ME608 - 2D SIMPLE Solver for Laminar Flow Over a Square Cylinder - Spring 2010

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Outline

- Geometry, Mesh, and BCs
- Solver details
- Results
- Validation
- Summary
Details of Flow Domain

Figure: Geometry of the flow over 2D square cylinder

- Side of the square $D = 1$ is the length scale.
- $H = 8D$; $L = 50D$; $Lin = 12.5D$;
- Channel is meshed with $500 \times 80$ control volumes with $10 \times 10$ across the square cylinder.
- Boundary Conditions:
  1. Inlet: Parabolic velocity inlet
  2. Outlet: Upwinded mass flow outlet
  3. Walls: No slip wall
Details of Solver

- SIMPLE solver on staggered mesh
- Gauss-Seidel for momentum equations
- LBL-TDMA for pressure correction equation

Discrete $u$ and $v$ momentum equations

\[
a_e^u u_e = \sum_{nb} a_{nb}^u u_{nb} + b_e^u + \Delta y(P_P - P_E) \tag{1}
\]

\[
a_n^v v_n = \sum_{nb} a_{nb}^v v_{nb} + b_n^v + \Delta x(P_P - P_N) \tag{2}
\]

Pressure correction equation

\[
a_PP' = \sum_{nb} a_{nb}P_{nb}' + (F_w^* - F_e^* + F_s^* - F_n^*) \tag{3}
\]
Results - Velocity

Figure: Velocity Profiles
Results - Pressure

(a) Re 1
(b) Re 10
(c) Re 20
(d) Re 30
(e) Re 40
(f) Re 50

Figure: Pressure Profiles
Results - Vorticity

Figure: Vorticity Profiles
Results - Streamlines

(a) Re 1  
(b) Re 10  
(c) Re 20  
(d) Re 30  
(e) Re 40  
(f) Re 50  

**Figure:** Streamlines
(a) Coefficient of Drag  
(b) Recirculation Length

Figure: Reynolds Number vs Coefficient of Drag and Recirculation Length
Closure

- Laminar 2D flow over a square cylinder was simulated using SIMPLE solver
- Validated against published results with good agreement

References

- ME 608 Class Notes
- Accurate computations of the laminar flow past a square cylinder based on two different methods: lattice-Boltzmann and finite-volume by: M. Breuer, J. Bernsdorf, T. Zeiser, F. Durst

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