SEPARATION PROCESS

PARTICLE HANDLING & PROCESSING

Part 1

by
Zulkifly bin Jemaat
Faculty of Chemical and Natural Resources Engineering
email: zulkifly@ump.edu.my

Introduction

Particle handling and processing plays a key role in nearly all major manufacturing industries (including chemical, mineral, paper, electronics, food, beverage, pharmaceutical, and biochemical industries), as well as in energy production, pollution abatement, and environmental control. It also serves to fulfill the vital needs of our daily life, since we must have cartridge oil/fuel filters for operating an automobile, a paper filter for the coffee machine, a sand filter bed for the municipal water treatment plant, and so on. In fact, modern society cannot function properly without the benefit of the Particle handling and processing.

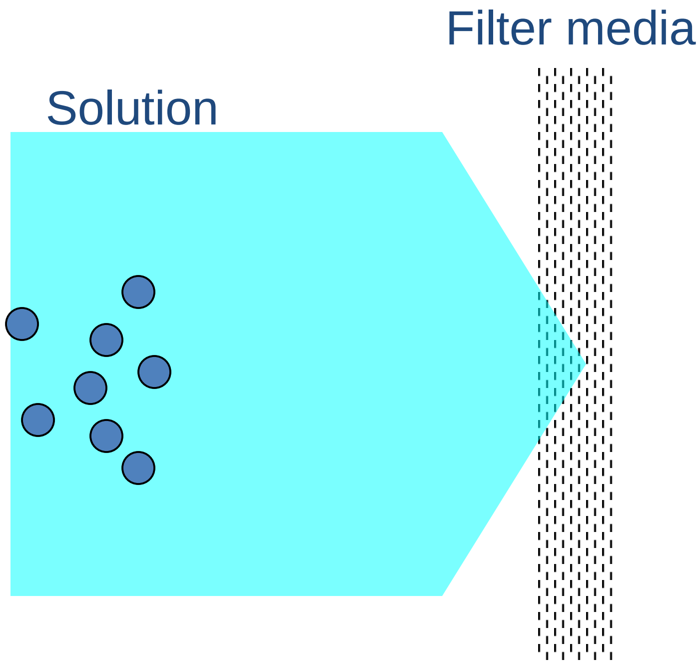
Technically, Particle handling and processing involves the removal and collection of a discrete phase of matter (particles) existing in a dispersed or colloidal state in suspension. This separation is most often performed in the presence of a complex medium structure in which physical, physicochemical and/or electrokinetic forces interact. Their analysis requires combined knowledge of fluid mechanics, particle mechanics, solution chemistry, and surface/interface sciences.

Introduction

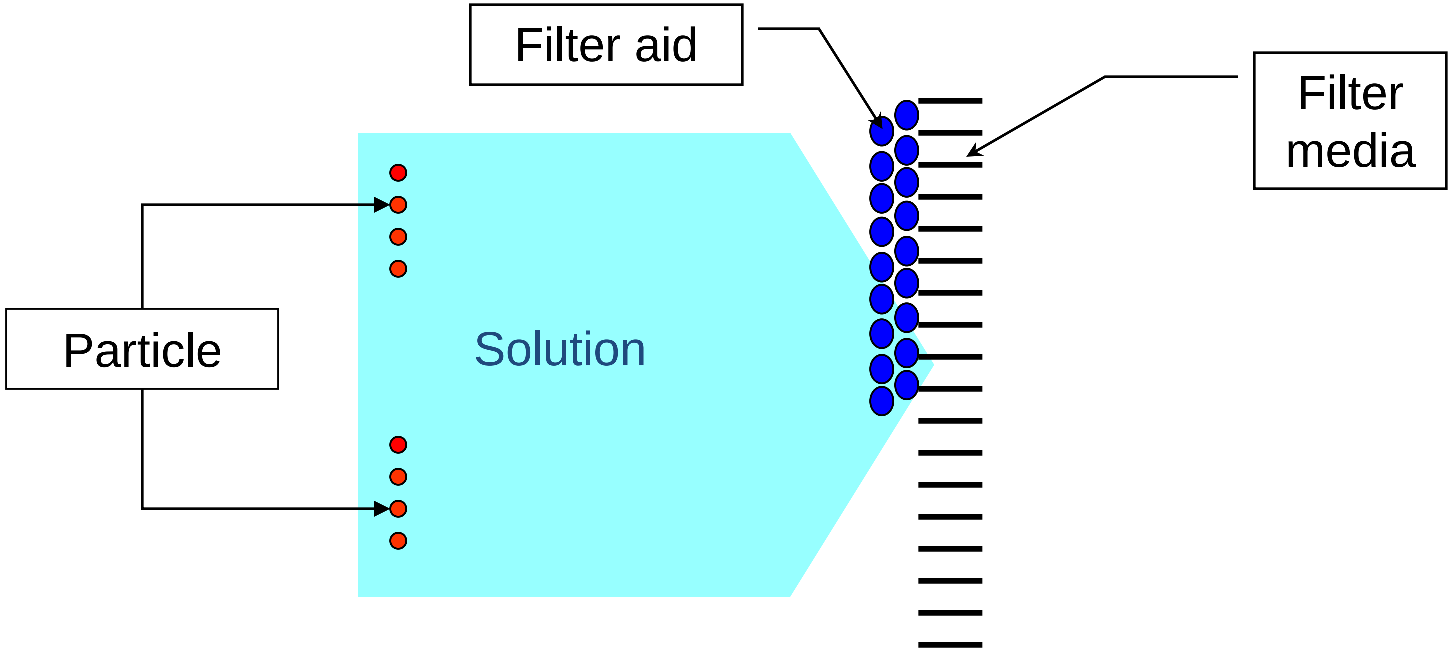
Mechanical-physical separation processes that are being considered in this chapter:

i. Filtration
ii. Settling & sedimentation
iii. Centrifugal settling & sedimentation
iv. Mechanical size reduction

Filtration



Filter aid



Filtration theory

If we take a section through a filter cake and filter medium at a definite time s from the start of the flow of filtrate. At this time the thickness of the cake is L_m (ft).

