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Economic Load Dispatch Using Genetic Algorithm

KEYWORDS: Economic load dispatch, Lambda iteration method, Genetic Algorithm

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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 on the system, at lowest possible cost, while satisfying various operational constraints on the system. This paper presents overview of economic load dispatch problems and solution methodologies. MATLAB programming of Lambda iteration method used for solving economic load dispatch problem was done and results are given in tabular form. Also presents overview of Genetic Algorithm concept.*

1 .INTRODUCTION

Economic load dispatch (ELD) problem is the one of the most important optimization problem in power system. Main goal of economic load dispatch problem is allocation of power generation to different thermal units to minimize total fuel cost while satisfying the load demand and operating constraints. Traditionally in ELD problems, the cost function for generating units has been approximated as a quadratic function[1].

Several techniques have been introduced to solve the optimization of ELD, which can be divided into conventional and stochastic methods. Conventional methods use a deterministic approach, such as the LaGrange multiplier, Linear Programming (LP) and Dynamic Programming (DP) [2]. These methods have limitations or drawbacks when coping with more complex problems. The DP method has a problem when the number of generators is increased and higher accuracy is needed [3].

Recent techniques have been developed using stochastic approaches for solving optimization problems. Examples are an Adaptive Hopfield Neural Network [4], the Simulated Annealing method [5], and Genetic Algorithms (GA), amongst others. These new methods offer alternative techniques which attempt to overcome the drawbacks of conventional methods.

2. ECONOMIC LOAD DISPATCH

2.1 Economic load dispatch

The Economic Dispatch can be defined as the process of allocating generation levels to the generating units, so that the system load is supplied entirely and most economically. For an interconnected system, it is necessary to minimize the expenses. The economic load dispatch is used to define the production level of each plant, so that the total cost of generation and transmission is minimum for a prescribed schedule of load. The objective of economic load dispatch is to minimize the overall cost of generation.

2.2 Generator Operating Cost

The total cost of operation includes the fuel cost, cost of labour, supplies and maintenance. Generally, costs of labour, supplies and maintenance are fixed percentages of incoming fuel costs. The power output of fossil plants is increased sequentially by opening a set of valves to its steam turbine at the inlet. The throttling losses are large when a valve is just opened and small when it is fully opened.

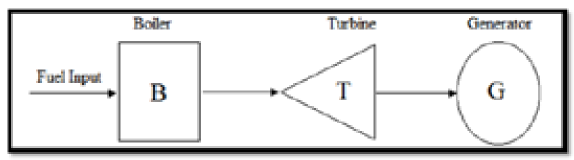
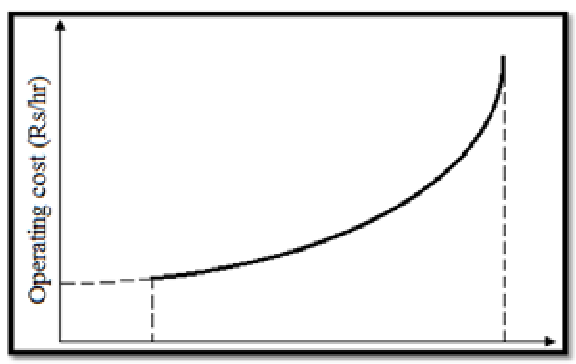


Figure 1 Simple model of a fossil plant

Figure 1.shows the simple model of a fossil plant dispatching purposes. The cost is usually approximated by one or more quadratic segments. The operating cost of the plant has the form shown in Figure 2.



P_{gi} min Output Power (MW) P_{gi} max

Figure 2 Operating costs of a fossil fired generator

The fuel cost curve may have a number of discontinuities. The discontinuities occur when the output power is extended by using additional boilers, steam condensers, or other equipment. They may also appear if the cost represents the operation of an entire power station, and hence cost has discontinuities on paralleling of generators. Within the continuity range the incremental fuel cost may be expressed by a number of short line segments or piece-wise linearization. The P_{gi} min is the minimum loading limit below which, operating the unit proves to be uneconomical (or may be technically infeasible) and P_{gi} max is the maximum output limit[6].

