



International Journal of Emerging Technologies in Computational and Applied Sciences (IJETCAS)

www.iasir.net

A Review Paper on Hydro-Thermal Scheduling

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Abstract: This paper presents a study of various researches which were come out in last few decades on hydro thermal scheduling problems. As we know that the Operation of mix both hydro and thermal plants is far more complex and is of much more importance in a modern power system. The aim of the hydrothermal scheduling problem is to optimize the electricity production and minimized the cost of power. This paper tells us an important review of a hydro thermal scheduling system. The paper demonstrates overview of various approaches and analytical methods applied on hydrothermal scheduling problem. All the assumptions made and a brief description of the solution methods is presented in the paper. The paper provides helpful information and resources for the future studies for researchers those interested in the problem or to do additional research in this area.

Keywords: hydro-thermal optimization Lagrangian Relaxation, Electrical Research Federal Commission Improved particle swarm optimization, Genetic algorithm.

I. Introduction

Mankind has an intense desire to know things. Our kind has craved for knowledge. The quest for knowledge starts back from prehistoric time, when human being invented and discovered some basic things like fire and wheel. Contributed to our intelligence and inner desire for knowledge, our species has gained improvement in quality of life. Now days, there are countless scientific inventions with continuous up gradations, owing to these, we have a lot of technologies for all area of importance to our kind. Over last few decades, we experience energy crisis. So, it is very important to utilize energy in an efficient manner. In order to utilize energy efficiently, cost must be as less as possible and This poses a requirement to develop scheduling methods that accommodate generation diversity and line flow limitations and concurrently can produce accurate scheduling results. when we talk about engineering field, power produced is much less as compared to power demand in our country. So the main aim of operation a power system is to generate and transmit power to meet the system load demand, losses at minimum fuel cost and minimum environmental pollution. Hence a mix of Hydrothermal scheduling is necessary. Basically the integrated operation of the hydrothermal system is classified into two different parts, long-term and short-term. The planning period is of one year for long-term problem and short-term hydrothermal scheduling problem is concerned with optimization over an hour, a day or a week. Numerous methods have been developed for electric power scheduling. These include analytical approach, dynamic programming and evolutionary methods. The paper focuses on hydrothermal scheduling problem. Several analytical and evolutionary methods given by various researchers are reviewed. The dynamic programming, genetic algorithm, Lagrangian relaxation approach, particle swarm optimization, a bundled method, a diploid genetic algorithm, co evolutionary Algorithm. Genetic algorithm, enhanced bacterial foraging algorithm, Lagrangian relaxation method, Augmented Lagrangian approach have come to be the most widely used tools for solving a hydrothermal scheduling concept.

The proposed work aim to present the overview and key issues of previously considered methods for hydro thermal scheduling problem. No attempt is made here to prove the effectiveness of the solution technique applied by researchers for hydrothermal scheduling problem

II. Review of Literature

Hydrothermal scheduling power system is a topic that has been extensively researched because of economic point of view. This poses a requirement to develop scheduling methods that accommodate generation diversity and line flow limitations and concurrently can produce accurate scheduling results. Hydro thermal scheduling is required in order to find the optimum allocation of hydro energy so that the annual operating cost of a mixed hydro thermal system is minimized. Over the last decade the hydrothermal scheduling problem has been the subject of considerable discussion in the power literature. The available approaches differ in the system modelling assumptions and the solution methods.

A new daily generation scheduling model for the ontario hydro system is presented in this paper. The model is capable of considering the thermal and hydro system together with system reserve requirement and transmission losses. The hydrothermal problem is decoupled into hydraulic and thermal sub system. An extension of the Frank-Wolfe technique is used to solve the hydraulic problem. The Ontario hydro systems consist of 4-nuclear, 6-thermal and 35 hydraulic plants [1].

A bundle method for hydrothermal scheduling is used here. The scheduling is concerned with the commitment and dispatch of generating units. The objective is to minimize the total generation cost over a period of up to one week. Subject to system wide demand and reserve requirements and individual unit constraints. The sub problem are solved by Lagrangian relaxation method. This paper presents an algorithm that utilizes the Bundle Trust Region Method (BTRM). The BTRM is used to update the multiplier for hydrothermal scheduling. The BTRM and quadratic programming were implemented in C++, and the resolution of individual sub problems and heuristics were implemented in FORTRAN. In result the fast convergence of BTRM is analyzed [2].

