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Project Summary

Assessment of Emerging Technologies for Metal Finishing Pollution Control: Three Case Studies

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The research program described in this report was initiated with the objective of bringing information concerning performance and cost of new wastewater treatment technologies to the attention of the metal finishing community.

Many novel approaches to treatment of electroplating wastewater had been evaluated based on available information under an earlier effort. The most promising of these were selected for further investigation to include sampling, performance verification, and cost analysis. The report presents the results of that investigation for the three emerging technologies selected.

The treatment methods studied included a system for treatment of electroplating wastes with ozone, a technique for chrome recovery by ion transfer, and a method of treating mixed wastestreams using ion exchange. Performance of each of these technologies was evaluated through sampling and analysis of prototype operation under normal production conditions. Performance data and cost projections for each system are presented.

Each of the three systems investigated was found to hold promise for improved cost-effectiveness of wastewater treatment for appropriate applications.

This Project Summary was developed by EPA's Industrial Environmental Research 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

This work under EPA Contract No. 68-03-2907, Work Effort 09 represents a continuation of EPA Contract 68-03-2672, WA 52. The objective of the earlier effort was to identify new or novel wastewater treatment technologies. The technologies reviewed were subjected to a worth assessment which evaluated factors such as costs, energy consumption, effectiveness on target pollutants, and degree of applicability against conventional precipitation treatment methods. The assessment considered technologies in all stages of development. Eventually, the first phase of the project identified promising projects in three categories of development stage: already demonstrated, in a research and development stage, and in a pilot stage.

The objective of the second phase of this project reported on herein is to characterize the highest ranking technologies in the already demonstrated category by gathering performance and cost data under actual operating conditions at production metal finishing facilities. This report examines three treatment systems identified as emerging technologies of significant promise for the electroplater. The technologies are presented in the form of case histories and have been evaluated with respect to their capability to reliably remove pollutants, the initial costs of installation, and the day-to-day costs of operating the system including labor, utilities, treatment chemicals, and sludge disposal.

The systems under consideration here were each sampled over 4 or 5 consecutive days of operation under normal production conditions. Four grab samples of influent and effluent of the system were collected over the production day at each plant for specific pollutant parameters. In addition, samples were collected when possible prior to and following specific unit processes to establish their performance. The basic cost data presented were supplied by the manufacturers.

The systems evaluated, as selected during the earlier phase of this effort, were:

- The Ozodyne treatment system
- The ChromeNapper™ chrome recovery system
- The Rinse-Loop ion exchange system

Results

A schematic of the Ozodyne system as installed at San Diego Plating is shown in Figure 1. The key feature of this treatment system is the method whereby ozone is introduced. As shown in Figure 1, the wastewater containing dissolved ozone and ozone gas enters a 1136-liter ozone reactor. The wastewater is injected tangentially into the rim of a small spinning stainless steel bowl. Rim speeds can be as high as 40,000 rpm. The wastewater is shattered into a cloud or mist, thereby enormously increasing the surface area of contact between the ozone and other molecules, including cyanide. From the reactor, the wastewater is pumped to a rotary vacuum precoat filter where it is dewatered. Solids are collected for disposal while filtered effluent is sent to the sewer.

To evaluate the performance of the treatment system at San Diego Plating, effluent was monitored over a 4-day period. In addition, sampling was done at the location of the influent to the system and at specific locations before and after each treatment step. A summary of the results of the sampling program is presented in Table 1.

The ChromeNapper™ system is a new electrolytic method designed to reduce the cost of chrome recovery. The system employs what the manufacturer calls an electrolytic ion transfer membrane. The membranes are a proprietary substance which requires no implanting of ion exchange resin as in electrodialysis membranes.

