EXPERIMENTAL STUDY INTO THE RAYLEIGH-TAYLOR INSTABILITY EVOLUTION IN A CONTINUOUS DISTRIBUTION DENSITY LAYER

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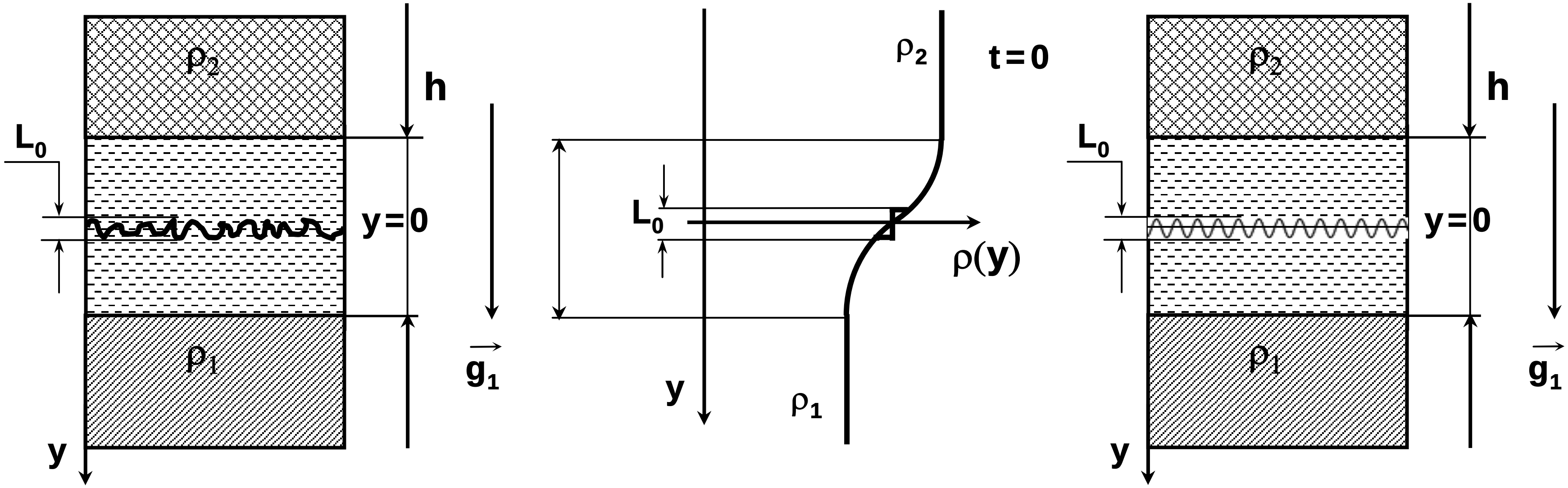
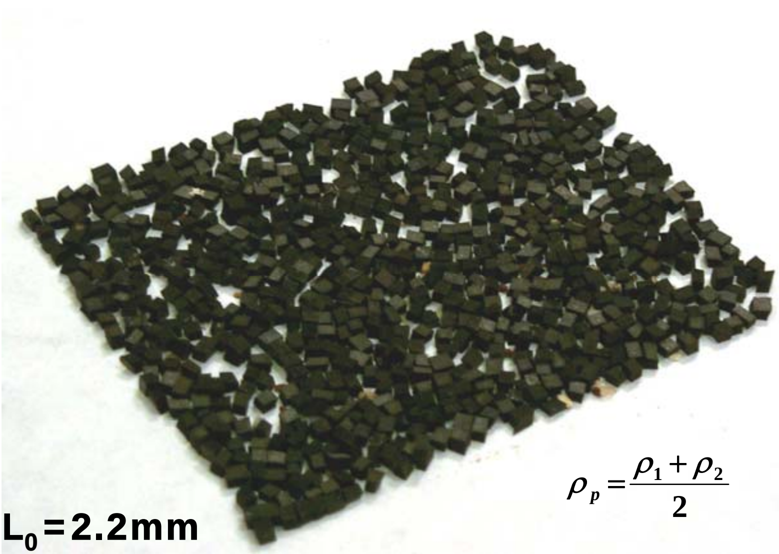
- It is known that at a flat contact boundary of two different density liquids with a density jump the Rayleigh-Taylor instability develops if the density and pressure gradients direct towards each other.
- At that small interface perturbations grow passing a number of stages in their evolution. Finally the instability evolution results in turbulent mixing which, under certain conditions, transforms into the self-similar regime. As a result, a turbulent mixing zone arises the width of which is an integral parameter.

