ME 207 | Fluid Dynamics

Computational Fluid Dynamics Lab Session 1

Due: Midnight of March 31, 2024

Problem Statement

Crude oil enters the pipe with diameter of 20 cm and length of 2 m. The density and viscosity of the crude oil can be taken as 860 kg/m^3 and 17.2 cP, respectively. Perform steady-state axisymmetric fluid flow simulation in the Ansys software and complete the following exercises.

1. For Re = 100, plot velocity and pressure at the centreline.
2. Calculate wall shear stress and Darcy's friction factor along the wall.
3. Perform mesh independence study (you must do at least three levels of mesh refinement to demonstrate the mesh independence)
4. Select 5 different Reynolds numbers in the range of 10 - 1000 and plot Darcy's friction factor Vs Reynolds number. The plot should be on a log-log scale.
5. Plot the radial velocity along the length (z-direction) at 5 cm from the centreline for 3 different Reynolds numbers.
6. Plot the pressure gradient along the centreline for 3 different Reynolds numbers.
7. Calculate the fully developed velocity profile $u(y)$ from analytical results using the pressure gradient from the CFD results. Show the analytically calculated velocity profile comparison with CFD results on the same graph.
8. Find the entrance length of the flow for 5 different Reynolds numbers and plot your results.
9. Plot the r and z components of velocity contours and streamline contour separately.
10. Mark and describe the flow features in the contours (should include boundary layer development and merging).

Instructions

- Each student should upload the individual report and the associated Ansys files in any cloud storage (Google Drive or Microsoft One drive) and share the link by submitting this Google form: https://forms.gle/8CXzaKfWVEmWFUbd9
- The report must consist of (1) geometry and boundary conditions, (2) mesh statistics and mesh independence study, (3) discretisation schemes and solution methodology, (4) results and discussion, and (5) conclusion.
- All the figures must be included in the results and discussion section (except mesh independence), and adequate physics-based reasoning should be provided.
- Report must be prepared using WORD or LaTeX. Handwritten reports will not be accepted.