THE TREATMENT OF WASTE INK WASH WATER BY ULTRAFILTRATION

By:

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INTRODUCTION

As municipal and federal regulation of hazardous waste disposal increases, paper converters find themselves compelled to meet tightening discharge limits for printing ink wash water. Soaring energy costs have led to large increases in the cost of solvents and solvent recovery for the waste treatment of traditional solvent-based inks. As a result, many converters are changing over to water based printing systems. Ultrafiltration provides a low-cost, energy-efficient method for the treatment of dilute water based ink waste streams.

The primary concerns in the treatment of ink wash up water are the complete removal of color from the effluent stream and the reduction of lead, chromium, and other heavy metal concentrations in the stream. Although new low lead ink compounds are now available, many municipal discharge limits are still lower than the amounts of metals present in the wash up streams. Ultrafiltration produces a clean water stream which is able to be discharged directly to a sewer or reused in the plant and a concentrated ink stream which is but a fraction of the original waste volume.

ULTRAFILTRATION

Ultrafiltration is a process in which a semipermeable membrane separates and concentrates the suspended solids, colloids, and high molecular-weight materials that are in solution. As shown in Figure 1, the feed solution flows under turbulent flow conditions through a membrane tube. The permeate (clear, filtered water) passes through the membrane and is collected in an annular space between the membrane and its housing. The permeate is then discharged to a sewer or available for reuse.

Unlike ordinary filtration, the waste stream flows parallel to the membrane surface, not perpendicular. As a result, no filter cake builds up on the membrane. Moreover, the structure of the membrane itself will not become plugged because the retained materials cannot penetrate the membrane. Turbulence at the membrane surface caused by the circulating waste stream carries retained materials from the membrane.
FIGURE 1.

TUBULAR ULTRAFILTRATION MEMBRANE

Fiberglass-reinforced Epoxy Support Tube

Tubular Ultrafiltration Membrane

Wash Water

Permeate

Concentrate
The membrane permeation rate (flux) is a function of flow, pressure, temperature and concentration.

Increased flow rates through the membrane tubes generally result in increased permeation rates. However, because of energy consideration, however, the optimum flow rate is between 30 and 35 gpm per pass of membranes.

Because pressures about 1.5 ATM produce only slight increases in permeation rates, the operating pressure is set by the desired system flow conditions which are usually 3.4 ATM [50 psig] inlet and 1.4 ATM [20 psig] outlet.

Permeation rates increase with increasing temperature. Operating temperature is limited by the membrane material and configuration. This limit ranges from 5 °C to 80 °C. The normal operating temperature is 30 °C to 50 °C.

Permeation rates decline with increasing concentration of total solids in the process fluid. Flux decline in low concentration ink waste is a result of build up of ink solids on the membrane surface. A once-a-week cleaning is required to remove these buildups from the surface of the membrane and to restore the initial process flux of the system.

Cleaning consists of washing the ultrafiltration system with a detergent solution for one to two hours. Rubber spongeballs are then flushed through the tubes, mechanically cleaning the membranes. The cleaning solution is then displaced back to the feed tank. Thus, no additional solid or liquid wastes are generated.

Abcor, Inc. manufactures several different types of membranes. However, the HFM-180 membrane was found to produce high quality permeate at good filtration rates. A ten-foot membrane tube contains 2.2 square feet of membrane area. Normally, there are eight tubes connected in series per pass and as many passes as needed are placed in parallel to obtain the proper amount of membrane area.
SIMPLIFIED UF-70 FLOW SCHEMATIC

To Transfer Pump
Process Liquid
(From collection tank)

Level Control

CLEANING TANK
50 GAL

Circulation Pump

Drain & Concentrate Disposal
2-5% of Original Volume

Permeate Return Line

Process Return Line

TUBULAR ULTRAFILTRATION MEMBRANES

Flow Meter

Permeate Discharge
95-98% of Original Volume

CUSTOMER SUPPLIED

ABCOR SUPPLIED
Since concentration parameters and thusly fluxes are similar for most waste ink streams, membrane area is primarily a function of the size of the waste stream.

PROCESS DESCRIPTION

Figure 2 shows a generalized flow schematic of an Abcor ultrafiltration system. No chemical pretreatment is necessary for Abcor's one-inch diameter ultrafiltration membrane. Filtering fibrous solids with a basket strainer, however, is recommended in order eliminate the possibility of damage to the pump and plugging of the piping system.

The usual method for waste treatment, as shown in Figure 2, is the modified batch operation. Waste water is circulated from the process tank through the membranes and back to the process tank. In the initial phase of the operation, as permeate is removed by the ultrafiltration system, fresh feed (from sumps) of equal volume is added to the process tank. In this manner, the concentration of the process tank is kept at a minimum, allowing the ultrafiltration membranes to operate at maximum efficiency. After a pre-determined volume of material has been processed, the fresh feed to the process tank is stopped and straight batch concentration begins. This allows many days of fresh waste to be added to the process tank before feed addition to the tank is discontinued. Once the change has been made from modified batch to batch operation, the ultrafilter will continue to concentrate the process fluid until flux declines.

