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EPA ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Electrical Rotating Devices

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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. In an effort to assist these manufacturers, 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). That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992). The WMAC team at the University of Tennessee performed an assessment at a plant that manufactures several varieties of electrical rotating devices. Metal stock is machined, cleaned, and surface-treated if required. Laminations, which are used in rotor, stator, and stepper assemblies, are manufactured in-house from strip stock. Rotors, stators, and steppers are manufactured through a series of operations and are then assembled into the finished devices. The team's report, detailing findings and recommendations, indicated that spent solutions from the four-stage aqueous cleaner are the waste streams generated in the greatest quantity and that significant cost savings could be achieved by discontinuing the use of Freon™ vapor degreasing for precision parts cleaning.

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, Philadelphia, PA.

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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 generation is to reduce or eliminate the waste at its source.

University City Science Center has begun a pilot project to assist small and medium-size manufacturers who want to minimize their generation of waste but who lack the in-house 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 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 in-house expertise in waste minimization.

The potential benefits of the pilot project include minimization of the amount of waste generated by manufacturers and reduction of 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 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

Several varieties of electrical rotating devices are manufactured by this plant. It operates over 4,000 hr/yr to produce more than 250,000 units annually.

Manufacturing Process

Carbon and stainless steel, aluminum, brass, and copper bar stock, nickel strip stock, plastic powder, fiberglass pellets, and powdered metal are the principal raw materials used in production.

The various types of metal bar stock are machined into component parts using automatic screw machines. Metal shafts that are produced are sent to the four-stage aqueous cleaner consisting of an alkaline wash tank, two rinse tanks, and a rust inhibitor rinse tank for carbon steel parts. Other parts produced by the screw-machines are machined further and then washed in the four-stage cleaner. Stainless steel and aluminum parts undergo surface treatment after cleaning.

Almost all of the stainless steel parts and all of the aluminum parts undergo a protective surface treatment to prevent corrosion. The stainless steel parts are submerged in a passivating bath, rinsed, dried, and cleaned in an ultrasonic vapor degreaser. Aluminum parts are submerged in a chromium dioxide solution and rinsed.

Laminations, which are used individually in rotor assembly and stacked and fixed together in stator and stepper assemblies, are produced in the plant. Individual laminates are cut from strip stock in a punch press and then washed in the four-stage washer and heat-treated. The laminations are transferred individually to the rotor assembly area or to spray painting, or are stacked and held in place by shrink wrap or by welding. The welded laminates are then sent to painting, and unwelded stacks are transferred to the stator and stepper assembly area.

Injection molding machines are used to press plastic insulating rings onto metal shafts and to press fiberglass pellets, plastic powder, and powdered metal into various component parts. The resulting parts are stored until needed for assembly.

In the rotor and stator assembly line, individual laminations are pressed onto metal shafts. Magnet wire is machine-wound onto the laminations and onto painted and unpainted laminate stacks. An insulating coating is manually stripped from the end of the contact wires using a stripping compound. Then, the stripped wires are welded to a contact point. The wire coils are impregnated with epoxy and oven-cured to fix the coils to the laminations. The resulting rotors and stators are machined, washed in the four-stage cleaner and in an ultrasonic vapor degreaser, and transferred to final assembly.

For use in stepper assembly, laminate stacks are preheated in an oven and powder-coated in a fluidized bed. The parts are cured in an oven and, after manual removal of excess coating, cleaned in an ultrasonic vapor degreaser. Magnet wire is wound onto the laminate stacks. Insulating coating is manually stripped from the end of the contact wires with a stripping compound and the stripped wires are welded to a contact point. The wire coils are impregnated with epoxy and oven-cured to fix the coils to the laminations. The resulting steppers are machined, washed in the four-stage aqueous cleaner and in an ultrasonic vapor degreaser, and transferred to final assembly.

