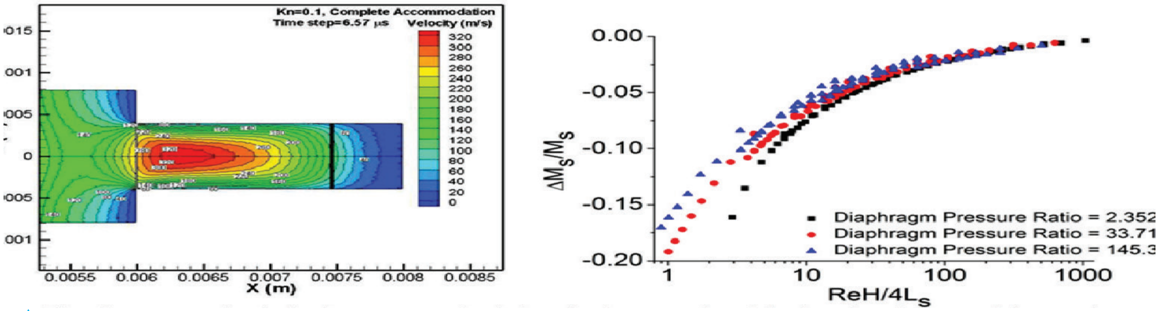
Computer simulation of shock waves at micro-scales



Simulation result with the shock wave (shown by the dark vertical line) and the flow-field details. The figure on the right shows the data

Shock waves are phenomena occurring in compressible fluids such as gases in which very large difference in pressure can occur over a very small distance. A shock wave can be thought of as a very thin front across which a large pressure increase exists, with the front moving rapidly in the fluid medium in which it is created. The sound waves generated when we speak are essentially very weak shock waves. When explosives go off, the shock wave generated as a consequence of the explosion is responsible for the damage that happens to the surroundings. One specific area of interest that has garnered significant attention in the past two decades is generation of shock waves at micro-scales, that is, in tubes of sub-millimeter scale diameters. The micro-shock waves can be used in several applications such as micro-particle drug delivery therapy for diseases such as cancer, combustion in miniaturised systems, material testing under nanometer-scales, micro-propulsion devices, to name a few.

Our work focuses on the fundamental aspects of shock wave propagation in micro-scale tubes, since such understanding of a process eventually leads to better system design in a given application. The shock wave propagation and behavior in micro-scale tubes requires a more detailed fluid dynamical model of description than the one used for its propagation in large tubes. Additionally, if the working pressures in the tube are sufficiently low, an altogether different approach is needed, wherein the fluid is described as an aggregate of a large number of discrete molecules. The work performed in the Computational Gas Dynamics Laboratory has employed computer simulations to describe how shock waves propagate in micro-scale tubes, using both approaches mentioned above. Using detailed computer simulations, the underlying fluid dynamical processes have been clearly explained. Large amount of the computer simulation data has been processed to develop a relation that describes how a shock wave moves in a micro-scale tube. In addition, a novel technique has been developed while employing the discrete molecular approach of simulation.

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