PTDL, Diagnostic Capabilities and Instrumentation

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Maturation of high-performance materials for thermal protection systems used during hyper velocity flight are an enabling technology for future reentry vehicles and high-speed aircraft. Progressing the understanding of how these materials behave in harsh thermal environments require advanced test methods and techniques. The objective of the Plasma Test and Diagnostics Laboratory at the University of Vermont is to develop improved material and gas dynamic testing capabilities. To achieve the labs goals, a small-scale inductively coupled plasma torch provides a high enthalpy flow replicating in-flight conditions and is optimized for advanced aerospace material testing and ablation analysis.

This unique lab implements cutting edge gas-phase laser diagnostics and traditional instrumentation to provide quantitative information about the important gas-material interactions. Material test samples have already been developed to provide fully-catalytic, non-catalytic and pyrolysis simulating surfaces. High purity graphite samples are used for ablation analysis, while machined quartz is used to simulate a non-catalytic surface. Pyrolysis simulation is performed using a water-cooled porous disc, where the desired gas is injected through the machined pores. Basic ablation analysis is documented using leading surface and profile video footage. This data combined with pre and post mass measurements can be useful to determine ablation rates. Externally mounted acoustic emission sensors are also implemented to monitor ablation. The sensors can detect waves propagating down the probes created from the thermal stresses in the sample. Advanced statistical analysis tools are currently being developed to extract useful information from the data. A Nd:YAG laser system provides the energy to detect oxygen, nitrogen and carbon monoxide through two photon absorption laser induced florescence (TALIF). Single photon laser induced florescence (LIF) can be used to analyze the production of nitric oxide. Emission spectroscopy measurements are taken using a spectrometer to detect plasma emission from 200 – 1100 nm. Through absorption spectroscopy, a diode laser allows for the detection of CO_2. Translational mounting of all of the collection optics allows for scanning in the axial and radial directions.

The progressive research that takes place at the PTDL is constantly evolving to meet future testing needs of agencies such as NASA and Air Force Research Laboratories. Quantitative data collected in the lab will directly affect advancements in thermal protection system concepts and will drastically increase the possibilities for landing locations and maximum payloads for a variety of missions including returns from low earth orbit, lunar returns and even human scale mars missions.