Experimental Research on Effects of Initial Perturbations on Rayleigh-Taylor Instability Growth at Gas-Liquid Interface

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Abstract

Effects of wavelength and amplitude of periodical 2D cosinusoidal perturbations on Rayleigh-Taylor(RT) instability growth at the gas-liquid interface was investigated. A layer of low-strength, dissolved-in-water-gelatin was employed for modeling the liquid driven with gas explosive mixture products. It was shown that wavelength was a main influence factor on RT instability growth, and short-wavelength perturbations grew more rapidly in the linear stage, but long-wavelength perturbations grew more rapidly in the nonlinear stage.

Introduction

Since 1979, VNIIEF has used the jelly technique to model and study time-dependent hydrodynamic flows. During the 1980s and 1990s, a number of studies performed using the jelly technique were published. This is the technique based on the use of test samples made of jelly that are subjected to pulsed pressure. Due to its relatively high strength, jelly is suitable for making quite intricately shaped test samples. Moreover, when loaded by several atmospheres pressure it behaves like incompressible liquid. Given jelly transparency, photography techniques can be used for observations.

This report presents the results of the experimental investigation of effects of wavelength and amplitude of periodical 2D cosinusoidal perturbations on RT instability growth at the gas-liquid interface.

Experimental scheme

The experiments have been performed on the experimental setup shown in Fig. 1.

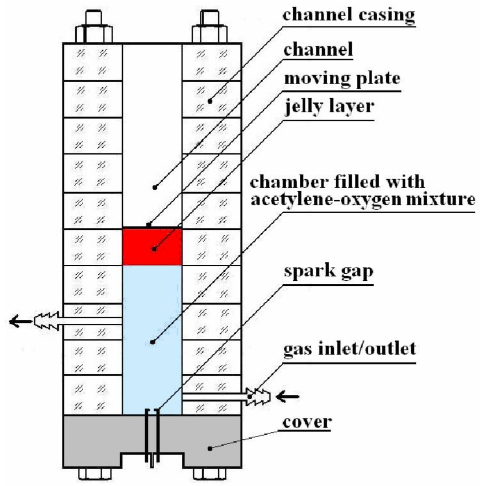


Fig.1. Schematic of experimental facility

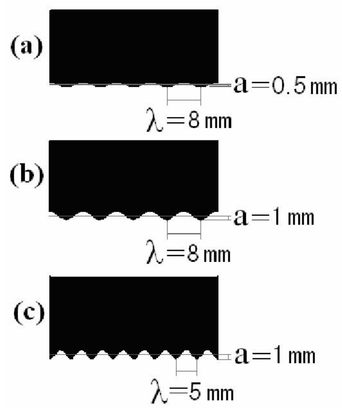


Fig.2. Schematic of initial perturbations

The experimental setup has consisted of a transparent channel of a square shape 40×40 mm and a metallic cover joined together. The channel was divided by the jelly layer into two parts: the accelerating channel and the chamber filled with gas explosive mixture (GEM, C_2H_2+2.5O_2). The GEM detonation was initiated by one electric spark at the cover centre.

The experiments used the jelly consisting of gelatin water solution with the concentrations C = 3.5%. The initial perturbations of the unstable interface were chosen in the form of 2D cosinusoidal perturbations.

The schematic of initial perturbations is presented in Fig.2.

