JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 3, 2022, 5538 - 5544
https://publishoa.com
ISSN: 1309-3452

Balancing Fuel Costs and Water Availability for Short-Term Optimal Scheduling of Hydrothermal Plants

Khan Nahid Ishrat Nasir Khan, Dr. Pratik R. Hajare

Department of Electrical Engineering, Mansarovar Global University, Sehore, M.P., India

Received: 2022 March 15**; Revised:** 2022 April 20**; Accepted:** 2022 May 10

Abstract

The effective functioning of hydrothermal power plants is an essential component in satisfying the demand for energy while simultaneously reducing the amount of money spent on operations and the negative impact on the environment. Both hydroelectric and thermal power production units are included in hydrothermal power systems. The availability of water resources and the cost of fuel are two factors that substantially impact the decisions that are made about the operation of these systems. Optimal hydrothermal scheduling aims to minimize fuel costs for thermal plants while maximizing efficiency, all within the constraints of water availability for hydro plants at a given time period. This research uses Kirchmayer's method for short-term optimum scheduling to find the Hydro-thermal plant's generating schedule, the hydro plant's daily water consumption, and the thermal plant's daily operating cost.

Keywords: Hydrothermal, Kirchmayer, Optimal scheduling, Plants, Short term

---

I.Introduction

Optimizing the usage of hydro and thermal resources to fulfill demand while reducing costs is essential for effective power system management, and short-term hydrothermal scheduling plays a part in this. In this procedure, optimization methods are crucial because they allow operators to make rapid, educated judgments. Several optimization methods for short-term hydrothermal scheduling are discussed in this article. Hydrothermal scheduling for the near future often makes use of Dynamic Programming (DP), a time-tested optimization method. The process entails addressing the issue iteratively by dividing it into smaller subproblems. DP takes a number of variables into account, including water input, reservoir levels, and thermal unit limitations, in order to find the most cost-effective and efficient generating plan to fulfill demand. Formulating the issue as a linear optimization model, Linear Programming (LP) provides an alternative method for short-term hydrothermal scheduling. Allocating hydro and thermal resources is optimized using LP approaches, which are based on objective functions and mathematical restrictions. In a short length of time, LP models may provide near-optimal solutions for large-scale systems. If the optimization issue has objective functions or constraints that are not linear, then nonlinear programming (NLP) methods are used. When planning hydrothermal operations for the near future, it is common practice to take nonlinear correlations between factors like generating costs and reservoir levels into account. Natural language processing techniques use iterative algorithms to discover cost-effective solutions that meet these nonlinear restrictions. By introducing the concept of discrete integer values for some variables, Mixed-Integer Programming (MIP) expands linear programming. Because choices like unit commitment and reservoir release dates are discontinuous, MIP models work well for short-term hydrothermal scheduling. More accurate solutions that represent real-world operational limitations are offered by MIP approaches because they include integer variables into the optimization process. When dealing with nonlinear, unpredictable, and complicated systems, metaheuristic algorithms provide an alternate optimization approach for hydrothermal scheduling in the short run. Some metaheuristic methods that have been used to solve this issue include Genetic Algorithms (GA), Particle Swarm Optimization (PSO), and Simulated Annealing (SA). Because of their adaptability and resilience, these algorithms can handle a wide variety of optimization goals

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 3, 2022, 5538 - 5544
https://publishoa.com
ISSN: 1309-3452
and constraints while exploring solution spaces. In order to make the most of each method's advantages and compensate for its weaknesses, hybrid optimization approaches integrate many methods.

A hybrid strategy might combine DP with metaheuristic algorithms to optimize thermal unit commitment and handle hydrological restrictions, for instance. In short-term hydrothermal scheduling, hybrid techniques may improve speed and scalability by combining several optimization strategies. Variations in demand, renewable energy production, and water input are some of the uncertainties that short-term hydrothermal scheduling entails. Stochastic optimization approaches attempt to manage these uncertainties. Monte Carlo Simulation, Robust Optimization, and Stochastic Programming are three popular stochastic methods. To guarantee the power system runs reliably and robustly, operators may use these methods to integrate risk management strategies and probabilistic predictions into scheduling. Optimization models for short-term hydrothermal scheduling are made more accurate and realistic with the use of modern modeling approaches. Among them, you may find Dynamic Stochastic Programming (DSP), which incorporates stochastic uncertainty into time-dependent choices, and Chance-Constrained Programming (CCP), which guarantees the satisfaction of operational requirements with a predetermined probability. Operators may make better scheduling choices by using sophisticated modeling approaches to account for complicated interactions between hydro and thermal units.

