
In-Process Recycling of Deburring Solution Using Ultrafiltration

By: Malcolm Boyle

Management of the Werner Company facility in Franklin Park, Illinois realized that something had to be done to reduce its waste stream from the water it discharges into the publically owned treatment works (POTW). The company decided to contact the Illinois Sustainable Technology Center (ISTC) for technical assistance about pollution prevention technologies.

The Werner Company generates approximately 1,500 gallons per day (gpd) of cleaning/deburring solution for discharge. The cleaning solution used in two deburring machines contributed to the fats/oils/grease (FOG), biochemical oxygen demand (BOD), and total suspended solids (TSS) in Werner's wastewater. The compliance limit of most concern to Werner was the FOG limit of 250 mg/L, because on occasion a system upset would make compliance with the limits a challenge.

ISTC engineers assessed the deburring process and recommended a project to evaluate the technical and economic potential of various technologies (i.e., hydrocyclones, coarse filtering, chemical treatment, and ultrafiltration) to recycle the cleaning solution. Over time, the solution becomes contaminated with a variety of waste products including media particulate, aluminum particulate, and oils. The fine particulate in the fluid presented the biggest challenge to recycling. The hydrocyclone and coarse filtering were not appropriate due to the fine particulate nature of the deburring waste stream. Chemical treatment would cost more than the continued dumping of the waste stream to the sewer since it has a high initial capital cost and the costs associated with required treatment of chemicals. ISTC discovered that Ultrafiltration (UF) proved cost-effective for this application; it removed the fine particulate and created a closed-loop system to eliminate this discharge stream.

Background

Werner Company is a manufacturer and distributor of fiberglass, aluminum, and wood climbing products. The Franklin Park facility employs more than 800 people and operates three shifts per day, six days per week. During the last five years the company has invested more than \$75 million in its facilities and overall infrastructure.

The cleaning/deburring operation uses a large rotary machine and a small vibratory machine. Both systems use the same cleaning agent and the machines overflow into a sump for discharge. Werner Company was interested in the elimination of the discharge and the associated FOG. In previous studies, ISTC analysis found that some cleaning solutions in their raw form can produce elevated FOG readings based on the Freon extraction laboratory procedure commonly used by POTWs. ISTC engineers suggested that Werner could substantially reduce its chemical usage and eliminate the discharge of this waste by implementing closed-loop recycling of the cleaning solution. An effective system would maintain solution effectiveness, reduce chemical costs and allow for recycling. Even though the cleaning solution becomes contaminated by particulate, FOG, and dirt during the deburring operation, many of the active ingredients in the chemicals are not depleted in the process. These ingredients could be recovered, reformulated to replace lost components, and reused in the deburring operation.

Technologies Evaluated

Hydrocyclone

A hydrocyclone is a system (basically an inverted cone) for separating solids from a fluid. In this case, the dirty cleaning solution is pumped through the upper section of a cyclonic cell causing a downward spiral motion. This centrifugal action forces the solid particles out of the fluid and into the lower portion of the inverted cone. Particles down to five microns are discharged through an opening in the lower portion of the inverted cone. Back pressure at the exit aerates the clean fluid and causes the fluid to rise as an inner cyclone, revolving in the same direction and exiting through the top of the cyclonic cell. In the deburring operation, large amounts of particulate are generated and become entrained in the solution. A hydrocyclone was evaluated for the initial removal of the particulate matter because it could be an inexpensive and easy way to remove the

particulate from the solution. Samples of the dirty cleaning/deburring solution were obtained and sent to Cyclomation Industries Inc., Racine, WI, for testing. The results indicated that the hydrocyclone would not work due to very poor sedimentation rates and because the particulate sizes were less than five microns.

Coarse Filtration

The next attempt to remove the particulate before recycling the solution was the use of coarse filtration (bag filters). Various filter pore sizes were used to determine their effectiveness in removing the entrained solids. It was anticipated that the FOG would not be affected, while the TSS should show some reduction. The one micron bag filter did remove some of the particulate which would be important for extending the life of pumps and reducing the sludge in the process tank. Table 1 shows the results of the coarse filtration testing.

TABLE 1: COARSE FILTRATION RESULTS

Sample Description	FOG (mg/L)	TSS (mg/L)
Unfiltered Deburring Waste	340	562
Coarse Filter 100 micron	479	528
Coarse Filter 1 micron	435	432

Chemical Treatment

This system consists of three tanks in a single unit. A waste water tank accumulates the waste solution for the primary settling of solids and oil removal with a skimmer. The treatment process consists of a series of chemical treatments. The material is added according to the system requirements. Sludge accumulates in the bottom of a tank and is dewatered by flowing the material through an indexing filter. The chemical treatment system was evaluated based on vendor furnished cost information, chemical usage, and waste generation. Table 3 shows the cost evaluation for chemical treatment. This system was rejected by Werner due to the annual operating costs and the waste sludge generated. Therefore, field testing of this technology was not necessary.

