optimization problem in power systems, based on linear and nonlinear programming were proposed, including Newton method, quadratic programming, and interior-point method. The mathematical methods utilize the first or second derivative information in essence. Furthermore, there is a difficulty of applying gradient-based optimization techniques. Therefore, various non-classical optimization methods have emerged to handle with some of the traditional optimization algorithms. The main modern optimization techniques evolutionary programming (EP), genetic algorithm(GA), artificial neural network(ANN), simulated annealing(SA) and partical swarm optimisation(PSO). These method have been successfully applied to wide range of optimization problems in which global solutions are more preferred than local ones. Particle swarm optimization(PSO) is first introduced by Kennedy and Eberhart in 1995 as a new heuristic method. There is a comprehensive coverage of different PSO applications in solving optimization problems in the area of electric power systems up to 2006. In a computer science technology, particle swarm optimization (PSO) is a computational method which solve a problem by iterative method and trying to improve a solution of candidate with given measure of quality. Particle swarm optimization (PSO) is metheuristic or it makes few assumptions or no assumptions about the problem being optimized and can search very large space of candidate solutions. Particle swarm optimization (PSO) does not use the gradient of the problem being optimized, which means PSO does not require that the optimization problem be differentiable as is required by classical optimization methods such as gradient descent and quasi-Newton method dispatch problem The objective of this paper is to optimize an objective function to solve constraint based quadratic cost function.Particle swarm optimization is employed for solving a load dispatch problem. The proposed algorithm is applied to load dispatch of conventional thermal generator. And performance of a generator will be observed.

II. PROBLEM FORMULATION

A. Objective Function

As applied to electrical power system, the economic dispatch problem is a classical optimization problem. The goal is to obtain an optimum allocation of power output among the various available generators with given constraints. The sum of the output is equal to the system load as a system is lossless.

The fuel cost function of each thermal generating units is expressed as a quadratic function. The total fuel cost in terms of the real power output can be expressed

$C = \sum_{i=1}^{N} F(Pi)$ (1)

$F(P_i) = a_i + b_iP_i + c_i\, P_i^2$ (2)

Where

N number of thermal units

P_i output of i^{th} thermal unit

a_i, b_i and c_i cost coefficient of i^{th} thermal unit.

The cost function is obtained based on these ripples effect for more accuracy. When a generator is with multiple valve the cost curve is not smooth. So by assuming cost function is smooth it becomes invalid and results are incorrect or erroneous. So the effect of valve point loading is taken into account by adding sine term in equation. The operating cost for conventional thermal generator is represented by quadratic equation with valve point effect as follows:

Min $F_{cost} = \sum_{t=1}^{T} \sum_{i=1}^{I} [C_i(P_{i,t}) + E_i(P_{i,t})]$

Where ,

$f_{cost}$is the total generation cost over the whole time horizon.

T is the number of periods;

Iis the number of thermal units;

$P_{i,t}$is the power output (MW) of the *i* th unit corresponding to time period t;

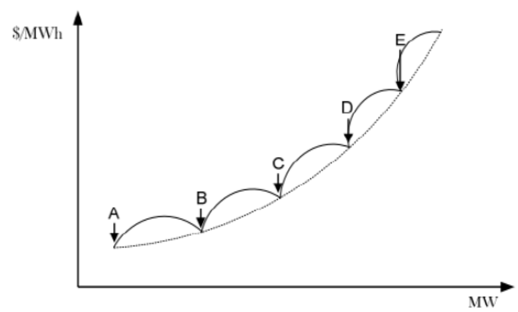
$C_i(P_{i,t})$is the generation cost of the *i* th unit corresponding to time period t;

$E_i(P_{i,t})$ is the valve point loading effect of the *i* th unit corresponding to time period t .

For thermal generator cost can assumed by a quadratic function of the power output which is practical for most cases, and is given by in equation (2).

