

Analysis of Spallation Products Using Arc-Jet Experiments

Ablative materials are often used in the thermal protection systems of spacecraft and contain a matrix made of carbon embedded in a resin. Using chemical reactions such as pyrolysis, oxidation, and vaporization, mass removal occurs to prevent heat transfer through this material to the spacecraft. Oxidation, however, can often cause the carbon fibers to weaken and erode, allowing particles of the material to break off and be ejected from the surface in a flow with high levels of enthalpy and shear, a process known as spallation. Not much is known about this phenomenon, and it is often modeled using an empirical rate. This research looks to discover the rate, size, and number of these particles to provide better information about this process. To analyze this, samples of ablative material were placed in an arc jet facility at the NASA Langley Hypersonic Materials Environmental Test System (HYMETS) with multiple different geometries, materials, and flow conditions, and particle ejection was captured using high-speed camera images. From these images, a particle tracking software was utilized to analyze the positions, velocities, and accelerations of these particles to build trajectories of the particle paths. Statistical analysis is being used to discover the amount, size, and speeds of these particles from their trajectories in order to discover more about this phenomenon and provide better data for future modeling purposes.