Figure 15

Effect of operating conditions on bed expansion

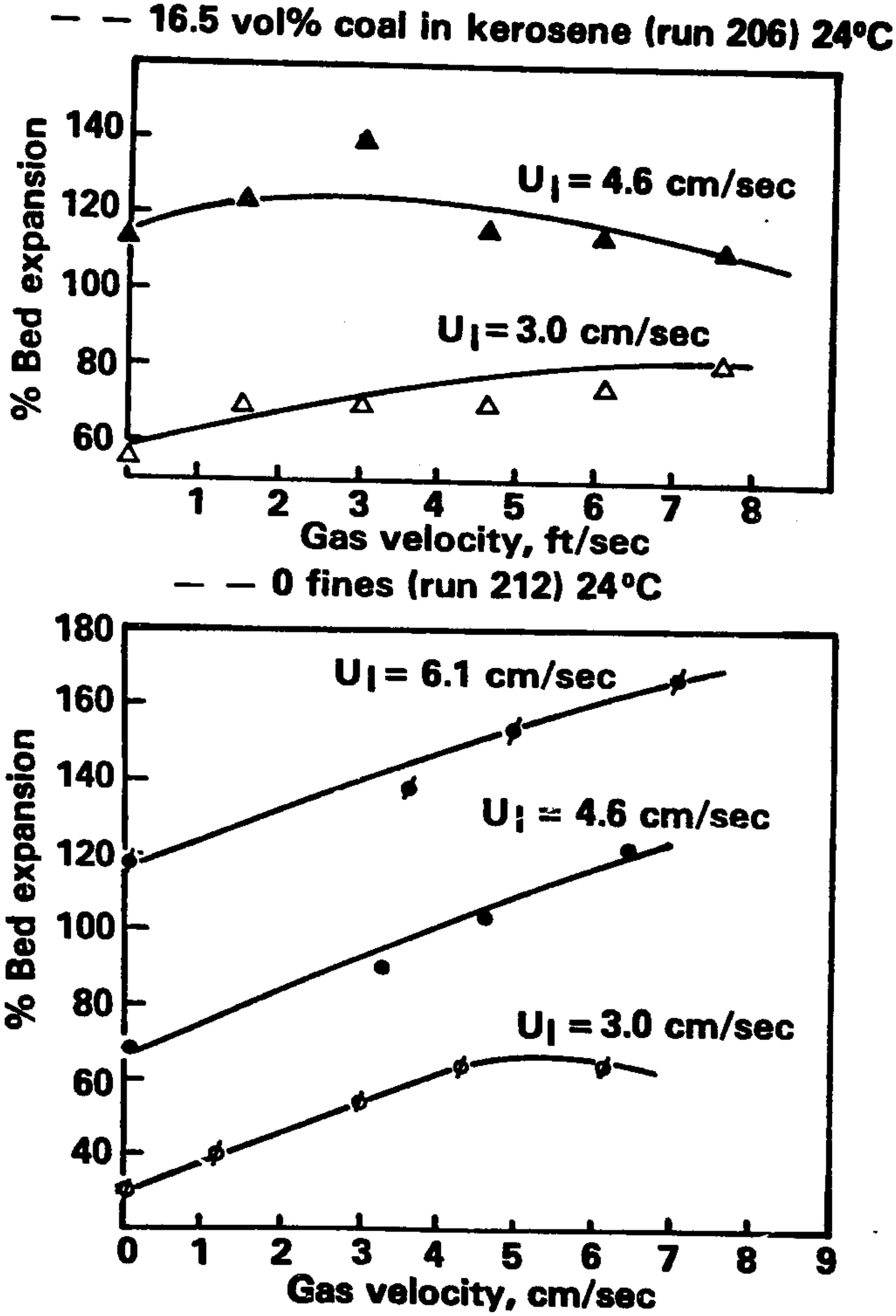


Figure 16

Effect of temperature on bed expansion