In the final assembly area, a bearing is inserted into a housing at one end of the stator or stepper. The insulating ring end of the rotor is inserted into a bearing plate. The rotors are matched with stators and steppers and inserted into them. The bearing plates are fastened, and a brushblock is fastened to ring contacts on the rotors. The completed units are tested, the motor housings are wiped clean and stamped with identifying markings, and the finished parts are packaged and shipped.

The flow diagrams shown in Figures 1-7 depict the operations used by this plant.

Existing Waste Management Practices

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

- Distillation units are used to recover usable TF-Freon™ from contaminated Freon™ in the plant's vapor degreasers.

- An in-drum waste compactor is used to reduce the volume and disposal cost of paper towel waste.

Waste Minimization Opportunities

The type of waste currently generated by the plant, the source of the waste, the waste management method, the quantity of the waste, and the annual treatment and disposal cost for each waste stream identified are given in Table 1.

Table 2 shows the opportunities for waste minimization that the WMAC team recommended for the plant. The minimization opportunity, the type of waste, the possible waste reduction and associated savings, and the implementation cost along with the simple payback time 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 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. 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 also should 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 may result when the opportunities are implemented in a package.

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**.

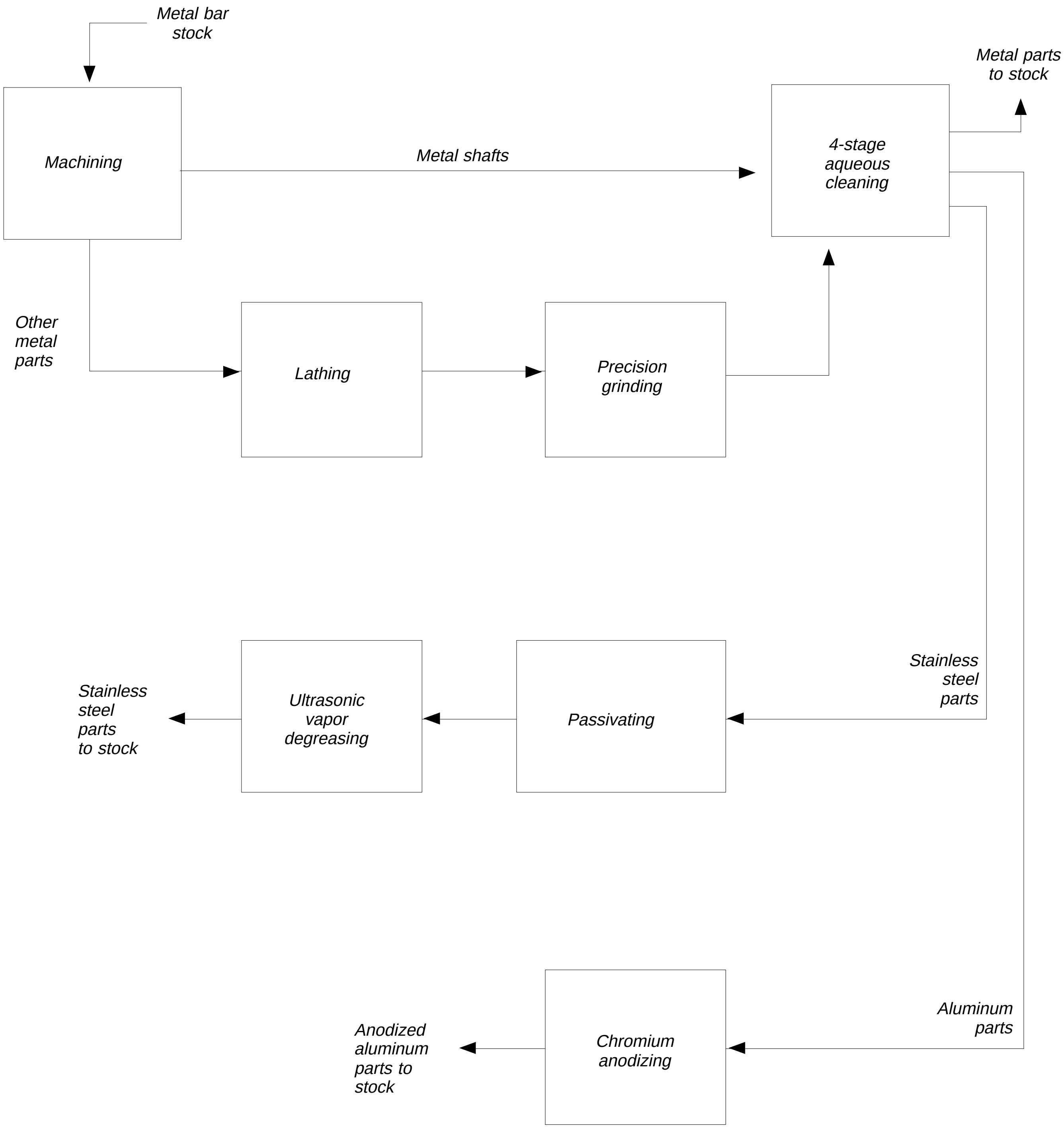

