Summary of the doctoral thesis

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Title: Numerical analysis of a scroll machine working chamber thermal-flow processes including the influence of a flank leakage on the heat transfer coefficient.

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A working gas thermodynamic processes in the power range up to 100 kW is mainly a field of positive displacement machinery like a scroll machine. Used as both – compressor (in HVAC) and expander (micro ORC, pneumatic engines) scroll machines have the design and the working principle which provide excellent heat transfer conditions for the working medium. Intense cooling of the machine elements results in the increase of thermodynamic process isothermal efficiency thus provides high reliability.

A possible heat transfer rate was investigated based on a case where the scroll wraps temperature is maintained constant and equal to the suction gas temperature. A numerical model was developed. It consisted a transient continuity, momentum and energy equations solved by using the Finite Volume method on a deforming numerical grid. The model took into account: flank gas leakage and wall heat transfer. The influence of a shaft rotational speed, working chamber geometry, discharge pressure and working medium was tested in numerical simulations in three variants: fully adiabatic, with one vane isothermal and two isothermal vanes. The analysis revealed flow patterns influencing the heat transfer rate.

Based on the scroll compressor model a general formula for the heat transfer coefficient was proposed. Unfortunately an experimental validation of the heat transfer model is impossible due to the process rapidity and working chambers geometry change. A solution was to build an experimental setup which simulates instantaneous geometry, motion and thermodynamic parameters of a scroll device working chamber in stationary conditions. The equivalent working chamber was formed between the circular cylinder and an eliptic stirrer rotating axially inside. The gas was heated by an electric coil. The cylinders wall was maintained at constant temperature of $11\ ^{\circ}C$ using a water jacket. Numerical modelling of the experimental stand proved that the flow pattern from original machine was imprinted in a satisfactory manner.

The test stand was built and tested in the laboratory. Experiments were made for a range of working pressures $1 \div 5\ bar$ (air and carbon dioxide), rotational speeds $1200\ \div 3000\ obr/min$, with a heat source up to $75\ W$. The cylinder wall and a gas inside temperatures were measured as well as a heat flux in the radial direction. These validated the numerical test stand model successfully.

In the paper the numerical model of a scroll positive displacement machine was proposed and verified. It was proven that the flank leakage in the working chambers affect the mass balance, flow field and thus the heat transfer conditions.