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NUMERICAL INVESTIGATION OF FLOW AROUND CYLINDER COVERED WITH SPANWISE GROOVES

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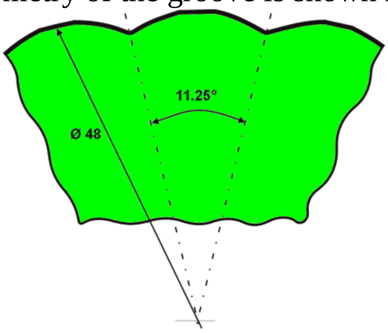
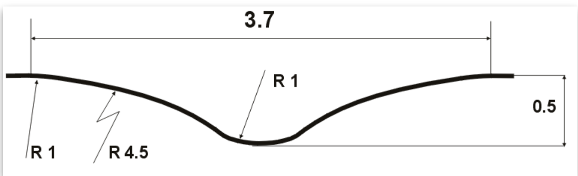
The aim of the paper is to study the flow around circular cylinder covered by spanwise grooves of different shapes. In spite of the simple form of the circular cylinder the resulting flow is one of the most challenging problems that is encountered in many different engineering fields. This simple geometry produces complex flow phenomena that is highly Re-dependent, has a turbulent transition in various flow regimes depending on *Re,* oscillating separation points and unsteady wake. The purpose of this paper was to design a grooves shape that would produce an appropriate amount boundary layer turbulence across a curved surface and to generate super-critical *Re* flow effects at a sub-critical *Re*. The surface covered by grooves results in the change of pressure distribution on the body and so the variation of the lift and drag. The concept of controlling the flow over circular cylinders is not novel, as many researchers have studied the effect of surface roughness on cylinders in the past (e.g. Achenbach, Heinecke, [1]). The others study was performed with the use of roughness strips, dimples or various types of groves

In the present investigations, the spanwise groves are studied. A starting point of the study was the geometry proposed by Yamagishi and Oki [3], with a curved sectional shape. This test case was then treated as a reference test case. The idea was to define such a shape that excite transition in the boundary layer and shift the separation towards the downstream side of the body. Figure 1a shows the geometry of the circular cylinder with grooves. Diameter of the cylinder equals 48 mm, while each groove has 3.7 mm width and 0.5 mm depth. The geometry of the groove is shown in Fig.1b.





a) Shape of cylinder with grooves b) Shape of groves

Figure 1. Circular cylinder with grooves

The calculation was performed using commercial software Ansys Fluent 13. The problem was considered as an unsteady two-dimensionless turbulent flow. For turbulence modelling the RNG k-e model with the standard wall function was used. Fig. 2 shows the drag coefficient C_D distribution as a function of Reynolds number, where dashed line shows the results obtained by Wieselsberger [2] for a smooth cylinder, squares and triangles shows experimental results obtained by Yamagishi and Oki [3], while open points refers to our own calculations. It is clear that drag coefficient significantly decreases for wavy surface. There is a small discrepancy between experimental and numerical data, which could results from small differences in grooves geometry or some numerical issues. The reason of this discrepancy need to be clarify.

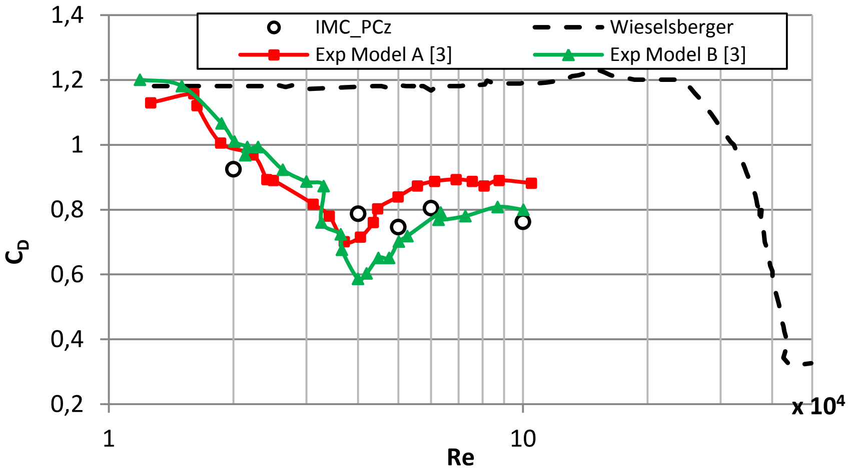
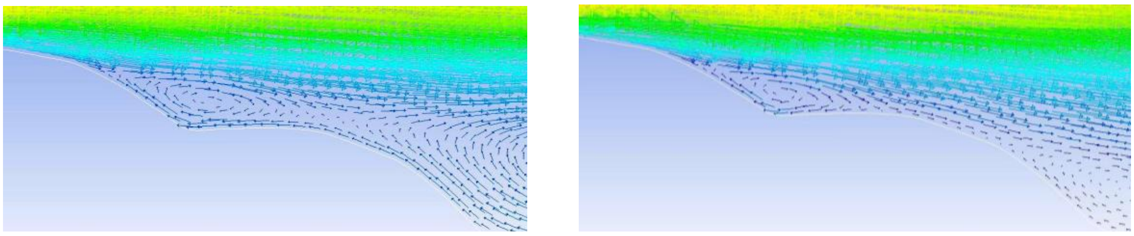


Figure 2. Drag coefficient for circular cylinder with groves



a) Contours of velocity field (t= 0.152) b) Contours of velocity field (t= 0.14)

Figure 3. Vectors of velocity field for Re =10^5

Figure 3 shows velocity vectors field close to the cylinder for Re = 10^5. One can observe that separation point shifts towards the downstream side of the body and varies between 103.9^o (figure 3a) and 114.4^o (figure 3b) depending on the downstream wake position, while for the smooth cylinder it equals ≈ 80°. It results from the increase of turbulence kinetic in the boundary layer due to the presence of spanwise grooves.

Acknowledgments

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