Flow around two circular cylinders in a tandem arrangement

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The drag of a circular cylinder and the vortex shedding phenomenon have been extensively investigated because of the significance in aerodynamic flows. Significant attention is now focussed on controlling the vortex shedding as well as reducing the drag in view of potential technological and economic benefits. Extensive results based on several investigations that have been carried out by placing a circular control cylinder of same or smaller diameter compared to the main cylinder are available in literature. Majority of these studies have been made by placing the control cylinder at different locations upstream of the main cylinder on the centre-line. The separation between the cylinders and flow in the gap region between the cylinders seem to be crucial in controlling the vortex shedding and drag reduction characteristics. However there does not appear to be any systematic investigation of the wake characteristics downstream of the main cylinder associated with the drag reduction phenomenon.

The main aim of the present study is two-fold:

- investigate the drag reduction phenomenon by placing a small diameter control cylinder upstream of the main cylinder on the centre-line and
- compare mean velocity and rms velocity fluctuations corresponding to the minimum drag configuration at several downstream locations with those for a single.

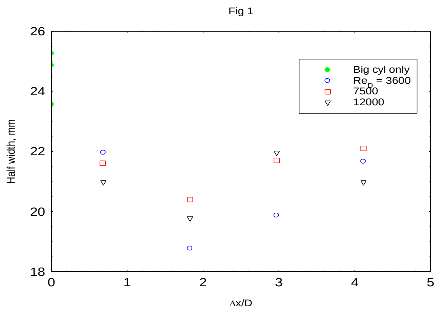
The influence of the geometry of the control cylinder - like a circle, square, triangle and channel section – on the drag reduction, vortex shedding and wake turbulence characteristics is another target of the present study. Results of these studies will be included in the full paper and presented at the conference.

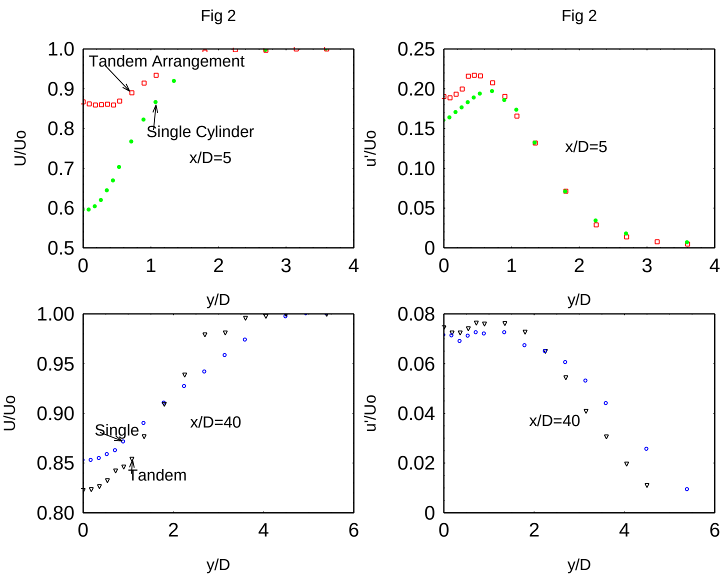
Measurements were made in a 2.2 m long and 0.34 m x 0.34 m test section of a low sped wind tunnel at three different Reynolds numbers Re_D = 3600, 7500 and 12000 based on the main cylinder diameter (D=11.1 mm). A 3mm diameter control cylinder was placed upstream of the main cylinder on the centre-line and the separation between the two cylinders was varied by using two micrometer screws attached to the main cylinder. The drag of the main cylinder was estimated from surface pressure distribution and the drag of the combined cylinder arrangement was estimated from mean velocity measurements at x/D = 40. A single 2.5 μm diameter hot wire probe was used to measure mean velocity and longitudinal velocity fluctuations at lateral locations y (measured form the centre-line) in the wake.

Main Results

The gap between the cylinders that yields minimum drag was determined by measuring the difference between the centre-line surface pressure on the upstream side and the downstream side of the main cylinder for different separation distances; the minimum value of the pressure difference corresponds to the minimum drag configuration. It was observed that minimum drag was obtained for a centre-line separation distance of 1.8D between the cylinders, a value which is in good agreement with results available in literature. (e.g. Zdrakovich, 1977). Nevertheless this value may depend on the cylinder diameter ratio and flow Reynolds number.

To investigate the influence of the gap on the wake structure, both mean velocity (U) and longitudinal turbulence velocity fluctuation (u) were measured at several downstream distances. Figure 1 shows the variation of wake half width with the cylinder separation distance (Δx) at x/D = 40 (x is the longitudinal distance) for three different Reynolds numbers. The wake half width has a minimum for Δx/D = 1.8. This suggests that the minimum drag configuration of the tandem cylinder arrangement results in the development of a wake with minimum width. Figure 2 shows the comparison of the distributions of mean velocity (U/U_o where U_o is the upstream velocity) and rms velocity fluctuation (u'/U_o) at x/D = 5 and 40 for Re_D = 7500 for the single (main) cylinder and the tandem cylinder arrangement. At x/D=5, velocity defect (U_o –U) is smaller for the tandem arrangement compared to that for a single cylinder reflecting a drag reduction whereas u' is slightly larger. However at x/D=40, the defect is larger and u' is smaller for the tandem arrangement. Note the significant reduction of wake width.





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