Where a_i, $b_i$and c_i are cost coefficients for the *i* th unit. , $E_i(P_{i,t})$is expressed as follows:

$E_I(P_{i,t}) = e_i \sin [F_i\,(p_{i\,min} - p_i\,)]$ (3)



Figur 1 Fuel cost curve of units with valve point effect.

B. Problem Constraint

For feasible solution in a practical system physical and operational limits is having a set of constraints that should satisfy throughout the system operations.

1) *Generation capacity constraints*

$P_{imin} \leq P_i \leq P_{imax}$ (3)

2) *Power balance constraints:* The total power from conventional thermal generator is equal to the load demand as a system is lossless.

$\sum_{i=1}^{M} P_i = P_D$(4)

The system input is equal to system load as a system is lossless.

III. PARTICLE SWARM OPTIMIZATION

Particle Swarm Optimization (PSO) technique is based on Swarm Intelligence technique and inspired by behavior of swarms. It is a population based stochastic optimization technique developed by Dr. Eberhart and Dr. Kennedy in 1995. , inspired by social behavior of fish schooling and bird flocking. PSO is having many similarities with evolutionary computation techniques such as Genetic Algorithms (GA). As Kennedy and Eberhart progressed in their research, they discover some modification that social behavior model can also serves as a powerful optimizer. Such species try to achieve their target in an optimal manner which helps to find the optimal solution of any mathematical optimization problem. The first version of particle swarm optimization was intended to handle only non linear continuous optimization problem. Particle swarm optimization having an attractive feature is its simplicity and easy to implement, computationally efficient and it has high convergence rate to get the best optimal solution.

A. Selection Parameter For Particle Swarm Optimization

Particle swarm optimization technique is based on the concept of multiple birds (particles) that search for the best food source (optimum) by using their inertia, their knowledge, and the knowledge of the swarm.

One example of a swarm bird: a group of swarms are randomly moving and searching for food in an area. There is only one piece of food in that area which they want to searched. So, all the swarms do not know where the location of food is. But they know how far the location of food is in each iteration. So the best strategy to find the food location is effective one is to follow the swarm which is nearest to the location of food.

In particle swarm optimization each single solution is a "bird" in the search space called as"particle". All of the particles in search space is having their own fitness value which are evaluated by the fitness function or objective function to be optimized, and have velocities which direct the flying of the particles. The particles fly through the problem space by following the current optimum particles. Particle swarm optimization is initialized with a group of random particles i.e solution and then searches for optimal solution by updating generations. In each iteration, each and every particle is updated by two "best" values. The first one is called as the best solution (fitness) it has achieved so far.This value is called pbest. Another "best" value which is obtained 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 is called gbest. After finding these two best values, the particles update their velocity and positions by sharing information from its own experience and experience of neighbor.Thepsition and velocity vector of the i^{th} particle of a d-dimensional search space can be represented as

$X_i = (X_{i1}, X_{i2}\ldots\ldots X_{id})$ and $V_i = (V_{i1}, V_{i2}, \ldots.., V_{id})$ respectively.

The modified velocity and position of each particle for fitness evaluation is $(k+1)^{th}$ iteration, are calculated using following equations:

$$V_{id}^{k+1} = w*V_{id}^{k} + C_1*U*(pbest_{id}^{k} - X_{id}^{k}) + C_2*U*(gbest_{d}^{k} - X_{id}^{k})$$

$$X_{id}^{k+1} = X_{id}^{k} + V_{id}^{k+1}$$

Where X_{id}^{k} , V_{id}^{k} are the position and the velocity of the i^{th} particlein the d^{th} dimension at an iteration k; n number of particles ina group; m number of members in a particle; w inertia weightfactor which controls the global and local exploration capabilities of the particle. C_1, C_2 acceleration factors C_1 pulls the particle towards local best position and C_2 pulls the particle towards global best position. Usually these parameters are selected in the range of 0 to 4. And U is uniform random numberin the range [0, 1].The velocity should be between $V_d^{min} \le V_{id} \le V_d^{max}$. If V_d^{max} is high, particles might move past good solutions. While V_d^{max} is too small, particles may not explore sufficiently beyond local solutions. selection of inertia weight w provides a balance between local and global exploration, thus requiring less iteration on an average to find a optimal solution. Since w decreases from 0.9 to 0.4 during a run, the following equation is used

