VORTEX STRUCTURES IN A NON-EQUILIBRIUM GAS

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Vortex structures formation and evolution in a non-equilibrium gas are considered by the example of two problems: convection in a horizontal cylinder and in a system of horizontal coaxial cylinders, and also the structure of the Karman vortex street. It is shown that, as against a linear regime of vortices propagation [1], in a nonlinear case there is an interaction of vortices with a non-equilibrium gas, resulting, on the one hand, in the redistribution of thermal flows and change of non-equilibrium gas parameters and, on the other hand, in the deformation of vortices. These problems, besides theoretical interest, have also the important practical value at designing laser systems and discharge and for the diagnostics.

We considered the problem of convection in the system of two horizontal coaxial cylinders with internal heat generation and various temperatures on the borders. The mathematical model which describes two-dimensional convection has been constructed and the program of calculation of hydrodynamic parameters of environment has been made. The critical surface Ra_T (Ra, σ) (Ra_T- modified Rayleigh number dependent on internal heat generation, Ra - Rayleigh number , σ - ratio of the inner cylinder diameter to the gap width), which generalizes the earlier known results with Ra_T=0 has been constructed. It has been shown that depending on the parameters of the problem we have two variants of two-dimensional currents - one and two-vortical. It has been established that the presence of convection has led to the reduction of the area of a maximum heated gas in comparison with the case of the absence of convection. The convection in the horizontal cylinder with constant heat generation has been considered and the comparison of the maximal temperatures at various system geometry has been made. It is shown that in the case of convection in a cylinder the maximal temperature reduces with increasing heat generation, while in the system of coaxial cylinders the maximal temperature increases at not so small radii of the internal cylinder (Fig.1) . The modification of thermal explosion theory for the cylinder with convection has been created.

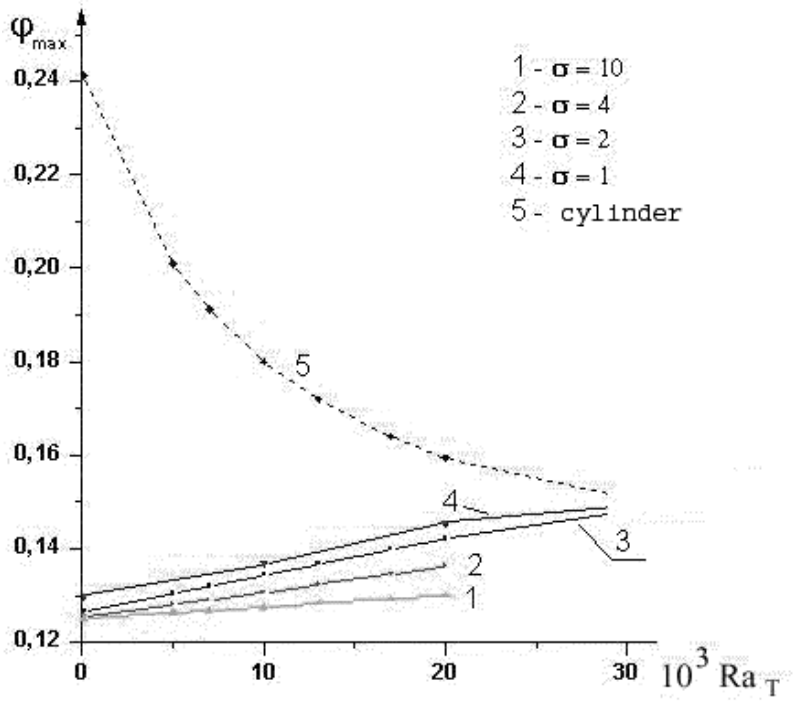

Fig. 1. The maximal temperature from Ra_T at different values of σ

The opposite example is the Karman vortex street in a vibrationally exited gas. The experimental results [2] show the vortex deformation due to vibration relaxation and the change in velocities spectra. The direct numerical simulation shows the main purpose of deformation. The temperature in the vortex street raises due to relaxation. (Fig.2). The three models of relaxation flow have been analyzed (from near incompressible fluid to a full system of hydrodynamics equations). The influence of the compressibility and the boundary condition on the cylinder surface has been discussed.

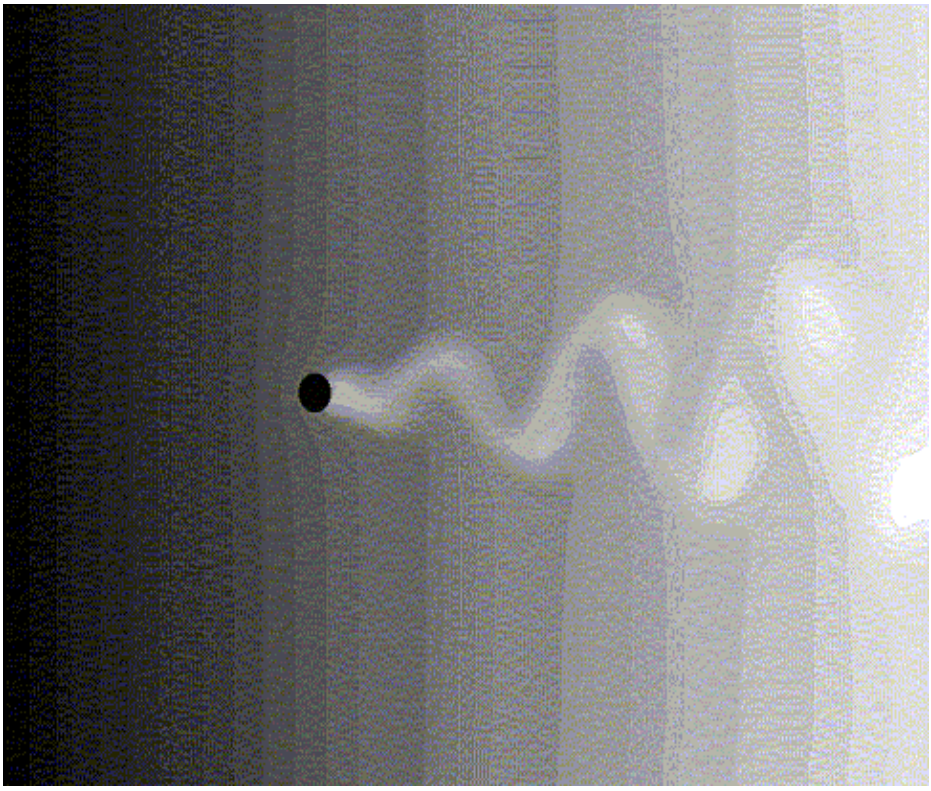

Fig. 2. The Karman vortex street in a non-equilibrium gas (temperature field)

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References

[1] Osipov A.I., Uvarov A.V. Physics-Uspekhi, 1996, **39**, № 6, p 597-608
[2] Gembargevskii G.V., Generalov N.A., Solov'ev N.G. Izvestiya RAN, Seriya Mehanika zidkosti I gaza., 2000, №2, P.81-91.