METHODS OF UNIT COMMITMENT CONSTRAINTS OF LOAD

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***Abstract*: Phenomenal increase in load and cost of electricity has raised many challenges ranging from security of the system to the economics of generation. For economic operation of power system, the solution to Unit Commitment problem is necessary. Unit Commitment aims to schedule the generation to meet the load demands at the most economical rate for the next few hours. It decides that which unit should be operated in that particular period of study and which should not. On time horizon basis, it can be varied from few hours to one week[1].**

The Unit Commitment Problem is to determine a minimal cost turn-on and turn-off schedule of a set of electrical power generating units to meet a load demand while satisfying a set of operational constraints. The production cost includes fuel, startup, shutdown, and no-load costs[2].

In India still around, 70 percent of power is still generated using fossil fuel based thermal power plants. With continuous growing fuel cost and depreciation in fossil fuel-based reserves, it is of great concern and demands usage of it with utmost care. The first step is by utilizing this reserve carefully so as they may last long and thus may optimize their usage. This problem needs a good tool to solve it efficiently and providing a reliable result.

***Keywords*: Unit Commitment problem, thermal power plant**

1. INTRODUCTION

Unit commitment problem is basically scheduling generators of any interconnected regulated/unregulated power system to minimize the cost of generation of power even though satisfying the load demand with all system constraints fulfilled. This problems solution is an hourly based plant of next couple of days ahead about how different generators should be operated and generators should supply what amount of power. Unit commitment problem differs from the ELD by the fact that it does not care about which load is to be supplied by which generator. Unit commitment is no new problem. It has been there from years. Initially it had been solved manually on the basis of priority of generator. Even today in some cases it is preferred.

Unit commitment problem is solved by system operators in real time. System operators in every power system has the duty to fine tune the supply demand in real time operation. Any difference in supply demand may have direct impact on all peripherals of power system including generators and load. Also, due presence of many constraints of power system solving unit commitment problem is a very complex problem to solve hence require efficient tool to solve. Fuzzy logic is one of such tools which will prove to be very superior in solving such complex problems. Fuzzy logic tool box is used with different constraints like generating limits, power balance constraints, minimum uptime, minimum down time and spinning reserve are used to form required rules and membership functions to solve unit commitment problem.

2. UNIT COMMITMENT CONSTRAINTS

After the brief introduction to unit commitment and its requirement in above space we have discussed regarding switching of generators based on load demand. Now this switching pattern while solving unit commitment method is not only restricted to demand-generation balancing but has many constraints to take care of some of them are discussed below.

2.1 P_{min} and P_{max}value constraint

Every generator has certain minimum and maximum power generating capacity to take care of generating energy less than P_{min} will directly affect boiler operation and hence will cause some serious damage to power plant and generating power more than P_{max} will directly lead to overheating of armature winding which will again lead to the generation of possible winding insulation failure of generation.

This problem can be solved using brute force technique. In this technique a table is prepared form the peak demand to the least demand at a scale of 100 MW. Now for each step a rule is prepared regarding which plant should be kept ON and which should be turned OFF. So, for peak load all generators are in operating mode. Slowly as demand is reduced in steps of 100 MW a point come where a generator can be switched off as others can fulfill demand.

Hence slowly a point when a generator alone can fulfill complete demand. The generator's order of switching OFF is decided from the ne with largest running cost to least. Hence one which has largest running cost is switched off first.

2.2 Spinning Reserve

The term "Spinning Reserve" is used for the capacity of generating station which is available to be used during abnormal condition. Such capacity work as a backup at the times when some section of power plants will stop working at any instant. In absence of spinning reserve at such situation will lead to under frequency problems. Thus, spinning reserves are important in power system to increase the reliability of system and also improve economic condition. Now the amount of spinning reserve is decided on the basis of either a part of peak load predicted for next day or equivalent to the highest generating station of the system.

Another factor regarding spinning reserve is that it should not be connected at one point but should be distributed throughout the line. the reason for that is that if we will keep spinning reserve at one point than the time when there is need of extra supply, the reserve supply will be transferred from same line which is already supplying regular requirement. Hence an additional supply will cross the transmission limit of line and may cause problems associated with heating and Circuit breakers/Relays operation. Hence optimized position and location of spinning reserve is also important.

