Extending the Life of Aqueous Cleaning Solutions

The bath life of an aqueous cleaning solution is limited by the buildup of the contaminants removed from parts. Although the cleaners may avoid some of the environmental issues associated with cleaning with organic solvents, the periodic disposal of the bath to maintain part quality results in its own environmental and economic problems. These problems can be minimized through techniques to extend the life of and recycle aqueous’ cleaning baths.

Don’t Trade One Problem for Another

In recent years, a number of companies have switched from cleaning using chlorinated solvents, such as 1,1,1-trichloroethane or trichloroethylene, to cleaning using aqueous solvents. These cleaners are water-based solutions that can contain a number of chemical components such as detergents, surfactants, saponifiers and rustproofing inhibitors. They are typically used in multi-stage systems, which may involve immersion, sprays, ultrasonics, rinsing, drying or other steps.

Two of the key motivators for finding alternatives to solvent-based cleaning are avoiding or minimizing the air emissions and hazardous waste generation associated with these processes. However, a company that switches to an aqueous cleaner may find itself with a new problem in a new environmental media. Both the components of the cleaner and the contaminant (typically oils and greases) are now introduced into the wastewater.

Fortunately, the impact of aqueous cleaning on wastewater can be minimized. Extending aqueous cleaning bath life through operating changes and/or through recycling may offer an environmentally sound alternative. It may also reduce costs, allowing cleaning solutions to be reused repeatedly, instead of becoming simply a wasted valuable raw material.

Companies that are currently in the process of selecting a new aqueous cleaning system may want to consider recycling option early in the selection process. This will help them select proper cleaning equipment and a cleaning solution that both effectively cleans parts and can be recycled in the most cost effective manner.

The Problem of Contaminants

The life of a cleaning bath will be limited by the build up of contaminants as they are removed from the parts. With time and use, cleaning effectiveness will be z-educed (Lindsey et all, 1991).

There are many options for maintaining cleaning baths and extending their lives. The option that will be most effective and feasible will be determined by a number of factors, including the volume and number of the baths, and the contaminant or contaminants most responsible for degrading the quality of the bath. This can include non-emulsified oil, emulsified oil, ions such as sodium or chloride, suspended solids and dissolved solids.

One of the most significant factors is whether the oil is emulsified, and how it became emulsified. Oil can become emulsified by a variety of factors such as heat agitation or the chemical components of the aqueous bath. Some options only address non-emulsified oil, some can also remove oil that is mechanically emulsified, and some can even remove chemically emulsified oil.

Mechanically emulsified oils are oils that have been broken apart by physical forces, such as agitation or heat, during cleaning operations. Over a period of time, if these physical forces are removed these oils may separate out by themselves. This process can be accelerated by equipment such as coalescers or separators, discussed later in this fact sheet.

More sophisticated recycling equipment can remove even chemically emulsified oil. This is oil which has been suspended by components of the cleaner, which were specifically designed to emulsify and suspend this oil to avoid redeposition (Peterson, 1995). Equipment to remove these oils is typically the most capital intensive of the systems discussed in this fact sheet.
Because of the problems inherent to removing chemically emulsified oil, the chemical make-up of the cleaning bath used will partially determine which systems are necessary to adequately remove the oil.

A cleaning solution which has less power to chemically emulsify the oil will inherently have less cleaning ability. Increasing the ability of the cleaner to remove oil results in a trade-off of decreasing ability of the oils to be easily separated from the cleaner at a later point in time for recycling purposes (Durkee, 1991).

### Extending Bath Life Prior to Recycling

Some options do exist for extending the life of an aqueous cleaning bath without the purchase of additional equipment such as recycling systems. These options are discussed below.

**Reduce sources of contamination** - Some contaminants, such as metalworking fluids or fingerprints can be reduced at the source through operating changes or increased care in handling during the processes prior to the cleaning stage. Some material, such as a rust protectant which a supplier intentionally puts on a metal part becomes a contaminant at a later point and has to be removed. The company performing the cleaning should carefully consider its inventory practices to determine if any of this contamination can be avoided or minimized.

**Reduce heat and turbulence during off-hours** - Reducing the heat and turbulence in aqueous baths during the night or off-hours may result in more of the mechanically emulsified oil rising to the top of the bath. This will allow more of the oil to be skimmed in the morning before operations begin.

**Partial bath replenishment** - A company may be able to extend bath life by only partially dumping baths and adding fresh water and chemicals to bring the solution up to volume. This may increase the effectiveness of the cleaning bath sufficiently for continued cleaning. Eventually, however, chemicals will need to be added at a rate that results in costs greater than the savings from dumping the bath and mixing a new solution. This indicates that the entire bath should be dumped refilled (PRC Environmental. 1989).

### Recycling

Many different types of systems exist to separate oil and other contamination from the aqueous cleaning baths. During discussions with equipment vendors it is important to emphasize the following: the company’s intention to reuse the aqueous baths, not simply pretreat them before discharging; the temperature of the baths; and the pH of the baths.

