qualification of helium flow cooling concept.

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Goal

For a high-tech project from one of our clients, a conduction cooling concept based on helium flow was considered. The suitability and performance of this method needed to be verified using numerical analysis and experiments to qualify the concept.

Challenging aspects for modelling of this cooling concept are the high mass flow rate through a small channel with large heat fluxes and uncertainty in the wall roughness parameters.

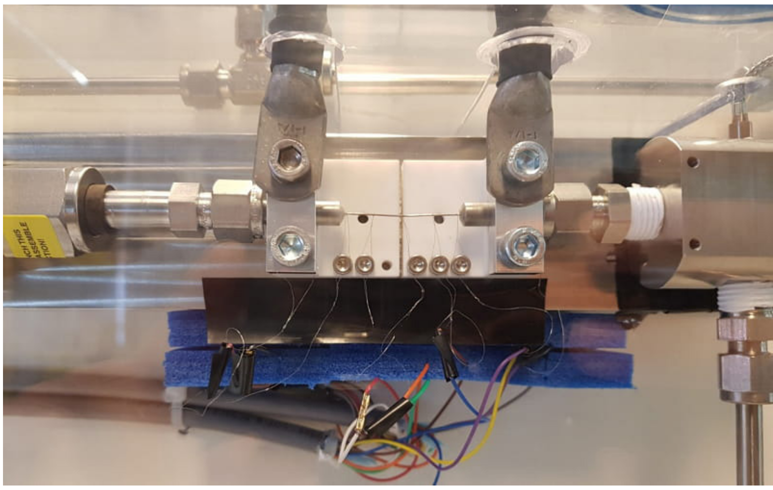

Figure 1. Experimental setup.

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Approach

The experimental setup (Fig.1) consisted of a heat flux applied to a single channel using joule heating (resistive heating by the use of a high electric current over the channel which is used as the conductor). A high flowrate helium flow was directed through the channel driven by a high pressure difference, $\Delta p > 50$ bar.

The flow temperature was measured on both sides of the test channel to determine the heat transfer coefficient. A variety of flowrates and heat fluxes were tested. The results of these experiments were used to refine the parameters used in the CFD model until good agreement was found between the two approaches.

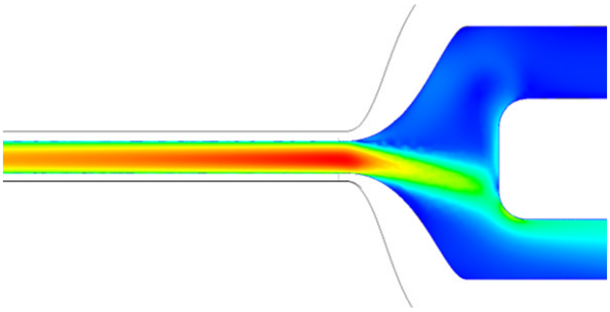

Figure 2. CFD model.

Results

The experimental results and the numerical calculations demonstrated that helium flow cooling is a suitable method for cooling a workpiece in this high-tech project. Fig. 3 shows the results of the experiments and CFD simulations, together with literature values (Norris and Gnielinski).

Further design optimization could be performed by virtual prototyping using numerical simulations (CFD simulations). The expected large influence of the surface roughness on the pressure drop and heat transfer coefficient was confirmed.

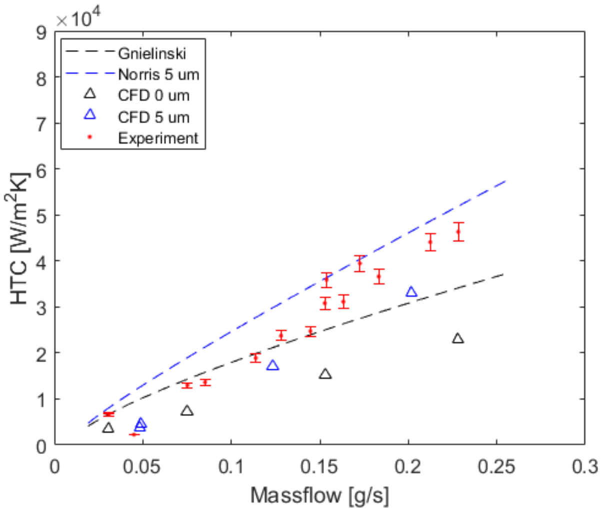

Figure 3. Heat transfer coefficient (HTC) versus mass flow, according to literature, experiments and CFD simulations.