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IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Smart Materials and Adaptive Structures (9)

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REUSABILITY OF RE-ENTRY CAPSULES USING SHAPE MEMORY ALLOYS

Abstract

Re-entry capsules are essential for safe and reliable return of spacecraft to Earth. However, current technologies lack reusability provisions, leading to high manufacturing costs. A proposed model, utilizing Shape Memory Alloys (SMAs) and a crushable layer, can address this issue and significantly reduce manufacturing costs. SMAs are metallic materials that exhibit a unique property known as shape memory effect, allowing them to recover their original shape after being deformed due to the presence of a reversible martensitic transformation in the material, which alters its crystal structure and shape. These properties can be used to create a heat shield with shape memory and superelasticity that absorbs thermal energy and regains its original shape after deformation during re-entry. The proposed model involves deploying a crushable material during re-entry that acts as a Hypersonic Inflatable Aerodynamic Decelerator (HIAD). The decelerator gradually erodes due to aerodynamic friction and thermal loads, slowing down the capsule by providing drag and reducing mass. The decelerator's shape, which is parabolic, is designed to provide sufficient drag, minimize shock effects, and be thick enough to erode up to a safe altitude of about 2 km. Once the capsule reaches this altitude, the parachute recovery system takes over. As the capsule structure is made of SMA which is chosen as Cu-Ni-Al alloy as it can sustain and recover any deformation which is below 500 degree celcius, any deformation caused by aerodynamic stresses and thermal loads can be recovered by exploiting the properties of SMA. This will lead to major cost savings for space agencies by reusing all major components. Using the commercially available softwares such as ANSYS , simulation such as structural, thermal and CFD Analysis has been done and the results are obtained from the same. In summary, the proposed model of utilizing SMAs and a crushable layer for re-entry capsules can provide a solution to the current lack of reusability provisions and significantly reduce manufacturing costs. The model's design allows for the safe return of spacecraft to Earth and the reuse of major components, leading to a more sustainable and cost-effective approach to space exploration.