PROPERTY AND PERFORMANCE MODELING OF SOLID ROCKET PROPELLANTS BASED ON MICROSTRUCTURE

Material property characterization and volume imaging of as-produced solid propellant grains are important issues in the design-to-performance analysis of rocket motors. In particular, it is critical that the ballistician has tools that will predict performance degradation related to defects or morphological changes in grains that arise from manufacturing or aging, as well as the determination of bulk thermomechanical material properties.

A project is in progress to enhance and commercialize software tools for imaging and three-dimensional reconstruction of as-produced propellant grains from micro-tomographic volume-imaging techniques; computational tools that can model the morphology of the propellant grain, including first-, second-, and third-order statistics; and computational tools that can determine local material properties, including elastic modulus, thermal conductivity, coefficients of thermal expansion, etc. Tentatively named TOMOPROP (Tomography-based Prediction of Material Properties), these tools will be validated by comparison with experimental data. The process explored during this project initiates with tomographic imaging of the actual material, then moves to statistical characterization of the as-cast propellant pack, reconstruction of a representative unit cell (RUC), validation of the RUC against the statistics from the original physical pack, and finally calculation of physical properties based on the statistics of the RUC. Several other technological advances made during earlier work will be significant components of the current work. These include implementation of generically shaped particle models and process/product implementation for aluminized and non-aluminized propellants.

A student working on this project will learn to run a variety of micromaterial simulation tools for characterizing tomographic data on rocket propellant (or surrogate material) and predicting the system bulk thermomechanical properties using finite element or statistical techniques. The student will be exposed to processing of experimental data, running scientific software on workstation and parallel computational clusters, and post-processing/analyzing simulation results. Ability to read basic C++ programs would be helpful but not required.