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Project Summary

An Automated Aqueous Rotary Washer for the Metal Finishing Industry

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Product quality, waste reduction, and economic issues involved in the use of an automated aqueous rotary washer in the metal finishing industry were evaluated in this study. The automated washer can be used for most metal parts that would ordinarily be cleaned by vapor degreasing, hand-aqueous washing, or alkaline tumbling. The automated washer had good potential to reduce waste, was economically viable, produced good product quality, and also avoided the vapor degreaser's use of perchloroethylene. When compared with hand-aqueous washing and alkaline tumbling, the automated washer used less chemicals. The payback period was about 7 years.

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 Pollution Prevention Act of 1990 establishes pollution prevention as a "national objective." The Act notes that there are significant opportunities for industry to reduce or prevent pollution at the source through cost-effective changes in production, operation, and raw materials use. Source reduction is fundamentally different from and more desirable than waste management and pollution control. Source reduction is defined in the law to mean any practice that reduces the amount of a hazardous substance, pollutant, or contaminant entering a wastestream or otherwise released into the environment before recycling, treatment, or disposal.

The objective of the U.S. Environmental Protection Agency's (EPA) Waste Reduction Innovative Technology Evaluation (WRITE) Program is to evaluate, in a typical workplace environment, examples of prototype or commercial technologies that have potential for pollution prevention. This particular evaluation was a cooperative effort among EPA's Risk Reduction Engineering Laboratory, Connecticut Hazardous Waste Management Service, and Quality Rolling and Deburring (QRD) Company. The study evaluated an automated aqueous washer for cleaning small metal parts in the metal finishing industry. The goal of the study was to provide information to potential users of this technology. The objectives were to evaluate (1) the product quality resulting from new automated washer versus each of three older processes, (2) the pollution prevention potential of the new technology, and (3) the economic attributes of the new technology.

One of the major steps in metal finishing is cleaning metal parts to remove oil and grease, dirt, and metal chips. Cleaning may involve washing with a detergent or degreasing with a solvent. Before installing the automated aqueous washer, QRD (the site for this study) routed metal cleaning jobs through one of three cleaning processes: vapor degreasing, alkaline tumbling, or hand-aqueous washing. The cleaning process chosen is based on the type of metal part and the suitability of the cleaning process.

Product Quality Evaluation

The product quality evaluation was based on (a) an examination of the cleaned metal parts from some of QRD's normally scheduled cleaning jobs, (b) an examination of cleaned test panels inserted along with the metal parts in the cleaning jobs, and (c) a water break test conducted on the cleaned test panels from the alkaline tumbler and automated washer.

Three cleaning jobs (each containing several thousand small metal parts) were selected from the several that QRD receives every day. Job A consisted of steel caplets that were suitable for cleaning on the vapor degreaser. Job B consisted of aluminum rivets that were suitable for cleaning on the hand-aqueous washer. Job C consisted of steel cylinders that were suitable for cleaning on the alkaline tumbler. Job C involved cleaning as well as electroplating (nickel plating).

Each job was split into halves. Half was cleaned by the automated washer, and the other half was cleaned by one of the older processes. This experimental design provided a one-to-one comparison between the automated washer and each of the three older processes.

After each cleaning run, a predetermined number (150) of randomly selected, cleaned parts were examined for product quality. Visual examination revealed no noticeable contamination on any of the parts for all three jobs nor on the cleaned test panels. The water-break test indicated that the parts destined for electroplating had been cleaned well. The results of these examinations, therefore, show that the three old processes and the automated process resulted in good product quality, although certain delicate parts still need vapor degreasing and some parts that are diffucult to clean need hand-aqueous washing.

Pollution Prevention Potential

Pollution prevention was measured in terms of waste volume reduction (Table 1) and pollutant reduction (Table 2). The total waste volume generated by the automated washer is much lower than either the alkaline tumbler or hand-aqueous washer. This indicates that the automated washer needs fewer resources to process wastes downstream.

Note that the processing energy requirement of the automated washer is higher than the energy requirement of any of the three older processes. The moderately higher processing energy requirement of the automated washer should, however, be weighed against the potentially higher energy requirements of the older processes in such other areas as waste treatment. Secondary pollution resulting from energy consumption was not a part of this evaluation.

