AERODYNAMIC DESIGN OF RADIAL INFLOW TURBINE FOR MEDIUM SCALE ORGANIC RANKINE CYCLE SYSTEM

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ABSTRACT

The Organic Rankine Cycle (ORC) has been considered to be the most feasible technology among the existing approaches to convert low grade heat source (such as geothermal energy) and industrial waste heat into electricity. For a medium scale ORC system with a general power range of 50kW to 500kW, radial inflow turbines, with low mass flow rate and high pressure ratio, are applied more often than other types of turbines, because they are more efficient, adaptable, stable and cost-effective. When developing such a turbine, aerodynamic design is a step of vital importance. This paper presents a complete aerodynamic design process of a 100kW radial inflow turbine, including preliminary design, three dimensional modelling of blades and volute, and three dimensional numerical simulation. The preliminary design is carried out by using ANSYS RTD which can efficiently generate an optimal solution whilst fixing the mass flow rate, the pressure ratio and the blade speed ratio. Then, based on the preliminary design results, the cascade shape modelling of stator and rotor is conducted through in-house code and ANSYS BladeGen respectively. Following that, the three dimensional modelling of stator and rotor is conducted by stacking the cascades along a specified line. The volute is defined by a series of radial circular sections on the periphery of the turbine and the radii of the sections are obtained through the free vortex theory. ANSYS DesignModeler is used to perform three dimensional modelling of the volute. Finally, three dimensional numerical simulation of the radial inflow turbine is carried out by employing ANSYS TurboGrid, ICEM and CFX, where the R245fa is used as the working fluid. Detailed analyses of the flow field across the turbine stage and the volute are presented and the performance assessment of the turbine in terms of efficiency, blade speed ratio and mass flow rate is illustrated.