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Project Summary

Watts Nickel and Rinse Water Recovery via an Advanced Reverse Osmosis System

C. Schmidt, I. Erbas-White, and R. Ludwig

The full report summarizes the results of an 8-mo test program conducted at the Hewlett-Packard Printed Circuit Production Plant, Sunnyvale, CA (HP) to assess the effectiveness of an advanced reverse osmosis system* (AROS). The AROS unit, manufactured by Water Technologies, Inc. (WTI) of Minneapolis, MN, incorporates membrane materials and system components designed to treat metal plating rinse water and produce two product streams: (1) a concentrated metal solution suitable for the plating bath, and (2) rinse water suitable for reuse as final rinse. Wastewater discharge can be virtually eliminated and significant reductions realized in the need for new plating bath solution and rinse water.

The AROS unit performed very reliably during the test program. During a 5,000-hr trial, approximately 190,000 gal of rinse water were treated to produce 1,100 gal of concentrated plating bath for recycle. The second output stream from the AROS unit was recycled as clean rinse water, reducing the demand for deionized water production. In addition, wastewater treatment and disposal costs were reduced by approximately $13,000. If operated at full capacity, the unit capital cost was estimated to have a payback period of approximately 2 yrs.

The AROS was evaluated under the California/EPA Waste Reduction Innovative Technology Evaluation (WRITE) Program, in which the cooperative efforts of the U.S. Environmental Protection Agency (EPA) and the California Environmental Protection Agency were used to evaluate innovative pollution prevention techniques.

This Project Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The metal plating industry produces large quantities of metal contaminated wastewater requiring treatment before discharge. An AROS manufactured by WTI was installed in the HP plant in Sunnyvale, CA, to treat and recover Watts nickel plating bath solution and rinse water. The technology approaches zero discharge capability. An 8-mo test program was conducted to assess the effectiveness of the AROS and estimate the incremental cost savings resulting from less use of deionized water, reduced wastewater volume being pretreated, lower effluent and sludge disposal quantities, and recovery of plating solution.

The HP facility manufactures printed circuit (PC) boards for use in personal computers. In one step of the manufacturing process, Watts nickel plating is used to plate a thin layer of conductive material on a non-conductive surface, like epoxy/plastic or ceramic. Watts nickel is also widely used in other industries for decorative plat-

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ing operations. The plating operation consists of the following steps:

- First, the PC boards are attached to moving racks. The moving racks carrying the parts move through the Watts nickel solution plating bath where the nickel plating is electrolytically applied to the PC boards. When the PC boards are removed from the bath, plating solution adheres to them. This adhering solution is called "dragout."
- Second, the PC boards move sequentially first through a "dirty" rinse tank and, second, through a "clean" rinse tank. The clean rinse water enters the second "clean" rinse tank and flows in the opposite direction from the movement of the PC boards. In this way, the PC boards encounter the cleanest rinse water last just before exiting the second "clean" rinse tank. This method of having the parts and the rinse water move in opposite directions is called countercurrent rinsing.

Normally, the discharge from the "dirty" rinse tank is wastewater to be treated and discharged. The AROS unit, however, treats this wastewater to separate out the metal compounds. This separation creates two product streams: a stream of deionized water called the permeate and a liquid stream of concentrated metal compounds called the concentrate. Both of these product streams are reused in the production process. The permeate stream is returned to the "clean" water rinse tank. The concentrate stream of metal compounds is returned to the plating bath. This recycling eliminates the need for normal wastewater discharge. In addition, the AROS unit greatly reduces the volume of new deionized makeup water needed for the rinse tank and generates concentrated Watts nickel solution that can be recycled to the plating bath.

The heart of the AROS unit is a specialized reverse osmosis unit. Reverse osmosis is a physical process in which water containing dissolved materials can be separated from those dissolved materials. Pressure is applied to the solution on one side of a membrane barrier. Water passes through the membrane, but dissolved metal ions remain behind, thus becoming more concentrated. The membranes are made of polyamide, thin-film plastics that can perform well under a wide range of pH conditions (1 to 13.5) and high pressures (400 to 1100 psi) as needed to reconcentrate a wide range of dilute rinse waters to produce recycled plating bath solutions.

In addition to the reverse osmosis membrane, the AROS unit contains pumps, valves, interim solution holding tanks, sensors, and piping needed to manage the flows into and out of the membrane unit. The operation is automatically controlled by a computer program that monitors flow quality (using conductivity), flow volumes, and other operating parameters. The unit is enclosed in a lidded box about 3 ft high by 4 ft wide by 8 ft long. The plumbing and electrical and communications connections are relatively simple.

The objectives of the study were to (1) evaluate the AROS unit performance and reliability, (2) assess the quality of the recycled plating bath solution and the recycled rinse water, and (3) analyze costs and benefits.

Procedure

The test program was conducted by HP with assistance from the AROS manufacturer. The program included continuous monitoring of flow volume, conductivity, and pH at various monitoring points in the system. Streams monitored include the deionized rinse water makeup line, the concentrate return line, and the permeate return line. The plating bath was sampled and analyzed weekly. Analyses were conducted for nickel, pH, Nickel PC-3 (Saccharin), boric acid, chloride, and ductility.

Independent sampling and analysis were performed by the EPA contractor over a 1-day period to verify results reported by HP.

