An Internal Thermal Environment Model of an Aluminized Solid Rocket Motor with Experimental Validation

Due to the severity of the internal solid rocket motor (SRM) environment, very few direct measurements of that environment exist; therefore, the appearance of such data provides a unique opportunity to assess current thermal/fluid modeling capabilities. As part of a previous study of SRM internal insulation performance, the internal thermal environment of a laboratory-scale SRM featuring aluminized propellant was characterized with two types of custom heat-flux calorimeters: one that measured the total heat flux to a graphite slab within the SRM chamber and another that measured the thermal radiation flux. Therefore, in the current study, a thermal/fluid model of this lab-scale SRM was constructed using ANSYS Fluent to predict not only the flow field structure within the SRM and the convective heat transfer to the interior walls, but also the resulting dispersion of alumina droplets and the radiative heat transfer to the interior walls. The dispersion of alumina droplets within the SRM chamber was determined by employing the Lagrangian discrete phase model that was fully coupled to the Eulerian gas-phase flow. The P_1-approximation was engaged to model the radiative heat transfer through the SRM chamber where the radiative contributions of the gas phase were ignored and the aggregate radiative properties of the alumina dispersion were computed from the radiative properties of its individual constituent droplets, which were sourced from literature. The convective and radiative heat fluxes computed from the thermal/fluid model were then compared with those measured in the lab-scale SRM test firings and the modeling approach evaluated.