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ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Machined Parts

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Abstract

The U.S. Environmental Protection Agency (EPA) has funded a pilot project to assist small- and medium-size manufacturers who want to minimize their generation of waste but who lack the expertise to do so. Waste Minimization Assessment Centers (WMACs) were established at selected universities and procedures were adapted from the EPA *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003, July 1988). The WMAC team at Colorado State University performed an assessment at a plant manufacturing machined parts — approximately 500,000 units/yr. This facility performs precision machine-shop work on a job shop basis. The process begins with cutting the stock to size, machining, and hand deburring the parts. Next, the parts are machine deburred in a large tumbler, washed, degreased, shipped offsite for chromating, and returned, assembled, inspected, packaged, and shipped. The team's report, detailing findings and recommendations, indicated that the majority of waste was generated by the deburrer rinse but that the greatest savings could be obtained by replacing the cutting fluid concentrate, thereby eliminating the need for degreasing with 1,1,1-trichloroethane.

This Research Brief was developed by the principal investigators and EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of an ongoing research project that is fully documented in a separate report of the same title available from University City Science Center.

Introduction

The amount of waste generated by industrial plants has become an increasingly costly problem for manufacturers and an additional stress on the environment. One solution to the problem of waste is to reduce or eliminate the waste at its source.

University City Science Center (Philadelphia, PA) has begun a pilot project to assist small- and medium-size manufacturers who want to minimize their formation of waste but who lack the inhouse expertise to do so. Under agreement with EPA's Risk Reduction Engineering Laboratory, the Science Center has established three WMACs. This assessment was done by engineering faculty and students at Colorado State University's (Fort Collins) WMAC. The assessment teams have considerable direct experience with process operations in manufacturing plants and also have the knowledge and skills needed to minimize waste generation.

The waste minimization assessments are done for small- and medium-size manufacturers at no out-of-pocket cost to the client. To qualify for the assessment, each client must fall within Standard Industrial Classification Code 20-39, have gross annual sales not exceeding $75 million, employ no more than 500 persons, and lack inhouse expertise in waste minimization.

The potential benefits of the pilot project include minimization of the amount of waste generated by manufacturers, and reduced waste treatment and disposal costs for participating plants. In addition, the project provides valuable experience for graduate and undergraduate students who participate in the program, and a cleaner environment without more regulations and higher costs for manufacturers.

Methodology of Assessments

The waste minimization assessments require several site visits to each client served. In general, the WMACs follow the procedures outlined in the EPA *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003, July 1988). The

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WMAC staff locate the sources of waste in the plant and identify the current disposal or treatment methods and their associated costs. They then identify and analyze a variety of ways to reduce or eliminate the waste. Specific measures to achieve that goal are recommended and the essential supporting technological and economic information is developed. Finally, a confidential report that details the WMAC's findings and recommendations (including cost savings, implementation costs, and payback times) is prepared for each client.

Plant Background

The plant produces machined parts on a job shop basis. The plant operates 2,210 hr/yr to manufacture approximately 500,000 units.

Manufacturing Process

This plant manufactures precision machined parts on a job shop basis. Raw materials include aluminum castings, aluminum sheet stock, and aluminum bar stock.

The following steps are involved in making the parts:

- Aluminum stock is cut to size then machined on computer numerically-controlled (CNC) machines. Periodically the cutting fluid is drained to a settling tank fitted with a belt oil skimmer. The tank allows solid contaminants to settle without filtration and the skimmer removes hydraulic oil and other tramp oils. "Treated" fluid is then reused in the machining equipment. Twice a year the "old" cutting fluid is drained from a machine and replaced with a cleaning solution to thoroughly clean the sump and fluid passages. The cleaner is then drained, the machine is rinsed with water, and the sumps are refilled with fresh, not recycled, cutting fluid.
- These wastes along with spilled cutting fluid, cutting fluid lost to machine failure, unrecyclable cutting fluid, and tramp oil are collected in a drainage tank. This tank is periodically drained and the contents are shipped offsite to a nonhazardous waste disposal facility. Metal chips from machining are shipped offsite to a metal dealer for recycling.
- After machining, parts are manually deburred then placed in a large tumbler deburrer. Water from this operation overflows to one of three settling tanks where a nonhazardous, clay-like sludge builds up. The sludge, containing polyester fibers, water, pumice, and metal bits, is shipped offsite to a municipal landfill while the wastewater requires no treatment and is discharged to the sanitary sewer system.
- From the deburrer, parts are processed through a large continuous line washer or a small batch-type washer. Wash water is replaced frequently to remove build up of oils, dirt, and other nonhazardous contaminants. This water is discharged to the sewer.
- Warm dip degreasing with 1,1,1-trichloroethane (TCA) is used to remove stubborn oils from machined parts. Spent solvent is distilled by an onsite solvent recovery unit. After degreasing, parts are sent offsite for chromating then returned for assembly, inspection, packaging, and shipping.

