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# EXPERIMENTAL AND NUMERICAL STUDIES OF SPALLATION PARTICLES EJECTED FROM A LIGHT-WEIGHT ABLATOR

**Abstract**

During atmospheric entry, thermal protection material (ablator) is strongly heated by aerodynamic heating. Due to this fact, micro-order particles are generated and ejected from an ablator surface, which is called 'Spallation'. In the previous experiments of ablation in an arc-heated facility, the presence of spalled solid particles has been confirmed upstream of a detached shock wave or a stagnation-point boundary layer. Spallation phenomena are considered to be a possible cause of increasing heat-transfer rates on an ablator surface in the downstream region. To estimate the effect of a spalled particle on an ablator, correct values of particle parameters (e.g., size, flight velocity, position) are needed, while those currently obtained are just estimated values. To obtain the detailed values, we have been carrying out the heating experiment for a trial manufactured light-weight ablator, and then detailed parameters for each particle have been analyzed directly from the visualized pictures. As for the visualization method, the in-line holography method, that uses a recorded hologram pattern appearing behind of an illuminated particle by a collimated laser beam, is applied to evaluate the particle parameters. Moreover, the flight path of a single spallation particle is numerically analyzed in the present study. For this purpose, the flow field over an ablator model corresponding to the experiment is numerically reconstructed by using a computational code of thermochemical-nonequilibrium flow analysis. In the computation, a single particle is ejected from the forward-facing surface of an ablator against an arc-jet flow direction. It is assumed that the particle is a sphere in shape and the gas phase is not influenced by the solid particle. In addition, we consider the effect of radiation from the particle surface, sublimation and reduction of the particle diameter caused by the sublimation. As a result, some particles ejected from an ablator surface are visualized in the upstream region and their parameters are evaluated successfully. This fact indicates the availability of the in-line holography method for evaluation of spallation-particle parameters. By using the obtained particle parameters, the effect of a spalled particle on an ablator surface is estimated. It is elucidated that the radiation heat transfer from a particle is about 1/1000 – 1/10000 of the convection heating and then its effect may be ineffective for the heat balance at the ablator surface.