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REVIEW OF UNIT COMMITMENT FOR ECONOMICAL OPERATION OF POWER SYSTEM

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Abstract

Unit commitment (UC) is an optimization problem used to determine the operation scheduled of the generating units at interval with varying loads under different constraints and environment. Many algorithms have been invented in the past decades for optimization of UC problem, but still researchers are working in this field to find new hybrid algorithm to make the more realistic. The important of UC increasing with constantly varying demand. Therefore, there is an urgent need in the power sector to keep track of the latest methodologies to further optimize the working criterions of the generating units. This paper focuses on providing clear review of the latest techniques employed in optimizing UC problems for stochastic and deterministic loads, which has been acquired from many review published paper. It has been divided in to many sections which include various constrains based on profit, security, emission and time. It emphasizes not only on de regulated and regulated environment but also on renewable energy and distributed generating systems. In term of contributions, the detailed analysis of all the UC algorithms has been discussed for the benefit of new researcher interested in working in this field.

Keywords- *Unit commitment (UC), Optimization, deterministic load, stochastic load, evolutionary programming (EP), Hybrid*

Introduction

Because human activity follows cycle, most power system supplies services to a large population experiences cycles. The unit commitment deal with the optimum amount of time for which generating unit must be operated at a time basis, (hourly) In case of electrical power system the total load on the system will generally be higher during the day time and early evening when industrial load are high and lower during the late evening and early morning when most of the people are sleeping. The use of electrical power has weekly cycle the load being lower over the weekend days than weekdays. But why is this problem in the operation of an electric power system? Why just not simply commit enough unit to cover maximum system load and leave them running? Unit commitment is therefore to "commit" a generating unit is to "turn it on" that is to bring the system up to speed synchronies it to the system, and connect it so it can deliver power to electrical power to the network. The problem with "commit enough unit and leave them online" is one of the economic reason, it quite expensive to run too many generating unit, money can be saved by turning unit off (de-committing them) when they are not needed.

Unit commitment for the best set of unit to be available to supply the predicted or forecast load of the system over a failure time period, "unit commitment" is therefore one way to suggest, just sufficient number of generating unit with sufficient amount of generating capacity to meet a given load economically with sufficient reserve capacity to meet any abnormal operating condition. Here we consider the problem scheduling fossil fired thermal unit in which aggregate cost such as startup cost, operating fuel cost and shutdown cost are to be minimized over daily load cycle.

Unit commitment is optimization problem. So the question here what do we optimize? Let's say we have two generators which are the load demand. Now, the can vary at any time and it won't be reasonable to keep on using

both generator if, let's say the load demand can be meet by using only one generator so, here we optimize an in which generator should be shut down and which should be running. This optimization becomes more essential when we are dealing with more number of power generators, because every power generators has its operating cost and obviously you would want to bring that cost down.

Unit commitment is an operational planning. The purpose of this planning is to determine a schedule called unit commitment schedule which tell us the beforehand when and which unit to start and shutdown during the operation over a pre-specified time, such that the total operating cost for that period become minimum.

The off peak and on peak demand of electricity may vary for different purposes. If the unit is properly observed, it may be possible to save some unit when the demand is less. The main objective of this paper is to operating time of different generating unit such that satisfied constraint. The unit commitment is applied to both deterministic and stochastic load [1]. The deterministic approach provide definite and unique conclusion. However, the result obtained for stochastic load may not exact. For the deterministic loads data envelopment analysis (DEA), the principal component analysis (PCA) approach is employed. DEA is a non-parametric method, in which the first input and output variable are defined. In the PCA, the numbers of variables used are reduced to minimum. However, in stochastic model, the constrained are change in to determinate constraints and then the formulation can be solved by any usual algorithms. The various kinds of objective functions for various environments are as follows.

