Comparison of Impeller-Baffle Interactions in Alumina Precipitators

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Abstract

Worldwide there are various open stirred systems for precipitators in use which are different in technical design, mixing quality as well as investment and operational costs. A review of the best known ones provides a good overview of advantages and disadvantages of the same. Derived from this and further new investigations into the baffle influence on mixing quality, this article gives an outlook on the future for open precipitator systems.

Keywords: Precipitator; impeller; baffle; mixing quality; investment; operational costs

1. Introduction / Mixing Basics

To design technically appropriate and reliable mixing equipment it is necessary to firstly have a close look at the physical properties of the liquid to be mixed. The essential parameters to pay attention to are:

- Rheology and mass fraction
- Homogenising and bottom off criteria
- Impeller design, type, shape, diameter
- Power input and required tip speed
- Descaling intervals due to scaling at the vessel wall and the apparent wall velocity

In this presentation, the important basics are shown and summarized and shall form a review of the current state of the art in precipitator stirring. The most common designs in operation are analyzed and possible variations are highlighted. Typical composition and properties for precipitators are shown in Table 1.

Table 1. Precipitator Slurry Properties.

Precipitator slurry data			
Solids density trihydrate	ρ_S	[kg/m³]	2,420
Continuous phase density	ρ_L	[kg/m³]	1,270
Slurry density	ρ_{SL}	[kg/m³]	1,650-1,750
Solids mass concentration	C_G	[%]	55
Solids volume concentration	C_V	[%]	40
Solid mass	C_{ms}	[g/l]	900 – 1,000
Particle size 80 % passing	d_P	[µm]	110-120

All slurries are in general polydisperse, with a broad particle distribution. Those data shall constitute the basis of the following considerations, knowing well that there is a wide variety of deviations in the one and other direction.

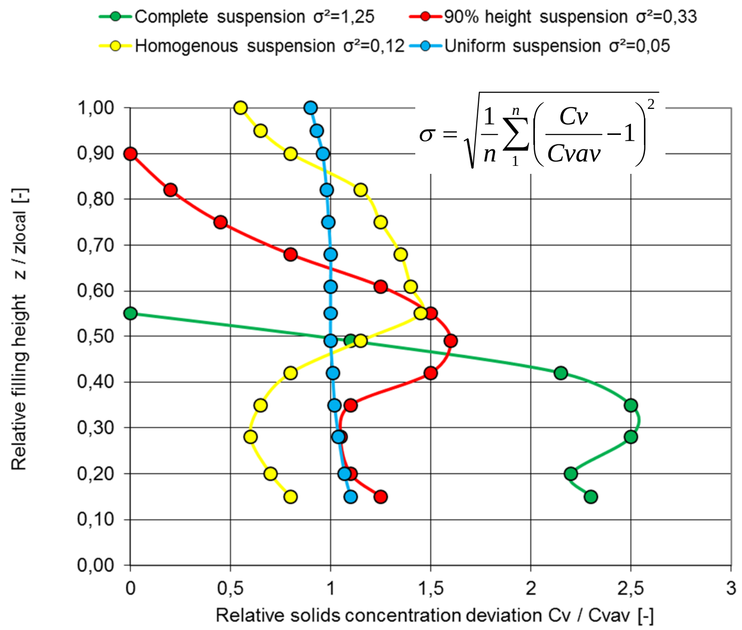

Figure 1. Solid Content Distribution.

To deal with suspension mixing tasks it is important to understand the behavior and flow pattern of the solids [3] [5] [8] [10] [12]. In Figure 1 solid distributions at different shaft speeds in relation to the solid concentration deviation are shown for different suspension criteria. Poorly mixed areas are in the bottom center below the impeller and relatively independent of the impeller type (Figures 2 and 3).

