APPENDIX E

CALCULATION:
FORCE TO SUSPEND A CATALYST PARTICLE

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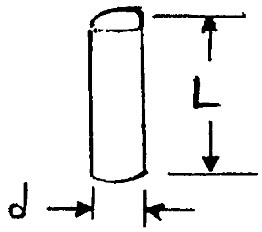
Extreme Case: No Impact from Other Particles:



By a Force Balance Shear Force + Buoyancy Force = Weight.

$$\tau_w \cdot \left(\pi dL + 2\frac{\pi d^2}{4}\right) + \frac{\pi d^2 L}{4}\rho_{sl}g = \frac{\pi d^2 L}{4}\rho_p g$$

Values used for calculation are listed in Table E-I.

$$\tau_w = 20.41 \ \frac{\text{gm-cm}}{\text{sec}^2} \ /\text{cm}^2$$

$$= 20.41 \ \text{dyne/cm}^2$$

$$= 2.04 \ \text{N/m}^2$$

By contrast, yield stresses measured by Battelle and ORNL are ~ 0.2.

The shear stresses predicted using the Bingham plastic model are expressed:

$$\tau_w = \tau_o + \dot{\gamma}\eta_{pl}$$

For the slurries tested:

$$\tau_o = 0.2 \ \text{N/m}^2$$

$$\eta_{pl} \approx 2.5 \ \text{cp}$$

$$= 2.5 \cdot 10^{-2} \ \text{gm/cm-sec} = 2.5 \cdot 10^{-3} \ \text{kg/m-sec}$$

$$= 2.5 \cdot 10^{-3} \ \frac{\text{N-sec}}{\text{m}^2}$$

Then $2.0 \ \text{N/m}^2 \approx 0.2 \ \text{N/m}^2 + 2.5 \times 10^{-3}\dot{\gamma}$

$$\dot{\gamma} \approx 720 \ \text{sec}^{-1}$$

For the PDU tests, this value was reduced to 450 sec^{-1} to account for the buoyant effect of the gas. A pseudo-viscosity was then calculated:

$$\eta^* \equiv \frac{\tau}{\dot{\gamma}} = \eta_{pl} + \frac{\tau_o}{\dot{\gamma}}$$

TABLE E-I

d	Particle diameter (1)	0.140 cm
L	Particle length (1)	0.332 cm
ρ_{sl}	Slurry density (2)	0.93 g/cm^3
ρ_p	Soaked Particle Density (2)	1.65 g/cm^3
τ_w	Shear stress, N/m^2	--
g	Gravitational acceleration	980.7 cm/sec^2
$\dot{\gamma}$	Shear rate, sec^{-1}	
τ_o	Yield stress, N/m^2	
η_{pl}	Plastic viscosity, cp	
η^*	Pseudo-viscosity, cp	

(1) Table 28, Reference 2.

(2) Nominal value--Table XIX.

(3) Nominal value--Table XVIII.