Figure 1. *Process flow diagram for machining and surface metal treatment.*

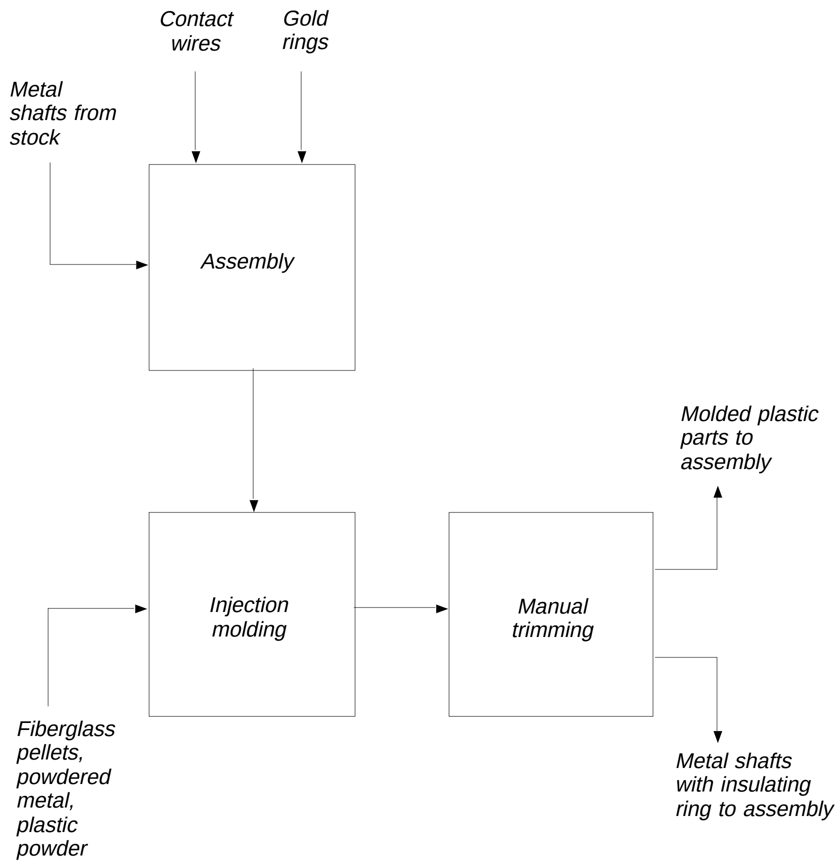

Figure 2. *Process flow diagram for injection molding.*

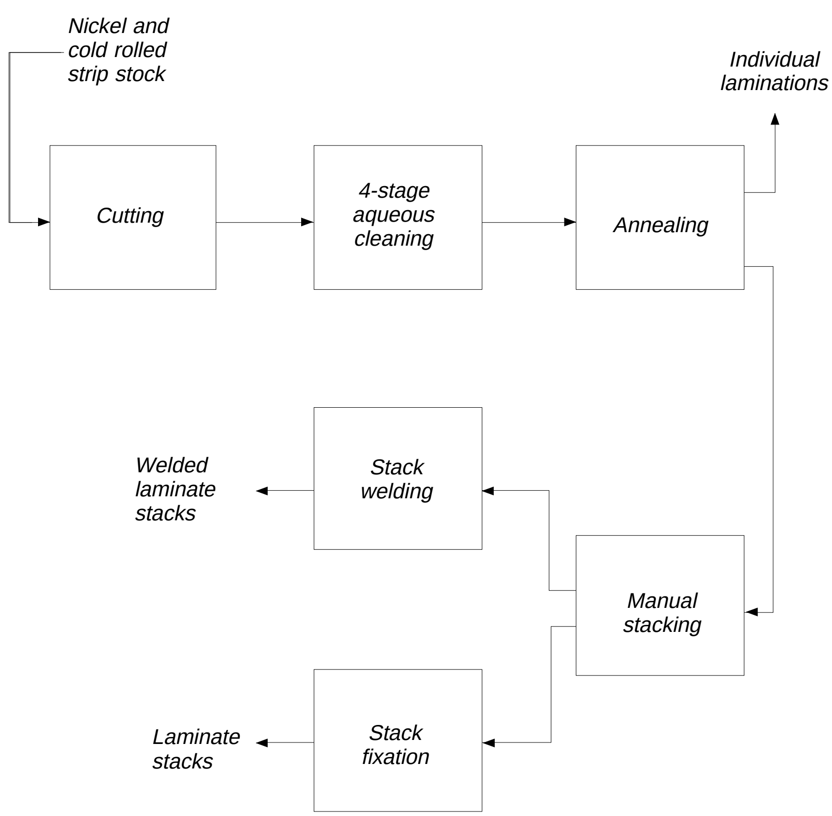

Figure 3. *Process flow diagram for laminate production.*

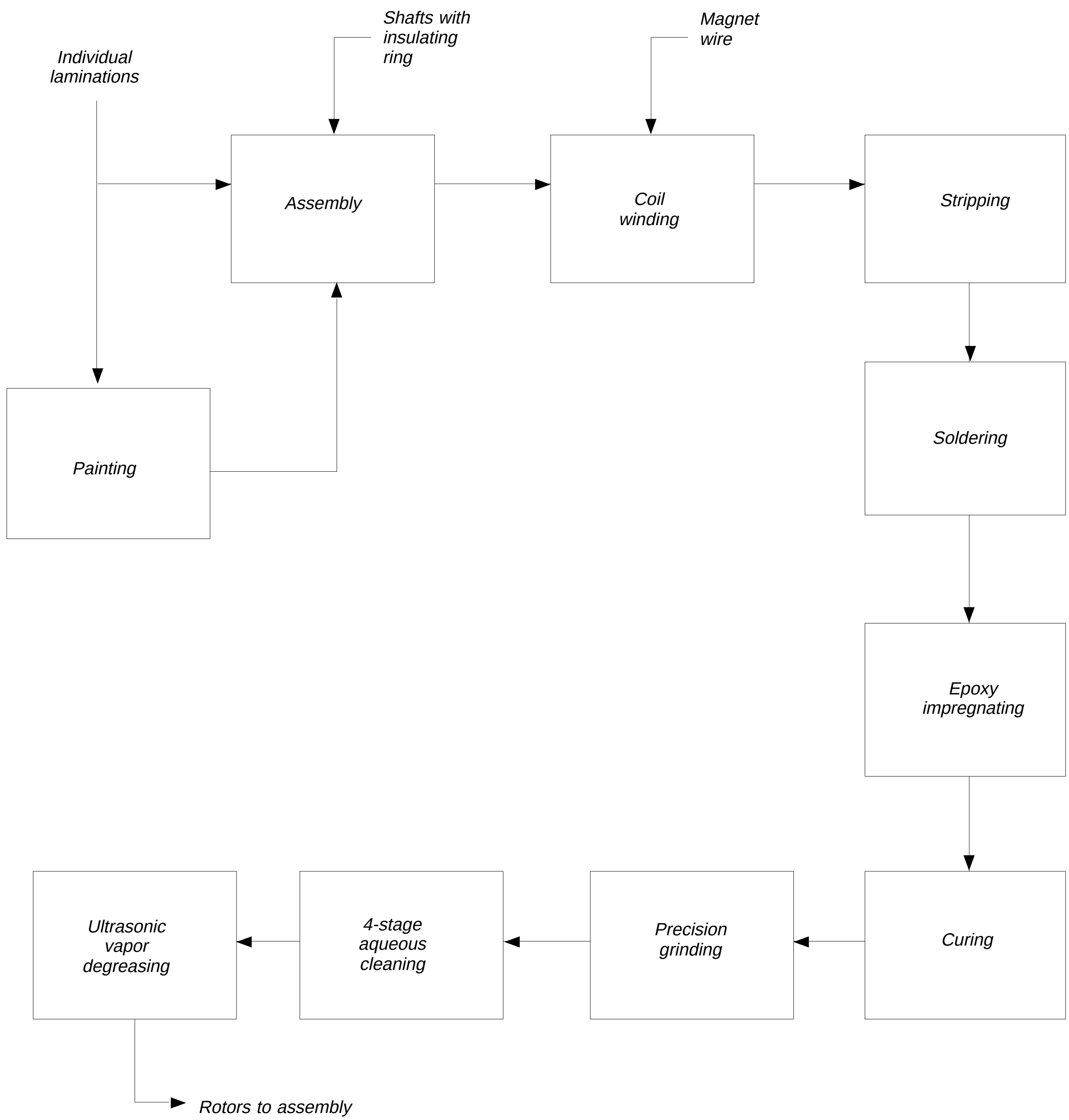

Figure 4. *Process flow diagram for rotor manufacture.*

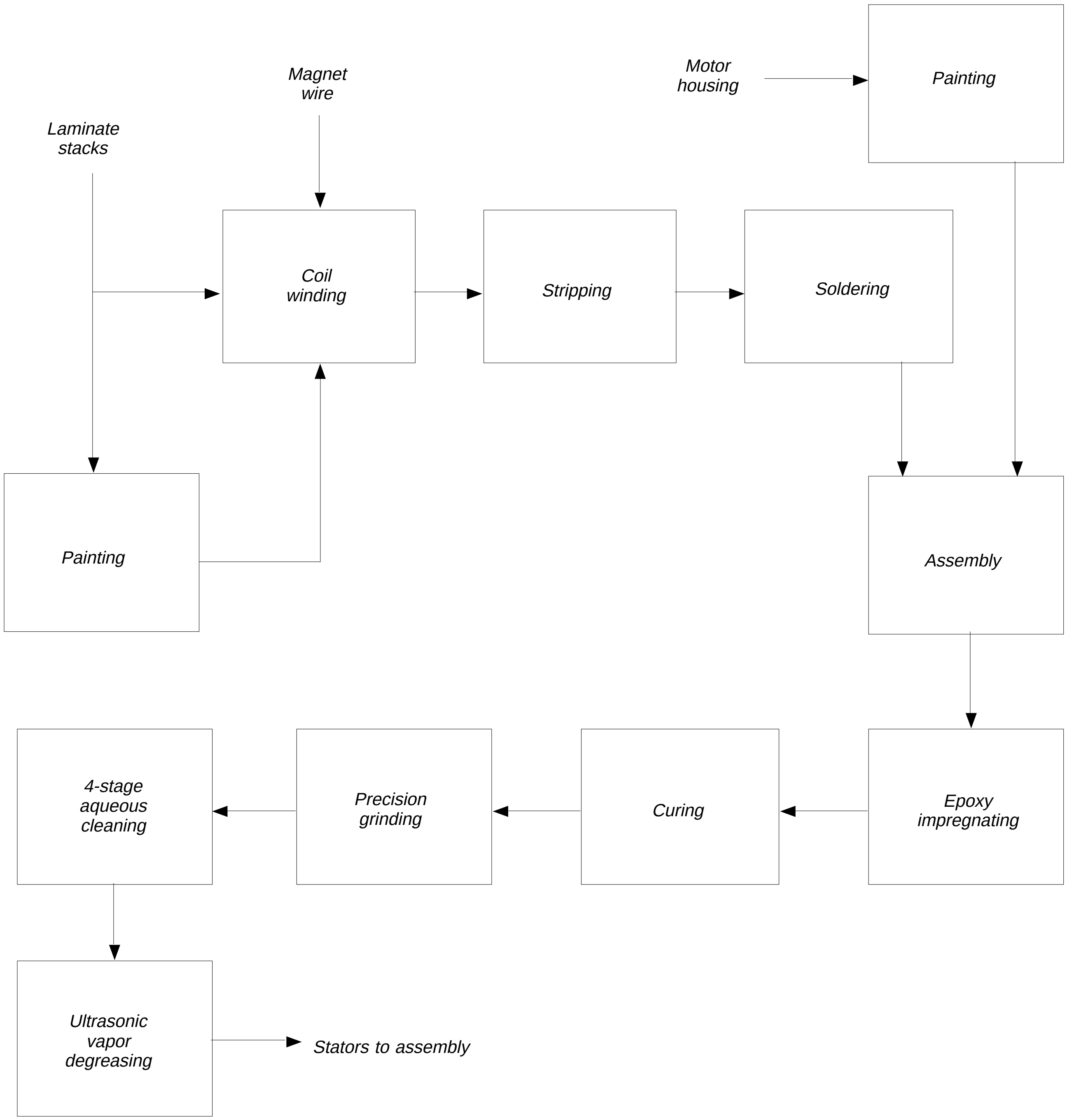

Figure 5. *Process flow diagram for stator manufacture.*

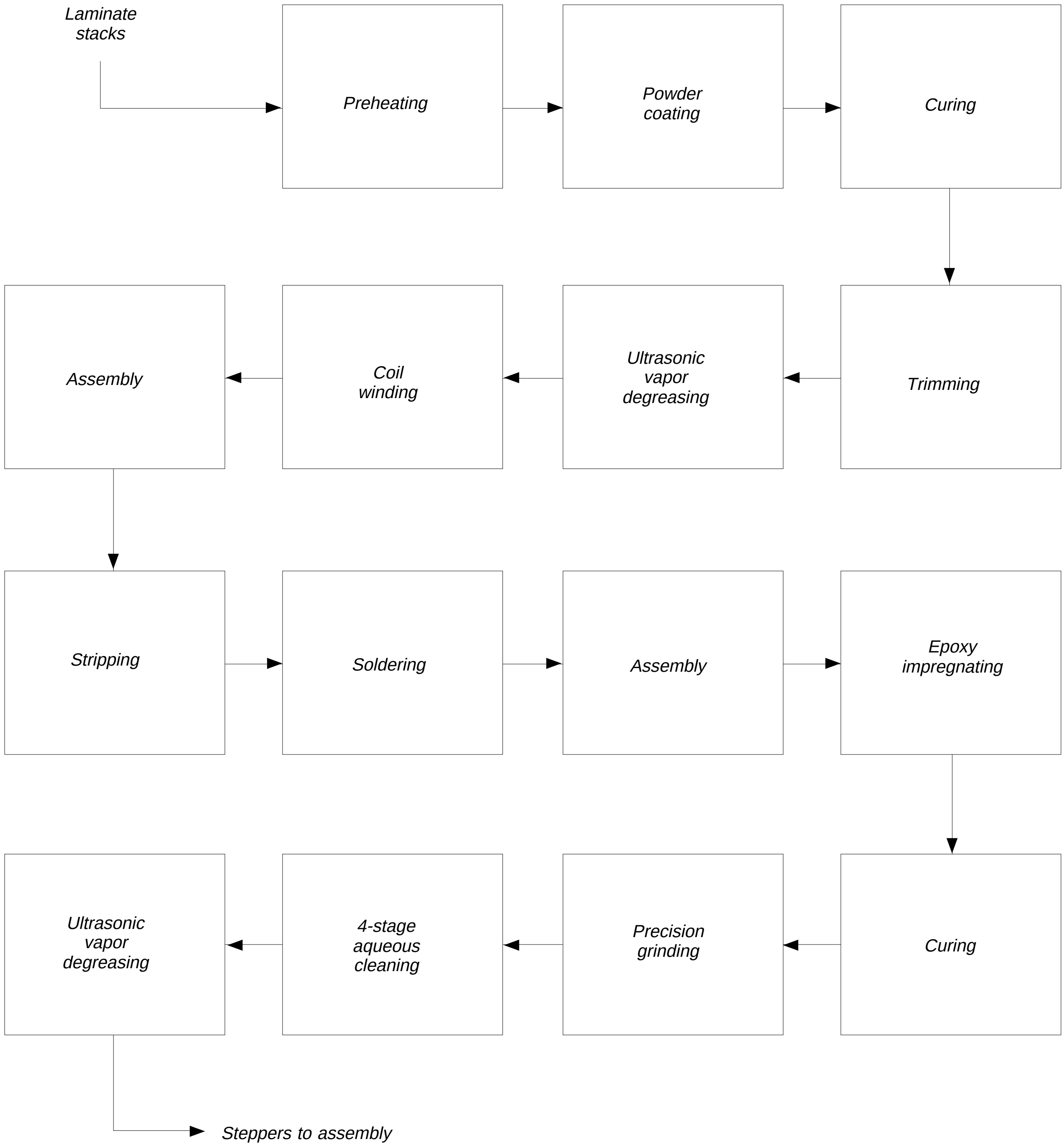

Figure 6. *Process flow diagram for stepper manufacture.*

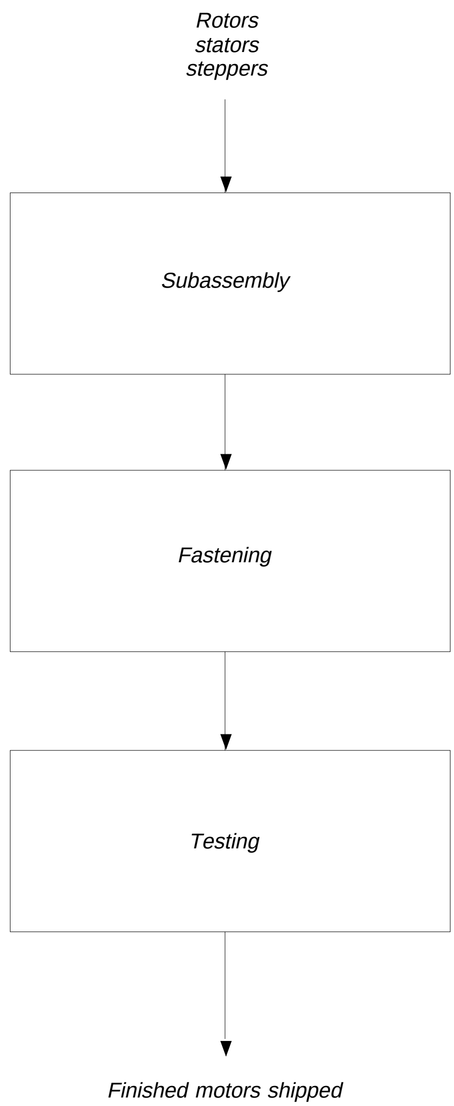

Figure 7. *Process flow diagram for motor assembly.*

Table 1. *Summary of Current Waste Generation*

Waste Generated	Source of Waste	Waste Management Method	Annual Quantity Generated (lb)	Annual Waste Management Cost
Oil-based lubricant	Machining and alkaline wash tank	Shipped offsite for use in fuel-blending	45,190	$3,350