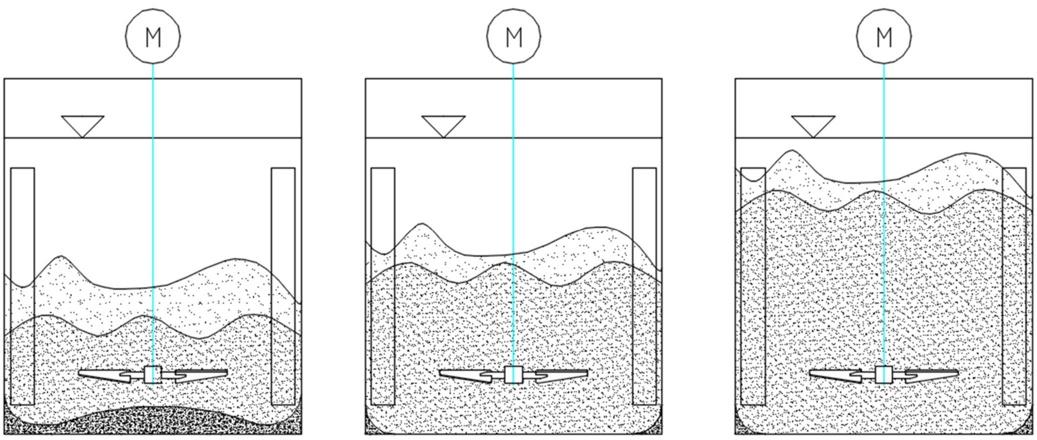

Figure 2. Suspension Criteria.

- Probably by using smaller impeller diameters, higher speeds and possibly even changing the impeller flow pattern partly to radial pumping may help to reduce investment, operational and maintenance costs.

6. References

1. Hong-Liang Zhao et al, Computational Fluid Dynamics (CFD) Simulations on multiphase flow in mechanically agitated seed precipitation tank, *The Minerals, Metals & Materials Society*, 2014.
2. Hong-Liang Zhao et al, Numerical simulations of solid-liquid stirred tank with an improved Intermig impeller, *American Institute of Physics*, 2013.
3. Inci Ayranci, Suzanne M. Kresta, Critical analysis of Zwietering correlation for solids suspension in stirred tanks, *Chemical Engineering Research and Design*, 2014.
4. Vakili M.H., Nasr Esfahany M., Effect of baffle arrangement on turbulent flow field in a stirred tank, *5th International Chemical Engineering Congress and Exhibition*, 2008.
5. M. Špidla et al, Effect of Baffle Design on the Off-bottom Suspension Characteristics of Axial-flow Impellers in a Pilot-scale Mixing Vessel, *Department of Chemical Engineering, Institute of Chemical Technology,* 2005.
6. C. Devarajulu, M. Loganathan, Effect of Impeller Clearance and Liquid Level on Critical Impeller Speed in an Agitated Vessel using Different Axial and Radial Impellers, *Journal of Applied Fluid Mechanics*, 2016.
7. Jie Dong et al, The Effect of Bottom Shape and Baffle Length on the Flow Field in Stirred Tanks in Turbulent and Transitional Flow, *International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering Vol:10, No:9,* 2016.
8. Yuan fa Ding et al, Experimental Study of Solid Dispersion in a Seeded Precipitation Tank with Slight Agitation for Gibbsite Crystallization, *Applied Mechanics and Materials Vol 456 (2014) pp 537-540,* 2014.
9. Piero M. Armenante, Ernesto Uehara Nagamine, Effect of low bottom impeller clearance on the minimum agitation speed for complete suspension of solids in stirred tanks, *Chemical Engineering Science, Vol. 53, No. 9, pp. 1757-1775,* 1998.
10. A. Tamburini et al, CFD Simulations of dense solid-liquid Suspensions in baffled stirred tanks: Prediction of solid particle Distribution, *Chemical Engineering Journal, 223 (2013) 875–890,* 2013.
11. Zhang Ting-an et al, Physical Simulation and Numerical Simulation of Mixing Performance in the Seed Precipitation Tank with a Improved Intermig Impeller, *Light Metals 2011*, 2011.
12. Hong-Liang Zhao et al, Process Optimization of Seed Precipitation Tank with Multiple Impellers Using Computational Fluid Dynamics, *The Minerals, Metals & Materials Society,* 2015.