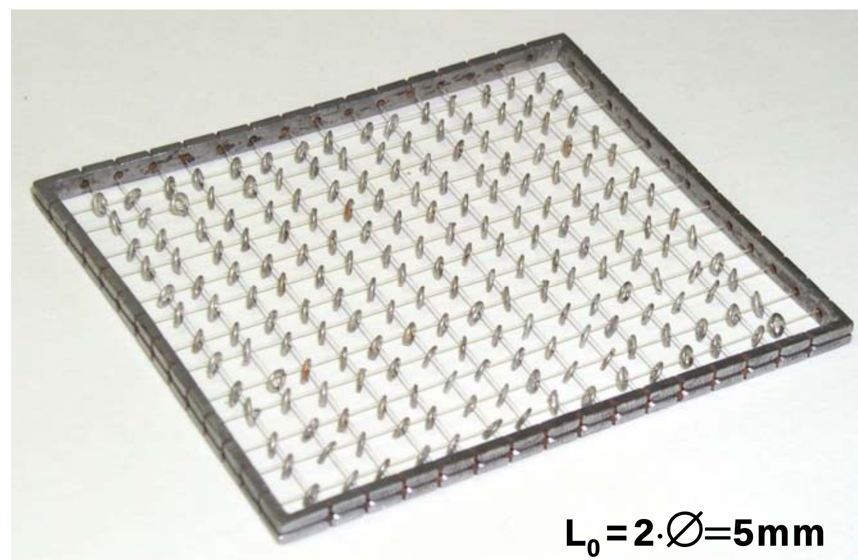
- If now to create a layer of width ***h*** with continuous distribution of density between a heavy liquid and a light one (transitional layer) and to generate perturbations by either method in the middle of that layer then, in the result of the Rayleigh-Taylor instability action, those perturbations will develop as well. But in this case the perturbations development will occur with less velocity in comparison with the case of a density jump. The goal of the present work is comparison of evolution rate of the perturbations being generated in the middle of the transitional layer and characterized by different initial and boundary conditions for different Atwood numbers.

