Modeling of Reservoir Operation for Power Optimization

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Abstract

Reservoir operation forms a very important part of planning and management of water resource system. Power generation can be optimized using reservoir operation techniques. Water resources projects involve three stages of decisions 1. Location & magnitude of reservoir. 2. Design & construction 3. Operation of reservoir.In this paper case study of Mahadayi river has been taken for Linear modeling through which we can perform reservoir operation for optimum power generation

Object function
1. To maximize Power generation in the system
2. Release pattern to be adopted to maximize energy generation..

KEYWORDS: Rule curve, linear model, Power, Energy

INTRODUCTION

Water and energy are two resources that are very necessary for humankind and are intricately connected. Water is the most important resource of the entire society.In India major Power generation is by Hydro Power

The water helps us for running our hydro electric turbines, the density of water helps us in floating our ships, the energy of water provide steam for running our locomotives and turbines, and also to warm our dwelling units; the electrical conductivity of water helps us in providing a wonderful solvent.

RESERVOIR OPERATION:

Depend on the flow charecters and stream we can plan the reservoir construction, once it is constructed then we have to look for good plan through which we can get maximum benefit, first thing is to decide whether it is for single purpose or multipurpose.A reservoir operation plan is devised to achieve the greatest value or benefit from the storage capacity. The plan must be based on a knowledge of the flow characteristics of the stream, i.e. a history of its past performance; the purposes of the reservoir must be analyzed to determine as to how the hydrograph of flow should be altered to produce the greatest benefits; and special considerations, such as the effect of sudden releases on stream banks and of long – sustained flows from the reservoir on agricultural developments in the alley below the reservoir.

The manner in which the co-ordination of different purposes is realized is controlled by the most important utilization of the dam. This in turn is determined by the character of the areas. For instance, power generation is usually considered a secondary benefit in comparison to other uses, but in some instances power is the main objective. In such cases the full flood control capacity is provided as the surcharge capacity so that any restriction of power generation should be precluded.

Scope of the present study

The objective of the present paper is to describe the linear model of reservoir operation through which we can see how we can generate maximum power with the available recourse.

TECHNIQUES FOR RESERVOIR OPERATION

Since lost three decades, one of the most important advances made in the field of water resources engineering is the development and adaptation of system analysis techniques for planning, design and management of complexwater resources system. The application of system approach to reservoir problems concerned with hydropower can be classified in to two categories; Optimization and Simulation based on the system technique to solve the problem.

Present study:

The present work concentrated upon the optimal multi reservoir operation for the two reservoirs namely, Kotni dam and Irti dam of Mahadayi hydroelectric project. The next step involves the formulation of mathematical model for the reservoir operation.

The working table for reservoir operation has been prepared for the present study of Mahadayi hydroelectric project. The period considered for the present work is from 1975 AD to 2000 AD (for both Kotni dam and Irti dam).The monthly inflow details are collected from Karnataka Power Corporation Limited (KPCL), Bangalore. (Monsoon Months namely, June, July, August, September, October and Non monsoon months from November to May)

ANALYSIS AND RESULTS:

For this present study, the reservoir operation table or working table (for both Kotni and Irti dam) with diversion without diversion and the mathematical modeling is prepared.

The hydrological aspects of reservoir planning are :

1. Water availability in the river on which the dam is proposed to be constructed.
2. Determination of storage capacity to serve the target pattern of demand and
3. Operation of reservoir with the given target pattern of demand.

STANDARD LINEAR OPERATING POLICY

The simplest of the reservoir operation policies is the standard linear operating policy (SLOP). according to this policy, if the amount of water available in storage is less than the target release, whatever quantity is available is released, if availability is more than target then a release equal to the target is made as long as storage space is available to store excess water and thereafter, all the water inexcess of maximum storage capacity is released. This policy is mathematically expressed as follows.

Ri = Si + Ii if Si + Ii <= T

T if T <= Si + Ii <= T+ S max

Si + Ii - Smax if Si + Ii >= T + Smax

whereRi = Release during time period i,

Si = Storage at the beginning period i,

Ii = Inflow during period i,

T = Target for release

Smax = Maximum reservoir storage capacity.

In present study, the objective function is to maximize the net benefits from power generation in the system and the release pattern to be adopted to maximize energy generation subjected to various constraints.

OBJECTIVE FUNCTION: subject to following constraints:

Max Z = $\sum B_1Q_{Kt} + B_2Q_{It} + B_3Q_{Tt}$ where t varies from 1 to 6 and B_1 B_2 B_3 are cost coefficient for Kotni reservoir, Irti reservoir and Tailrace reservoir which are main dams under study.

