Paper ID: 35373

MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Science Results from Ground Based Research (4)

Author: Prof. Alevtina Ivanova
Russian Federation, a.ivanova@pspu.ru

Prof. Victor Kozlov
PSHPU, Russian Federation, kozlov@pspu.ru
Dr. Ramil Siraev
State National Research Polytechnical University of Perm, Russian Federation, romauld@mail.ru
Dr. Aleksey Vjatkin
PSHPU, Russian Federation, a.a.vjatkin@mail.ru

STEADY THERMAL CONVECTION IN ROTATING ANNULUS EXCITED BY EXTERNAL FORCE FIELD

Abstract

We study the thermal convection in a quickly rotating annulus with isothermal boundaries of different temperatures. The axially symmetric temperature distribution is disturbed by static external force field, which results in liquid oscillations in the cavity frame and steady convection excitation [1] due to "thermovibrational" convection mechanism [2]. Thus, two mechanisms, centrifugal and "thermovibrational" determine the convection. We experimentally study the stability and heat transfer in a rotating horizontal annulus of various relative thickness, as well as solve the problem of convective stability and study the heat transfer by DNS. The theory is based on the equations of thermal vibrational convection in rotating systems, which were obtained by averaging in [3].

Experiments are performed using a special technique to study the flow structure and the wave length of the convective structures. The threshold of convection onset and the heat transfer in the supercritical region are studied. When heating the annulus from the outside, the well-known centrifugal convection manifests itself; the convective rolls diameter is close to the thickness of the layer. When heated from inside in case of rapid rotation, the fluid in the annulus is in equilibrium under the action of centrifugal force. With decreasing the rotational speed, a system of convective rolls parallel to the axis of rotation appears in the layer. Thus, the "thermovibrational" convection takes place even in a stably stratified fluid. All results are presented on the plane of the governing dimensionless parameters, centrifugal Rayleigh number and vibrational parameter. The results of linear analysis, DNS and experiment agree.

Acknowledgement: The work is supported by Russian Science Foundation (Grant 14-11-00476).

References

[1] Vjatkin A.A., Ivanova A.A., and Kozlov V.G.: Convective stability of a nonisothermal fluid in a rotating horizontal coaxial gap. Fluid Dynamics 45:10–18, 2010.
[2] Gershuni G.Z., Lyubimov D.V.: Thermal Vibrational Convection. N.Y.: Wiley, 1998.
[3] Kozlov V.G.: Thermal vibrational convection in rotating cavities. Fluid Dynamics 39:3–11, 2004.