Physical scheme of set up of experiments





Irregular shape solid particles

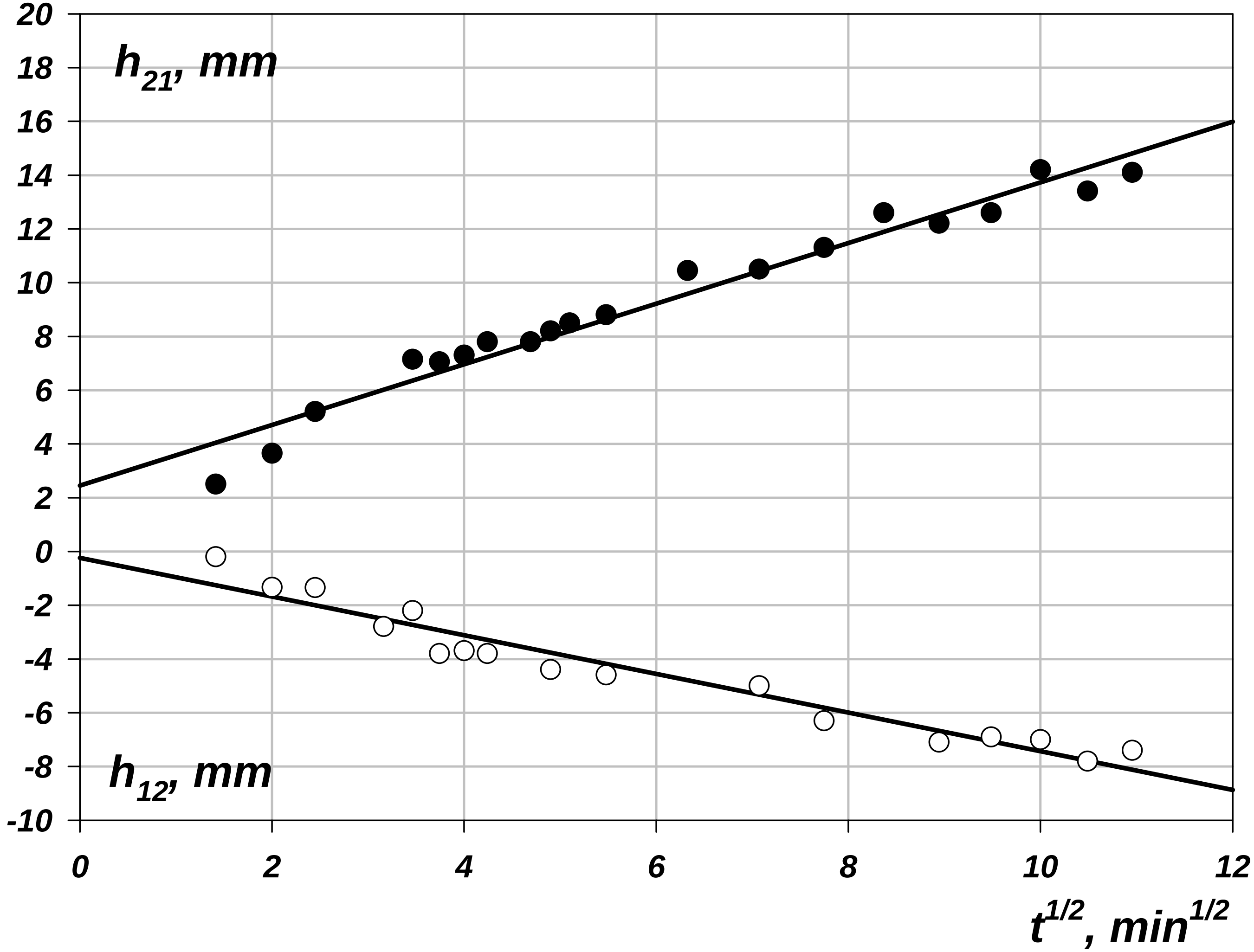


Grid with small rings for generating a single mode perturbation

Transitional layer forming

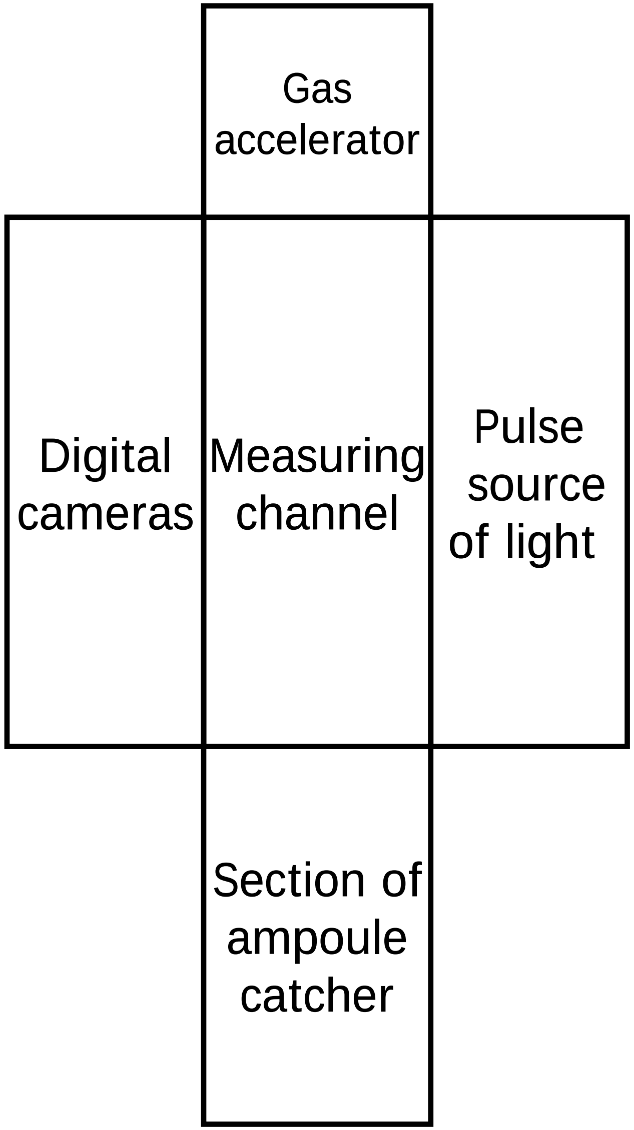
- The transitional layer forms owing to mutual diffusion of miscible liquids composing an investigated system.
- At the initial moment of time a light liquid is above a heavy one in the Earth field of gravity, and there is a flat contact boundary between them. The principal difficulty here is to create a flat contact boundary between the liquids in the course of the ampoule filling.
- A light liquid is placed upon a heavy one with using a special arrangement which provides smooth spread of a light liquid along the heavy liquid surface at the initial moment of the liquids contiguity.

Transitional layer boundaries positions for the system of aqueous solution of zinc chloride – water versus time (density ratio *n* = 2)



