Implicit LES for Two-Dimensional Circular Cylinder Flow by Using COMSOL Mutiphysics®

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Introduction:

•When an object is accelerated from its zero speed to fast speed, it experiences the all of laminar, turbulent and transition. Therefore, we have to treat it automatically.

•Fluid flow past a body can be controlled by surface roughness such as tripping wire or surface dimple of golf ball. So, the flow field around a body with microstructure, is very important.

•The Navier-Stokes equations have a rich physics of natural fluid flow.

•If you solve this equation directly, you can predict laminar flow, turbulent flow and transition between them.

•This paper shows you can do it easily if you using implicit LES[1] to be introduced here.

•Through this study, you notice COMSOL Multiphysics® provides us implicit LES and besides it is default settings.

Computational Methods:

Implicit LES uses no explicit turbulence model. Therefore, tool to be used is very simple as follows:
1)The Navier-Stokes equation is solved.
2)The boundary mesh technique is utilized in order to resolve boundary layer flow and its separation on the body surface.
3)As stabilization techniques, GLS and crosswind diffusion stabilization are utilized, which has already been set in COMSOL Multiphysics® as a default.[2]

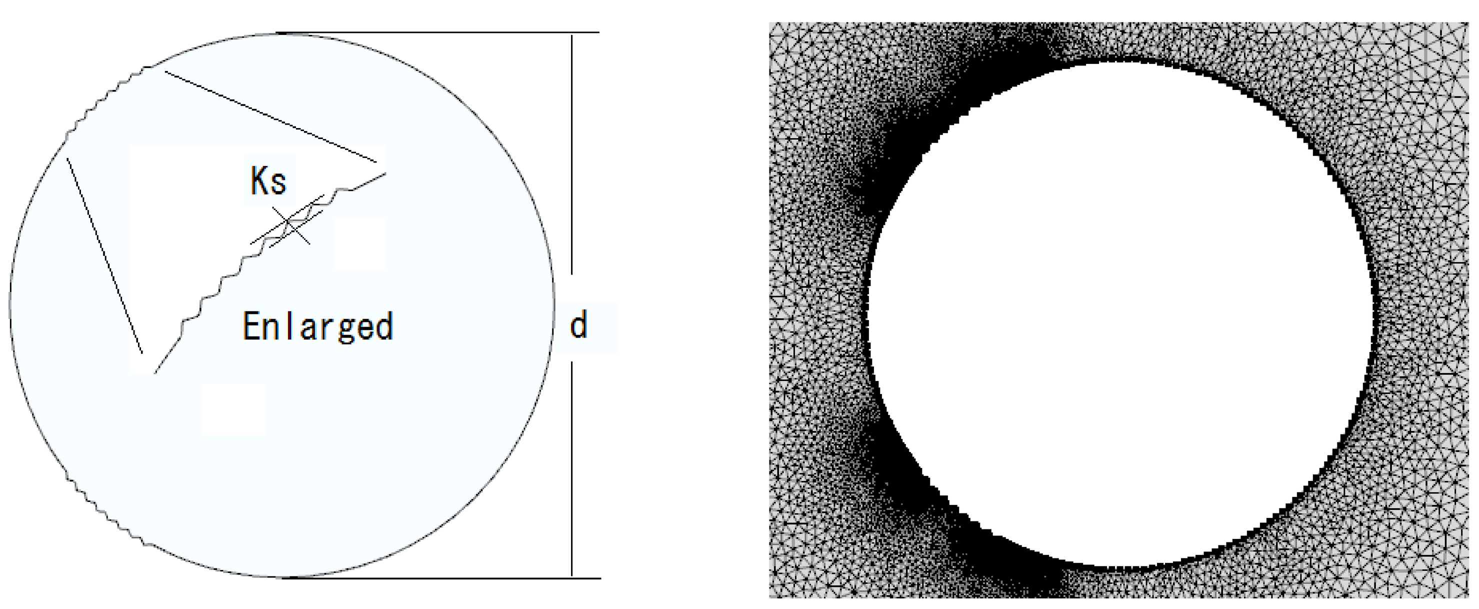


Figure 1. Circular cylinder with surface roughness and mesh system around it.

Results:

In this paper, a wide range of Reynolds number from 0.1 to 1,000,000 are computed, and the results show good agreement with existing data.

