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THERMAL RESPONSE AND RECESSION RESISTANCE OF A NEW THERMAL PROTECTION SYSTEM USING HIGH-TEMPERATURE CFRP SANDWICH PANEL

Abstract

A spacecraft such as re-entry capsule uses Thermal Protection System (TPS) in order to protect its inside from severeenvironments. One of the most reliable TPS is the heat shield using ablator. Ablator is a thermal protection material using ablation cooling system, and it has been used for some re-entry capsules, HYABUSA, STARDUST, USERS and so on. The capsules have required the weight reduction of ablator. For example, the ablator of HAYABUSA accounts for 50wtAn ablator covers the capsule structure consisting of aluminum alloy. One of the main reasons for designing thickness of high density ablator is an operating temperature limit of capsule structure consisting of aluminum alloy. The ablator consists of three zones from the surface after exposing on severe environments, which are charred zone, pyrolysis reacting zone, and virgin zones. In most case, the depth of charred zone and pyrolysis reacting zones is less than half of the thickness. Although the virgin zone shows no function of ablation cooling, this zone is required to lower the temperature enough to maintain mechanical properties of the aluminum alloy. The target of this research is a development of new light weight TPS applying ablator and a high-temperature sandwich panel. In the previous study, we developed the high-temperature sandwich panel, which consists of CFRP skin panel using polyimide resin and porous carbon core. This sandwich panel shows the high specific mechanical properties up to 300C. Further, this panel has a high thermal insulation performance. Thus, the function of virgin zone of ablator might be unnecessary when this panel is applied as the capsule structure. In this study, we calculated the required thickness of ablator when the high-temperature sandwich panel was the capsule structure. Furthermore, arc wind tunnel tests were carried out to evaluate thermal response and recession resistance. The calculation of ablator thickness was carried out by a thermal conduction analysis, Abaqus ver.6.13. As a result, 17 mm thickness was required to maintain the mechanical properties of high-temperature CFRP sandwich panel at 2.0 MW/m2 and 60sec. In this case, the areal density became 44 % of existing ablator. Further, the recession was approximately 1 mm at 6.0 MW/m2 and 30 sec. These results indicated the quite high potential of the new system using ablator and high-temperature CFRP sandwich panel as a lightweight TPS.