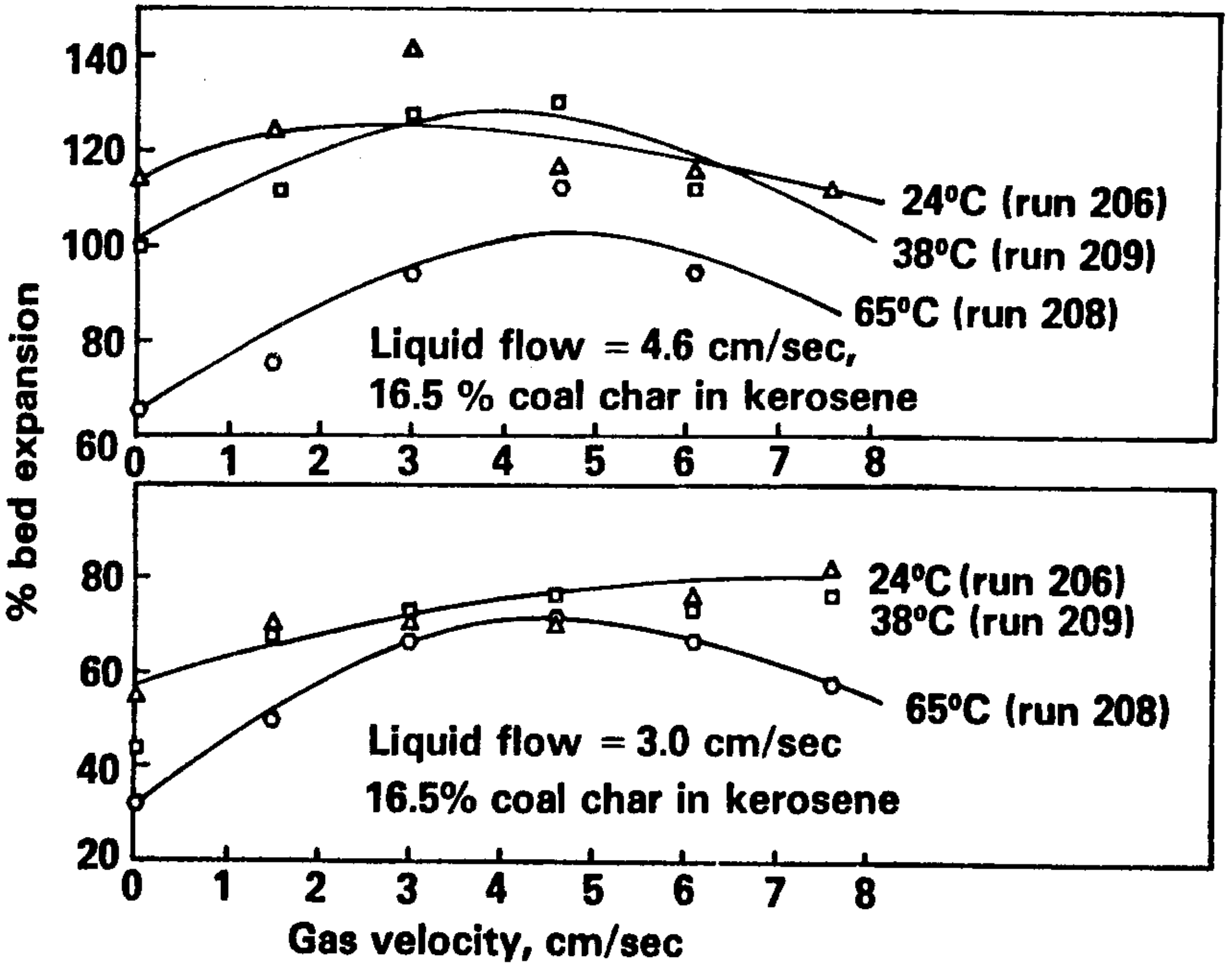


Figure 17

Effect of operating conditions on catalyst holdup

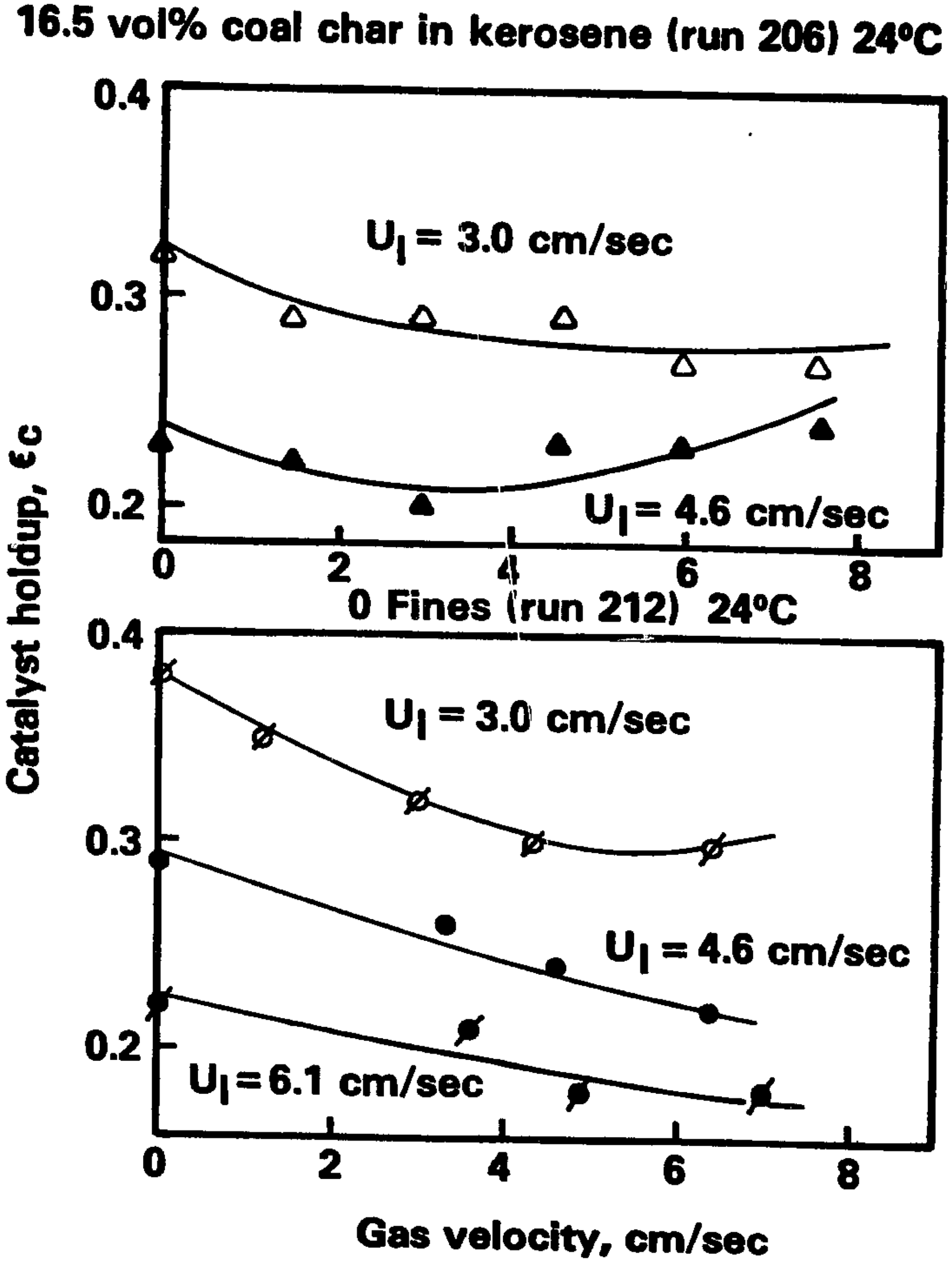
