Numerical Investigation on the Start/Unstart Performance of a Supersonic Inlet

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Abstract:

The unstart phenomenon is one of the most urgent problems for the supersonic inlet, since it causes a large decrease of both engine thrust and specific impulse for hypersonic air-breathing engines. Computational Fluid Dynamics is an efficient approach to aid experimental tests, perform parametric studies, and check whether design changes are worth testing experimentally. Further, it also provides important insight into complex flow phenomena like separations, shock wave/boundary layer interactions, mode transition and turbulence/chemistry interactions, thus significantly improving the flow-path design process for relatively lower costs compared to costly experimental tests alone. In the current study, Favre-Averaged Navier-Stokes (FANS) equations have been solved with density based (coupled) double precision solver of FLUENT, and the RNG k-ε turbulence closure model has been employed to numerically simulate the flow field in the supersonic inlet. Second order spatially accurate upwind scheme (SOU) with the advection upstream splitting method (AUSM) flux vector splitting has been utilized, and the Courant-Friedrichs-Levy (CFL) parameter has been kept at 0.5 with proper under-relaxation factors to ensure stability. At the same time, the numerical method has been validated through the grid independency analysis and the experimental data available in the open literature. The influences of the freestream Mach number,the angle of attack,the isolator geometric configuration, and the back pressure on the start/unstart of the supersonic inlet have been performed. The predicted results show reasonable agreement with the experimental data, and the grid scale makes only a slight difference to the numerical results of the supersonic inlet. With the increase of the angle of attack, a large separation region is generated on the upper wall of the isolator, and a small one is formed on the fourth compression ramp of the inlet. When the angle of attack is large enough, the freestream can not go through the flow path of the inlet completely, and the unstart phenomenon occurs. At the same time, the large freestream Mach number can prevent the supersonic inlet from unstart, and the isolator with long length can reduce the pressure disturbance from the supersonic combustion. The divergent angle is also helpful for the supersonic combustion. Further, when the back pressure increases, the possible of the unstart phenomenon increases.

Key words: start/unstart, supersonic inlet, numerical investigation, the angle of attack, divergent angle, back pressure

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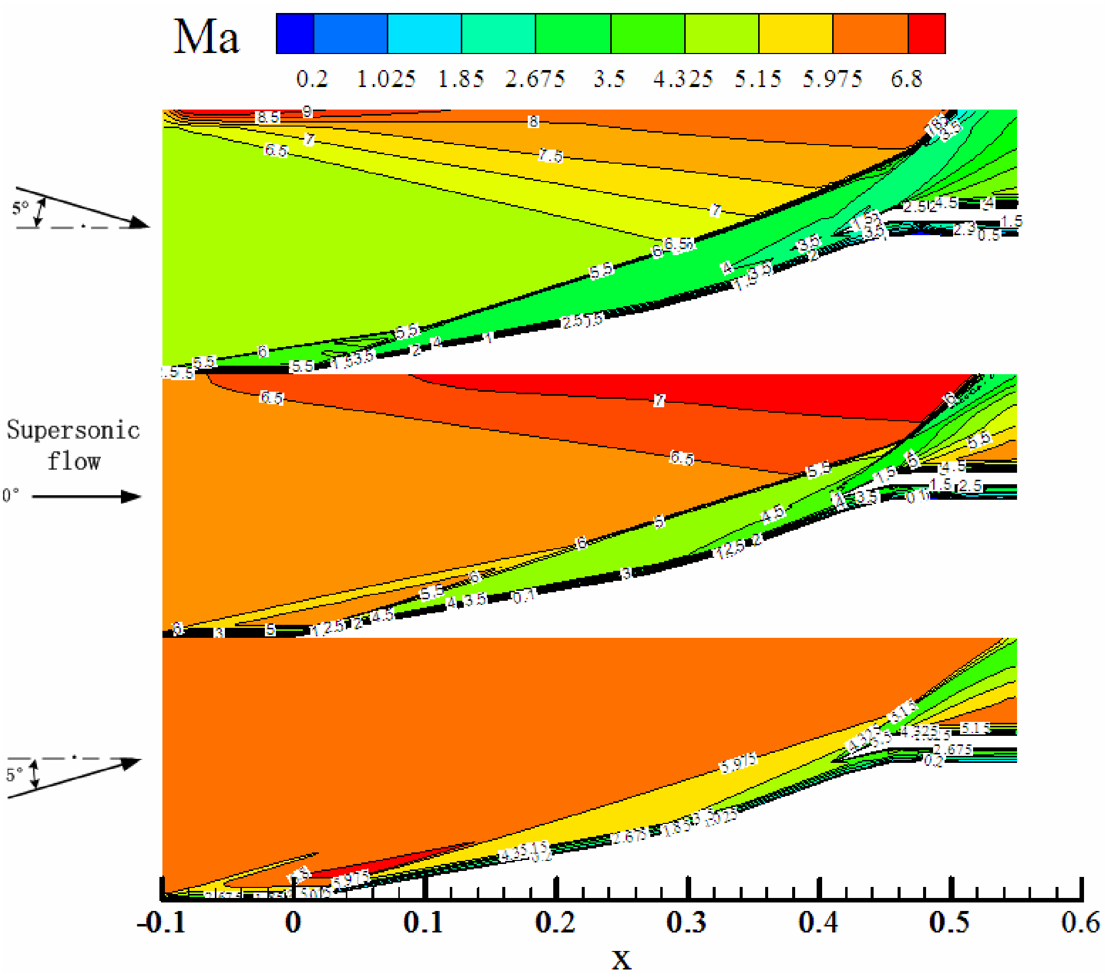

Comparison of Mach number contour with different angles of attack