



ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Custom Molded Plastic Products

Richard J. Jendrucko* and Phylissa S. Miller**

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 Tennessee performed an assessment at a plant manufacturing custom-molded structural foam plastic products — approximately 840,000 parts per year. Resin pellets are blended with colorant pellets and regrind, then processed through a mold and press machine. Unfinished products are degated to remove seams, have attachments inserted, and are drilled, if necessary. Next, parts are patched and sanded. Finally, the part undergoes finishing operations including nickel coating, spray fill application, and top coat application. The team's report, detailing findings and recommendations, indicated that the majority of waste was generated in the mold and press machines but that the greatest savings could be obtained by utilizing electrostatic spray equipment in the finishing department to reduce (by 28%) the amount of paint solids waste generated.

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 the University of Tennessee's (Knoxville) 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 As-*

* University of Tennessee, Department of Engineering Science and Mechanics

** University City Science Center, Philadelphia, PA



essment Manual (EPA/625/7-88/003, July 1988). The WMAC staff locate the sources of waste in the plant and identifies 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 manufactures custom-molded plastic products including dashboards, door seals, and fan shrouds for automobiles, television cabinets, postage meter housings, and computer disk storage organizers. The plant operates 6,240 hr/yr to produce approximately 840,000 parts.

Manufacturing Process

This plant manufactures its various finished products from structural foam. Primary raw materials consist of seven types of resin pellets and colorants. Other raw materials necessary for the production processes are various solvents, paints, and finishing materials.

The following unit operations are involved in manufacturing the products:

Structural Foam Production

- Resin pellets are blended with colorant pellets and "regrind" from material recycling in a batch mixing process, and are then vacuum fed into hoppers on each of the ten mold and press machines.
- Pellets proceed through an electrically heated zone and to a zone where a blowing agent, hydrocerol or nitrogen gas, is added. Next, molten plastic is injected into a mold. Nitrogen gas is sometimes used during this process to pressurize the mold. Chilled water is continuously circulated through the press molds for cooling.
- From the mold and press machines, the product may be sold to the customer unfinished or may be directed to one of four work areas: inserting, degating, and drilling (considered as one operation), finishing department, secondary department, or defective product recycling.

Inserting, Degating, or Drilling

- The majority of molded parts are manually "degated" to remove seams formed in the presses. Following degating most parts have brass or aluminum fastener attachment inserts applied which are ultrasonically bonded to the piece. Inserting may also include an ultrasonically-induced bonding process (between molded pieces) in the production of shelving.
- A smaller portion of formed molds is drilled as needed along with the remaining product from degating not transferred to inserting. All molds from drilling proceed to inserting and then are transferred to either the secondary department or the finishing department.

Secondary Department

- Products from inserting, degating, and drilling along with products directly from the mold and presses enter a patching process where a filler is applied to improve surface smoothness.

- A very small product fraction may proceed to binding where toluene is applied for the mating of two surfaces.
- Products from bonding and patching are manually power-finish-sanded and either transferred to the finishing department or shipped directly to the customer.

Finishing Department

- Products brought to the finishing department begin at nickel coating, "spray-fill", or top-coat. Items that are nickel-coated proceed to "spray-fill" and to top-coat. Those beginning at spray-fill continue to top-coat.
- At nickel coating, a conductive paint and methyl ethyl ketone (MEK) thinner are mixed and then air-sprayed onto the product in spray booths. Next, the items are positioned on an overhead conveyor for an 11-12 minute passage through an infrared oven followed by transfer to a "spray-fill" booth.
- At a "spray-fill" booth, "spray-fill", reducers, and catalyst are mixed and applied. Products are passed through the same infrared oven for drying followed by finish-sanding.
- Products proceed to a top-coat paint booth where paint, solvent reducers, and a catalyst are mixed and applied by hand-held spray guns. Painted parts proceed through the infrared oven described above. Next, some product pieces are textured with a catalyzed polyurethane paint. These items are dried in a propane gas-fired oven and then boxed for shipment to the customer.
- A mixture of several solvents including acetone, MEK, and recovered solvent is used to spray clean equipment and wipe down walls. Overspray in each paint booth collects in a water bath from which paint solids are skimmed once per shift. Additional overspray coats the paint booth walls from which residue must be scraped periodically.

An abbreviated process flow diagram is shown in Figure 1.

Existing Waste Management Practices

This plant already has implemented the following techniques to manage and minimize its wastes:

- The plant has purchased approximately 13 new paint guns to improve paint application efficiency to result in some reduction of overspray occurring during the painting process.
- Approximately four years ago, water baths were installed in each booth to collect overspray and reduce airborne emissions.
- Plant personnel installed a distillation unit to recover waste solvent used for cleaning paint guns and paint booth walls.
- Inhouse waste surveys have been conducted sporadically for approximately 7-8 years in order to reduce the amount of waste produced.

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.

