Karlsruher Institut für Technologie

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Master thesis-numerical

CFD modeling of non-equilibrium condensation in supersonic steam nozzles

Background:

Formation of liquid droplets as a result of condensation in high-velocity fluid flows is an important phenomenon with application in steam turbines and other types of expansion devices. When the velocity is high, the condensation does not obey the classical thermodynamics, which is based on the equilibrium assumption. As a result, droplets can form later but with a greater rate compared to what classical thermodynamics suggests. This can lead to a very dynamic and multi-physical process. Computational Fluid Dynamics (CFD) along with so-called nucleation theories are widely used for the prediction of this phenomenon in steam turbines and other similar devices. Since condensation can significantly influence the 2^{nd} law efficiency as well as the longevity of the turbines, its accurate prediction is of great practical importance, which calls for robust and reliable CFD solvers.

Content of the thesis:

The final goal of this thesis will be prediction of non-equilibrium condensation in supersonic convergent-divergent nozzles. Well-established experimental data are available for a number of geometries, which will be used for the validation of the CFD results. As the first step, the nozzle geometries and computational grids must be generated using the commercial software ICEM-CFD. The compressible CFD code – SPARC – will be used for the Eulerian-Lagrangian simulation of the flow field. It will be followed by the validation of the solution against experimental data and physical interpretation of the results.

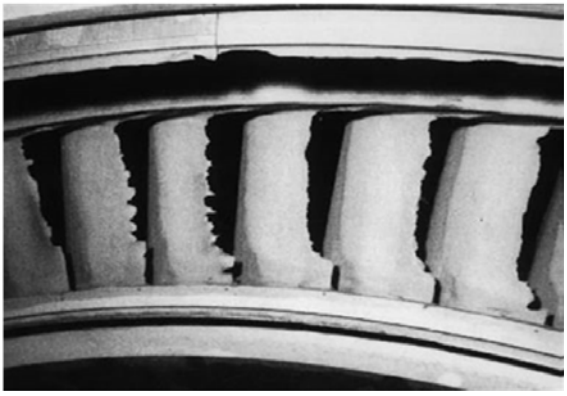

Figure 1. Erosion of a steam turbine's blades due to the impact of water droplets. Picture from Martinez et al., Energy & Power Engineering 4 (2012).

Requirements:

Fair knowledge of fluid mechanics and thermodynamics

Beneficial Skills:

Some knowledge of CFD and gas dynamics

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