Mixed Metal Hydroxide Treatment

A cost-effective and environmentally-sound solution

Background

Electro-chemical machining (ECM) technology is a relatively new process that is utilized by aviation engine parts manufacturers. The parts manufactured include: forged cases for turbine engines, gas turbine fan and compressor blades, and machined turbine vanes, blades, disks, seals and shrouds. This technology is used to produce turbine engine components primarily from nickel-based and titanium-based alloys. With the increasing use of computers to design turbine engines, the shape of components has become much more complex. The ECM technology allows precise machining of these complex shapes, which are often nearly impossible to achieve through conventional methods.

In the ECM process, a workpiece (either bar stock or oversized forging) is positively charged. An inverse of the shape that is to be produced (called the cathode) is negatively charged. The cathode and part to be machined are then brought together with a high-pressure circulation of a salt solution electrolyte in a DC electrolytic cell. The end result is a finished component that has close tolerances and a very good surface finish. Compared to conventional milling operations that require a series of passes to create a full contoured shape, ECM technology machines the entire contoured shape with one pass, regardless of the hardness of the metal.

In the ECM industry, high purity electrolyte/water solution is required to ensure proper operation of the machining process. High purity electrolyte solution improves the efficiency of the process for electro-chemical machining and reduces the use of chemicals for the process. Continuous removal of metal hydroxides formed during the processing is necessary. Traditionally, chemical addition/ coagulation/ clarification and cross-flow membrane systems were considered as preferred technologies for separating the metal hydroxides. However, chemical addition/coagulation/clarification suffers from high cost of chemicals required and the large space that is needed for the equipment. Conventional cross-flow membrane technologies also suffer from the high cost of the pretreatment equipment required and the membrane replacement costs due to fouling.

Objective

To meet the requirements of both ecology and economy, the filtration of spent electrolyte solutions from the electro-chemical machining (ECM) process allows the process to meet the stringent requirements for a more efficient system performance. The continuous treatment of the electrolyte solution is required for maintaining the metal hydroxide concentrations below the required design criteria and reducing the excessive chemical requirements and disposal costs.

Solution

Technological advances in membrane filtration systems have created an opportunity for treatment of electrolyte solutions or streams to remove metal hydroxides in order to meet stricter system performance. The “Vibratory Shear Enhanced Processing” or VSEP™, developed by New Logic International makes it possible to filter the spent electrolyte solutions or effluent streams without the fouling problems exhibited by conventional membrane systems. The VSEP membrane system will significantly reduce mixed metal hydroxides, thus reducing total dissolved solids (TDS) and total suspended solids (TSS) from influent streams originated from electro-chemical machining or similar processes, thus minimizing treatment costs.

The VSEP treatment system uses nanofiltration membrane modules to treat the influent electrolyte solution in order to generate a permeate stream that meets the electro-chemical machining criteria for the required concentration of suspended and dissolved solids. The untreated electrolyte solution is fed to a large storage/process tank and a side stream is withdrawn on a continuous basis for filtration. The clear permeate from the filtration system is then recycled back to the storage/process tank. Reverse osmosis filtration can also be used if dissolved solids are an issue. In summary, the VSEP treatment system can be used to reduce the level of metal hydroxides in the electrolyte storage/process tank. VSEP will eliminate the pretreatment requirements and will substantially reduce chemical usage for electro-chemical machining and thus would reduce disposal of spent chemicals and the associated costs.

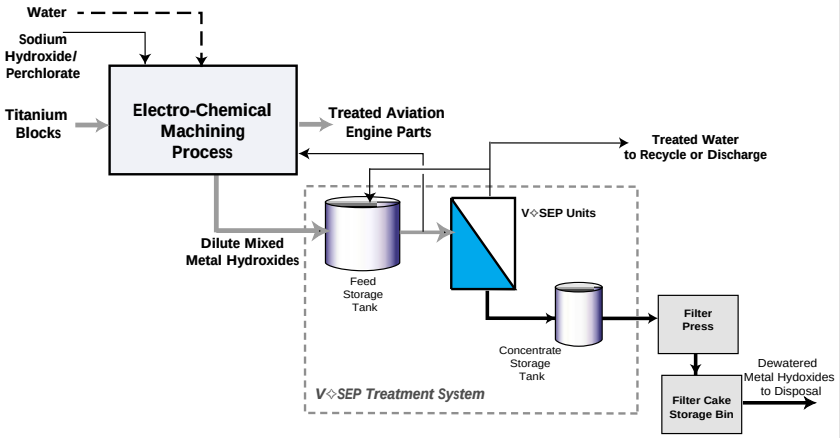
Several technologies are currently being used for treatment of metal hydroxides for electro-chemical machining processes or similar electro-chemical processes in general. Table 1 presents a summary of the benefits of VSEP when comparing with selected competitive technologies such as chemical addition/ clarifier systems, and spiral membranes. VSEP offers significant advantages over these technologies (Table 1).

