DEVELOPMENT OF CONTROL STRATEGIES FOR WATER LEVEL CONTROL OF A FORE BAY FED BY AN OPEN CHANNEL

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Open channel-reservoir systems are used in many engineering applications such as hydropower houses, water treatment plants and irrigation canal systems. In this paper development of automatic level control strategies for a particular system of open channel-fore bay system is discussed. The open channel is used to transport water from a reservoir to a fore bay, which supplies water demands of a mini-hydro scheme, a water treatment plant and of irrigation. The key problem address by this study is that how to regulate the water level of a very small fore bay while it supplies large and varying demands of flow. An increment of flow demand caused by a generator switching ON can empty the fore bay unless outflow rate from the channel increases within a short time. On the other hand a decrement of flow caused by a sudden generator tripping OFF can lead to waste water by overflowing the fore bay unless outflow rate of the channel decreases with a short period.

To overcome the difficulties encountered in experimenting with real systems for tuning of controllers and testing various control strategies an open channel simulator based on numerical solutions to well-known St.Venant equations was developed assuming a gradually varied flow region.

From the simulation investigations of the physical system concerned the strong dependence of water level regulation of the fore bay on the flow control of the open channel was established and the primary importance of fast flow control capabilities were identified. In controlling the water level of the fore bay by manipulating the inflow to the channel at its upstream end, predictive controllers are preferable due to the time delay of the channel flow transportation. Predictive flow controllers based on Smith predictor structure were designed using simple PI architecture and coefficient diagram (CDM) techniques using the first and second order linear models derived from the data generated from the channel simulator. The inefficiencies of linear modeling of the nonlinear system and variable nature of dead time of the system set limitations on the tuning of above controllers in achieving fast response.

Hence a novel rule-based flow controller was designed based on the basic mechanism (predictor plus complementary feedback controller) of the Smith predictor. The predictor of the new controller was designed to generate control actions, which operate mostly in the actuator saturation limits. Therefore the system response approaches near optimal pattern in terms of speed and settling. The design of the rule-based controller is viable on the assumption that set point changes and disturbances to the flow controller can well be modeled by long-lasting steps. Under the assumed conditions the novel rule-based controller has proved superior in performance to other linear controllers.

The final water level control was achieved by using the open channel flow control system combined by disturbance estimator. It was found that the strong disturbances created by generator switching ON/OFF cannot be rejected by any feedback controller alone due to large dead time of the open channel as well as the limited capacity of the fore bay. It is shown that if the disturbances of the prescheduled generator switching ON are known and fed into the control systems they can regulate the fore bay water level better.

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