5 Filtration

Filtration is the most common and, in the majority of cases, the cheapest unit operation aimed to separate a fluid phase from solid particles. It is often employed upstream more refined operations in order to pretreat the stream by removing the bigger impurities. The separation occurs because the so called "filter" mechanically intercepts the solid phase letting the fluid one pass.

Different filtration typologies, that is different applications, exist according to the solid particles size to be separated (cf. Table 5.1). Other classifying criteria are the driving force, the filtration mechanism, the purpose or batch vs continuous operation.

The choice of the most suitable material for the filter depends on the nature of the process stream and of the filter itself.

The most common filtration models are the so called "constant pressure drop" models. They assume the hypothesis of a non-compressible cake, whose properties don't change in time, and they are valid for non-compressible precipitates and constant pressure filtration. On the other hand the geometrical properties of the panel filter change. Among this models the Darcy one is the most popular by far; it attributes the decrease of filtration velocity to the increase of the height of the panel due to the accumulation of solids causing a higher resistance to flow. On the other hand the cross-sectional area available for filtration remains equal to the filter area.

5.1 Filtration time optimization

A homogeneous suspension undergoes a batch filtration cycle with a $\Delta P = 3\,kg/cm^2$, forming in 1 h a 20 mm cake and producing $6\,m^3$ of filtrate.

After each cycle the cake is washed with water; the washing phase occurs with the same operating conditions consuming $1\,m^3$ of water.

Before each filtration and washing operation, 2 minutes are required to load the filter; after each of them the cake is drained for 3 minutes. Then filter assembling operations

Size [μm]	**Mixture type**	**Filtration typology**	**Example of particles**
>100	Suspension	Macrofiltration	Solid particles
0.1/100	Suspension	Microfiltration	Bacteria, algae and fungi
0.001/0.1	Solution	Ultrafiltration	Virus, colloids
0.0001/0.001	Solution	Reverse osmosis	Big molecules

Table 5.1: Filtration processes classification

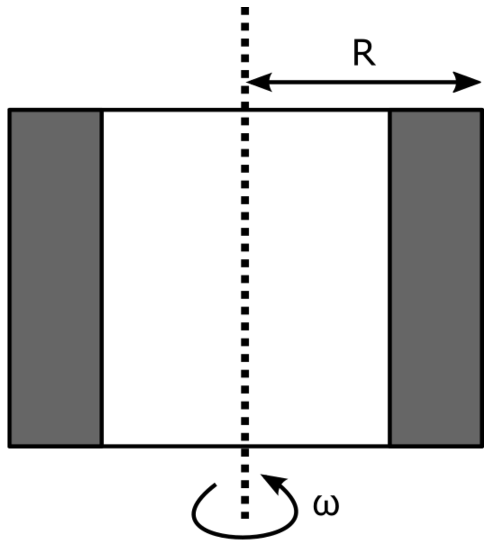

Figure 5.1: Centrifugal filtration scheme

globally require 6 minutes.

It is assumed the filtrate and washing water to have the same properties and the filtering leaf resistance to be negligible. The hypotheses of Darcy equation applies.

Requests are namely:

- Calculate the daily filtrate volume;
- Calculate the daily filtrate volume whether a 12 mm cake was formed corresponding to a 3.6 m^3 of filtrate volume. The washing water vs. filtrate volume ratio as well as all the other operating conditions stay unchanged;
- Optimize the filtration time.

5.2 Centrifugal filtration

Given a basket loaded with a liquid to be filtered according to the data reported in Table 5.2 and the scheme in Figure 5.1, calculate:

- The decantation time under the hypothesis of solid particles laminar flow;
- The time according to the Darcy law required to filter the 98 % of the liquid.

Property	**Symbol**	**Value**	**Unit**
Solid concentration	C_s	100	kg/m^3
Loaded fraction	ξ	0.5	m^3/m^3
Particle diameter	D_P	$1 \cdot 10^{-3}$	m
Channel diameter	D	$5 \cdot 10^{-5}$	m
Solid density	ρ_s	2200	kg/m^3
Water density	ρ_w	1000	kg/m^3
Angular velocity	ω	1	$round/s$
Viscosity	μ	10^{-3}	$Pa \cdot s$
Basket height	H	0.4	m
Radius	R	0.25	m
Cake void fraction	ε	0.4	1

Table 5.2: Physical properties and operating conditions