II.Short-Term Optimal Scheduling

Considering the fast-paced and ever-changing nature of the modern world, the notion of scheduling has developed into an essential component in a wide variety of fields, spanning from the manufacturing and transportation industries to the healthcare and project management fields. Within this expansive environment, the field of short-term optimum scheduling stands out as a significant area of research and application that is of key importance. As a result of its emphasis on instantaneous decision-making and resource allocation within limited time frames, short-term optimum scheduling plays an essential part in the enhancement of efficiency, productivity, and resource utilization across a wide range of sectors. At its foundation, short-term optimum scheduling is centered on the efficient distribution of resources in order to accomplish particular goals within a constrained amount of time. On the other hand, short-term scheduling is concerned with duties that are immediate or near-future, and it often falls within the scope of hours, days, or weeks. This is in contrast to long-term planning, which typically covers months or years. Because of this temporal proximity, decision-makers are faced with a unique set of challenges, including the need to navigate through uncertainties, dynamic demand patterns, resource availability constraints, and operational disruptions, all while attempting to optimize a variety of performance metrics, including throughput, efficiency, cost, and customer satisfaction.

There is a wide range of businesses that can benefit from the implementation of short-term optimum scheduling, including but not limited to manufacturing, transportation, healthcare, logistics, and other service industries. When it comes to manufacturing, for example, effective production scheduling ensures that resources like machinery, people, and raw materials are utilized in a timely manner in order to fulfill output objectives, limit idle time, and reduce manufacturing lead times. In a similar vein, efficient scheduling of vehicle routes, assignments, and deliveries in the transportation and logistics industry optimizes fleet utilization, lowers transportation costs, and boosts customer service levels by ensuring that deliveries are made on time. Additionally, the healthcare industry is significantly reliant on short-term optimum scheduling in order to maximize the usage of operating rooms, patient visits, staff scheduling, and hospital resource allocation. Hospitals are able to increase their operational efficiency, decrease the amount of time patients have to wait, and enhance the overall quality of treatment they provide if they match their healthcare resources with the patterns of patient demand and clinical priorities. Additionally, in service sectors such as contact centers, airlines, hotels, and restaurants, it is essential to effectively schedule personnel shifts, client appointments, and service supply windows in order to accomplish the goals of maintaining service levels, reducing wait times, and increasing customer satisfaction.

III.Review Of Literature

Hassan, Mohammed (2016) While hydro plants are mostly cost-free to operate, there is a limit to how much water can be utilized for hydro production at any one time, which makes integrating thermal plants into a system more challenging. It is comparable to the difficulty of lowering the operational cost of a hydrothermal system to reduce the fuel cost of thermal plants while being constrained by the availability of water for hydro production during a certain operation period. Several optimization methods, like as gradient search and dynamic programming, have been used to solve hydrothermal scheduling problems before. But there are some drawbacks to these methods, such the fact that they are computationally difficult and take a long time to calculate. The authors of this paper claim to have solved the problem of short-term hydrothermal scheduling. To solve this problem, we used the Particle Swarm Optimization (PSO) tool in Matlab..

Barisal, Ajit et al., (2015) This study presents a new invasive weed optimization method that is both effective and trustworthy. It is designed to solve the scheduling issue of hydro-thermal systems with cascaded reservoirs. To account for the non-linear relationship between water discharge rate, net head, and power production, multi-chain cascaded hydro-thermal systems work. It considers the time it takes for water to travel between cascaded reservoirs, restricted operating zones, transmission losses, and valve point loading effects. The validity of the proposed method is shown by a single standard test configuration using four cascaded hydro units and a thermal unit that is functionally equivalent. The literature shows that the proposed method outperforms other popular techniques with respect to convergence characteristics and solution quality.

