

Optimization of Economic Load Dispatch Problem Using Various Algorithm Techniques

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ABSTRACT: Economic load dispatch (ELD) is a process of finding optimal generation scheduling of available generators in an interconnected power system to meet the demand of the system, at lowest possible cost, while satisfying various operational constraints on the system. More just, the soft computing method has received supplementary concentration and was used in a quantity of successful and sensible applications. Here, an attempt has been made to find out the minimum cost by using different algorithm techniques using the data of six generating units. In this work, data has been taken such as the loss coefficients with the max-min power limit and cost function. All the methods are executed in MATLAB environment. The effectiveness and feasibility of different methods were demonstrated by six generating unit's case study and the results compared have been shown in the tabular form.

KEYWORDS: Economic load dispatch, Particle Swarm Optimization, Simulated Annealing, Differential Evolution, Artificial Bee Colony

I. INTRODUCTION

Since an engineer is always concerned with the cost of products and services, the efficient optimum economic operation and planning of electric power generation system have always occupied an important position in the electric power industry. 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 charges of the electric energy. A saving in the operation of the system of a small per cent represents a significant reduction in operating cost as well as in the quantities of fuel consumed. The classic problem is the economic load dispatch of generating systems to achieve minimum operating cost. This problem area has taken a subtle twist as the public has become increasingly concerned with environmental matters, so that economic dispatch now includes the dispatch of systems to minimize pollutants and conserve various forms of fuel, as well as achieve minimum cost. In addition there is a need to expand the limited economic optimization problem to incorporate constraints on system operation to ensure the security of the system, thereby preventing the collapse of the system due to unforeseen conditions. However closely associated with this economic dispatch problem is the problem of the proper commitment of any array of units out of a total array of units to serve the expected load demands in an 'optimal' manner. For the purpose of optimum economic operation of this large scale system, modern system theory and optimization techniques are being applied with the expectation of considerable cost savings.

Increasing load demand of power system leads to more complexity of the network. More and more generating units are added in the existing power system network, this increase in complexity results in uneconomical operation of the power system. As we know electricity has become an important resource of our country and thus efficient use of it is a must for an electrical engineer. The uneconomical operation of electrical energy is a waste of energy and money of the country. In this research an attempt has been made to operate any power system network in the most economical manner thus reducing power losses and also making the network cost efficient

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II. LITERATURE SURVEY

A.J Wood [1] has described power generation operation and control of different types of power plant. The cost characteristics of generation at different load is helpful to understand the economic load dispatch of the power plants.

HadiSaadat[2] has explained the concept of economic load dispatch considering transmission losses and neglecting transmission losses.

DP Kothari and JS Dhillon[3] has proposed different optimization techniques. The algorithm of these methods helps to prepare the MATLAB program of respective optimization techniques.

M. Venkatesh[4] Simulated Annealing (SA) algorithm for optimization inspired by the process of annealing in thermodynamics to solve economic load dispatch (ELD) problems. The proposed approach is found to provide the optimal results while working with operating constraints in the ELD and valve point loading effects.

NidulSinha[7] Evolutionary programming has emerged as a useful optimization tool for handling nonlinear programming problems. Various modifications to the basic method have been proposed with a view to enhance speed and robustness and these have been applied successfully on some benchmark mathematical problems. But few applications have been reported on real-world problems such as economic load dispatch (ELD).

MukeshGarg[10] From this paper, it is to identify the optimal combination of generation level of all generating units which minimizes the total fuel cost while satisfying the load. It explains how conventional load dispatch problem has to be solved to find the generation level that minimize the cost or minimize the emission level or their combination subjected to load balance.

III. PROPOSED METHODS

Particle Swarm Optimization:

PSO simulates the behaviours of bird flocking. Suppose the following scenario: a group of birds are randomly searching food in an area. There is only one piece of food in the area being searched(unknown) and all the birds do know how far the food is in each iteration. These birds follow the bird, which is nearest to the food and PSO used this technique to solve the optimization problems. In PSO, each single solution is a "bird" in the search space called "particle". All particles have fitness values, which are evaluated by the fitness function to be optimized, and have velocities.

The particles fly through the problem space by following the current optimum particles. 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 called p-best. and another "best" obtained so far by any particle in the population called g-best. After finding the two best values, the particle updates its velocity and positions.

