LENGTH OF PARTICLES BED IN BATCH SOLID-LIQUID SPOUTED AND FLUIDIZED SYSTEMS
—EXPERIMENTAL STUDY FOR THE REGION OF TRANSPORT BED—

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A number of workers\(^2\)\(^{-4}\) have proposed equations for estimating the length of the particles bed for the case where \(U < U_t\) in the spouted or fluidized bed. In their predictions, bed length increases with increasing velocity as long as the superficial velocity is smaller than the terminal velocity of the particle \(U_t\). But there are no equations for the case where \(U > U_t\); that is, the region of transport bed.

In this paper, the length of the particles bed in solid-liquid spouted or fluidized bed for four kinds of particles is studied for the case where \(U > U_t\). In this case, superficial liquid velocity \(U\) is defined as the amount of volumetric water flow rate \(Q\) divided by area of the test column \(\pi D_T^2/4\). An empirical equation well fitted to the experimental data is proposed for both the spouted and the fluidized beds.

1. Experimental Apparatus and Method

The experimental apparatus and method employed are similar to those in our previous work\(^1\). The water distributors used are orifices of \(D_o = 10\) and \(15\) mm with an angle of conical base \(\theta = 60^\circ\) in the spouted bed, and a perforated plate in the fluidized bed.

In the case where \(U > U_t\), the development of the length of the particles bed is qualitatively illustrated with lapse of time in Fig. 1; that is, the bed is expanding and ascending from the orifice in the manner of piston movement. In this case, \(L\) is measured when the ascending velocity of the particles group at the top of bed reached a value of \(U - U_t\). As can be seen from Fig. 1, the particles bed had already departed upwards from the orifice when

![Fig. 1 Schematic diagram for length of the particles bed with lapse of time in spouted bed](image)

2. Experimental Results and Correlation

The experimental data of \(L\) in the spouted and fluidized beds are shown in Fig. 2. The value of \(L\) was measured when the ascending velocity of the particles group at the top of the bed reached the value of \(U - U_t\). As can be seen from Fig. 1, the particles bed had already departed upwards from the orifice when

| Table 1 Physical properties of particles used |
|---|---|---|---|
| No. | Particles | Density \(\rho_p\) [kg/m\(^3\)] | Diameter \(D_T\) [mm] | Terminal velocity \(U_t\) [mm/s] |
| 1 | Toyoura sand | 2670 | 0.240 | 31.7 |
| 2 | Toyoura sand | 2670 | 0.210 | 26.2 |
| 3 | Zircon sand | 4650 | 0.155 | 31.9 |
| 4 | Stainless steel powder | 7800 | 0.104 | 29.8 |

\({}^1\) Values at 20°C in water

* It was recognized experimentally that \(L\) was kept constant for the region between the height from the distributor where the ascending velocity of the particles group at the top of bed reached the value of \(U - U_t\) and the height of the exit of the column from the distributor (\(-2.3 \) m).
the ascending velocity of the bed reached the point of $U-U_t$; from this fact, the influence of the jet flow through the orifice on $L$ can be considered to diminish in the spouted bed; that is, the behavior of the particles group in the spouted bed could be considered to be similar to that in the fluidized bed. Figure 2 also shows that $L$ decreases with increasing value of $U-U_t$, and it can be recognized that the downward movement of the particles group is obstructed violently by an upward superficial velocity in the case where $U>U_t$.

In Fig. 3, $L$ is affected by the four kinds of particles but not affected by column diameter $D_T$ or by initial holdup of particles $S_i$.

Figure 4 shows all the data obtained in this work. It is found that $L$ is markedly correlated with a modified Froude number. From Fig. 4, an empirical equation is derived as follows.

$$L = 1.2 F_{rm}^{-0.25}$$

where

$$F_{rm} = \left( \frac{(U-U_t)^2 g D_p}{\rho_f (\rho_s - \rho_f)} \right)$$

$F_{rm} = 0.05 - 2.5$, $D_p = 0.104 - 0.240$ mm

$\rho_s = 2670 - 7800$ kg/m$^3$, $U-U_t = 15 - 80$ mm/sec

$D_T = 66.5 - 100$ mm

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Nomenclature

$D_o, D_p, D_T = \text{diameter of orifice, particle and column, respectively}$

$g = \text{gravitational acceleration}$

$L = \text{length of the particles bed when the ascending velocity of bed reached the value of } U-U_t$

$Q = \text{volumetric water flow rate}$

$S_i = \text{initial holdup of particles}$

$t = \text{time}$

$U = \text{superficial water velocity}$

$U_t = \text{terminal velocity of the particle}$

$\theta = \text{an angle of conical base}$

$\rho_f, \rho_s = \text{density of fluid and particle, respectively}$

$F_{rm} = \text{a modified Froude number}$

$$F_{rm} = \left( \frac{(U-U_t)^2 g D_p}{\rho_f (\rho_s - \rho_f) (\rho_f g D_p)} \right)$$

Literature Cited


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