TURBULENCE MODELS ON THE CHEMICAL/TURBULENCE INTERACTIONS IN THE TRANSVERSE GASEOUS INJECTION FLOW FIELD

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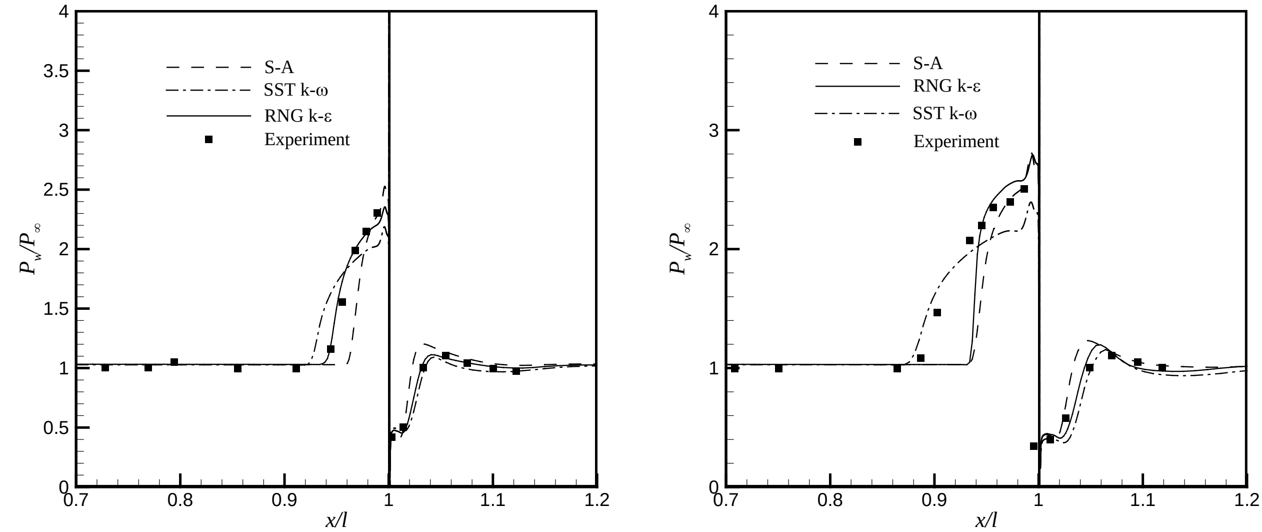
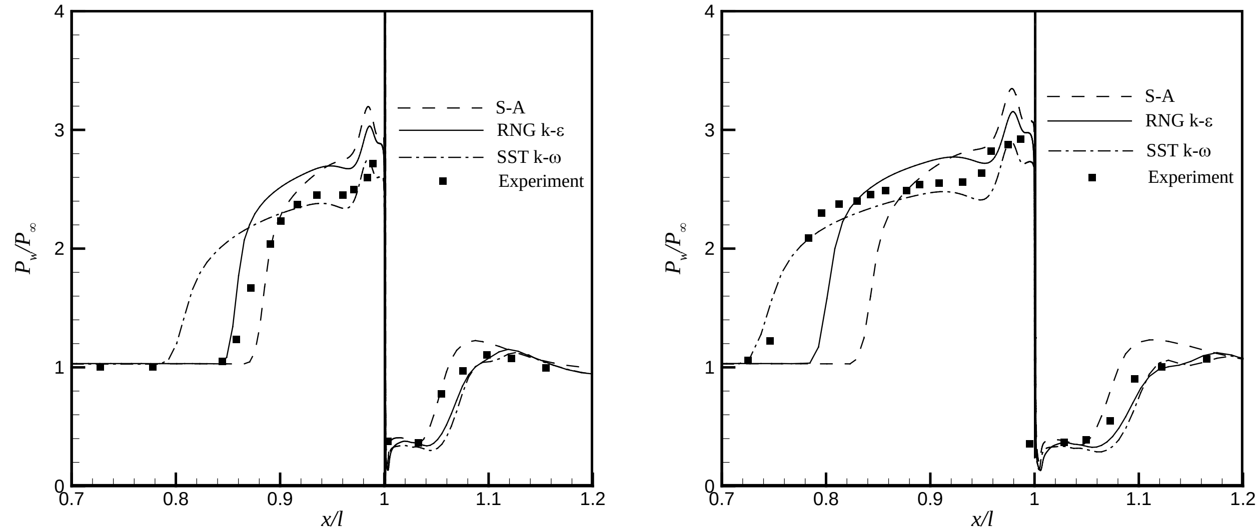
Abstract The combustion process of a sonic circular jet with a supersonic crossflow has been the subject of interest in the area of aerospace engineering, and it has attracted an increasing attention worldwide. The influence of the turbulence model on the chemical/turbulence interactions has an important impact on the prediction of the combustion efficiency in the scramjet combustor, and it results in the variance of the heat release accordingly. In the current study, the transverse gaseous injection flow field in the supersonic crossflow has been investigated numerically, and the reacting flow field has been considered primarily. At the same time, the effect of the turbulence model on the chemical/turbulence interactions has been performed as well, and the predicted results have been compared with the experimental data obtained by Spaid and Zukoski in order to validate the numerical method. 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 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 and the methane have been taken as the fuel respectively. The obtained results show that the numerical results show good 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. The turbulence model has a very large impact on the chemical/turbulence interaction, and it results in a very different wall pressure profile, see Fig.1. 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.2-3, and the separation length increases with the increase of the jet-to-crossflow pressure ratio. The separation zone provides a good 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.



