A METHODOLOGY FOR AEROTHERMODYNAMIC SHAPE OPTIMIZATION OF HYPersonic ENTRY AEROSHELLS

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ABSTRACT

Previous work by the authors [1] focused on the optimization of entry aeroshell shapes based solely on objectives related to aeroshell geometry and hypersonic aerodynamic performance. That multi-objective optimization framework has now been extended to include the impact of hypersonic aerothermodynamics – that is, aerodynamic heating is now considered alongside the previously-developed objectives.

The methodology used to perform aerothermodynamic analyses has been adapted from research [2] that demonstrated the ability to obtain an approximate three-dimensional heating distribution using only axisymmetric analyses. Following the precedent in [3], these axisymmetric analyses are performed along equivalent axisymmetric bodies that have been generated from surface meridians originating from the geometric stagnation point. With the satisfaction of certain similarity criteria, these axisymmetric solutions provide an estimate for the heating on the three-dimensional body.

In this work, aeroshell shapes are parameterized using non-uniform rational B-spline surfaces that provide a high level of design flexibility. Estimates of axisymmetric aerothermodynamics are obtained at multiple levels of fidelity: either by coupling Newtonian inviscid solutions with axisymmetric boundary-layer relations, or by using an axisymmetric Navier-Stokes solver. This multi-fidelity approach provides a means to exploit the computational efficiency of low-fidelity analyses while leveraging with the accuracy of higher-fidelity analyses where necessary. Optimization is performed using both single- and multi-objective genetic algorithms.