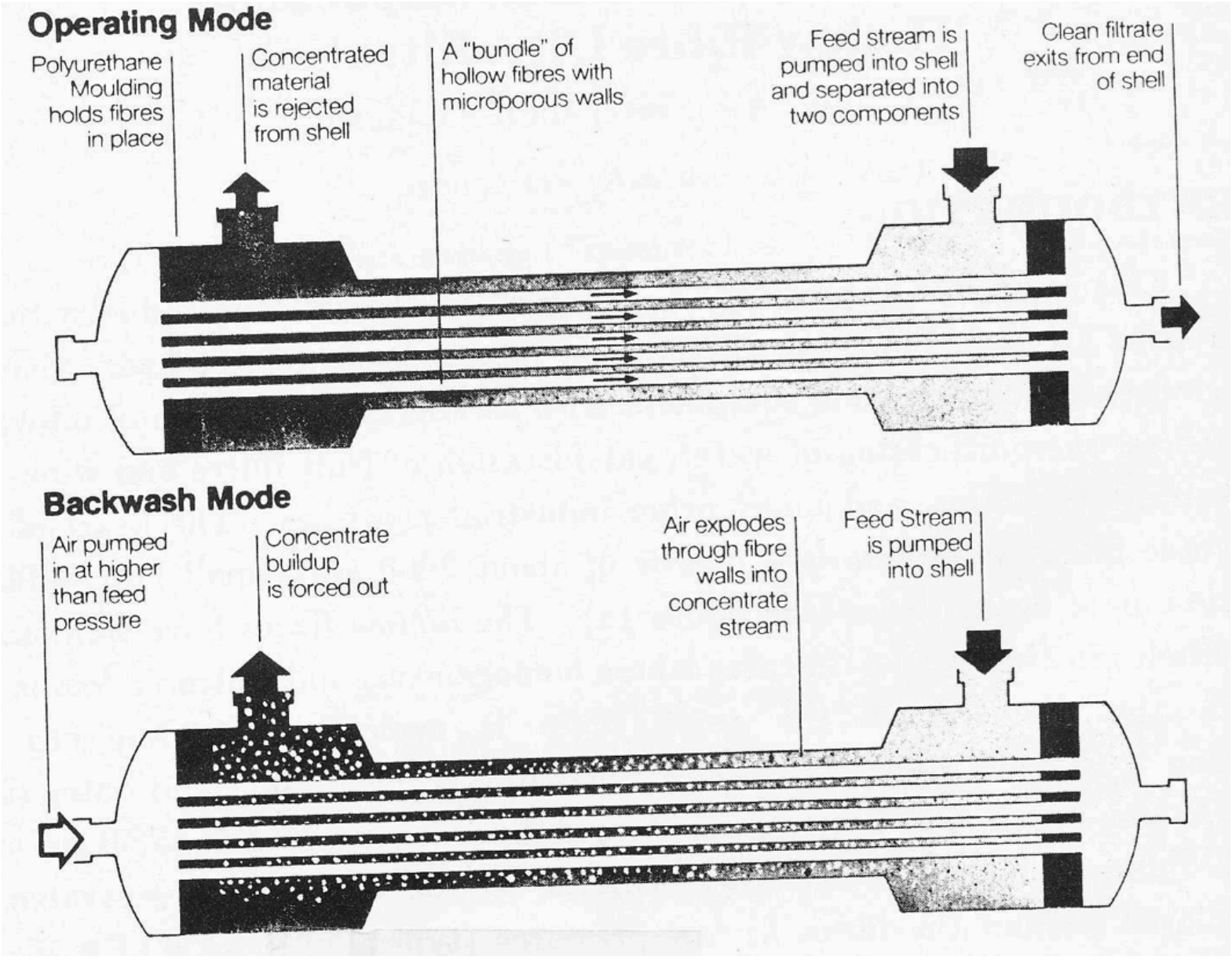
Workshop Wits 3013: Ultrafiltration Design

Nev Fowkes
neville.fowkes@uwa.edu.au

School of Maths an Stats
University of Western Australia

January 6, 2013

The Filter


Operating Mode
Polyurethane Moulding holds fibres in place
Concentrated material is rejected from shell
A "bundle" of hollow fibres with microporous walls
Feed stream is pumped into shell and separated into two components
Clean filtrate exits from end of shell
Backwash Mode
Air pumped in at higher than feed pressure
Concentrate buildup is forced out
Air explodes through fibre walls into concentrate stream
Feed Stream is pumped into shell

- 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 $=330 \times 10^{-6}$m) hollow fibres made of plastic foam.
- The fibres have millions of tiny holes (radius 0.1 mu) 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 Pa=1 $newton/m^2$)
- 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 ϵ is porosity (0.7),
μ the viscosity (1×10^{-3}Pa sec for water),
k is the hydraulic permeability ($2 \times 10^{-16} m^2$),
$\epsilon\mathbf{v}$ is volume flux/area.