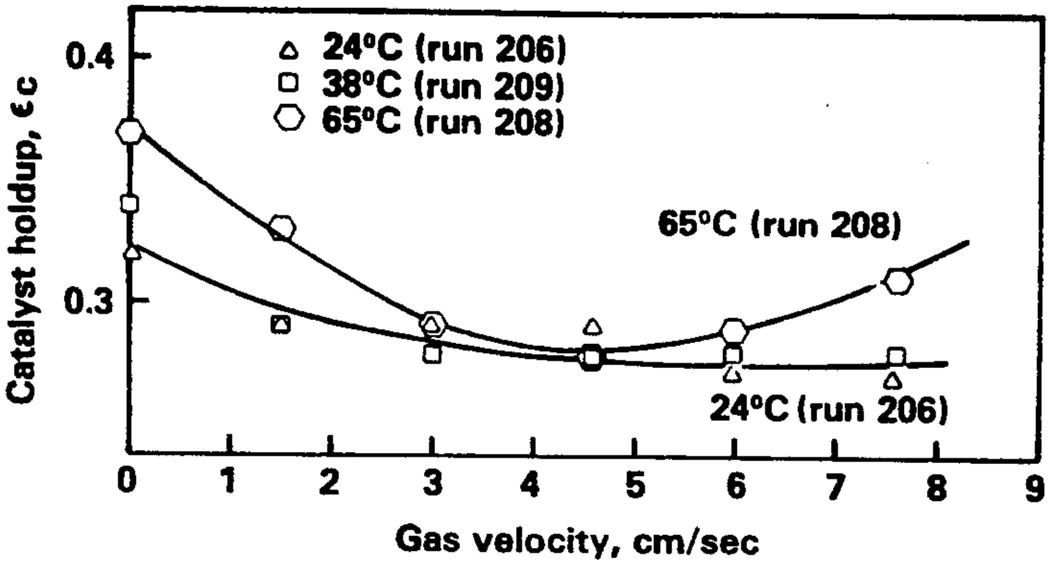


Figure 18

Effect of temperatures on catalyst holdup
Slurry velocity=3.0 cm/sec
16.5 vol% coal char in kerosene



