by John S. Schroeder

The Best Technology Is Not Always The Best Answer

A case study in wastewater management.

ELECTROWINNING
ULTRAFILTRATION ION EXCHANGE
DISTILLATION EVAPORATION
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How can the small to medium-sized fabricator meet the new restrictions in a cost-effective manner?

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For everyone in the printed circuit fabrication business the wastewater treatment, spent solution treatment, and sludge handling associated with plating and etching have become facts of life. Worse yet, the restrictions surrounding these non-productive operations are becoming tighter and tighter. Traditional technologies and systems no longer seem to fit the bill.

The new treatment technologies, particularly ion exchange followed by electrowinning, the so-called "sludgeless" systems, seem to fit the regulatory bill, but the price tag is very high. At NEPCON West '89, I was quoted a cost of $50,000 for such a system rated at two gallons per minute. Of course, several such systems would have to be installed since they require the segregation of waters based on the metals in them. Additionally, such systems cannot handle spent solutions; so yet another method is required to deal with them.

Sludgeless systems have the advantage of allowing the user to recycle a large percentage of the water used, but to offset the capital costs involved, water usage would have to be in the range of 100,000 gallons a day or more. Reduction in sludge disposal costs also helps offset the capital costs, but three or four cubic feet of sludge a day would have to be produced. Manufacturers of sludgeless systems will generally support these figures. This leaves the small to medium-sized fabricator in a serious bind. How can he meet the new restrictions in a cost effective manner?

This points out a situation where the best technology may not be the best answer. In this article, I will present a case study of a board plating shop that fit the scenario outlined and what we did to handle his waste management needs.

The Basic Approach

The shop to be studied is a printed circuit board plater. The operations in the shop include chromic acid-based desmear and etchback, electroless copper, electrolytic copper, electrolytic tin/lead, nickel tips plating, and gold tips plating. The desmear/etchback, surface prep, electroless copper tanks and associated rinse tanks are all 40 gallons. The rinse tanks in these operations flow only when boards are present. The copper and tin/lead tanks are 300 gallons each. There are four copper tanks and two tin/lead tanks. The rinse tanks have a 50 gallon capacity and run continuously. The tips plating tanks are 30 gallons each, with still rinses on the gold and one 15 gallon continuously running rinse tank on the nickel. Total water usage was about 12,000 gallons per day.

Regulatory pressure in early 1987 forced this company to look into improving its wastewater treatment capabilities. At the time, they were simply dosing caustic prior to a three-stage clarifier. Additions and adjustments were made at the time to bring the facility into compliance. The land ban on F006 wastes of August 1988 has forced further adjustment to the operation. The added treatment and disposal costs would have driven them out of business. The company had no capital to work with and a limited cash flow. As is true with most organizations of this size, the technical expertise available in-house was from years of being in the business; there was no formal engineering staff. Those years in the business had not prepared anyone to deal with water treatment and waste disposal.

When the regulatory pressure arose in 1987, the company decided to hire the services of a consultant, namely me. The reasoning behind this decision was very straightforward. By hiring a consultant, the company paid only for the engineering and technical services required, without adding to the payroll. The wisdom of this decision is reinforced considering that once the changes were made, the technical requirements dropped significantly and we were able to achieve the required results for a fraction of the cost of off-the-shelf treatment equipment. In this case, the changes cost about $25,000, only 25 percent of the cost of a treatment system.

The ban on landfilling of F006 sludges in August 1988 once again forced changes on the company. The cost of stabilizing the sludge prior to landfill was prohibitive. The sludge produced was of insufficient quality to allow for economical metals recovery. A sludgeless system was again evaluated, but the capital was still too high. Instead, we made changes to the current operation and were able to arrive at a workable system for 50 percent of the cost of changing to a sludgeless system, while eliminating altogether the land disposal of the sludge.

