VISUALIZATION ON VORTEX OF CROSS FLOW PAST A CIRCULAR CYLINDER NEAR A WALL BY PIV

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For a long time, researchers are interested in the flow characteristic of flow past circular cylinder or non-streamline body. With the widely application of circle structure in practice, the researches on the vibration of the cylinder and the flow field characteristic attract more and more concern.

Several experiments have been performed on this subject. Several experiments have been performed on this subject. In the investigations by Bearman and Zdravkovich(1978), the Reynolds number is 4.8×10^4 and the gap ratio, G, ranges from 0 to 3.5. The flow structure is observed and the pressure distributions around the cylinder and the wall are measured, they draw the conclusion that the Strouhal number keeps constant of 0.2 for $G \geqslant 0.3$. Based on Bearman's work, Freds Φ e and Hansen(1987) have explored the lift force of a circular cylinder in steady flow for $G<0.3$. Lei(1999) has researched the relationship of the gap ratio, boundary layer thickness and velocity gradient, lift force, drag force and vortex shedding, with the Reynolds number ranging from 1.30×10^4 to 1.45×10^4 .

It can be seen that the above experiments were almost conducted in wind tunnel. Furthermore, the researches were seldom performed in the sub-critical range of low Reynolds number. Limited by measurement means, the investigations were focused on lift force coefficient and drag force coefficient. The vortex formation, development and shedding process in the wakes are not well obtained because instantaneous flow field is not available. Therefore, a series of experiments have been carried out in this paper with PIV system, which has higher spatial resolution and could get instantaneous flow field.

The experiments are held in a open glass flume with size of 100×50×1300cm. The Reynolds number, Re, is defined throughout on the diameter of the cylinder and the velocity, U, far from it, is from 900 to 8000 according to the glass flume.

In the experiments, the particle density is controlled to $0.35g/l$ and the enquiring region is chose to $32pixel\times32pixel$, which have ensured high density pattern of the flow field and the average particle number is 11. It's very important of tracing particle selection. Through sampling analysis of the particles in the operating water, the percentage of particles whose diameter is between $0.005mm$ and $0.05mm$ is over 97% and the density is $1.071g/cm^3$, which indicates that the particle is clay powder. According to the motion equation of particle moving in the water, which is simplified with Stocks method, we can get the expression $\frac{|V-U|}{|V|}<7.4\times10^{-5}$, where V represents Lagrangian velocity, U represents Euler velocity. Based on the equilibrium of the drag force, inertial force and quality force on a particle, the expression of characteristic time is $\tau=\frac{d_P^2}{18\nu}(\frac{1}{2}+\frac{\rho_P}{\rho})$, in the experiments the

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characteristic time τ is estimated to $2.2\times10^{-4}s$, which indicates that the particle have favorable tracking ability.

By PIV system and Tecplot post-process software, the velocity streamlines in the wake behind a cylinder are obtained, which display the vortex formation, development and shedding process in a period for the Reynolds number 5702 and the cylinder diameter 4.5cm. The period time is about 2.16s and the vortex size is almost equal to the diameter of circular cylinder. The regular 'Karman vortex street' is not found in the wake because the flow is not symmetrical; the flow above the cylinder has little effect on the wakes and the flow under the cylinder is 'pushed' by the bottom wall and raising up, doing a pendulum motion periodically with the vortex shedding. An attaching vortex appears at the bottom of the wakes, where the larger particles are accumulated. This phenomenon is much different from that of flow past a circular cylinder without a wall near by. Through a series of experiments, it's found that the vortex shedding law is almost the same in the case of other two diameters (3.5cm and 5.5cm). The vortex pair in the wake has regular structure. As the vortex begins to come out, the state is very unsteady, then it is enhanced with the continued flow, finally sheds away when it reaches certain intensity. In the course complex flow structures are contained such as vortex abruption, combination and coupling.

Strouhal number, St, indicates the vortex shedding characteristic. Fig.1 gives the relationship between Reynolds number and Strouhal number, which indicates that St is about 0.2 in Reynolds number range of 900~8000. It shows the 'regularity in the unsteady' flow structure of cross flow past a circular cylinder near a wall. The conclusion drawn by Bearman(1978) was that the Strouhal number keeps constant 0.2 when $Re=4.8\times10^4$ and $G>0.3$. Bearman's result illustrates that if there is not a wall near the cylinder the Strouhal number keep constant 0.2 when Reynolds number is in the sub-critical range, that is, $300\leq Re<3\times10^5$. It can be found from above discussions that although the two cases have great differences in the flow structure, they are similar on the vortex shedding characteristics.

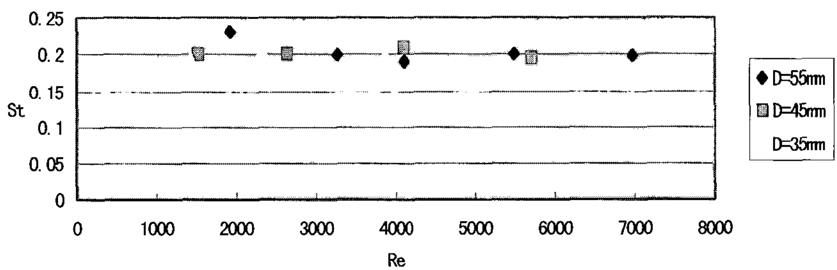

Fig. 1 Relationship between Reynolds number and Strouhal number

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