CT4471 Drinking water I

Dr.ir. S.G.J. Heijman

micro- and ultrafiltration





Delft University of Technology

Application area filtration processes



October 16, 2007



Application area filtration processes

	Bacteria	Virusses	Multivalent salts	Monovalent salts
Microfiltration MF	+	_	_	_
Ultrafiltration UF	+	+		_
Nanofiltration NF	+	+	+	_
Reversed Osmosis RO	+	+	+	+

October 16, 2007







Full scale







Module



A _{spec}	$=\frac{A_{mem}}{I_{module}}=\frac{n\cdot\pi\cdot d\cdot L}{\frac{1}{4}\cdot\pi\cdot D^{2}}$
A _{spec} A _{mem} I _{module} N d L D	 = specific membrane surface [m²/m³] = membrane surface area [m²] = module volume [m³] = number membranes in module [-] = diameter membrane [m] = length membrane [m] = diameter module [m]







Dead-end Filtration

filtration



backwash or backflush





Mass balans

Filtration time



Filtration run = filtration time + back wash time

October 16, 2007



Theory

 \mathbf{C}

Recovery

$$\gamma = \frac{V_{\rm p} - V_{\rm r}}{V_{\rm p}}$$

$$\begin{array}{ll} \gamma & = \mbox{ recovery [-]} \\ V_p & = \mbox{ permeate production } [m^3] \\ V_r & = \mbox{ volume needed for cleaning } [m^3] \end{array}$$

Recovery as high as possible (>90%):

- long filtration time
- short cleaning time
- low cleaning flux

Kinetics





Fouling mechanisms





Theory

 \mathcal{O}

Trans membrane pressure



 \mathcal{C}

12

October 16, 2007





Different cleaning methods:

- forward flush or cross flow
- backflush or backwash
- Airflush or air/water flush
- Chemical enhanced flush or chemical backwash
- intensive chemical cleaning or cleaning-in-place (CIP)



Forward flush



Cleaning with high cross flow velocities

 $Re > 2300 \qquad Re = \frac{V_0 \cdot d_h}{v}$

Need cross flow for turbulent conditions

d [mm]	v _o [m/s]	drukval [Pa]	
5,2	0,58	1473	
1,5	2,01	61370	
0,7	4,30	603850	

October 16, 2007



Back flush



permeate

Backwash flux = 2 tot 2,5 filtration flux

Time needed to flush a membrane of 1 meter with a backwash flux of 250 l/(m²·h)

d [mm]	flush time [s]	
5,2	19	
1,5	5	С С
0,7	3	
October 16, 2007		15



heory

Back flush with forward flush







Forward flush with air injection higher turbulence



Water

Design concepts

Different modules:

- tubular membranes
- capillary membranes
- 1. flat sheet membranes

Different operational modes:

- dead end
- cross flow
- under pressure
- constant pressure
- constant flux

Different orientation:

- vertical
- horizontal

Different materials:

- polymer
- ceramic

Tubular membranes



Diameter channel = 5 – 25 mm

Easily cleaned

Low specific surface area

Low clogging potential





Capillary membranes





Diameter channel = 0.5 – 5.0 mm

Well cleaned, but not as good as tubular membranes

High specific surface area

High clogging potential

October 16, 2007



Choosing a module

Economical balance:

low investment costs vs low exploitation costs or high specific surface area vs low clogging potential

High flux >>> fast fouling

October 16, 2007



Vertical - horizontal











- CF: Application with high suspended solid contents
- **CF: High cross flow velocities, high energy costs**



Under pressure membrane filtration Design concepts **Feed water** concentrate membranes permeate air elft

Ceramic microfiltration



Octobe

ŤUDelft

Ceramic microfiltration



October 16, 2007

