66th International Astronautical Congress 2015

MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Fluid and Materials Sciences (2)

Author: Dr. Denis Polezhaev
Russian Federation, polezhaev@pspu.ru

Mrs. Veronika Dyakova
PSHPU, Russian Federation, dyakova@pspu.ru
Prof. Victor Kozlov
PSHPU, Russian Federation, kozlov@pspu.ru

OSCILLATORY FLOW AND STEADY STREAMING INSIDE A RAPIDLY ROTATING HORIZONTAL CYLINDER PARTIALLY FILLED WITH LIQUID

Abstract

The dynamics of annular low-viscous liquid layer inside a horizontal rotating cylinder is experimentally studied. In a rapidly rotating cylinder, fluid performs forced oscillations under gravitational force. The free surface of annular fluid layer is stationary in the laboratory frame and has a form of a cylinder which axis is below the axis of the rotating cylinder. In the rotating frame, a fluid distribution is considered as a two-dimensional surface wave propagating in the direction opposite to the cylinder rotation. The travelling surface wave induces azimuthal retrograde steady streaming.

We report the first experimental investigation of oscillatory flow and steady streaming by using a high-speed camera. It is found that frequency of low-viscous liquid oscillations equals to rotation rate and the amplitude has different values near the solid boundary and at the free surface. According to the observations, amplitude of oscillations increases with decrease in rotation rate. The experimental results agree qualitatively with data obtained in theory [1]. Furthermore, the intensification of liquid oscillations under resonant excitation of inertial waves is revealed. Hence, the oscillatory flow represents the superposition of forced and wavy disturbances.

Additionally, azimuthal steady streaming velocity of the free surface is larger than velocity in the bulk of liquid. This is a consequence of the fact that steady streaming is induced by oscillatory viscous flow at free and solid boundaries. It is found that steady streaming velocity is inversely proportional to rotation rate. The observed azimuthal velocity is in good agreement with experimental measurements of free surface velocity [2].

The work is supported by Russian Scientific Foundation (project 14-11-00476).

1. Phillips O.M. Centrifugal waves // J. Fluid Mech. 1960. Vol. 7. pp. 340 – 352.
2. Ivanova A.A., Kozlov V.G., Chigrakov A.V. Dynamics of a fluid in a rotating horizontal cylinder // Fluid Dynamics. 2004. Vol. 39. 4. pp. 594 – 604.