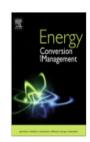


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## Three dimensional optimization of small-scale axial turbine for low temperature heat source driven organic Rankine cycle



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## ABSTRACT

Advances in optimization techniques can be used to enhance the performance of turbines in various applications. However, limited work has been reported on using such optimization techniques to develop small-scale turbines for organic Rankine cycles. This paper investigates the use of multi-objective genetic algorithm to optimize the stage geometry of a small-axial subsonic turbine. This optimization is integrated with organic Rankine cycle analysis using wide range of high density organic working fluids like R123, R134a, R141b, R152a, R245fa and isobutane suitable for low temperature heat sources <100 °C such as solar energy to achieve the best turbine design and highest organic Rankine cycle efficiency. The isentropic efficiency of the turbine in most of the reported organic Rankine cycle studies was assumed constant, while the current work allows the turbine isentropic efficiency to change (dynamic value) with both operating conditions and working fluids. Three-dimensional computational fluid dynamics analysis and multi-objective genetic algorithm optimization were performed using three-dimensional Reynolds-averaged Navier-Stokes equations with k-omega shear stress transport turbulence model in ANSYSR17-CFX and design exploration for various working fluids. The optimization was carried out using eight design parameters for the turbine stage geometry optimization including stator and rotor number of blades, rotor leading edge beta angle, trailing edge beta angle, stagger angle, throat width, trailing half wedge angle and shroud tip clearance. Results showed that using working fluid R123 for a turbine with mean diameter of 70 mm, the maximum isentropic efficiency was about 88% and power output of 6.3 kW leading to cycle thermal efficiency of 10.5% showing an enhancement of 14.08% compared to the baseline design. Such results highlight the potential of the 3D optimization technique to improve the organic Rankine cycle performance.

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