THE RESPONSE OF THE LEVEL OF A LIQUID
FLUIDIZED BED TO A SUDDEN CHANGE
IN THE FLUIDIZING VELOCITY

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Summary

When the fluidizing velocity in a liquid fluidized bed of solid particles is
suddenly changed, a discontinuity in the porosity is introduced at the bottom
of the bed. This discontinuity is propagated upwards through the bed. The
boundary between the old and the new porosity broadens or remains sharp
depending on whether the porosity is increased or decreased. This behaviour
is reflected in the way in which the bed level changes as a function of time.
For a few different systems such response curves have been measured by
means of a specially designed follow-up system. On the basis of the above
mechanism a quantitative theory was developed for the response of the bed
level to a step-wise change in the fluidizing velocity. This theory proved to
give a satisfactory agreement with the observed facts.

List of symbols

m.k.s. units have been used for the purpose of calculation.

\( d_p \) = diameter of particle.
\( h \) = instantaneous height of the fluidized bed.
\( n \) = constant in eq. (2).
\( t \) = time.
\( u \) = average velocity of the fluidized particles with respect to the wall,
positive in the direction of the liquid flow.
\( U_s \) = settling velocity of single particle in tube; constant in eq. (2).
\( v \) = average liquid velocity with respect to the wall.
\( w(\varepsilon) \) = velocity of propagation of a disturbance \( d\varepsilon \) at a porosity \( \varepsilon \).
\( x \) = coordinate in the direction of flow.
\( \varepsilon \) = porosity, void fraction.
\( \rho_p \) = particle density.
\( \Phi^* \) = liquid velocity in region above particles, volumetric flow per unit
area of empty tube.
index 0 refers to the steady situation for \( t \ll 0 \).
index 1 refers to the steady state situation state reached after \( t = t_1 \).
§ 1. Introduction. During an investigation concerning the dynamic behaviour of a liquid fluidized bed, among other things the response of the bed level to a step-wise change in the fluidizing velocity was measured. It was found that there is an essential difference between the shape of the response curve resulting from a sudden increase of the fluidizing velocity and that resulting from a sudden decrease. This phenomenon is illustrated by fig. 1.

![Fig. 1. Response curve of fluidized bed level to a step-wise increase (a) and decrease (b) of the fluidizing velocity at time t = 0.](image)

Furthermore, it was observed that in the transition period following a change in the fluidizing velocity the new porosity of the bed (i.e. the equilibrium value belonging to the velocity after the step-wise change) is first created at the bottom of the bed and then extends in upward direction until the entire bed has obtained the new equilibrium porosity. Apparently, the way in which the bed level changes is related to the manner in which the porosity disturbance, caused by a change in the fluidizing velocity, travels upward. The theory of this phenomenon and its relation to the behaviour of the bed level will be treated in the next section. After that, the experimental work will be discussed.

§ 2. Theory. Steady state behaviour. If the fluidizing velocity is changed from a constant value \( \Phi_0 \) to a constant value \( \Phi_1 \), the porosity and the level of the bed change from the initial values \( e_0 \) and \( h_0 \) to the final steady state values \( e_1 \) and \( h_1 \). Because the amount of solids in the bed remains constant, we have

\[
(1 - e_0)h_0 = (1 - e_1)h_1. \tag{1}
\]