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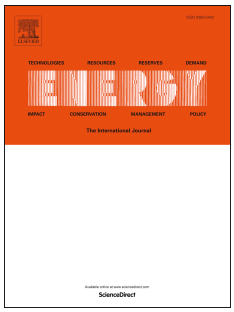

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Impact of Shape-Optimization on the Unsteady Aerodynamics and Performance of a Centrifugal Turbine for ORC applications

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Abstract

This paper presents the results of the application of a shape-optimization technique to the design of the stator and the rotor of a centrifugal turbine conceived for Organic Rankine Cycle (ORC) applications. Centrifugal turbines have the potential to compete with axial or radial-inflow turbines in a relevant range of applications, and are now receiving scientific as well as industrial recognition. However, the non-conventional character of the centrifugal turbine layout, combined with the typical effects induced by the use of organic fluids, leads to challenging design difficulties. For this reason, the design of optimal blades for centrifugal ORC turbines demands the application of high-fidelity computational tools. In this work, the optimal aerodynamic design is achieved by applying a non-intrusive, gradient-free, CFD-based method implemented in the in-house software FORMA (Fluid-dynamic OptimizeR for turboMachinery Aerofoils), specifically developed for the shape optimization of turbomachinery profiles. FORMA was applied to optimize the shape of the stator and the rotor of a transonic centrifugal turbine stage, which exhibits a significant radial effect, high aerodynamic loading, and severe non-ideal gas effects. The optimization of the single blade rows allows improving considerably the stage performance, with respect to a baseline geometric configuration constructed with classical aerodynamic methods. Furthermore, time-resolved simulations of the coupled stator-rotor configuration shows that the optimization allows to reduce considerably the unsteady stator-rotor interaction and, thus, the aerodynamic forcing acting on the blades.

Keywords: Centrifugal turbine; ORC power systems; shape-optimization; evolutionary algorithm; stator-rotor interaction; aerodynamic forcing

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