Reservoir Operation of Hyderabad Water Supply System

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Abstract - The Reservoir Operation studies are being carried out for deriving the reservoir operation policies for maximizing the performance of the reservoir using various optimization and simulation techniques. The Hyderabad water supply system is having multi reservoir sources among them Osmansagar is one of the reservoir source supplies water on gravity mode. The historical reservoir operations was compared with the simulation studies and found that the scientific based reservoir operation policies will improve the overall performance of the reservoir and helps for the demand management in the downstream system for minimizing the deficits.

Keywords: Reservoir Operation, Simulation, Performance, Minimizing Deficits.

I. INTRODUCTION

Development and Operation of Reservoirs System & Management of Demand System, for Water Supply is a high priority particularly in the developing countries for the health & hygienty of the people residing under the system area.

Evolving the suitable Reservoir operation policy of existing Reservoir systems and suitable demand management strategies is extremely relevant and the present study is an apt exercise for such objective.


S. Vedula & S. Mohan (1991)⁸, Real-time Multipurpose Reservoir Operation for Irrigation and Hydropower generation for case studies of Bhadra reservoir system in Karnataka using SDP.

Shrestha (1996)⁹, developed fuzzy relations for input and output of reservoir operating principles and defuzzified to get the crisp outputs.

Durbovin et al (2002)⁹, Real time reservoir operation model based on total fuzzy similarity and compared with fuzzy inference method.

Inspite of considerable work done on Reservoir Operations, very rare attempts were made for combined study of Reservoir Operation Policy & Demand Management to evolve deficit minimizing strategies linking to Drinking Water Supply System.

II. PRESENT STUDY

In this paper, the Reservoir Operation of Osmansagar reservoir was carried out using the observed inflow data, evaporation data in the continuity equation model.

The objective of the study is to evolve the Reservoir operating policies. In the first phase, the release policy for the given initial storage & known inflows with defined operating policy for a given simulation period is determined using sequential process simulation. The model results were compared for the historic data.

III. SYSTEM STUDY

The Osmansagar reservoir is built across the River Musi in the Krishna basin and being operated exclusively for drinking water supply of Hyderabad city. The reservoir has a active storage capacity of 113.0 Mm³.

IV. SYSTEM DATA

Monthly inflow data of Osmansagar reservoir system for 23 water years (1994-2016, water year beginning 1st January and ending 31st December), and monthly withdrawls data for 23 years (1994-2016) were used in the study.
In the Table-I the annual inflows in Mm³ for Osmansagar reservoir for the period 1994-2016 are presented.

Evaporation loss data for the period from 1994-2016 were used in deriving the relationship between the evaporation and average storage in each month by least squares fitting and evolved the evaporation curves & used in the model.

The initial Storage for Osmansagar Reservoir at January 1994 is 100Mm³.

Table I

<table>
<thead>
<tr>
<th>Year</th>
<th>Osmansagar</th>
<th>Year</th>
<th>Osmansagar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>562</td>
<td>2006</td>
<td>200</td>
</tr>
<tr>
<td>1995</td>
<td>2957</td>
<td>2007</td>
<td>410</td>
</tr>
<tr>
<td>1996</td>
<td>2306</td>
<td>2008</td>
<td>1989</td>
</tr>
<tr>
<td>1997</td>
<td>200</td>
<td>2009</td>
<td>569</td>
</tr>
<tr>
<td>1998</td>
<td>3308</td>
<td>2010</td>
<td>4161</td>
</tr>
<tr>
<td>1999</td>
<td>200</td>
<td>2011</td>
<td>200</td>
</tr>
<tr>
<td>2000</td>
<td>3033</td>
<td>2012</td>
<td>210</td>
</tr>
<tr>
<td>2001</td>
<td>751</td>
<td>2013</td>
<td>240</td>
</tr>
<tr>
<td>2002</td>
<td>200</td>
<td>2014</td>
<td>220</td>
</tr>
<tr>
<td>2003</td>
<td>1244</td>
<td>2015</td>
<td>200</td>
</tr>
<tr>
<td>2004</td>
<td>184</td>
<td>2016</td>
<td>2312</td>
</tr>
<tr>
<td>2005</td>
<td>2870</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: HMWSSB Reservoir Log Records – (2016)³⁴

V. WATER DEMAND

Monthly demands in the command area Osmansagar reservoirs and for the total Hyderabad Water Supply System were computed for 20 nodal demand centers based on the LPCD guidelines given by the CPHEEO, GoI. In the computation of the Demands, basis was considered as peoples access through service connection to the system, category wise consumption pattern such as domestic slum consumption pattern and quantities, domestic general, commercial, industrial, mobile supply etc in conformity with the approved norms of the applied system.

