Micro-scale Thermo-Mechanical Coupling and Oxidation Model for Carbon Fibers in Charring Ablative Materials

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Abstract

Light-weight charring ablative materials are ideal for Thermal Protection System of atmospheric entry vehicles. Usually this type of materials is made of rigid carbon fibers impregnated with phenolic and subjected to large heat flux and withstand sharp temperature gradient during the re-entry. At the same time, the high temperature and the oxygen oxidize the surface of the carbon and cause increasing of surface roughness. As a result, voids start to form on the surface of carbon fibers and those pits would likely to change the performance of the materials.

In this study, a developed thermo-mechanical modeling tool is applied to individual carbon fiber to predict both the thermal and structural responses under large heat load in micro-scale. A novel pitting model is also developed to study the impacts of surface oxidation. Results reveals that the pits can change the distribution of temperature and displacement significantly and lead to local stress concentration, which further result in breakage of the fibers.