For the industrial electro-chemical machining systems, as well as similar electro-chemical process industries, VSEP membrane systems can now be utilized where traditional cross-flow membrane technologies faced substantial membrane fouling problems

Table 1
Benefits of VSEP when Comparing with Competitive Technologies

Technology	Benefits of VSEP
Chemical Addition/Clarifier Systems	• **The main advantage of VSEP over a clarifier system is it is time efficient which leads to less hold-up volume, smaller space requirements and no cloudy overflow.** • VSEP can handle wide variations in feed concentrations • VSEP generates a permeate quality with 0 ppm suspended solids versus about 500 ppm from a clarifier treatment process • VSEP is a one step process where as the clarifier treatment process generally requires pre and post treatment • VSEP can obtain higher quality permeate, typically less than 1 mg/L of TSS when nano or RO membrane is used • VSEP offers a small foot print, thus much lower building/facility costs • The chemical consumption for clarifiers is usually high and significant overdose is required for proper control of the clarifier effluent.
Cross-flow Filtration/ Spirals	• **Product recovery is poor with cross flow systems, with cross flow at e.g. 60% to 75% versus 80 to 90% typical for VSEP** • **Cross flow filtration normally requires substantial pretreatment** • **VSEP offers a higher solids concentrate stream** • Frequent membrane replacement for the cross flow system can become expensive • Cross flow membranes will plug up with higher solid streams • Hold-up volume of cross flow system is high • Need larger feed/working tank with cross flow filtration • Larger piping is required for cross flow filtration • VSEP offers 2 to 3 times higher flux • VSEP offers one pass operation • VSEP can handle wide variations in feed concentrations • VSEP can obtain higher quality permeate, typically less than 1 mg/L of TSS when nano or RO membrane is used • VSEP offers much lower power requirement. • VSEP offers smaller foot print, thus much lower facility cost

Figure 1
Overall Flow Chart
Electro-Chemical Machining Process
Including V✧SEP Treatment System



in the past. The VSEP is an attractive alternative to conventional filtration methods due to its vibrational, shear-enhanced design.

Process Conditions

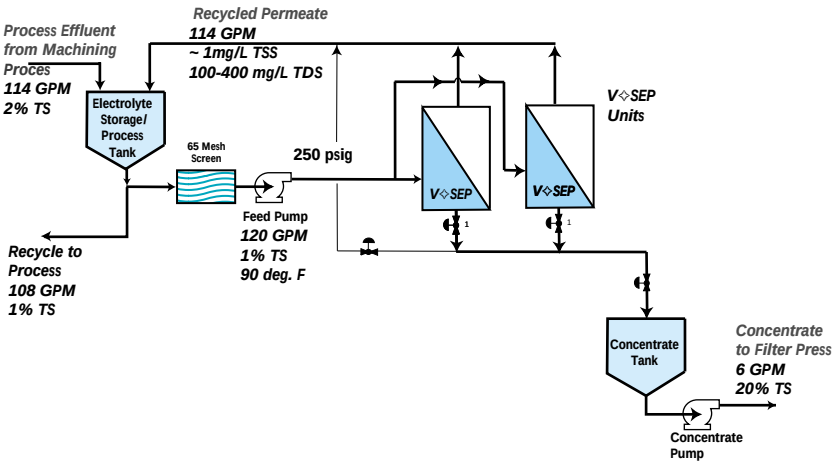
Figure 1 presents an overall flow chart for the electro-chemical machining process and treatment of mixed metal hydroxides using a VSEP system. The electrolyte solution containing dilute mixed metal is fed to a large storage/process tank (30,000 gallons). The contents of this tank are continuously processed through a VSEP treatment system, with VSEP acting as a kidney to remove metal hydroxides (primarily titanium hydroxide), generating a concentrated stream of the metal hydroxides. The spent electrolyte solution would have to be treated to meet the requirements for electro-chemical machining criteria.

Figure 2 presents a process schematic for treatment of metal hydroxides using a VSEP treatment system at an industrial manufacturing facility. This diagram also includes the overall material balance for the electrolyte treatment process and illustrates its performance. This system is using a nanofiltration membrane system to replace the entire pretreatment step that would be usually required, i.e. chemical addition and clarification, dual media filtration and cross-flow membrane filtration. The spent electrolyte solution is treated in a single step VSEP treatment system.

