Dynamical behaviors of countercurrent axisymmetric shear flows

Xi-Lin Xie[1]

W. W. Mar[2]

H. L. Zhou[1]

[1]*Fudan University, Dept. Mechanics & Engineering Science*
[2]*Donghua University, College of Basic Science*
xiexilin@online.sh.cn

The dynamical behaviors of the coherent structures in the countercurrent axisymmetric shear flows have been experimentally studied. Axisymmetric vortices play an important role in the case of the forward velocity U_1 ranging from 3 to 20 m/s. A critical forward velocity$U_1^{cr} = 6.8\ m/s$ was defined and subsequently the subcritical regime: $U_1 > U_1^{cr}$ and the supercritical regime: $U_1 < U_1^{cr}$. In the subcritical regime the flow system could happen to shear layer self-excited oscillation in a certain range of the velocity ratio. In the supercritical regime, the spatial evolution of the coherent structures undergoes following stages: K-H instability causing vortices rolling-up → first time vortices conglomeration → jet column self-excited oscillation → shear layer self-excited oscillation → 'ordered tearing' → turbulence in the case of U_1 is less than 4 m/s. The 'ordered tearing' does not exist when U_1 is greater than or equal to 4 m/s. Correspondingly, the spatial evolution of the time asymptotic behaviors of the dynamics system could be described as follows: Hopf bifurcation → subharmonic bifurcation → inverse superharmonic bifurcation → superharmonic bifurcation → chaos ('weak turbulence') in the case of U_1 is less than 4 m/s. Superharmonic bifurcation does not exist when U_1 is greater or equal to 4 m/s. The terms: superharmonic and inverse superharmonic bifurcations newly put forward are characteristic of the frequency doubling rather than period doubling.