The company will also need to determine the combined volume of the cleaning tanks and the average time between tank changeout and should prepare copies of material safety data sheets. It should also consider analytical testing to determine whether the primary contamination is chemically or mechanically emulsified oil, non-emulsified oil, suspended solids, dissolved solids, or other type of contaminant. Some vendors will conduct this testing themselves.

### Filtration

Literature indicates that in-tank filter cartridges can extend bath life. Filters can be selected to remove non-emulsified oils or solids, but not emulsified oils.

One company reported the purchase of used filtrations equipment for $500 with installation costs of $350 for filtering an electrocleaner and acid pickle (105 gallons each). They estimated that the filtration extended the life of the electrocleaner by 10 times.

The results of a user survey in the book, “Pollution Prevention and Control Technologies for Plating Operations” indicated that of 265 alkaline soak processes, 21 utilized in-tank filtration and one used external filtration for bath maintenance (Cushnie, 1993).

However, some experts indicate that the cleaning ability of filters is insufficient to make a significant change in bath life because of their inability to remove any emulsified oil. One vendor indicated that filters may become coated so quickly with oil that the cost of either replacing or washing the filters might outweigh the financial benefits of extended bath life.

Experimentation with filters may indicate whether or not they significantly increase bath life for a particular application.

### Mechanical separation of oil

Several different types of equipment exist to separate certain oils from the cleaning solutions.
Decantation - High volumes of non-soluble oil (only) can be removed through decantation of the oily cleaning solution while in a holding tank. These systems should be designed to prevent oil from being circulated through process pumps, so the pumps can not further emulsify the oil. Collected oil can be skimmed into a decanting chamber where a more complete separation can be achieved. (Temple, 1990).

Separation - Both non-emulsified oil and mechanically-emulsified oil (but not chemically emulsified oil) can be removed through a separation unit (this may be referred to as a plate separator, a gravity separator or a coalescing unit) or a combination of filtration and a separation unit. Separation units can be central or dedicated, and can take up relatively small amounts of space. These units speed up the natural separation of mechanically emulsified oil by agglomerating oil droplets. This causes them to separate from the cleaner due to differences in density (Peterson, 1995).

Although the variety of separation units available function in essentially the same manner, they will differ greatly from each other based on the vendor and on the specific needs of the customer. See Figure 1 for an example of a generic separation unit.

One advantage of combination filtration/separation systems is that they do not risk removing the additives in the aqueous bath as membranes filtration systems sometimes do.

One electrical component manufacturer switched from simple manual skimming to a separation system. The vendor analyzed a sample of the used bath to determine the internal configuration of the coalescing unit. The system was installed for less than $10,000 and resulted in a first year savings of more than $29,000 chemical costs (Batutis, 1989).

Membrane Technologies

In traditional filtration the entire stream is passed through a filter. Crossflow filtration, typically used for ultrafiltration and microfiltration, flows the stream across a membrane using pressure to force filtration to occur. See Figure 2 for a diagram of crossflow filtration. Ultrafiltration and microfiltration may offer effective, means to remove contaminants and increase bath life. They may also be the most capital intensive options discussed in this fact sheet. The type of membrane system chosen depends on factors such as the most significant type of contamination, the volume of fluid to be processed, and the temperature of the solution.

Suspended solids may need to be removed prior to ultrafiltration, which is capable of removing dissolved solids; and/or mechanically or chemically emulsified oil. It removes particles in the 0.005 - 0.1 micron range.

Many. membranes are not compatible with hot and/or caustic solutions. This may preclude use of these systems entirely, or necessitate the use of a holding or cooling tanks, which would require extra floor space. Ultrafiltration may require some type of pretreatment, either by filtration or by oil separation. For instance, a vendor may provide packages with attached filtration for suspended solids. Or, the system may use a tramp oil separator for pretreatment to remove mechanically dispersed and free oils. Which system is best can only be determined after testing and through communication with vendors.

Microfiltration removes particles in range of 0.1 to 5 microns. Many microfiltration systems are available with ceramic filters that can withstand the high temperatures and caustic solutions associated with many cleaning baths. This may avoid the need for a holding tank or cooling tank saving floor space. A microfiltration unit may take up less space than an office desk.

Microfiltration can remove solids, non-emulsified oil, or mechanically or chemically emulsified oil, but may require pre-filtration or pre-separation. Microfiltration works best with non-silicated cleaners.
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The book “Pollution Prevention and Control Technology for Plating Operations” provides an example of return on investment for a microfiltration system. The bath volume was 2400 gallons, and the cleaner cost was $0.42/gallon. Equipment and installation costs were $27,000, and operating costs were $6,250/year. Total savings were $18,715. The return on investment was 2.1 years (Cushnie, 1991).

One of the most significant concerns regarding the use of membrane technologies is that some components of the cleaning solution may be removed along with the contaminants. If this happens, chemicals will have to be added to the bath before it can be reused.

