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Optimal Dispatch for Deregulated Power Systems using Fuzzy Logic Decision Making Technique

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Abstract **Review Article**

System losses can be reduced and the voltage profile can be improved with reactive power. The stability index, fuel cost, and losses are all calculated using membership functions. Utilizing load flow equations and fuzzy logic, an attempt is made in this paper to optimize fuel cost and line flow in order to minimize actual power loss over the transmission lines. The Decision Maker (DM) is assumed to have vague or imprecise goals for achieving each objective in this paper. The fuzzy decision satisfaction maximization method, which is an effective method for obtaining a trade-off solution to multi-objective problems, is used to solve the multi-objective problem. On an IEEE 57 bus system, the developed algorithm for optimizing each objective is tested.

Keywords: Real power, Reactive power, losses, membership functions, Newton Raphson and fuzzy logic.

INTRODUCTION

The power system operator solves the economic load dispatch optimization problem in order to allocate the power required to be produced by generating stations taking into account their production costs and utility demand profiles. We need the production costing functions or curves of various types of generating stations to solve the economic dispatch problem. The dispatch issue has developed in tandem with the system's increasing technical and financial complexity. It includes spot pricing mechanisms, the allocation of transmission rights, and power flow constraints to determine generator dispatch and is frequently referred to as the Optimal Power Flow (OPF) formulation. Cost of fuel function: Due to the fact that hydropower plants have virtually no variable operating costs and nuclear power plants typically operate at constant output levels, the costs of the fuel used in fossil fuel plants fall under the dispatching procedures category. Fuzzy decision making is one new method being used to solve the economic load dispatch problem. Different readings will result in the same thing. In the Optimal Power Flow (OPF) combinatorial problem on the IEEE 57-bus Electrical Network, the Fuzzy Logic optimization algorithms are demonstrated in this paper. Programming in the MATLAB environment was used to create the algorithm (R2010a).

RESEARCH GAP

According to the literature, the power system experiences frequent and large variations in load, making it impossible to dispatch loads to meet every possible load demand. because there is no standard method for determining the best way to alleviate network congestion and economical load distribution. Therefore, the optimization problem is modeled for the issues of economic load distribution and network congestion.

Because it demonstrates that it has true optimum generations, the fuzzy decision-making technique is found to be superior to many other methods. Therefore, this method can be used to reduce network congestion and operating costs for ELD issues.

PROBLEM FORMULATION

Several methods for scheduling power plants and determining their production level have been developed in order to operate power systems in an effective and dependable manner. Power dispatch and minimum network congestion are methods that optimize system operation by adjusting a control variable and allocating power throughout the system. There are two ways power is distributed: Problems with real power dispatch and reactive power dispatch Allocating power generation to various thermal units in order to reduce operating costs while still adhering to the power system's equality and inequality constraints is the traditional real power dispatch problem. The real power dispatch problem becomes a nonlinear constrained optimization problem as a result of this. As a result, the power dispatch issue with system loss in mind can reasonably improve both real and reactive power dispatch at the same time. As a result, the power dispatch issue, which takes into account network, social, and economic congestion, can be solved as a multi-objective optimization issue. For the multi-objective power dispatch optimization, the fuzzy decision-making method is also used.

FORMULATION OF PROBLEM:

The main objective function is to minimize the operating cost.

$F(P_{Gi}) = \sum_{i=1}^{NG}(a_i P_{Gi}^2 + b_i P_{Gi} + c_i)\ \$/h$ ………………………………………….……………… (1)

Subject to

Energy balance equation

$\sum_{i=1}^{NG} P_{Gi} = P_D + P_L$ ……………………………………………………….…………………. (2)

The inequality constraints

$P_i^{min} \le P_i \le P_i^{max}$

$(i = 1,2, \dots, NG)$……………………………………………………………………… (3)

Where

a_i, b_i, c_i are cost coefficients of the ith unit

P_D is load demand.

