Mixing and combustion characteristics for the transverse injection flow field in supersonic crossflows

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The mixing of a sonic circular jet with a supersonic crossflow has been the subject of interest in the area of aerospace engineering, and it has attracted an increasing attention worldwide. The mixing between the injectant and the supersonic crossflow has an important impact on the improvement of the combustion efficiency in the scramjet combustor, and it results in higher heat release accordingly. However, the mixture stays in the supersonic flow with very short residence timescale, and the mixing and combustion process in the supersonic flow is still a vital problem for the design of the scramjet engine. In the current study, the transverse injection flow field in the supersonic crossflow has been investigated numerically, and both the nonreacting and reacting flow fields have been considered. At the same time, the predicted results have been compared with the experimental data obtained by Aso et al. in order to validate the numerical method, and three different grid scales have been employed to analysis the gird independency, namely the coarse grid, the moderate grid and the refined grid. Further, the influences of the jet-to-crossflow pressure ratio and the fuel molecular weight on the mixing and combustion characteristics of the transverse injection flow field have been carried out. The jet-to-crossflow pressure ratio is set to be 4.86, 10.29, 17.72 and 25.15, and the hydrogen, nitrogen and methane have been taken as the fuel. The obtained results show that the numerical results show reasonable agreement with the available experimental data in the open literature, and the gird scale has only a light impact on the wall pressure profiles for the transverse injection flow field. A hovering vortex is formed between the separation region and the barrel shock wave because of the value of the large negative density gradient, see Figs.1-2, and the separation length increases with the increase of the jet-to-crossflow pressure ratio. The separation zone provides a mixing region for the jet and the subsonic crossflow boundary layer, and it is formed by the interaction between the separation shock wave and the boundary layer.

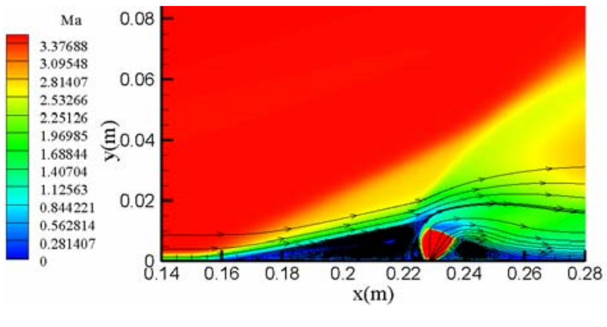

Fig.1 Mach number contour and streamline sketch for the transverse injection flow field.

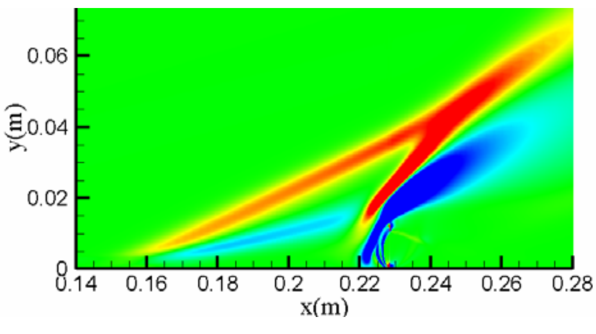

Fig.2 Density gradient contour for the transverse injection flow field.