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AEROSPIKE: MISSION SIMULATION AND OPTIMAL DESIGN

Abstract

One of the characteristics of an hypersonic vehicle (in particular for missiles, rockets and re-entry vehicles) is the presence of a blunt body at the stagnation point on the fuselage: this architecture is mandatory to allow the presence of a reasonable inner space to store the payload, the electronics and eventually the crew which also helps to decrease speed during the re-entry.
The presence of this dome-shaped part induces, for instance i) an increase of the pressure load onto the body, ii) ablation of hull covering materials, iii) mechanical failures, iv) heat damage to the onboard electronic packages, v) communication failure due to air ionization ahead of the vehicle. Those effects are related to the shock wave onset near the dome that induces large drag and temperature increase in the near-body region.
One of the possible solutions is to install a static device, called Aerospike (made up by a spike, point-shaped, or with an head, the aerodisk), to reduce aforementioned effects.
It creates a more streamlined shape reducing compressibility-related effects thanks to the insurgence of an oblique shock wave instead of a normal one. Moreover, shock effects are detached from the main body thus contributing to the protection of surface materials and payload with a weaker impact due to the onset of an oblique wave. Further, it creates a low pressure separated flow region behind the head of the spike involving a pressure field on the dome which is weaker than the one without the aerospike.
The length of the spike, the radius and the shape of the head have a great impact on the separation characteristics behind the head, the shock pattern and strength, the virtual streamlined body effect.
Previous CFD-based optimization frameworks highlighted the effects of spike length and head radius (the shape was fixed) on the drag and dome surface temperature allowing to find geometric proportions to minimize drag and surface temperature. The aim of the project is to define the optimal head shape using the adjoint technique and include chemical effects in the CFD framework.
In this case, the objective functions used are:

- Drag reduction, related to efficiency and performances;
- Static temperature control onto the dome, related to thermal protection.