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Author: Dr. Nikolai Kozlov
PSPU, Russian Federation

Ms. Anastasiya Salnikova
PSPU, Russian Federation
Prof. Moncef Stambouli
Ecole Centrale de Paris, France

VIBRATIONAL DYNAMICS OF TWO IMMISCIBLE LIQUIDS UNDER ROTATION

Abstract

Influence of oscillating force fields on the dynamics of two immiscible liquids of different density in a rotating cylindrical container is studied experimentally. The problem is considered from the vibrational mechanics point of view – the average dynamics of the system is investigated. In the absence of vibrations, the rotating liquids form an axisymmetric coaxial system. The two-liquid system is subject to the action of translational vibrations, longitudinal and transversal relative to the container axis, as well as transversal vibrations of circular polarization with the frequency equal to that of rotation. The latter case is modeled by rotating a horizontal container in a static force field (gravity).

It is found that the oscillating force fields produce strong average effects. These are mostly expressed in case of the resonant excitation of the system proper oscillations. Under longitudinal vibrations a standing inertial wave is excited on the interface. An axisymmetric system of toroidal vortices is then formed in the internal liquid layer. The differential azimuthal rotation of the interface is excited. At the relative vibration frequency increase, excitation of a space periodic axisymmetric quasi-stationary relief on the phase interface is revealed.

Transversal vibrations excite circular oscillations of the light liquid column relative to the container. This is due to an azimuthal inertial wave, appearing in a resonant way. Depending on the vibration frequency, the wave propagation in the container frame occurs either in the sense of the container rotation, or in the opposite direction, and is accompanied by an outstripping or retrograde motion of the interface, respectively. In case of intensive vibrations a relief consisting of longitudinal crests is formed on the liquid-liquid interface. The ratio of vibration and rotation frequencies is one of the governing parameters for dynamics of a two-liquid system.

At the vibrations of circular polarization, the excitation of azimuthal waves is observed. It also results in generation of average flows, particularly, azimuthal motion of the liquids. At certain liquids volume ratio, auto-oscillations of the system are observed: a periodic change of the interface shape at unchanged experimental conditions.

The research results are of interest for the vibrational control of multiphase systems in the microgravity conditions.

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