REAL-TIME OPERATION OF RESERVOIRS

by

Dr. S.K. Jain,
Scientist E,
NIH, ROORKEE.

1.0 INTRODUCTION

Once the structured facilities like dams, barrages, which are required for utilization of water resources come into being, the benefits that could be reaped, depend to a large extent, upon how these facilities are managed. The efficient use of water resources requires not only judicious design but also proper management after construction. Reservoir operation is important part of planning and management of water resources systems. Once a reservoir has been developed, detailed guidelines have to be given to the operator which enable him to take decisions about storing or releasing water. For the existing reservoirs, better management means higher reservoir yield through improved operation rather than future expansion.

A reservoir operation policy specifies the rate of water releases to be made from the storage at any time depending upon the state of the reservoir, magnitude of demands and information about the likely inflow in the reservoir. A single purpose reservoir is constructed to serve only one purpose. The operation problem for such reservoir is to decide about the releases to be made from the reservoir so that the benefits for that purpose are maximized. For a multipurpose reservoir, it is also required to optimally allocate the release among various purposes.

While operating a multipurpose reservoir, conflicts arise among various uses. These conflicts are:

(a) Conflicts in space - When a reservoir (of limited storage) is required to satisfy divergent purposes, for example, water conservation and flood control.

(b) Conflicts in time - when the temporal use pattern of water varies with the purpose. The release for one purpose does not agree with the other purpose.

(c) Conflicts in discharge - The conflicts in daily discharge are experienced for a reservoir which serves more than one purpose.

1.1 CONVENTIONAL TECHNIQUES OF RESERVOIR OPERATION

The reservoirs are normally operated based on rule curves. A rule curve or rule level specifies the storage to be maintained in a reservoir during different times of the year. It is assumed that a reservoir can best satisfy its purposes if the storage levels specified by the rule curve are maintained in the reservoir at different times. The rule curve as such does not give the amount of water to be released from the reservoir.

The rule curves are generally derived by operation studies using historic or generated flows and implicitly reflect the established trade-off among various project objectives in the long run. The operation of a reservoir by strictly following the rule curves becomes quite rigid. Many times, in order to provide flexibility in operation, different rule curves are followed in different circumstances.

1.2 THE CONCEPT OF REAL-TIME RESERVOIR OPERATION

Generally, the reservoir operation rules are developed taking into account the demands of the past and using data from historical or synthetic time series of hydrological variables. But the probability that an actual event will occur in the same way as prior events of the same type is very small. A reservoir system can be efficiently operated if the time interval between the occurrence of an event and the execution of the control adapted for that event is short. In real-time operation, the release decisions are based on short term information.

The definition of short-term varies in accordance with the purpose of the reservoir. If the reservoir is operated for flood control, then short-term may refer to (multi)hourly operation and if the system is mainly for irrigation purpose, then the short-term may be a week or a month.

The term "Real-time" reservoir operation is used to denote that mode of operation in which the control decisions for a finite future time horizon are taken based on the condition of the system at that instant of time when these decisions are to be taken and the forecast about the likely inputs over this time horizon. After a known time interval the new information about the state of the system becomes available, the forecasts are updated and the control decisions are modified in light of these.

The real-time operation is especially suitable during floods where the catchment response changes very fast and decisions have to be taken quickly and adapted frequently. A model of the system is developed in which the release is a decision variable. A forecasting algorithm is used to provide inflow forecast for a finite number of future time periods based upon the present state of the system as well as its past behaviour. Using the information about the state of the system and forecast of inflows, the model is used to determine the optimum amount of water to be released from the reservoir so that the reservoir purpose are served. Although the optimum releases are determined for finite number of future time periods, they are implemented only for one immediately next time period. After this period, the next set of observations becomes available which is used to update the information about the state of the system. This entire process is repeated at end of each time interval.

2.0 LOGISTICAL REQUIREMENTS FOR REAL TIME OPERATION

A successful application of the real-time operation procedure requires a good telemetry system through which data can be observed on-line. The term "on-line" implies that the data are collected, transmitted, fed to a model, the model's output is obtained and used in one uninterrupted sequence of activities. Due to increasing prevalence of high capability and low cost process control computers, all this is technically and economically feasible.

A number of models for forecasting discharge based on the measured data and the models for determining optimal reservoir control using the forecasts of discharge are available and can be executed in sufficient short time.

2.1 Real-Time Hydrological Forecasting

Hydrological forecasting is one of the most important aspect of applied hydrology. The benefits from real-time operation of a reservoir can be substantially increased if good forecasts are available. The main components involved in the inflow forecasting are weather forecasting, rainfall runoff modeling and channel routing. For a forecast in proper time, the transmission of information and processing of data has to be done very quickly. This is possible only with the help of a computer.

Real-time flood forecasting involves the estimation of discharges in a river some period prior to it's occurrence. The forecast lead time proves useful in mitigating some of the adverse effects of flooding. The forecast lead time depends on catchment characteristics which affect the time taken by the catchment to transform the rainfall into the discharge at a point.