Rasoulzadeh-akhijahani, Ali & Mohammadi-ivatloo, Behnam (2015) Finding the best plan for hydro and thermal generation is the main goal of the SHGS problem, which stands for short-term hydrothermal generation scheduling. By doing so, we hope to meet a number of operational and physical constraints while keeping thermal plant fuel costs to a minimum. Conventional wisdom is that SHGS is useful for planning with a one-day or one-week horizon. It is a challenging non-linear, non-convex, and non-smooth optimization problem when the influence of valve point loading (VPL) on thermal power plants, transmission loss, and other constraints is addressed. This work introduces a modified dynamic neighborhood learning based particle swarm optimization (MDNLPSO) as a potential solution to the SHGS issue. The proposed approach has the swarm's particles grouped into several neighborhoods, where any particle may pick up knowledge from any other particle in its immediate vicinity. The neighborhood's memberships are updated via a refreshing procedure that occurs at regular intervals. Thereby, every single particle in the swarm may take part in the data exchange. An improvement in exploration and exploitation capabilities is shown when comparing the classic PSO to the one described above. The usefulness of the presented technique is shown using three separate multi-reservoir cascaded hydrothermal test systems. These results are contrasted with other recently established techniques. The results of the simulation clearly show that the MDNLPSO method may get a better and different result.

Narang, Nitin et al., (2014) This work elucidates the predator-prey based optimization (PPO) approach, which is used to get the optimal generation schedule for a short-term hydrothermal system. PPO is capable of addressing complex optimization problems on a wide scale, particularly those involving non-linear functions. It is closely associated with swarm intelligence. A PPO-based strategy combines the ideas of particle swarm optimization with the predator effect to maintain diversity within the swarm and prevent premature convergence to a local sub-optimal solution. This study employs a blend of random heuristic search and PPO to successfully address the optimum hydrothermal scheduling problem. Subsequently, it explores viable solutions for thermal and hydropower generation. In order to address the equality constraint, the variable removal strategy is used to explicitly eliminate variables. The penalty approach restricts the availability of surplus units by taking into account these excluded criteria. Slack hydro units provide equitable distribution of water, whereas slack thermal producing units maintain power balance equality within each sub-interval. The recommended technology is effectively shown by both fixed-head and variable-head hydrothermal power systems. A comparison is conducted between the results generated by the current methodology and the proposed technique. Based on the numerical data, the PPO based strategy produces greater results.

Bisht, Vimal et al., (2012) The functioning of a power grid that is interconnected with both hydro and thermal plants is much more intricate and vital in today's context. The STHS problem aims to optimize electricity production, with a specific emphasis on the immediate future. This article provides a comprehensive analysis of a hydrothermal scheduling problem with a constrained time frame. The essay demonstrates the results of using several analytical and evolutionary approaches to address a short-term hydrothermal scheduling problem.The article presents all the underlying assumptions and offers a succinct overview of the methodologies used to address the challenge. Those with a keen interest in the topic or intending to further explore this subject may find the paper's content and supplementary materials valuable for future research endeavors.

Datta, S. et al., (2012) This paper presents the Biogeography Based Optimization (BBO) approach as a solution for finding short-term hydrothermal scheduling, taking into account the majority of constraints related to equality and inequality. Biogeography is the scientific discipline that investigates the spatial distribution of organisms. The process of species evolution, migration across habitats, and ultimately extinction is elucidated by using mathematical models of biogeography. The presented algorithm offers a solution to the challenges faced in hydrothermal scheduling in real-world power systems. It surpasses the competition in terms of both processing time and minimizing fuel cost.

George, Abraham et al., (2010) The goal of this study is to elucidate two distinct approaches for accomplishing multi-task, short-term hydrothermal scheduling. The former refers to a hybrid method that combines the genetic algorithm with the classical Newton-Raphson approach. In contrast, the latter is mostly recognized for its use of genetic algorithms in combination with heuristic searches. The hybrid algorithm utilizes genetic methods to create a population of weight vectors. The objective function values are calculated for each weight vector using the Newton-Raphson technique inside the optimization period. Ultimately, fuzzy approaches are used to ascertain the overall pleasure or adequacy of the solution. Once the population has been adjusted, the population's weight vectors and the fitness values of its individuals are both determined. The cycle will continue until the maximal fitness value achieved approaches saturation. Most of the procedures in both algorithms are the same. However, in the heuristic search method, the objective function values for the optimization interval are obtained via a sub-process that utilizes both fuzzy logic and genetic algorithms. The algorithm achieves improved efficiency by the usage of specific crossover methods in every genetic search. Additionally, this analysis incorporates the implementation of coal-constrained thermal plants, which serves as another distinctive feature of the research.