P_i is real power generation and will act as decision variable.

P_L is power transmission loss.

NG is the number of generator buses.

The objective function of reactive power dispatch problem is to minimize the active or real power loss, subjected to various equality and inequality constraints.

Problem formulation for reactive power dispatch problem is given below:

Minimize: $F_2 = P_{Loss}$ ………………………………………………………..…….. (4)

Subjected to: $h(P_{Gi}) = 0$

i=1,2,3……….NG ……………………………………………………….……….. (5)

$g(P_{Gi}) \le 0$…………………………………………………………………….……… (6)

F_2 is the total Real power loss

P_{Loss} is the total power loss

The reactive power dispatch is used to solve the power flow equations. Hence as a result an improved voltage profile can be obtained. Reactive power dispatch is defined as following by using load flow equations.

$Q_{Gi} - Q_{di} + V_i \sum_{m=1}^{n} V_m Y_{im} \sin(\theta_{im} + \delta_m - \delta_i) = 0$ ……………………….………….. (7)

Where

i=1, 2, 3…..n

Q_{di} is total system demand of reactive power bus.

Q_{Gi} is total system generation of reactive power bus.

V_i is magnitude of votage at bus i^{th} bus.

δ_i is voltage phase angle at i^{th} bus.

Y_{im} is admittance matrix of i^{th} and m^{th}bus.

COMPUTATION OF LINE FLOWS

Consider that line is connecting the buses I and m. The Real power is injected from bus I to M and is given as following.

$[P_{im} + jQ_{im} = V_i[(V_i - V_m)Y_{im} + V_i Y_{im0}]]$ ………………………………………… (8)

Reactive power is injected from bus N to bus I as following

$P_{mi} + jQ_{mi} = V_m[(V_m - V_i)Y_{mi} + V_i Y_{mi0}]$ …………………..…………………….. (9)

Where

Y_{im} is the series admittance

Y_{im0} is the shunt admittance

V_i is the voltage at the i^{th} bus

$S_{im} = P_{im} + jQ_{im}$………………………………………………………………… (10)
$S_{mi} = P_{mi} + jQ_{mi}$ ………………….…………………………………………..… (11)
Power losses in the (I-M) th line is the sum of the power flows in the (I-M) th line from the i^{th} bus and the m_{th} bus.
$P_{Lim} = S_{im}+S_{mi}$ …………………..……………………………………………. (12)

Implementation of Fuzzy Decision Making Technique for Optimization

Step 1. Input parameters of system, fuel cost co-efficient and specify lower and upper boundaries and define minimum fuel cost function.
Step 2. Get the power generation for seven generating units and total fuel cost neglecting losses.
Step 3. Input bus data and branch data and take values of real power and reactive power for 57 bus system considering constraints. Also specify voltage and phase angle.
Step 4. Get the values of P_{Gi} (i = 1, 2….7) and fuel cost with Economic load dispatch and voltage and phase angle for 30 bus system.
Step 5. Calculate complex power S from Y bus using voltage and phase angle obtained in step 4.
Step 6. Substitute value of Complex power in minimizing line flow in branch 3(1-2) and get values of voltage, phase angle, fuel cost, P_{Gi} and line flow.
Step 7. Take fuel cost obtained in step 4 and step 6 and line flow values from step 6.
Step 8. Define linear membership function for fuel cost and line flow obtained in step 4 and step 6.
Step 9. Apply Fuzzy decision making technique with linear membership function μ for optimal point.
Step 10. Get the value of membership function for line flow and cost which lies on same point.