Slurry velocity=4.6 cm/sec
16.5 vol% coal char in kerosene

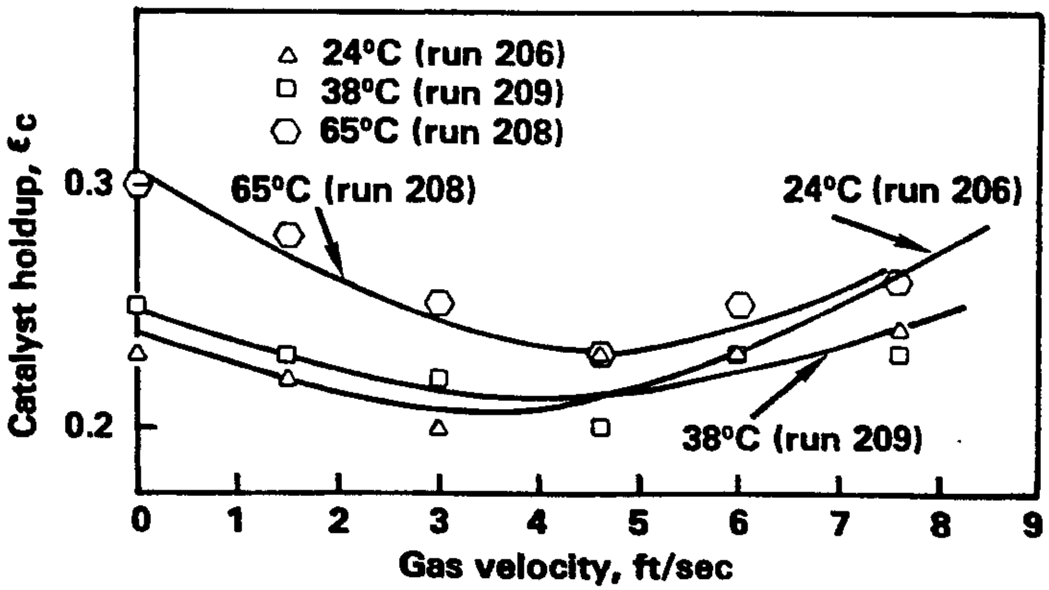


Figure 19

Drift flux vs. gas holdup

0 vol% coal char in kerosene (run 212) 24°C

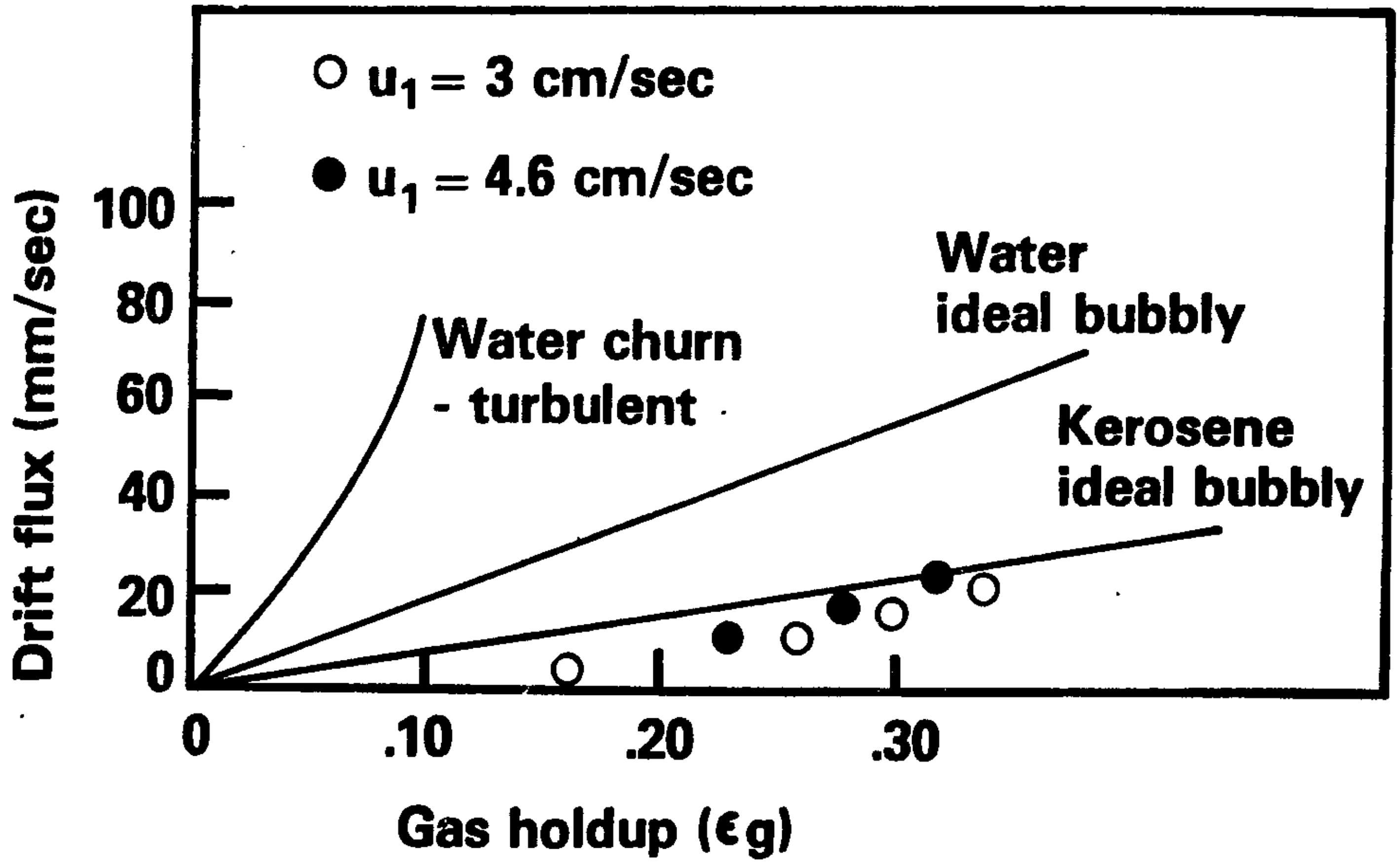


Figure 20

Drift flux vs. gas holdup