$B_1 = \beta_1 \alpha 1$; $B_2 = \beta_2 \alpha_2$; $B_3 = \beta_3 \alpha_3$ where β_1 , β_2 and β_3 are returns. At present the revenue of the electrical energy is 87 paise per unit. Hence the same has been adopted in the calculations whereα_1 ,α_2 and α_3 are the energy constants. These are computed as α=[(0.2383)/100] x H (net head)

The equation for calculation of energy constant is as follows;
It is assumed that 93 % efficiency is achieved in each generator and turbines.
Power in kw = 0.93 x 0.93 x 9.81 x H x Q
Power in MW = [8.58 Q x H]/1000
Energy in MU = [Power in MW x 0.024]/1000
Discharge 1 Mcum = 11.57 cumecs
$B_1 = \beta_1\alpha_1$ for Kotni reservoir with net head 72 metres = (0.2383 x 72 7 0.87)/100 = 0.15
B_2 = 0.97 for Irti reservoir and B_3 = 0.06
Now the objective function is simplified as
Max Z = 0.15 Q K_t + 0.97 Q I_t + 0.06 Q $T_t$subject to the continuity and inequality constraints.

1. Continuity constraint: The water released during any period “t” can not exceed the content of the reservoir at the beginning plus the inflow into the reservoir during the period “t”
2. Inequality constraints

Release ≤ availability

Reservoir	Maximum storage	Minimum storage
Kotni	KS_t= 420.52 Mcum	KS_t= 49.17 Mcum
Irti	IS_t = 107.31 Mcum	IS_t = 72.36 Mcum
Tail Race	TS_t = 9.17 Mcum	TS_t = 6.25 Mcum

The water released during any period “t” cannot exceed the content of the reservoir at the beginning plus the inflow into the reservoir during period t.

For Kotnireseroir:

KSt+1 = KSt + KIT – K Su t-Q Kt – Div t

KSt + K Su t + QKt = Kit – K Et – Div t

For Irti reservoir:

ISt+1 = Ist + Iit – I Su t – I Et – Q It + Q Kt

Ist + I Sut + Qit – Q Kt = I It – I Et

INEQUALITY CONSTRAINTS:

Releases <= Availability

For kotni reservoir: Q Kt + KSt + K Sut<= Kit – Ket – Div t

For Irtireseroir: Qit + ISt+1 + ISt + Isut<= I It – I Et

Capacity constraints: Storage should be less than or equal to maximum capacity of the reservoir.
Maximum storage at the beginning of the period “t” should be less than or equal to the capacity at FRL.

For Kotni reservoir:

K St <= 420.52 (capacity at FRL in M.Cum)

For Irti reservoir:

I St<= 107.31(capacity at FRL in M.Cum)

Minimum storage at the beginning of the period t should be greater than or equal to the capacity at the minimum draw down level (MDDL) in reservoir.

Minimum storage constraints:

For Kotni reservoir:

K St <= 49.17 (storage capacity at MDDL in M.Cum)

For Irti reservoir:

I St<= 72.36 (storage capacity at MDDL in M.Cum)

Power constraints:

The withdrawal of power should not exceed the power draft for full installed capacity at Kotni power house and Irti power house are 20 MW and 300 MW respectively.

NOTATIONS:

QK = Releases from Kotni reservoir
QI = Releases from Irti reservoir
KE = Evaporation losses from kotni reservoir
IE = Evaporation losses from Irti reservoir
KI ,II = Inflows to Kotni and Irti reservoir respectively.
K Su, I Su = Spills (surplus) from Kotni and Irti reservoir respectively.
Div= Mandatory release from Kotni reservoir
KS, IS = storages at Kotni and Irti reservoir respectively.

Typical planning models generally include at least one objective function that is either maximized or minimized. Sometimes planning problem is stated in the form of maximizing an objective function subject to probabilistic constraints. One statement representing this class of constraint is the probability that the power produced is greater than or equal to the power requirement must not be less than .95. Such a probabilistic constraint might be written as
Pr[power produced > = power requirement] . = 0.95 where 0.95 is the limit on the function fraction of time which the power requirement is to be met.

CONCLUSION.

With the help of modeling techniques, we can use minimum water from resources to generate maximum power which is today's basic need. With the help of rule of curve and linear modeling we can get up to 95percent efficiency. We can adopt simulation techniques to get the better result which is my future planning.

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