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ENVIRONMENTAL RESEARCH BRIEF

Waste Reduction Activities and Options for a Manufacturer of Hardened Steel Gears

Alan Ulbrecht and Daniel J. Watts*

Abstract

The U.S. Environmental Protection Agency (EPA) funded a project with the New Jersey Department of Environmental Protection and Energy (NJDEPE) to assist in conducting waste minimization assessments at 30 small- to medium-sized businesses in the state of New Jersey. One of the sites selected was a facility that manufactures hardened steel gears of various sizes and application. The manufacturing steps include grinding, cutting, degreasing, and surface finishing. A site visit was made in 1990 during which several opportunities for waste minimization were identified. Options for pollution prevention include changes in use of metal working coolants, degreasing operations, and the rinsing procedures used in the plating operations. Implementation of the identified waste minimization opportunities was not part of the program. Percent waste reduction, net annual savings, implementation costs and payback periods were estimated.

This Research Brief was developed by the Principal Investigators and EPA's Risk Reduction Engineering Laboratory in Cincinnati, OH, to announce key findings of this completed assessment.

Introduction

The environmental issues facing industry today have expanded considerably beyond traditional concerns. Wastewater, air emissions, potential soil and groundwater contamination, solid waste disposal, and employee health and safety have become increasingly important concerns. The management and disposal of hazardous substances, including both process-related wastes and residues from waste treatment, receive significant attention because of regulation and economics.

* New Jersey Institute of Technology, Newark, NJ 07102

As environmental issues have become more complex, the strategies for waste management and control have become more systematic and integrated. The positive role of waste minimization and pollution prevention within industrial operations at each stage of product life is recognized throughout the world. An ideal goal is to manufacture products while generating the least amount of waste possible.

The Hazardous Waste Advisement Program (HWAP) of the Division of Hazardous Waste Management, NJDEPE, is pursuing the goals of waste minimization awareness and program implementation in the state. HWAP, with the help of an EPA grant from the Risk Reduction Engineering Laboratory, conducted an Assessment of Reduction and Recycling Opportunities for Hazardous Waste (ARROW) project. ARROW was designed to assess waste minimization potential across a broad range of New Jersey industries. The project targeted 30 sites to perform waste minimization assessments following the approach outlined in EPA's *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003). Under contract to NJDEPE, the Hazardous Substance Management Research Center at the New Jersey Institute of Technology (NJIT) assisted in conducting the assessments. This research brief presents an assessment of the manufacturing of hardened steel gears (1 of the 30 assessments performed) and provides recommendations for waste minimization options resulting from the assessment.

Methodology of Assessments

The assessment process was coordinated by a team of technical staff from NJIT with experience in process operations, basic chemistry, and environmental concerns and needs. Because the EPA waste minimization manual is designed to be primarily applied by the inhouse staff of the facility, the degree of involvement of the NJIT team varied according to the ease

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with which the facility staff could apply the manual. In some cases, NJIT's role was to provide advice. In others, NJIT conducted essentially the entire evaluation.

The goal of the project was to encourage participation in the assessment process by management and staff at the facility. To do this, the participants were encouraged to proceed through the organizational steps outlined in the manual. These steps can be summarized as follows:

- Obtaining corporate commitment to a waste minimization initiative
- Organizing a task force or similar group to carry out the assessment
- Developing a policy statement regarding waste minimization for issuance by corporate management
- Establishing tentative waste reduction goals to be achieved by the program
- Identifying waste-generating sites and processes
- Conducting a detailed site inspection
- Developing a list of options which may lead to the waste reduction goal
- Formally analyzing the feasibility of the various options
- Measuring the effectiveness of the options and continuing the assessment.

Not every facility was able to follow these steps as presented. In each case, however, the identification of waste-generating sites and processes, detailed site inspections, and development of options was carried out. Frequently, it was necessary for a high degree of involvement by NJIT to accomplish these steps. Two common reasons for needing outside participation were a shortage of technical staff within the company and a need to develop an agenda for technical action before corporate commitment and policy statements could be obtained.

It was not a goal of the ARROW project to participate in the feasibility analysis or implementation steps. However, NJIT offered to provide advice for feasibility analysis if requested.

In each case, the NJIT team made several site visits to the facility. Initially, visits were made to explain the EPA manual and to encourage the facility through the organizational stages. If delays and complications developed, the team offered assistance in the technical review, inspections, and option development.

No sampling or laboratory analysis was undertaken as part of these assessments.

Facility Background

The facility is a manufacturer of hardened steel gears of various sizes for different types of applications. The facility purchases steel and through grinding, cutting, and metal working forms the parts into the desired shape. Subsequently, the surface is treated to provide the expected level of hardening and wear resistance.

The facility is located in an urban area and employs about 50 people.

Manufacturing Processes

The production of the hardened steel gears is a multi-step process which involves a combination of mechanical metal working processes and a series of surface modifications in which chemical usage is required.

The first step in the production process requires the shaping of the raw steel into gears of the desired size and configuration. The shaping is accomplished by appropriate combinations of cutting, grinding, and metal working. These steps typically require the use of metal working coolants to facilitate processing.

The next step is degreasing, required in order to remove any material on the surface of the gear that might interfere with the metal finishing. Degreasing is accomplished by first dipping the gear into a vapor degreasing tank containing 1,1,1-trichloroethane, drip draining the part over this tank, then dipping the part into a hot alkaline cleaner using periodic reverse electrical current for final grease removal. An additional alkaline descaler with periodic reverse current is then used to complete the cleaning process and any excess of the solution is rinsed from the part using a hose over the tank.

