Development of webcam-based near-infrared thermography in support of high temperature heat pipe experiments on Magnum PSI

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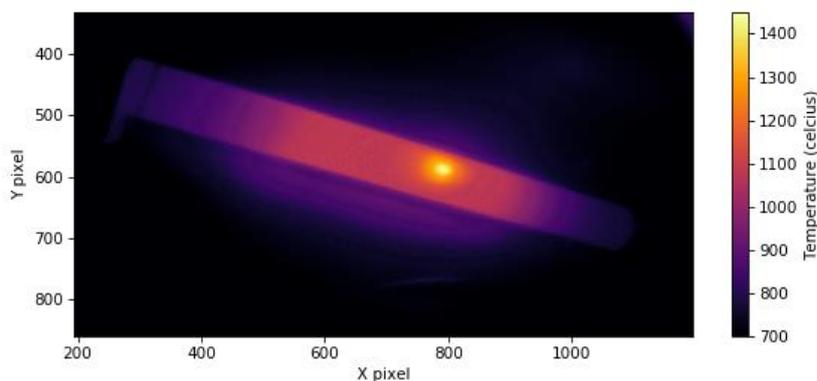[3] Sandia National Laboratories, Albuquerque NM 87185, USA

Figure 1: Temperature image of a heat pipe (side view) under plasma load in Magnum-PSI, obtained with webcam-based thermography. The plasma beam is impinging horizontally from the right of the image.

Recent experiments on Magnum-PSI exposed a lithium-filled heat pipe to a hydrogen plasma beam to demonstrate the potential of radiatively cooled, high temperature heat pipes as modular, replaceable plasma facing components.

Monitoring the temperature distribution over the full 20cm length of the pipe was a crucial element of the experiment, requiring wide field-of-view infrared thermography diagnostics able to operate in the confined space and high magnetic field in the bore of the Magnum-PSI superconducting magnet. Here we present the development of a near-infrared (NIR) thermography system based on commercial high-resolution webcams (1920x1080 pixels) for this purpose. By removing the webcams' internal NIR blocking filter and replacing it with an external bandpass filter of $\lambda = 1.07\mu m$, FWHM = 10nm, the cameras are sensitive for thermography over the temperature range ~500 - 1900°C (for emissivity $\varepsilon = 0.4$). The voice coil motor auto-focus mechanism was removed from the webcams to enable operation in high magnetic fields, which was successfully demonstrated at up to 1T. A laboratory black body source was used for absolute calibration, after characterisation of the camera response curve shape in visible light. Python software for low frequency data acquisition (~1.25Hz) has been developed and provides live calibrated images, temperature plotting and the ability to issue simple temperature-based alarm signals over a serial port for overheating protection. Two of these cameras were used in the Magnum PSI heat pipe experiments, with an example image from one camera shown in figure 1. We will present details of the diagnostic development; calibration & data analysis methods, and example results from this experiment.