Department of Mechanical Engineering

ME537 Multiphase Flows. Final Exam.

Assigned on 12-11-2018, due 12-14-2018 at 8 pm

Consider Bubbly Flow in a pipe:

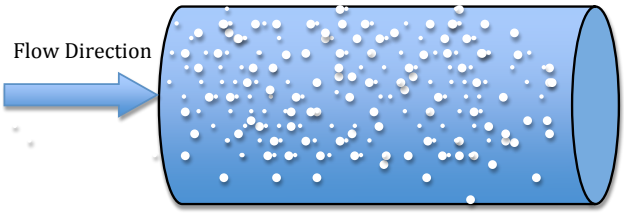

Figure 1: Turbulent Bubbly Flow in a straight section of pipe.

Turbulent flow in a pipe (round) or channel (rectangular cross section) is characterized by two distinct regions:

- Centerline region where the mean velocity is uniform and the turbulence is homogeneous and isotropic, and

- Wall region where the boundary layer is dominated by shear (velocity differences) and there are different layers induced by the velocity field.

- How does the turbulence in these two regions influence the bubble concentration and velocity fields?

- How do the bubbles influence the liquid velocity field (and therefore the wall friction)?

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After a 90^o bend downwards, a bubble of a specific size gets trapped due to the balance between drag and buoyancy. At a curved pipe, for high enough Reynolds numbers, there is an inertial instability (due to centrifugal effects) that creates a secondary flow consisting of two symmetric vortices where flow is outwards of the bend near the pipe's centerline and back inwards along the pipe's periphery.

- What size would be captured by the flow?
- Where in the pipe's cross section, shown in figure 2, will the bubble remain in a stable position?
- If the flow is subject to high frequency pressure fluctuations, what do you think will be the bubble's response? (Discuss the evolution of the bubble's volume, as well as the trajectory of its center of gravity).

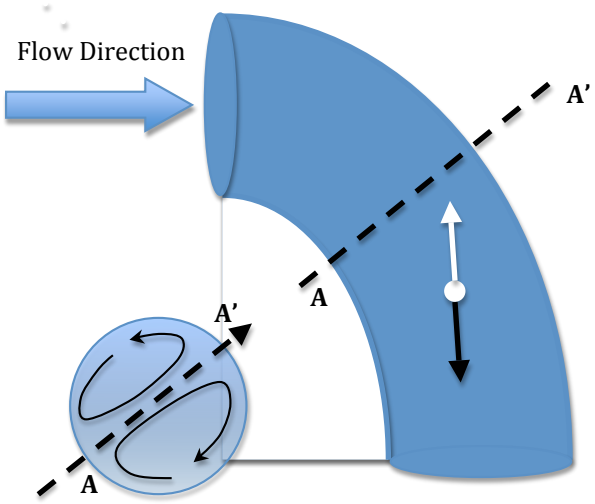

Figure 2: Cross section of the pipe at the bend. Dean's vortices are visible as the centrifugal effects lead to development of a secondary flow in the plane perpendicular to the mean flow direction.