Water-based lubricant	Machining	Shipped offsite for disposal	36,530	4,900
Metal scrap	Machining and assembly	Sold to recycler	40,000	(57,370)[1]
Aqueous cleaner and rinse water	4-stage aqueous cleaner	Sewered	1,195,200	5,250
Rust-inhibitor solution	4-stage aqueous cleaner	Sewered	250	220
Spent passivating solution	Passivating of stainless steel parts	Shipped offsite for disposal	660	940
Passivating rinse water	Passivating of stainless steel parts	Treated in onsite WWTP; sewered	102,960	920
Spent Stoddard solvent	Water removal following passivating	Shipped offsite for disposal	920	1,400
Evaporated Stoddard solvent	Water removal following passivating	Evaporates to plant air	2,830	0
Spent TF-Freon™	Vapor degreasing	Distilled onsite; reused	23,760	1,820
Evaporated TF-Freon™	Vapor degreasing	Evaporates to plant air	39,510	103,520
Spent chromic acid solution	Anodizing of aluminum parts	Shipped offsite for disposal	1,650	1,200
Anodizing rinse water	Anodizing of aluminum parts	Treated in onsite WWTP; sewered	597,600	4,100
Plastic flashing	Trimming after injection molding	Shipped to municipal landfill	40	140
Evaporated cooling water	Injection molding machines	Evaporates to plant air	796,800	160
Paint waste	Water curtain paint spray booth	Shipped offsite for disposal	27,500	30,200
Evaporated solvent	Painting	Evaporates to plant air	2,180	1,440
Stripper waste	Assembly of rotors, stators, and steppers	Shipped offsite for disposal	1,450	2,800
Waste solder	Soldering	Sold to recycler	200	(250)[1]
Epoxy waste	Assembly of rotors, stators, and steppers	Compacted; shipped offsite for disposal	18,000	20,180
Waste powder coating	Powder coating during stepper assembly	Shipped offsite for disposal	4,400	3,200
Acetone-wetted rags	Wiping and cleaning in final assembly	Shipped offsite for disposal	6,340	5,360