Ultrafiltration (UF)

ISTC engineers felt that a membrane filtration process, such as ultrafiltration, may be beneficial to remove FOG contaminants. The technology uses a thin-film membrane and turbulent flow to generate a consistent flow rate (flux) and a high quality filtrate (commonly referred to as permeate). Initial test results from a portable ultrafiltration unit (0.2 micron membrane) are presented in Table 2. Ultrafiltration membranes are semipermeable barriers capable of separating feed stream components according to particle size. Large size particles are retained while smaller components pass through. Membrane filters can be reused by removing the particulate matter by flushing or mechanical cleaning. The flow of feed solution also can be controlled to limit contaminant buildup which allows for longer periods of operation without cleaning the membrane. A pilot-scale ultrafiltration system manufactured by Arbortech Corporation was installed at Werner, next to the deburring machines. The system was equipped with a series of four tubular membranes with a total membrane surface area of 4.4 square feet. The system was evaluated for one month. The dirty solution was pumped from the deburring machine sump to the ultrafiltration system's 55-gallon process tank. Samples of the clean permeate were collected and evaluated. Contaminants removed from the cleaning solution by the ultrafiltration process were concentrated in the process tank. When the flux dropped to a predetermined level, the concentrated contaminants in the process tank were pumped out to a drum for disposal, the membranes were cleaned, and fresh solution was introduced into the process tank.

TABLE 2: ULTRAFILTRATION RESULTS

Sample Description	FOG (ppm)	TSS (ppm)
Unfiltered Deburring Waste	340	562
UF Retentate (concentrated waste)	633	412
UF Permeate (recycled solution)	119	006

Werner Company compared the ultrafiltration test results to the other technology options (see Table 3 below) and determined that ultrafiltration would meet its economic and recycling needs. Therefore, Werner purchased and implemented a permanent ultrafiltration unit (see pictures). The unit has been operating 16 -24 hours per day and it has eliminated the FOG problem associated with the discharge of this waste stream.

TABLE 3: COST ANALYSIS OF VARIOUS OPTIONS

Do Nothing (continue as is)	Capital Costs:	\$0
	Operating Costs:	\$23,000/yr
Chemical Treatment	Capital costs:	\$37,000
	Operating costs:	\$25,000/yr
Ultrafiltration System	Capital costs:	\$42,000
	Operating costs:	\$8,000/yr

The ultrafiltration membranes selected for this project were chosen for their ability to remove oil, grease, and particulate contaminants. An ultrafiltration system, equipped with a series of eight tubular membranes with a total membrane surface area of 17 square feet, was connected to the existing rotary and vibratory deburring machines. One system serviced both machines.

The cleaning solution's primary function is to facilitate the deburring operation; its secondary function is to clean the parts. Analytical tests on the quality of the recycled cleaning solution indicate that the oil and the suspended solids content were considerably reduced. Cleaning chemical quality was also maintained. It is estimated that the total cleaning chemical consumption would be reduced by 75% through the installation of a full-scale ultrafiltration system. A capital investment of \$42,000 would be required to install a permanent ultrafiltration system for this operation. However, an estimated \$15,000 in annual savings would be realized in reduced operating expenses and chemical consumption. Investment in a permanent ultrafiltration system for the deburring operation should pay back in approximately two and a half years.

Update

Due to the sensitivity of the UF membranes to chemicals in other processes the Werner Company discovered an added benefit after the installation of the UF system. The company evaluated the lubricants and chemicals used in the cutting, machining, and stamping operations and processed by the deburring operations using the UF membranes. This approach allowed the Werner Company to critically review and replace various solvents that it had historically used in its operations, with more "environmentally friendly" lubricants. This not only helped the recycling of deburring solution, but further reduced material usage in its processes and significantly reduced volatile organic compound (VOC) fugitive emissions.

The results of recycling the cleaning/deburring solution are:

- X Werner Company has eliminated the FOG problem. The FOG levels are now less than 30 mg/L, considerably below the 250 mg/L discharge limit.
- X The TSS is drastically reduced. Before installing the UF system, the effluent was cloudy, now it is clear.
- X The cleaning chemical was being used at a rate of 275 gallons every 1½ months. After implementing the UF system to recycle the cleaner, the usage rate has dropped to 20 gallons every 1½ month - a 92% reduction.
- X The amount of waste being generated by the deburring process has been reduced by 98%.
- X Water usage has dropped from 1,500 gpd to 15 gpd - a 99% reduction.
- X The close looping of the deburring operations and recycling of the cleaner/deburring solution has eliminated this waste stream from being discharged to the POTW.
- X No quality issues related to the recycling of the cleaner have been experienced.
- X Werner Company is evaluating the addition of eight more membranes to double the capacity of the UF system to accommodate higher production rates.