As presented in Figure 2, the spent electrolyte solution collects in a large storage/process tank, which is continuously regenerated using the VSEP treatment system. VSEP withdraws a side stream of 120 gpm from the electrolyte storage/process tank and generates a permeate stream of about 108 gpm which is sent back to the storage/process tank to maintain the level of metal hydroxides/solids for further process use. The VSEP also produces a concentrated waste stream at a flow rate of 6 gpm, which is routed to the concentrate holding tank and final processing through the filter press. The filter press will then generate a dewatered metal hydroxide sludge for final disposal off-site.

Two industrial VSEP treatment units, with nanofiltration membrane modules, are provided. The electrolyte solution in storage/process tank feeding VSEP is at a concentration of about 1% total solids of mixed metal hydroxides. The permeate concentration is reduced to <1 mg/L of TSS and about 100 to 400 mg/l of TDS, all well below the design criteria. The process effluent from the electro-chemical machining process is also fed into the storage/process tank at a concentration of about 2% total solids. By recycling all of the treated permeate from the VSEP, the concentration of metal hydroxides in the storage/process

Figure 2
Schematic of Metal Hydroxides Treatment Using V✧SEP



tank is maintained at about 1% or less total solids.

Using a nanofiltration module in the VSEP system is a commercially viable option for treatment of spent electrolyte solutions at electro-chemical processing facilities. Nearly 95% of the influent electrolyte solution is recovered as treated solution suitable for recycle to the storage/process tank, while less than 5% is left as concentrate for final processing.

Membrane selection is based on material compatibility, flux rates (capacity) and concentration requirements (TSS, TDS and conductivity). In this example, the TSS is reduced to less than 1 mg/L and TDS is also reduced to 100 to 400 mg/L. The permeate quality from the VSEP can be controlled though laboratory selection of membrane materials available to fit the application parameters.

After successful pilot tests at New Logic, a commercial project is currently treating a dilute waste slurry of metal hydroxides at a Midwest United States industrial facility. Depending on: influent water/solution concentration levels, process temperatures, membrane selection and the requirement for reduction of TSS, TDS, and conductivity from the influent streams, the permeate flux rate in the VSEP can range from 40 to over 70 gallons per day per square foot (GFD).

The concentration level out of the VSEP unit is controlled by an automatic timed control valve. A multi-stage feed pump or a progressive cavity pump supplies the VSEP unit at a pressure suitable for the membrane used. A variable frequency electronic drive is used to set feed pressure through P.I.D. (Proportional-Integral-Derivative) control loop. This kind of drive acts to control the rotational speed of the pump, thus controlling the flow rate.

Economic Value

New Logic's VSEP system provides an alternative approach for metal hydroxides treatment applications. In a single operation step, VSEP will reduce metal hydroxides, TSS, TDS, and conductivity to provide a high quality electrolyte solution stream for electro-chemical machining as well as electro-chemical processes in general. In many applications, the addition of VSEP will eliminate conventional treatment process requirements and technologies without chemical treatment demands. The justification for the use of VSEP treatment system in your process is determined through analysis of the system cost and benefits including:

- Reduction of metal hydroxides, TSS, TDS, and conductivity from the electrolyte solution.
- Provision of high quality solution for reintroduction into the process.
- Reduce or offset fresh water demands and pretreatment cost.
- Retain heat in recycled process water as a possible method to reduce energy requirements.
- Elimination of biological growth, and odor in effluent.
- Reduction of effluent discharge volume and associated treatment cost.
- Simplify influent or effluent treatment with a compact, low energy system.

Summary

New Logic International has supplied VSEP separation technology successfully into many industrial processes. The electro-chemical machining plants as well as the general electro-chemical industries' effort to meet system performance criteria and environmental regulations will be enhanced with the utilization of membrane filtration combined with "Vibratory Shear Enhanced Processing". The development towards applications for metal hydroxides treatment, along with the availability of new membrane materials and VSEP technology make it possible to treat the more difficult streams with very successful, economic results.

Contact a New Logic representative to develop an economic analysis and justification for the VSEP in your system. For additional information and potential application of this technology to your process, visit New Logic's Website @ http:/ www.vsep.com or contact New Logic, 1295 Sixty Seventh Street, Emeryville, CA 94608, Phone: 510-655-7305, Fax: 510-655-7307, E-mail: info@vsep.com.