§1. Studies on Behavior of Solid Hydrogen Pellets in a Drift Tube

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When the pellet is traveling in the curved drift tube, it is expected that the pellet undergoes mass attrition due to melting/evaporation caused by radiation from the tube wall and friction heat with the wall and the erosion by collision with the wall. Present study aims to estimate the effects of behavior when the pellet attacks/leaves on the wall, especially contact angles of the pellet, on the mass attrition numerically.

Material Point Method is applied for calculation of pellet's motion. For prediction of temperature inside the pellet and the impingement wall, Smoothed Particle Hydrodynamics (SPH) method is used. That is, in present scheme, both pellet and tube wall are regarded as assembly of material particles. For SPH method, the resultant reproduction of heat conduction at the interface of contact between pellet and tube wall strongly depends on the distance between each material particle. Therefore, contact heat transfer is approximated by the analytical solution of contact heat transfer rate of two semi-infinite bodies. Sliding friction is described by means of Amonton and Coulomb's law and frictional heat is assumed that the decrease in total energy of pellet is converted to the heat. After calculation of input energy of pellet as frictional heat, the temperature of material particles of pellet located in vicinity of contact surface is calculated. If above obtained temperature exceeds the melting point of hydrogen, the exceeded energy is assumed to be spent for sublimation of pellet. Then mass attrition for the sublimation is calculated from the latent heat of sublimation.

The pellet is assumed to be a cube moving at 100m/s as initial velocity. The initial temperatures of pellet and tube wall are 4K and 300K, respectively. Before impingement, the flight attitude of pellet is inclined: 0, 10, 20, 30 and 40 degrees. When the pellet impinges the wall, the impact angle is varied from 4 to 8 degree as a calculation parameter. The friction coefficient is assumed to be constant value of 0.15.

Fig.1 shows the snapshots of pellet's behavior in the case that flight attitude angle is 10 degree. The pellet impinges on the wall twice. When first contact is occurred, the edge of pellet is deformed and additional rotational force is added to the pellet. Then the pellet leaves from the wall after second contact is succeeded. Fig.2 shows the effect of flight attitude angle of pellet on the mass attrition rate. For all impact angles, the mass attrition rate becomes minimum when the flight attitude angle of pellet is 30 degree. When the flight attitude angle of pellet is below 30 degree, the pellet is rotated by the additional force due to first contact and the contact period is elongated. In the case of 30 degree, the second contact is not occurred. So that, the mass attrition rate is decreased in the case of 30 degree compared to cases of the shallow angles. Though the pellet also impinges the wall once in the case of 40 degree, the amount of eroded mass at the contact is larger than that of 30 degree case. That makes the contact area of pellet broad, so that the mass attrition rate is increased.

As next step, actual pellet configuration, the effect of gasified hydrogen near the heat transfer interface, plastic deformation of pellet and meso-scale modeling of friction should be taken into account.

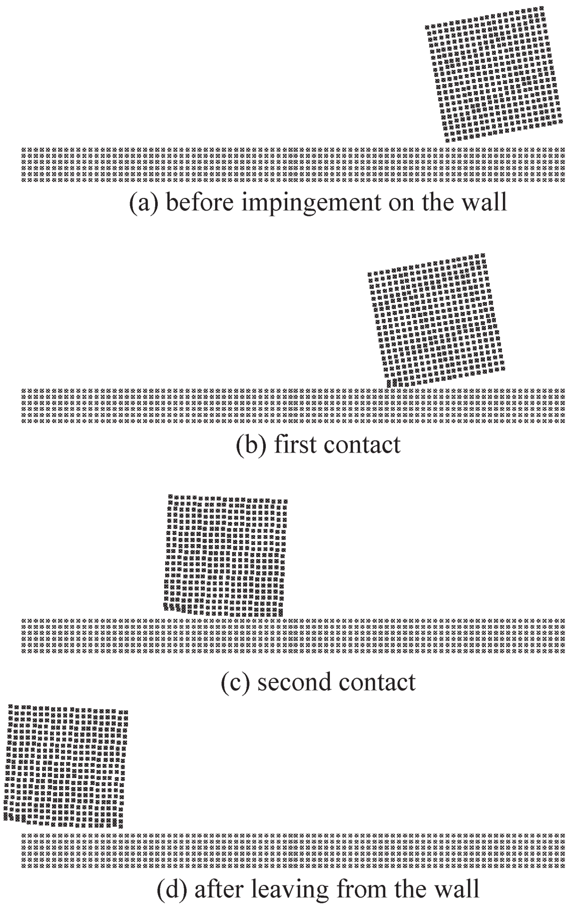

Fig. 1. Snapshot of behavior of pellet impingement

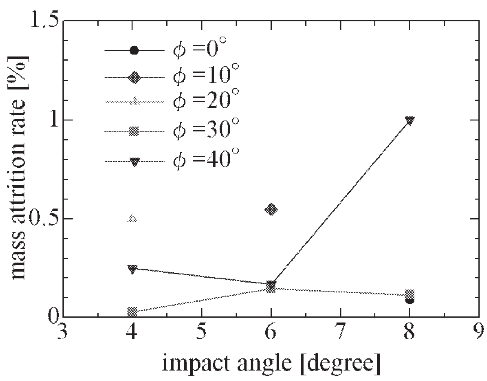

Fig. 2. The effect of flight attitude of pellet on the mass attrition rate.