Washing of the filter cake

4.5. Filtration practice:

1. The filter medium.
2. Blocking filtration.
3. Effect of particle sedimentation on filtration.
4. Delayed cake filtration.
5. Cross-flow filtration.
6. Preliminary treatment of slurries before filtration.
7. Washing of the filter cake.

Washing of the filter cake:

When the wash liquid is miscible with the filtrate and has similar physical properties, the rate of washing at the same pressure difference will be about the same as the final rate of filtration. If the viscosity of the wash liquid is less, a somewhat greater rate will be obtained. Channeling sometimes occurs, however, with the result that much of the cake is incompletely washed and the fluid passes preferentially through the channels, which are gradually enlarged by its continued passage. This does not occur during filtration because channels are self-sealing by virtue of deposition of solids from the slurry. Channeling is most marked with compressible filter cakes and can be minimized by using a smaller pressure difference for washing than for filtration.

Washing may be regarded as taking place in two stages. First, filtrate is displaced from the filter cake by wash liquid during the period of *displacement washing* and, in this way, up to 90 percent of the filtrate may be removed. During the second stage, *diffusional washing*, solvent diffuses into the wash liquid from the less accessible voids and the following relation applies:

$$\left(\frac{\text{volume of wash liquid passed}}{\text{cake thickness}}\right) = (\text{constant}) \times \log\left(\frac{\text{initial concentration of solute}}{\text{concentration at particular time}}\right)$$

Although an immiscible liquid is seldom used for washing, air is often used to effect partial drying of the filter cake.

In case of filter press:
Two methods of washing may be employed, **"simple"** washing and **"through"** or **"thorough"** washing.

Simple washing, the wash liquid is fed in through the same channel as the slurry although, as its velocity near the point of entry is high, erosion of the cake takes place. The channels which are thus formed gradually enlarge and uneven washing is usually obtained. Simple washing may be used only when the frame is not completely full.

In **thorough washing**, the wash liquid is introduced through a separate channel behind the filter cloth on alternate plates, known as washing plates and flows through the whole thickness of the cake, first in the opposite direction and then in the same direction as the filtrate. The area during washing is one-half of that during filtration and, in addition, the wash liquid has to flow through twice the thickness, so that the rate of washing should therefore be about **one-quarter** of the final rate of filtration.

$$\left.\frac{dV}{dt}\right|_w = \frac{1}{4} \times \left.\frac{dV}{dt}\right|_f$$

In case of rotary drum filter:
For continuous filtration the resistance to the filter medium is negligible compared with the resistance to the filter cake so: the rate of wasting in rotary drum filter is **equal** to the rate of filtration

$$\left.\frac{dV}{dt}\right|_w = \left.\frac{dV}{dt}\right|_f$$

Total time of filtration:

For batch filtration:

Total time=time of filtration + time of washing + time of cleaning+ time of resample + time of dismantle.

For continuous filtration: such as rotary drum, and pressure drop is held constant for the filtration, the filtration time ***t*** is less than total cycle time t_c

$$t = f\, t_c$$

where *f* in rotary drum is the fraction submergence of the drum surface in the slurry

4.6 The filter press:

The filter press is one of two main types, the *plate and frame press* and the *recessed plate or chamber press.*

The plate and frame press

The optimum thickness of cake to be formed in a filter press depends on the resistance offered by the filter cake and on the time taken to dismantle and refit the press. Although the production of a thin filter cake results in a high average rate of filtration, it is necessary to dismantle the press more often and a greater time is therefore spent on this operation. For a filtration carried out entirely at constant pressure, a rearrangement equation 22a gives:

where B_1 and B_2 are constants.
Thus the time of filtration t is given by:

$$t = B_1 V^2 + B_2 V \quad \text{.......................................26}$$

The time of dismantling and assembling the press, say t' is substantiall independent of the thickness of cake produced. The total time of a cycle in whic a volume V of filtrate is collected is then $(t + t')$ and the overall rate of filtratio is given by:

$$W = \frac{V}{B_1 V^2 + B_2 V + t'} \quad \text{.......................................27}$$

W is a maximum when $dW/dV = 0$.

Differentiating W with respect to V and equating to zero:

$$B_1 V^2 + B_2 V + t' - V(2B_1 V + B_2) = 0$$

$$t' = B_1 V^2 \quad \text{.......................................28}$$

or

$$V = \sqrt{\left(\frac{t'}{B_1}\right)} \quad \text{.......................................29}$$

Email (abbas.khaleel.Ibrahim@uomus.edu.iq)

If the resistance of the filter medium is neglected, $t = B_1V^2$ and the time during which filtration is carried out is exactly equal to the time the press is out of service. In practice, in order to obtain the maximum overall rate of filtration, the filtration time must always be somewhat greater in order to allow for the resistance of the cloth, represented by the term B_2V. In general, the lower the specific resistance of the cake, the greater will be the economic thickness of the frame.

4.7 Rotary-drum filter:

This type of filter is used for continuous operation, where in this type the feed, filtrate, and the cake move at steady, continuous rate. In a rotary drum the pressure drop is held constant for the filtration. The cake formation involves a continual change in conditions. In continuous filtration the resistance of the filter medium is generally negligible compared with the cake resistance. So, the rate of filtration is: -

$$\frac{dV}{dt} = \frac{A^2(-\Delta P)}{r\mu v V}$$

$$\frac{V^2}{2} = \frac{A^2(-\Delta P)t}{r\mu v} \quad \text{..............................15}$$

$$\frac{t}{V} = \frac{r\mu v}{2A^2(-\Delta P)}V \quad \text{..............................16}$$

Email (abbas.khaleel.Ibrahim@uomus.edu.iq)

Where t is the time required for the formation of the cake ,while in rotary drum filter, the filter time t is less than the total cycle time t_c as:-

$$t = f\, t_c$$

where f in rotary drum is the fraction submergence of the drum surface in the slurry. Therefore the rate of filtration is :-

$$\frac{V^2}{2} = \frac{A^2(-\Delta P) f\, t_c}{r \mu \upsilon} \quad \ldots\ldots\ldots\ldots30$$

Rearrange equation (30) :-

$$\frac{V}{t_c} = A\left[\frac{2 f(-\Delta P)}{t_c\, r \mu \upsilon}\right]^{1/2} \quad \ldots\ldots\ldots\ldots31$$

When short times are used in continuous filtration and/or the filter medium resistance is relatively large , the filter resistance term must be included :-

$$\frac{dV}{dt} = \frac{A^2(-\Delta P)}{r\mu\upsilon(V+V_e)} \quad \ldots\ldots\ldots\ldots20$$

$$t = \frac{r\mu\upsilon}{A^2(-\Delta P)}\left(\frac{V_1^2}{2} + V V_e\right) \quad \ldots\ldots\ldots\ldots22b$$

and equation (22b)become:-

$$\frac{V}{t_c} = A\left(\frac{-V_e/t_c + \left[V_e^2/t_c^2 + 2r\upsilon(-\Delta P) f/\mu\, t_c\right]^{1/2}}{r\upsilon}\right) \ldots\ldots\ldots23$$

Email (abbas.khaleel.Ibrahim@uomus.edu.iq)