Tiller's Critical Pressure Drop: Filtration of Super-Compactible Material

Filter cakes can be categorized as incompactible, moderately compactible or super-compactible. During filtration of incompactible or moderately compactible materials, filtrate flow rate increases as pressure increases. However, when filtering super-compactible materials, for example, bio-materials, flocculated solids or fine particles, filtrate flow rate increases with pressure drop only below a certain limit. As pressure drop increases beyond some critical value, applied pressure has no effect on either the filtrate flow rate or cake solid content as shown in Figure 1.

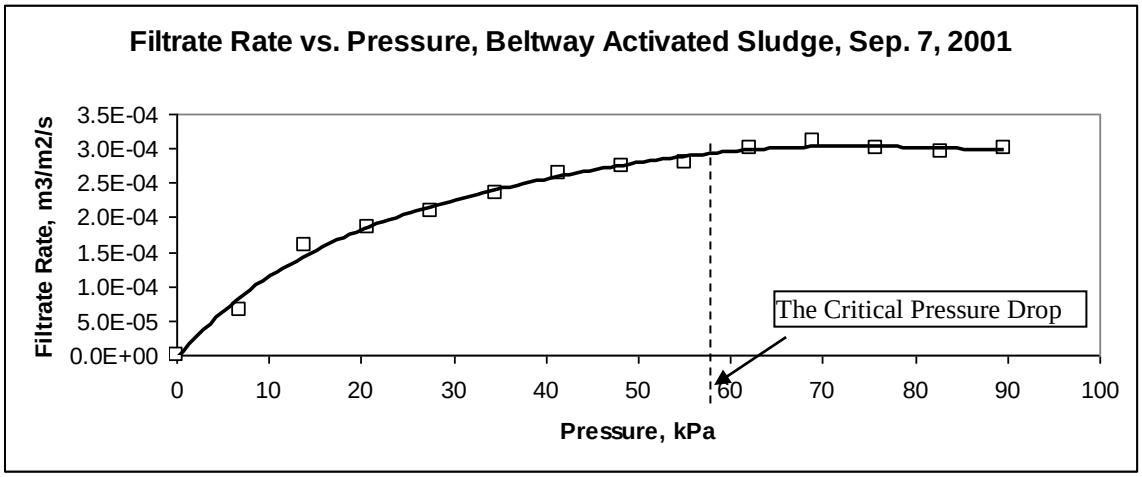

Figure 1 Filtrate Flow Rate vs. Pressure on Activated Sludge[1].

Tiller[2] called this pressure threshold "Critical Pressure Drop" and defined it as the pressure at which flow rate reaches 90% of its maximum value. Using Darcy's law, stress analysis and cake constitutive equations[1,2,3], Tiller proposed that the Critical Pressure Drop can be expressed as:

$$\Delta p_{cR} = p_a \left[10^{1/(n-1)} - 1\right] \tag{1}$$

in which Δp_{cR} is the critical pressure drop, p_a is a cake constitutive parameter, and n is a cake compactibility parameter, which increases with the degree of cake compactibility.

Filtration of super-compactible solids can be optimized by operating below the Critical Pressure Drop. Explanation of the unexpected behavior of super-compactible material lies in the formation of a highly impermeable thin layer of cake next to the filter media side related to a nonlinear pressure distribution inside the filter cake. There are two ways to avoid the formation of such a flow-restrictive skin and, therefore, to raise the critical pressure drop and improve filtering rates of super-compactible material. The first is to alter effective pressure distribution by applying mechanical expression or squeezing on the cake surface. The other is to decrease the cake compactibility with a lower n in Equation 1 by addition of incompactible particles such as filter aids to the liquid suspension of solids[4].

References:

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