The filter cross-sectional area is A and the linear velocity of the filtrate in the L direction is u m/s (ft/s) based on the filter area A m^2.

The flow of the filtrate through the packed bed of cake can be described by an equation similar to Poiseuille's law, assuming laminar flow occurs in the filter channels.

$$-\frac{\Delta p}{L} = \frac{32 \mu v}{D^2} \quad \text{(SI)}$$

$$-\frac{\Delta p}{L} = \frac{32 \mu v}{g_c D^2} \quad \text{(English)} \qquad \textbf{(14.2-1)}$$

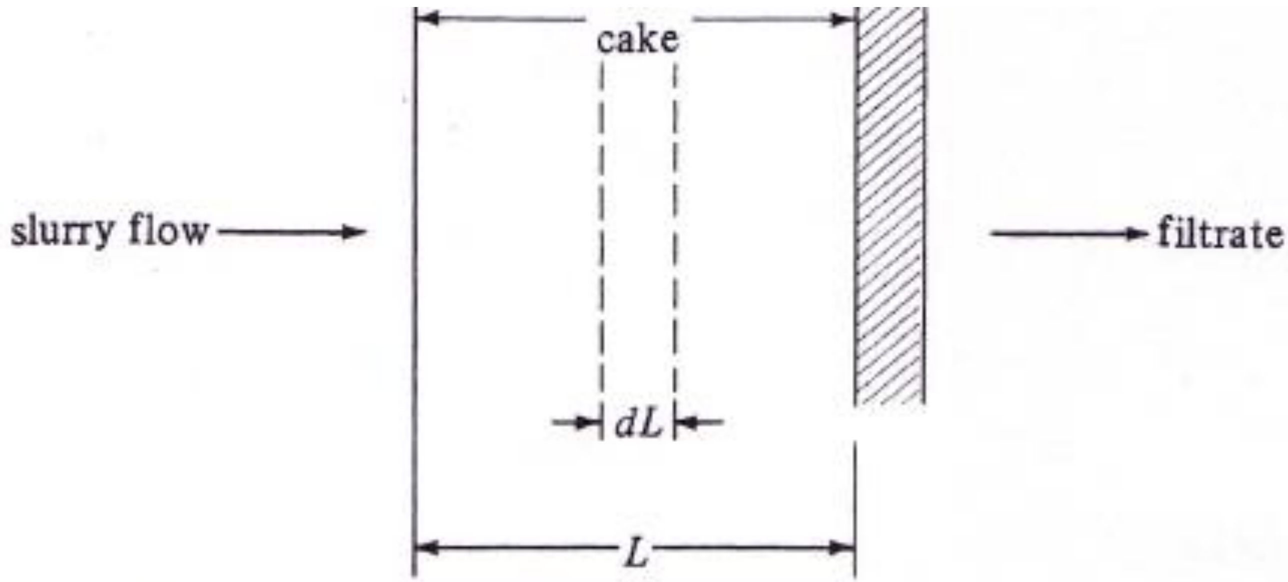


FIGURE 14.2-6. *Section through a filter cake.*

I. Basic equations for filtration rate in batch process.

$$\frac{dt}{dV} = \frac{\mu \alpha c_S}{A^2(-\Delta p)} V + \frac{\mu}{A(-\Delta p)} R_m = K_p V + B \quad (14.2\text{-}13)$$

where K_p is in s/m^6 (s/ft^6) and B in s/m^3 (s/ft^3):

$$K_p = \frac{\mu \alpha c_S}{A^2(-\Delta p)} \quad \text{(SI)}$$

$$K_p = \frac{\mu \alpha c_S}{A^2(-\Delta p) g_c} \quad \text{(English)} \quad (14.2\text{-}14)$$

$$B = \frac{\mu R_m}{A(-\Delta p)} \quad \text{(SI)}$$

$$B = \frac{\mu R_m}{A(-\Delta p) g_c} \quad \text{(English)} \quad (14.2\text{-}15)$$

For constant pressure, constant α, and incompressible cake, V and t are the only variables in Eq. (14.2-13). Integrating to obtain the time of filtration in t s,

$$\int_0^t dt = \int_0^V (K_p V + B)\, dV \qquad \textbf{(14.2-16)}$$

$$t = \frac{K_p}{2} V^2 + BV \qquad \textbf{(14.2-17)}$$

Dividing by V

$$\frac{t}{V} = \frac{K_p V}{2} + B \qquad \textbf{(14.2-18)}$$

where V is total volume of filtrate in m^3 (ft^3) collected to t s.

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Credit to the authors:
Syed Mohd Saufi, Assoc. Prof
Ahmad Ziad Sulaiman, Prof
Azilah Ajit
Hayder Bari, Prof
Rosli Mohd Yunus, Prof