A flow visualization study of flow through a cluster of three equispaced cylinders at various orientation angles

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Flow development through a triangular cluster consisting of three equally spaced cylinders at multiple orientation angles was studied experimentally. The experiments were carried out in the University of Waterloo water flume facility. Hydrogen bubble technique was used to visualize the interaction of separated shear layers from each cylinder and their role in the vortex shedding mechanism in the wake. Based on the diameter of a single cylinder, the operating Reynolds number was 2.1 103. For this study, the spacing ratio P /D between the cylinders was fixed at a value of 1.35. The results indicate a range of complex flow patterns for the studied orientation angles. The existence of different vortex shedding frequencies behind each cylinder form complicated structures in the near wake of the cluster. Certain flow characteristics observed in studies with two cylinders are also seen for some orientations in this study. For example at = 0, a narrow and wide are visible in the wake of both downstream cylinders, suggesting the flow is bi-stable. However, the presence of the third cylinder diminishes this mechanism for = 60. When = 30, i.e., when upstream and downstream cylinders are in a tandem arrangement, no reattachment of the upstream separated shear layers are seen, as one would expect if the third cylinder was not present. Another interesting phenomena was the existence of the Kelvin-Helmholtz instability in certain shear layers and their interaction with larger structures at some orientation angles.