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3. PROBLEM FORMULATION

3.1 Objective Function

The objective of the economic dispatch problem is to minimize the total fuel cost while satisfying the constraints.

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

$F(P_{gi}) = a_i P_{gi} * 2 + b_i P_{gi} + c_i$ Rs/ hr…………..(1)

Where a_i, b_i, c_i, are cost coefficients for ith unit. $F_i(P_{gi})$ is the total cost of generation. P_{gi} is the generation of ith unit.

3.2 Constraints

3.2.1 Power balance constraints

Generated power should be the same as the total load demand PD (in MW). In this case, the active power balance is given by

$P_D = \sum_{i=1}^{n} Pgi$ …………..(2)

The transmission and generator losses have been neglected.

3.2.2 Generation limits

The output power of each generating unit has a lower and upper bound so that it lies in between these bounds.

$P_{gi} \min \le P_{gi} \le P_{gi} \max$ ....3)

Where P_{gi} min and P_{gi} max are the minimum and maximum output of generator i, respectively.

4. LAMBDA ITERATION METHOD

The solution to this problem can be approached by considering a graphical technique for solving the problem and then extending this into the area of computer algorithms. The lambda-iteration procedure converges very rapidly for this particular type of optimization problem. The actual computational procedure is slightly more complex [7]. We use following MATLAB code formulated for no losses as:

```
clc;
clear;
disp ('The minimum generation limit for generator 1 is 30 MW and maximum is 175 MW');
disp ('The minimum generation limit for generator 2 is 20 MW and maximum is 125 MW');
IFC = [0.2 40; 0.4 30];
disp ('The minimum and maximum values of lambda for the individual generators are');
lam_min_Pg1 = (IFC(1,1) * 30) + IFC(1,2)
lam_max_Pg1 = (IFC(1,1) * 175) + IFC(1,2)
lam_min_Pg2 = (IFC(2,1) * 20) + IFC(2,2)
lam_max_Pg2 = (IFC(2,1) * 125) + IFC(2,2)
disp ('The minimum load demand = 30 + 20 = 50 MW');
disp ('The maximum load demand = 175 + 125 = 300 MW');
load = 50;
Pg = [0, 0];
lambda = lam_min_Pg2;
del_lambda = 0.01;
result = [0];
for (i = 1:1:26)
while (abs(load - Pg(1) - Pg(2)) > 1)
if ((load - Pg(1) - Pg(2)) > 0)
lambda = lambda + del_lambda;
else
lambda = lambda - del_lambda;
end
for (j=1:1:2)
Pg(j) = (lambda - IFC(j,2))/IFC(j,1);
end
end
result(i,1) = i;
result(i,2) = lambda;
result(i,3) = Pg(1);
result(i,4) = Pg(2);
result(i,5) = Pg(1)+Pg(2);
result(i,6) = load;
load = load + 10;
end
disp(' Sr.no. lambdaPg(1) Pg(2) Pg(1)+Pg(2) Load');
disp (result);
```

5. GENETIC ALGORITHM

5.1 Introduction

The basic principles of GA were first proposed by Holland [8]. Thereafter, a series of literature [9], [10], [11] and reports became available. A Genetic Algorithm (GA) is a search technique used in computing to find exact or approximate solutions to optimization and search problems. Genetic algorithms are categorized as global search heuristics. Genetic algorithms are a particular class of Evolutionary Algorithms (EA) that use techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover.