2.3 Thermal Unit Commitments

Such constraints exist in system because of limitation of thermal power plant to switch OFF/ON instantaneously unlike other power generating plants. The reason behind this is after switching OFF the thermal plant it takes some time for pressure and temperature of boiler to come to normal stage. This time ranges from (8-10 hour). This time is called as minimum up time. Similarly, if a generator is in OFF state for long time and is started again it will take some minimum time before it will take some minimum time before it will start generating power to be connected to grid. This minimum time is said to be minimum down time.

Now this constrain is not limited to minimum up-down time only. This switching ON will also responsible for some additional cost of operation. When generator is switched OFF for long time such that boiler core is completely cooled, fuel is burned for many hours to make boiler core temperature and pressure sufficient high enough to generate power to b connected to grid. This heating process does not generate any power but it consumes fuel which lead to additional cost which is known as startup cost.

Similarly, if generator is switched OFF but very recently hence boiler of thermal power plant is at a high level of temperature and will be easy to start in short time than the previous condition and is less costly also. This cost is said to be banking startup cost.

$$\text{Startup cost cold start} = F_C * 1 - e^{\frac{-t}{\alpha}} * F + F_f$$

Where F_C = cold Start cost,

F=full cost

Ff= fixed cost

A=thermal time constant of unit

T=time in hrs the unit was cooled

Startup cost during banking = $F_t * t * F + F_f$

Where F_t= cost of maintaining unit at operating temperature and pressure.

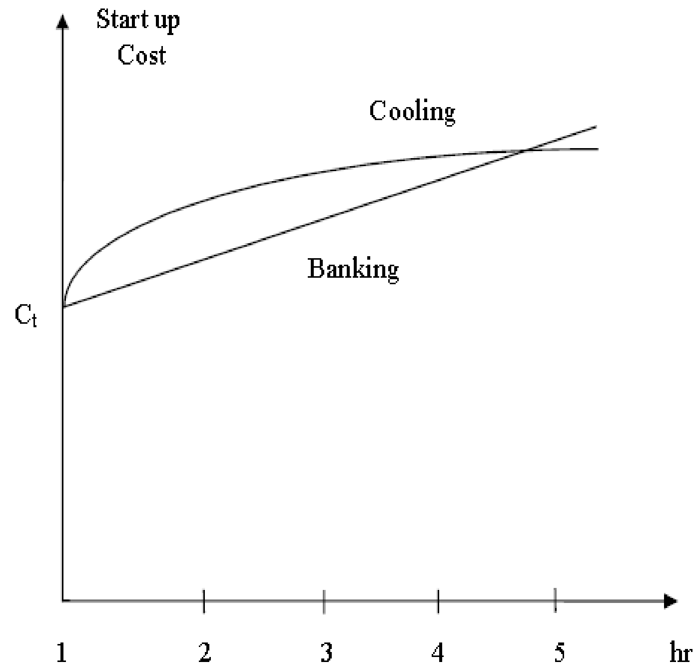

Fig 2.1: Cost of startup w.r.t to time

3. METHODS OF SOLVING UNIT COMMITMENT PROBLEM

Many different techniques are proposed in past in different researches regarding optimal solution of power system unit commitment problem. Some of these techniques are discussed in the precious chapter literature review. In this section some of the most popular and effective techniques are discussed. Three of the top methods are:

3.1 Priority list method

Priority list method of unit commitment problem comprises of a priority list formed by list of generators on the basis of AFLC (Average full load cost) of each one of them. The AFLC value of each generator is calculated separately and the one with least value will be most economical and hence will be switched OFF at the last and the one with highest value will be least economical and hence will be switched of at first. The planning is for each step of load variation ranging from the maximum value to the minimum value of peak load. For each step a combination is formed of generators to operate to fulfill that demand and be economical. Hence at peak load all generators will be switched ON and slowly as load decreases one by one based on above list generators with highest value of AFLC are switched OFF reducing cost of generation.

AFLC can be calculated using the following equation

$$AFLC = \frac{(net\ heat\ rate\ at\ full\ load * fuel\ \ cost)}{maximum\ power\ capacity}$$

Following points are kept in mind while forming priority list:

- If a significant drop is seen in load demand on hourly basis, decision over to drop a generating unit top in priority list or not is made after calculating that if the unit is switched OFF will there be sufficient power available to fulfill demand along with reserve capacity or not.

- Calculate the time for which the generating unit is to be switched OFF based on Load demand pattern.
- Keep the time of shut down of generator in mind because if generator require more time to shutdown than the time it is not required than it will be not feasible to switch it OFF.
- If above condition occurs there are two option one to the study again till the above condition does not occur or second to calculate the cost both when plant is allowed to operate for next couple of hours of operating time and whine plant is shut down then its shut down cost plus startup cost and the one which is minimum is taken.

