Unit Commitment Problem in Power System

Dr. Deepak P. Kadam
Department of Electrical Engineering, Bhujbal Knowledge City, MET- Institute of Engineering, Nashik, India

Abstract: In power industries, fuel expenses constitute a significant part of the overall generation costs. In general, there exist different types of thermal power units based on fuel used, with different production costs, generating capacities and characteristics in a system. The system usually operates under continuous variation of consumer load demand. Determining an optimal economical dispatch schedule of a set of generating units to meet a load demand while satisfying a set of operational constraints is called the Unit Commitment Problem**.** This paper describes the application of genetic algorithm and fuzzy logic for determining short-term commitment of thermal units in electrical power generation. Feasibility of these methods is examined and preliminary results to determine near optimal commitment order of thermal units in studied power system over short term are reported. The results obtained from genetic algorithm and fuzzy logic based approach are compared with the priority list method solution to unit commitment problem. The comparison proves that genetic algorithm and fuzzy logic based approach are powerful tools for solving such highly non-linear, multi constrained optimization problems in electrical power systems.

Keywords: *Unit Commitment, Genetic Algorithm, Fuzzy Logic, Priority List.*

I. INTRODUCTION

The Unit Commitment Problem (UCP) 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. Some of the operational constraints that must be taken into account includes,

i. The total power generated must meet the load demand plus system losses.
ii. There must be enough spinning reserve to cover any shortfalls in generation.
iii. The loading of each unit must be within its minimum and maximum allowable rating.
iv. The minimum up and down times of each unit must be observed [5].

There have been several mathematical programming techniques proposed so far to solve unit commitment problems. They include Priority List, Dynamic Programming, Branch and Bound, Lagrangian Relaxation, Simulated Annealing, Expert Systems, Artificial Neural Networks [3].

The more commonly used method being simple and fast by electricity utilities is the priority list method. This method is used to rank generating units in a heuristic with increasing operation cost.

Genetic Algorithm (GA) provides a solution to UCP by working with a population of individuals each representing a possible solution. Together with a set of the main genetic operators of crossover and mutation this method provides a powerful global search mechanism, whose computation code is simple.

Fuzzy logic (FL) is useful in reducing the need for complex mathematical models in problem solving. Fuzziness is used to describe uncertainty, which is applicable to the UCP. Loading of generators, start up cost, incremental cost and production cost are considered to be fuzzy variables with the UCP.

II. THERMAL UCP FORMULATION

A. Fuel Cost (FC)

For a given set of N committed units (i = 1, …., N) at hour H (j = 1, …..H), the total fuel cost at that particular hour, is minimized by economically dispatching the units subject to the following constraints:

i. The total generated power must be equal to the demand.
ii. The power produced by each unit must be within certain limits.

This problem can be stated as follows.

$$\text{Min FC} = \sum_{h=1}^{H} \sum_{i=1}^{N} U_{ih}\,(FC_i)\,P_{ih}.$$

where, U_{ih} : Status of the unit i at hour h: 1 (ON) or 0 (OFF)
P_{ih}: Power output of unit i at hour h in MW

B. Start-up Cost(ST)

As, the temperature and pressure of thermal unit must be changed slowly, a certain amount of energy will be expended to bring the unit online. This energy, does not result into any MW generation from the unit, is called start up cost [13]. Two functions are commonly used to model start-up costs as a function of the temperature:

1. Two-step function

$$ST_i = \begin{cases} STc & \text{if } x(t) \geq T_{cold\ start}. \\ ST_h & \text{otherwise.} \end{cases}$$

T_{cold} start is the number of hours it takes for the boiler to cool down. The STc and ST_h costs are the start-up costs incurred for a cold and hot start. Respectively and x (t) is consecutive time that unit been up (+) or down (-) at time t.

2. Exponential function

$$ST_i = b_1 [1 - \exp(-b_3 * X_i)] + b_2.$$

b_l, b_2 and b_3 are start-up cost parameters and X_i the number of consecutive hours for which the unit i has been down [4].

C. Objective function

The objective (or cost) function (OF) of the UCP is to determine the state of the units U_{ih} (0 or 1) at each period H, so that the overall operation cost is a minimum within the scheduling time span.

$$\text{Min OF} = \sum_{h=1}^{H} \sum_{i=1}^{N} U_{ih}(FC_i)P_{ih} + ST_i U_{ih}(1-U_{i,h-1}) + SD_i\, U_{i,h-1}(1-U_{i,h})$$

Subjected to the constraints