STUDY ON SINGLE AND MULTI-PHASE LAMINAR FLOW CONTAINING SPHERICAL OR SLENDER PARTICLES IN A STIRRED TANK USING DPIV

Nong Xu, Memorial University of Newfoundland; Department of Process Engineering, Faculty of Engineering and Applied Science, Canada
nongxu@gmail.com
Long Fan, Memorial University of Newfoundland, Canada

Stirred tanks are ubiquitous in the chemical, polymer, and pharmaceutical industries and used extensively for conducting a variety of single liquid phase and multiphase operations. Turbulent flow is most often encountered in stirred tanks. While efficient mixing is often achieved under turbulent conditions, there are many applications in which turbulence is precluded because fluids are too viscous or shear sensitive materials may be damaged by vigorous agitation. In such cases, stirred tanks must be operated under laminar flow conditions. The low Reynolds number regime arises in many practical applications, such as culture of shear-sensitive cells, manufacture of creams and detergent. Therefore it is necessary and important to study the laminar flow in stirred tanks.

Both single phase and solid-liquid two-phase systems are frequently encountered in stirred tanks, and the presence of solid particles makes the flow in stirred tanks more complicated. Little literature on laminar solid-liquid flow in stirred tanks is available. To the authors' best knowledge, only Jones and Weinberger (1) studied the laminar solid-liquid flow in a baffled tank stirred by a Rushton turbine. Dyster *et al.* (2) experimented on the radial discharge laminar flow in a baffled stirred tank. Bakker *et al.* (3) using laser Doppler velocimetry (LDV) and digital particle image velocimetry (DPIV) investigated the flow field generated by a pitched-blade turbine in laminar operations. Their stirrer is either paddle impeller or Rushton turbine. Therefore, it would be a very interesting experiment if we can combine the measurement of the laminar flow field in a baffled stirred tank with the DPIV technology.

Also in literature, solid particles are usually taken as spherical particles. Seldom research is about non-spherical particles. Slender particle is a representative of non-spherical particles. It has more and more applications in process engineering due to its special shape. Different from spherical particles, slender particles are orientation dependent and are characterized by their aspect ratio *ar*, ($ar=l/d$, consider that slender particles are rigid cylinders of length l and diameter d).

Thus, in this paper, the laminar flow in a baffled stirred tank was measured with DPIV, as shown in Figure 1. The data of the whole flow field are achieved, including single-phase flow and solid-liquid two-phase flow containing spherical or slender particles. The orientation of slender particles is also obtained using DPIV. The influences of impeller speed, aspect ratio on velocity and orientation are discussed. Figure 2 shows a typical result from the achievements.

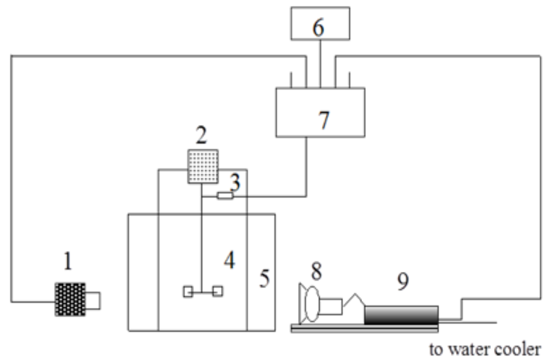

Figure 1. Schematic diagram of experimental system
(1.CCD camera;2.motor;3.position sensor;4.stirred tank;5.glass box;
6.computer,7.synchronizer,8.sheet lens,9.laser)

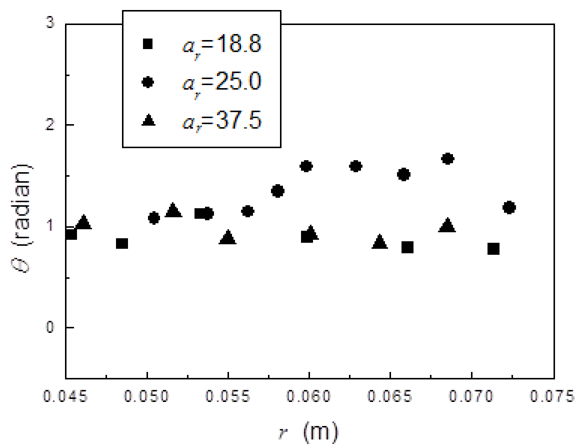

Figure 2. Influence of aspect ratios on orientation of slender particles
in a laminar flow
(r, radial coordinate; θ, the angle between the particle and the plane normal to velocity; a_r, aspect ratio)

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