

# Workshop Wits 3013: Ultrafiltration Design

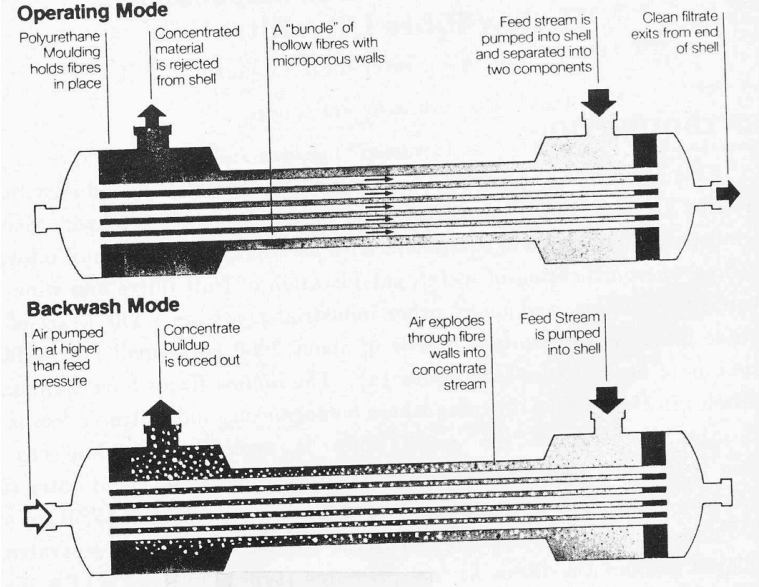
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# The Filter



- ▶ The filter is used for the purification of water, the treatment of wastes, the separation of oil from water etc.
- ▶ The heart of the filtration system is a bundle of about 3000 very small (radius  $330 \mu\text{m} = 330 \times 10^{-6}\text{m}$ ) hollow fibres made of plastic foam.
- ▶ The fibres have millions of tiny holes (radius  $0.1 \mu\text{m}$ ) in their walls which allow the pure water through (for example) but filters out small particles.
- ▶ The fibres are contained in a cartridge (15-50cm long, diam 7cm) and the impure water is circulated around the fibres at low pressure (100 kPa). ( $1 \text{ Pa} = 1 \text{ newton}/\text{m}^2$ )
- ▶ The permeate moves almost radially through the fibres and then axially along the insides of the fibres (or the lumen) to be gathered at the cartridge ends.
- ▶ The filtration unit is novel in that the filtration surface is the outside of the tubes not the inside as one might expect.

# The cleaning cycle

Periodically the fibres have to be cleaned and this is done by exposing the ends of the lumen to a high pressure (500-700 kPa), short duration air pulse (small viscosity). This expands the fibres by 10% dislodging particles.

# Objectives

- ▶ The issues are: What length and radius fibres, fluxes? What pore size?
- ▶ How to optimise the operation of the filter cycle to achieve maximum throughput?
- ▶ Fibre collapse (buckling or plastic collapse)?

## **Tools:**

Poiseuille Flow (viscous flow in a tube). D'Arcy flow (porous material flow), Mathematica.

We'll work together to build up the needed skills.

## Further information

D'Arcy Flow

$$\nabla p = -\frac{\mu}{k}(\epsilon \mathbf{v}) \text{ or}$$

$$\text{volume flux } \mathbf{q} = \frac{k}{\mu} \nabla p$$

where  $\epsilon$  is porosity (0.7),  
 $\mu$  the viscosity ( $1 \times 10^{-3}$  Pa sec for water),  
 $k$  is the hydraulic permeability ( $2 \times 10^{-16} \text{ m}^2$ ),  
 $\epsilon \mathbf{v}$  is volume flux/area.