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THERMAL CONVECTION IN ROTATING CAVITY SUBJECT TO TRANSVERSAL VIBRATIONS

Abstract

The impact of translational vibration on the flow structure and heat transfer in a rotating fluid with internal heat release is investigated experimentally. The cavity of cylindrical shape has isothermal lateral boundary. In experiments, the parameters of rotation and vibrations, cavity dimensions and characteristics of the liquids are varied. The study is carried out for the case of relatively rapid rotation, when due to centrifugal force the axisymmetric temperature distribution appears with maximal temperature at the cavity axis and the liquid in a state of stable mechanical equilibrium.

The experiments show that the vibration perpendicular to the axis of rotation disturbs the liquid quasi-equilibrium if the frequencies of rotation and the vibrations coincide. The temperature in the cavity center decreases which indicates the occurrence of the flows and heat away from the center. The heat transfer depends on both amplitude of vibration and the rotation velocity. It could be so intensive, that decrease the temperature on the axis few times. The tiny plastic particles with a density slightly less than the density of the liquid are used for liquid flows visualization. If the frequencies of rotation and vibrations differ significantly the visualizing particles cluster near the cavity axis under the action of centrifugal force, the flow inside the cavity is absent. If the frequencies coincide the particles demonstrate the intense convective currents and arrange in the form of the column along the entire length of the cavity at a certain distance from the axis. The distance between the axis and the particles increases with the amplitude of vibration. The heat transfer strongly depends on the difference between the frequencies of vibration and rotation. Although the width of this area is quite small, the heat transfer curve has a complicated form.

The theoretical description of the found phenomena is elaborated. It is demonstrated that transversal vibration of rotating cavity with a frequency coinciding with the frequency of rotation results in production of an effective average force field in the cavity frame. This field is analogous to the gravity. It is shown that this novel vibrational mechanism and the centrifugal one play a key role in the development of the convection. The results of the research are generalized in the plane of the governing parameters – vibrational and centrifugal Rayleigh numbers.

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