Simulated Annealing:

For certain problems, Simulated Annealing may be more efficient than exhaustive provided that the goal is merely to find an acceptably good solution in a fixed amount of time, rather than the best possible solution. The name and inspiration come from annealing in metallurgy, a technique involving heating and controlled cooling of a material to increase the size of its crystals and reduce their defects. The heat causes the atoms to become unstuck from their initial positions and wander randomly through states of higher energy; the slow cooling gives them more chances of finding configurations with lower internal energy than the initial one.

By analogy with this physical process, each step of the SA algorithm replaces the current solution by a random "nearby" solution, chosen with a probability that depends both on the difference between the

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corresponding function values and also on a global parameter temperature T , that is gradually decreased during the process. The dependency is such that the current solution changes almost randomly when T is large, but increasingly "downhill" as T goes to zero. The allowance for "uphill" moves potentially saves the method from becoming stuck at local optima which are the bane of greedier methods.

Artificial Bee Colony:

Artificial Bee Colony (ABC) is a swarm based a stochastic search algorithm which imitates the scrounging behaviour of honeybees. In ABC algorithm, the colony of artificial bees consists of three groups of bees: employed bees, onlookers and scouts. Some of the bee of colony consists of employed artificial bees and the some includes the onlookers. Here, the number of employed bees is equal to the number of food sources around the hive. The employed bee whose food source has been abandoned becomes a scout. In ABC algorithm the position of food source determines the solution and the amount of nectar represents the fitness of the respective solution. An artificial onlooker bee chooses a food source depending on probability value associated with food source.

In ABC, provided that a position cannot be improved further through a predetermined number of cycles, that food source is assumed to be abandoned. The value of predetermined number of cycles is an important control parameter of the ABC algorithm, which is called limit for abandonment.

Differential Evolution:

The DE algorithm is a stochastic population based algorithm similar to Genetic Algorithms (GA) using the operators; crossover, mutation and selection. The key dissimilarity between GA and DE is that GAs rely mostly on crossover while DE relies on mutation operation. The algorithm uses mutation operation as a search mechanism and selection operation to direct the search toward the prospective regions in the search space. Mutation in DE uses differences of randomly sampled pairs of solutions in the population and greediness may be embedded in it. The DE algorithm also uses a non-uniform crossover that can take child vector parameters from one parent more often than it does from others.

By using the components of the existing population members to construct trial vectors, the recombination (crossover) operator efficiently shuffles information about successful combinations, enabling the search for a better solution space. An optimization problem consisting of N parameters can be represented by an N -dimensional vector. In DE, a population of solution vectors is randomly created at the initialization stage. This population is successfully improved by applying mutation, crossover and selection operators thus evaluating the objective function or the fitness function. An initial population of candidate solutions is formed by assigning random values to each decision parameter of every individual in the population. And then the fitness function value of the new individual is computed and the best individual selected for the next generation.

IV. PROBLEM FORMULATION

The model used to test the mentioned algorithm techniques for minimisation of loss in the system is shown below.

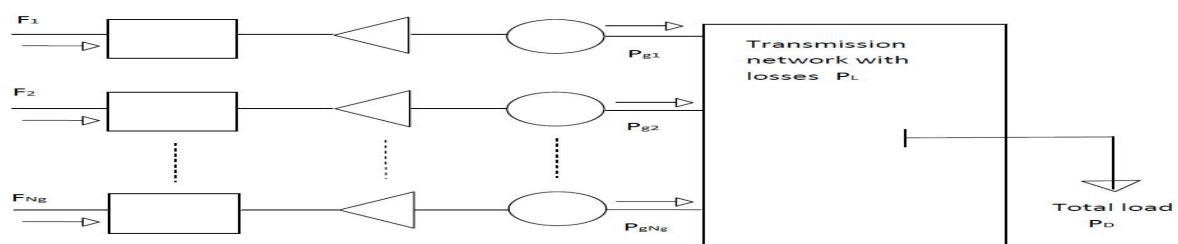


Fig1N thermal units connected to serve a load through transmission network

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Figure 1 represents the schematic of a system in which entire thermal power generating units are connected to an equivalent load bus via transmission network. In this figure the load and transmission losses are supplied by N thermal units.

The objective of ED is to minimize the total generation costs of a power system over an appropriate period (usually one hour), while satisfying various constraints. The ED planning must perform the optimal generation dispatch among the operating units in order to satisfy the system load demands and practical operation constraints of generators, which include ramp rate limits, maximum and minimum limits, and prohibited operating zones. Fuel cost function of each thermal generating unit is expressed as a quadratic function. In terms of real power output, total cost can be expressed as the following:

$$F_i(P_{gi}) = a_i P_{gi}^2 + b_i P_{gi} + c_i \text{ \$/h}$$

where a_i , b_i , and c_i are the fuel cost coefficients of i^{th} generator. a_i represents interest and depreciation, salary and wages and is not dependent on the generation. b_i includes the fuel cost and c_i represents the losses in system.

