Water Conservation in Metal Finishing

BACKGROUND

The metal preparation industries are heavy users of water resources and, with water prices increasing with population growth, are under considerable pressure to reduce consumption and waste discharges. Although some simple techniques do exist for limiting water use, they are unable to adapt to changing conditions and cannot verify both the cleanliness of reused water and the required rinse flows needed to clean metal parts. Measurement of electrical conductivity has been found to be an excellent technique for controlling rinse water, typically reducing water consumption by 40%[1].

THE PROCESS

Metal finishing is used to produce metal surfaces of a specific texture. Many different processes can be involved, including pickling, electroplating, anodizing, coating, and mechanical surface preparation. Exactly which processes are used will depend on the kind of metal and the specifications of the finished product. Prior to each of these operations, however, there will be rinsing steps to remove unwanted oils, greases, and other substances. Using fresh water at each rinse would be most desirable, but can be prohibitively expensive. Simple reuse of rinse water may contaminate process baths with dissolved solids such as sodium, iron, or chromium.

A representative process flow diagram is shown in Figure 1. The initial step is cleaning either in a tank or using a spray washer. The cleaning solution is usually slightly alkaline and is frequently a proprietary recipe of various surfactants. Theoretically, the strength of the cleaning solution can also be controlled using conductivity; however, interference from the contaminants washed off the metal parts can lead to false readings. Although conductivity can provide excellent real-time feedback on the strength of the cleaner, it is a non-specific measurement and will respond to all ions present in the solution. Frequent manual titrations should be used to verify proper operation at this location.

The next step will rinse the cleaner and any drag-out soils from the previous stage. Fresh water is traditionally used, but using conductivity controllers on rinse tanks can cut water consumption by 40% by only allowing new fresh water when the conductivity reaches a certain setpoint. The setpoint depends on the chemical being rinsed and the desired cleanliness of the work piece. Figure 2 can be used as a guide for typical industry setpoints. Toroidal conductivity measurements will have an economic payback of about one year with a minimum of maintenance.

Further steps depend on the type of processing desired. In electroplating, the metal surface will be treated with a strong acid (pickling) solution to remove the impure surface layer, then rinsed, soaked in the plating solution, rinsed again, soaked in a rust inhibitor (traditionally chromate based), rinsed yet again, and dried.

In painting, the metal part will be dipped in a phosphate etching solution to create surface imperfections for the paint to adhere to. Following a rinse, a rust inhibitor will typically be used to protect the surface prior to painting. Another rinse, and the part is ready for painting.

Other surface finishing techniques include electroless plating, vapor deposition, powder coating, and anodizing. Rinse steps are used in all of these procedures to clean work pieces between stages. Instrumentation needs will depend on the process, with conductivity measurement best suited to stronger (i.e. pickling) solutions and pH measurement best suited for weaker acids like phosphates or chromates.

THE PRODUCTS

Conductivity in metal finishing baths is easily measured using Emerson Process Management's toroidal conductivity sensors. The toroidal (or inductive) technique isolates the measuring electrodes from the process, preventing corrosion and sensor damage from strong chemicals. Emerson offers several different models, including the versatile high performance Model 228, constructed of PEEK. Toroidal conductivity sensors are relatively free from coating effects and tend to work indefinitely if properly used.

All Emerson conductivity sensors include an integral RTD for compensating the conductivity reading for temperature changes. The multi-parameter Model 1056 analyzer can continuously display and output the temperature to a PLC or datalogger. The Model 1056 can measure pH, ORP, conductivity, dissolved oxygen, chlorine, and flow, and can monitor two inputs of any kind.

1 "Water Efficiency: Industry Specific Processes — Metal Finishing." North Carolina Department of Environment and Natural Resources' Division of Pollution and Environmental Assistance, 1999.

INSTRUMENTATION

Model 1056 Analyzer

- Multiparameter measurements of pH, ORP, conductivity, dissolved oxygen, chlorine, and flow.
- Large local operator interface
- Easy to use menu structure
- Dual Input Capable
- PROFIBUS and HART Digital communications protocols available

Model 228 Toroidal Conductivity Sensor

- Reduced cleaning requirements provided through the use of inductive measuring principles.
- Chemically resistant materials with stands the effect of highly corrosive solutions.

Model 396P Insertion/Submersion TUpH pH/ORP Sensor

- Polypropylene reference junction and helical pathway mean longer sensor life in process solutions containing heavy solids.
- Disposable, convenient and economical one-piece construction minimizes trouble-shooting and maintenance downtime.
- Versatile. Suitable for flow-through, submersion, and insertion applications.

FIGURE 1: The Electroplating Process

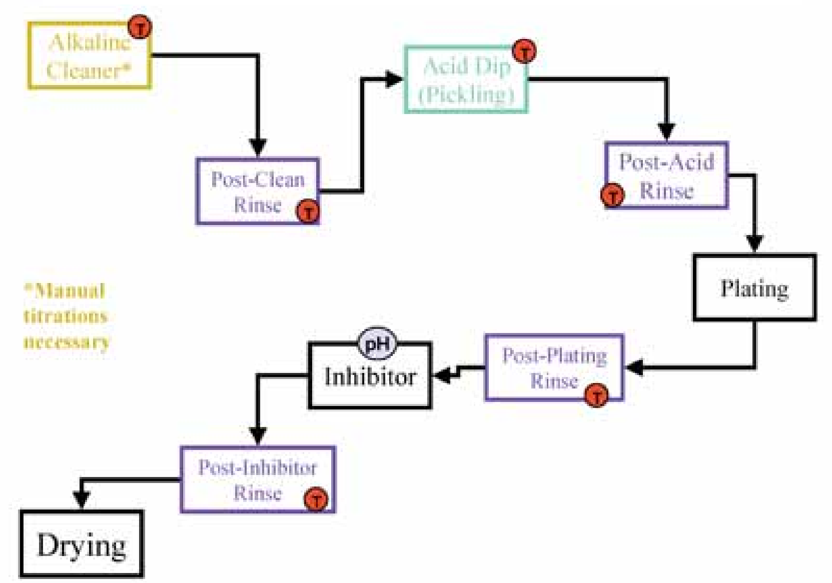

FIGURE 2: Acceptable Rinse Water Contaminant Limits [1]

Rinse bath for	Conductivity (µS/cm)
Alkaline cleaner	1,700
Hydrochloric Acid	5,000
Sulfuric acid	4,000
Tin acid	500
Tin alkaline	70-340
Gold cyanide	260-1,300
Nickel acid	640
Zinc acid	630
Zinc cyanide	280-1,390
Chromic acid	450-2,250

[1] North Carolina Department of Environment and Natural Resources' Division of Pollution and Environmental Assistance.

CASE STUDY [1]

Conductivity Controller

Artistic Plating and Metal Finishing in Anaheim, California, installed electrodeless conductivity controllers on nine rinsing tank systems. Artistic Plating is saving 55,000 gallons per week, which equates to a 43 percent rinse water savings. The conductivity system resulted in decreased rinse water use, wastewater generation, wastewater treatment chemical use, and sludge generation. Artistic Plating experienced no adverse quality effects using the controller. Total system payback was one year.

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