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The influence of nozzle diameters on the interaction characteristic of combustion-gas jets and liquid

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Abstract: To investigate the controlling method of interior ballistic stability of bulk-loaded propellant guns, the combustion-gas generator and cylindrical stepped-wall chamber are designed aiming at the injection processes of combustion-gases in liquid. The expansion courses of Taylor cavities and the turbulent mixing characteristic of gas-liquid are recorded by means of high speed photographic system. Based on the experiment, three-dimensional unsteady model on the interaction of gas and liquid is established to simulate expansion characteristics of twin combustion-gas jets in liquid under different nozzle diameters. The distribution regularities of characteristic parameter in jet field are obtained and analyzed. The results show the pressure, velocity and temperature distributions under different nozzle diameters are basically the same at the initial time. As time goes on, these characteristic parameters under different nozzle diameters have large differences.

Keywords: fluid mechanics, combustion-gases, Taylor cavities, jet shape; bulk-loaded propellant

1. Introduction

The researchers and scholars all over the world are concerning about gas jets in water in recent years. Its applications are so wide in the engineering technology, involving underwater welding and cutting, underwater missile launch and the bull-loaded propellant gun (BLPG) [1, 2]. Aiming at the fluid mechanics mechanism of underwater combustion-gas jets, predecessors had carried out a lot of researches. Dai [3] revealed the evolutionary processes of back-attack of the gas jet by means of visualization experiments. Xu [4] tracked the gas-liquid interface by adopting the VOF model and did numerical simulation on flow field of combustion-gas jets in water without considering vaporization. Weiland [5] analyzed that the supersonic gas jet in water is highly turbulent and unsteady and obtained that when the shock wave inside the jet came across the unsteady gas-liquid interface, it reassembled the energy and then reflect back with impacting the nozzle surface. So the "back-attack" is actually a feedback phenomenon of shock wave. Guo [6] studied the gas-liquid complex flows of gas jets in water and indicated the gas jets are wobbling at random due to the effect of large scale energy exchange by gas-water mixing and entrainment, and the wobble effect is affected a lot by environment flow at the zone of established flow. In addition, based on the BLPG, the ignition method of combustion-gas jets with high temperature and high pressure at the breech is usually adopted and the liquid propellant filling in the combustion chamber is broken to form a certain burning surface under the effect of fluid instability. However, the ignition processes with this breakup mechanism of liquid propellant has a great random, just resulting in uncontrolled interior ballistic performance in the BLPG. To introduce some controlling means, Talley [7] proposed a