THE STABILIZATION OF CONVECTIVE FLUID STABILITY IN A CUBIC CAVITY BY ROTATION

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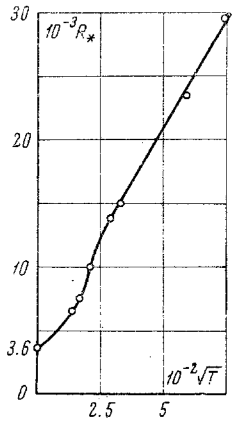
Peper [1] described the experimental investigation of the stability of mechanical equilibrium of a fluid heated from below in a cubic cavity. Two critical convective motions were discovered. The first critical Rayleigh number $R_* = 3650$ corresponds to approximately circular fluid flow in a vertical plane parallel to the boundary of the cube. For $R > 6000$ more complicated three-dimensional critical flow was possible, less stable than the first, and transferring less heat. It is of interest to investigate the effect of rotating the cavity on the development of perturbations of these two types of flow.

Experiments were performed using the same model and method as described in [1]. The cavity was rotated around its vertical axis of symmetry by a synchronous electric motor using a toothless frictional drive. During the time of the experiment the velocity of rotation was maintained constant with an accuracy of 1%. Temperature measurements were carried out on the rotating model in a quasi-steady cooling regime, in which a vertical temperature gradient was created at the beginning of the experiment. Heat transfer curves $N - 1 = f(R)$, where N is the Nusselt number, were constructed for each velocity of rotation. The critical Rayleigh number was determined from the discontinuity of these curves.



The experiments showed that not very far above the critical region $(N - 1)^2 \sim R - R_*$. Thus the Landau law remains valid for rotation. In contrast to the case of a stationary cavity the second type of critical motion could not be observed on rotation. The figure gives the first critical Rayleigh number as a function of $\sqrt{T}$:

Here T is the Taylor number, l is the length of the edge of the cavity, ν is the kinematic viscosity of the fluid for the temperature at the center of the cavity. It is clear from the graph that for $T > 6 \cdot 10^4$, R_* increases linearly with $\sqrt{T}$. For smaller Taylor numbers the maximum central acceleration in the cavity does not exceed $0.5 \cdot 10^{-3} \sqrt{T}$, where e/g is the acceleration due to gravity. In this case the curve straightens out if T is plotted along the abscissa axis. Such a linear function is in qualitative agreement with the results of the theoretical investigation of convective stability of a fluid cube with free boundaries [2].

REFERENCES

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2. M. I. Shliomis, "The stability of a fluid which is rotated and heated from below relative to perturbations which are periodic in time," PMM, vol. 26, no. 2, pp. 267–272, 1962.

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