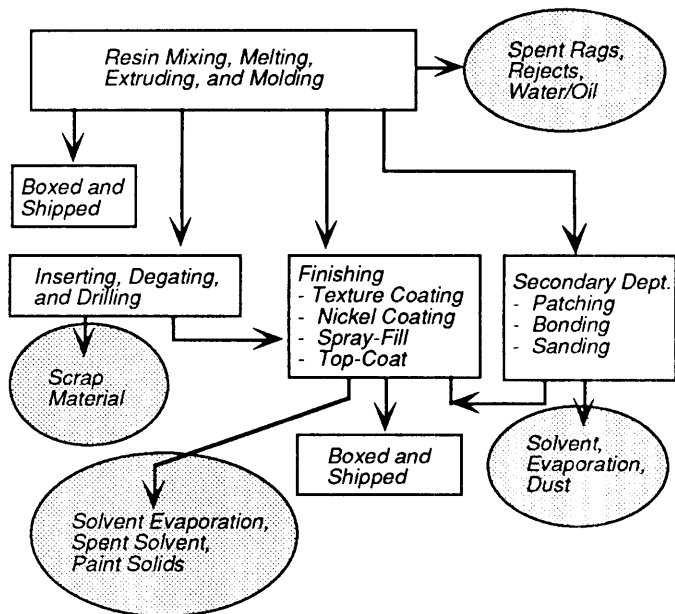


Figure 1. Abbreviated process flow diagram.

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, three additional measures were considered. These measures were not completely analyzed because of insufficient data, implementation difficulty, or a projected lengthy payback. 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.

- Wash clean-up rags used during painting and on the mold and press machines inhouse.
- Send molds to a vendor for application of Teflon coatings to eliminate the need for the use of the mold release agent. Teflon can operate continuously at temperatures up to 550 °F. Thus, it would be suitable for use in these molds since their operating temperature is 300 to 400 °F.
- Install a carbon adsorption solvent recovery system for the paint booths to recover finishing solvents.

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.

Table 1. Summary of Current Waste Generation

Waste Generated	Source of Waste	Annual Quantity Generated	Annual Waste Management Cost
Decanted water from oil separator	Hydraulic oil leaks and seepage from molds and presses. Water leakage during changing of press and mold cooling water manifolds.	23,737 gal	\$12,003
Waste solvents (still bottoms)	Spray gun cleaning and periodic paint booth wall cleaning.	4,620 gal	35,082
Paint solids	Painting booth water baths.	16,280 gal	92,079
Landfilled materials (e.g., dust, sanding belts and disks, etc.)	Grinding of recycled parts. Sanding operations in the Secondary Department.	79,412 lb	1,994
MEK evaporation ¹	Cleaning, painting, and mixing operations in the finishing department.	4,426 gal	17,261
Toluene evaporation	Cleaning, painting, and mixing operations in the finishing department.	1,100 gal	2,310
Acetone evaporation	Cleaning, painting, and mixing operations in the finishing department.	2,204 gal	6,546
Xylene evaporation	Cleaning, painting, and mixing operations in the finishing department.	771 gal	2,776
Catalyst evaporation	Cleaning, painting, and mixing operations in the finishing department.	3,012 gal	7,681
Recovered solvent evaporation	Cleaning, painting, and mixing operations in the finishing department.	1,714 gal	0 ²
Rejected forms	Rejects from molding, degating and finishing department. Items returned by the customer for unacceptable finish, dimensioning, cracking, and paint quality.	853,531 lb	0 ³
Spent hydraulic oil	Hydraulic oil leaks and seepage from molds and presses.	2,250 gal	6,188 ⁴

¹Figures provided under Annual Waste Management Cost for all solvents reflect raw materials cost only as there is currently no additional waste management cost associated with evaporation.

²Recovered solvent, according to plant personnel, has no raw material cost component.

³Plant personnel report no raw material costs or waste management costs associated with recycling rejected forms.

⁴Figure provided is the raw material cost only as plant personnel report no incremental cost associated with recycling spent oil through a reclaimer.

Table 2. Summary of Recommended Waste Minimization Opportunities

<i>Waste Generated</i>	<i>Minimization Opportunity</i>	<i>Annual Waste Reduction Quantity</i>	<i>Reduction Percent</i>	<i>Net Annual Savings</i>	<i>Implementation Costs</i>	<i>Payback Years</i>
<i>Paint solids/Solvents</i>	<i>Utilize electrostatic spray equipment in the finishing department.</i>	<i>81,385 lb</i>	<i>28</i>	<i>\$203,923</i>	<i>\$48,200</i>	<i>0.2</i>
<i>Paint solids/Solvents</i>	<i>Re-train paint personnel to improve paint spraying techniques.</i>	<i>4,831 lb</i>	<i>3</i>	<i>20,392</i>	<i>3,500</i>	<i>0.2</i>
<i>Water</i>	<i>Modify molding press cooling water manifolds.</i>	<i>98,513 lb</i>	<i>50</i>	<i>3,011</i>	<i>2,320</i>	<i>0.8</i>
<i>Paint solids (water fraction)</i>	<i>Install a vacuum dryer system to reduce the amount of water in paint solids shipped offsite.</i>	<i>44,929 lb</i>	<i>50</i>	<i>33,269</i>	<i>30,800</i>	<i>0.9</i>

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