In addition, instead of using thin membranes separating three compartments as in a conventional electrodialysis cell, the new system uses a single, thick (1.2 cm) ion-permeable membrane which separates two compartments. Figure 2 shows a schematic representation of a membrane module. The membrane surrounds an inner compartment approximately 3.4 liters in volume. Platinum-plated titanium anodes are inserted through the top of the module which contains the recovered chromic acid/sulfuric acid anolyte. The outside of the membrane is wrapped in a stainless steel mesh cathode. Rinsewater is the catholyte solution. Ion transfer and concentration of the chromic acid are accomplished by applying a direct current between the anodes and the mesh cathodes on the outside of each cell. Chromic acid concentrates in the anode compartment of the cell while treated dilute rinsewater is returned to the rinse tanks.

The ChromeNapper™ system application in this study was markedly different than the other two technologies investigated in that the ChromeNapper was dedicated to the chromium line in a closed-loop mode for the purpose of

Table 1. *Summary of Sampling Results San Diego Plating*

Parameter	Influent Range	Influent Average	Effluent Range	Effluent Average	Average % Removal
Cyanide	3.75 - 0.05	1.02	0.87 - <0.02	0.08	>92.5
Total chrome	6.62 - 0.82	1.41	1.55 - 0.05	0.40	>71.6
Copper	33.0 - 5.05	9.45	1.32 - 0.04	0.05	99.5
Nickel	60.0 - 10.2	20.32	0.37 - <0.10	0.13	>99.4
TSS	559 - 35	135	93 - <1	11.6	>91.5
pH	12.2 - 3.4	6.4[a]	12.4 - 5.8	8.4[a]	—

[a]Median.
Average solids content of sludge = 74 percent.
Influent and effluent values, except pH, in mg/l.

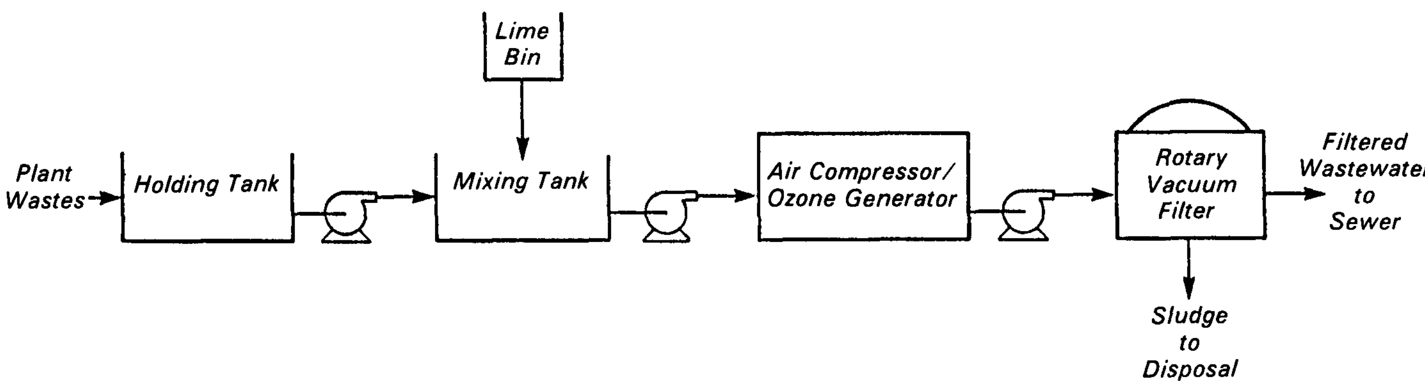

Figure 1. *Diagram of treatment system at San Diego Plating.*

recycle reuse as opposed to the end-of-pipe applications of the other two systems. In the closed-loop mode, ChromeNapper's purpose was to maintain a relatively constant chrome concentration in the final rinse, with no discharge of rinse water to waste. Thus, as the chrome concentration increased from dragout, the ChromeNapper removed the excess.

Sampling was conducted over a 5-day period at U.S. Plating. A summary of the sampling results, presented in Table 2, shows the ranges of influent and effluent concentrations encountered as well as averages for the sampling period. Influent to the recovery system is from the final rinse tank. Effluent from the recovery unit is returned to the final rinse. The flow rate through the ChromeNapper™ system is chosen to be such a value that the chrome concentration into and out of the unit is held nearly constant. Table 2 shows that this is being accomplished.

