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Fuzzy Logic solution for Unit Commitment

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Abstract-- The process of determining start up or shut down schedule - of generating units is referred as Unit Commitment (UC). The main objective of UC problem is to schedule the generating units so as to meet the predicted power demand at minimum operating cost while observing all plant and system constraints over a given schedule period [1]. The resultant schedule minimizes the system production cost during the period while simultaneously satisfying the power demand, spinning reserve, physical and operational constraints of the individual units. It has been mathematically formulated as a non-linear, large scale, mixed integer combinatorial optimization problem with various constraints.

Index Terms— MATLAB, UC, Spinning cost, Must run condition, start up cost, minimum down time, crew constrains.

1 INTRODUCTION

The earlier efforts of solving unit commitment problem by using classical methods such as priority list [2,9,30], dynamic programming [3,7,30], integer programming [4], mixed integer programming, branch and bound method [5] and Lagrangean relaxation method [6,8]. Among these methods, the priority list method is a simple method but the quality of solution is rough. Similarly dynamic programming, which is based on priority list method, is flexible method to give optimal solution but more computational time is required in finding the optimal solution due to curse of dimensionality.

2 CONVENTIONAL METHODS

The branch-bound method adopts a linear function to represent the fuel consumption and time dependant start cost and obtain the lower and upper bounds. The major problem associated with this algorithm is that the more computational time is required to achieve the accurate solution for large scale UC problem. The integer and mixed integer methods adopt linear programming techniques to solve and check for integer solution. However, these methods are well suited for small UC problems. The Lagrangian relaxation method provides fast solution but it may suffer from the numerical convergence.

The unit commitment is an optimization problem that economically schedules generating units over a short-term planning horizon subject to the satisfaction of demand and other system operating constraints. Many optimization methods have been proposed to solve the unit commitment problem. These methods include priority list methods, dynamic programming methods, sequential method and Lawgrangian relaxation methods etc. Lagrangian relaxation methods are now among the most widely used approaches to solving unit commitment.

Because generating units of a utility company are normally located in different areas interconnected via transmission lines, power flows are subject to thermal limit of transmission lines. This may result in rescheduling of some generating units and may incur significant costs. This paper presents a method for solving the unit commitment problem using Dynamic Programming approach. A first attempt to incorporate AC load flow constraints in unit commitment optimization was detailed in with promising although limited computational testing. At present, the computational requirements of that approach would be prohibitive for practical size problems but that might change with the rapid development in computation technology.

The transmission constraints are formulated as linear constraints based on a DC power flow model. I have considered the transmission constrained unit commitment problem using a dynamic programming method. I have proposed a practical method for solving the security-constrained unit commitment problem using Dynamic programming method. This approach has two types of constraints viz., demand constraints and spinning reserve

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constraints.This method takes full account of these constraints in the optimization phase and also in locating a feasible solution.

In this project I implemented the dynamic programming method of solving the unit commitment problem. The dynamic programming technique, when applicable, represents or decomposes a multi stage decision problem as a sequence of single decision problems. Thus, an n variable problem is represented as a sequence of n single variable problems, which are solved successively. In most of the cases these n sub problems are easier to solve than the original problem. The decomposition of n sub problems is done in such a manner that the optimal solution of the original problem can be obtained from the optimal solution of n one-dimensional problem.

The advantage of dynamic programming is its ability to maintain solution feasibility, unlike priority list method, which is highly heuristic, and mostly yield sub optimal solutions. Dynamic programming builds and evaluates the complete decision tree to optimize the problem at hand.

3 UNIT COMMITMENT PROBLEMS

The main objective of UC problem is minimization of the total production cost over the scheduling horizon. A successful UC schedule should be able to minimize the total operational cost to meet the predicted power demand and satisfy all unit constraints. The objective function and various constraints of UC problem are explained in the fallowing sections.

A. Objective function the objective function of UC problem is expressed as the sum of fuel cost, the start up and shut down cost of individual units for the given period subjected to various constraints. Mathematically, it can be formulated as follows,

$$.F = \sum_{t=1}^{T} \sum_{t=1}^{ng} ci(pi,t)Ii,t + SUi,t + SDi,t$$

Where

F = is total fuel cost

$ci(pi,t)$ = Fuel cost of generating unit

Ii,t = Status of units

SUi,t =Start up cost of the unit

SDi,t =Shutdown cost of the generating unit

T=no of hours

Ng=No of generating units

B. Constraints

The UC problem is subjected to many constraints such as the power balance, spinning reserve and the other constraints including the thermal constraints, fuel constraints and security constraints.

