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Optimization Technique for Short Term Hydro-Thermal Scheduling

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***Abstract*— The objective of optimum hydrothermal scheduling is to minimize the cost of fuel for thermal plants under constraints of water availability for hydro plants for a given time. In this paper, generation scheduling for hydro-thermal plants, daily water used by hydro plant and daily operating cost of the thermal plant is obtained using Kirchmayer's method for short term optimal scheduling.**

Keywords— hydro-thermal scheduling, Kirchmayer's method and optimization.

I. Introduction to Hydro-Thermal Scheduling

The hydro plants requires less starting time and takes load in very short time as compared to thermal plants which takes more time to make the turbine system, superheater and boilers ready to take the load. Hydro plants have capability to handle fast changing loads but thermal plants are slow in response. Due to this, hydro plants are preferred to operate as peak load plants and thermal plants as base load plant. In order to utilize energy efficiently, cost must be as minimum as possible. So the main aim of operation of power system is to generate and transmit power to meet the system load demand at minimum fuel cost and minimum environmental pollution[1]. Hence, hydrothermal scheduling is important. The objective of optimum hydrothermal scheduling is to minimize fuel cost of thermal plants under constraints of water availability for hydro plants over a given period of time.

The hydrothermal scheduling is classified into:-

1.Long term Coordination is considered from one week to one year or several years. This is used for long term minimization of cost of the whole system. The long term coordination problem becomes very difficult to solve due to its size, time span and randomness in flow of water for long time [2].

2.Short term Scheduling is required for one day or one week. In short term problem, the head of water is assumed to be constant as there will not be any appreciable change in the water level in the reservoirs. So, this is quite easy to solve due to its size, time span (one week).

II. SHORT-TERM HYDRO-THERMAL SCHEDULING

Short-term scheduling is required for one day or one week. It includes the hour-by-hour scheduling of both hydro and thermal plants in order to get minimum cost for production in the given time. In this scheduling problem, the load, the hydraulic inflows and unit availability are assumed to be known[3]. In addition, the generating unit limits and the load demand over the scheduling interval are known. In short term problem, the head of water is assumed to be constant as there will not be any appreciable change in the water level in the reservoirs. Several mathematical techniques for optimization have been used to overcome short term hydrothermal scheduling problems[4]. Load cycle, expected water inflow, water head and generation in hydro plant, incremental fuel cost of thermal plant and incremental transmission loss are the various factors on which the economic operation of hydro-thermal scheduling depends.

The various methods used for hydro-thermal scheduling are constant hydro generation method, constant thermal generation method, maximum hydro-efficiency method and Kirchmayer's method [5]. Many research work have been done to broadly investigate the short-term hydro scheduling problem. Main computational techniques that have been employed are maximum principal [6], variational calculus [7], dynamic programming [8] and non-linear programming [9]. In this paper, Kirchmayer's method for short term optimal scheduling is presented. The proposed method is one of the effective method for solving short term hydro-thermal scheduling problem.

III. Problem Formulation

The objective is to minimize the operating cost of the plant. A two plant hydro-thermal system having a steam plant near load and hydro plant at a remote end as shown in fig1.

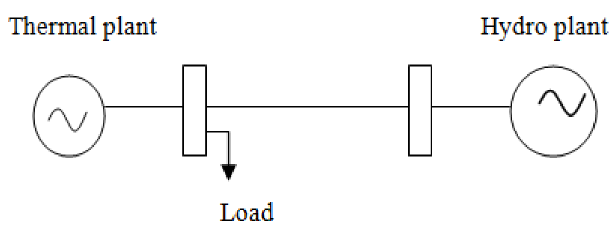

Fig 1:- Typical Hydro-thermal system

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The characteristics of units are

