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ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Baseball Bats and Golf Clubs

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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 the University of Louisville performed an assessment at a plant manufacturing baseball bats and golf clubs — approximately 1,500,000 bats/yr and 550,000 golf clubs/yr. To make the bats, wood billets are oven-dried and machined to a standard dimension. After sanding they are branded and finished. The golf clubs are made by finishing and assembling purchased heads and shafts. Cast heads, forged heads, persimmon-wood heads and stainless steel shafts are used. The cast heads are ground and finished, then driven onto the shafts. The forged heads are bored for the shaft, ground, milled, polished, nickel-plated and pressed onto the shafts. The persimmon-wood heads are drilled for the shaft, fitted with a brass back plate and an aluminum soleplate, stained, finished and bonded to the shafts. Grips, labels and shaft bands are applied to the shafts, which may be coated with polyurethane. The team's report detailing findings and recommendations, indicated that the most waste, other than rinse water discharged to the publicly owned treatment works (POTW) and wood turnings which are sold, consists of scrap cardboard and paper from the shop and offices, and that the greatest savings, including new income, could be obtained by segregating the cardboard and paper wastes for sale to a local recycler.

This Research Brief was developed by the principal investigators and EPA's Risk Reduction Engineering Laboratory (RREL), 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 RREL, the Science Center has established three WMACs. This assessment was done by engineering faculty and students at the University of Louisville's 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.

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The potential benefits of the pilot project include minimization of the amount of waste generated by manufacturers, reduced waste treatment and disposal costs for participating plants, 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 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 baseball bats and golf clubs. The plant operates 2040 hr/yr to produce approximately 1,500,000 bats/yr and 550,000 golf clubs/yr.

Manufacturing Process

To make the bats, white ash billets are oven dried, cut to a standard length and turned in a lathe to a standard dimension, sanded, branded and finished. The golf clubs are made by finishing and assembling cast, forged or persimmon-wood heads and stainless steel shafts. The raw materials include wood billets, water-based stains, tape for grips, investment casting heads, forged stainless steel heads, persimmon wood heads, stainless steel shafts, paint, epoxy adhesive, labels, reagent chemicals for nickel and chrome plating, brass back plates, aluminum sole plates, shellac, stains, filler, and sealant, primer and polyurethane coatings.

The following steps are involved in making the bats:

- White ash billets are oven-dried, cut to length, turned in a lathe to a standard dimension, and sanded smooth.

- The bats are burn-branded, foil-branded or silk-screened with a logo and specified markings, then finished with water-based stain and topcoat.

- Waste wood cutting shavings, sawdust and sanding dust are collected and sold for use in particle board. Spent stain filters are discarded for landfill disposal, and stain rinse water is discharged to the POTW. Mylar film from foil branding is discarded for landfill disposal, and spent solvent from washing silk screens is shipped for disposal as hazardous waste.

An abbreviated process flow diagram for baseball bat manufacturing is shown in Figure 1.

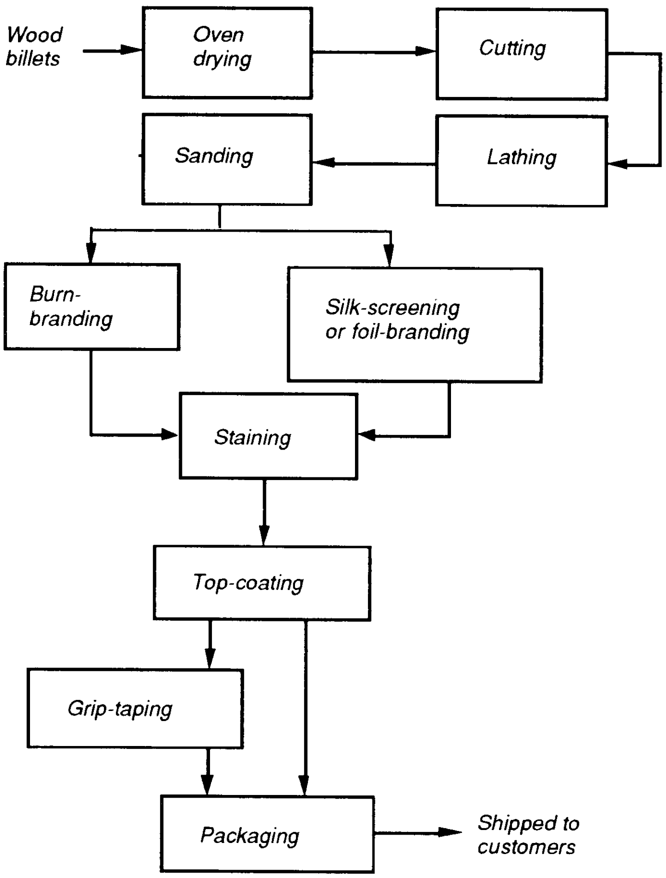

Figure 1. *Abbreviated process flow diagram for baseball bat manufacturing.*

These steps are involved in making iron golf clubs:

- Investment casting heads (purchased) are ground and polished to the proper weight, sanded, paint filled and driven onto the shaft. An epoxy adhesive is used for bonding. Tape is applied to each club for the grip, and self-adhesive labels are applied as shaft bands.

