Title: *Drag Reduction of a Hypersonic Aerospike using an Adjoint-Based Shape Optimization Approach*

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Topic Area: Aerothermal (Design, Analysis)

Abstract:

The use of adjoint-based shape optimization in computational fluid dynamics (CFD) has increased in recent years. While applications of adjoint methods for low-speed flows are numerous, its use for supersonic and hypersonic flows is not as common. Hence, there is a need for examine the efficacy of the adjoint approach for high-speed flow configurations.

In this study, the drag reduction of a hypersonic vehicle aerospike model at Mach 6 is examined using the adjoint solver available in the general-purpose CFD code Ansys Fluent. The aerospike model corresponds to a well-documented test case for which data are available [1]. The geometry of the aerospike consists of an aerodisk mounted to the tip of a fixed-length spike which is attached to an axisymmetric vehicle body as shown in the figure below. The purpose of the aerodisk-spike arrangement is to reduce the vehicle drag by altering the bow shock position and strength in the vicinity of the main body.

The adjoint solver in Ansys Fluent is used to compute the adjoint sensitivity fields for the axial component drag force. The sensitivity fields are then applied to a shape optimization of the aerodisk, which in the present case consists of modifying the aerodisk surface mesh using mesh morphing techniques. The CFD solution is recomputed with the modified geometry to determine the change in the drag force relative to the previous shape. By repeating this process for several design iterations, a significant reduction in drag can be realized. One of the main advantages of an adjoint-based shape optimization in this case is its ability to create an organic, parameter-free shape while subject to specific user-defined design constraints.

The present work will describe the adjoint methodology and workflow used for the hypersonic aerospike case and will provide results for a Mach 6 freestream flow with a zero angle of attack orientation of the vehicle. It will be seen that using multiple design iterations, the drag can be reduced using a modified aerodisk shape as determined by the adjoint sensitivity fields.

*Reference [1]: Huebner, L., et al., “Experimental results on the feasibility of an aerospike for hypersonic missiles “, 33rd Aerospace Sciences Meeting and Exhibit, Aerospace Sciences Meetings, Reno, NV, 1995.*