16.5 vol % coal char in kerosene (run 206) 24°C

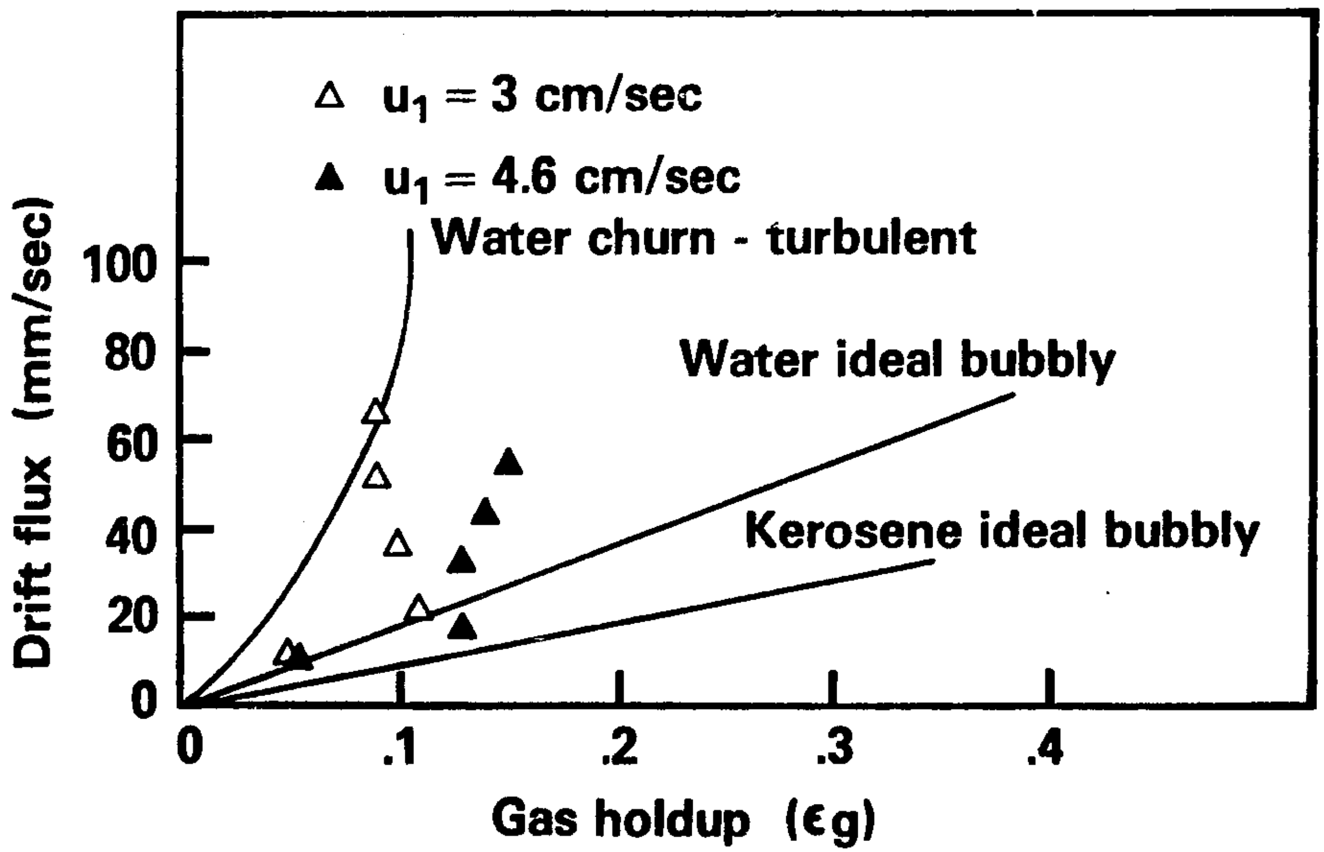


Figure 21

Effect of temperature on drift flux

Drift flux vs. gas holdup   Liquid velocity = 3 cm/sec

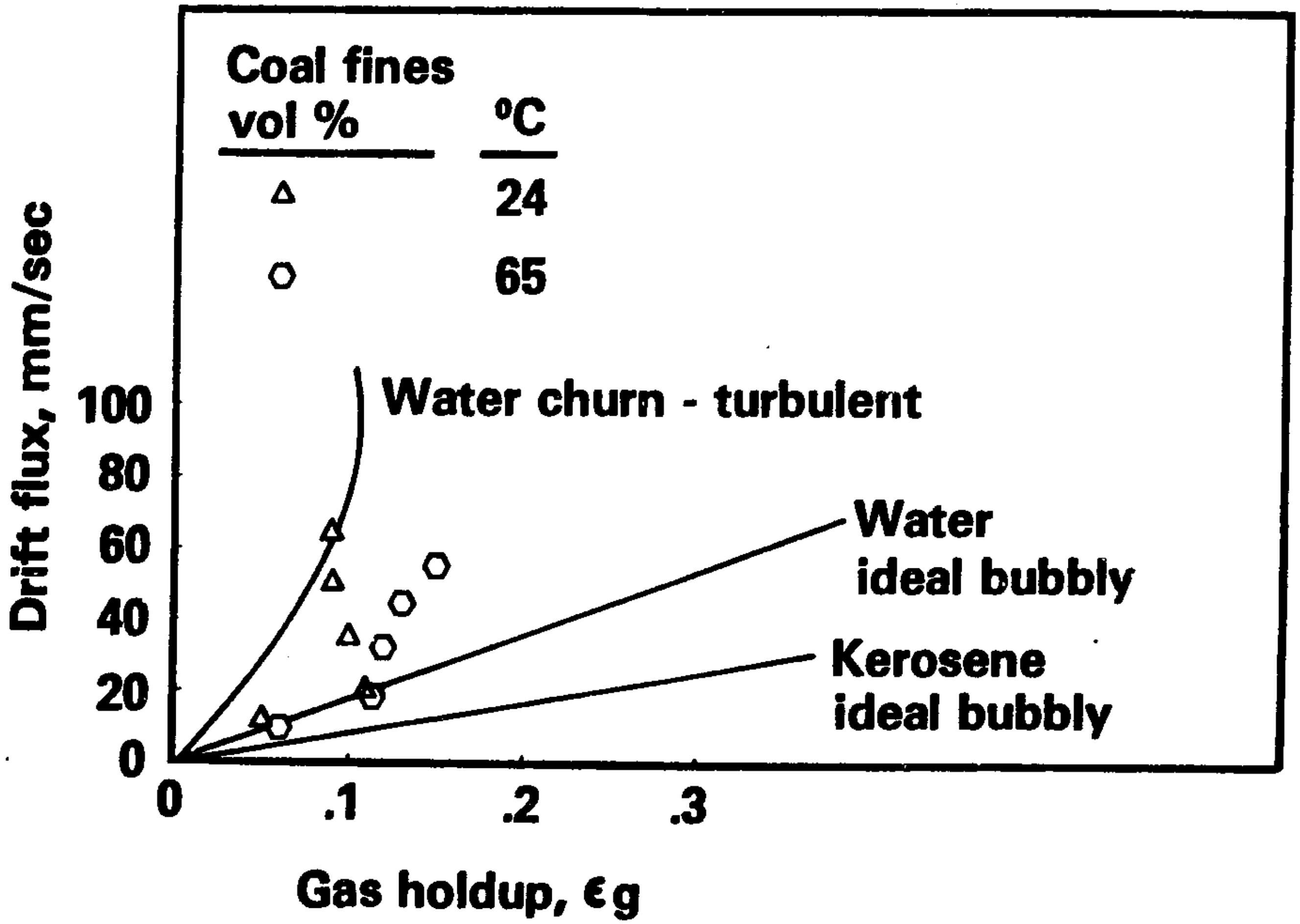


Figure 22