(a) $P_j/P_\infty = 8.74$ (b) $P_j/P_\infty = 17.12$



(c) P_j/P_∞ = 42.79 (d) P_j/P_∞ = 63.5

Figure 1. Comparison of wall pressure profiles for different jet-to-crossflow pressure ratios, namely P_j/P_∞ = 8.74, 17.12, 42.79 and 63.5.

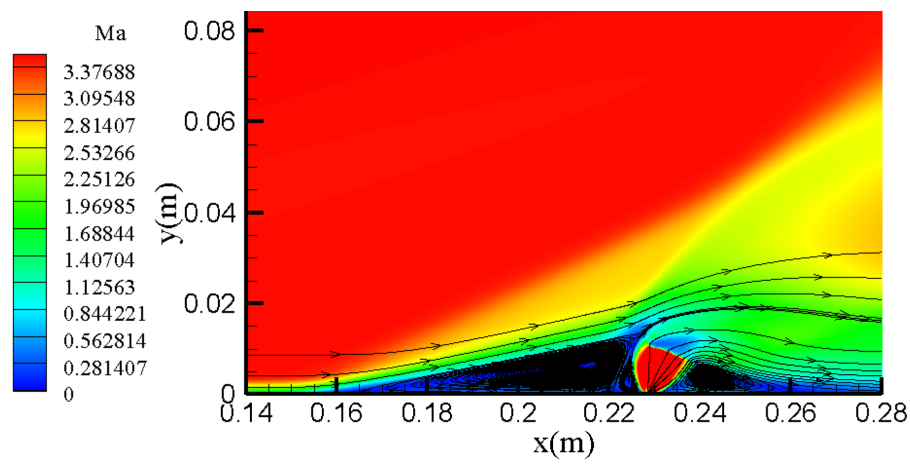


Figure 2. Mach number contour and streamline sketch for the transverse injection flow field.

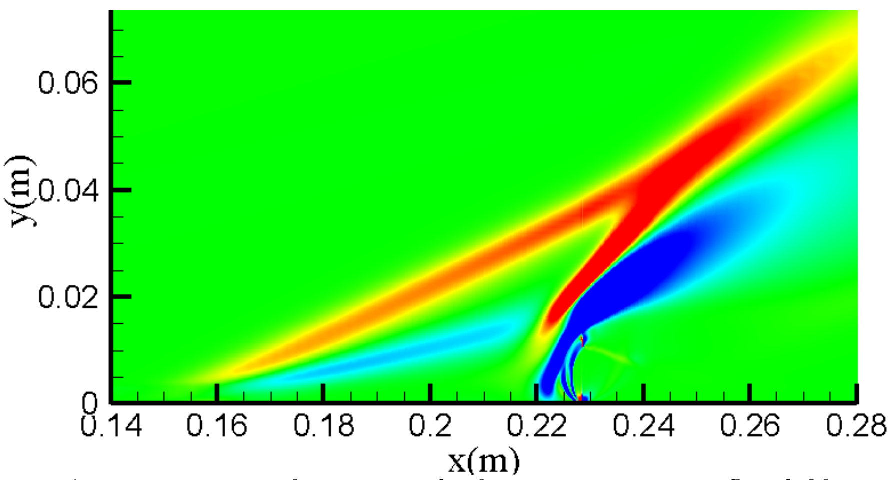


Figure 3. Density gradient contour for the transverse injection flow field.