European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)

International Conference on Renewable Energies and Power Quality (ICREPQ'10)
Granada (Spain), 23rd to 25th March, 2010

A control system for low-head diversion run-of-river small hydro plants with pressure conduits considering the tailwater level variation

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Extended abstract

This paper presents a control system for low-head diversion run-of-river small hydro plants with pressure conduits. Since these hydropower plants usually have lower or null water storage capacity, the water discharged through the turbines is adapted to the possible extent to the natural river inflow. For this purpose, a control scheme aimed at maintaining a constant water level in the head pond is normally used in these cases. As an alternative, a control system aimed at maintaining a constant water level in the surge tank is proposed in this paper.

With respect to more frequently used schemes, this control system may introduce some improvements in the dynamic response, since the intermediate elements between the controlled and control variables have been removed from the first control loop. Additionally, the distance to the water level transducer is shorter, thus eliminating the need for long distance signal transmission.

The proposed control system is structured in two different control loops. The first one is a closed PI control loop aimed at maintaining a constant water level in the surge tank by continuously adjusting the wicket gate position. The second one is an open control loop aimed at restoring the head that could have varied as a consequence of the action of the first loop. This task is done by readjusting the reference level of the first loop once the dynamics associated to the first control loop is practically extinguished. To avoid undesirable effects due to dynamic coupling between the two control loops, the change in reference level is carried out by means of a slow ramp, thus allowing the first loop to follow the change in the smoothest way possible.

Since the plant is operating in a near steady state, the updated surge tank reference level is deduced from the wicket gates position, the use of a flowmeter being not necessary.

A small-perturbation stability analysis has been carried out in order to analyze the influence of the plant design and controller parameters in the plant dynamic response. By applying the Routh-Hurwitz stability criterion to the linearized system, an analytical expression for the system stability region in terms of the controller parameters has been obtained.

Finally, in order to illustrate the applicability of the proposed control system, it has been applied in a hydro power plant, which is in the planning stage, by means of simulations.

The plant stability region has proved to be considerably larger than those obtained in previous studies for a more conventional case of head pond water level control, thus compromising the surge tank design to a lesser extent.

The controller parameters have been adjusted by means of a heuristic criterion based on the root locus method.

From the simulation results, it can be stated that the proposed control system manages to follow the changes in river flow in a stable way and make the best possible use of the available water resources.

The results of this study could be used as a support tool to make decisions about certain design parameters of several plant components such as the tailrace, surge tank and head pond areas and about the tuning of the controller parameters.