Comparison of experimental catalyst holdups with holdups calculated by the Bhatia & Epstein Correlation (33)

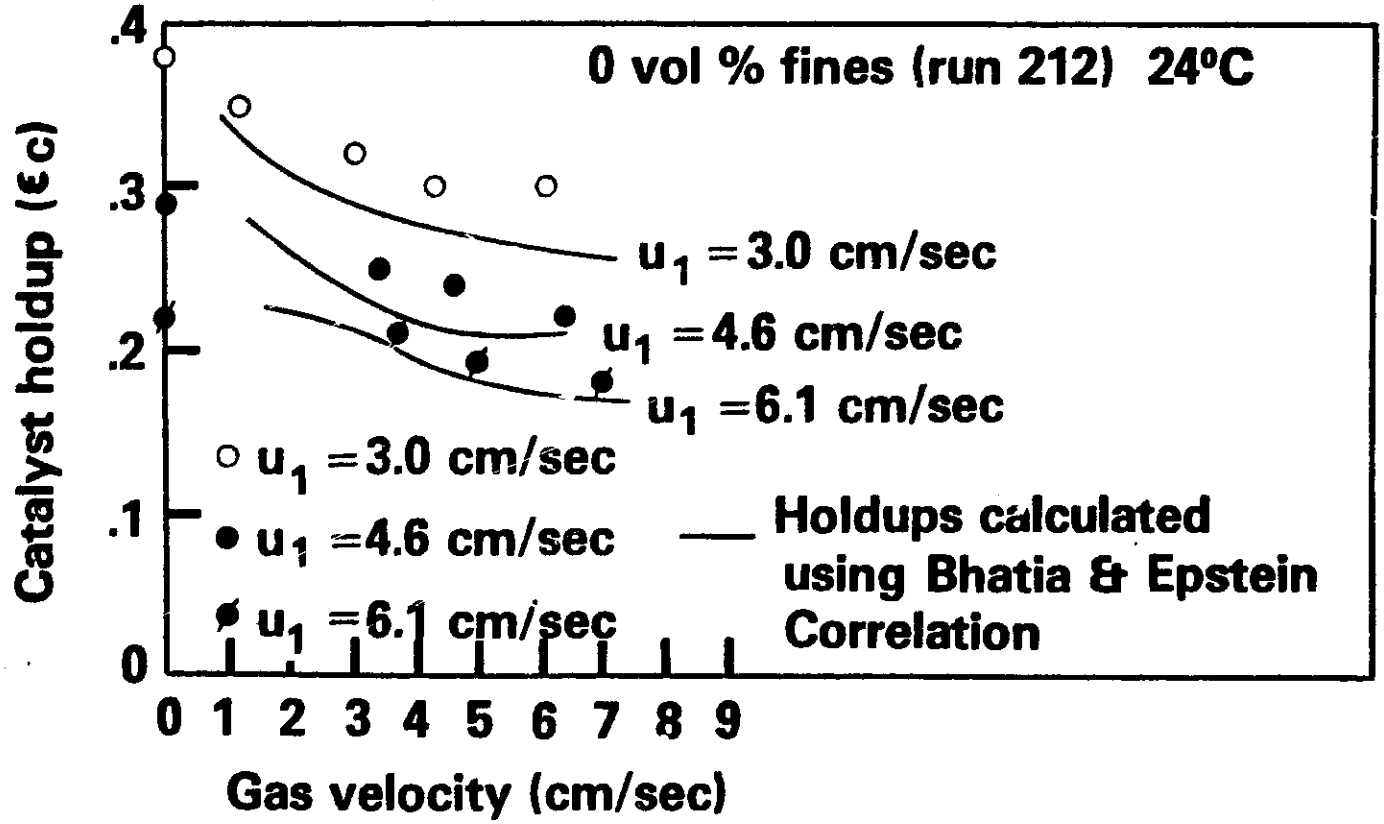


Figure 23

Comparison of experimental catalyst holdups with catalyst holdups calculated by the Bhatia & Epstein Correlation (33)