- Forged heads (purchased) are first bored for the shaft and ground to obtain a flat face. Score lines are pressed into the face, the back of the head is milled, and the heads are ground to proper weight.

- After vibratory polishing, the forged iron heads are nickel-plated, sandblasted, chrome-plated, and pressed onto the shafts. (Stainless heads are not plated.) The clubs are then finished in the same manner as those with cast heads.

- Metal dust from grinding and polishing and chips from boring and milling are shipped offsite for disposal. Spent solvent from paint cleanup and naphtha used in applying the grips are shipped offsite for disposal as hazardous waste. Worn rags are discarded as non-hazardous waste. Sludge from vibratory polishing is dewatered and discarded for landfill. The water separated is recirculated or discharged to the POTW.

- Spent cleaner solution and rinse water, neutralized spent acid pickling solution, and nickel and chrome plating rinse waters are discharged to the POTW.

An abbreviated process flow diagram for iron golf club manufacturing is shown in Figure 2.

These steps are involved in making persimmon-wood clubs:

- A nose and neck piece are cut from the persimmon-wood heads, which are then sanded, drilled and tapered for the shaft. A slot is milled in the face for a plastic insert, and a slot is milled in the back for a brass back plate. An aluminum sole plate is added with a layer of epoxy.

- The heads are polished, faces are coated with masking shellac, and hot stain is applied for color. Filler is applied twice. The heads are then wiped with rags and sanded to proper dimensions, removing the shellac.

- Metal surfaces are cleaned with steel wool, and wiped with naphtha. A sealer and primer are applied and oven cured.

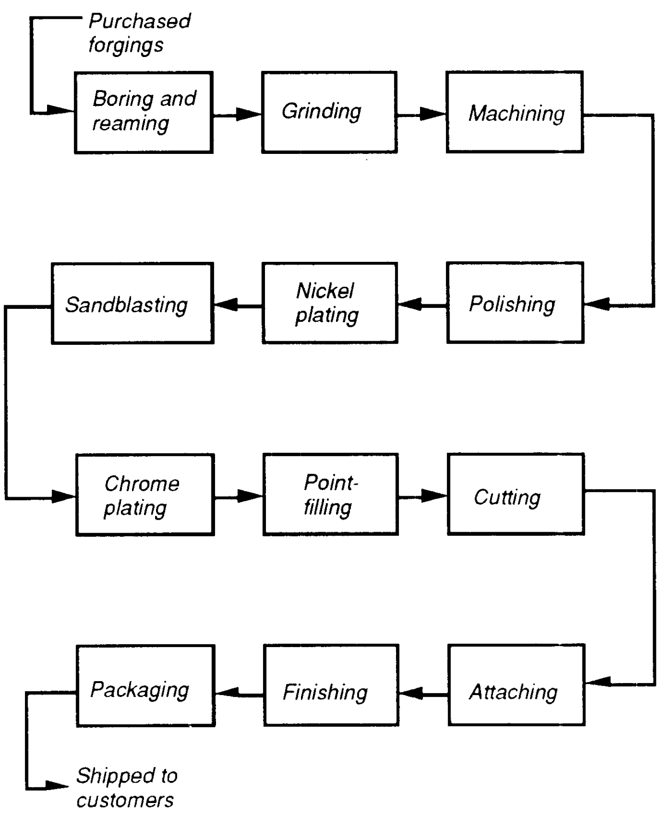

Figure 2. *Abbreviated process flow diagram for golf club manufacturing.*

- Shafts are epoxy-bonded to the heads, grips are applied, and polyurethane topcoat is sprayed on and oven cured. Whipping is applied to the necks, and bands are applied to the shafts.

- Stainless steel shaft cuttings, brass cuttings, and aluminum cuttings are sold for scrap. Spray booth cartridge filters, when spent, are discarded for landfill.

Existing Waste Management Practices

- Vibratory polishing sludge is dewatered before disposal as landfill.

- A fume suppressant is used in chrome plating, and plating tank hood exhausts are scrubbed before venting.

- The paint and coating spray booth exhaust is filtered before venting.

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 time are given in the table. The quantities of hazardous 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 hazardous 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, several additional measures were considered. These measures were not analyzed completely because of insufficient data, implementation difficulty, or a projected lengthy payback as indicated below. Since one or more of these approaches to waste reduction may, however, increase in attractiveness with changing conditions in the plant, they were brought to the plant's attention for future consideration.