The demands for various categories of domestic slums, domestic general, commercial, industrial, mobile supply etc were show in Table-II for each month.

For the purpose of the present study, the Reservoir operation with node wise demands and releases are taken for monthly simulation.

VI. RESERVOIR OPERATION MODEL

Storage Continuity Equation:

\[ S_{t+1} = S_t + I_t - R_t - E_t - O_t \]

Capacity Constraints:

\[ S_{t+1} \leq S_{\text{Cap}} \]

Spill Constraints:

\[ \text{Spill}_t = S_{t+1} - S_{\text{Cap}} \]
\[ \text{Spill}_t \geq 0 \]

Release Constraints:

\[ R_t < D_t \]
\[ \text{Deficit} = D_t - R_t \]
\[ \text{Min Def} = \sum (D_t - R_t)^2 \]

Generally:

\[ R_t = f (S_t, I_t) \]

Any release of Reservoir is function of \( S_t \), \( I_t \). But it can also be operated as \( R_t \) is independent of \( I_t \).

The inflows were considered as deterministic as obtained from the measured records of the respective reservoirs. The operating policy derived from the crisp model is a set out of rules specifying the storage at the beginning of the next period for each combination of initial storage and inflow for the current period thus specifying the release for the current period.
The objective of the model is to obtain the release values as per the defined release policy based on the crisp concepts. The Model Release Curves are as below:-

![Model Release Curve](image)

**Fig.I – Model Release Curve.**

In figure-I the model releases based on the simulation are shown through graphical plots for Osmansagar reservoir are found to be satisfactory as per the historical operation.

In the second phase, the fuzzy model simulation was performed to derive the monthly operating policy using the storages, inflows, release values into fuzzy sets, fuzzy intervals with associated membership functions, fuzzy rules, fuzzy inferences and defuzzification for obtaining the file storages and release values. In the both model the evaporation equations were used in the storage continuity equation with the storage constraints, release constraints, demand constraints etc.

![Fuzzy Model Releases](image)

**Fig.II – Fuzzy Model Releases.**

In figure-II the graphical plots are based on the fuzzy model releases for Osmansagar reservoir which are found to be superior over the crisp model releases.

**VII. MODEL RESULTS**

**Table. III**

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Model Releases</th>
<th>Mean Value</th>
<th>Variance Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osmansagar</td>
<td>Crisp</td>
<td>2.3475</td>
<td>1.41742</td>
</tr>
<tr>
<td></td>
<td>Fuzzy</td>
<td>2.5358</td>
<td>1.62233</td>
</tr>
</tbody>
</table>

In Table-III the model releases statistical performance was evaluated through mean and variance values for Osmansagar reservoir which are found to be in order. The results are the research study outcome of authors.[9]

After evaluation, the monthly releases are recommended from the Fuzzy Model study to the supply nodes through integrated system along with the fixed releases as shown in the Table-IV as below.

**Table-IV**

<table>
<thead>
<tr>
<th>Month / Year</th>
<th>Osmansagar</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>3.52</td>
</tr>
<tr>
<td>February</td>
<td>3.3</td>
</tr>
<tr>
<td>March</td>
<td>3.52</td>
</tr>
<tr>
<td>April</td>
<td>3.41</td>
</tr>
<tr>
<td>May</td>
<td>3.52</td>
</tr>
<tr>
<td>June</td>
<td>3.41</td>
</tr>
<tr>
<td>July</td>
<td>3.52</td>
</tr>
<tr>
<td>August</td>
<td>3.52</td>
</tr>
<tr>
<td>September</td>
<td>3.41</td>
</tr>
<tr>
<td>October</td>
<td>3.52</td>
</tr>
<tr>
<td>November</td>
<td>3.41</td>
</tr>
<tr>
<td>December</td>
<td>3.52</td>
</tr>
</tbody>
</table>

**VIII. CONCLUSION**

The simulation model has been developed successfully. It was found that the developed model is working satisfactorily for reservoir operation by 8.02% increase in efficiency over conventional operation of reservoir system.

**Acknowledgement**

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**REFERENCES**


[8] Shrestha (1996), developed fuzzy relations for input and output of reservoir operating principles and defuzzified to get the crisp outputs.