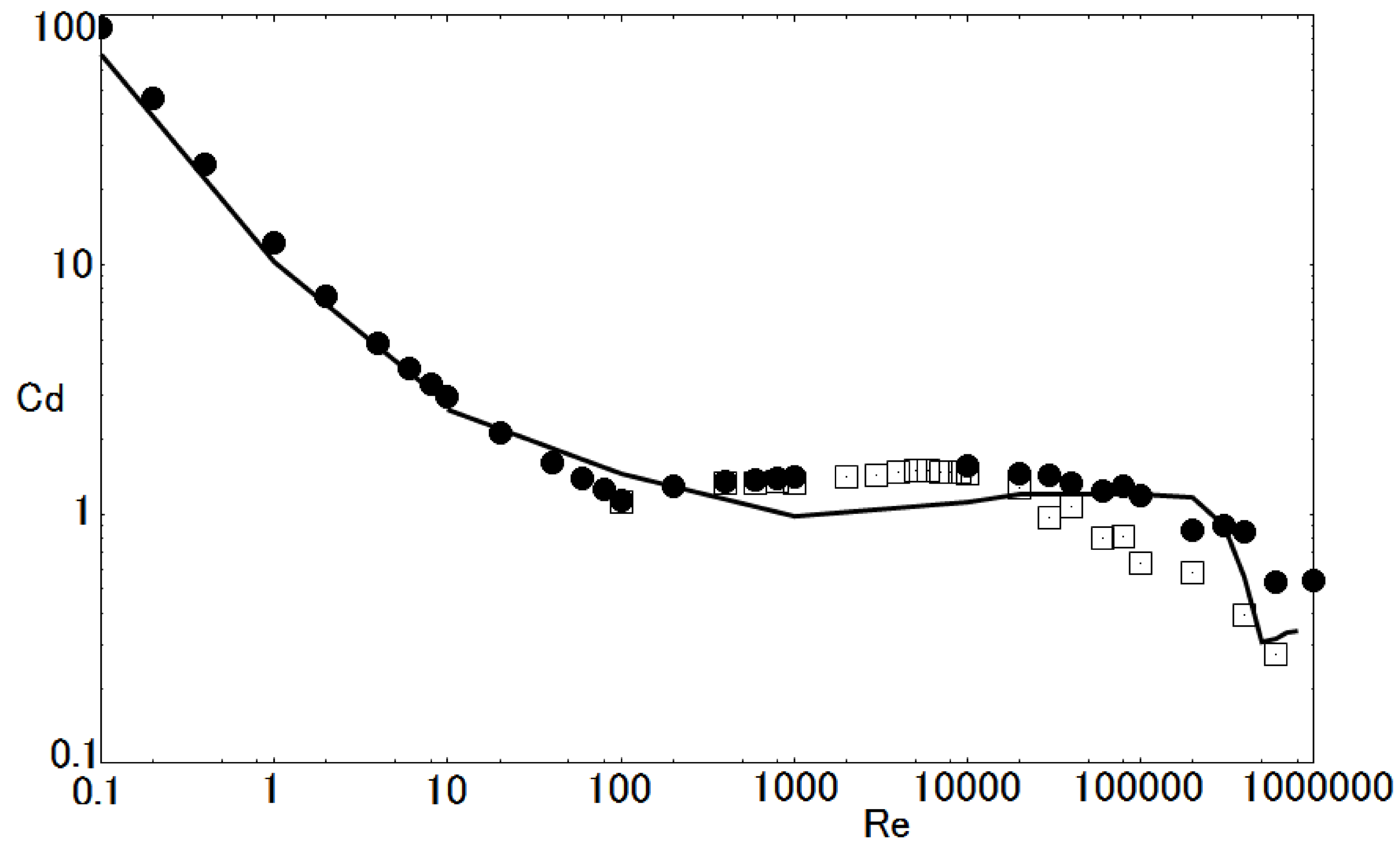
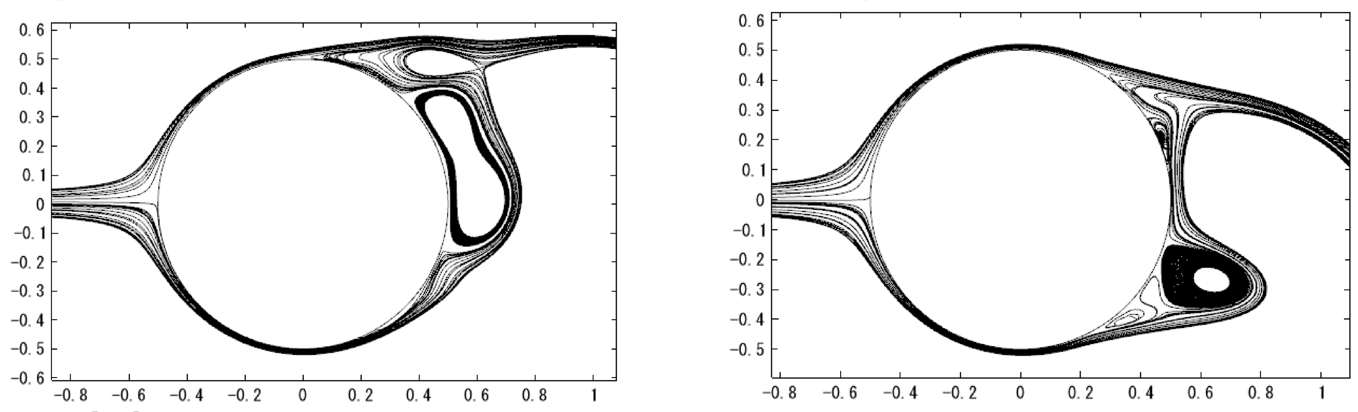
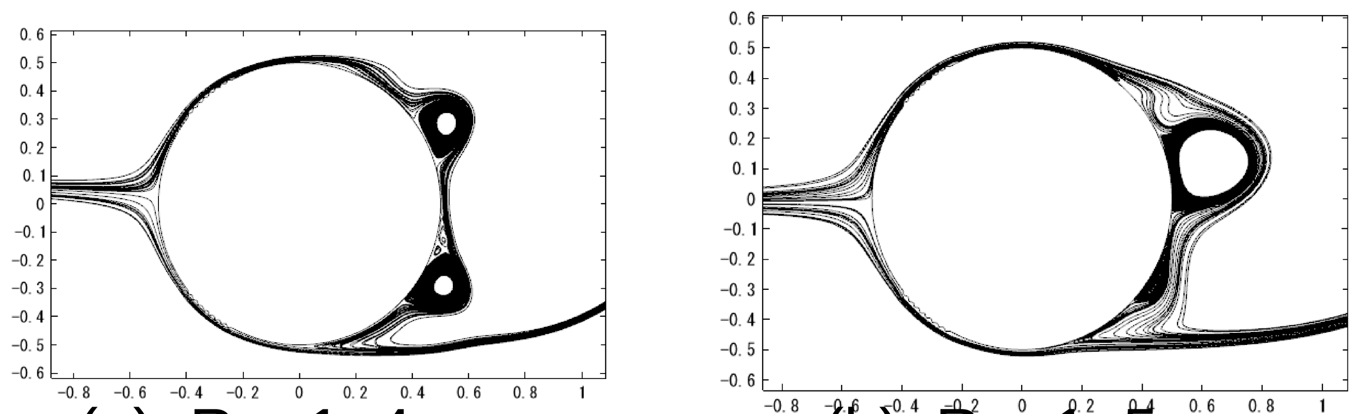


Figure 2. Drag coefficent versus Reynolds number ; ●, smooth surface circular cylinder; □, with surface roughness which is shown in Fig.1.



(a) Re=1e5 (b) Re=1e6

Figure 3. Instantaneous streamlines; smooth surface.



(a) Re=1e4 (b) Re=1e5

Figure 4. Instantaneous streamlines; surface roughness.

Conclusions:

Here, it was shown that the present implicit LES can capture drag crisis of circular cylinder w/o surface roughness including flow transition from laminar to turbulent automatically. The present results suggest an advantage of multiphysics simulation using COMSOL Multiphysics®, in particular, for the design of flying objects which is varying its speed.

References:

1. Hashiguchi, M., Possibility of Implicit LES for Two-Dimensional Incompressible Lid-Driven Cavity Flow Based on COMSOL Multiphysics, COMSOL Conference Tokyo 2012(2012). http://www.comsol.jp/paper/download/159355/hashiguchi_paper.pdf/.
2. COMSOL_ReferenceManual.