Although the waste volume generated by the vapor degreaser is lower than that of the automated washer, it is much more hazardous.

Table 1. *Comparison of Annual Waste Volume from the Cleaning Processes*

Wastestream	*Volume Generated Per Year (gal)*	*Wastestream*	*Volume Generated Per Year (gal)*
Vapor Degreasing [a]		*Automated Washing* [a]	
Wastewater in separator	*200*	*Wastewater*	*143,000*
Still bottom sludge	*1,440*	*Oily Liquid*	*962*
Air emissions	*see Table 2*		
Alkaline Tumbling [b]		*Automated Washing* [b]	
Wastewater	*1,010,880*	*Wastewater*	*85,800*
		Oily Liquid	*577*
Hand-Aqueous Washing [c]		*Automated Washing* [c]	
Wastewater	*296,400*	*Wastewater*	*57,200*
		Oily Liquid	*385*

[a] *Based on 5,200 bbl/yr run on automated washer instead of vapor degreaser.*
[b] *Based on 3,120 bbl/yr run on automated washer instead of alkaline tumbler.*
[c] *Based on 2,080 bbl/yr run on automated washer instead of hand-aqueous washer.*

Perchloroethylene, used in vapor degreasing, is a hazardous chlorinated solvent on the EPA's Toxics Release Inventory. Perchloroethylene is also one of the 17 priority pollutants targeted in the EPA Administrator's 33/50 Program for 50% reduction in releases by 1995. It is used in degreasing because it has a high boiling point and is therefore suitable for removing high melt waxes and for cleaning light-gauge metal parts.

Perchloroethylene can be a health problem, with inhalation and skin as the main entry routes. Occupational Safety and Health Administration exposure limits are 100 ppm (8-hr time weighted analysis), 200 ppm (acceptable ceiling concentration), and 300 ppm (acceptable maximum peak). Vapor inhalation can cause eye irritation (at 400 ppm), respiratory irritation (at 600 ppm), or anesthesia (200 ppm for 8 hr) according to the *Metals Finishing Guidebook and Directory* (1988). Prolonged or repeated skin exposure can cause dermatitis.

Spent perchloroethylene is listed under Resource Conservation and Recovery Act (RCRA) as a hazardous waste (EPA hazardous waste number F001). Other commonly used degreasing solvents are methylene chloride, 1,1,1-trichloroethane, and trichloroethylene, all of which are hazardous. The use of the automated washer reduces the use of these solvents.

The automated washer generates a wastewater containing surfactants, which are a much lower hazard both in terms of occupational safety and the environment. Surfactants are not RCRA hazardous wastes. They can, however, cause environmental problems. Phosphate detergents are the main cause of increased algal growth (eutrophication) in

Table 2. *Pollutants Generated by Cleaning Processes*

Pollutant	*Medium*	*Amount Generated Per Year (lb)*	*Pollutant*	*Medium*	*Amount Generated Per Year (lb)*
Vapor Degreasing [a]			*Automated Washing* [a]		
Perchloroethylene	*Sludge*	*45*	*Anionic surfactant*	*Water*	*2*
Perchloroethylene	*Water*	*negligible*	*Non-ionic surfactant*	*Water*	*22*
Perchloroethylene	*Air*	*6,145*			
Alkaline Tumbling [b]			*Automated Washing* [b]		
Anionic surfactant	*Water*	*43*	*Anionic surfactant*	*Water*	*1*
			Non-ionic surfactant	*Water*	*13*
Hand-Aqueous Washing [c]			*Automated Washing* [c]		
Non-ionic surfactant			*Anionic surfactant*	*Water*	*1*
	Water	*105*	*Non-ionic surfactant*	*Water*	*9*

[a] *Based on 5,200 bbl/yr run on automated washer instead of vapor degreaser.*
[b] *Based on 3,120 bbl/yr run on automated washer instead of alkaline tumbler.*
[c] *Based on 2,080 bbl/yr run on automated washer instead of hand-aqueous washer.*

face waters where they are discharged, cause waters to have an obnoxious odor and taste, have a detrimental effect on fish because of the high biochemical oxygen demand (BOD) they create, and become a nuisance for recreational activities. Hence, nonphosphate detergents are increasingly being used.

