NUMERICAL INVESTIGATION OF THREE-DIMENSIONAL EFFECTS WITHIN A CHARRING ABLATOR

Alexandre Martin, Ovais U. Khan and Huai-Bao Zhang
Department of Mechanical Engineering
University of Kentucky, Lexington, KY
alexandre.martin@uky.edu

Re-entry of a spacecraft occurs at hypersonic regime where flow field is extremely complex. High temperature gradients occurring in the shock-layer region ionizes and dissociates the air. Even if a large portion of heat generated during this process is convected away in the surrounding air, a fraction of it is still transferred to the vehicle. Therefore, it is important to protect the vehicle with a suitable kind of shielding. Of many techniques available today, the use of ablator material is increasing in popularity. The basic idea behind an ablating heat shield is that the energy incident on the spacecraft is used to vaporized the material, thus preventing a significant part of heat to be transferred into the structure. Available literature indicates that most of the past investigations either do not consider the actual physical processes taking place during ablation, or are limited to a one-dimensional model. The present communication shows the development of a numerical model for simulating the multidimensional heat transfer phenomena that occurred in a typical ablative TPS. Figure 1a) illustrates the computed temperature distribution for the IRV-2 vehicle after 4 seconds of constant exposure. As expected, maximum levels of temperature is observed at the blunted nose section of the body. A gradual decrease in temperature values is also apparent as one move towards the base section. Figure 1b) to c) illustrates the same results while using different values of an anisotropic thermal conductivity. As can be seen, the results are significantly different. These results illustrates the first steps of an ongoing project to develop a comprehensive multiscale, multi-physics and multi-dimensional material response code aimed at modeling charring and surface ablators.

Figure 1: Temperature distribution within the IRV-2 vehicle after 4 seconds of exposure.