μ, σ_1, σ_2 = material functions
ϕ = $p - \alpha z$

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Solid Particle Deposition From a Turbulent Gas Stream

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Friedlander and Johnstone (*1*) presented experimental data for the wall deposition of small iron and aluminum particles from a turbulent air stream. The data were compared with an analysis considering equal eddy diffusion of the particles and gas. The eddies were assumed to carry the particles to one stopping distance of the wall because of the relatively stagnant fluid layer at the wall. The distance that a particle with a given initial velocity will move through a stagnant fluid is defined as the stopping distance. This is represented by the equation

$$S = \frac{m}{3\pi\mu d_p} v_p \qquad (1)$$

A transport equation was derived using the Lin, Moulton, and Putnam (*2*) eddy diffusion equations for the sublayer and transition region and with the assumption that the mass flux from the center line to the wall is equal to the mass flux at the wall. A particle velocity of $0.9u^*$ was assumed and solution of the derived equation showed agreement with the experimental data except for the 0.8 micron particles.

Hughmark (*3, 4*) has proposed diffusion equations for the sublayer and transition region which represent a higher eddy diffusion rate than is shown by the equations used by Friedlander and Johnstone. Earlier work (*5*) shows a numerical integration of equations for the turbulent flow velocity profile and eddy diffusion to calculate mass transfer for a smooth circular pipe. This calculation technique can be used with the eddy diffusion equations to determine mass transport in an air stream without the molecular diffusion contribution. The Friedlander and Johnstone experimental data for mass transfer can thus be used to estimate the distance from the pipe wall that corresponds to the observed mass transfer rate. This distance can then be compared with the stopping distance in accordance with Equation (1) to estimate the particle velocity. Figure 1 shows the dimensionless particle velocity as a function of the dimensionless stopping distance. Data for 0.8 micron particles in the 0.54 cm. diam. pipe are not shown because these data are not in agreement with the other particle data. The average value of $0.5u^*$ for the particle velocity corresponds to the radial fluctuating velocity at $y^+ \approx 12$ observed by Laufer (*6*). A wall region analysis (*4*) indicates that the source of the wall region fluctuations corresponds to $y^+ \approx 12$. Thus the assumptions of equal particle and gas diffusion, stopping distance, and particle velocity equal to fluctuating velocity appear to be consistent with the experimental data.

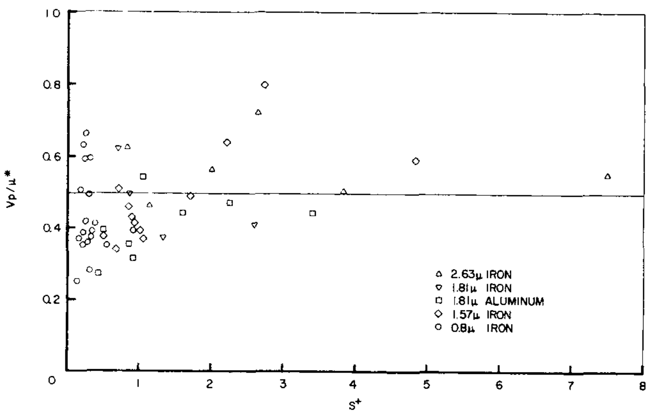

Fig. 1. Particle velocity.

NOTATION

d_p = particle diameter
f = friction factor
m = mass of particle
S = stopping distance
S^+ = reduced stopping distance, Su^*/ν
u^* = $v_{av}\sqrt{f/2}$
v_{av} = average gas velocity
v_p = particle velocity
y = distance from wall
y^+ = yu^*/ν
μ = gas viscosity
ν = kinematic viscosity

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