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DESIGN OF A NOVEL INTEGRATED STRUCTURE CONSIDERING HEAT-TRANSPORT AND LOAD-BEARING CAPACITIES FOR HYPERSONIC VEHICLES

Abstract

The hypersonic vehicle encounters severe aerodynamic force and heat concentration effects. The excessive heat should be transported from the high-temperature region to safer and low-temperature regions. Thus, load-bearing structures with the integration of heat transport function are entirely necessary and well in line with the development of hypersonic techniques.

In this work, an integrated structure for the leading edge of a hypersonic wing is designed and a design process considering the heat-transport and load-bearing capacities is developed. The design process contains the calculation of aerodynamic force and heat, the topology optimization of heat transport and load transfer paths and the size optimization of integrated structure. The optimal topological paths are obtained by the density-variable optimization method with objectives of the minimum mechanical and thermal compliances, while the optimal structural sizes are obtained based on genetic optimization algorithms with objectives of the minimum weight. The highest and average values of structural temperature and stress are considered as constraints in the optimization process. In this work, no specific heat-transfer medium is involved and the effects of volume fraction limits and thermal conductivities of medium on the structure design are studied.

The results show that: the structural heat transport capacity increases with the increase of medium's thermal conductivity and volume fraction; the integrated structure is available in temperature range of 1500 to 2000 K,and creates a temperature reduction of more than 500 K under certain conditions.