Proper design of high performance industrial heat transfer equipment relies on accurate knowledge and prediction of the thermal boundary conditions. In order to enhance the overall gas turbine efficiency, advancements in cooling technology for gas turbines and related applications are continuously investigated to increase the turbine inlet temperature without compromising the durability of the materials used.

Numerical predictions using a computational fluid dynamics approach with popular turbulence models are benchmarked against a semi-empirical correlation for bulk heat transfer and friction in a circular channel with repeated-rib roughness to demonstrate some shortcomings of the models used. For more detailed design, local distributions are needed in addition to bulk quantities. Detailed local distributions require advanced experimental techniques whereas they are readily available using numerical tools. An experimental setup was developed, capable of measuring the local heat transfer distributions on all four channel walls of a rectangular channel (with aspect ratios between 1 and 5) at Reynolds numbers up to 150,000. The setup utilizes transient thermochromic liquid crystals technique using narrow band crystals and a four camera setup.

Using the transient thermochromic liquid crystals technique and applying it underneath high conductivity, metallic surface features, it is possible to calculate the heat transfer coefficient using a lumped heat capacitance approach. The enhanced lumped capacitance model is used to account for heat conduction into the substrate material. An exact, closed-form analytical solution to the enhanced lumped capacitance model is derived. The temperature evolution in a representative 2D turbulated surface is simulated using Fluent to validate the model and its exact solution. Traditional transient thermochromic liquid crystals technique utilizes the time-to-arrival of the peak intensity of the green color signal. The technique has been extended to utilize both the red and green color signals, increasing the throughput by recovering unused data while also allowing for a reduction in the experimental uncertainty of the calculated heat transfer coefficient.