Effect of local suction or blowing on the wake behind a cylinder in compressible subsonic flows

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A numerous of studies of vortex shedding formation behind bluff bodies shows a great complexity and importance of this physical phenomenon. One of simple configurations of such kind of the motion is a cross streamlining of the circular cylinder which has a large number of applications both in industry (the flow past moving vehicles, around bridges and buildings, etc.), and in natural phenomena. In most cases it is gone with flow separation and attachment effects which can significantly influence both on aerodynamic performances of the moving body and on the flow parameters downstream. The recent experiments in incompressible flows gave evidence that flow separation and the vortex shedding are unsteady and three dimensional. With the velocity increasing, around the circular cylinder is realized the flow with more complicated structure in comparison with incompressible velocities.

Local suction or blowing of gas through the permeable surface of the cylinder can significantly change a streamlining pattern both in its vicinity and downstream. It can result in both a qualitative changing in process of nonstationary separation onset and its development character and in quantitative transformation of the mean and fluctuation flow structure downstream the body. Besides, it is necessary to know the flow pattern nearby the cylinder and further downstream to reduce drag, increase heat transfer or mixing, and enhance combustion. There were some investigations considering a flow manipulation consisting in the application of gas suction or blowing at low subsonic velocities. However there is almost no literature dealing with this problem in compressible flows.

The experiments were performed using the wind tunnel T-325M of the Khristianovich Institute of theoretical and applied mechanics (ITAM) with rectangular test section 4×4 cm^2 at freestream Mach numbers $M = 0.5 \div 0.7$ and Reynolds numbers based on the cylinder diameter up to $Re_d = 10^5$. The hollow circular cylinder 4 mm in diameter with 0.5 mm wall thickness placed across the flow before the test section was used to produce compressible turbulent wakes. One butt of the cylinder was designed for gas supplying and other one was blanked-off. There was a spanwise slot in the cylinder wall covered with polymer film 12 micron in thickness. Polymer film was punched with pores 50 nm in diameter on average (porosity about 10^7 pore/mm^2). It made possible to inject (air/helium) or suck (air) small portions of gas through the cylinder wall into/off the flow. Pitot tube and concentration aspirating probe were used to determine mean flow parameters. Constant current anemometer designed at ITAM and single hot wire probes with tungsten sensitive element 6 μm in diameter and 1.2 mm length have been used for fluctuation measurements within wakes past the cylinder. The frequency range of anemometers is 200 kHz at all overheating parameters. The hot-wire output was digitized by 14-bit analog-to-digital converter with the sampling rate up to 5000 kHz. After converting the analog signal to digital type the data were transferred to PC for further processing.

In the given experimental study the vortex shedding frequency and the wake flow behind the circular cylinder affecting with local gas blowing or suction trough its permeable wall at high subsonic speeds are studied. The new information about the mean flow, intensity and spectral composition of fluctuations obtained due to local suction or blowing of gas through of the cylinder wall at the different slot position is given. Some interpretations of the possible mechanism of the formation and suppression of the vortex shedding are proposed, and it is suggested that the vortex generation process is associated with unstable properties of the near flow field around the cylinder.

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