Numerical Fluid Mechanics II

Summer Semester 2018

DELIVERABLE TASK II:
Turbulent flow over a square cylinder

Given: Friday, 18/05/2018
Deadline: 15/06/2018

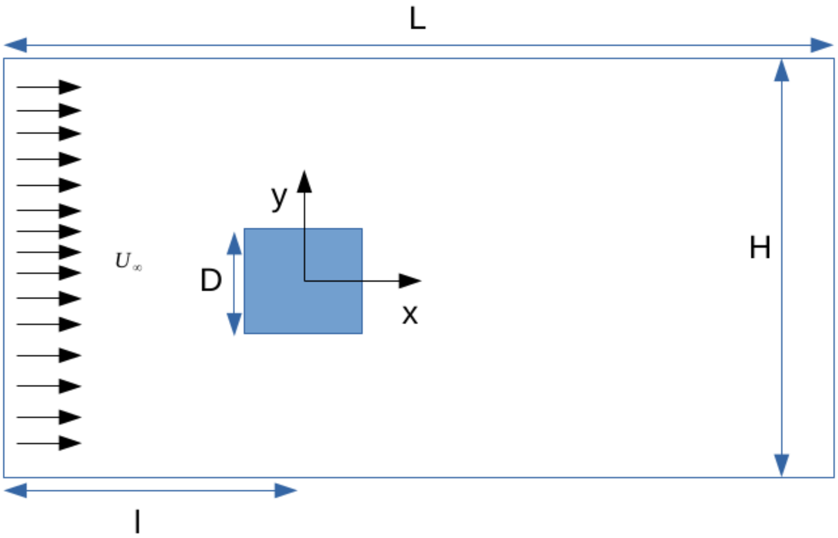
Institute of Fluid Mechanics
Department of Biochemical Engineering, Technical Faculty
Friedrich-Alexander University Erlangen-Nuremberg

Md. Ashfaqul Bari, Dr. Manuel Münsch

Simualtion of laminar flow over a square cylinder

The objective of the Second deliverable task is to simulate the Turbulent flow over a square cylinder by using $K - \epsilon$ turbulence model.

The computational domain is as follows:



A square cylinder of side length $D = 4$cm is placed inside a rectangular domain of length $L = 24D$ height $H = 14D$ and width $10D$. The entrance length (distance between inlet and center of the block) is selected to be $l = 10D$.

The Reynolds number is typically defined as $Re = UD/\nu$. The velocity in the $x-$, $y-$ and $z-$ directions are denoted as u, v and w, respectively.

- $Re = 22000$, $u = 0.54ms^{-1}$,
- Turbulent intensity $I = 2\%$ and turbulent length scale $l = 10\%$

A group of 4 students will complete the task and submit a combined report.

Tasks

The Deliverable Task I should contain the case folder of OpenFOAM (20p) and a written report (80p) describing the following results:

- (15p) summerize RANS model implemented in openFoam. Summerise pros and cons of RANS turbulence model.

- (5p) calculate the k and ϵ values for the RANS model.
- (20p) **Grid convergence study**: perform grid convergence study by computing Grid Convergence Index (GCI). Calculate and plot the $y+$ value along the top cylinder wall for the final grid you have chosen for your simulation.
- (40p) **Results and interpretation**: with the mesh and relaxation factors chosen above perform the simulations and Generate a figure for each of the following quantities for each Re:
  - (4p) the velocity contour on the complete domain.
  - (4p) streamwise u and cross streamwise v along the centerline ($y = 0$) behind the cylinder and give explanation. (2 figure side by side 1 for u 1 for v)
  - (4p) streamwise velocity u at $x = 0, 4$and 8 and give explanation.
  - (4p) cross flow velocity v at $x = 0, 4$and 8 and give explanation.
  - (4p) wall shear stress (τ_w) along the cylinder wall.
  - (4p) pressure coefficient ($C_p = (P - P_\infty)/0.5\rho U_\infty^2$) along the cylinder wall.
  - (4p) friction coefficient ($C_f = \tau_w/0.5\rho U_\infty^2$) along the cylinder wall.
  - (4p) lift coefficient ($C_l = F_l/0.5\rho A U_\infty^2$)
  - (4p) drag coefficient ($C_d = F_d/0.5\rho A U_\infty^2$)
  - (4p) Calculate Strouhal Number S_t and the vortex shedding frequency.
- Explain your results and make your final conclusions about the Deliverable Task.

Bonus task (10p)

What modification is required to perform LES using openFoam. set up the case for LES simulation and and explain the choice of different parameters. Submit your case folder. No simulation required.

Deadline: 14th June,2018 23:59 email: md.ashfaqul.bari@fau.de