JOINT INFLUENCE OF GRAVITATIONAL, TEMPERATURE, ELECTRIC, AND MAGNETIC FIELDS UPON THE APPEARANCE OF CONVECTION IN A CONDUCTING FLUID MEDIUM

O.I. Raychenko, O.O. Raychenko[1]

I.M. Frantsevych Institute for Problems of Materials Science,
Nat. Acad. Sci. of Ukraine
(*3, Krzhyzhanivs'ky Str., Kyiv 03142, Ukraine;*
e-mail: raitch@ipms.kiev.ua),
[1]Physico-Technological Institute of Metals and Alloys,
Nat. Acad. Sci. of Ukraine
(*34/1, Academician Vernadsky Prosp., Kyiv 03142, Ukraine*)

S u m m a r y

The factors influencing conditions of the 'equilibrium – onset of convection" transition in a fluid (liquid, gas) depend on the conductivity and the thermal coefficient of the conductivity of this fluid. These factors (besides the thermal expansion in the gravitational field) include the magnetic and electric fields also. If the spatial Lorentz-force arising due to the superposition of crossed electric and magnetic fields is directed downwards, then its exertion strengthens the action of gravitation, and the critical Rayleigh numbers must be decreased. One must wait the opposite situation in the case of the Lorentz-force directed upwards (increasing the critical Rayleigh numbers). A degree of such exertions is determined by the dimensionless value – the ratio of the spatial Lorentz-force to the hydrostatic head in the gravitational field.

We reveal also the essential importance of the ratio of the temperature coefficients of conductivity and volume expansion for conservation of the fluid medium equilibrium or demolition of this equilibrium. It is determined that the competition between the electromagnetic force which is a result of the nonuniformity of conductivity (due to a temperature dependence of this conductivity) and the Archimedean force (buoyancy) may have ambiguous effect: both an increase or a decrease of the critical Rayleigh numbers. The formula, which is derived for the reduced effective Rayleigh number, shows that this value is a function of two dimensionless values (similarity criteria): 1) the ratio of the Lorentz-force to the hydrostatic head in the gravitational field, and 2) the ratio of the temperature coefficients of conductivity and volume expansion. The theory allows one to forecast the behaviour, for example, of liquid metals. On the analysis of a state of the terrestrial atmosphere, it is proposed to take into account (besides the factors influencing the arising of thermal convection of the Rayleigh–Benard type) the opportunity of appearance of additional factors, which are influenced sometimes, particularly, by Sun's activity: 1) the Lorentz-force which arises due to the interaction between atmospheric electric currents and the terrestrial magnetic field, to which the magnetic field of the particle streams from the Sun is added; 2) the nonuniformity of atmospheric electric currents. The result of the named disturbances may be a peculiar 'gushing" of air masses over the conditional upper boundary of the atmosphere. This phenomenon, in turn, may increase the gas density locally in the space over the atmosphere, create the aerodynamic drag for Earth's satellites flying in these places, and change their trajectories. The proposed approach, maybe, is applicable to the analysis of situations in liquid conductors, conductive gases (plasma), and terrestrial, planetary, and stellar atmospheres.