The Rinse-Loop ion exchange treatment system installed at Chicago Modern Plating is markedly different from any other ion exchange system used for treating industrial wastestreams in that it treats a mixed wastestream containing both heavy metals and cyanide with layers of resins in a single column. Typical ion exchange systems completely deionize wastewater, replacing cations with hydrogen ions and anions with hydroxyl ions. The system at Chicago Modern, however, uses weak- and strong-acid cation resins in the sodium form and strong-base anion resins in the hydroxyl form. The weak-acid resin is selective for cations which include toxic metals (in addition to calcium and magnesium) and exchanges its sodium ions for those in the wastewater. The anion resin removes cyanide, chromate, and other anionic metal complexes from the wastewater. It is this arrangement of resins which allows the treatment of the combined wastestream. A schematic of the Rinse-Loop system is shown in Figure 3.

Table 3 is a summary of the analytical results from sampling the ion exchange portion of the treatment system. The ion exchange columns performed well except when resins were allowed to become so saturated that breakthrough occurred, causing high concentrations of metals in the discharge. For instance, Samples 1 through 5 showed consistently low concentrations of pollutants regardless of influent concentrations. However, Sample 6 (taken on Day 2) representing an on-stream time of 11 to 12 hours for the columns, showed a significant increase in effluent concentrations. After regeneration, Sample 7 once again generally showed low levels of metals and cyanide.

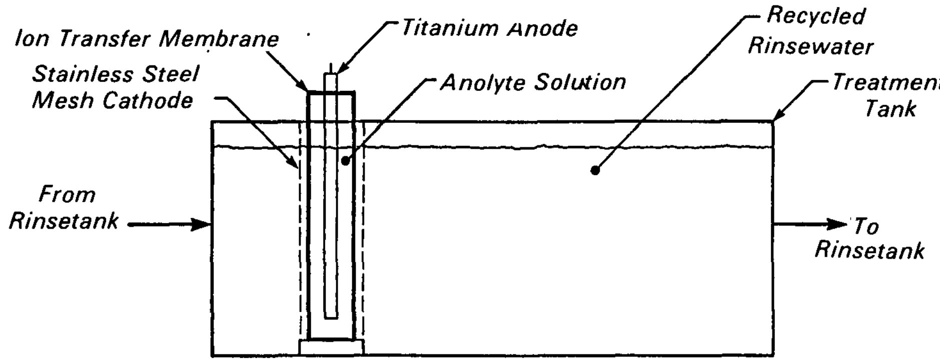

Figure 2. *A membrane module - assembled.*

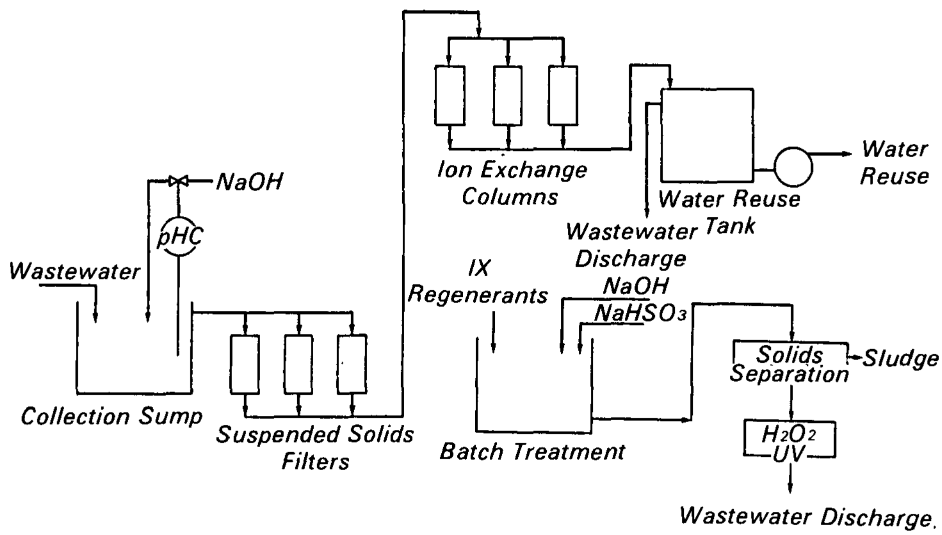

Figure 3. *Rinse-loop system.*

Conclusions

Specific conclusions with regard to each of the systems evaluated follow.

