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EPA

Project Summary

Evaluation of the HSA Reactor for Metal Recovery and Cyanide Oxidation in Metal Plating Operations

The electrochemical removal of heavy metals and cyanide from the wastewaters from electroplating shops is one alternative available to plating shops in achieving compliance with effluent regulations. Several of such systems manufactured by HSA Reactors*, Ltd., have been installed since 1981 with varying degrees of success. This report is the result of a brief survey of the effectiveness of several of these installations.

Six installations of electrochemical recovery systems were tested to establish the performance that may be expected from the technology. Results showed that performance varied widely ranging from nearly ineffective to a metal removal and cyanide destruction capability sufficient to achieve compliance with effluent regulations. The tests conclude that the technology is a viable solution to the pollution control problem under certain circumstances.

This Project Summary was developed by EPA's Water Engineering 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

Regulations promulgated by the U.S. Environmental Protection Agency (EPA) govern the allowable pollutant content of discharges from industrial processes. The metal finishing industry is one of the major sources of heavy metal and cyanide pollution. The capital expenditures for equipment to remove these pollutants from wastewaters and wastes impose a considerable economic burden on the industry. In addition, the disposal of metallic sludges produced by conventional waste treatment systems is becoming increasingly more difficult and costly. A system such as the HSA (high surface area) Reactor, which permits recovery and recycle of the plating metals and destruction of cyanide in plating wastewaters, holds great potential for providing a cost-effective solution to this environment problem.

Conventional electrolytic control of spent plating baths and rinse waters is costly because the removal efficiency of electrolytic processes is decreased as the solution becomes more dilute. The metal concentration of plating rinse streams is very dilute compared with that of the plating tank solution. One method of increasing the removal efficiency in dilute solutions is to increase the surface area of the electrode upon which the metal is plated (cathode).

The HSA Reactor, based upon just such a technology, is capable of removing toxic pollutants from metal finishing wastewaters by electrodeposition. The system utilizes a special carbon fiber cathode and a metallic anode, both nonconsumable. This system provides dramatically improved performance, in terms of metal removal rates, compared with competitive electrochemical techniques. The reactor also can electro-oxidize and destroy cyanides to levels below detection limits

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

at a cost that appears much lower than that of the conventional alkali-chlorination process.

Findings

Analytical results of the testing of the HSA Reactor at six installations showed that the technology is capable of removing cadmium, zinc, and the cyanide associated with these solutions from electroplating dragout. The concentration of the metal and cyanide in the discharge from the following rinse was usually low enough to meet current effluent regulations (Table 1). Those shops where reduction of concentrations in the rinse overflows to effluent regulation levels was not achieved were experiencing equipment and/or operational problems at the time of testing. However, the metal concentration of the running rinse overflow from the plating line being tested does not reflect the metal concentration in the plant effluent. Rinses from other plating operations such as cleaners, acid dips, etc., would dilute the plating rinse stream further. Therefore, even those shops that were experiencing abnormal conditions would likely be in compliance with discharge limitations.

Plating shops using the HSA recovery systems have been reluctant to reuse metal recovered from the HSA cathodes in their plating baths because of possible contamination with other metals. In addition, metal recycling firms have refused to accept the metals because of the unknown content of the metal. Therefore, samples of the recovered metal were collected during the testing and analyzed, and the results as reported are given in Table 2. The recovered cadmium proved to be 99.34 to 99.94 percent pure; zinc, 98.74 to 99.39. These results indicate that the metals removed from the waste plating solutions are recovered in a form highly suitable for recycling into primary or secondary metals markets.

An attempt was made to determine the quantity of metal recovered during each cycle of the HSA Reactor. At some shops, the metal from the spent cathodes is redissolved by reversing the current in a stripping solution. Other shops transfer the metal to stainless steel cathodes by electrolytic means. The stainless plates are then mechanically stripped of the metal. Depending on the procedure used at the particular shop, the weight of recovered metal is determined by either analyzing the stripping solution before and after stripping or weighing the cathodes before and after stripping.

