Investigation of the Richtmyer-Meshkov Instability with Double Perturbation Interface in Non-uniform Flows

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Abstract

A non-uniform SF_6 gas flow initial condition has been actualized in the context of shock tube experiment for the Richtmyer-Meshkov instability study. Two kinds of amplitude have been used to design the membrane supports which initially materialize the gaseous interface. The visualizations of Air/SF_6 sinusoidal interfaces and shock wave propagations in the non-uniform field were obtained by Schlieren photography. Experiments are in very good agreement with simulations for the Air/SF_6 case, but due to the initial non-uniform effects, Sadot model and Zhang-Sohn theory are far beyond the experimental and calculation results.

Introduction

Richtmyer-Meshkov (RM) instability has been studied in many theoretical, numerical, and experimental works. Pure hydrodynamics RM experiments are mainly realized in shock tubes. In the case of the RM instability, the interface between the two gases is always unstable due to the vorticity production linked with the misalignment between the pressure and the density gradients when the shock wave passes through the interface. Afterwards the interface perturbations grow and develop into spikes and bubbles which can evolve into mushroom structures. The small perturbations initially presented on the interface will grow first linearly, then at later time, nonlinear development of the perturbations will take place and subsequent transition to turbulence will occur. The shock wave interaction with instable interface has gained much attention over the past decades, due to its importance in physics systems such as inertial confinement fusion (ICF) and astrophysical phenomena. As we all know that different initial conditions have a major effect on the development and evolution of the interface instability throughout the process. Numerous papers stress the uncertainty about the initial conditions of the interface and it can induce more uncertainty in the use of experimental data to test numerical schemes. In all known horizontal or vertical shock tube experiments, the initial interfacial conditions are rarely accurately measured but often backwards estimated. Recently, a novel method to produce an accurately profiled initial interface has been developed to study the instability of a gaseous interface impulsively accelerated in a shock tube. As a consequence, experiments that are more suited to both theoretical and numerical studies are needed.

In those papers published, whether experimental or numerical simulation studies interface instability, the initial flows are almost seen as a uniform flow field. However, we are well aware that the initial flow state could produce to a certain extent effect on development and evolution of the interface instability. Thus, the aim of the present paper is to investigate the influence of non-uniform flow initial conditions on the interface instability.

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