Short-term scheduling of hydrothermal system by using extended differential dynamic programming and mixed coordination. The problem is first decomposed into a thermal sub problem and a hydro sub problem by relaxing the supply demand constraints. The thermal sub problem is solved analytically. The hydro sub problem is further decomposed into a set of smaller problem that can be solved in parallel. Extended differential dynamic programming and mixed coordination are used to solve the hydro sub problem. In this paper two problems are tested and the result shows that the approach performs well under a simulated parallel processing environment, and high speed up is obtained. The algorithms are written in FORTRAN [3]

An AL approach that incorporates as well, transmission constraints and pumped-storages units is discussed here. Here the problem is decomposed into thermal sub problem, hydro sub problem and pumped storage sub problem. Dynamic programming approach is used to solving individual thermal sub problem. The results of an IEEE-24 bus test can show that the approach can provide better scheduling results over a planning horizon at a minimal cost with no constraints violation. It requires no iteration with economic dispatch algorithm. Computational model all is coded in C and run on LINUX operating PC [4].

Dual programming algorithms are applied to the problem of large scale thermal generation scheduling arising in the framework of short-term hydro-thermal coordination. Two algorithms are compared: the former derives from a work by Goldfarb and Idrani, while the latter is based on continuation method technique. The two methods are tested on a small sample system, as well as on a large scale problem corresponding to a quarter hour discretization of the daily thermal scheduling for the Italian Electricity Board (ENEL) production system. The dual programming procedures considered were implemented in FORTRAN [5].

The short-term hydro-thermal coordination problem is solved here. This problem is large scale, combinatorial and nonlinear. It is usually solved using a Lagrangian Relaxation approach. In the framework of the Lagrangian Relaxation, this paper provides a novel, non-oscillating and efficient multiplier updating procedure. This procedure advantageously compared with previously reported procedures such as subgradient and bundle method. This problem is solved to determine the start up and shut down schedule of thermal plants during a short term planning horizon. The objective is to meet customer demand with appropriate levels of spinning reserve so that total operating costs are minimized. In case study the generating system is based on the electric energy system of mainland Spain. It consists of 60 thermal plants and 30 hydraulic plants [6].

A goal programming methodology for solving maintenance scheduling of thermal generating units under economic and reliability criteria is discussed here. The advantage of a multicriteria approach will be demonstrated by comparing the effect that costs and reliability have on each other in power plants maintenance scheduling. The problem is formulated as a large scale mixed integer programming problem implemented in the mathematical programming language GAMS and solved using OSL. Weekly maintenance scheduling of the large scale Spanish power system for a year period illustrates the proposed methodology. The Spanish Power System has about 16 thermal plants and 130 hydro units [7].

A new method for solving the unit commitment problem by simulation of a competitive market where power is traded through a power exchange is presented here. The method is used on a standard unit commitment problem with minimum up/down times, start up cost and spinning reserve requirement taken into account. Comparison with solution provided by Lagrangian Relaxation, Genetic algorithm and de-commitment procedure demonstrate the potential benefits of this new method. Simulation competition (SIMCOM) algorithm is used to solve the problem. The optimization horizon is 24 hours. The method is programmed in FORTRAN 90 [8].

A diploid genotype based genetic algorithm (GA) is applied to solve the short-term scheduling of hydrothermal system. The proposed genetic algorithm used a pair of binary strings with the same length to represent a solution to the problem. The model can concurrently handle the requirements of power balance, water balance and water traveling time between cascaded power stations, which are more difficult for other approaches to manage. The algorithm is written in C language. The result shows that GA is a power search algorithm for solving optimization problem. The program runs for 10 times with different initial population created at random. It shows that the algorithm has a good robustness [9].