Measuring module scheme

(SOM facility)



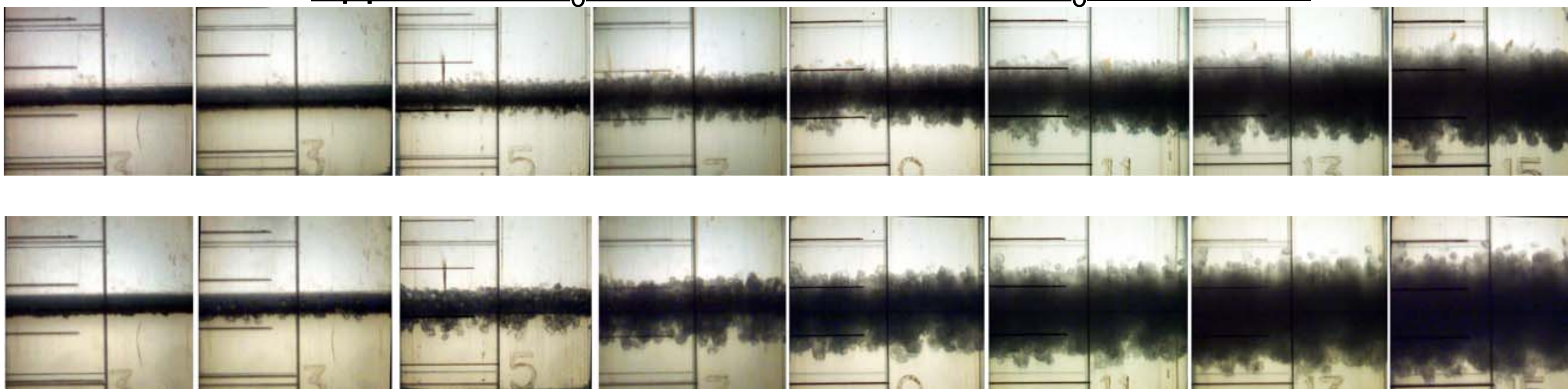
- Investigated liquids were put in a hermetic ampoule of rectangular cross section equipped with transparent windows.
- Dimensions of the working volume of the ampoule were (52x64x120) mm^3.
- The ampoule was accelerated with gas flow of the initial pressure $\boldsymbol{P}_0 = 9.5 \times 10^5$ Pa.
- The initial acceleration of the ampoule for the 1st, 3rd, and 4th series of experiments was $\boldsymbol{g}_1 = 380\boldsymbol{g}$ (specific mass of the equipped ampoule was 25.1 g/cm2) and for the 2nd and the 5th ones - $\boldsymbol{g}_1 = 280\boldsymbol{g}$ (specific mass of the equipped ampoule was 34.05 g/cm^2), $\boldsymbol{g}$ is the Earth's gravity field acceleration.
- There were performed five series of experiments. Each series consisted of several groups of 12 – 15 experiments in each group.

