Solid Particles Distribution on Dished Base of a Stirred Tank Using Conventional Impellers and Novel SATAKE Impellers

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1. Introduction

Since pioneering work by Zwietering [1], solids suspension has been extensively studied in flat base tank using high density particles (glass ballotini or sands, ρ_s=1600～2600kg/m^3) in a range from low to medium solids concentration (0.5 ～ 20wt%). However, in industrial practice, solids suspension in dished base tank is also widely used. Moreover, in some cases, higher solids concentration (>20wt%) is also required. Therefore, it is a practical interest to understand solids suspension characteristics under these conditions.

Subsequently, there are three main objectives of this study as follows: (1) To investigate the solids suspension characteristics and performance for a range of conditions (effect of impeller clearance and solids concentration) in a stirred tank. (2) To make clear the performance of novel SATAKE impellers by comparing with the conventional impellers. (3) To identify the effect of flow inside stirred tanks on solid particles distribution on the tank base and suspension efficiency of impellers used.

2. Experimental

A dished base tank of diameter 155mm equipped with four standard baffles was used in this study. The impellers used were conventional impellers 4PP and 3P, SATAKE novel impellers HR100 and HS604, of impeller diameter, d, to tank diameter, D, d/D=0.52. The impeller clearance from the tank base was set at C/d=0.25, 0.5, 0.75 and 1.0 for 4PP, 3P, and HR100, and C/D=0.02 for HS604.

Spherical shape of Poly Methyl Metacrylate (PMMA) (d_p=75.2μm, ρ_s=1300kg/m^3) as the solid phase was suspended in the water as the liquid phase. The solids concentration was set at 5, 10, 15, 20, 30 and 40wt%.

The just suspension speed, N_{js} was visually observed based on Zwietering criterion. The repeatability of the N_{js} measurement in this work was found to be within 5%. Torque reading at the determined N_{js} was measured by using ST−3000II. The mean of the torque reading was used to determine mixing power and other related parameters used in this study. The flow pattern inside stirred tank was measured by using PTV (Particle Tracking Velocimetry).

3. Results and Discussion

Table 1 shows power consumption at complete suspension in low, medium and high solids concentration for respective impellers. It can be seen that HS604 is the most efficient with lowest power demand even when the solids concentration reaches 40wt%. The HR100 also requires lower power and least affected even at higher impeller clearance compared to 4PP and 3P, making it the second best impeller for the PMMA solids suspension.

Table 1 Power consumption at complete suspension

Solids concentration [wt%]	MIXING POWER [W]						
	4PP		3P		HR100		HS604
	C/d						C/D=0.02 (Const.)
	0.5	1.0	0.5	1.0	0.5	1.0	
5	0.14	0.23	0.14	0.26	0.07	0.08	0.02
20	0.34	0.72	0.34	0.63	0.18	0.21	0.06
40	0.94	1.76	1.28	2.22	0.57	0.66	0.12

Fig. 1 displays flow pattern for 4PP and HR100 at C/d=0.5, and HS604 at C/D=0.02. It is clearly observed that in the case of HR100, a strong axial flow is generated by the blades. However, in the case of 4PP, less axial flow is generated, causing more particles accumulated at the center base due weak secondary flow forms beneath the impeller. This significantly leads to an increase in power demand for 4PP compared to HR100. In the case of HS604, by mounting this impeller close to the tank base, the discharged flow passes along the tank base and tank wall, and sufficiently stronger than other impellers. This flow characteristic of HS604 makes this impeller advantageous to eliminate particles from accumulates at the center base. Hence, this exhibits to the lowest power demand even at high solids concentration for HS604.

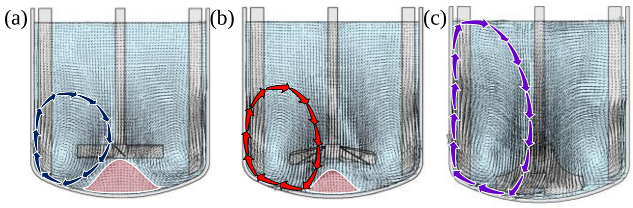

Fig.1 Flow pattern inside stirred tank (a) 4PP (b) HR100 (c) HS604

4. Conclusion

HR100 and HS604 are more efficient in suspending PMMA solid particles, particularly at high impeller clearance and solids concentration compared to the 4PP and 3P. Additionally, the effect of flow inside stirred tank and suspension ability of impellers used on solid particles distribution on the tank base is also identified.

Reference

[1] Zwietering, T.N., *Chem.Eng.Sci.*, 8, 244-253 (1958)

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