Modeling Flow Fields in Stirred Tanks

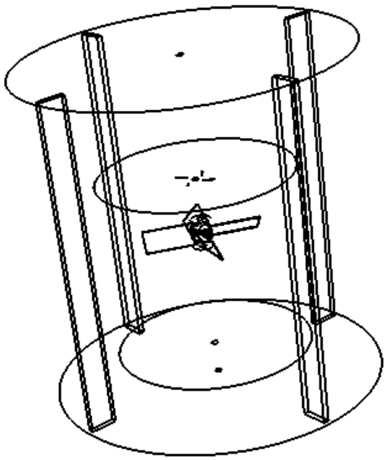
Reacting Flows – Homework 4

Instructor: André Bakker

Homework assignment

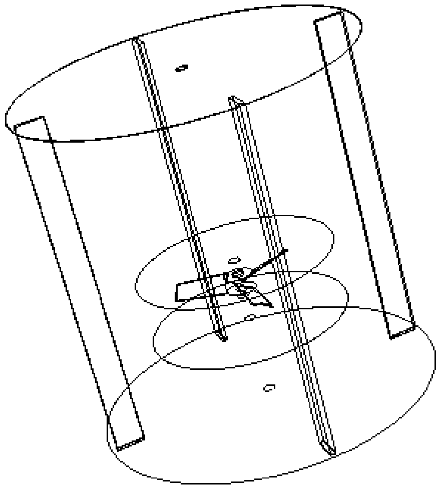
- The purpose of this homework assignment is to calculate a time averaged flow field in a stirred tank.
- Students will be provided with the computational mesh for one of the following cases:
  - Pitched blade turbine
  - HE-3 impeller
  - Rushton turbine
- Assignment:
  - Calculate the flow field at two Reynolds numbers: RE=10 and Re=10,000. Use the moving reference frame (MRF) impeller model.
  - Calculate the power number and pumping/flow number for both Reynolds numbers. Compare these with data from the literature (e.g. from http://www.postmixing.com/mixing%20forum/impellers/impellers.htm)
  - Qualitatively compare the flow predicted with flow fields presented in the literature.
  - Provide results and interpretation in either a PPT or DOC file.
  - Provide final FLUENT case and data files.
- Note: students who already have significant experience with such flow field predictions may propose an alternative assignment to the instructor.

Pitched blade turbine



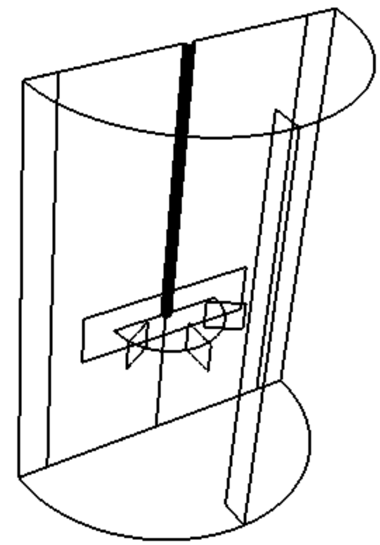
- Filename: pbt.msh.gz
- Specifications:
  - T=Z=H=0.292 m
  - D/T=0.35
  - C/T=0.44 (bottom impeller blade to bottom vessel)
- Setup hints:
  - Define | Grid Interfaces | interface-inner & interface-outer
  - “fluid-impeller” is fluid region. Motion type=moving reference frame. Rotation-axis origin (0,0,0). Rotation-axis direction (1,0,0). Positive angular velocity will give clockwise rotation seen from the top of the vessel and impeller will pump down.
- Post-processing hints:
  - The axial (x-direction) extents of the impeller blade are from (0.15058 to 0.16542)
  - The radial extents of the impeller blades are from (0.008689 to 0.05154)
- Suggestion for reference:
  - The laminar and turbulent flow pattern of a pitched blade turbine. Bakker et al. 1996.

HE-3 impeller



- Filename: he3.msh.gz
- Specifications:
  - T=Z=H=0.292 m
  - D/T=0.394
  - C/T=0.33 (bottom impeller blade to bottom vessel)
- Setup hints:
  - Define | Grid Interfaces | interface-13 & interface-5
  - “fluid-impeller” is fluid region. Motion type=moving reference frame. Rotation-axis origin (0,0,0). Rotation-axis direction (1,0,0). Positive angular velocity will give clockwise rotation seen from the top of the vessel and impeller will pump down.
- Post-processing hints:
  - The axial (x-direction) extents of the impeller blade are from (0.183562 to 0.195494)
  - The radial extents of the impeller blades are from (0.01257 to 0.05759)
- Suggestion for reference:
  - Ward. 1995. DPIV investigation of flow pattern instabilities of axial flow impellers.

Rushton impeller



- Filename: rushton.msh.gz
- Specifications:
  - T=0.31m
  - Z=H=0.42m
  - D/T=0.4838
  - C/T=0.40 (bottom impeller blade to bottom vessel)
- Setup hints:
  - No grid interfaces. The mesh was created with the two fluid zones connected.
  - “fluid-impeller” is fluid region. Motion type=moving reference frame. Rotation-axis origin (0,0,0). Rotation-axis direction (0,-1,0). Positive angular velocity will give clockwise rotation seen from the top of the vessel.
  - For “fluid”, motion type=stationary. But do specify rotation-axis origin (0,0,0) and rotation-axis direction (0,-1,0). This is necessary for the definition of the rotationally periodic boundary conditions.
  - This mesh is for half a vessel. Need to set up rotationally periodic boundaries. After specifying rotation axes for the two fluid zones, from the text interface:
    - Define boundary-conditions modify-zones make-periodic
      - periodic11 periodic12 yes yes
    - Define boundary-conditions modify-zones make-periodic
      - periodic21 periodic22 yes yes
- Post-processing hints:
  - The axial (y-direction) extents of the impeller blade are from (0.125 to 0.155)
  - The radial extents of the impeller blades are from (0.0375 to 0.0075)
- Suggestion for reference: Computation of flow fields and complex reaction yield. Middleton et al. 1986.

Rushton impeller – more difficult

- Review the paper titled:
  - Investigation of laminar flow in a stirred vessel at low Reynolds numbers.
  - Rice M., Hall J., Papadakis G., Yianneskis M. Chemical Engineering Science 61 (2006) 2762-2770.
- Use the Rushton mesh to calculate the flow field at Re=1, 10, and 28, as in the paper.
- Compare the results with Rice et al.
- Notice that the impeller off-bottom clearance is different, and comment on how that may have affected the comparison.