Ultrafiltration of Desizing Effluents

Lecture 24
Ultrafiltration of Desizing Effluents

Textile sizes can be removed from the fabric in the same form as they were applied to the warp and the recovery of the size from the effluent is possible by means of ultrafiltration. Ultrafiltration is a low pressure membrane filtration process used for separating macro-molecules and suspended solids from water.

A semi-permeable microporous membrane performs the separation. Water and low molecular weight solutes pass through the membrane and are removed as permeate. The feed stream flows parallel to the membrane surface. For ordinary filtration, a filter cake builds up on the membrane surface, resulting in frequent filter replacement or cleaning.
In ultrafiltration, the cross flow conditions prevent filter cake build up and high filtration rates or fluxes can be maintained continuously. The membranes for desizing effluent should be able to withstand high temperatures (80°C) and a wide pH range (to allow cleaning). The two types of modules suitable for this application are tubular and spiral-wrap. For desizing effluents the spiralwrap modules offer the best compromise between operability, surface-to-volume ratio, power requirements and replacement costs.

Ultrafiltration successfully recovers PVA, CMC and PAA sizes. Starch based sizes are normally not recoverable by this process because of the need for degradation prior to removal in desizing. The total amount of water needed for desizing (high-expression washer plus conventional washer) is not significantly reduced because of the diffusion properties of the size from the inner parts of the cloth threads. Hence to reduce the pollution load of the effluent an ultrafiltration (UF) based size recovery plant would be quite effective to treat the effluent from the conventional washer.
The closed loop recycle system using UF separates the polymer sizing agents into a concentrate for reuse in sizing and the effluent is purified for reuse in desizing. This is illustrated in Figure which shows flow schematic for textile sizing recovery by ultrafiltration.
Ultrafiltration Membranes

The major ultrafiltration membrane manufacturers are listed in Table. Each manufacturer has a range of molecular weight cutoff membranes listed in Table. In general, UF membranes are fairly robust with pH and temperature ranges of 2-12 and 10-90°C respectively. The membrane and module specifications for the ultrafiltration treatment of polymeric sizing solutions are:

(i) Temperature capability above 75 oc. High temperature operation minimizes microbial degradation of the effluent.
(ii) High turbulence device to minimize gel-polarization at a reasonable pumping rate.
(iii) Membrane resistance to cleaning solutions.
(iv) Nominal molecular weight cut-off in range 20000-50000.
(v) High flux performance per unit pressure.
## Commercial Ultrafiltration Membranes

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Membrane Type</th>
<th>Module Configurations</th>
<th>pH Range</th>
<th>Temperature Range (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abcor</td>
<td>Cellulosic</td>
<td>Tubular /</td>
<td>3 - 9</td>
<td>60</td>
</tr>
<tr>
<td>carre</td>
<td>Non-cellulosic</td>
<td>Spiral</td>
<td>2 - 13</td>
<td>90</td>
</tr>
<tr>
<td>Dorr-Oliver</td>
<td>Dynamic</td>
<td>Tubular</td>
<td>3 - 10</td>
<td>100</td>
</tr>
<tr>
<td>DDS</td>
<td>Non-cellulosic</td>
<td>Plate &amp; frame</td>
<td>3 - 11</td>
<td>60</td>
</tr>
<tr>
<td>PCICellulosic</td>
<td>Plate &amp; Frame</td>
<td>3-8</td>
<td>3 - 12</td>
<td>50</td>
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<tr>
<td>Romicon</td>
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<td>Tubular</td>
<td>3 - 8</td>
<td>70</td>
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<tr>
<td></td>
<td>Cellulosic</td>
<td>Linear Thin</td>
<td>3 - 12</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Non-cellulosic</td>
<td>Channel</td>
<td>3 - 11</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Non-cellulosic</td>
<td>Hollow Fibre</td>
<td>2 - 11</td>
<td>60</td>
</tr>
</tbody>
</table>