The need for on-line control arises where the response of the system to the application of control is quick and any delay in taking a decision may result in significant losses. This requirement arises during the operation of a reservoir for flood control where the decisions have to be implemented, evaluated and modified in quick succession. A number of models are available for forecasting of streamflow. Some of these are : SSARR (Streamflow Synthesis and Reservoir Regulation) model, HEC-1F, Stanford Watershed model, Sacramento model and NAM model.

2.2 DATA-ACQUISITION SYSTEM

Real-timely hydrological forecasting depends to a large extent, on the availability of hydrological/ hydrometeorological data at the forecasting station. A system of forecasting for real -time operation consists of :

i) Observation and collection of operational data at sites,
ii) Transmission of data to forecasting centre,

iii) Formation of forecast.

Various hydrological/hydrometeorological data acquisition systems in use in India are :

(i) Manual observation/transmission and forecasting

Rainfall data, river levels and flows are observed at fixed hours and are transmitted to the control room by P&T land line, telegrams, telex, or VHF/UHF voice transmission. Delay in data transmission due to bad weather or transmission link failure is likely.

(ii) Automatic sensing, transmission and computer system for forecasting

Specified river gauge, rainfall, temperature and other hydrological parameters are measured with automatic recorders and are transmitted with the help of repeater stations via VHF transmission. The master teleprocessor at the forecasting station coordinates the data collection and proper storage.

A sophisticated hydrological model and a fast computer system serve their useful purpose only if the data acquisition system is reliable and fast. The exchange of information between widely separated data collection centre and forecasting centre is called telemetry. In this system, usually no human element is involved and this completely eliminates the human error and reduces the time of observation and transmission of data.

3.0 SPECIAL CONSIDERATIONS IN REAL-TIME OPERATION

The necessity for real-time operation arises from the fact that the inflows to reservoirs are random in nature and uncertain. To know the actual inflows in the reservoir and to forecast future inflows, adequate data collection and transmission network is required. During the periods of high flows, operation of gates becomes an important aspect and needs to be given due consideration. In case, where it may not be possible to fully absorb the flood in the reservoir, efficient information dissemination system is required to warn the people downstream well in advance.

(a) Data Requirements

In addition to the data required for conventional reservoir operation methods, additional data is required for real time operation. To account for the current state of the system, present level of water in reservoir, level of demands for various uses, amount of inflow entering the reservoir is required. To account for the forecasting of future inflows, values of hydrometeorological/hydrological parameters in the catchment is required.

(b) Gate Operation

The operation of gates is an important aspect of real-time operation. The gates can be operated manually or mechanically. In the manual operation, the rate of opening is slow. The advantage of the mechanical system is that the gate operation is rapid and uniform rate of opening can be maintained. In real-time operation, if there are rapid variation of inflow or if some emergent situation arises, gates are operated frequently and the time taken for opening/closing of gates becomes an important parameter. Stand-by arrangements must be made for supply of electric power.

(c) Information dissemination

Whenever high outflow is likely to released from the dam, it is the duty of the in-charge of reservoir operation to intimate the situation to higher authorities. This information must also be communicated to civil authorities, revenue and panchayat authorities, police and general public for taking precautionary measures in respect of alerting and evacuating the people in the area likely to be affected.

To take full advantage of real-time operation, it is necessary that a good information dissemination system is available in the basin. In Real-time operation, advance information can be given about the likely outflow and if the public is informed in time, the flood damage can be significantly reduced.

4.0 ADVANTAGES OVER CONVENTIONAL METHODS

The advantages of real-time operation over the conventional methods are as follows:

(a) Real-Time operation is highly flexible in comparison to the conventional methods. It takes into account the current state of the system and forecast future inflows which are not considered in conventional methods. It is the most realistic operation for reservoirs as operation decisions are frequently updated with the availability of new information.

(b) In case of emergency such as floods, it gives high lead time to the authorities to take precautionary measures in respect of alerting and evacuating the area likely to be affected.

5.0 CONCLUSIONS

Due to increase in population and urbanization, the conservation demands as well as damage potential of floods are increasing day-by-day but it is not easy to create new reservoirs because of social and environmental ramifications. Therefore it is essential to operate the existing reservoirs as efficiently as possible. Real-time operation is an efficient way of operating a reservoir system in which the control decisions are taken on the basis of prevailing conditions of the system and the forecast about the likely inflow in the reservoir. For real time operation of a reservoir, automatic telemetry system is essential for direct transmission of data at regular interval to the forecasting station from where the forecasts are issued. This hydrological forecasting is used as an input in the operation model to find the optimized value of release from the reservoir.

A lot of work on real-time operation is going on and effects are on to develop models which require lesser memory space and lesser computational time. Computation time is an important aspect in real-time operation as the 'lead time' of a forecast is affected by it. A number of models using different optimization techniques like linear programming, dynamic programming and goal programming have been developed and applied to various real life problems in form of case studies.

Due to the increasing prevalence of high capability and low cost computers with telemetry networks and remote control features, the hardware required for this purpose is easily available. A considerable amount of software is also available. Using this, a number of decision support systems have also been developed which can assist the operator in making better decisions.

***