The Ozodyne System at San Diego Plating

The system exhibited reliable performance when operating on mixed wastewaters, reducing effluent concentrations of cyanide, metals, and total suspended solids to very low levels, often less than the limits of detectability.

The vacuum filter employed as part of the system was able consistently to dewater the resulting sludge to a very dry 75 percent solids content.

The system should become highly competitive on a cost basis with conventional treatment as sludge disposal costs escalate.

The ChromeNapper™ System at U.S. Plating

The system exhibited reliable performance on a continuous unattended basis over the several days of monitoring, successfully recovering and returning to the plating tank all chrome other than that plated on the workpiece.

Very small quantities of solid waste were produced (about 1.89 liters of sludge per week), resulting in negligible sludge disposal cost.

Economic comparison with conventional evaporative recovery shows the

ChromeNapper™ system to be highly attractive.

The Rinse-Loop System at Chicago Modern Plating

Although the system was plagued with operational difficulties from ancillary equipment, the basic ion exchange technology operated satisfactorily on the mixed wastewaters during those limited periods when it was possible to pay sufficient attention to maintenance.

Considerable operator attention was required. The system as installed at Chicago Modern Plating was operating in a shake-down mode. The system in its observed embodiment was not functioning in such a manner that its transfer to other environments can be recommended at this time.

The cost comparison with conventional technology shows no advantage for the Rinse-Loop system. However, the ability to achieve consistent operation with less operator attention would change that conclusion.

Table 2. *Summary of Sampling Results at U.S. Plating*

	Influent to ChromeNapper™		*Effluent from ChromeNapper™*	
Parameter	*Range*	*Average*	*Range*	*Average*
Total chrome	*17.5 - 5.0*	*11.5*	*16.0 - 3.5*	*9.9*
Hexavalent chrome	*9.5 - 1.8*	*6.2*	*11.1 - 1.60*	*5.4*
Nickel	*4.35 - 1.68*	*3.1*	*4.22 - 1.78*	*2.9*
pH	*8.6 - 7.2*	*7.8*[a]	*8.6 - 7.6*	*8.0*[a]

[a]*Median.*
All values, except pH, in mg/l.

Table 3. *Summary of Sampling Results of Ion Exchange Unit at Chicago Modern Plating*

	Influent		*Effluent*		
Parameter	*Range*	*Average*	*Range*	*Average*	*Average % Removal*
Cyanide	*25.5 - 4.4*	*13.63*	*10.0 - 1.0*	*3.48*	*74.5*
Total chromium	*32.2 - 2.04*	*11.03*	*24.0 - 1.30*	*6.40*	*42*
Copper	*2.50 - 0.50*	*1.29*	*11.0 - 0.23*	*1.16*	*10.1*
Nickel	*13.2 - 1.60*	*5.45*	*6.2 10*	*1.4*	*74.2*
Zinc	*46.0 - 13.2*	*25.23*	*56.0 38*	*9.43*	*62.6*
TSS	*360 - 7.0*	*91.0*	*456 - 2.0*	*46.8*	*48.6*
pH	*8.6 - 3.0*	*6.7*[a]	*11.8 - 6.3*	*8.2*[a]	*—*

[a]*Median.*
Influent and effluent values, except pH, in mg/l.

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The complete report, entitled "Assessment of Emerging Technologies for Metal Finishing Pollution Control: Three Case Studies," (Order No. PB 81-244 485; Cost: $8.00, subject to change) will be available only from:
National Technical Information Service
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