SUSPENSION OF SOLID PARTICLES

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The results of agitator speed measurements for complete suspension of solid particles reported earlier were completed by new measurements in larger vessel and with smaller particles and with particles of different density. Good agreement between earlier and new results justifies the applicability of the correlation proposed for calculation of critical agitator speed.

In the recent paper[1] experimental results on impeller speed required for complete suspension of solid particles were presented. The results for the volumetric concentration c_v = 2.5% were described by the following equations:

$$Fr' = 16.6\,(d_p/D)^{0.6} \quad \text{for} \quad d_p/D < 0.073 \qquad (1)$$

$$Fr' = 0.855 \quad \text{for} \quad d_p/D > 0.073\ . \qquad (2)$$

These results were obtained by laboratory measurements with glass ballotine of diameter in the range from 0.18 to 6 mm in vessels of the inner diameter 200, 300 and 400 mm. The aim of this paper is to present a verification of results mentioned above by measurements with particles of a smaller size or of different density and by measurements using a larger vessel.

EXPERIMENTAL

Six pitched blade turbines characterized by the ratio of vessel to the agitator diameter D/d = 3 and impeller bottom clearance $H_2 = 0.5d$ were used in experiments. The measurements were carried out in flat bottomed vessels equipped with four baffles. The water suspensions of fine glass ballotine, polystyrene, PVC and steel particles were investigated in a glass vessel with the inner diameter of D = 300 mm. The measurements in a perspex vessel with diameter D = 1 m were carried out with glass ballotines only. All particles were spherical with exception of granular PVC in the shape of cylinders with diameter 4 mm and length in the range from 2.5 to 4.5 mm. The mean volumetric diameters d_p and densities of particles are given in Table I. The solid phase mean volumetric concentration was c_v = 2.5%. The impeller speed required for complete suspension was determined visually and measured with photoelectrical pick-up. More details concerning the experimental procedure and equipment were given in ref.[1].

RESULTS

The earlier[1] experimental results expressed in the form of dimensionless dependence $Fr' = f(d_p/D)$ were completed with the results of 7 new measurements – see Fig. 1. From this figure a good agreement can be seen between the new and original results. This fact justifies the applicability of the dimensionless dependence $Fr' = f(d_p/D)$ given by Eqs (*1*) and (*2*) and obtained from small-scale measurements with glass ballotine also for calculation of critical agitator speed necessary for the suspension of different

TABLE I
Solid particles used in experiments

Material	d_p, mm	ρ_s, kg m^{-3}
Glass ballotine	0.075, 0.99, 1.54	2 630
Polystyrene (PS)	1.35	1 035
Polyvinyl chloride (PVC)	3.0	1 280
Steel	0.7	7 750

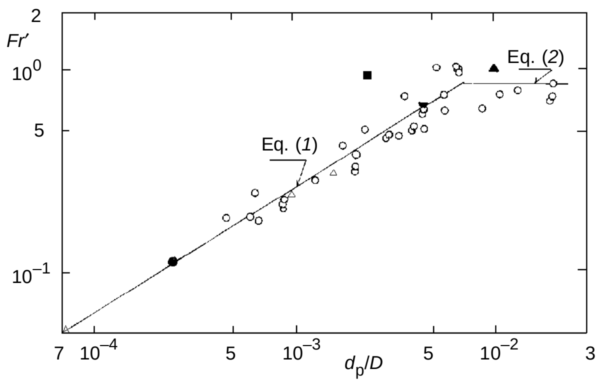

FIG. 1
Modified Froude number Fr' vs dimensionless particle diameter d_p/D: ❍ results reported in Rieger and Ditl[1]; Δ glass ballotine, D = 1 m, this work; ▼ PS, ▲ PVC, ■ steel, ● glass ballotine, D = 0.3 m, this work

particles in industrial-scale equipment. An exception has to be made for suspensions of the heavy steel particles. In this case, higher agitator speed is required for a complete suspension. Similar results were observed by Ditl, Nauman and Mikulasek[2], who studied the behaviour of suspensions in a vertical tube.

SYMBOLS

c_v	mean volumetric concentration of solid particles
d	agitator diameter, m
D	vessel diameter, m
d_p	mean volumetric diameter of particles, m
Fr'	modified Froude number, $Fr' = n^2 d\rho / g\Delta\rho$
g	gravity acceleration, m s^{-2}
H_2	impeller bottom clearance, m
n	agitator speed, s^{-1}
ρ	density of liquid, kg m^{-3}
ρ_s	density of particles, kg m^{-3}
$\Delta\rho$	density difference of particles and liquid, kg m^{-3}

REFERENCES

1. Rieger F., Ditl P.: Chem. Eng. Sci. *49*, 2219 (1994).
2. Ditl P.: Private communication.