EXPERIMENTAL RESEARCH OF TURBULENCE GENERATION IN COMPLEX JET FLOWS

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Abstract In this Letter, we observed and analyzed some spatial evolution (rolling up, growing up, pairing, merging and breaking up) of vortexes by self-developed flow facility. Some typical phenomenons are observed directly by using the flow visualization. We changed the inner flow rectangular exits into different shapes (square, small rectangular, big rectangular, small elliptical, big elliptical, and circular) or taken advantage of three parallel jets engender planar-symmetric shear flows. Furthermore, with dynamic surveying technology, we research the typical flow field which we studied by using of auto-power spectrum, cross-spectrum and multiple-spectrum. The following conclusions may be drawn from our work. We have found toroidal vortexes and spiral vortexes both in two experiments above. The pairing of toroidal vortexes has the Batchelor's couples or tri-poles phenomena. The spiral vortexes change to different structures during the change of Reynolds and velocity ratio. It is also revealed that the production of vortexes is determined by the speed at exits, nothing to do with the shape of exits. Besides, after it is engendered, the toroidal vortexes deflect during the change of the speed, and turn to spiral vortexes behind a certain critical value of Reynolds number which is determined by the shape of outlets. The spiral vortexes have the left-hand and right-hand phenomena, and the direction of rotation of it will reverse if attend to another certain velocity. The screw pitch of spiral vortexes structure is in direct proportion to velocity ratio.

Turbulent jets issuing from rectangular exits are of importance for a number of engineering applications. It has been found that certain characteristics of rectangular turbulent jets depend on exits shape, Reynolds number and aspect ratio. The purpose of this paper is to provide for the flow additional data characterizing the influence of exit shape, aspect ration and exit velocity (Reynolds number).

It is found that the certain critical value of Reynolds is closely related to the inner flow rectangular exits shapes when toroidal vortexes turn to spiral vortexes. The greater the exits curvature, the greater the certain critical value of Reynolds number. It also depended on and increased with aspect ratio. As shown in figure 1.

When the flow facility engender planar-symmetric shear flows, it mainly form spiral vortexes. The spiral vortexes have the left-hand and right-hand phenomena, and the direction of rotation of it will reverse if attend to another certain velocity. As shown in figure 2, the selection of the object is the upper boundary of the shear layer.