Parameters of the experiments

Series Number	Studied system	Atwood Number	h, mm	L_0, mm
1	Aqueous solution of zinc chloride – water. Single mode perturbation, $\lambda = 4$ mm.	0.2	13.0	5.0; 8.0; 13.0.
			19.0	
			25.0	
2	Clerichi liquid – water. Single mode perturbation, $\lambda = 4$ mm.	0.5	10.5	5.0; 8.0; 13.0.
			17.0	
			25.5	
3	Aqueous solution of zinc chloride – water. Perturbations were generated with solid particles.	0.2	13.0	1.1; 2.2; 4.2.
4	Aqueous solution of zinc chloride – water. Perturbations were generated with solid particles.	0.33	22.0	1.5
			10.7	1.5
			22.0	7.0
5	Clerichi liquid – water. Perturbations were generated with solid particles.	0.5	10.5	1.0; 2.4; 4.0.
			17.0	
			25.5	

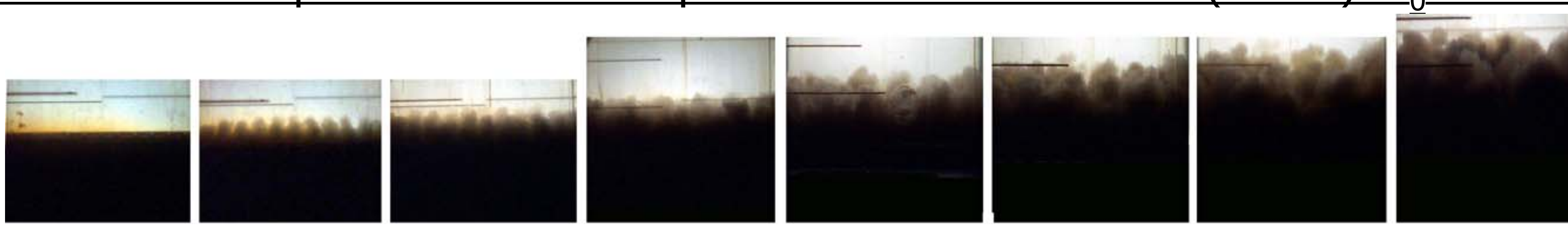
Photo images of the perturbations evolution

Evolution of the perturbations for two experiments of the 3rd series (A=0.2).
Upper row: L_0 = 1.1 mm, lower row: L_0 = 2.2 mm.