$$W = W_{max} - [(W_{max} - W_{min}) / iter_{max}] * iter$$

Where W_{max} is the initial weight

$W_{min}$is the final weight

$iter_{max}$is maximum iteration number.
iter is current iteration number.

B. Algorithm for Particle Swarm Optimization

The step by step procedure of Particle swarm optimization algorithm is given as follows:

1) Initialize a population of particle as $P_i=(P_{i1},P_{i2},P_{i3}\ldots\ldots\ldots\ldots,P_{iN})$ where N is number of generating units. Population is initialized with random values and velocities within the d-dimensional search space. Initialize the maximum velocity magnitude of any particle Vmax .evaluate the fitness of each particle and assign the position to P-best position and fitness to P-best fitness. Verify the best between the p-best as g-best and store the fitness value of G-best.
2) Update the velocity and position of the particle according to equation. For every particle, evaluate the fitness, if all decision variables are within the search space.
3) . Compare the fitness evaluation with its previous P-best. if the current value is better than the previous P-best, then set the P-best value equal to the current value and the P-best location equal to the current location in the d-dimensional search space.
4) Compare the best current fitness evaluation with the population G-best. If the current value is better than the G-best, then reset G-best to the current best position and fitness value to current fitness value
5) Steps 2-5 until a stopping criterion, till good G-best or a maximum number of iteration is met.

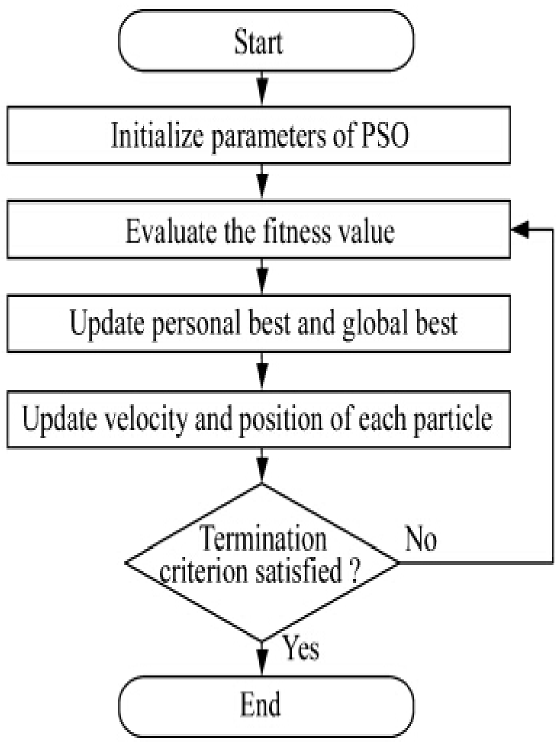


Figure 1 Flowchart Of Particle Swarm Optimization

C. Implementation Of Particle Swarm Optimization For LoadDispatch Problem.

The main objective of economic load dispatch is to obtain the power generated by each generator, while achieving a minimum generation cost within constraints.According to algorithm of basic particle swarm optimization it is implemented for economic load dispatch problem.

IV. TEST SYTEM AND RESULTS

The above developed algorithm is validated through case studies. The validation is done for thermal conventional generator using a particle swarm optimization. All these simulations are carried out in MATLAB.A test system is taken for validation of solving a problem of economic load dispatch of conventional generator using particle swarm optimization. Its. A load curve i.e 24 hour load demand is considered its maximum and minimum generation limits are also considered.

