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Characteristics of the Wake behind a Heated Cylinder in Relatively High Reynolds Number

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Abstract : Thermal effects on the dynamics and stability of the flow past a circular cylinder operating in the mixed convection regime is studied experimentally for Reynolds number (ReD) between 1000 and 4000, and different cylinder wall temperatures (Tw) between 25 and 75°C by means of Particle Image Velocimetry (PIV). The experiments were conducted in a horizontal wind tunnel with the heated cylinder placed horizontally. With such assumptions, the direction of the thermally induced buoyancy force acting on the fluid surrounding the heated cylinder would be perpendicular to the flow direction. In each experiment, to acquire 3000 PIV image pairs, the temperature and Reynolds number of the approach flow were held constant. By adjusting different temperatures in different Reynolds numbers, the corresponding Richardson number (RiD = Gr/Re^2) was varied between 0:0 (unheated) and 10, resulting in a change in the heat transfer process from forced convection to mixed convection. With increasing temperature of the wall cylinder, significant modifications of the wake flow pattern and wake vortex shedding process were clearly revealed. For cylinder at low wall temperature, the size of the wake and the vortex shedding process are found to be quite similar to those of an unheated cylinder. With high wall temperature, however, the high temperature gradient in the wake shear layer creates a type of vorticity with opposite sign to that of the shear layer vorticity. This temperature gradient vorticity weakens the strength of the shear layer vorticity, causing delay in reaching the recreation point. In addition to the wake characteristics, the shedding frequency for the heated cylinder is determined for all aforementioned cases. It is found that, as the cylinder wall is heated, the organization of the vortex shedding is altered and the relative position of the first detached vortices with respect to the second one is changed. This movement of the first detached vortex toward the second one increases the frequency of the shedding process. It is also found that the wake closure length decreases with increasing the Richardson number.

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