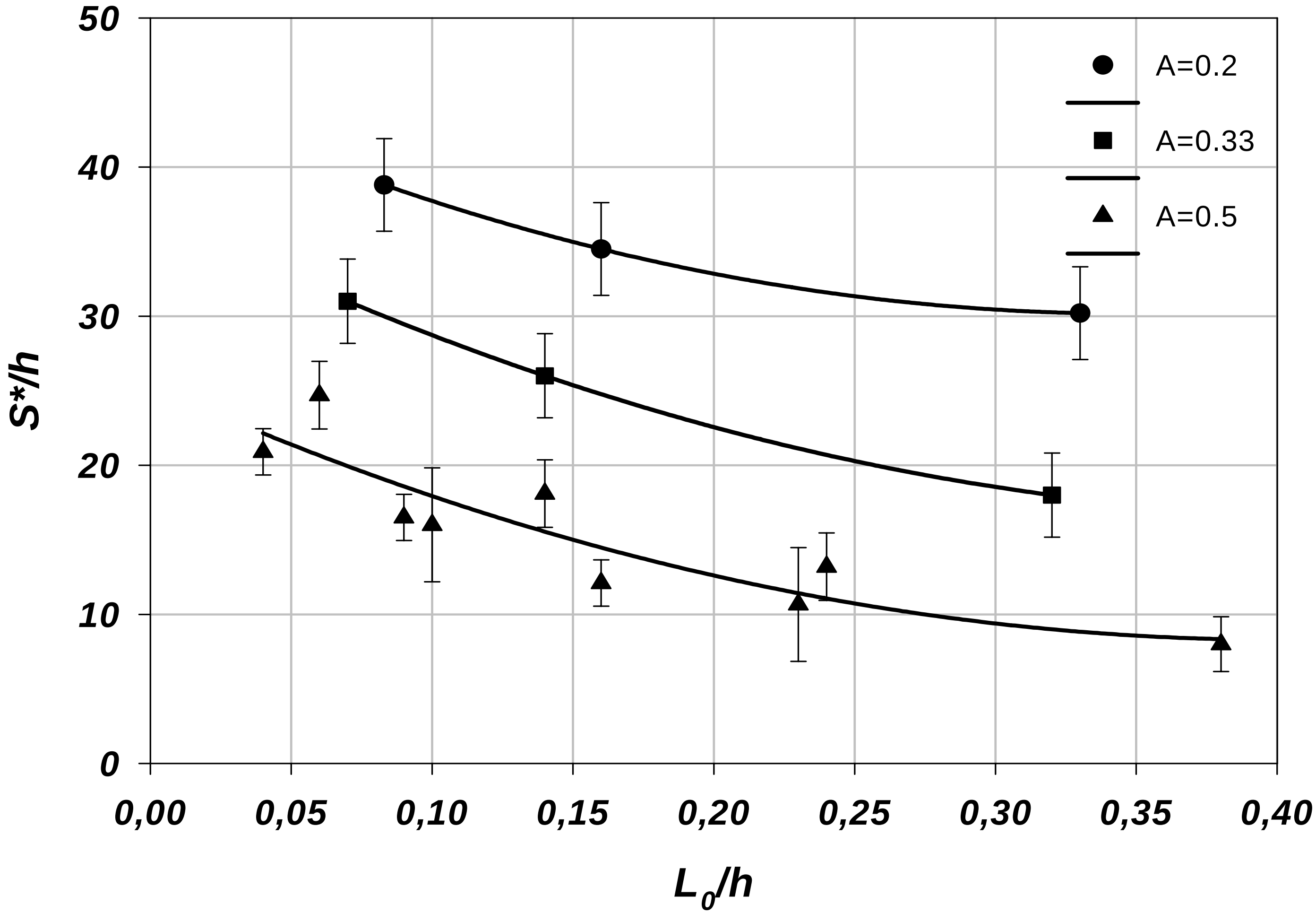
S=0mm S=56mm S=168mm S=280mm S=392mm S=504mm S=616mm S=728mm

Evolution of the perturbations for experiment of the 2nd series (A=0.5). L_0 = 5 mm.