The next step involves plating of the degreased gears with copper using a copper cyanide bath at 150°F. The purpose of the plating is to protect the surface from unwanted effects in the final steps of the manufacturing process.

When necessary, the parts are dipped into black oxide for rust resistance. This is followed by heat treatment which includes carburizing, hardening, and nitriding.

Following the heat treatment, the excess copper is deplated in a sodium cyanide solution.

Existing Waste Management Activities

The manufacturing process generates three major waste streams—the metal working coolants, the degreasing system residues, and the rinses from the plating operations.

The metal working coolants are critical to successful metal working by providing both lubrication and cooling of the metal being worked and the tools being used. Individual metal working processes have been established using particular cooling fluids, therefore there are several different types of coolants in use at the facility. The coolant is typically an oil-water mixture. The facility generates about 800 gal of waste coolants each week that are sent for disposal offsite. The total waste volume for lubricants and coolants is 40,000 gal.

The residues from degreasing consist of both chlorinated solvents and aqueous residues. The aqueous residues come from alkaline degreasing steps and are pH adjusted prior to disposal. The organic and aqueous phases are separated before being sent offsite for disposal. There remain traces of halogenated solvent in the aqueous waste. About 7000 lb of 1,1,1-trichloroethane are sent offsite for disposal each year. It is estimated that approximately another 3000 lb are lost by evaporation. Approximately 700 gal of aqueous waste are generated each year.

The rinses from the plating operation include both copper and cyanide constituents. The annual flow of this waste stream is about 5.5 million gal and is sent to the POTW for disposal. The waste from the deplating step is sent offsite for disposal. The annual volume of this waste stream is about 2000 gal.

Waste Minimization Opportunities

The type of waste currently generated by the facility, the source of the waste, the quantity of the waste and the annual treatment and disposal costs are given in Table 1.

Table 2 shows the opportunities for waste minimization recommended for the facility. The type of waste, the minimization opportunity, the possible waste reduction and associated savings, and the implementation cost along with the payback time are given in the table. The quantities of waste currently generated at the facility and possible waste reduction depend on the level of activity of the facility. All values should be considered in that context.

It should be noted that the economic savings of the minimization opportunity, in most cases, results from the need for less raw material and from reduced present and future costs associated with waste treatment and disposal. It should also be noted that the savings given for each opportunity reflect the savings achievable when implementing each waste minimization opportunity independently and do not reflect duplication of savings that would result when the opportunities are implemented in a package. Also, no equipment depreciation is factored into the calculations.

Regulatory Implications

There do not seem to be significant regulatory implications which would hamper pollution prevention initiatives at this facility. However, international agreements addressing ozone depletion and global warming may further inhibit the use of 1,1,1-trichloroethane. Also, 1,1,1-trichloroethane is 1 of 17 chemicals which EPA has targeted under a voluntary program with industry (the 33/50 Industrial Toxics Program) to reduce releases to the environment. This program may lead to reduced use of solvent. If additional regulations concerning use and disposal of halogenated degreasers and metal plating residues become effective, pollution prevention changes at this type of facility will become even more important.

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Pollution Prevention Research Branch
Risk Reduction Engineering Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

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

Table 1. Summary of Current Waste Generation

Waste Generated	Source of Waste	Annual Quantity Generated	Annual Waste Management Costs
Metal Working Fluid	Lubricant and coolant from gear shaping operations	40,000 gal	$40,000
1,1,1-Trichloroethane	Degreasing operations	7,000 lb	3,200
Aqueous Waste	Degreasing operations	700 gal	1,200
1,1,1-Trichloroethane (air emissions)	Degreasing operations	3,000 lb	(no direct costs)
Aqueous Waste	Rinses from plating operations	5,500,000 gal	1,700
Aqueous Waste	Copper deplating operation	2000 gal	7,000

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Table 2. *Summary of Recommended Waste Minimization Opportunities*

Waste Stream Reduced	Minimization Opportunity	Annual Waste Reduction Quantity	Percent	Net Annual Savings	Implementation Cost	Payback Years *
Metal Working Fluid	Change practices to use a single type of metal working fluid throughout the facility. This will permit the use of a fluid reconditioning procedure to facilitate the reuse of the material. Such reuse will save on disposal costs and material replacement costs, but will incur some processing costs.	24,000 gal	60	$4000 (The savings come from the difference in treatment costs from a mobile fluid recovery unit and from savings in the purchase of new fluid.)	$0	immed.
1,1,1-Trichloroethane	Explore possibility of degreasing using only the alkaline degreasing baths. If solvent degreasing is still required, evaluate use of non-halogenated alternatives such as a terpene based material. If alternative solvent is required, then savings will be reduced.	7,000lb	100	17,000	0	immed.
	If the vapor degreasing can be eliminated there will be additional savings from solvent losses to the atmosphere that will no longer occur. Alternative technologies, such as ultrasonics, should be explored.	3,000 lb	100	2,000	0	immed.
Aqueous Rinse Waters	Install new rinsing procedures, including counter-flow rinses, and reuse of highest concentration rinse water as make-up water for the plating bath.	5,390,000 gal	98	1,650	3,000	1.8

* Savings result from reduced raw material and treatment and disposal costs when implementing each minimization opportunity independently.

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