$$C = 130 + 50\, P_{GT} + 0.1P^2_{GT} \quad (1)$$

$$W = 0.00300\, P^2_{GT} + 0.8P_{GT} \quad (2)$$

Loss coefficient, B_{HH} =0.001 MW^{-1}

γ_j is the constant to convert the incremental water rate of hydro plant j into an incremental cost and must be selected in such a way that the specified amount of water is used during its operation period. Table I represents load demand for a day. In this paper, generation schedule, daily water used by hydro plant and daily operating cost of the thermal plant is obtain using Kirchmayer's method for short term scheduling. Kirchmayer's method is a conventional approach for short term scheduling. This approach is the simplest approach for hydro-thermal scheduling. Since it is a short term problem, there will not be any appreciable change in the water level in the reservoirs during the rainfall. So, the head of water is assumed to be constant[10].

Table I:- Load Demand for a day

S No.	***Load***	***Hours***
1.	450 MW	16
2.	300 MW	08

Coordination equation for thermal unit is

$$dC/dP_{GT} = 50+0.2P_{GT} \quad (3)$$

Condition for optimal scheduling is

$$(dC/dP_{GT})L_T = \gamma_j\, (dW/d\, P_{GH})[1/1\text{-}0.002\, P_{GH}] = \lambda \quad (4)$$

and power balance equation is

$$P_{GT} + P_{GH} = P_D + P_L \quad (5)$$

where P_{GH} is the power generation at hydro plant(MW)

P_{GT} is the power generation at thermal plant(MW)

P_D is the power demand(MW)

P_L be the power losses(MW)

dC/dP_{GT} be the incremental fuel cost of thermal plant (Rs./MWh)

dW/dP_{GH} be the incremental water rate of hydro plant (m^3/s/MW)

γ_j is the constant to convert the incremental water rate of hydro plant j into an incremental cost

λ be the Lagrangian multipliers and

$L_T = 1/(1\text{-}dP_L/dP_{GT}) = 1$

Since the load is near to thermal plant, the transmission loss is only due to hydro plant. Therefore, $B_{TT} = B_{TH} = B_{HT} = 0$

Loss Coefficient, B_{HH}=0.001 MW^{-1} (given)

$$P_L = B_{HH}P^2_{GH} \quad (6)$$

IV. RESULTS AND DISCUSSION

For P_D= 450 MW and P_D =300 MW, using equations (3),(4),(5) and (6), following data shown in tableII is obtained.

TABLE II:- shows hydro-thermal scheduling for two different load demand.

S.N0.	P_D = 450MW	P_D = 300MW
1.	P_{GH} =82.5MW	P_{GH} =52.24MW
2.	P_{GT} =374.306MW	P_{GT}=250.48MW
3.	P_L =6.806MW	P_L=2.72MW

The daily operating cost of thermal plant is obtained using equation(1) for two different load demands is shown in table III and the daily water used by hydro plant is obtained using equation(2) for two different load demands is shown in table IV. Daily operating cost of the thermal plant is equal to operating cost of thermal plant for meeting 450 MW of load for 16 hours plus operating cost of thermal plant for meeting 300 MW of load for 8 hours. Also, the daily water used by hydro plant is equal to daily water quantity used for 450 MW of load for 16 hours plus the daily water quantity used for 300 MW of load for 8 hours.

Table III:- Daily operating cost of thermal plant

For P_D= 450MW and P_D = 300MW	
Daily operating cost of thermal plant	C=677116.95 per day

Table IV:- Daily water used by hydro plant.

For P_D= 450MW and P_D = 300MW	
Daily water used by hydro plant.	W=6417000 m^3

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V. CONCLUSION

The paper presented an effective method for solving short termhydro-thermal scheduling problem by using Kirchmayer's method to minimize fuel cost of thermal plants under constraints of water availability for hydro plants over a given period of time. Generation schedule, daily water used by hydro plant and daily operating cost of the thermal plant is obtained for two different power demands. Thus, the proposed method is one of the effective methods for solving short-term hydro thermal scheduling problem.

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