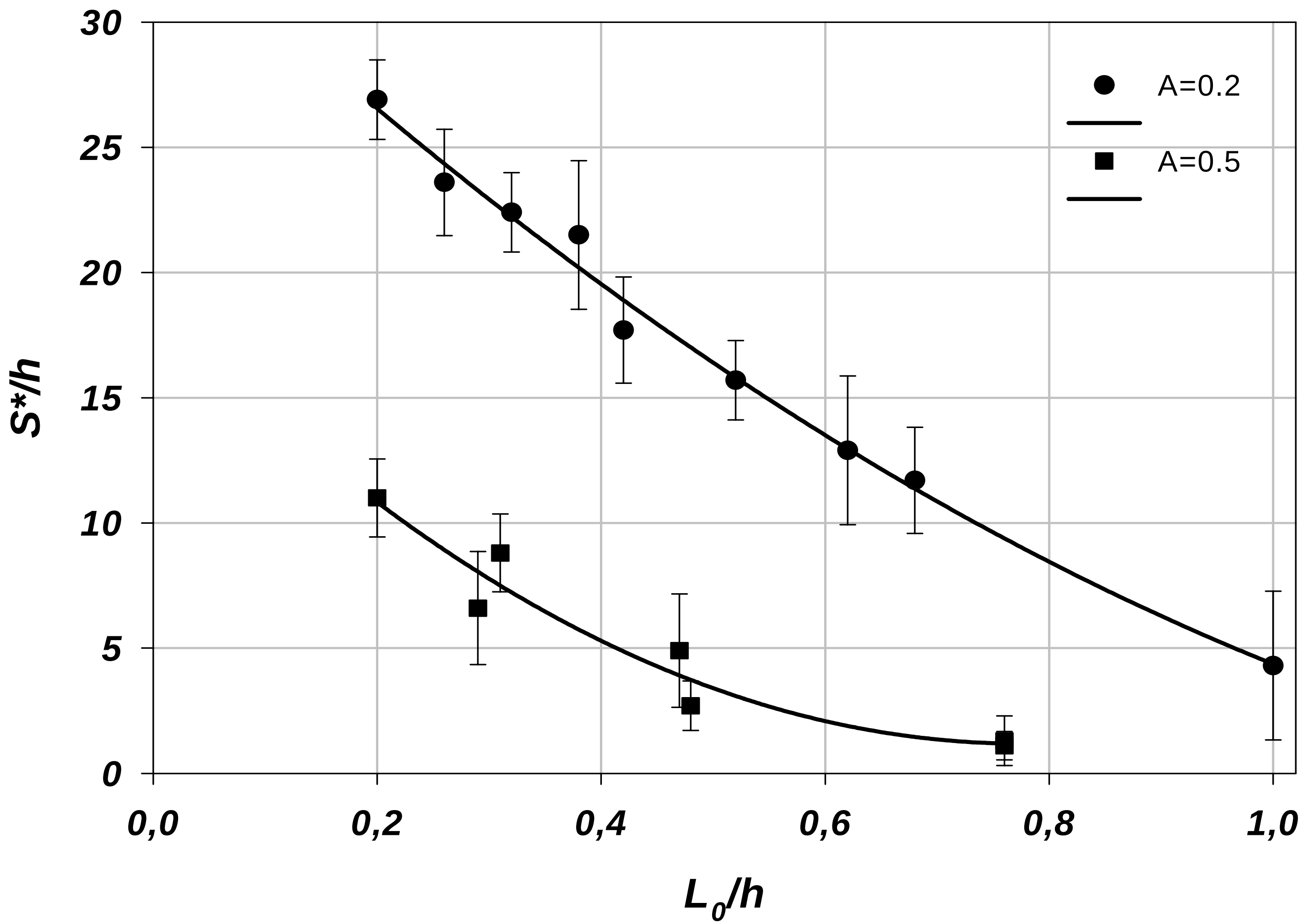


S=0mm S=56mm S=168mm S=280mm S=420mm S=532mm S=644mm S=756mm

By photo images in each experiment there was determined the flight distance of the ampoule ***S**** (displacement of the initial contact boundary of the system) at that the perturbation amplitude exceeded the transitional layer bounds. This quantity characterizes the growth rate of the perturbation amplitude.



Dependences of S^*/h on the initial relative width of the perturbation zone L_0/h of solid spectrum for three pairs of liquids



Dependences of S^* / h on the initial relative width of the single mode perturbation (λ = 4 mm) zone L_0/h for two pairs of liquids.

Conclusion

- It was obtained that the perturbations evolution in the transitional layer is the faster the greater both the initial ratio of the perturbation zone width to the transitional layer width $\boldsymbol{L}_0/\boldsymbol{h}$ and the Atwood number of the studied liquid are. It follows from the obtained results that location of the transitional layer at the interface of different density liquids for small values of $\boldsymbol{L}_0/\boldsymbol{h}$ can greatly delay evolution of turbulent mixing.