These very significant cost savings resulted from the basic approach we used in solving the crisis. This approach is based on a few simple principles. The first principle is that we worked on the manufacturing processes before we worked on treatment equipment. By making changes in the processes, we were able to reduce water consumption by nearly 50 percent. Increased production by the company has increased water usage since that time, but it is still only 70 percent of the original level. The second priniciple of our approach was to use available material whenever possible. Much of the equipment we used in the systems was culled from the "junk" pile. (Most companies have some stockpile of decommissioned or unused equipment.) The third principle of our approach was simplicity. Monitors, redundant components and the like are very pretty, and the best engineering, but they are also expensive. The final principle of our approach is that in-house labor, properly directed, can get the job done.

What We Did

When regulatory pressure began affecting this business, we considered the factors discussed earlier and decided that alkaline precipitation was the only viable option available. But, first, we reduced water usage and contaminant levels wherever possible.

Many of the problems stemmed from chelated forms of the metals in the wastewaters. Our first step was to eliminate ammonium persulfate microetchants and substitute potassium persulfate. We halted the use of all continuously flowing rinses and substituted a system of dragout rinses followed by on-demand flowing rinses. Further, all employees were instructed to let boards drip as long as possible over process tanks to reduce the load on rinse tanks.

The next step was to create a semi-continuous treatment system to handle the flow of rinse water. (See graphic.) Many parts of the system were from the junk pile. Even those that were purchased were much less expensive than buying an assembled system. Digital process controllers were chosen because they proved to be simpler and less expensive than relay ladders and timers. To keep costs down, and operations simple, it was decided to use this system only for low contaminant level flowing rinse waters, allowing us to use the three-stage clarifier as the liquid/solid separation system. Not the best engineering, but it worked. We decided to use a sulfide-based antichelating and flocculating reagent with the system.

To handle the dragout rinse waters and spent solutions, we also built a manual batch treatment system. This system was constructed primarily out of two decommissioned plating tanks. The wastes were collected in these tanks and then treated by manual addition of reagents. A manifold of bag filters was constructed to separate the sludge. Occasionally, the slurry in the clarifier is pumped through the bag filters.

When the land ban came down, we again decided to stay with the same technology. Our first step was to reduce the amount of sludge produced as much as possible. Several measures were taken to accomplish sludge reduction. The first was to switch from chromatic acid-based desmear and etchback to potassium permanganate. We also set up a small tank with old copper anodes in it. Electroless copper bailout is poured into the tank and copper plates on the anodes. This metallic copper is sold with the old anodes.

The next step was to improve the quality of the sludge we continued to produce. The basic problem here was to reduce the amount of water present in the sludge. Economical metals recovery requires a certain percentage of metal in the sludge. Two basic changes were made. The first was to install a filter press for liquid/solid separation, replacing the bag filters and the clarifier. The second change was to convert some drying ovens from the junk pile into the sludge dryers. This required installing a vapor scrubber to treat the exhaust from the ovens. The sludge is placed in trays and dried in that form.

The second phase of operations was aided by the availability of low cost, state guaranteed loans for waste minimization. Many states have such programs and the reader would be wise to investigate the possibilities in their locale.

Finally, as time has progressed we have made many small improvements in the systems. Engineering redundancies originally left out are one example of additions that have been made as dollars became available. There is one very distinct advantage to using the approach discussed: You can end up with very good equipment by meeting basic requirements and then adding improvements over time.

Conclusions

Based on the experiences of this shop there are several conclusions that can be drawn. First of all, there is an obvious gap between regulatory requirements and affordable treatment technology for small and medium-sized shops. While regulators must address these issues, fabricators have to find means for compliance or run considerable risk in criminal and civil liability. Secondly, traditional technology can provide the means for compliance. Even with traditional technology, capital expenditures are necessary, but they can be kept to a minimum. Finally, expert guidance is necessary, not only because such expert advice can provide the technical knowledge required, but because the expert can make sure you do not break one set of rules when complying with another.

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