THE INFLUENCE OF TRANSLATIONAL VIBRATIONS OF CIRCULAR POLARIZATION ON FLUID CONVECTIVE INSTABILITY AND FLOW PATTERNS

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Summary The stability of the mechanical equilibrium, heat transfer and currents of movements fluidy in horizontal plane layer subject to circular translational vibration is investigated experimentally. The ground experimental modeling of thermovibrative currents in the field of translational inertial accelerations with reference to dynamic conditions on space vehicles is planned also. The map of convection modes is constructing. The heat-mass transfer in cavity, both at heating from below and from above were investigated.

In the stratification of density media (gases, liquids, etc.) and under certain external conditions convective movement caused by Archimedean force can arise. The amplified attention to studying convective processes in non-stationary force fields, with reference to conditions of orbital flight, is caused by the development of space technologies, such as the growth of semi-conductor and biological crystals, the reception of especially pure and composite materials, electrophoresis, etc. [2,3] The analysis of weightlessness in real conditions on a space vehicle has shown a necessity to take into account the influence on technological processes not only concerning the gravitational mechanism of convection but also varying in inertial accelerations [3,4]. Measurements of variables inertial accelerations onboard orbital stations " MIR " and "SALUT - 6", and also the " Space Shuttle " show that up to 95 % of capacity accelerations is concentrated in a range of frequencies of 0.1-14 Hz [4,5]. The specified interval corresponds to a range of own frequencies convective systems that determines an opportunity of dynamic excitation convection in microgravity conditions [1]. The performance of necessary researches on space vehicles (SV) is connected to the complexity and the cost of experiments. Therefore it is expedient to carry out laboratory modelling of the phenomena in ground conditions before first-hand experiences on space vehicles.
At laboratory modelling to intensify the vibrational effects in comparison with gravity effects ones it is necessary to create the conditions when Rayleigh vibrational number $Ra_V = (b\beta\omega\theta h)^2/2\nu\chi$ exceeds with gravitational parameter $Ra_G = g\beta\theta h^3/\nu\chi$. Here ν, χ, a are , kinematic viscosity, thermal conductivity of fluid, θ - temperature difference across the layer, h – layer thickness, g and β - acceleration due to gravity and thermal expansion coefficient, b –amplitude and ω - frequency of the vibration The ratio $Ra_V/Ra_G \sim (b\omega)^2\beta\theta/2h$ shows that it is need to use the layers with small thickness, the great temperature difference and mechanical vibrator that the higher vibration velocity is provide.

The stability of the mechanical equilibrium

The threshold curves of mechanical equilibrium are presents in fig. 1(h = 2 mm, heptane). The value of the Ra>0 is account heating from below and $Ra_G < 0$ – heating from above. The line a is represents theoretical border of instability, which cuts on a horizontal axis a piece value Ra_G * = 1.7*10^3, that appropriate to a threshold of occurrence thrmogravitational convection. On a vertical axis the piece Ra_V =2,1*10^3, that appropriate to a threshold of excitation vibroconvection in conditions of weightlessness is cut. The border of stability quasiequilibrium for "high" frequencies is served a curve "b". For "low" frequencies, curve "c", the border of stability quasiequilibrium is displaced in area of higher numbers Ra_v. According to experimental data, it is possible to consider frequencies above 5.5 Hz "high", and is lower 5.2 Hz "low". The results of experiment indicate that of the inertial acceleration, polarized on a circle, decrease the threshold of mechanical equilibrium stability in a flat horizontal layer of a liquid at $Ra_G > 0$. Convective current arises at smaller numbers Ra_G, than critical number Ra_G * in a static case. Besides the given vibrations raise convective movemenent at heating from above – in a situation, absolutely steady in absence of oscillation of a layer, and the threshold curves depends on frequency of external influences.

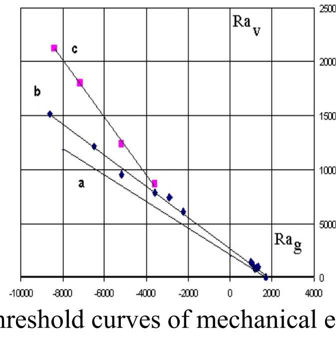

Fig. 1 The threshold curves of mechanical equilibrium a – high frequency line (theory), b – high frequency line (exper-t.), c low frequency line (exper-t.).

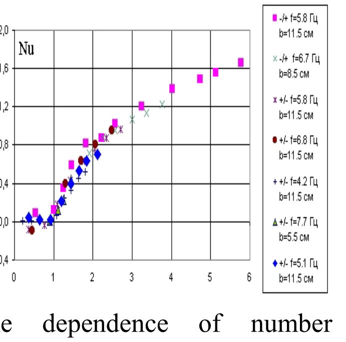

Fig. 2 The dependence of number Nu from supercriticality μ.

In figure 2 the dependence of a dimensionless thermal flow - number Nusselta *Nu* from supercriticality μ is submitted. As it is visible from the diagram, in researched area of parameters experimental value, within the limits of an error, it is good overlay on one curve. The specified behaviour will well be coordinated to root dependence *Nu* ~ Rag1/2, having a place in many convection tasks. It is necessary to notice also that, according to the diagram in figure 3.5, the number Нуссельта at supercriticality equal 4 accepts value 1,4. For comparison, at convection in a static field of weight the number *Nu* for Ra_G/Ra_G^* = 4 accepts value 1. It testifies to substantial growth heat transfer, caused by the vibrating mechanism of the convection, in comparison with a heat transfer caused by the gravitational mechanism of the convection.

Conclusions

The influence polarized on a circle inertial acceleration on stability of mechanical equilibrium of a liquid in a flat horizontal layer is investigated. Is established, that the circular vibrations lower a threshold of occurrence convective of current of a not isothermal liquid. The dependence of a dimensionless thermal flow - number Nu is investigated depending on conditions heating and intensity of vibrations. Influence of forward vibrations of the mentioned above polarization on structures convection also is investigated. Are found out near-threshold oscillatory modes of convection such as "zipper"- state.

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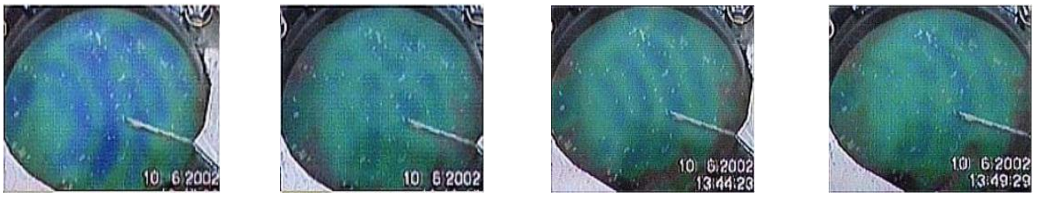

Fig. 3 It is near-threshold oscillations. $Ra_G = 2{,}2*10^3$, b = 11,5 cm, ω = 4,5 Hz

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