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AERODYNAMIC HEATING REDUCTION WITH JET ARRAYS OVER THE SHARP EDGE OF A HYPERSONIC VEHICLE

Abstract

The reusable thermal protection design for the sharp edge of a reentry vehicle is a huge challenge and key technology with severe aerodynamic heating environment during reentry, where the ablative thermal protection systems are usually applied. A novel thermal protection system via opposing jet arrays could be applied to reduce the aerodynamic heating in such critical regions. This paper is aimed to obtain the aerodynamic heating reduction mechanism of jet arrays over the leading edge for hypersonic vehicle. A CFD study on the aerodynamic heating on the wing tip of a reentry vehicle by jet array injection was conducted, with a free-stream Mach number of 15. Focus on the severe aero-heating positions from CFD results without jets, the jet array layout and flow parameters were designed for the shock interaction region and the rear of wing tip respectively. Simulations were performed with different total pressure ratios of jet to the incoming flow between 0.002 and 0.02, and the regional flow field and surface heat flux features were obtained. Furthermore, the calculated results were compared and analyzed. More than 50 percent of aerodynamic reduction was achieved at the jet impinged positions both in the shock interaction and wing tip rear regions. In the region of middle wind tip without jets, the heat flux was increased by almost 10 percent with a total pressure ratio of 0.002, while the heat flux would be decreased by about 80 percent due to the total pressure ratio increased. It woul be concluded that the aerodynamic heating reduction with jets was due to the jets injection which could push the high temperature gas far from the wall and make the regional high heat flux down, which should be very effective to reduce the sharp edge aerodynamic heating for a hypersonic vehicle.