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A NEW CONCEPT IN DESIGNING THE THERMAL SHIELD FOR A SMALL REENTRY SPACECRAFT

Abstract

The study of atmospheric reentry physics is crucial in the context of a continuous exploration of the solar system. A reentry vehicle is subjected to a severe aerodynamic heating environment when reentering the atmosphere of a planet. As a consequence, the study of the effects of the aerothermodynamic environment over the reentry spacecraft has great importance. For protecting the spacecraft, the ablative materials are usually used as thermal shield for the reentry spacecraft. In particular, an ablator made of phenolic carbon fiber-reinforced plastics (CFRP) is known to possess superior resistance against aerodynamic heating. In the late years, lightweight ablators started to get more attention since their performance equals the performance of the heavyweight ablators. Using lightweight ablator, the mass of the spacecraft, and hence the cost, is reduced. Recently, a new lightweight CFRP called the lightweight ablator series for transfer vehicle systems (LATS) was developed in Japan. The new lightweight CFRP is made of a carbon fiber felt and resin with a manufacturing method different from that of PICA, which was developed by NASA, and it will be used for MERS (Microgravity Experiment Recoverable Satellite) reentry project, a joint project between University of New South Wales (Australia), Japan Aerospace Exploration Agency/JAXA (Japan) and Kyushu Institute of Technology (Japan). The MERS reentry project consists of a small reentry spacecraft, with the maximum radius of 0.5 m and a mass of 46.0 kg, containing a number of microgravity experiment compartments. The launch is estimated to be in the next 3 years. One of the most important aspect of the ablation phenomenon which occurs at the reentry is the estimation of the mass recession rate. Its estimation is especially difficult for the new lightweight ablator series for transfer vehicle systems (LATS). LATS contains resin, and its quantity depends on the density. Consequently, classical methods cannot be applied to LATS materials. The paper describes a new estimation method for calculating the mass recession of the ablator system made of LATS, used for MERS spacecraft. This method is based on Arrhenius equation for low temperatures and, for high temperatures, on an empirical method applied for the recession phenomenon, method which takes into account the presence of the resin inside the materials. The results will contribute to a better estimation of the ablation phenomenon, estimation which has high importance for the design of the MERS reentry spacecraft.