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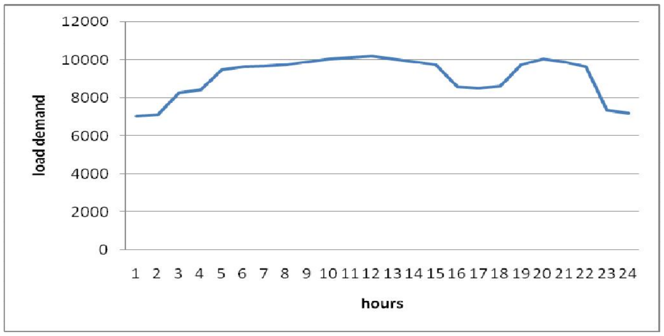

Figure 2 load curve of a 24 hour

Table 1 Various Load Demand of 24 hour

Sr.No.	Load demand P_D (MW)
1.	7036
2.	7110
3.	8258
4.	8406
5.	9480
6.	9628
7.	9702
8.	9776
9.	9924
10.	10072
11.	10146
12.	10220
13.	10072
14.	9924
15.	9776
16.	8554
17.	8480
18.	8628
19.	9776
20.	10072
21.	9924
22.	9628
23.	7332
24.	7184

The developed algorithm is validated through a test system. The validation is done for conventional thermal generators using a particle swarm optimization technique. All these simulation are done on MATLAB environment.
The power demand is taken as 10500MW. The total power generated is to be system load demand.
The cost function characteristics of 40 machine system and generators minimum and maximum generation limits are given.
The proposed Particle swarm optimization method is to obtain the minimum generation cost. Gbest values provide the output of generator. Simulation results for different load demands are observed.

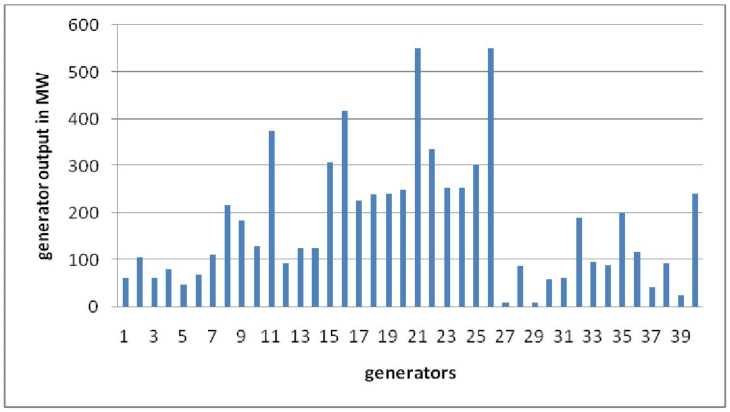

Figure 3 Contribution of generators at a load demand of 7036MW.

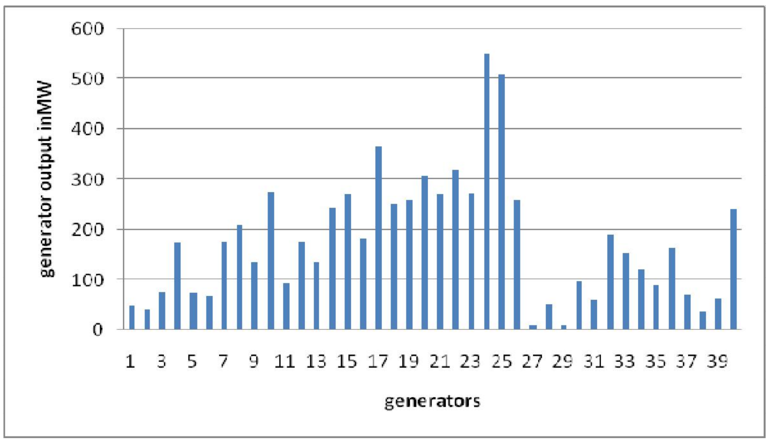

Figure 4 Contribution of generators at a load demand of 7110MW.

