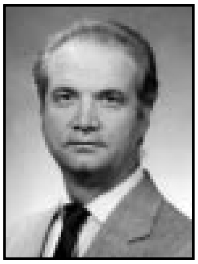

Advice & Counsel

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Can Process Automation Replace the Chemist?

Dear Advice & Counsel,

Our company performs sulfamate nickel, acid sulfate copper and hard chromium plating. My employer is designing a new facility and wants it to be the most modern possible. Money is no object. The owner is looking at automating everything, including the chemical process control of the plating lines. I've not heard of this, and am in need of information about how well these systems work and the possible problems they may cause. Could such a system take my place?

Signed, Plant Chemist

Dear Plant Chemist,

I suppose at some point in the future such systems may make your job obsolete, but I wouldn't spend a lot of time polishing up my resume. Automated process control systems have been available for some time for some processes, such as electroless nickel plating solutions. In specific applications, they can work very well, but I am not aware of anyone applying this technology to the processes you mention.

Let's start with the description of the system you provided. The automated control system consists of four modules: Analyzer, computer control system, chemical addition manager, and physical condition monitor.

Analyzer

This unit performs on-line automated analysis of each process solution. Test results are sent to the computer control system. The unit employs self-calibration and diagnostic routines to maintain accuracy. The analyzer can be configured to sample up to 30 process tanks or streams. It can perform wet chemical titration, pH readings, oxidation-reduction titration, and other sophisticated analyses.

Samples are drawn automatically through plastic tubing (up to 100-ft distance). Dilution, digestion and mixing of reagents is automatic, per the analytical procedure. Wet chemical analyses employ multiple detectors, such as pH, redox, ion selective probes, x-ray fluorescence and colorimetric sensors.

The unit performs each determination several times to yield precision data. The data can be manipulated to yield trend status, range checking and process adjustment calculations.

Self-diagnostics monitor sample delivery rates, syringe operation, stirrer performance, reagent supplies and other appropriate analytical parameters. Calibration is automatic and can be repeated as often as desired.

Computer Control System

This system requires an operator (see, your job is safe). The data generated by the analyzer is displayed and stored. The unit provides alarms for test results that look suspicious and calculates additions/modifications to the process chemistry. The system records the information it receives into a database and maintains historical records. The existing operating conditions are compared to established set point limits, to provide alert and alarm indications. Data is displayed on a computer screen in graphical format yielding:

- Process line status.
- Tank/stream parameter status: Parameter history; parameter set point; parameter data accumulation schedule; parameter replenishment information.
- Status of other operating modules.

Chemical Addition Manager

Chemical addition instructions generated by the computer control system are received by the addition manager, which performs the addition of chemicals. It also adds ingredients consumed by ampere-hr on an automatic basis. The operator of the system can override an addition. The system also keeps track of chemicals in-stock and alerts the operator when the inventory is low.

Chemical additions are made through a feed module that consists of:

- An air driven pump.
- Flow regulator.
- Flow-rate sensor.
- Solenoid valves.

The system allows the operator to command an addition to any of the controlled tanks.

Physical Condition Control Module

This module monitors and adjusts temperature, liquid level, conductivity, pH, current, voltage, agitation level, and other physical parameters that can be metered (as long as the instrument measuring the parameter is capable of sending a digital or analog signal). It stores readings and provides alarms for operating conditions outside pre-set windows. It also operates various hardware to adjust heating/cooling, liquid level, conductivity, etc.

Now, let's look at the parameters your employer wishes to monitor/control with this system:

1. Sulfamate Nickel
   Nickel sulfamate
   Nickel chloride
   Boric acid
   Sulfamic acid
   pH
   Temperature
   Solution level

Current
Voltage

2. Acid Copper

Copper sulfate
Sulfuric acid
Temperature
Solution level
Current
Voltage

3. Chromium

Chromic acid
Sulfuric acid
Temperature
Solution level
Current
Voltage

Your plans call for automated additions of sulfamic acid to the nickel plating solution, sulfuric acid to the copper plating solution, and chromic acid to the chromium plating solution.

Finally, let’s discuss the operational needs of each solution:

1. Nickel Sulfamate

- The pH of this solution tends to slowly rise, as it is used under normal conditions, so automated addition of sulfamic acid may be desirable. Polarized anodes, however, may result in a *decrease* of pH, which the system will not adjust. This will result in poor deposits if a timely correction is not made. The system would sound an alarm, and an operator would need to make the adjustment with nickel carbonate.
- The nickel metal is consumed by ampere-hr and drag-out. Your system monitors, but does not adjust the concentration.
- The boric acid is consumed by drag-out. Your system monitors the concentration, but does not make additions. Boric acid is very difficult to dissolve and automation of such an addition would be very difficult.
- The nickel plating solution typically will employ stress reducers, grain refiners, brighteners, etc. The system you are contemplating does not analyze, monitor, or make additions.
- Nickel plating solutions are not very tolerant of impurities. Copper can have a very negative effect on appearance, and is typically analyzed by atomic absorption spectroscopy. The proposed system does not analyze or control these impurities.

2. Acid Copper

- Sulfuric acid consumption is drag-out related, but such solutions can operate satisfactorily with a very broad range of sulfuric concentration. This brings up the question: “Why bother to automate this?”
- Copper sulfate content of such solutions tends to climb as anode dissolution exceed cathode deposition rates. The automated system will monitor the copper sulfate concentration, but a “bleed” system will be needed to remove plating solution as the copper sulfate concentration exceeds the operating window.
- Acid copper plating solutions typically employ a few ppm of chloride (40-80) that result in a tremendous impact on deposit grain structure. Your system provides for no monitoring or control of this ingredient.
- Acid copper plating solutions typically employ grain refiners/brighteners that also result in a tremendous impact on deposit grain structure. Your system does not provide monitoring control of this ingredient.

3. Chromium Plating Solution

- A conventional chromium plating solution operates best when the ratio of chromic acid to sulfate is about 100:1. The chromic acid is consumed by drag-out and ampere-hr, while the sulfate is consumed mostly by drag-out. The result is a constantly varying ratio that must be analyzed and adjusted. The automated system you are contemplating monitors and adjusts chromic acid content, but only monitors sulfuric acid. Sulfuric acid additions would need to be made manually. Excess sulfuric acid also needs to be controlled by careful additions of barium carbonate. The automated system you are considering does not perform this.
- Chromium plating solutions are very tolerant to impurities, but are typically analyzed for copper, iron, and nickel content using atomic absorption spectroscopy. The proposed system does not analyze or control these impurities.
- Chromium plating solutions generate trivalent chromium, which must be monitored and controlled to maximize solution efficiency. The proposed automated system does not monitor or control trivalent chromium.

All of the solutions discussed here are typically tested on a periodic basis using a Hull Cell to monitor and control additives (in the case of nickel and acid copper) and throwing power (in the case of chromium). The nickel solution may also require periodic testing with a spiral contractometer or rigid strip tester for stress.

As you can see, you will still be needed and will probably be very busy making certain that the automated system is performing to specifications.

The most important considerations are:

- What happens when the automated system breaks down?
- Will tanks overflow, solutions get the wrong additions, parts be ruined, hours be spent cleaning, replacing and repairing probes and sensors?
- What will happen when there is a computer crash?
- What happens if there is a pump failure or clogged valve?

Someone will be needed to respond to such problems, so I think your job is safe. P&SF

Author’s note to AESF members: If you have experience with automated analytical control systems for plating solutions, please FAX or e-mail your opinions of them to me, and I’ll publish a future article updating the writer of this month’s letter.