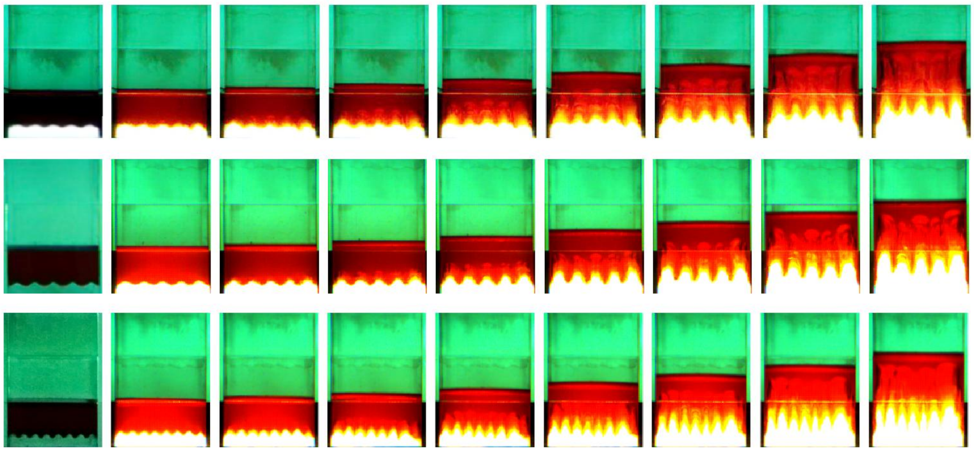
Experimental results

The experimental results for investigation of evolution of perturbations initially specified in the form of 2D cosinusoidal perturbations on unstable surface of the plane jelly layer are given in Fig. 3.

a)

b)

c)



t= 0 μs 100 μs 200 μs 300 μs 400 μs 500 μs 600 μs 700 μs 800 μs

Fig.3. Photochronography of the jelly layer accelerated by the gas explosive mixture products. a)－a=0.5 mm,λ=8 mm; b)－a=1 mm,λ=8 mm; c)－a=1 mm,λ=5 mm.

Fig.4 presents the handling results for these experiments:

- the dependence of the averaged penetration depth(bubbles into jelly) h_b on jelly displacement Z;
- the dependence of the averaged penetration depth(jelly(jets) into bubbles) h_s on jelly displacement Z;

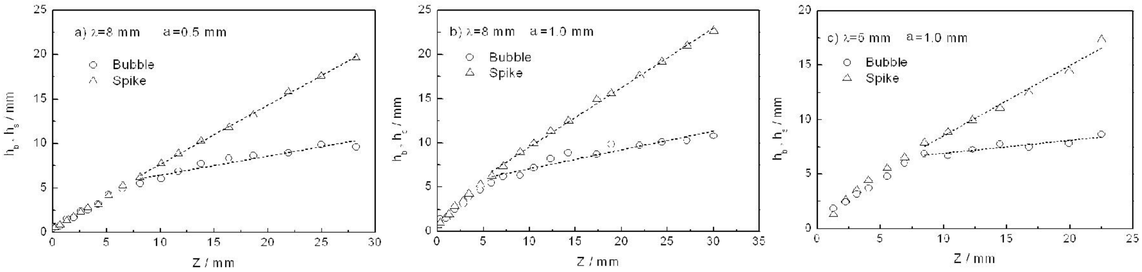


Fig.4. Processed results: the dependence of the averaged penetration depth h_b and h_s on jelly displacement Z. a)－a=0.5 mm,λ=8 mm; b)－a=1 mm,λ=8 mm; c)－a=1 mm,λ=5 mm.

Table.1. The experimental results of α_s and α_b

λ /(mm)	a /(mm)	α_s	α_b
8.0	0.5	0.3325	0.1063
8.0	1.0	0.3364	0.1064
5.0	1.0	0.3225	0.0598

Particular attention is given for the following:

- During the linear stage, the averaged amplitude h(h= h_b +h_s) of the initial short-wavelength perturbation grew more rapidly. At the end of this stage, in the case of λ=5 mm the averaged amplitude h increased to 12.55 mm, however, in the case of λ=8 mm the averaged amplitude h only increased to 10.2 mm(a=0.5 mm) and 10 mm(a=1 mm).

- During the nonlinear stage, the averaged amplitude h(h= h_b +h_s) of the initial long-wavelength perturbation grew more rapidly. Table.1 presents the experimental results of the spike and bubble growth coefficients α_s and α_b. In this stage, for the bubble, α_b obviously increased with the wavelength; for the spike, α_s almost had no increasing with the wavelength.

Conclusions

The results of the experiments are:

- The wavelength was a main influence factor on RT instability growth during both the linear stage and the nonlinear stage
- Short-wavelength perturbations grew more rapidly in the linear stage,
- Long-wavelength perturbations grew more rapidly in the nonlinear stage.

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