Renewable Energy and Power Quality Journal (RE&PQJ), ISSN 2172-038 X, No.9, 12th May 2011, Reference Paper: 643

COMPARISON IN THE APLICATION OF THE EXPLOITATION BY OPTIMAL HEAD MODEL TO HYDROELECTRIC POWER STATIONS IN RUN-OF-THE-RIVER SYSTEMS EQUIPPED WITH DIFFERENT TYPES OF TURBINES

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Abstract

Hydroelectric power plants in diversion scheme systems utilize the water flowing through the river, since they present the necessary facilities and infrastructures to channel and harness the water, without having in their initial conception any storage systems.

This type of power stations are designed and automated to operate between certain limits of water head, working with "constant head", using the heads available at any moment. The operating limits are determined by the "nominal flow" for which the power plant has been designed and the "minimal technical flow" which corresponds to the minimum value of the flow with which the plant can work, which depends on each type of turbine.

By means of the presented optimization algorithms we can take advantage of those periods of time with low levels of flow (low water levels) to utilize the channels in the power station as storage elements of flow under the technical minimum, making the power plant undergo sequential cycles of emptying/filling of channels, allowing for the energetic exploitation, that will be denoted as "optimal flow".

In this article, we intend to determine how we can adapt each type of turbine to the new optimization algorithms proposed, establishing the increments in production obtained for each type of turbine and the possibility of applying the "optimal flow" algorithms.

Key words

Renewable energies, hydroelectric power plants, optimisation, Automation, Regulation.

Optimization model

The turbines represent the limiting factor of operation of the hydroelectric plants, since their limitations are determined by the maximum operating flow (flow of equipment) and a minimum flow that is limited by a minimum value of the turbine performance, 70%. The flows that set the minimum vary between 10%, 25% and 40% of rate of plant equipment, depending on the type of turbine used.

In the figure below, the curves for various types of hydraulic turbines can be observed, which, in the case of Pelton turbine, the technical minimum is at about 10% of the nominal flow, while for the Francis turbine the technical minimum flow is about 40% of the nominal flow.

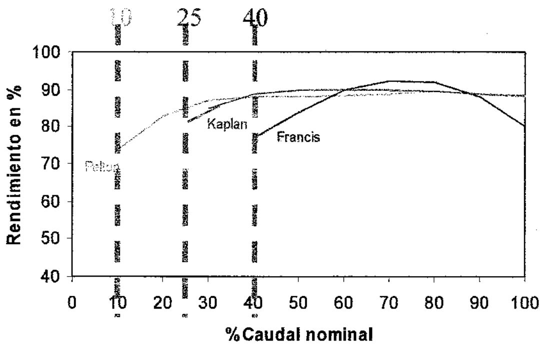

Fig. 1 Performance characteristic of different turbine types, applied the technical minimum flow.

For the range of flow rates of the turbines, the energy use obtained is:

$$E = \int_T Pa \cdot dt$$

Fig. Performance characteristic of different turbine flow applied technical minimum.

Where the power (Pa) can be obtained depending on the head (Hn) and flow (Q) parameters.

$$Pa = Q \cdot \rho \cdot g \cdot Hn \cdot \eta t$$

Expression in which the head is considered constant. Moreover, the average performance at this stage of calculation can be estimated at around 80%; thus, the above expression yields: