Key features of the Solver

The solver based on the model developed by Wang et al. (2001), which uses a thermodynamically consistent fully conservative approach for the treatment of contact discontinuities based upon the concept of Total Entropy Conservation of the Mixture (ThCM), is implemented to study the Richtmyer-Meshkov instability. This method utilizes a high resolution Godunov-type scheme based upon a fast exact Riemann solver and the Piece-wise Spline Method (PSM) for data reconstruction of primitive variables at cell interfaces with fourth order accuracy.

ThCM Model

In the two-dimensional simulation of the Richtmyer-Meshkov instability, the hyperbolic conservation laws with the ThCM model are given by:

\[ U_t + F(U)_x + G(U)_y = 0 \]

where \( U \) are the conservative variables and \( F \) and \( G \) are the conservative fluxes in the \( x \) and \( y \) directions respectively.

Simulation of the Wisconsin RM Shock Tube Experiments

A series of two Richtmyer-Meshkov instability experiments were conducted in the University of Wisconsin’s shock tube and have been simulated with the numerical model. In these experiments, the distance from the interface to the center of the test section was 0.587 m and an initial condition was obtained by the extraction of a sinusoidal copper plate which resulted in a Rayleigh-Taylor instability. The RT formed initial condition just prior (< 10 ms) before the shock interaction was recorded. A time series representation of the initial condition was used as the input initial condition for the simulation. The parameters of each of the experiments and the details of the calculations are presented below.

Simulation of Test Problem #1

Boundary condition

Inflow condition of air with parameters behind shock is set on the left boundary and other boundaries are rigid walls.

Mesh

The mesh is square for \( x \times y \). Zone size of 0.2 cm and 60 zones per region width.

Initial conditions

\[
\begin{align*}
\text{Density} & \quad 18.2641 & \quad 12.05 & \quad 1.67 \\
\text{Pressure (bar)} & \quad 1.804997 & \quad 1.17 & \quad 1.67 \\
\text{Mass velocity (m/s)} & \quad 0.0001 & \quad 0.0002 & \quad 0.0003
\end{align*}
\]

Results

The left most series of images shows the volume fractions of the two gas species as a function of time. The center set of images are 5% and 95% volume fraction isolines. The third column shows the local velocity vectors.

The graph below shows the total mass of each material in the mixing zone (from 5% to 95% of the volume fraction). The points on the graph correspond to the times in the images on the left.