1) Power balance equation: The sum of the output powers of on line generators is equal to the forecasted system power demand in each period of time

2) Limits of generating units The output power of each generating unit must be within its allowable minimum and maximum limits.

3) Spinning reserve constraints Spinning reserve must be considered to meet abrupt load variations and unexpected generating unit outage. It is the total amount of power generation available from all units minus present load.

4) Ramp rate limits Due to physical restriction on generators, the rate of change of generation must be limited within a certain range. If the ramp rate constraints are included in the UC problem, the quality of the solution will be improved but the computational time is increase.

5) Thermal constraints

a) Minimum up time once a unit is start, the unit cannot shut it down before a minimum up time period is met.

b) Minimum down time When a generating unit in shut down, it cannot start up again before a minimum down time has passed.

4 FUZZY-LOGIC

Fuzzy logic can be conceptualized as a generalization of classical logic. Modern fuzzy logic was developed by Lotfi Zadeh in the mid-1960s to model thoseproblems in which imprecise data must be used or in which the rules of inference are formulated in a very general way making use of use categories In fuzzy logic, which is also sometimes called di use logic, there are not just two alternatives but a whole continuum of truth values for logical propositions. A proposition A can have the truth value 0.4 and its complement Act he truth value 0.5. According to the type of negation operator that is used, the two truth values must not be necessarily add up to 1.

Fuzzy logic has a weak connection to probability theory. Probabilistic methods that deal with imprecise knowledge are formulated in the Bayesian framework but fuzzy logic does not need to be justified using a probabilistic approach. The

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common route is to generalize the endings of multi valued logic in such a way as to preserve part of the algebraic structure Set of rules to determine output based on input values

Fuzzy Example.

Automotive Speed Controller

3 inputs:

speed (5 levels)

acceleration (3 levels)

distance to destination (3 levels)

1 output:

power (fuel flow to engine)

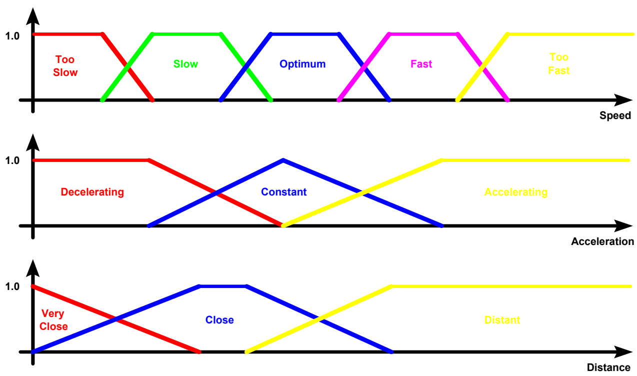

Fig.1 Membership function

Example Rules

IF speed is TOO SLOW and acceleration is DECELERATING,

Then increase power greatly

IF speed is SLOW and acceleration is DECREASING,

Then increase power greatly

IF distance is CLOSE,

Then increase power greatly

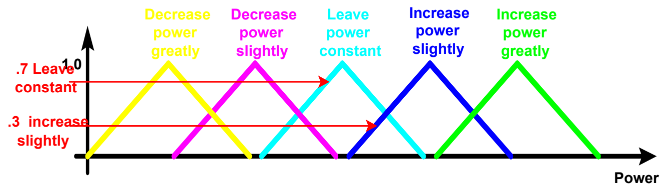

Fig.2 Fuzzy output

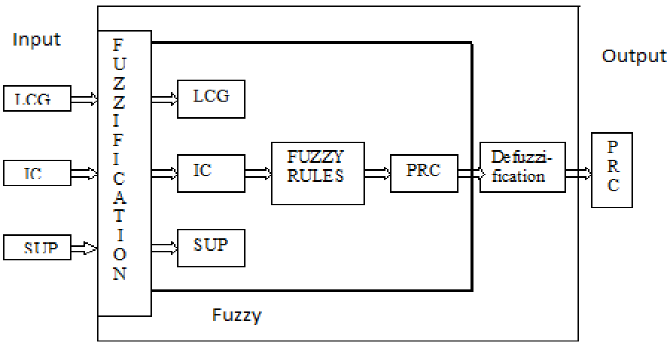

Fig.3 Block diagram of unit commitment

Case study:

Ten units are taken for case study.

