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Letter to the Editor

Comments on "On the variation of precessional flow instabilities with operational parameters in stirred vessels" by L. Nikiforaki, J. Yu, S. Baldi, B. Genenger, K.C. Lee, F. Durst and M. Yanneskis

The article written by Nikiforaki et al. [1] consists of analysis of the phenomenon "flow macro-instabilities" (MI) in liquid stirred by axial or radial high-speed impellers under transitional flow regime. One of the sources of the MIs origin is considered a precessing vortex between rotating shaft and vessel walls with radial baffles. The shape of the vortex is given by the radial profile of the tangential component of the ensemble-averaged mean velocity: decreasing with increasing radial coordinate. It follows from results of LDA experiments that the shape of this profile depends both on the operational conditions of the stirred system (e.g. number of baffles, impeller/vessel diameter ratio) and on the impeller Reynolds number.

Although the results of the commented article are valid for transitional region of flow of agitated liquid and their experimental evidence was confirmed in the space above the rotating Rushton turbine impeller (RT), i.e. in the recirculation bulk flow, the origin of the radial profile discussed lies in the impeller discharge flow. Here under turbulent regime of flow the angular momentum flow between the rotating impeller and cylindrical vessel wall can be considered [2,3]:

$$M = \text{const.} = \rho Q(r) r \overline{w_{\text{t,av}}(r)} \tag{1}$$

where ρ is a density of agitated liquid, r a radial coordinate with the origin in the axis of symmetry of the cylindrical vessel and coaxially located RT and Q a volumetric flow rate of the RT impeller discharge flow depending linearly on the radial coordinate [4]:

$$Q(r) = K(r - \tfrac{1}{2}D) + Q_{\text{p}} \tag{2}$$

where D is an impeller diameter and Q_{p} its pumping capacity. Quantity $\overline{w_{\text{t,av}}}$ i.e. the tangential component of the ensemble-averaged mean velocity averaged over the width of the impeller discharge stream, here considered as the tangential axially symmetrical cylindrical submerged jet [5] of the width $(z_2 - z_1)$ at the radius r is:

$$\overline{w_{\text{t,av}}(r)} = \frac{1}{z_1 - z_2} \int_{z_1}^{z_2} \overline{w_{\text{t}}(z)} \text{d}z, \; r = \text{const.} \tag{3}$$

Combination of Eqs. (1) and (2) gives relation:

$$\overline{w_{\text{t,av}}(r)} = \frac{M}{\rho r [K(r - D/2) + Q_{\text{p}}]} \tag{4}$$

which characterizes a dependence of the quantity $\overline{w_{\text{t,av}}}$ on radial coordinate r in the RT impeller discharge stream. This nonlinear decreasing dependence corresponds to the found experimental courses $\overline{w_{\text{t,av}}}$ in commented article, but with increasing axial (vertical) distance from impeller upwards the slope of this dependence decreases. This gradual change of the gradient $\text{d}\overline{w_{\text{t,av}}(r)}/\text{d}r$ with increasing axial coordinate can contribute to the origin of the MIs in an investigated space even under transitional regime of flow of agitated liquid, because the RT impeller discharge stream exhibits a turbulent character even under transitional region of the bulk (recirculation) flow of agitated liquid [6].

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