Contribution ID: **7** Type: **Oral**

Multi-jet Gas Cooling of In-beam Foils or Specimens: CFD Predictions of the Convective Heat-transfer Coefficient (LA-UR-18-27366)

Thursday, 11 October 2018 16:10 (20 minutes)

Metallic foils are often employed as windows for gas and liquid targets. They are also used to isolate the beamline vacuum from target materials at accelerator facilities. These beam exit windows normally consist of two closely spaced foils through which a high flow-rate gas is circulated to remove the heat induced by the beam. Helium-cooled Havar windows are popular in radionuclide production applications as these foils have excellent mechanical strength even at elevated temperatures and can be thin enough to cause minimal energy degradation to the beam.

At the 2016 INTDS Conference, we presented a paper on single-jet gas cooling of beam windows [1] in which we pointed out that certain empirical relations based on dimensional analysis have good predictive power. In addition, more advanced modelling based on computational fluid dynamics (CFD) proved useful to gain a better understanding of the turbulence and heat transfer inside such window assemblies. We also presented an experimental set-up designed to measure convective heat-transfer coefficients with a single gas jet. We also had in our possession a set of measured data for multi-jet impingement heat transfer, which we did not present because we did not know how to interpret those results at that time. We are now in a better position to present that work as well as corresponding CFD simulations to assist with the interpretation.

One reason why we struggled to understand multi-jet cooling was because we tried to implement a strategy based on correlations between dimensionless hydrodynamic quantities and geometric ratios, which worked well in the case of single jets. This was attempted for multi-jet heat transfer by many authors over the years, with limited success. In 1970, however, a seminal study [2] concluded that power functions of dimensionless parameters cannot be correlated with experimental results in the case of multi-jet heat transfer. We now know that even decades after that enlightening publication, various groups still tried.

In this presentation, we will discuss various aspects of multi-jet gas cooling and present our own results on this topic for the first time.

[1] G.F. Steyn, C. Vermeulen, Single-jet gas cooling of in-beam foils or specimens: Prediction of the convective heat-transfer coefficient. AIP Conf. Proc. 1962 (2018) 030020.

[2] D.M. Kercher, W. Tabakoff, Heat transfer by a square array of round air jets impinging perpendicular to a flat surface including the effect of spent air. J. Eng. Power 92 (1970) 73–82.

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Session Classification: Session 5-Targets for High Intensity Beams

Track Classification: 5 - Targets for high intensity beams