- Separate the components of waste metal dust for sale. The cost of separation was found to be too large.

- Eliminate plating wastes by sending the work to a commercial plating shop. Increasing use of stainless steel golf clubs will reduce the need for plating, but a shop capable of the needed high quality plating was not found.

- Reduce overspray wastes by monitoring the spray coating techniques in use for possible improved efficiency. Data were not available for further analysis.

- Use dibasic esters (DBE) in place of acetone for cleanup. DBE has a lower evaporation rate and generates no hazardous waste. It might also substitute for MEK or naphtha in some applications and can be reclaimed by vacuum distillation. Data were not available for further analysis.

- Reduce solvent evaporation by use of containers that are covered or close automatically and by reducing the amount of solvent applied to rags for cleaning. Data were not available for further analysis.

- Re-use spent naphtha for cleaning. The clarity of the spent naphtha indicated that it could be used again. Data were not available for further analysis.

- Use water-based inks for silk screening so the screens can be cleaned with aqueous cleaners, eliminating the generation of hazardous solvent waste. The possibility of increased BOD levels in the wastewater must also be considered. Data were not available for further analysis.

- Consider alternative disposal of spent solvents. Lower disposal cost would be expected for burning the waste in a fuels program, or if the individual solvent components can be recovered. Data were not available for further analysis.

This Research Brief summarizes a part of the work done under Cooperative Agreement No. CR-814903 by the University City Science Center under the sponsorship of the U.S. Environmental Protection Agency. The EPA Project Officer was Emma Lou George. She can be reached at:

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Table 1. *Summary of Current Waste Generation*

Waste Generated	Source of Waste	Annual Quantity Generated	Annual Waste Management Cost
Wood scrap, wood chips and sawdust	Wood wastes are pulverized, collected in a vacuum dust collector, and sold for use in particle board.	3,300,000 lb	($12,430)[1]
Dumpster waste	Scrap paper and cardboard, spent filters, mylar film and worn rags are disposed of as landfill.	939,000 lb	10,932
Metal dust	Dust from grinding and polishing golf club heads is disposed of as landfill.	11,700 lb	2,148
Stainless steel cuttings	Cuttings from golf club shafts are sold as scrap.	2,000 lb	(60)[1]
Aluminum and brass cuttings	Cuttings from golf club head sole plates and backs are sold as scrap.	110,000 lb	(3,000)[1]
Vibratory polishing sludge	After settling and decanting, sludge from polishing is dewatered off-site and disposed of as landfill.	1,815 gal	2,210
Spent colored lacquer	Spent lacquer from baseball bat staining is disposed of as hazardous waste.	110 gal	280
Combined spent solvents	Spent solvent from cleaning parts and machinery is disposed of as hazardous waste.	4,430 gal	11,100
Spent cutting oil and lube oil	Spent oil from machining and lubrication is disposed of as hazardous waste.	275 gal	700
Spent nickel stripping solution	Spent solution from stripping nickel plating is concentrated and disposed of as hazardous waste.	55 gal	290
Spent rinse water	Water from plating rinse, bat coating rinse and vibratory polishing is neutralized for pH control and discharged to POTW.	2,424,000 gal	3,175
Solvent vapor losses	Fugitive and stack emissions of solvent vapors are lost to the atmosphere.	3,997 gal	10,992

[1]The annual waste management cost is shown as negative because this waste stream generates revenue for the plant when sold.

Table 2. Summary of Recommended Waste Minimization Opportunities

Waste Generated	Minimization Opportunity	Annual Waste Reduction Quantity	Annual Waste Reduction Percent	Net Annual Savings	Implementation Cost	Payback Years
Dissolved nickel anode chips	Nickel anode chips are to be removed from the plating bath when it is not in use. This will extend their life.	Unknown	0	$2,684	0	0
Scrap cardboard and paper	Cardboard and paper wastes are to be segregated and sold to a recycler.	930,000 lb	100	31,500	0	0
Combined spent solvents	Spent solvents are to be segregated at their sources and recovered by distillation.	3,402 gal	90	21,817	$11,440	0.5
Vibratory polishing sludge	Use a hydroclone to dewater the sludge to 70% solids before shipping offsite for disposal.	935 gal	52	1,490	6,207	4.2
Paint overspray and spent filter	Paint several golf club heads on a rack, instead of individually, for improved efficiency.	148 gal	33	3,365	900	0.3
Used cleaning rags	Used rags are to be laundered and re-used	7,058 lb	75	2,823	0	0
Paint overspray and spent filters	Paint golf club heads with an air-assisted spray for improved efficiency.	202 gal	80	4,589	5,600	1.2

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