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Streszczenie pracy doktorskiej mgr. inż. Filipa Wasilczuka pod tytułem:

Fluidic Control of Shroud Leakage Flow in Gas Turbine

(Polski: Zastosowanie Strugi do Redukcji Przepływu w Uszczelnieniu Nadłopatkowym Turbiny Gazowej)

This thesis presents a study of a novel method of reducing the leakage flow in the labyrinth seal of a gas turbine. The air curtain technique uses the essence of labyrinth seal flow, the pressure-drop on the fins, to generate high velocity jets, injected into the clearance above the fins. This is done using the bypass slots in the fins. The jets block the flow in the gap and increase the kinetic energy dissipation by generating additional streamwise vortex structures in the seal. This research is a proof of concept study for a novel configuration, thus extensive preliminary study on the basic principles of the flow through the labyrinth seal was conducted. The preliminary study gave an insight into the flow, allowing the author to investigate means of enhancing air curtain performance. Additionally, it showed what simplifications can be introduced to the configuration to create a reasonably accurate model of the labyrinth seal flow for experimental and numerical investigation. Moreover, tests on possible locations of the air curtain and a parametric study of the slot dimensions were performed. A test rig for measuring the leakage flow and the pressure distribution in various configurations of the labyrinth seal was designed. Finally, the impact of the air curtain on the labyrinth seal flow in the framework of the turbine stage was studied numerically.

The measurements proved air curtain effectiveness for a wide range of flow conditions. The leakage reduction depends on the size of the gap. For the lowest gap size, the leakage reduction was up to 8%, while for the highest it reached 16% for the largest gap height. In addition to the measurements, RANS and LES simulations were conducted. This allowed an insight into the flow structure, revealing the complex vortex structure resulting from the introduction of jets into the flow. Additional streamwise vortices are generated due to the presence of the air curtain jet. A more complex vortex structure increases kinetic energy dissipation, leading to higher effectiveness of the sealing. Based on LES simulations, kinetic energy spectra were created. They confirm the increase of turbulent kinetic energy in the air curtain case.

In the turbine stage configuration, the air curtain also leads to a reduction in seal leakage, in addition to an increase in generated power as well as stage efficiency improvement. The flow structure for the turbine stage configuration was also presented and compared with the flow structure in the experimental configuration.