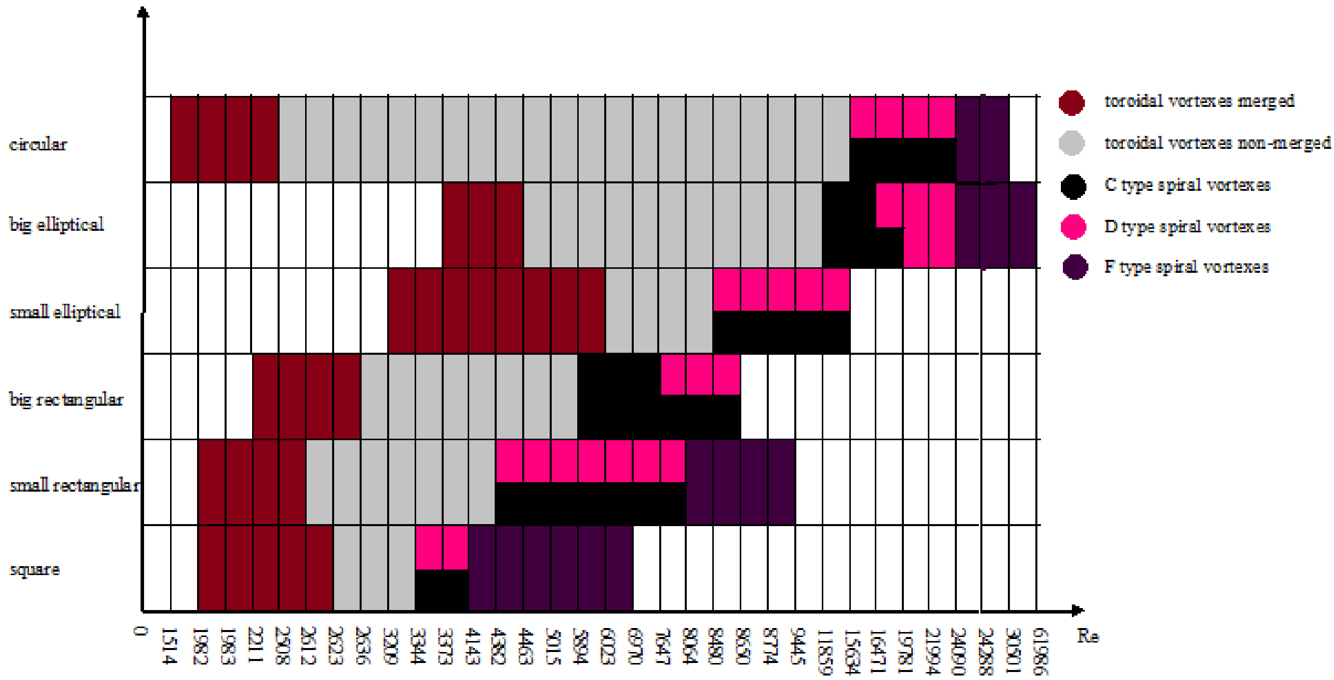

Figure 1. The Reynolds and the type of vortexes at different inner flow rectangular exits shapes.

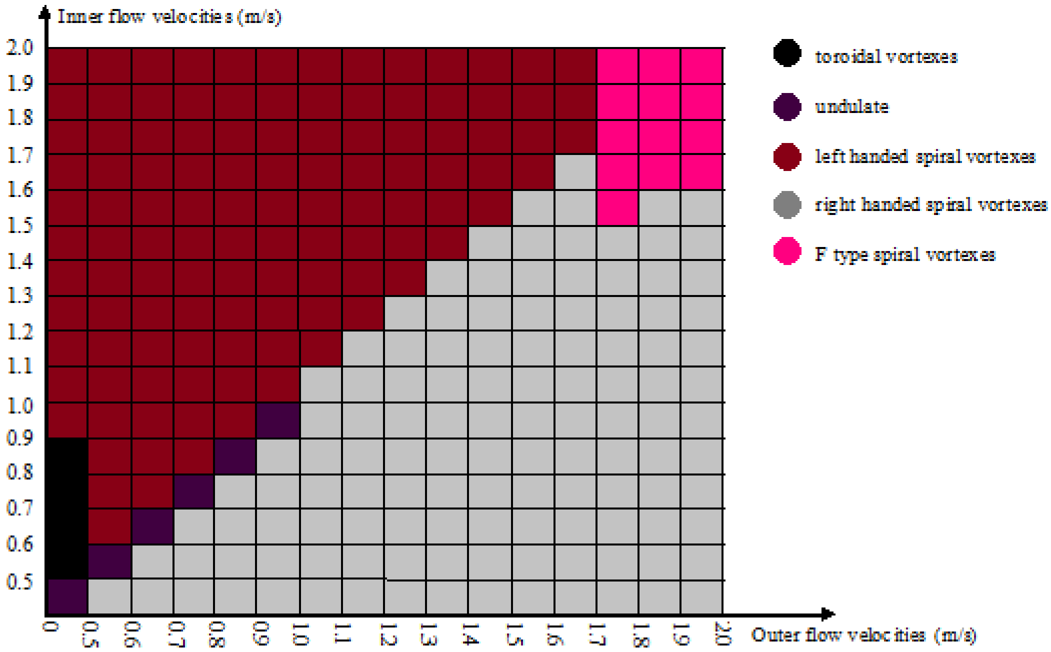

Figure 2. The analyse of planar-symmetric shear flows

The mechanical explanation of cross-spectrum phase spatial evolution.
Monochromatic plane waves,

$$A_0(f_m)\exp[-\alpha_i(f_m)y]\cdot\exp i[\alpha_r(f_m)y-2\pi f_m t+\varphi_0(f_m)]$$

Time Fourier function with fixed and reference position,

$$Y(f_m)\sim A_0(f_m)\exp[-\alpha_i(f_m)y]\cdot\exp i[\alpha_r(f_m)y-2\pi f_m t+\varphi_0(f_m)$$

$$X(f_m)\sim A_0(f_m)\exp[-\alpha_i(f_m)x]\cdot\exp i[\alpha_r(f_m)x-2\pi f_m t+\varphi_0(f_m)$$

The cross-spectrum,

$$Y(f_m)X^*(f_m)\sim\exp[-\alpha_i(y+x)]\cdot\exp i[\alpha_r(f_m)\cdot(y-x)]\sim<Y(f_m)X^*(f_m)>$$

$$ArgS_{yx}(f_m)\sim\alpha_r(f_m)\cdot(y-x)$$

$$C_r(f_m)=2\pi f_m/\alpha_r(f_m)$$

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