5.2 Overview of Genetic Algorithm

GA is a method for deriving from one population of "chromosomes" (e.g., strings of ones and zeroes, or bits) a new population. This is achieved by employing "natural selection" together with the genetics inspired operators of recombination (crossover), mutation, and inversion. Each chromosome consists of genes(e.g. bits), and each gene is an instance of a particular allele(e.g,0 or 1).The selection operator chooses those chromosomes in the population that will be allowed to reproduce, and on average those chromosomes that have a higher fitness factor(defined bellow),produce more offspring than the less fit ones. Crossover swaps subparts of two chromosomes, roughly imitating biological recombination between two single chromosome ("haploid") organisms; mutation randomly changes the allele values of some locations (locus) in the chromosome; and inversion reverses the order of a contiguous section of chromosome

5.3 PROPERTIES OF GA

- Generally good at finding acceptable solutions to a problem reasonably quickly
- Free of mathematical derivatives
- No gradient information is required
- Free of restrictions on the structure of the evaluation function
- Fairly simple to develop

6. RESULTS AND DISCUSSIONS

Lambda iteration method is implemented on case of without losses and with generation limits.

Incremental fuel costs in rupees per MWh for a plant consisting of two units are

$dF_1(P_1)/dP_1 = 0.20P_1 + 40$ unit of cost/MWhr

$dF_2(P_2)/dP_2 = 0.40P_2 + 30$ unit of cost/MWhr

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and the generator limits are

30 MW ≤ P_1 ≤ 175 MW and 20 MW ≤ P_2 ≤ 125 MW

Output:
The minimum generation limit for generator 1 is 30 MW and maximum is 175 MW

The minimum generation limit for generator 2 is 20 MW and maximum is 125 MW

The minimum and maximum values of lambda for the individual generators are

lam_min_Pg1 =
46

lam_max_Pg1 =
75

lam_min_Pg2 =
38

lam_max_Pg2 =
80

The minimum load demand = 30 + 20 = 50 MW

The maximum load demand = 175 + 125 = 300 MW

Sr.no.	lambda	Pg(1)	Pg(2)	Pg(1)+Pg(2)	Load
1.0000	43.2100	16.0500	33.0250	49.0750	50.0000
2.0000	44.5400	22.7000	36.3500	59.0500	60.0000
3.0000	45.8700	29.3500	39.6750	69.0250	70.0000
4.0000	47.2100	36.0500	43.0250	79.0750	80.0000
5.0000	48.5400	42.7000	46.3500	89.0500	90.0000
6.0000	49.8700	49.3500	49.6750	99.0250	100.0000
7.0000	51.2100	56.0500	53.0250	109.0750	110.0000
8.0000	52.5400	62.7000	56.3500	119.0500	120.0000
9.0000	53.8700	69.3500	59.6750	129.0250	130.0000
10.0000	55.2100	76.0500	63.0250	139.0750	140.0000
11.0000	56.5400	82.7000	66.3500	149.0500	150.0000
12.0000	57.8700	89.3500	69.6750	159.0250	160.0000
13.0000	59.2100	96.0500	73.0250	169.0750	170.0000
14.0000	60.5400	102.7000	76.3500	179.0500	180.0000
15.0000	61.8700	109.3500	79.6750	189.0250	190.0000
16.0000	63.2100	116.0500	83.0250	199.0750	200.0000
17.0000	64.5400	122.7000	86.3500	209.0500	210.0000
18.0000	65.8700	129.3500	89.6750	219.0250	220.0000
19.0000	67.2100	136.0500	93.0250	229.0750	230.0000
20.0000	68.5400	142.7000	96.3500	239.0500	240.0000
21.0000	69.8700	149.3500	99.6750	249.0250	250.0000
22.0000	71.2100	156.0500	103.0250	259.0750	260.0000
23.0000	72.5400	162.7000	106.3500	269.0500	270.0000
24.0000	73.8700	169.3500	109.6750	279.0250	280.0000
25.0000	75.2000	176.0000	113.0000	289.0000	290.0000
26.0000	76.5400	182.7000	116.3500	299.0500	300.0000

Table:1 Economic Load Dispatch Using Lambda iteration Method

7. CONCLUSION

This paper gives overview of economic load dispatch problems and solution methodologies.

Implementation is done using MATLAB programming and results are given in tabular form.Conventional method like lambda iteration method converges rapidly but complexities increases as system size increase also lambda method always requires that one be able to find the power output of a generator, given an incremental cost for that generator.

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