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Design and Optimization of a Small Hydraulic Propeller Turbine

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Abstract : A design and optimization procedure is proposed and developed to provide the geometry of a high efficiency compact hydraulic propeller turbine for low head. For the preliminary design of the machine, classic design criteria, based on the use of statistical correlations for the definition of the fundamental geometric parameters and the blade shapes are used. These relationships are based on the fundamental design parameters (i.e., specific speed, flow coefficient, work coefficient) in order to provide a simple yet reliable procedure. Particular attention is paid, since from the initial steps, on the correct conformation of the meridional channel and on the correct arrangement of the blade rows. The preliminary geometry thus obtained is used as a starting point for the hydrodynamic optimization procedure, carried out using a CFD calculation software coupled with a genetic algorithm that generates and updates a large database of turbine geometries. The optimization process is performed using a commercial approach that solves the turbulent Navier Stokes equations (RANS) by exploiting the axial-symmetric geometry of the machine. The geometries generated within the database are therefore calculated in order to determine the corresponding overall performance. In order to speed up the optimization calculation, an artificial neural network (ANN) based on the use of an objective function is employed. The procedure was applied for the specific case of a propeller turbine with an innovative design of a modular type, specific for applications characterized by very low heads. The procedure is tested in order to verify its validity and the ability to automatically obtain the targeted net head and the maximum for the total to total internal efficiency.

Keywords : renewable energy conversion, hydraulic turbines, low head hydraulic energy, optimization design
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