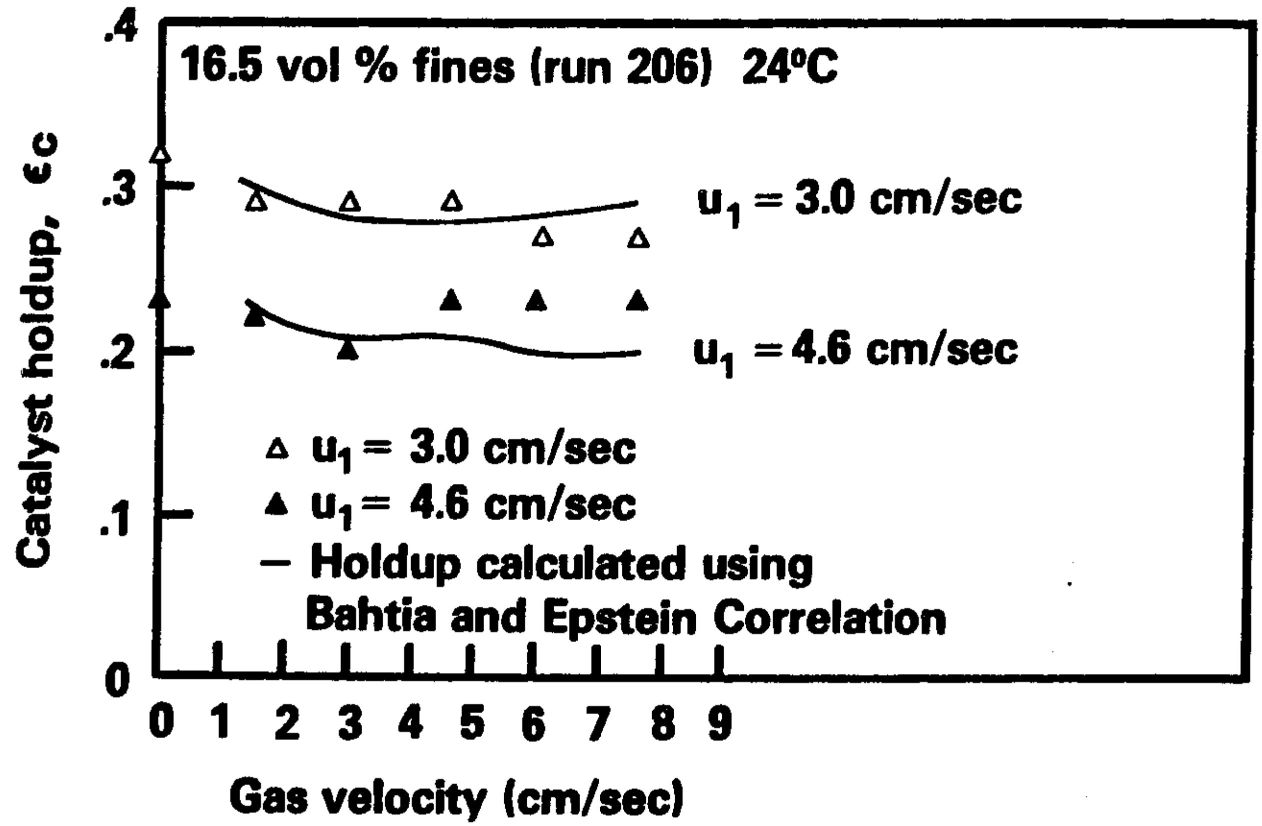
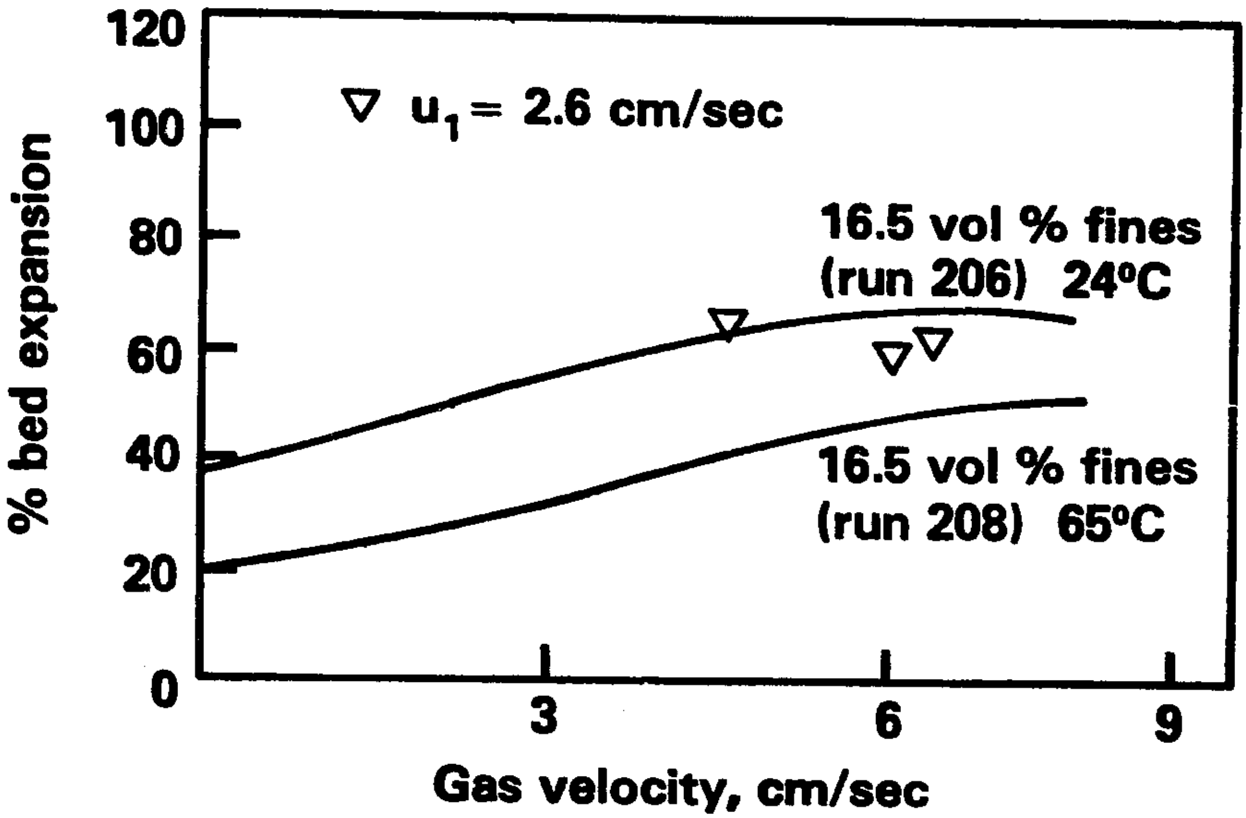