A noise annealing neural network based hydroelectric generation scheduling method for the determination of the optimum hydro schedule has been developed. The neural network is proposed to speed up hydroelectric generation scheduling and to reach the globally optimal solution in power system. The hydroelectric generation scheduling problem has been formulated as a quadratic programming problem and the noise annealing neural network can be employed to yield the desired hydro schedule. The problem was coded in Borland C++ and implemented on a PC-pentium computer. The effectiveness and practical application of the proposed approach are demonstrated by short term hydro generation scheduling of Taiwan Power System [10].

The solution of the hydrothermal scheduling problem by using evolutionary algorithm is developed here. The aim of this study is to minimize the fuel cost and ramping cost of thermal units by utilizing both hydro and thermal units optimally. In evolutionary programming, new generation are produced from randomly generated initial vector by Gauss and Cauchy mutation and they compete with parent vectors and each other. Better individuals are selected for the next generation the new generation process lasts until either reach to defined iteration number of a minimum function value or the point where developed solution are no longer different. The algorithm is implemented in MATLAB [11].

A fast efficient decision support system to plan the real time unit generation scheduling at British Columbia Hydro Power (BCH) is discussed here. The problem is formulated and solved with a novel procedure that incorporates three algorithms. First, an expert system is used to eliminate infeasible and undesirable solution. Second, dynamic programming is used to solve the optimal static unit commitment problem for a given plant loading, feasible unit combination, and current hydraulic condition. Third, the dynamic unit commitment and loading (DUCL) problem is formulated and solved as a large scale network problem with side constraints. The British Columbia Hydro Power Authority (BCH) in Canada operates 30 hydroelectric facilities. The network model uses two software packages: AMPL, which is used to formulate the optimization problem as a large scale network problem with side constraints; and CPLEX is employed to solve it [12].

A genetic algorithm solution to the hydrothermal coordination problem is presented. The generation scheduling of the hydro production system is formulated as a mixed integer, nonlinear optimization problem and solved with an enhanced genetic algorithm featuring a set of problem-specific genetic operators. The thermal sub problem is solved by mean of a priority list method, incorporating the majority of thermal unit constraints. The results of the application of the proposed solution approach to the operation scheduling of the Greek Power System, comprising 13 hydro units and 28 thermal units, demonstrate the effectiveness of the proposed algorithm [13].

The price-based unit commitment (PBUC) problem based on the mixed integer programming (MIP) method is formulated. The proposed PBUC solution is for a generating company (GENCO) with thermal, combined cycle, cascaded hydro, and pumped storage units. The PBUC solution by utilizing MIP is compared with that of Lagrangian relaxation (LR) method. Test result on the modified IEEE 118-bus system (54-thermal, 12-combined-cycle, 7-cascaded-hydro and 3-pumped storage units) show the efficiency of our MIP formulation and advantage 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 pumped storage unit in the LR-based framework of hydrothermal coordination. Numerical experiments on large systems show that the MIP based computation time and memory requirement would represent the major obstacles for applying MIP to large UC problem. The case study in this paper utilizes CPLEX 9.0 on a personal computer [14].

The hydrothermal electricity producer self-scheduling problem in day ahead energy and reserve market is considered here. A mixed integer linear formulation of the producer self-scheduling problem is presented, which allow a realistic modeling of the unit's operating phases. Prohibited operating zones and daily hydro energy production constraints are modeled. Test results address the effect of the energy and reserves market clearing price on the producer unit's day-ahead commitment status and profits. The developed method has been tested for the scheduling of a hypothetical producer with 5 thermal and 2 hydro units. The model were implemented in GAMS using the CPLEX [15].

A novel fast straightforward method for thermal generating unit scheduling is presented. The new method decomposes the solution of the unit commitment problem into three sub problems. In the first sub-problem, the quadratic cost functions of units are linearized and hourly optimum solution of unit commitment is obtained considering all constraints except the minimum up/down time constraints. In the second sub-problem, the minimum up/down time are enforced through a novel optimization process by modifying the schedule obtained in the first step. Finally in the third sub-problem, the extra reserve is minimized using a new decommitment algorithm. For testing the proposed method, the conventional 10 unit test system and its multiplier with 24-h scheduling horizon have been solved. Comparison of results with those of other methods justifies the effectiveness of the proposed method with regards to minimizing both the total operation cost and execution time. The proposed method was implemented in MATLAB optimization toolbox [16].