Case Studies

Ultrafiltration

An Illinois manufacturer of painted steel shelving units cleans metal surfaces prior to painting to remove mill oils and metalworking fluids. Parts are cleaned and phosphated in a 5000 gallon heated, aqueous immersion tank using nonionic surfactants, and rinsed with a fresh water spray. The pH of the bath is maintained at 3.5 and the concentration of the cleaner is checked regularly (the cleaner contains both surfactants and phosphates).

Although the change to this aqueous system eliminated some issues associated with the previously used trichloroethylene degreasing tank, oil buildup in the cleaner and rinse tank were unacceptable. The bath had to be disposed of approximately every three to four months because of poor product quality. The spent bath was classified as a hazardous waste and was incinerated off-site in a cement kiln. Management costs for transportation and incineration totaled approximately $15,000 annually.

With the assistance of the Hazardous Waste Research and Information Center, Illinois, the company tested and installed an ultrafiltration unit primary objectives were to reduce waste and to preserve product quality.

The ultrafiltration process preferentially removed surfactants from the cleaning solution. However, simply adding additional chemical solution would have resulted in excessively high phosphate concentrations. The company resolved the issue by adding a neutral cleaning additive that contained the surfactant component in the original cleaner.

Although the ultrafiltration system did require significant capital investment savings were achieved through reduced raw materials usage, plant down time, and waste disposal costs. Ultrafiltration has extended the bath life to over 3.5 years. The payback period was 6.9 months, the net present value was $152,143, and the interest rate of return was 178 percent (Lindsey et all., 1991).

Microfiltration

An Ohio company that fabricates commercial aluminum cookware uses aqueous cleaning followed by a deionized rinse to remove machine_oil, kerosene and dirt from parts prior to hard anodizing. This system originally resulted in wastewater with up to 150 milligrams per liter of oil and grease, exceeding local regulatory limits of five milligrams per liter for both oil and grease and kerosene.

A microfiltration system was installed to remove these contaminants. The resulting solution could be discharged under current limits. Even better, contaminants are sufficiently removed for the water to be reused for cleaning.

The system, which allows 99 percent of water to be reused, had a payback period of less than three months, based on the cost of off-site disposal (EPOC, date unknown).

Conclusion

If you have decided that your aqueous cleaning bath is not accomplishing all you had hoped for, either environmentally or economically, it is not too late to consider options to maximize the bath life or to recycle the bath. Keep in mind that the more chemical emulsifying power your cleaner has, the harder it will be to remove the contaminants later. You may want to consider switching to a cleaner with less cleaning ability, and relying more on physical mechanisms such as agitation, sprays and...
ultrasonics to remove oil and other contaminants.

If you are in the market for a new aqueous cleaning system, consider recycling alternatives at the same time.

References/Sources of Information


August 22, 1994, telephone conversation with Scott Striker, District Manager, Osmotics. 800/848-1750.


Vendors

Alfa Laval Separation, Inc. 955 Meams Road Warmiinter, PA 18974 215/443-4030 (ultrafiltration. filtration)

Aqualogic 20 Devine Street North Haven, CT 203/288-4308 (ultrafiltration. filtration)

Atotech 2 Riverview Drive P.O. Box 6768 Somerset, NJ 08875 1/800/PLATING (filtration)

Baker Brothers Systems 44 Campanilli Parkway Stoughton, MA 02072 617/344-1700 (filtration)

DJM Industrial 10440 Travis St. Walton, KY 41094 (ultrafiltration. filtration)

EPOC Filtration and Separation Systems 3065 North Sunnyside Fresno, CA 93727 290/291-4926 (separation, membrane technology)

Hawken Technologies 463 Turner Drive, Unit 103 Durango, CO 81301 303/247-4655 (ultrafiltration)

Hyde Product, Inc. 28045 Ranney Parkway Cleveland, OH 44145-1188 216/871-1188 Fax 216/871-1143 (ultrafiltration. separation)

Industrial Filter 5900 West Ogden Avenue Cicero, IL 60650 708/656-7800 (filtration)

Ionics, Inc. 65 Grove Street Watertown MA. 02172 617/926-2500 (filtration)

Iverson Industries 9799 Princeton-Glendale Cincinnati, OH 45246 (filtration)

Janis Manufacturing 125 Space Park South Nashville, TN 37211 615/781-3093 (filtration)
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This is the thirty-first in a series of fact sheets Ohio EPA has prepared on pollution prevention. For more information, call the Office of Pollution Prevention at 614/644-3469.

The Office of Pollution Prevention was created to encourage multimedia pollution prevention activities within the state of Ohio, including source reduction and environmentally sound recycling practices. The office analyses, develops and publicizes information and data related to pollution prevention. Additionally, the office increases awareness of pollution prevention opportunities through education, outreach and technical assistance programs directed toward business, government and the public.