Permeate removed from the ultrafilter usually meets current effluent standards and, therefore, can be discharged directly to the sewer. In some cases, however, the feed stream contains very small amounts of dissolved pigment which permeate through the membrane, giving the effluent a slight tint. This can be removed efficiently and inexpensively by activated carbon filtration.

An overall material balance for the process is shown in Figure 3. On the basis of 1,000 gallons of feed at 1% total solids an ultrafiltration
FIGURE 3.

OVERALL MATERIAL BALANCE
ULTRAFILTRATION OF WASTE INK WASH WATER

ULTRAFILTRATION SYSTEM

FEED
Wash water
1000 GPD
1% Ink

CONCENTRATE
40 GPD
25% Ink

PERMEATE
960 GPD
system will produce 960 gallons of a clean permeate stream and 40 gallons of a 25% ink concentrate. This concentrate stream represents a 96% volume reduction when compared with the initial waste feed. The permeate stream has been found to contain less than 2 ppm Pb and less than 1 ppm Cr. In addition to sewer discharge, permeate may be recycled within the plant as starch make-up water, as ink dilution water or again as wash up water.

ULTRAFILTRATION EQUIPMENT

A typical system for the ultrafiltration of water based ink waste is the Abcor Model UF-70. It's nominal capacity is 2,000 gallons of waste per day. The unit contains up to four passes of eight membrane tubes in series. The system is completely skid-mounted and includes a 10 h.p. circulation pump, 50 gallon tank for membrane cleaning, electrical control box and panel, safety devices allowing for 24 hr. unattended operation, and all internal piping and wiring. Feed and return hook-ups to a 1,000-2,000 gallon process tank and electrical tie-in are the only installation requirements.

ECONOMIC ANALYSIS

Table 1 shows an operating cost estimate and economic analysis for the UF-70 ultrafiltration system. Electrical power to operate the circulation pump is the only energy cost involved with system operation. Labor is estimated at one-hour per day which includes weekly cleaning. Membrane replacement is calculated on a yearly basis, however it is quite possible that as much as two or more years will pass before a retube becomes necessary. The operating cost estimate which also includes expenses for membrane cleaning chemicals, depreciation, and concentrate disposal is approximately $18,000 per year or 3.5¢ per gallon of waste processed. Based on a raw waste disposal cost without ultrafiltration of 12¢ per gallon, the UF-70 shows an annual savings of $42,000.
UF-70

OPERATING COST ESTIMATE FOR THE PROCESSING OF
FLEXOGRAPHIC INK WASH WATER

BASIS: 2,000 Gal/Day (500,000 Gal/Year) 1% T.S.

CAPITAL COST

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
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<tbody>
<tr>
<td>UF-70 Unit</td>
<td>$34,350.00</td>
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<tr>
<td>Installation</td>
<td>$17,000.00</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$51,350.00</strong></td>
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ANNUAL OPERATING COST

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Power</td>
<td>$1,900.00</td>
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<tr>
<td>Labor</td>
<td>3,000.00</td>
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<tr>
<td>Membranes</td>
<td>3,360.00</td>
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<tr>
<td>Maintenance</td>
<td>300.00</td>
</tr>
<tr>
<td>Cleaning Chemicals</td>
<td>1,800.00</td>
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<tr>
<td>Hauling (disposal) Cost for 25% Concentrate</td>
<td>2,400.00</td>
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<tr>
<td>[80 Gal/Day at 12$/Gal]</td>
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<tr>
<td><strong>Sub-Total</strong></td>
<td><strong>$12,760.00</strong></td>
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DEPRECIATION [10 Yr. straight line] $5,135.00

Total Costs $17,895.00

ANNUAL SAVINGS

<table>
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<tr>
<th>Item</th>
<th>Cost</th>
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<tr>
<td>Gallons treated per year</td>
<td>500,000</td>
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<tr>
<td>Hauling cost without ultrafiltration (12$/Gal)</td>
<td>$60,000.00</td>
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<tr>
<td>Ultrafiltration operating cost</td>
<td>$17,895.00</td>
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<tr>
<td><strong>Total Annual Savings</strong></td>
<td><strong>$42,105.00</strong></td>
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CONCLUSION

Ultrafiltration is able to treat water based ink wastes generated by paper converters efficiently and economically. After ultrafiltration, the clean effluent can be discharged to a sewer or recycled within the plant. Energy requirements are low. Electrical power to operate a pump motor is all that is necessary. Membrane replacement is estimated on a yearly basis, although membrane life could prove longer. The process is not a labor intensive operation requiring only minimal operator attention for shutdown, startup and cleaning. At operating costs of only 3.5¢ per gallon processed, ultrafiltration provides a substantial cost savings over other methods of waste treatment.

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