Organic Rankine cycle (ORC) power systems have recently emerged as promising solutions for waste heat recovery in low- and medium-size power plants. Their performance and economic feasibility strongly depend on the expander. The design process and efficiency estimation are particularly challenging due to the peculiar physical properties of the working fluid and the gas-dynamic phenomena occurring in the machine. Unlike steam Rankine and Brayton engines, organic Rankine cycle expanders combine small enthalpy drops with large expansion ratios. These features yield turbine designs with few highly-loaded stages in supersonic flow regimes. Part A of this two-part paper has presented the implementation and validation of the simulation tool TURAX, which provides the optimal preliminary design of single-stage axial-flow turbines. The authors have also presented a sensitivity analysis on the decision variables affecting the turbine design. Part B of this two-part paper presents the first application of a design method where the thermodynamic cycle optimization is combined with calculations of the maximum expander performance using the mean-line design tool described in part A. The high computational cost of the turbine optimization is tackled by building a model which gives the optimal preliminary design of an axial-flow turbine as a function of the cycle conditions. This allows for estimating the optimal expander performance for each operating condition of interest. The test case is the preliminary design of an organic Rankine cycle turbogenerator to increase the overall energy efficiency of an offshore platform. For an increase in expander pressure ratio from 10 to 35, the results indicate up to 10% point reduction in expander performance. This corresponds to a relative reduction in net power output of 8.3% compared to the case when the turbine efficiency is assumed to be 80%. This work also demonstrates that this approach can support the plant designer in the selection of the optimal size of the organic Rankine cycle unit when multiple exhaust gas streams are available.
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