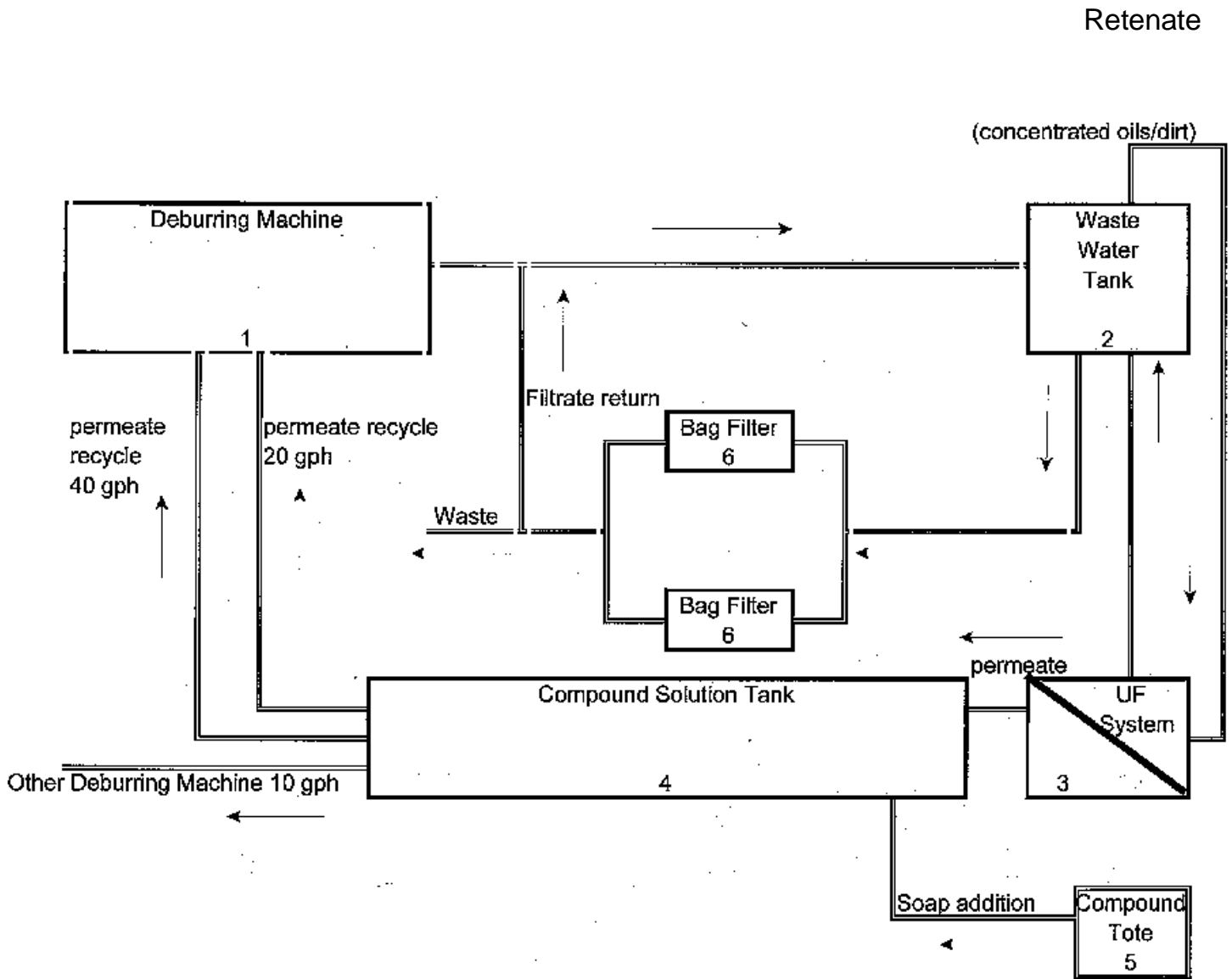
**Werner Company UF system
on
deburring operation**



**Werner Company UF system
and process tanks on
deburring operation**



Werner Company
Franklin Park, IL Cleaning/Deburring Solution UF
System Schematic



PROCESS FLOW:

- 1 Deburring Machine
- 2 Waste Water Tank
- 3 UF System
- 4 Compound Solution Tank
- 5 Compound Tote
- 6 Bag Filter

*Originally published: June 2001
Revised: May 2013*