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CONCEPTUAL DESIGN OF A NEW HYBRID CAPSULE FOR MANNED ATMOSPHERIC RE-ENTRY APPLICATIONS

Abstract

The study for the success of the re-entry phase of a space mission has always been focused on ideas and systems to ensure the dissipation of the kinetic energy accumulated in the previous phases of the mission, without damaging the re-entry vehicle itself. The solutions for this problem led to the configuration of the first manned capsule (Vostok), which with its spherical shape and with an adequate thermal protection allowed to contain the high heat flux of the re-entry phase. On the other hand the perfect ballistic re-entry of the Vostok capsule didn't allow any control of the vehicle and exposed the astronaut at high acceleration (8-9 g). With the purpose of limiting this acceleration up to a maximum of 3g-4g, the re-entry capsules have been improved, trying to provide to the vehicle a greater aerodynamic efficiency that could allow a certain control of the trajectory. Going from low-lifting configurations, such as the Apollo capsule (or the current Soyuz), they have come to full-lifting vehicles, as in the case of the Space Shuttle, able to return the crew on the Earth's surface like a normal aircraft. The full-lifting vehicle, however, has two major disadvantages: a high cost of mission/maintenance and an extremely high risk in atmospheric re-entry. In this context the Hybrid Capsule represents a new solution between the simple configuration of the modern capsules and the advantages of the full-lifting vehicles. The configuration of the Hybrid Capsule here presented is like a normal capsule, but with four lifting surfaces which are controllable separately. The lifting surfaces can change the ballistic coefficient of the vehicle during re-entry (by increasing the total surface area but maintaining a constant mass), with immediate advantages on heat flux and velocity reduction, and can generate specific moments around the center of mass of the capsule, allowing the trajectory control and the ability to land in a precise airstrip. The innovation of this vehicle is its simplicity and versatility for many atmospheric re-entry applications, such as emergency re-entries from the International Space Station or from other planets such as Mars. In this paper the concept design of the hybrid capsule is presented; the trajectory of the capsule has been studied and the heat flux has been calculated in order to set the input conditions for the numerical analysis. The materials has been selected by thermo-mechanical tests and the design has been structurally verified by numerical simulations.