An abbreviated process flow diagram is shown in Figure 1.

Existing Waste Management Practices

This plant has already implemented the following practices to manage and minimize its wastes.

- At the time of the initial visit, plant personnel were testing a cutting fluid which would not leave a tramp oil residue on machined parts. If the cutting fluid proved to be satisfactory, then subsequent solvent degreasing operations would be eliminated.
- A cutting fluid maintenance program is in place that includes periodic fluid maintenance and re-use. The equipment used in the program includes a sump sucker, a belt skimmer, and a settling tank.
- A solvent recovery unit is used to recycle TCA.
- Metal chips are shipped offsite to a scrap metal dealer for recycling.

Waste Minimization Opportunities

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

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

It should be noted that, in most cases, the economic savings of the minimization opportunities result from the need for less raw material and from reduced present and future costs associated with waste treatment and disposal. Other savings not quantifiable by this study include a wide variety of possible future costs related to changing emissions standards, liability, and employee health. 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.

Additional Recommendations

In addition to the opportunities recommended and analyzed by the WMAC team, one additional measure was considered. This measure was not completely analyzed because of insufficient data. Since this approach to waste reduction may, however, increase in attractiveness with changing conditions in the plant, it was brought to the plant's attention for future consideration.

- Reduce inventory and evaporative loss of TCA. During the period considered, approximately 10 55-gal drums of TCA were purchased even though waste TCA is distilled onsite and reused. Because the degreasing unit has been redesigned to accommodate larger pieces, the cooling coils above the vapor zone are no longer used since the refrigeration unit is now undersized for the current tank volume. One way to reduce evaporative losses is to improve housekeeping and a list of housekeeping measures appropriate to the plant were provided in the assessment report.

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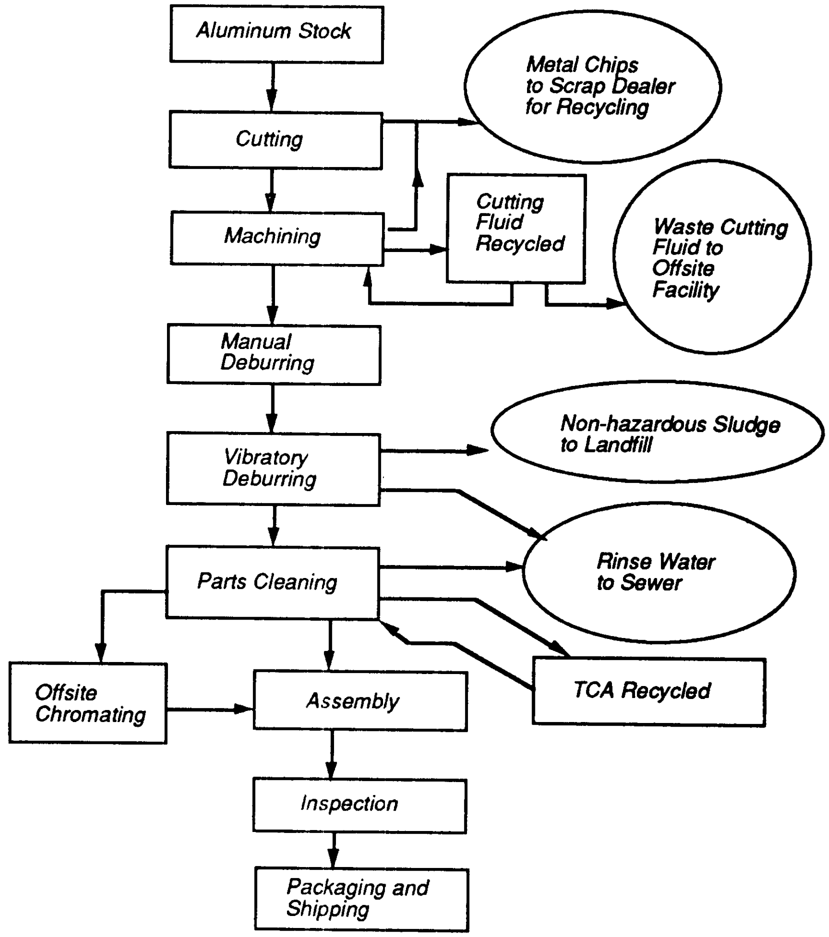