Different surfactants vary widely in terms of aquatic toxicity and ease of biodegradation. Surfactants accumulate within aquatic organisms and impair their functions. When compared with alkaline tumbling or hand-aqueous washing, the automated washer generates lower amounts of these surfactant wastes.

The results of the study indicate that measurable pollution prevention accrues from using the automated washer instead of any of the three older cleaning processes.

Economic Evaluation

The economic evaluation of automated washing was based on (a) major operating costs of the automated washer compared with each of the three older cleaning processes and (b) an estimation of the return on investment (ROI) and payback period for the automated washer. The number of barrels of metal parts that were used in this estimate was based on the annual number of barrels processed through the automated washer. This total was divided into three parts based on the percentages of the parts run on the automated washer that could have gone to each of the three older processes. Of the 10,400 barrels run on the automated washer per year, 5,200 would have gone to vapor degreasing, 3,120 to alkaline tumbling, and 2,080 to hand-aqueous washing.

Tables 3, 4, and 5 compare the operating costs of the older cleaning processes and those of the automated washer. The results of the economic calculations showed that, based on a capital requirement of $207,260, the payback period for QRD (where the ROI exceeds 15%) was about 7 yr. Reducing the amount of solvent used can also reduce possible liability resulting from health claims or pollution fines, but these savings were not quantified by this study and were not in the economic calculations.

Discussion and Conclusions

The automated aqueous washer evaluated in this study is an example of a pollution prevention technology for the metal finishing industry. Source reduction is achieved by substituting an aqueous cleaning process for a solvent cleaning process (vapor degreasing). Source reduction is also achieved by reducing the amount of raw materials (cleaners or detergents) and process water used (alkaline tumbling and hand-aqueous washing). Automated washing reduces the volume of wastewater that has to be treated (either onsite or at the publicly owned treatment works) and discharged downstream. This is done without compromising the cleaned product quality, and no additional skill (above that required to operate the old processes) is required to operate the automated washer. Parts cleaned in the automated washer can be either electroplated or sent out as finished products.

One current limitation is that the automated washer cannot yet totally substitute for the three older processes. Certain delicate parts have to be sent through the vapor degreaser and some difficult-to-clean parts have to be processed through the hand-aqueous washer. Most jobs that can be run on the older processes can, however, be routed through the automated washer. Thus the automated washer is a good technology for metal finishers who are considering an expansion in capacity.

In summary, use of the automated washer results in good product quality, increased pollution prevention, and economic savings. An added incentive for using the automated aqueous process is its potential to reduce liability as a result of reducing solvent use.

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Table 3. *Operating Costs of Vapor Degreasing and Automated Washing*

Cost Element	Vapor Degreasing Cost [a] ($/Yr)	Automated Washing Cost [a] ($/Yr)
Labor(base rate)	13,866	17,300
Energy	2,943	10,712
Chemicals	1,795	2,711
Water	0	665
Onsite Waste Treatment	Negligible	1,032
Offsite Waste Disposal	1,440	2,624
Total	20,044	35,044

[a] Based on 2,080 bbl/yr.

Table 4. *Operating Costs of Alkaline Tumbling and Automated Washing*

Cost Element	Alkaline Tumbling Cost [a] ($/Yr)	Automated Washing Cost [a] ($/Yr)
Labor	18,720	10,380
Energy	2,847	6,427
Chemicals	2,434	1,626
Water	4,700	399
Onsite Waste Treatment	7,299	619
Offsite Waste Disposal	0	1,574
Total	36,000	21,025

[a] Based on 3,120 bbl/yr.

Table 5. *Operating Costs of Hand-Aqueous Washing and Automated Washing*

Cost Element	Hand-Aqueous Washing Cost [a] ($/Yr)	Automated Washing Cost [a] ($/Yr)
Labor	16,640	6,920
Energy	3,256	4,285
Chemicals	33,134	1,084
Water	1,213	266
Onsite Waste Treatment	2,140	413
Offsite Waste Disposal	0	1,050
Total	56,383	14,018

[a] Based on 2,080 bbl/yr.

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The complete report, entitled "An Automated Aqueous Rotary Washer for the Metal Finishing Industry," (Order No. PB92-228469/AS; Cost: $19.00, subject to change) will be available only from:
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