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Laboratory results on the effect of channel geometry on a Rotary Hydraulic Pressure Machine

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Thanks to the international efforts to promote the use of renewable sources, hydropower is experimenting new interest by companies and research centers. However, most of the sites suitable for large hydroelectric plants, in Europe, have already been exploited. Instead sites with very low head differences are widely spread in rivers and canals and there is a great hydro potential yet to be exploited. In order to promote the installation of micro-hydro plants, new technologies are being developed with the aim of installing environmentally friendly and efficient turbines. In recent years, in order to propose an efficient and economical alternative to the traditional wheels for very low head (VLH) differences (i.e. the Sagebien wheel and the Zuippinger wheel), the hydrostatic pressure machine (HPM) that applies the hydrostatic pressure conversion has been proposed (e.g. Senior et al. 2007). For this machine the VLH is generated by the wheel, so that this machine can be installed in straight canals. The geometry of the wheel is designed to be economical, to allow the sediment passage and to permit downstream passage of fish.
In this work, the laboratory results carried out at the Politecnico di Torino on a scaled model are shown. The laboratory tests were aimed to examine mainly three aspects that may impact the efficiency of the RHPM: the canal width compared to that of the wheel, the lateral position of the turbine into the canal (as the blades are diagonal the wheel is not symmetric) and the effects of the water surface levels upstream and downstream the wheel.
The results of the laboratory tests can be useful for practical applications and can be so resumed:
1) the wheel has a higher efficiency for low rotational speed and therefore with the increase of the wheel size for a given discharge. The chosen size of the wheel will be the largest one consistent with the dimension of the channel and with the gearbox (whose efficiency decreases with the increase of the multiplication ratio and can reduce the benefits of the increased wheel).
2) The wheel behaviour is largely influenced by the lateral entry/exit of the water on/from the blade that is conditioned by the channel walls proximity to the wheel. Given the diagonal shape of the blade, the impact of the left and right channel walls is not the same. It resulted that a better efficiency is reached when the distance between the wheel and the channel wall at the side where the water laterally enters into the blade is greater than 0.3 times the width of the wheel.
3) Dealing with water surface levels there is a benefit for both the efficiency and the output power, when the level upstream the wheel increases above the hub, even in spite of the emergence of a counterforce.

Short references

J. A. Senior, G. Muller, and P. Wiemann, “The development of the rotary hydraulic pressure machine,” in PROCEEDINGS OF THE CONGRESS-INTERNATIONAL ASSOCIATION FOR HYDRAULIC RESEARCH, 2007, vol. 32, p. 709.