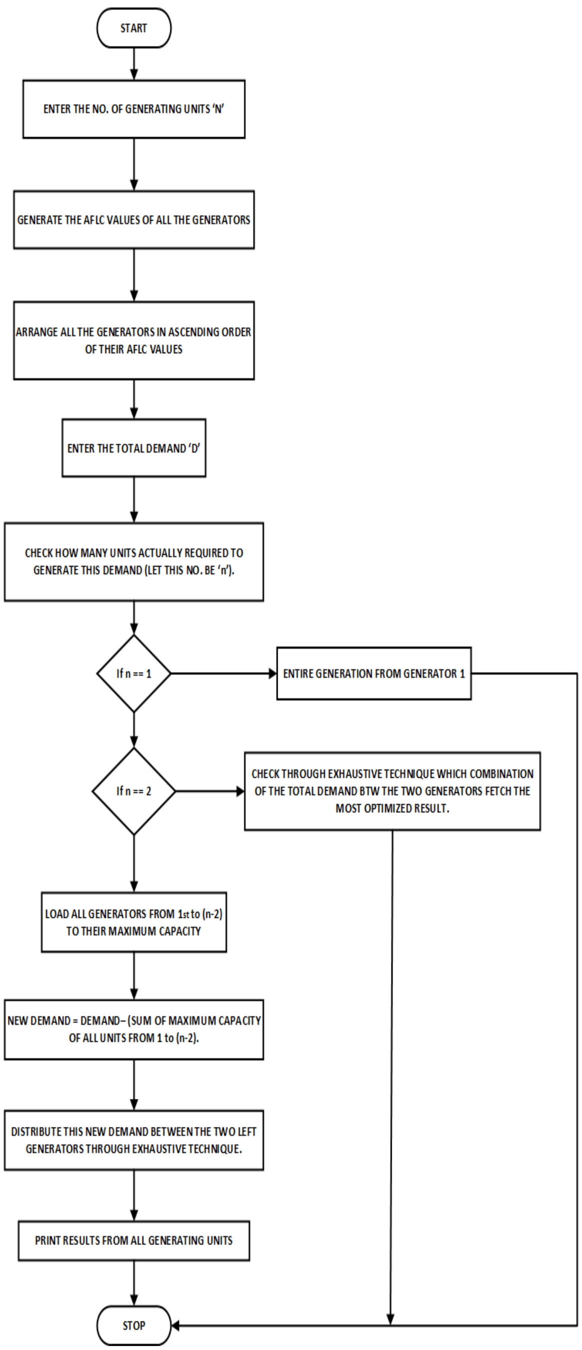

Figure 3.1:Flow chart of Priority list

3.2 Dynamic Programming Method

This is the method with which we have compared fuzzy logic method in present work. Before preparing the complete planning, sheet using some the assumptions are made they are:

- The shutdown cost of all the generators is taken as Nil.
- The startup cost of all generators is taken constant irrespective of the time it has been in OFF state i.e. cold of hot state does not matter.
- There must be a specific number of units always in working order with variation in load demand.

After this assumption the procedure to prepare table of operation using is table by taking a single generation at a time. Considering a load demand D on system. In generator 1 is capable of full filling this demand then no other generator unit will be operated. Now suppose load is increased such that forcing system to switch generator 2 ON. Now next thing is how to divide load between two generating units. This done by calculating cost of operation for each step of say 20 MW increase in share of generator 2.

There will be a point where on comparison of cost we can conclude the most economical share of load between the two. That point is saved for future use. Similarly, this procedure is repeated with different loads and a chart will be prepared for action plan in future conditions of load. If further any more generating units are added then the will be done in the same manner as above although now the first two units are considered a single unit as their optimal share is already calculated and the third units share is calculated similarly as we have done for second unit. The main advantage of this unit is that it will reduce the computation time as on addition of new unit no calculation for previous generating units is to be done.

Mathematically the equations can be expressed as

$$F_N(x) = minimum\ cost\ in\ \frac{Rs}{hr}\ of\ generating\ xMW\ by\ n\ units$$

$$f_N(y) = Cost\ of\ generating\ y\ MW\ by\ the\ N^{th} unit$$

$$F_N(x-y) = minimum\ cost\ of\ generating\ (x-y) MW by\ the\ remaining\ units\ (N-1)$$

$$F_N(x) = \min_{y}\{F_{N-1}(x-y) + f_N(y)\}$$

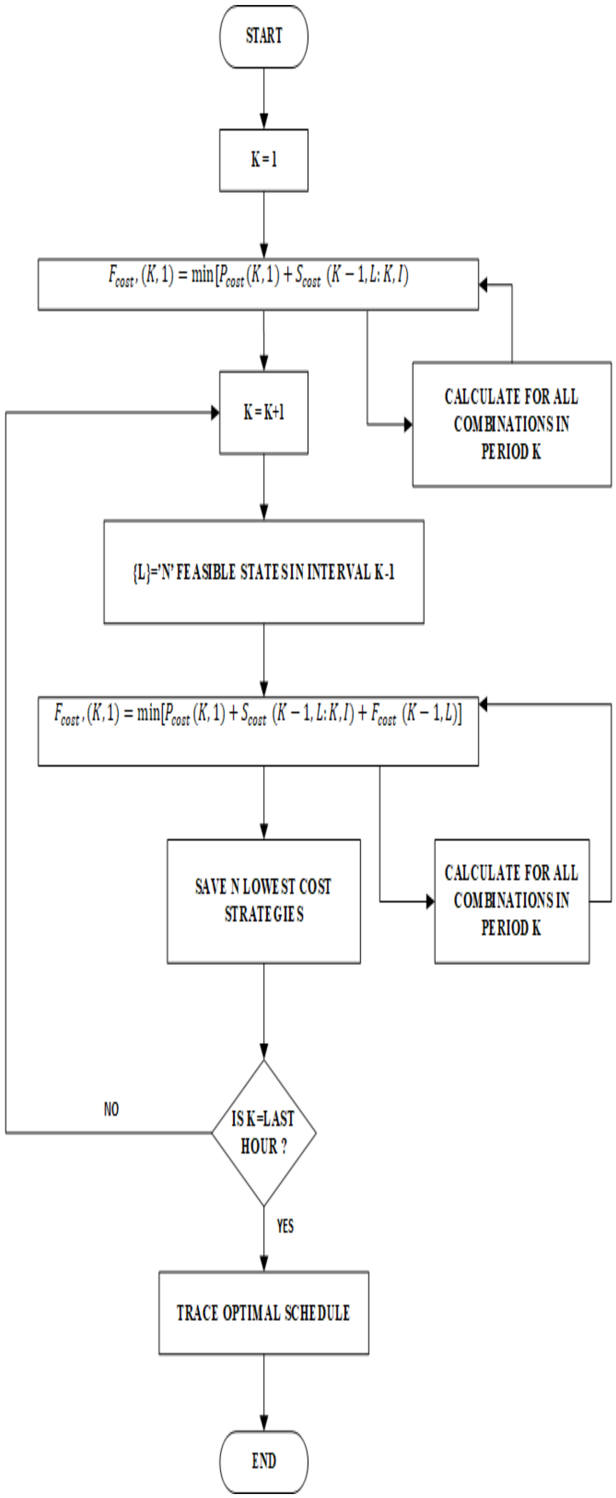

Figure 3.2 flow chart of Dynamic Programming

3.3 Lagrange Multiplier method

This method of solving unit commitment method is applicable for such power system which has large number of generators. This process is explained in the flow chart below.

