SIMULATION AND CONTROL OF OPEN CHANNEL FLOW IN A MINI HYDRO POWER STATION

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Open channels are used to transport water from reservoir to fore bay of many mini hydro power plants. The control of the water level of the fore bay at the downstream end of the channel is essential to satisfy the proper functioning of the power plant. In controlling the water level by manipulating the inflow to the channel at its upstream end, the time delay of the channel flow transportation must be taken into account. Predictive control strategies are usually used to control processes with time delays. However, developments of such control strategies demand the knowledge of the process dynamics, and furthermore, it is required to carryout extensive test runs with the real system. To overcome the difficulties encountered in experimenting with real systems for tuning of controllers and testing various control strategies, as the first phase, an open channel simulator was designed and tested.

In developing the channel simulator, the flow behavior of the open channel was assumed to be in the gradually varied flow region, and therefore, well-known St. Venant equations were used to describe the flow behavior. To achieve a better stability in solution of the equations, method of characteristics was used for solving St. Venant equations. When schemes proposed by early literature were studied, it was understood that some modifications had to be made to adapt them for a channel simulator. Instead of a hydraulic jump at upstream end, the inflow rate itself to the channel from the sluice opening was used as the upstream boundary condition. Since the high rate of change of inflow rates can cause surges, which is outside the bounds of gradually varied flow region, a constraint had to be imposed on the rate of change of inflow rate to the channel. This really refers to one of the significant limitations of the channel simulator, but on the other hand, when we consider the limitations of the rate of opening of the sluice gate, this may be a natural limitation of the real system. The entire simulation is carried out in Matlab 6.0 environment. The program is structured in multi-functional form and they interact to form the final simulator.

A simple Smith predictor controller was designed to control the water flow rate at the downstream end of the channel, considering a linear model of the channel flow response at the downstream end derived from the channel simulator results for a nominal operating inflow. The open loop time constant of the flow response at the end of the channel is approximately 30 minutes for a nominal flow rate of 30 cubic feet per second, and when the Smith predictor based controller is used the time constant dropped to about 18 minutes. Furthermore as a result of the controller, the channel delay reduced from 17 to 14 minutes. The simulation results are to be validated by comparison with hydrograph data collected from the field.

This simulator can now be used to design and test various other controllers in simulation level, and development of more complex controllers to improve the flow response and the control of water level of the fore bay is underway.

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