## Range of Ultrafiltration Membranes

<table>
<thead>
<tr>
<th>Nominal Molecular Weight Cut-off</th>
<th>Apparent Pore Diameter (Å)</th>
<th>Water Flux* (M/m2h)</th>
<th>Temperature Range °C</th>
<th>pH Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>21</td>
<td>9</td>
<td>60</td>
<td>3.0-11.0</td>
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<tr>
<td>2 5000</td>
<td>24</td>
<td>15</td>
<td>45</td>
<td>1.5-9.0</td>
</tr>
<tr>
<td>5 000</td>
<td>30</td>
<td>68</td>
<td>75</td>
<td>1.5-13.0</td>
</tr>
<tr>
<td>10 000</td>
<td>38</td>
<td>60</td>
<td>75</td>
<td>1.5-13.0</td>
</tr>
<tr>
<td>30 000</td>
<td>47</td>
<td>920</td>
<td>75</td>
<td>1.5-13.0</td>
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<tr>
<td>50 000</td>
<td>-</td>
<td>-</td>
<td>75</td>
<td>1.5-13.0</td>
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<td>66</td>
<td>305</td>
<td>50</td>
<td>1.5-13.0</td>
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<td>80 000</td>
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<td>-</td>
<td>50</td>
<td>1.5-13.0</td>
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<tr>
<td>100 000</td>
<td>110</td>
<td>1000</td>
<td>60</td>
<td>3.0-11.0</td>
</tr>
<tr>
<td>300 000</td>
<td>180</td>
<td>600</td>
<td>60</td>
<td>3.0-11.0</td>
</tr>
</tbody>
</table>
Ultrafiltration Module Types

The membranes are assembled into several different module types:

- Tubular
- Plate and frame
- Spiral
- Hollow fibre

Each module type has its own processing characteristics and limitations. Membrane types are specific to certain modules. Typical ultrafiltration flux rates are in the range 10-200 litres of product per m² of membrane area per hour and this is about 1/200th of that in normal barrier filtration.

Thus membranes must be packed into a small volume leaving little space for a flow channel and no room for a filter cake. Hence UF modules are operated in the cross-flow mode with two outlet streams: the product (permeate) and the concentrate (reject).
Ultrafiltration Plant Configuration

The three common UF system designs are:

- batch concentration,
- continuous feed and
- bleed and continuous multi-stage feed bleed.

Ultrafiltration Pilot-Plant The design of the effluent treatment pilot-plant is shown in Figure 9.5 and 9.6. Membrane Cleaning The degree of fouling of the membranes can be evaluated by measuring the water flux of the membranes and determining the membrane permeability constant. A decrease in water flux can be caused by:

(i) membrane compaction
(ii) chemical fouling of the membrane surface
(iii) mechanical fouling of the feed spacer mesh.
The water flux of a new membrane is in the region of 200M/m²h but after about two months operation the flux drops to 80-120M/m²h. This membrane compaction is irreversible.

Chemical fouling is due to the build-up of PVA, waxes, starches and metal hydroxides on the membrane surface. The water fluxes can be restored by water rinses or by chemical cleaning with peroxide solution or ammonium citrate rinses.

Mechanical fouling is caused by the blockage of the feed spacer mesh by particulates leading to an increased pressure drop through the module. In addition, the effective membrane area is decreased.

Fouling is considerable under non-polarized conditions, namely high reject flow rates, low inlet pressures and low concentrations of PVA. Short (2 h) rinses with cold water or hot sodium peroxide rinses restore performance of the membrane. These rinses should take place daily.

In the longer term, 3 or 4 monthly-rinses with following clearing solutions are required to maintain the membrane permeability.
Cleaning Solutions

(i) Cold water rinses Recirculate cold water or permeate for 2 hours

(ii) Sodium Peroxide
  10 mM/M sodium peroxide (80 %)
  6.6 mM/M sodium hydroxide (400 g/M)
  Recirculate at 50-60°C for 2 hours and then flush out with permeate

(iii) Ammonium citrate
  20 g/M citric acid
  Adjust pH to 2.5 with ammonia solution
  Circulate for 2 hours and then flush out with permeate.
Maintenance

The UF size recovery plant requires no special maintenance. Attention should be paid to various aspects which reduced plant capacity, namely.

(i) Ensuring the minimum amount of water used to desize
(ii) Removal of all the lint from the feed to the UF plant
(iii) Maintaining the feed temperature as high as possible
(iv) The reject flow rate from the modules be kept as high as possible
(v) Regular cleaning of the membranes.
(vi) Returning the size at the lowest possible concentration