Wastewater treatment sludge	Onsite WWTP	Shipped offsite for disposal	24,750	21,890
Still bottoms	Onsite solvent recovery still	Shipped offsite for disposal	2,640	9,940

* Includes waste treatment, disposal, and handling costs and applicable raw material costs
[1] Net credit received

Table 2. *Summary of Recommended Waste Minimization Opportunities*

Minimization Opportunity	Waste Reduced	Annual Waste Reduction: Quantity (lb)	Annual Waste Reduction: Per cent	Net Annual Savings	Implementation Cost	Simple Payback (yr)
Discontinue the use of the water curtain paint spray booth and install an electrostatic powder coating system. A small amount of powder overspray waste will be generated and disposed.	Paint waste Evaporated solvent	27,500 1,250	100 57	$33,270[1]	$78,44	2.4
Minimize the use of paper towels during adhesive and epoxy application by collecting drip waste for convenient clean-up or glass table covers and in small trays. Reuse collected material before it dries.	Epoxy waste	14,400	80	17,850	760	0.04
Discontinue the use of Freon™ vapor degreasing for cleaning of precision parts. Use the existing 4-stage aqueous cleaner for precision cleaning. Generation of aqueous cleaning waste will increase slightly.	Spent TF-Freon™ Evaporated TF-Freon™ Still bottoms	19,010 31,610 2,110	80 80 80	49,400[1]	3,150	0.06
Install a sludge drying oven to reduce the volume of sludge shipped offsite.	Wastewater treatment sludge	12,380	50	8,530[1]	37,200	4.4
Cover the vapor degreaser tanks except when parts baskets are being lowered into or taken out of the tanks.	Evaporated TF-Freon™	19,760	50	51,760	2,060	0.04

[1] Total savings have been reduced by an annual operating cost required for implementation of this opportunity.

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