Richtmyer-Meshkov Instability Studies of a Convergent Shock-Tube Flow

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Richtmyer-Meshkov instability (RMI) is a fundamental fluid phenomenon [1-3], consisting of a non-stationary and nonlinear physical process, and subjected to an intensive investigation in many applications.

In this study, we are concerned with physical aspects of three-dimensional RMI and resulting turbulent mixing characteristics in a convergent geometry. A two-fluid two-layer system, a layer of a heavy gas (Xenon, Xe) enclosed by a light gas (Air), is considered. A feature is imposed at one of two randomly perturbed material interfaces to enunciate the presence of a macroscopic perturbation. A schematic of an initial configuration and flow conditions, including: geometry dimensions, an incident shock, perturbed interfaces, a feature representing a macroscopic perturbation and fluid properties, is shown in Figure 1.

The overall configuration is represented by a convergent shock tube with a non-dimensional size of 4[0, 4] × π/2([-π/4, π/4]) × 0.8([0, 0.8]) in cylindrical coordinates (r, θ, z). The initial interfaces are placed at r=1.0 and r=2.25, respectively. An incident shock, originated at a radius of 3.5, propagates towards the centre of the convergent geometry with a Mach numbers of 1.74.

To gain a more thoroughly understanding of the mixing dynamics, TURMOIL3D, a Monotonic Integrated Large Eddy Simulations (MILES) code [4], is employed to numerically simulate physics of the fluid system and interrogate the RMI mechanism embedded in such a setting.

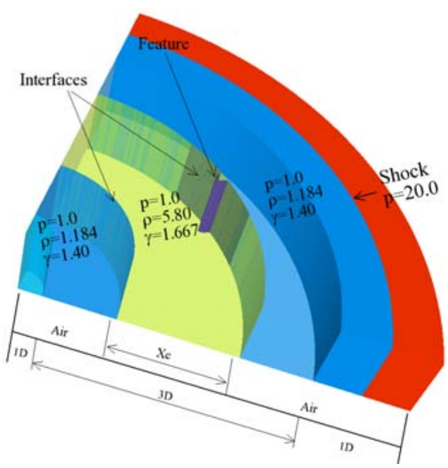

Fig. 1. Geometry of the converging shock tube

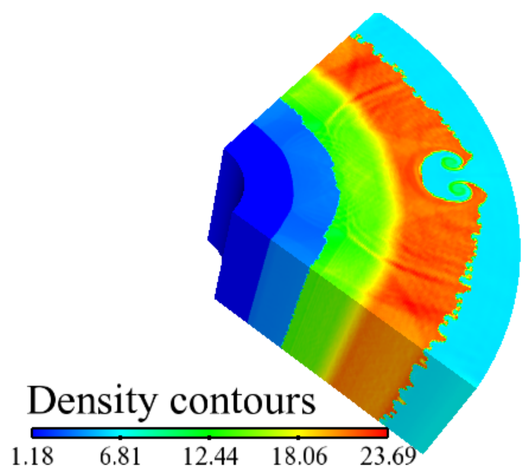

Fig 2. The density contour fields

Preliminary computational results demonstrate the complexity of the flow field under the consideration. In Figure 2, we present simulated density contour at a non-dimensional time of 0.0025. The detailed wave and fine-scale mixing structures are visualised, with small-scale structure and fragments exhibited. A significant difference can be observed in the presence of the macroscopic feature, with additional rollups and complex jet-like structures presented. It is suggested that the discrete feature, in conjunction with the random perturbations, significantly influences the RMI and turbulent mixing characteristics.

In the full paper, we present a comprehensive investigation of the mixing properties and insights into RMI in a convergent geometry and in the presence of the feature. Material mixing and subsequent turbulent characteristics are investigated and explored in details.

References

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