T

S.N	Pmax	Pmin	a	b	c	Incremental fuel cost
1	455	150	1000	16.19	0.00048	16.7
2	455	150	970	17.26	0.00031	16.26
3	130	20	700	16.6	0.002	16.19
4	130	20	680	16.5	0.00211	16.2
5	162	25	450	19.7	0.00398	16.19
6	80	20	370	22.26	0.00712	16.19
7	85	25	480	27.74	0.0049	16.19
8	55	10	660	5.92	0.00413	16.19
9	55	10	665	27.27	0.00222	16.19
10	55	10	670	27.79	0.00173	16.19

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Table.2. Load pattern

Period(hrs)	Load (MW)
1	700
2	750
3	800
4	900
5	1000
6	1050
7	1100
8	1150
9	1200
10	1300
11	850
12	800
13	900
14	950
15	1000
16	1050
17	1150
18	1200
19	1150
20	1400
21	850
22	950
23	1100
24	900

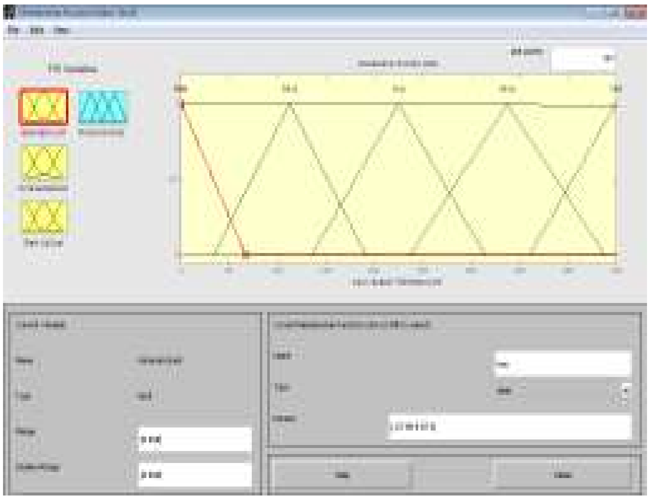

Fig.4 Fuzzy input

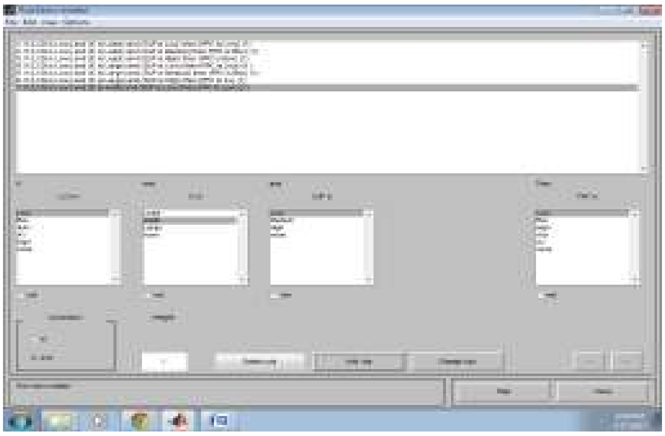

Fig.5.Fuzzy Rule editor

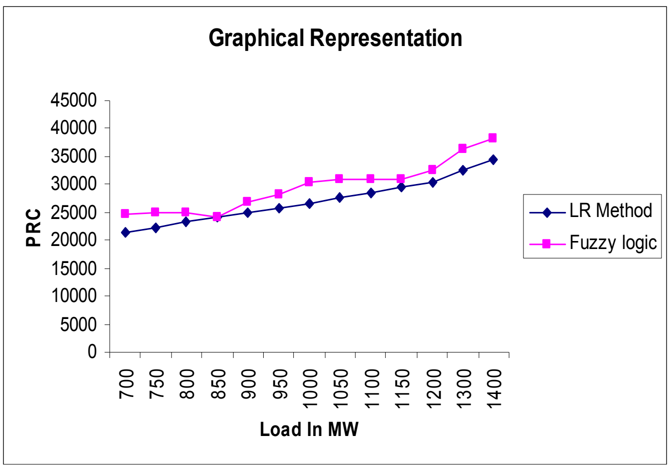

Fig.6 Cost comparison fuzzy with LR METHOD

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5 CONCLUSION

This paper has suggested new approach with fuzzy method for solving unit commitment problem. Initially, for all power demands, the unit status can be obtained from control centre. A salient feature of the proposed method is that it gives high quality solution with less computational time compare to the other methods, which are mentioned in the case studies.
Irrespective of the system complexity, at any power demand, the proposed method converges in less iteration. This aspect is useful for solving large-scale problems. The simulation results show that the proposed method is capable of being applied successfully to the unit commitment problem for large scale systems.

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BIOGRAPHY

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