Table 1. *HSA Reactor Performance*

		Metal			Cyanide	
*Shop**	*Sample Set*	*Source mg/L*	*HSA Tank mg/L*	*Rinse mg/L*	*Source mg/L*	*HSA Tank mg/L*
1	1	13400	154	1.06	+	111
	2	15000	68	0.45	2990	49.45
	3	6980	21	0.14	4690	30.0
2	1	538	122	1.29	+	950
	2	538	218	2.3	10000	949
	3	538	345	3.65	+	951
3	1	1980	2.5	B.D.#	10250	0.4
	2	2770	0.59	B.D.	10750	0.6
	3	1640	0.46	B.D.	12250	0.1
	4	1580	0.61	B.D.	11250	0.2
4	1	20400	140	0.22	86500	0.02
	2	20400	5.45	0.01	+	0.02
	3	18900	29	0.05	72000	0.02
5	1	4560	3200	11.67	26000	20000
	2	7400	1240	4.52	36000	28000
6	1	29730	900	3.57	60430	8770
	2	17950	3470	13.7	59330	25280

**Metal concentration is for cadmium for all shops except shop 2, for which zinc removal is given.*
+Sample analysis is not given.
#B.D. = below detection limit.

Table 2. *Purity of Recovered Metal*

		Composition, %					
Shop No.	*Plated Metal*	*Cd*	*Cr*	*Cu*	*Fe*	*Ni*	*Zn*
2	Zinc	.08	.32	.02	.75	.08	98.74
	Zinc	.04	.11	.02	.41	.04	99.39
3	Cadmium	99.94	.00	.01	.02	.02	.01
4*	Cadmium	25.08	1.59	43.86	13.48	14.53	1.10
5	Cadmium	99.63	.01	.07	.05	.08	.15
6	Cadmium	99.34	.00	.14	.34	.10	.07

** The HSA system had been used to dispose of a solution of nickel/copper stripping solution.*

The weight of metal recovered at the various test sites showed a variation of 159 to 44723 grams/cycle for cadmium and 150 to 559 for zinc (Table 3). This wide range is attributed to the operation of the HSA cycle based on a fixed time rather than on cathode capacity. Wide variations in dragout rate are experienced because of the type of parts plated and production fluctuations. Such variations reduce the removal efficiency of the HSA system.

All personnel at the shops visited felt that the HSA systems "as-delivered" required modification for industrial use. Specifically, extensive changes in piping and/or equipment were necessary before acceptable operation was attained. Some operators felt that there were still operating problems that needed to be solved. The most obvious shortcoming of the equipment is the lack of instrumentation to clearly indicate to the operator the status of the cathodes. Regeneration cycles, determined on a trial-and-error basis, have generally been based on a fixed time rather than cathode capacity.

Conclusions

The HSA Reactor is an effective means of removing cadmium, zinc, and cyanides from the dragout of electroplating operations. Based on observations and/or analytical results of samples from the test sites, the following conclusions were reached.

1. Any process change that will reduce the chemical load on the HSA system will improve its performance. The average concentration can be lowered in the HSA tank and in the solution dragged from it by using a dragout, or a dragin/dragout tank between the plating tank and the HSA tank.
2. System performance at Site #3 was outstanding because this is a captive shop that has little variation in the parts plated; therefore, the chemical load on the HSA system is relatively constant. Conversely, job shops experiencing widely varying load rates from the wide variety of parts plated saw reduced performance of the HSA Reactors. This reduced performance is thought to be related to operator interaction with the HSA system under variable conditions.
3. Additional development of the technology is needed to produce systems that will indicate when regeneration is required. Also the development of systems to remove other metals as well as cadmium and zinc is desirable.

The full report was submitted in fulfillment of Contract No. 68-03-1721 by CENTEC Corporation under the sponsorship of the U.S. Environmental Protection Agency and Environment-Canada.

Table 3. *Metal Recovered*

Shop No.	*Metal*	*Metal (wt, g)*
1	Cadmium	159
1	Cadmium	273
1	Cadmium	1272
2	Zinc	229
2	Zinc	150
2	Zinc	559
3*	Cadmium	227
3*	Cadmium	227
3*	Cadmium	227
3*	Cadmium	227
4	Cadmium	5299
4	Cadmium	926
5	Cadmium	44723
5	Cadmium	8945
6	Cadmium	1923
6	Cadmium	3830

* *Recovered metal at this shop was determined by weighing the cathode before and after stripping.*

The Project Report was authored by personnel of CENTEC Corporation, Reston, VA 22090. The Project Summary was authored by ***John O. Burckle*** *(also the EPA Project Officer, see below), who is with the Water Engineering Research Laboratory, Cincinnati, OH 45268.*

The complete report, entitled "Evaluation of the HSA Reactor for Metal Recovery and Cyanide Oxidation in Metal Plating Operations," (Order No. PB 87-111 167/AS; Cost: $11.95, subject to change) will be available only from:

National Technical Information Service
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Springfield, VA 221611
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