Conventional fuel based environment [2]

In eq. (1), there are three costs to minimize. The first one is P(i,t) which is generation of unit i at

Time t, and C(P(i, t)) is a fuel cost of unit *i* at time *t*. The second one is the start –up cost and the third, shutdown cost.

$$\boldsymbol{min} \sum_{t=1}^{ni} * \sum_{t=1}^{n0} [\boldsymbol{Ci}(\boldsymbol{P}(\boldsymbol{i},\boldsymbol{t})) + \boldsymbol{SU}(\boldsymbol{i},\boldsymbol{t}) + \boldsymbol{SD}(\boldsymbol{i},\boldsymbol{t})] \qquad (1)$$

Stochastic environment [3]

Stochastic environment is one in which randomness is included either in the objective function or to the constrained. In eq. (2) the second part creates randomness due to the addition of wind generation. Nowadays, uncertainly occur in power system due to large scale integration of renewable resource like solar, wind, etc. Hence, the demand and supply may also differ for the successful and reliable operation of the system within uncertainty environment which are also called a stochastic environment.

$$\boldsymbol{min} \sum_{t=1}^{N} [\sum_{t=1}^{T} (\boldsymbol{CiPi},\boldsymbol{t} + \boldsymbol{Ci},\boldsymbol{t},\boldsymbol{u} + \boldsymbol{Ci},\boldsymbol{t},\boldsymbol{d})] + \boldsymbol{M} \sum_{k=1}^{N} \sum_{t=1}^{N} (\boldsymbol{Wk},\boldsymbol{t} - \boldsymbol{Wk},\boldsymbol{t}) \qquad (2)$$

Literature review

Unit commitment is the problem of determine the scheduled of generating unit within a power system subject to device and operating constraints. The unit commitment problems solving techniques are classified into conventional techniques, non-conventional techniques and hybrid algorithms.

Conventional techniques include priority list method, dynamic programming solution, and Lagrange relaxation method.

Priority list method this the simplest unit commitment solution method consist a creating a priority list scheme could be obtained after an exhaustive enumeration of all unit combination at each load level.[3]

Dynamic programming (DP) has many advantages over the enumeration scheme, because it has a reduction because it has a reduction in the dimensionality of the problem, suppose we have found a unit in a system

and any combination of them could be serve the (single) load there could be a maximum of 24-1=15 combination to test.[4]

Lagrange relaxation techniques solve the unit commitment problem "relaxing" or temporary ignoring the coupling constrain and solving the problem as if they did not exist this is done through the dual optimization procedure.[5]

Non-conventional techniques include hybrid ant colony optimization. Ant colony optimization is inspired by the rule in the real environment of ant. Real ants are capable of finding the shortest path from the sources of the food to the ant's nest. Every ant from population leaves substance called pheromone while getting to the source of food. This substance attracts other ants to come in to that direction.[6]

Hybrid Lagrangian relaxation- in hybrid lagrangian relaxation approach the system operating cost function of the unit commitment problem is related to the balanced and the spinning reserve constraints via two set langragian multiplier to form a lagrangian dual function. The langrangian relaxation procedure solves the unit commitment problem through the dual problem optimization attempting to reach the constraint optimum. The dual procedure will attempt to minimize the lagrangian multiplier while minimizing with respect to other variables.[7]

Hybrid Genetic Algorithm (GA) unlike other search and optimization techniques a genetic algorithm promised convergence but not optimality, not even that it finds local maxima. This implies that the choice of when to the genetic algorithm process when 50 generation have gone by with no better chromosome identified. Since there is no guarantee of optimality, successive run of genetic algorithm will provide different chromosome with varying fitness measure.[8] This is the one of the drawback of using a genetic algorithm for optimization since there is no guaranty of optimality, there is always the chance that there is a better chromosome burking somewhere in search space. The genetic algorithm is coupled with local

search mechanisms to find the optimum chromosome in a region. So, if we use hybrid algorithm, the problem reduced to ensuring that we run the genetic algorithm as many time as is needed to pick out all the good regions.[9]

Hybrid particle swarm optimization (PSO) is a population based optimization techniques concept inspired by the flocking behavior of the swarm of animal like birds or fishes. An active line of research in particle swarm optimization is the introduction of various variant that were shown to improve over the particle swarm optimization.[10] Among these variant we have particle swarm optimization with inertia weight, the usage of various topologies for the particle neighborhood. These variant try to introduce variation on how balanced diversification and intensification of the search beyond the pure timing of the parameters possible in the basic particle swarm optimization algorithms [11].