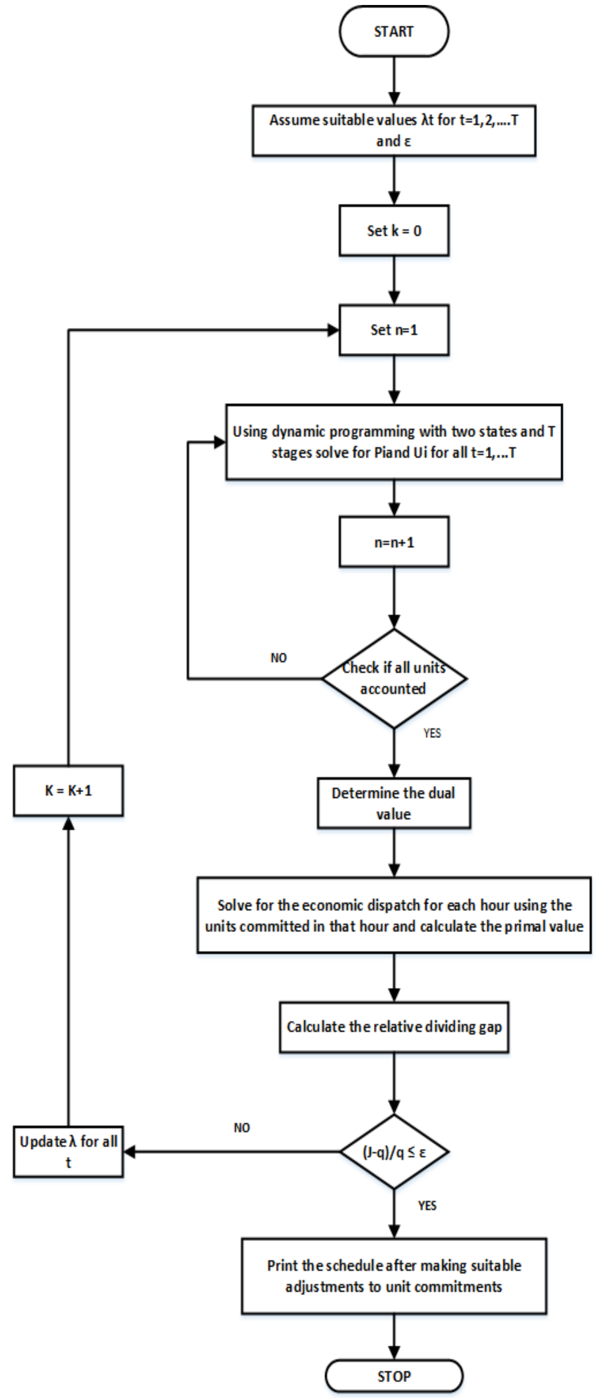

Figure 3.3 flow chart of Lagrange Multiplier

4. CONCLUSION

Though the global optimality is desirable, but in most practical cases near optimal solutions are generally sufficient. This paper attempts to find the best schedule from a set of good feasible commitment decisions The result shows that it is possible to achieve improvements using these methods. These methods guarantees the production of solution that do not violet system or unit constraints; so long as there are generators available in the selection pool to meet the require load demand.

It is recognized that the optimal unit commitment and economic load dispatch of power system effects in a great saving for electric usefulnesses. Unit Commitment is the problem of determining the schedule of generating units subject to device and operating constraints. The formulation of unit commitment has been talked about and the solution is obtained by dynamic programming method. The effectiveness of this algorithm has been tested on systems and analyses the conduct of demand, production cost and function cost of the system with respect to time. It is found that the result obtained for the unit commitment and economic load dispatch using dynamic programming is minimum.

REFERENCES

[1] Vinay Arora and Saurabh Chanana "Solution to Unit Commitment Problem using Lagrangian Relaxation and Mendel's GA Method" *International Conference on Emerging Trends in Electrical, Electronics and Sustainable Energy Systems (ICETEESES–16)* 2016 IEEE.

[2] D. P. Kadam, P. M. Sonwane, V. P. Dhote, B. E. Kushare "Fuzzy Logic Algorithm for Unit Commitment Problem"international conference on "control, automation, communication and energy conservation -2009, 4th-6th June 2009.

[3] A. J. Wood and B. F. Wollenberg (2006), "Power generation operation and control", John Wiley and sons (Asia), second edition, 2006.

[4] A. Perlin and P. Sandrin (May 1983), "A new method for unit commitment at Electricite De France", IEEE Transaction on Power apparatus and system, Vol. PAS-102, No. 5, pp 1218-1225.

[5] B. Gerald, Sheble and George N. Fahd (Feb 1993), "Unit Commitment Literature Synopsis", IEEE Transactions on Power System, Vol.9, No.1, pp 128-133.

[5] Chuan-Ping Cheng, Chih-Wen Liu & Chun-Chang Liu (May 2000), "Unit commitment by Lagrangian relaxation & Genetic Algorithms", IEEE Transaction on Power system, Vol.15, No.2, pp 707-714.

[6] P.K. Singhal, "Generation scheduling methodology for thermal units using lagrangian relaxation," in Proc. 2nd IEEE Int. Conf. Current Trends in Technology, pp. 1-6, Dec 2011.

[7] T. Senjyu, K. Shimabukuro, K. Uezato, and T. Funabashi, "A fast technique for unit commitment problem by extended priority list," IEEE Trans. Power Syst., vol. 18, no. 2, pp. 882-888, May 2003.