A model for the simulation of the optimal medium-term operation of a hydrothermal system is presented here. System stochastic parameters are modeled by Monte Carlo Scenarios, which are solved on distributed processors. For each scenario a yearly hydro-thermal scheduling (HTS) problem with hourly time resolution is formulated and solved as a large mixed integer linear programming (MILP). HTS modeling includes unit commitment, start

up costs and minimum up/down time constraints. The model is applied to the Greek Power System, comprising 29 thermal units and 13 hydro plants. Test result includes both medium-term objectives, such as reservoir water management, and short-range decisions such thermal unit start up decisions. The optimization problem was implemented in GAMS and solved under CPLEX 9.0. Result shows the total run time is more than 16 times faster than in sequential implementation [17].

The co-evolutionary algorithm (CEA) based on Lagrangian method was presented for solving the hydrothermal generation scheduling problem. The hydrothermal generation scheduling problem was converted into a numerical formulation. To solve this problem, the Lagrangian function was first form the primal problem using the Lagrangian method. The CEA then employed two genetic algorithms to evolve the control variables and Lagrange multiplier of the dual function in parallel. To demonstrate the effectiveness of the proposed CEA based on Lagrangian method, hydrothermal generation scheduling of Taiwan Power system was performed. The results revealed that the proposed method is very effective in reaching an optimal generation schedule. The execution time is speed up by the proposed method. The study system is comprised of 48 thermal units and 11 hydro plants. All the programs were developed using Borland C++ language and run on a PC [18].

A nonlinear model with individual representation of plants for the centralized long term hydrothermal scheduling problem over multiple areas is developed. The proposed model is solved by a sequential quadratic programming (SQP). The case study based on the Brazilian Power System illustrates the application of the proposed model. The prototype of the model has been implemented and solved by an SQP algorithm as made available by the MATLAB optimization Toolkit. The tests were performed with different assumptions in term of exchange limits. The results were analyzed and compared, providing operational characteristics of the optimal solutions. The benefits obtained from the availability of exchangeable power have been assessed by an increase in hydropower generation and a corresponding decrease in thermal output and cost [19].

A novel approach for short term hydrothermal power system with cascaded reservoirs using cultural algorithm (CA) is presented in this paper. The large scale hydrothermal scheduling involves optimization of a non-linear objective function with a set of system and hydraulic constraints. The approach takes the water transport delay time between connected reservoirs and complicated hydraulic coupling into accounted, the cost characteristics of individual thermal units are also considered. The cultural algorithm combine with a novel equality constraint handing mechanism provides better solution at a lesser computational effort. The developed algorithm is illustrated for a test system consisting of 4 hydro plants and 3 thermal plants. The test results are compared with those of improved particle swarm optimization (IPSO) technique. It is noted that the CA technique is able to provide better solution in term of fuel cost and computational effort [20].

The optimal scheduling of hydro-thermal generation system with variable-head hydro plants has been determined. An enhanced bacterial foraging algorithm has been presented and used to solve the short range problem. The Glimn-Kirchmayer and Hamilton-Lamont model have been implemented to represent the hydro plants. Simulation results have demonstrated the effectiveness of the algorithm in finding the optimal power generation schedule [21].

A small population based particle swarm optimization approach has been presented to find the optimal schedule for the short term hydro thermal scheduling problem. The proposed approach has been tested on three hydrothermal test systems. The result has been compared with those obtained by other evolutionary algorithm. It is quite evident from the comparisons that the proposed SPPSO approach provides the competitive performance in term of quality of optimal solution as well as computational time and effort [22].

III. Conclusion

In this paper, an overview and important issues of different research studies for hydro thermal Scheduling is presented. Approaches based on different methods have been proposed and use to solve the hydrothermal scheduling problem. The effectiveness of the developed methods was tested on different systems and the results were also compared with other methods. It was observed that by using the control parameters of algorithms wisely the quality of result's can be improved. The provided information in the paper can be helpful researchers can lead to additional studies in the field. This poses to develop scheduling methods that accommodate generation diversity and line flow limitations and concurrently can produce accurate scheduling. So by this maximizing the effectiveness of scheduling techniques

IV References

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