Binary / real coded particle swarm optimization (BPSO) which adopts the concept of the genotype-phenotype representation and maturation of genetic algorithms. It means a feature is that the BPSO can be treats as continuous PSO. The proposed BPSO algorithm is tested in various bench mark function and it is performance compared with that original BPSO. Experiment result shows that the modified BPSO out performs the original PSO algorithm.[12]

Fuzzy turned particle swarm optimization (FTPSO) PSO is a mathematical modeling and simulation of food searching activities of a flock of bird each particle move different velocity toward the optimal point. The velocity of a particle is calculated by three component; inertia, cognitive, and social. The particle move round the multidimensional search space unit they find the optimal solution.[13] A fuzzy system is utilized to turn the inertia weight and learning the factor be best fitness (BF) the fuzzy turned particle swarm optimization (FTPSO) has been applied to a 10 and 20 bus system in MATLAB and is proven to increase the reliability of the system. It is faster

than ACO and BP is capable of solving both small scale and large scale problem [14].

Mimetic algorithm (MA) is hybrid computational model of two sources. The first source is a model by a GA that mimics biological or Darwinian evolution of ideas the unit information in a GA is termed as genes are improved by crossover and mutation operators that are part of the GA and the memes are improve by a local search operators [15].

Environment for unit commitment

Priced based unit commitment this paper formulate the price based unit commitment (PBUC) problem based on the mixed integer programming (MIP) method. The proposed PBUC solution for generating company (GENCO) with thermal, combined-cycle, cascaded hydro, and pumped storage unit. The PBUC solution by utilizing MIP is compared with that langragian relaxation (LR) method. Test result on the modified IEEE 118 bus system show the efficiency of our MIP formulation and advantages of the MIP method for solving PBUC it is also shown that MIP could be applied to solve hydro-sub problems including cascaded hydro and pump storage unit in the LR based frame work of hydro-thermal co-ordination.[16]

Numerical experiment large system shows that the MIP based computation time and memory requirement would represent the major obstacle for applying MIP to large UC problems. It is noted that the solution of large UC problems could be accomplished by improving the MIP formulation, the utilization of specific structure of UC problems and the use of parallel processing.[17]

Profit based unit commitment PBUC must be obtained in a short time even though there is an increase in generating unit, nowadays, computing resources are available in plenty and effective utilization of these resources will be advantageous for reducing the time complexity for large scale power system. Here the massage passing interface based technique is used

in the algorithms in distribution and share memory model. Time complexity and solution quality with respect number processor.[18]
Security based unit commitment since the demand response playa more and more important role in a smart grid, security constrained unit commitment model considering the interactive impact of priced based demand response is integrated with basic security constrained unit commitment (SCUC) model, then the interactive impact are considered. In the user side the comprehensive electricity satisfaction is considered.[19] And the power flow balanced is considered in the system side which forma more safely model. The case study on the six bus system demonstrate that the interactive impact constrained can guarantee the economics of effectiveness of DR without affecting users 'felling, and simultaneously optimize the power flow disturbance to decrease the cascading failure. [20]

Unit Commitment in Deregulated Environment

In the present scenario of the deregulated market, it require from the GENCOs to summit their power bids separately. Each bid consist of cost function and set of parameters that define the operative limits of a generating unit. Cost sub optimal solution that result to lower price may exit and therefore the applicability of cost minimization UC models for power auction is questioned. In August 2003, Sum-im T, Ongasakul W. investigates the existence, determination and effect of competitive market equilibrium on UC power pool auction to avoid the complicit of interest and revenue efficiency.[21] A new formulation of the UC problems suitable for electric power producer in deregulated market has been provided by Valenzuela and Mazumdar.

Conclusion

This paper present a review on concept of the UC problem and methodologies proposed for solving it. In solution methodologies, more

details about the newly evolved hybrid model has been given, which is the combination of both classical and non classical methods, and can handled the present day complex UC problems commonly seen in the word. This paper is based many research articles published in some many years and periodic bibliography update on this topic will useful for next researchers in the field of UC. UC paper for the past decade is stated by classifying the kind of algorithm used by the authors of this paper, objective function, constrained, test problem etc.

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