Figure 24

Bed expansion vs. gas velocity

Comparison of HRI PDU run 7 results with 16.5 vol % coal char in kerosene



APPENDIX A

CALCULATION OF GAS/LIQUID/FINE/CATALYST VOLUME FRACTIONS IN THE REACTOR

The volume fraction of catalyst is calculated from measurement of the bed height and mass of catalyst in the reactor:

$$\epsilon_c = \frac{M}{\rho_c A H}$$

where: M = mass of dry catalyst added to the reactor.
ρ_c = density of a dry catalyst particle.
A = cross-sectional area of the reactor.
H = catalyst bed height

The volume fraction of liquid can then be calculated using either gamma-ray scan or pressure drop measurements.

For liquid/catalyst tests, the following equations should be used:

For gamma-ray scan data:

$$\epsilon_l = \frac{\dfrac{\ln\frac{I_l}{I_m}}{d} - \mu_c\rho_c + \mu_l\rho_l}{\mu_l\rho_l - \mu_c\rho_c + \dfrac{\omega_f\rho_l(\mu_f\rho_f - \mu_c\rho_c)}{\rho_f(100 - \omega_f)}}$$

For pressure drop measurements:

$$\epsilon_l = \frac{\dfrac{\Delta P}{HD} - \rho_c}{\rho_l - \rho_c + \dfrac{\rho_l\omega_f}{100 - \omega_f}\left(1 - \dfrac{\rho_c}{\rho_f}\right)}$$

When three phases are in the reactor, gas/liquid/catalyst, these equations should be used:

Gamma-ray:

$$\frac{\dfrac{\ln\frac{I_l}{I_m}}{d} - \mu_c\rho_c\epsilon_c + \mu_l\rho_l}{\mu_l\rho_l + \dfrac{\mu_f\omega_f\rho_l}{(100 - \omega_f)}}$$

Pressure drop:

$$\epsilon_l = \frac{\frac{\Delta P}{HD} - \rho_c \epsilon_c}{\rho_l + \frac{\omega_f \rho_l}{100 - \omega_f}}$$

In either case:

$$\epsilon_f = \frac{\epsilon_l \rho_l \omega_f}{\rho_f (100 - \omega_f)}$$

$$\therefore \epsilon_g = 1 - \epsilon_l - \epsilon_c - \epsilon_f$$

In the dilute phase above the catalyst bed, ϵ_c is set to 0.0 and the same equations are solved.

HD = height between pressure taps
I_l = gamma-ray intensity through liquid
I_m = gamma-ray intensity at test conditions
ΔP = pressure drop

ϵ_c = volume fraction catalyst
ϵ_f = volume fraction fines
ϵ_g = volume fraction gas
ϵ_l = volume fraction liquid
ρ_c = catalyst density
ρ_f = fines density
ρ_l = liquid density
μ_c = catalyst mass absorption coefficient
μ_f = fines mass absorption coefficient
μ_l = liquid mass absorption coefficient
ω_f = wt% fines