EFFECT OF ECCENTRICITY ON THE PUMPING CAPACITY IN AN UNBAFFLED VESSEL

Hidalgo-Millán, A.[1], Soto, E.[1], Zenit, R.[2] and Ascanio, G.[1]

1. Centro de Ciencias Aplicadas y Desarrollo Tecnológico, Universidad Nacional Autónoma de México,

Abstract

Mixing in stirred tanks is one of the most common unit operations in the process industry. As many products exhibit diverse proprieties, mixing is usually carried out at low to moderate Reynolds number in unbaffled tanks. Under these conditions, flow structures such as pseudocaverns, defined as well-mixed regions around the impeller are formed when agitating Newtonian fluids. Furthermore, dead zones can be formed the far away zones from the impeller. As a consequence, either infinites or very long mixing times are required to reach a desirable homogeneity level into the mixing tank resulting in an inefficient process. The mixing process can be improved by increasing the impeller speed resulting in higher energy consumption; therefore other approaches should be considered. Dynamics perturbations were proposed by Yao et al. 1998 by using unsteady rotational speeds, this effect decreased significantly the mixing time. Other approach is based on the use of geometrical perturbation by displacing the agitation shaft from the vessel centerline. Ascanio et al. (2002) and Alvarez et al (2002) found that flow structures formed in the beginning are readily destroyed when using eccentric impellers; as a consequence shorter mixing times are obtained. Pumping capacity have been studied many times by several investigators, Aubin, et al., 2001, studied the pumping capacity of the pitched blade turbine(PBT) and a mixel TT (MTT) impellers, reported more circulation for the MTT impeller than the PBT impeller. Zadghaffari, et al., 2009 who develop a simulation in a double-Rushton turbine reported the pumping capacity experimental and with the simulation results. Rice, et al., 2006 performed an experimental study in laminar regime at three different *Re* (1, 10, 28) with a Rushton turbine showing a figure of the flow number at different *Re*. However, no information about the relationship among the eccentricity and the pumping capacity has been provided in the literature. A study of the pumping capacity has been performed under steady and unsteady flow conditions with the impeller centered and off-centered, respectively. The experimental setup consists of a polycarbonate transparent vessel of diameter T of 165 mm and a liquid height H = T. The cylinder vessel is placed inside a square tank contained the same fluid under study. A Rushton turbine, and a PBT having both a diameter of 55 mm (1/3 $T = D$) were chosen as impellers for operating at $Re = 10$ and 100 (laminar and transition regime). The impeller was driven by a DC motor of 248 W, which speed was set from a DC controller in an open-loop mode. Aqueous solution of polyethylene glycol at 40 wt % and 10 wt % having a dynamic viscosity μ of 1.5 and 0.02 Pa·s, respectively, were used as working fluids. The tests were performed with the impeller centered and off-centered. The off-centered defined by

$$X^* = \frac{x}{r}$$

where *x* is the distance from the vessel centerline to the impeller radial position (x = 30 mm) and *r* is the vessel radius (T/2), thus $X^* = 0.36$. In the off-centered impeller cases, 18 different planes of measurements in the θ direction were performed. The particle image velocimetry (PIV) technique was used for visualizing the flow into the stirred vessel (Dantec Dynamics). In order to obtain statically robust results on each plane, 500 individual images were taken by the camera. The pumping capacity on centric and eccentric position as well as flow patterns observed will be presented during the symposium.

Alvarez, M., Arratia, P.E. and Muzzio, F.J., 2002, "Laminar mixing in eccentric stirred tank systems", Can. J. Chem. Eng., 80, 546-557. Ascanio, G., Brito-Bazan, M., Brito-De La Fuente, E., Carreau, P.J. and Tanguy, P.A., 2002. Unconventional Configuration Studies to Improve Mixing Times in Stirred Tanks. Canadian Journal of Chemical Engineering 80, 558-565. Aubin, J., Mavros, P., Fletcher, D. F., Bertrand, J., and Xuereb, C., 2001. Effect of axial agitator configuration (up-pumping, down-pumpimg, reverse rotation) on flow patterns generated in stirred vessels. Trans IChemicalE 79 part A 845-856. Rice, M., Hall, J., Papadakis, G. and Yianneskis, M., 2006. Investigation of Laminar flow in a stirred vessel at low Reynolds numbers. Chemical Engineering Science 61, 2762-2770. Yao, W. G., Sato, H., Takahashi, K. and Koyama, K., 1998. "Mixing performance experiments in impeller stirred tanks subjected to unsteady rotational speeds", Chem. Eng. Sci., 53(17), 30313040. Zadghaffari, R., Moghaddas, J. S., and Revstedt, J., 2009, A mixing study in a double-Rushton stirred tank. Computers and Chemical Engineering 33, 1240-1246.