Cost information was provided by HP and the AROS manufacturer. Where possible, the costs were checked against other sources.

Results and Discussion

The AROS unit achieved excellent separation of contaminants from the influent dirty rinse water. Removals of contaminants usually ranged from 95% to 97%. Overall the HP staff regard the AROS unit as having shown good performance during the test period. Rinse water quality was maintained at a low level of nickel contamination. It was reported that no printed circuit boards were rejected because of Watts nickel plating deficiencies. The recycling of the rinse water resulted in a dramatic 98% reduction in the use of new deionized water makeup for this plating process, equivalent to about 425,000 gal annually per shift per plating line.

The AROS unit also successfully produced concentrated Watts nickel solution of adequate quality to return to the plating bath solution. Fresh Watts nickel solution costs about $5.00/gal, so recovery and recycling represented a significant direct savings. It was also calculated that approximately 3 tons of category F006 sludge was not generated by the industrial waste water treatment system that otherwise would have been without use of the AROS unit.

The AROS unit demonstrated excellent reliability during most of the test period. For example, during the period February 28 through June 29, 1990, the system was on-line 3,594 hrs and experienced a downtime of only 20 hrs. Mechanical failures experienced in July and August1990, however, caused over 200 hrs of downtime during these months. The manufacturer is reported to have made design changes that will prevent similar future mechanical failures.

Economic Analysis

Cost information provided by HP (see Table 1) indicated that the AROS unit would produce an estimated annual cost savings of $26,250 at the HP facility using the unit at less than half its rated hydraulic capacity. This savings is reduced by an estimated annual operating and maintenance cost of $9,419 for a net annual savings of approximately $17,100/yr. Capital investment is approximately $75,000, which represents approximately $63,000 for the AROS unit plus another $12,000 for making the installation permanent and for training of operating personnel. Dividing $75,000 by $17,100 results in a payback period of 4.4 yrs and a 23% return on investment.

The AROS unit at HP was operated at less than 50% of its capacity. The economic benefits would have been more favorable if the Watts nickel plating process had been operating for more hours and producing more printed circuit boards. The AROS unit volumetric design capacity for influent rinse water is over twice the volume of rinse water processed at HP

Another economic factor is that at HP the AROS unit treated only a small fraction, e.g., about 3%, of the total wastewater flow. Therefore, in its cost analysis HP made no allowance for reduced labor cost at its main wastewater pretreatment plant. At another facility, however, the AROS unit treated a larger percentage of the total wastewater flow, a labor reduction credit might have been included in the cost analysis.

Finally, the HP facility has a fully amortized wastewater treatment facility in place. Elsewhere at a new facility under design, it could be feasible to reduce the capacity and capital cost of the wastewater treatment facility because the inclusion of an AROS unit would reduce design flow volume. In addition, it would be possible to reduce the capacity of the deionized water production units. Economic cost-benefit analysis will be different for each potential application of an AROS-type unit depending upon the site specific situation.

Conclusions and Recommendations

- Overall the AROS unit performed very well during the test program. Recovery and recycling of plating bath solution and deionized rinse water was routinely successful and no loss of plating quality occurred.
- Significant cost savings resulted from reduced use of deionized water, reduced wastewater volume being pretreated, less effluent and sludge disposal, and recovery of plating solution.
- Payback period and return on investment will vary depending on site-specific conditions. If the AROS unit was operating near capacity at HP, the payback period is estimated at about 2 yrs. This demonstration indicates that there are many situations where the unit should be considered for its economic benefits as well as its environmental waste minimization advantages.

The full report was submitted in fulfillment of Contract 68-C8-0062, WA 3-18, by Science Applications International Corporation under the sponsorship of the U.S. Environmental Protection Agency.

Table 1. *Estimated Annual Incremental Savings from Use of the AROS Unit as Reported by Hewlett-Packard Company, 1990 Costs*

Description of Costs	*Estimated Savings ($/gal)*	*Quantity (gal)*	*Total Annual Savings ($)*
Sewer discharge fees and water costs	*0.004*	*1,275,000*	*5,100*
*Deionized (DI) water production cost**	*0.0064*	*1,275,000*	*8,160*
Plating wastewater treatment costs+	*0.0062*	*1,275,000*	*7,905*
Purchase of new plating chemicals at 85% reduction	*5.00*	*1260x 0.85*	*5,355*
	Total estimated annual savings		*$26,520*

** DI water production cost is for chemicals, electricity, and resin replacement only. No labor, depreciation, or other costs are included because it is assumed that they would remain the same whether the AROS unit was used or not.*

+ Plating wastewater treatment cost includes sludge disposal, chemicals, and electricity. As in the note above, no labor, depreciation, or other costs are included because it is assumed that they would remain the same whether the AROS unit was used or not.

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C. Schmidt and I. Erbas-White are with Science Applications International Corp., Santa Ana, CA 92705, and R. Ludwig is with the California Environmental Protection Agency, Sacramento, CA 95812-0806.
***Lisa M. Brown** is the EPA Project Officer (see below).*
The complete report, entitled "Watts Nickel and Rinse Water Recovery via an Advanced Reverse Osmosis System," (Order No. PB93-229 011/AS; Cost: $19.50, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
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U.S. Environmental Protection Agency
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