Hota, Prakash et al., (2009) This study presents a unique approach to address the problem of optimizing power generation for short-term hydrothermal scheduling using the improved particle swarm optimization (IPSO) technique. Finding the global optimum using traditional optimization approaches is a tough challenge in real hydrothermal systems owing of their high complexity, nonlinear problem variables, cascading hydraulic network, water transport delay, and scheduling time linkage. In order to speed up the optimization process while keeping the basics of the traditional PSO technique, this study provides an upgraded PSO methodology that employs a dynamic search-space squeezing mechanism to deal with inequality restrictions. The efficiency and robustness of the proposed IPSO are shown using a multi-reservoir cascaded hydro-electric system that includes restricted operating zones and a thermal unit with valve point loading. We juxtapose the numerical results with those obtained from methodologies such as differential evolution (DE), evolutionary programming (EP), nonlinear programming (NLP), and dynamic programming (DP). When compared to proven methods such as EP and DE, the simulation results demonstrate that the proposed IPSO provides the best combination of convergence speed, solution time, and overall cost.

IV.Experimental Setup

In order to accomplish this objective, it is necessary to minimize the operational expenses of the facility. Figure 1 shows a hydro-thermal system comprising of two plants, with the steam plant situated near the load and the hydro plant positioned at a distant location.

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 3, 2022, 5538 - 5544
https://publishoa.com
ISSN: 1309-3452

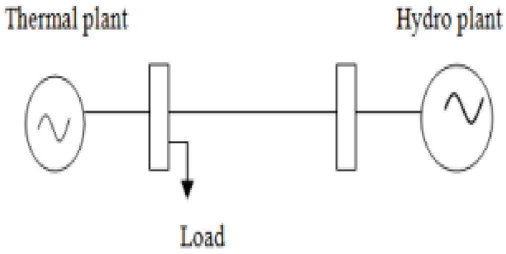

Figure 1: Typical Hydro-thermal system

This table displays the load demand for a single day. In this specific text, Kirchmayer's technique is used to acquire a producing schedule, the daily water need for the hydro plant, and the daily running cost of the thermal plant for short-term scheduling. Conversely, Kirchmayer's strategy is a conventional approach to near-term scheduling. Among the several approaches in hydro-thermal scheduling, this technique is the most direct and uncomplicated option. As the problem is temporary, the water level in the reservoirs will remain relatively stable over the rainy season. Thus, it is assumed that the water level stays constant.

Table 1: Load Demand

S. No.	Load	Hours
1	450 MW	16
2	300 MW	8

V.Results And Discussion

The following data may be obtained for a power demand (PD) of 450 MW and a power demand of 300 MW. The information is shown in table 2.

Table 2 Hydro-thermal scheduling

S. No.		450MW	300MW
1.	PGH	82.5MW	52.24MW
2.	PGT	374.306MW	250.48MW
3.	PL	6.806MW	2.72MW

Both the daily water consumption of the hydro plant and the daily operating expenditures of the thermal plant are included in Table 3, which depicts both of these figures. These statistics are derived for two different combinations of load demands that are potential alternatives. The daily operating cost of the thermal plant is equal to the operating cost of the thermal plant for meeting 700 MW of load for eight hours in addition to the operating cost of the thermal plant for meeting 450 MW of demand for sixteen hours. This is the total cost of the thermal plant's daily operations. In addition, the amount of water that is consumed by the hydro plant on a daily basis is similar to the amount of water that is consumed for 450 megawatts of load for sixteen hours, in addition to the amount of water that is spent for 300 megawatts of load for eight hours. This is the amount of water that is consumed.

Table 3: Daily operating cost and daily water used for PD= 450MW and PD = 300MW

Daily operating cost of thermal plant	677116.89 per day
Daily water used by hydro plant	6417003 m3

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 3, 2022, 5538 - 5544
https://publishoa.com
ISSN: 1309-3452

VI.Conclusion

The research concludes that the optimization framework is a big step forward in solving the complicated problems of hydrothermal power plant short-term scheduling. The model ensures cost-effective and dependable power generation by factoring in reservoir levels, inflow predictions, fuel prices, and energy demand estimations, among other variables. Incorporating stochastic optimization and sophisticated forecasting methodologies allows for robust decision-making under uncertainty, which is essential for adjusting to the inherent fluctuation in future water intakes and renewable hydropower output. To make the optimization model more practical, we include operational restrictions like reservoir capacity limitations, environmental rules, and market circumstances. This way, we can maximize economic efficiency while still complying with regulations. By improving decision-making tools for hydrothermal power system operators and planners, this study helps make hydroelectric power generation more sustainable by making better use of available resources. To further improve the current state of the art in short-term scheduling of hydrothermal plants, future study might investigate using the optimization framework in real-world operating conditions and making more improvements to it.