From above graph it is observed that some of the generators is generating very less amount of output power. And some of the generators is producing large amount of output power. The costly generators are producing less amount of power where as cheaper generators are producing large amount of power. So the fuel cost of every generator is calculated. Contribution of one generator for 24 load demand will be observed.

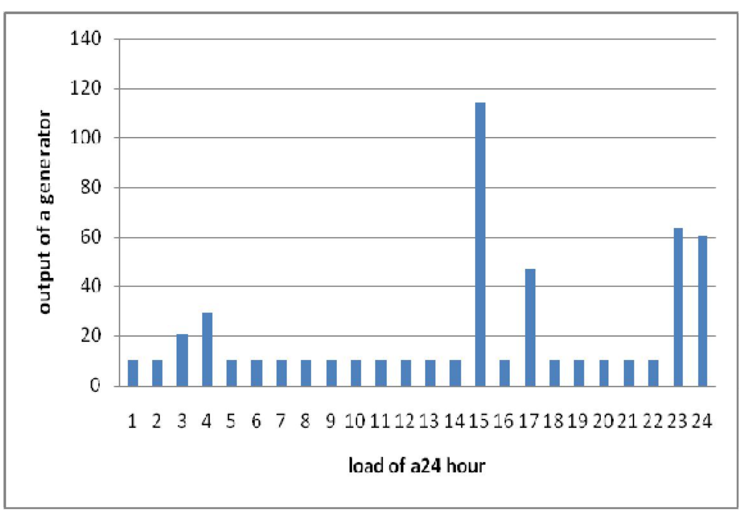

Figure 5 Contribution of generator 29 for a load curve.

Generator 29 is continuously producing less amount of power somewhere as it is generating more amount of power from somewhere.

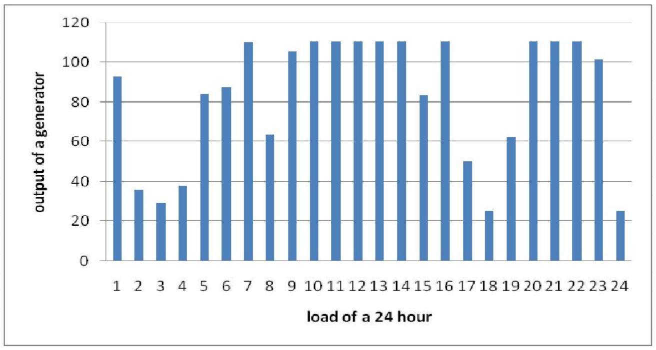

Figure 6 Contribution of generator 38 for a load curve.

From above graph behavior of every generator will be observed for various load demand.

V. CONCLUSION AND FUTURE SCOPE

Economic load dispatch is used in energy management system control by most programs to allocate the total generation among the all available units. The economic load dispatch of a conventional thermal generator is done. Contribution of generator at every load demand is observed. Contribution of a generator at a one load demand is observed. The costly generator is producing less output power. And cheaper generator is producing high output power.

particle swarm optimization has been successfully introduced to obtain the optimal solution of economic load dispatch. The program is done in MATLAB and results are observed. The simulation result shows that particle swarm optimization is capable of maintaining better results.As in future instead of using non renewable energy sources, there are many renewable energy sources. But now a day's wind energy is widely used in electrical power system. Most of the countries like USA, Germany, Spain and China are using wind energy. New technological developments in wind energy design have contributed to the significant advances in wind energy penetration and to get optimum power from available wind. The general features of wind power is not having a fuel cost so it is a non polluting source of energy. It is also called as clean source of energy. There are many affecting parameters while considering a wind power energy sources. Wind power must compete with conventional generation sources on a cost basis. By incorporating wind energy along with conventional power generators there will be effect on output and total cost of generation.

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