Figure 1. Abbreviated process flow diagram.

Table 1. Summary of Current Waste Generation

Waste Generated	Source of Waste	Annual Quantity Generated	Annual Waste Management Cost[1]
Cutting fluid wastes	Machining. Cutting fluid that can no longer be recycled, tramp oil, spilled cutting fluid, and waste cleaning solution are shipped offsite to a disposal facility where the waste is blended into cement.	7,300 gal	$13,190
Deburrer rinse water	Large tumbling deburrer. Wastewater from the deburrer goes through a settling tank and is sewered.	413,556 gal	630
Clay-like sludge	Settling tank. Sludge from the settling tank associated with the deburrer rinse water is sent to the municipal landfill.	Not available	0
Large washer rinse water	Large, continuous line parts washer. Wastewater from the continuous line parts washer is sewered.	33,800 gal	50
Small washer rinse water	Small, batch-type parts washer. Wastewater from the batch-type parts washer is sewered.	9,100 gal	10
Spent 1,1,1-Trichloroethane (TCA)	Parts degreasing. Spent TCA is distilled onsite and reused.	15,600 gal	2,800
TCA still bottoms	Onsite solvent recovery unit. Still bottoms are accumulating onsite.	0[2]	0
Aluminum chips	Machining. Scrap aluminum is sold to a recycler.	Not available	Not available

[1]Includes applicable raw material costs.
[2]Over a 3-yr period, less than a 55-gal drum of still bottoms has accumulated.

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Table 2. Summary of Recommended Waste Minimization Opportunities

Waste Generated	*Minimization Opportunity*	*Annual Waste Reduction*		*Net Annual Savings*	*Implementation Costs*	*Payback Years*
		Quantity	*Percent*			
1,1,1-Trichloroethane	*Replace current cutting fluid concentrate with a cutting fluid that does not leave an oily film on machined parts. This will result in elimination of warm dip solvent degreasing after machining.*	*15,600 gal [1]*	*100*	*$4,820 [2]*	*0*	*immediate*
Cutting fluid wastes	*Acid treat cutting fluid wastes to induce the physical separation of organic and aqueous phases. The organic phase would be disposed of as before and the aqueous waste fraction would be sewered.*	*0 [3]*	*0*	*3,470*	*1,000*	*0.3*
Cutting fluid wastes	*Evaporate cutting fluid wastes to effect a volumetric reduction in disposal quantity.[4]*	*0 [3]*	*0*	*2,440*	*2,800*	*1.2*
1,1,1-Trichloroethane	*Replace 1,1,1-trichloroethane with an aqueous cleaner.*	*15,600 gal [1]*	*100*	*1,340*	*3,520*	*2.6*

[1]Figure given reflects total volume processed through the solvent distillation unit per year. The generation of still bottoms will be eliminated also. Implementation of either the first or the last Waste Minimization Opportunity will result in the elimination of solvent use and the solvent recovery process.
[2]Net annual savings include annual purchase cost of 1,1,1-trichloroethane and the cost difference between the existing and proposed cutting fluid concentrates.
[3]This WMO results in cost savings only.
[4]An air discharge permit may be required for the emissions that may result.

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