CASE STUDIES AND RESULTS

Table 1: Performance parameters for IEEE 57 Bus System

Cases	Power Losses (MW)	Line Flow (MW)	Fuel cost($/h)
With Losses	.28	53.72	591.29
With Minimization of Line Flow in Branch 3(1-2)	.94	20.24	1687.86
When Fuzzy Decision Making is Applied	.25	42.99	662
Linear Membership Function		.9	.9

Table 2: Voltages for different Load Buses of different test cases

Bus No.	Voltages with Economic Load Dispatch (Volts)	Voltages with Minimization of Line Flow (Volts)	Voltages with Fuzzy Decision Making Technique (Volts)
1	1.04	1.00	1.02
2	1.05	1.00	1.03
3	1.06	1.08	1.05
4	1.06	1.07	1.05
5	1.05	1.07	1.06
6	1.06	1.08	1.06
7	1.04	1.07	1.05
8	1.05	1.10	1.05
9	1.02	1.04	1.02
10	1.01	1.01	1.00
11	1.01	1.02	1.00
12	1.02	1.02	1.00
13	1.01	1.00	1.00
14	1.01	0.99	0.99
15	1.03	1.01	1.01
16	1.02	1.00	1.00
17	1.02	0.99	1.00
18	1.07	1.09	1.06
19	1.00	1.00	0.99
20	0.99	0.98	0.98
21	1.05	1.05	1.04
22	1.05	1.05	1.04
23	1.05	1.05	1.04
24	1.05	1.06	1.04
25	1.04	1.04	1.03

Bus No.	Voltages with Economic Load Dispatch (Volts)	Voltages with Minimization of Line Flow (Volts)	Voltages with Fuzzy Decision Making Technique (Volts)
26	1.01	1.02	1.00
27	1.04	1.06	1.04
28	1.05	1.08	1.06
29	1.07	1.10	1.07
30	1.02	1.02	1.01
31	0.99	0.99	0.98
32	1.00	1.00	0.99
33	1.00	1.00	0.99
34	1.00	1.00	0.99
35	1.01	1.00	1.00
36	1.02	1.01	1.01
37	1.03	1.02	1.02
38	1.06	1.05	1.04
39	1.03	1.02	1.01
40	1.02	1.01	1.00
41	1.04	1.04	1.03
42	1.01	1.01	1.00
43	1.05	1.05	1.04
44	1.06	1.05	1.05
45	1.08	1.07	1.06
46	1.10	1.09	1.09
47	1.07	1.07	1.06
48	1.07	1.06	1.05
49	1.07	1.06	1.06
50	1.06	1.05	1.04
51	1.08	1.08	1.07
52	1.04	1.07	1.04
53	1.03	1.06	1.03
54	1.05	1.07	1.05
55	1.08	1.10	1.08
56	1.01	1.02	1.00
57	1.01	1.01	1.00

Table 3: Demand with different Test cases

Test Cases	PG1 (MW)	PG2 (MW)	PG3 (MW)	PG4 (MW)	PG5 (MW)	PG6 (MW)	PG7 (MW)
Without Losses (P_d =12.508 MW)	2.2741	1.1379	2.2698	1.1368	2.2755	1.1379	2.268
With Losses (With NR Method) (P_d =12.508)	2.2476	1.1081	2.2321	1.1575	2.3493	1.1956	2.4354
With Minimization of Line Flow (With NR Method) (P_d =12.508)	0	0	8.7336	1.3047	1.1668	0.8302	1.354
Fuzzy Decision Making Technique (P_d =12.508)	1.7751	1.7419	1.7746	1.7824	1.8466	1.8833	1.9515

CONCLUSION

In this paper, fuzzy decision-making technique have been used for solving the economic load dispatch and to minimize the line flow. Four different test cases of seven-unit system are taken. The comparative simulations with and without losses, illustrate that power plants have powerful performance in total cost production and can reduce total cost in power systems. Fuzzy Decision-Making technique is applied to economic power generation for seven generating units. Fuzzy Decision-Making Technique was employed to solve the ELD problem for four cases of seven generating unit system without losses and with losses. The conclusion describes the capability of the proposed fuzzy decision multi-objective technique to solve the problems of economic load dispatch and line flow.

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