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# Turbulent mixing of multiphase flows in a gravitational field

**Edward Son**

Department of Physical Mechanics,
Moscow Institute of Physics and Technology, Russia
son@son.rector.mipt.ru
http://www.fizteh.ru

Turbulent mixing of stratified multiphase flows in a gravitational field is considered. Examples of multiphase flows are the flow of gas-oil-water in channel or pipe inclined to the horizon, convective gas flow of different densities, etc. At given pressure drop along the horizontal channel velocities of fluids of different densities give the result of slip velocities at the interfaces between layers and as result the Kelvin-Helmholtz instability. In the case of stable stratification this instability suppresses by gravity field (inverse Rayleigh-Taylor instability) and we can observe linear and then nonlinear stages of mixing layer development. At high Reynolds numbers turbulent mixing arises and the mixing layer in the gravity field is stabilized at some level. Experimental investigations for gas convective flow has been published Harlow (2001) and for multiphase flows Theron&Unwin (1996). In the present report we have developed linear theory of combined Kelvin – Helmholtz instability Inogamov et all (1999) in multiphase laminar viscous flows suppressed by gravity fields, nonlinear development of this instability, transition to the turbulence and turbulent models Onuphriev et all (2003) for high Reynolds numbers. Some preliminary LES and DNS results are also presented. For the simple case of two stratified fluids of very different densities like gas and liquid the solution for both the liquid and the gas regions can be obtained satisfying matching conditions at the interface. Such a solution will be applicable only to smooth surfaces, for the case of instability or turbulent flows it will be quite complex. Some essential results for mixing turbulent layers achieved in experiments and computations in accelerating shock waves and in ocean wind surface have been used for formulating turbulent models.

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## References

Inogamov N.A., Demianov A.Yu., Son E.E., 1999 Hydrodynamics of mixing. Periodical structures. Subharmonics generation. MIPT Publishing House, 464 p.

Son E.E. 2003 Multiphase Hydrodynamics, MIPT Conf. Invited Lecture.

Onuphriev A.T., Sapharof R.A., Son K.E., Son E.E. 2003 Semiempirical models of Turbulence. Theory and Experiment. Moscow, Science Publisher House (NAUKA) 346 P.

Theron B.E.&Unwin T. 1996 Stratified Flow Model and Interpretation in Horizontal Well, SPE 36560, SPE Conference USA, Denver, Colorado.

Harlow F. 2001 Los Alamos Report.