The Mechanism of Liquid Dispersing from a Cylinder Driven by Central Dynamic Shock Loading

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Abstract. A systematic investigation on the mechanism of dynamic liquid dispersing process via theoretical and experimental approach is presented. Based on the experimental results, dynamic analysis, one-dimensional characteristics analysis and some numerical simulation are carried out. The stretching and shearing actions, spall fracture mechanism and characters of cavitation layered are explored. Then the thermodynamic non-equilibrium process, metastable liquid dispersing, cavitation generation and some multiscale mechanisms are revealed.

1. Introduction
The transient process of liquid atomizing dispersion driven by dynamical shock loading is a complicated phenomenon relating not only macroscopic mechanical forces, but also microscopic physicochemical actions as well as mesoscopic effects [1]. The typical dispersing system is a cylindrical container filled with liquid substances and a central dynamic shock loading source structure.

Since 1959, in order to control the efficiency of vaporization and the generation efficiency of aerosol for the low volatile liquid, the experimental works and theoretic analysis on the mechanism of explosive dissemination of liquid have been carried out [2]. During the following several decades, a series of systematic investigations were conducted, and their research contents involved that the equations of state of liquids, the propagation of blast waves, the stability of detonation products-liquid interface, the cavitation on liquid-air interface and spreading into the inside of liquid fill, the formation of cavitation layers in liquid, the mixing dispersing flow of liquid particles and liquid vapor, the energy threshold for different instability pattern, as well as the modeling for numerical simulation etc. [3-5].

In this paper, we focus on the multiscale mechanism of shock interacting with liquid during the atomizing dispersal driven by central dynamic shock loading.

2. Overview of the experimental results of liquid dispersing flow
The following sections include our further analysis to the typical experimental results for further revealing the mechanism of dynamic liquid dispersion driven by shock loading, which are the dispersing flow of mixture of vapor and liquid droplets, the viscous liquid spallation dispersal, the effects of cylindrical shell constraints on liquid dispersing flow, and the cylindrical shell expanding and breaking process captured by flash-X radiograph.

3. Dynamic state of liquid under the action of blast waves
By the means of analysis of the variation characteristics of shock wave pressure in liquid, the shock compression characteristics of liquids, the expansion action of detonation products, the liquid being only subjected to the medium and low intensity shock wave, the shock wave cannot directly inducing the phase transition of water and glycerol, and the propelling action of expanding bubble being difficult to become the driving force of liquid dispersion are clarified. Whereas, the blast waves formed by shock wave and its reflected rarefaction wave are the real power of liquid dispersion.

4. The mechanism of liquid atomized dispersal driven by central explosion

Based on the principle of wave propagation and interaction, the mechanism of tensile stress and cavitation fracture of liquid can be qualitatively analyzed.

![Figure 1](image)

**Figure 1.** The characteristics diagram of propagation of partial blast waves in detonation products gas, liquid and air. (a) is for weak constraint and (b) is for strong constraint.

In figure 1., FTL means the line of first tension which is determined by the intersection of heads and tails of two rarefaction wave RW (2) and RW (3), which can be used to reveal the mechanism of glycerol spallation and cavitation layered in liquid, the influence of cylindrical shell to the liquid dispersing flow, and the metastable liquid dispersion mechanism.

5. Conclusion

In view of the fact that during the process of explosion-driven liquid dispersion, the liquid is subjected to the shock compression, negative pressure stretching, tensile shear and other complex mechanical states, the microscopic mechanisms of thermodynamics, nucleation and chemical reaction need to be made some in-depth investigations and explorations in the future.

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