References: -

[1] Hassan, Mohammed. (2016). Short Term Hydrothermal Scheduling Using Particle Swarm Optimization.

[2] P. Ramesh, “Short term hydrothermal scheduling in power system using improved particle swarm optimization,” International Journal of Advanced Engineering Technology,March 2016.

[3] Barisal, Ajit & Prusty, R.C. & Dash, S.S. & Kisan, S.K.. (2015). Short Term Hydro Thermal Scheduling Using Invasive Weed Optimization Technique. Smart Innovation, Systems and Technologies. 33. 395-405. 10.1007/978-81-322-2202-6_36.

[4] Rasoulzadeh-akhijahani, Ali & Mohammadi-ivatloo, Behnam. (2015). Short-term hydrothermal generation scheduling by a modified dynamic neighborhood learning based particle swarm optimization. International Journal of Electrical Power & Energy Systems. 67. 10.1016/j.ijepes.2014.12.011.

[5] Narang, Nitin & Dhillon, J.S. & Kothari, D.P.. (2014). Scheduling short-term hydrothermal generation using predator prey optimization technique. Applied Soft Computing. 21. 298–308. 10.1016/j.asoc.2014.03.029.

[6] Bisht, Vimal & Sood, Dr.Yog & Kushwaha, Nikhil & Kant, Dr. (2012). SHORT TERM HYDRO THERMAL SCHEDULING PROBLEM: A REVIEW. International Journal of Electronics and Electical Engineering. 2231-5284. 10.47893/IJEEE.2014.1104.

[7] Datta, S. & Basu, Meheli & Bhattacharya, Aniruddha. (2012). Biogeography-Based Optimization for short-term hydrothermal scheduling. 38-43. 10.1109/ICETEEEM.2012.6494441.

[8] Bhattacharya, Aniruddha & Datta, S. & Basu, Meheli. (2012). Gravitational Search Algorithm Optimization for short-term hydrothermal scheduling. Proceedings - ICETEEEM 2012, International Conference on Emerging Trends in Electrical Engineering and Energy Management. 216-221. 10.1109/ICETEEEM.2012.6494479.

[9] Kamal, Niladri, “Optimal Scheduling of Cascaded Hydrothermal systems using a New Improved PSO Technique,” Smart Grid and Renewable Energy, vol2,2011.

[10] George, Abraham & Reddy, Dr & Sivaramakrishnan, Dr. (2010). Multi-objective, short-term hydrothermal scheduling based on two novel search techniques. International Journal of Engineering Science and Technology. 2(12). 7021-7034.

[11] Takigawa, F.Y.K., E.C. Finardi and E.L. da Silva, A decomposition strategy to solve the short-term hydrothermal scheduling based on lagrangian relaxation,Proc. IEEE/PES Transmission and Distribution Conf. and Exposition: Latin America (T&DLA), 681688 (2010).

[12] Hota, Prakash & Barisal, Ajit & Chakrabarti, Ritashree. (2009). An improved PSO technique for short-term optimal hydrothermal scheduling. Electric Power Systems Research. 79. 1047-1053. 10.1016/j.epsr.2009.01.001.

[13] Farhat, I.A. & El-Hawary, Mo. (2009). Optimization methods applied for solving the short-term hydrothermal coordination problem. Electric Power Systems Research. 79. 1308-1320. 10.1016/j.epsr.2009.04.001.

[14] Mandal, Kamal & Basu, Mousumi & Chakraborty, N.. (2008). Particle Swarm Optimization Technique Based Short-Term Hydrothermal Scheduling. Appl. Soft Comput.. 8. 1392-1399. 10.1016/j.asoc.2007.10.006.

[15] Yu, Binghui & Yuan, Xiaohui & Wang, Jinwen. (2007). Short-term hydro-thermal scheduling using particle swarm optimization method. Energy Conversion and Management. 48. 1902-1908. 10.1016/j.enconman.2007.01.034.