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Summary of doctoral thesis

„ Multi-criteria efficiency optimization of heat turbine flow systems using hybrid algorithms”

Over the past few years, low-power thermal cycles have become the subject of intensive research, due to the global trend of energy transformation towards greener sources, as well as in pursuit of overall energy efficiency improvement. In addition to the small thermal power plants using the Rankine and Brayton cycles, the so-called ORC (Organic Rankine Cycle) units have become a particularly promising technology for utilization of small heat sources.

ORC technology is used to produce electricity and heat from local low and medium temperature sources. The heat sources for ORC can be geothermal sources, solar energy, heat from biomass combustion, waste heat from technological processes, combustion engines and gas turbines. Nowadays, due to the high potential of ORC technology, its dynamic development is recorded. This applies to many aspects of ORC power plant operation, and practically to all its components, including heat exchangers, circulation pump and the heart of the whole system - turbine.

In flow of a working medium through a turbine, including an ORC turbine, a number of loss components prevent the complete conversion of thermal energy into mechanical energy. The dissertation is concerned with numerical optimization supporting the process of designing the flow systems for ORC turbines. A mathematical model of flow based on the RANS method and taking into account the real properties of the working media used in ORC systems is discussed. Most frequently used state equations to describe the properties of ORC working media are presented.

Optimization of turbine flowpaths requires the use of modern optimization methods that allow reducing the time needed for the whole optimization process. A number of optimization methods are used in this work, starting from deterministic through stochastic and ending with hybrid methods. As a result of hybridization, i.e. combination of several algorithms, effective

optimization methods are obtained. The final effect of optimization depends not only on the optimization algorithm, but also on a correctly defined description of the optimized geometry. During the research, a number of polynomial curves are used to describe the flowpath geometry of axial and radial inflow turbines.

The results of optimization of four blading systems of heat turbines designed to operate in ORC units are described in the dissertation. The presented approach allowed us to achieve measurable benefits in the form of reduced flow losses, and consequently an improved efficiency of the flow system

Experimental validation of the computational method for two ORC turbine flow systems working on different media is also carried out. A satisfactory convergence between numerical and experimental results is reported.