Chair: Physics of Fluids group

Heat transfer and temperature statistics in turbulent bubbly flow

Description

Turbulence is regarded as one of the most important unsolved problems in classical mechanics. It is chaotic, irregular, and has strong fluctuations. Turbulence is omnipresent and occurs all around us: from blood flowing through your veins, to flow around cars, flows going through pipes, to the plasma flows in the sun. Even more, the system can be two-phase (e.g. liquid-gas) like in chemical reactors.

For practical and scientific purpose, it is important to understand how bubbles enhance the heat and mass transfer and how the scalar field (temperature, local concentration) being mixed in bubbly flow with turbulence. Previous findings suggested, by injecting bubbles in vertical convection system, that the heat transfer (Nusselt number) can be enhanced a factor of 20 as compared to single phase flow, and the temperature field changes from active to passive scalar due to the mixing by bubbles [1].

By using the newly built Twente Mass and Heat Transfer tunnel (MHT) (Fig. 1), one can simultaneously heat the liquid, generate turbulent flow, and injecting gas bubbles. These allow us to systematically investigate how liquid turbulence and bubble agitations affect the mixing of the temperature field, the corresponding statistics, and the heat transport.

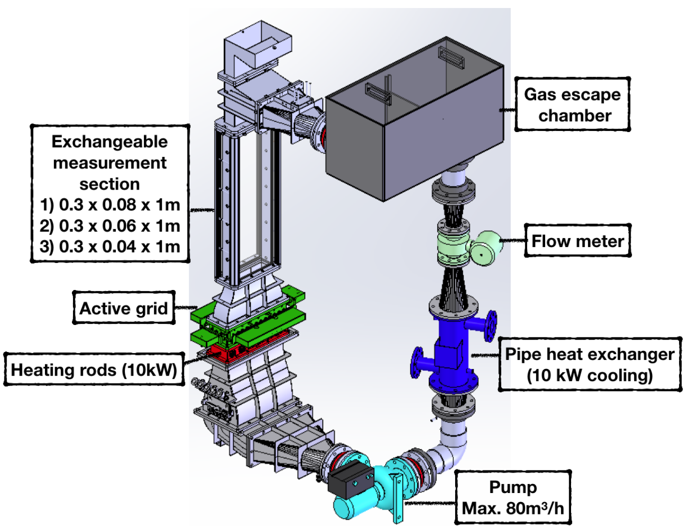

Figure 1: 3D CAD of the Twente Mass and Heat Transfer tunnel

Figure 2: Bubbly flow in the measurement section of MHT tunnel

Assignment

We will consider some of the following measurements and analysis:
A) Simultaneous local velocity and temperature measurements for varying: (1) the temperature/heat flux from the heating rods, (2) turbulent grid speed (turbulent intensity), (3) gas volume fraction and (4) incident mean upward flow. With the results, perform statistical analysis which includes extracting the local heat flux, global heat flux, and calculating the moments and structure functions.
B) Capture the bubbles rising motions subjected to turbulent flow by high-speed cameras with different control parameters (see A). Perform image analysis on the bubble rising motions to extract their velocities and sizes.
C) Investigate the physical relationships between the heat transfer, temperature statistics, bubble Reynolds number and incident flow statistics, length and time scales.

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References

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[2] Risso, F. 2018. Agitation, Mixing, and Transfers Induced by Bubbles. Annu. Rev. Fluid Mech. 42, 335364.