Numerical study of instability between two cylinders in case of 2D flow

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Investigation of flow stability between two cylinders have besides fundamental interest, also large practical sense, because such flows often meet with different technical equipments.

Problem definition. Mathematical model based on inviscid compressible gas model and involve integral laws of conservation of mass, energy, kinetic momentum. The system of equations closes by equation of state of ideal gas. Supposed, that number of Reynolds (numerical Reynolds) sufficiently great, that flow be able instability. In the capacity of initial data takes the Couette flow. In the middle of clearance between cylinders carries in the local perturbation of radial componentry of velocity with small amplitude and define frequency. At the border used nonflow conditions. Such approach base on [1].

Numerical experiment. Numerical simulation maked with TVD method [2]. We chose the polar mesh with dimension $n_r - n_\varphi$, where n_r - the number of radial nods, n_φ - the number of angle nods. Also, was carried out the investigations on clearing of character of mesh influence, they showed, that mesh small influencing on scale of large vortexes. At reducing of mesh, the numerical viscosity was decreasing, and correspondingly the numerical Reynolds was increasing (in the order of increase the dimension of net $\mathrm{Re} = 1.2*10^5, 1.5*10^5, 1.8*10^5$), the energy of developed turbulent flow also was increasing. In the numerical experiment had calculated the turbulent energy

$E_t = \frac{1}{E_0}\int((u')^2 + (v')^2)dV$, where E_0 - the kinetic energy in initial time, u', v' - the pulsations of radial and angular componentry of velocity correspondingly. The pulsations calculated the follow method: took corner averaging both components of velocity: $\overline{f}(r) = \frac{1}{2\pi}\int_0^{2\pi} f(r,\varphi)d\varphi$, where $\overline{f}$ - the average value of function. Then were calculating pulsations: $f'(r,\varphi) = \overline{f}(r) - f(r,\varphi)$. The investigation had taken on several parameters of job: difference of velocities of internal and external cylinders, width of clearance between cylinders, amplitude and frequency of disturb. In process of calculations, inner cylinder was resting, external was rotating.

Results. Finding of investigation showed, that how large the difference of velocity thereby unsteady the flow. At certain width of clearance ($\Delta R \sim 0.2$) the dependence graph of time t' from ΔR have minimum. The amplitude of perturbation weakly influences on flow. In case frequency of perturbation, had observed long-wave instability: than less the frequency of perturbation, that earlier flow becoming unstable. Beginning of the instability is going with birth of large vortexes. Bearing, the vortexes is beginning actively interaction between itself and are coupling, in total to end of calculations have remained several vortexes with size about width of clearance between cylinders.

Conclusion. Received the dependences of time beginning turbulence of flow t' from different parameters of job, some of dependences received their explanation. Investigated the influence of mesh on parameters of turbulent flow.

Literature

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