The problem can be stated as:

➤ Minimize:

$$F(P_{gi}) = \sum_{i=0}^{N_g} F_i(P_{gi})$$

Subject to the constraints:

i. Power balance constraint

$$\sum_{i=0}^{N_g} P_{gi} = P_D + P_L$$

ii. Generator capacity constraints

$$P_{gi}^{min} \leq P_{gi} \leq P_{gi}^{max}$$

V. RESULTS AND DISCUSSION

If transmission losses are very small or generators are connected close enough to the load centre, the transmission losses can be neglected. But when generating units are situated at different distance from the load, the transmission losses plays very important role and the economic dispatch will be affected by cost of different transmission losses. The concept of economic load dispatch considering transmission losses has been considered in my thesis. The proposed methods are used to find the optimal results while working with operating constraints in the ELD.

Here we have considered a standard IEEE six generator system to find ELD using different Optimization techniques. With the data and the loss coefficients given below the generator output has been calculated.

The below shown table gives the fuel cost and plant generation limits of the six plants used in our case study.

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Table 1: Table showing fuel cost coefficient and plant limits for six generator system

S.No.	Rs/MW ²	Rs/MW	Rs	Plant limit(MW) lower	Plant limit(MW) upper
1.	.007	7	240	100	500
2.	.0095	10	200	50	200
3.	.009	8.5	220	80	300
4.	.009	11	200	50	150
5.	.008	10.5	220	50	200
6.	.0075	12	200	50	120

In the calculation of Economic Load Dispatch Problem along with the above generator information the B-coefficient are also required. Here, B-coefficient matrix is used for representing the transmission losses.

The matrix is given as below:

$$B=1e-4* \begin{bmatrix} 0.14 & 0.17 & 0.15 & 0.19 & 0.26 & 0.22 \\ & 0.17 & 0.6 & 0.13 & 0.16 & 0.15 & 0.2 \\ & 0.15 & 0.13 & 0.65 & 0.17 & 0.24 & 0.19 \\ & & 0.19 & 0.16 & 0.17 & 0.71 & 0.3 & 0.25 \\ & & & 0.26 & 0.15 & 0.24 & 0.3 & 0.69 & 0.32 \\ & & & & 0.22 & 0.2 & 0.19 & 0.25 & 0.32 & 0.85 \end{bmatrix}$$

Power demand=700MW

The below shown table(2) shows the comparison of active power generation of six plants performing Economic Load Dispatch.

Table 2: Comparison of active power calculation of six plants performing Economic load dispatch

S.No.	Algorithm techniques	P_{g1} (MW)	P_{g2} (MW)	P_{g3} (MW)	P_{g4} (MW)	P_{g5} (MW)	P_{g6} (MW)
1.	PSO	204.9	60.14414	220.1	96.65	53.69	77.27
2.	SA	323.64	76.68	158.93	50.00	51.97	50.0
3.	ABC	323.63	76.68	158.42	50.01	51.97	50.0
4.	DE	323.63	76.68	158.43	50.07	51.97	50.0

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The below shown table(3) shows the comparison of fuel cost generated and the power loss computed while solving Economic Load Dispatch by different algorithm techniques. It also gives an idea of total time taken by the various techniques.

Table 3: Comparison of fuel cost and power loss computed by various algorithm techniques

Algorithm techniques	PSO	SA	ABC	DE
FuelCostRs/Hr ×10³	8.577	8.4226	8.3526	8.3223
Power loss (MW)	12.8176	10.7354	10.7356	10.7334
Time Elapsed (seconds)	4.6886	8.119308	3.1192	2.116953

VI. CONCLUSION

In this work, the formulation and implementation of solution methods to obtain the optimum solution of Economic Load Dispatch problem using various algorithm techniques. The effectiveness of the developed algorithm is tested for six generator system and the result has been shown in the tabular form. From the result obtained we can conclude that although PSO algorithm is a faster way of solving an economic load dispatch problem but it has higher power losses as compare to Simulated Annealing.

More accurate results can be obtained by incorporating more constants. The above system can also be extended to a large system having more no of generators. The algorithm technique used can be hybridized with more advanced techniques to produce even more better results.

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