Source Reduction and Recycling Opportunities for a Fiberglass Reinforced Plastics Shop

Minnesota Technical Assistance Program ■ INTERN PROJECT SUMMARY—

Intern Project Date: Summer 1994
Intern: Nate Gruber, Winona State University Composite Materials Engineering Student
Company: Astoria Industries; Jackson, Minnesota
MnTAP Contact: Randy Cook

Process Background

Astoria Industries employs approximately 45 people and manufactures fiberglass reinforced plastic (FRP) components for truck utility bodies and livestock trailers. The manufacturing process uses an open-mold, spray lay-up process, which involves applying a fiberglass and catalyzed polyester resin mixture onto open molds.

A large quantity of solid waste is generated during the fabrication process, which must be disposed of in a landfill. The three primary types of wastes include:

- **Overspray Waste. This** waste consists of over-sprayed resin and glass that misses the mold during the spray-up operation and lands on the spray-booth floor. It also includes cardboard, which is used to cover the spray-booth floor.
- **Trim Waste.** Trimmings are over-sprayed FRP trimmed off the edges of both the product and the open mold. This waste also includes a small quantity of paper used for masking.
- **Cut-out and Grinding Waste. This** consists of solid FRP laminate cut out or ground away from a product to make openings for doors, wheel wells and trim. It also includes excess solid laminate that remains after a door has been cut out.

Incentives For Change

In 1993, Astoria disposed of approximately 176,200 pounds of solid waste. Approximately 60 percent of this total was cured FRP waste. Astoria wanted to reduce the amount of FRP waste it generated for two primary reasons:

1. **Disposal Costs: In 1993**, Astoria spent approximately $11,000 on landfill disposal fees. Astoria anticipated that landfill disposal costs would continue to increase in the future.

2. **Limited Landfill Space.** Local landfill space was becoming increasingly limited, causing Astoria to send its solid waste out of state for disposal. In addition, Astoria was concerned that strict regulations imposed by "recent federal legislation could make siting future local landfills difficult.

Intern Activities

During the summer of 1994, a MnTAP Intern worked at Astoria to help find ways to reduce the FRP waste. The goals of the intern project were to: 1) identify and evaluate solid waste reduction opportunities in Astoria's FRP fabrication processes; and 2) evaluate the feasibility of processing cured FRP waste into a board-like product, which could be substituted for the particleboard used as reinforcing material in Astoria's products.

Waste Assessment. The intern identified the manufacturing processes that produce the majority of FRP solid waste, determined the composition of each waste stream, and measured their respective amounts generated (in pounds). These wastes were periodically collected and weighed at each process area. Weights of the raw material used and products

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made were also measured during this period. The results are listed in Tables 1 and 2 below:

Table 1. Composition of FRP Wastes

Component Material	Composition of Wastes (percentages)		
	Over-spray Wastes[1]	Trim Wastes[1]	Grinding/ Cut-out Wastes[1]
Resin	40	45	43
Filler	30	33	32
Fiberglass	20	22	21
Cardboard	10		
Particleboard			2
Gelcoat[2]			2

[1]**Percent by weight.**

[2]**Gelcoat is the pigmented resin veneer outer surface of FRP products.**

Table 2. Percentage of FRP Waste in Total Raw Material Used and Waste Generated

Type of Waste	% of Total Raw Material Used[1]	% of FRP Wastes Generated[1]
Over-spray Waste	7	27
Trim Waste	2.5	10
Grindings/Cut-out Waste	15.8	63

[1]**Percent by weight.**

Source Reduction Opportunities. While evaluating the current practices that generate FRP waste, the intern gathered information on best operating practices that can reduce the amount of cured FRP waste generated. " Processes reviewed by the intern included the spray booth trimmings from open molds and utility body modules; and cut-outs and grindings. Based on his findings, the intern made the following suggestions to the company supervisor:

- Substitute lightweight tar paper for the cardboard sheets used to line the spray booth. This reduces the total volume and weight of over-spray waste (overspray **and** liner). In addition, the cost of the tar paper is about half that of the cardboard.
- Properly maintain and periodically clean the spray lay-up equipment. Poor equipment maintenance leads to glass jamming in the spray gun chopper mechanism, which then must be cleaned. Each time the spray lay-up gun is cleaned

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and checked for proper operation, resin and glass are sprayed onto cardboard lying on the booth floor, creating additional over-spray waste.

- Train spray booth operators to aim the spray lay-up gun perpendicular to the open mold to increase the FRP transfer efficiency.

- Redesign open molds to reduce the quantity of cut-out and grinding waste generated. A new mold design currently used to produce a standard model incorporates the door opening into the mold. This new design has resulted in an 88 percent reduction in cut-out waste over the previous mold, saving 15 pounds of FRP from going to a landfill each time it is used. Currently, this idea applies only to one product line because of the variability of the customized utility body designs.

Complete elimination of FRP waste through source reduction methods was not feasible at the time of this project because of the nature of the open mold spray-up method and the need to make the cut-outs for doors.

Recycling. The technical and economic feasibility of recycling cured FRP was evaluated. The goal was to determine if the FRP scrap waste could be reused to make a substitute for the particleboard currently used to reinforce and divide product modules into compartments. Astoria was looking for **a** testable recycled product that: 1) could easily incorporate scrap FRP, 2) was adequately cured and void-free, and 3) could match the mechanical and physical properties of the product currently made with raw materials.

To incorporate the scrap FRP into its product lines, the scrap needed to consist of free glass fibers and granulated resin. The scrap FRP was ground to reduce its size and used as a filler material mixed with new resin and fiberglass.

Samples of the over-spray and cut-out wastes, in quantities representative of their composition in Astoria's overall waste stream, were ground by 12 different grinding-equipment 'suppliers to reduce the size of the scrap to very fine particles.

The appearance and characteristics of the ground FRP samples returned from the different companies varied greatly in particle size-from a very fine powder up to 3/4-inch pieces. Jacobson Companies (Minneapolis, Minnesota) and Rapid Granulator (Rockford, Illinois) ground the scrap FRP into a finely divided resin, which maintained a good glass fiber retention.

Using the finely ground scrap samples provided by the two companies (Jacobson and Rapid Granulator), the intern developed a filler-to-resin mixture of 1:1 for making test panels. This ratio allowed the resin to adequately contact glass fibers and filler throughout the mixture.

The intern made FRP scrap panels in thicknesses of 1/4 and 7/16 inches; which were compared against those standard thicknesses of particleboard. To make the panels, **a** combination of FRP scrap, resin, and methyl ethyl ketone peroxide (MEKP) catalyst were added to a bucket and hand-mixed for one minute. The mixture was poured into a 16 x 21 x 0.5-inch open mold and the mold top was fixed in place. Then a pressure of 25 pounds per square inch (psi) was applied to the mold using a 10-ton hydraulic press.

The sample panels were allowed to cure for a minimum of two hours and were then subjected to the following tests performed at the Composite Materials Technology Center [COMTEC] in Winona, Minnesota:

Mechanical Properties

- **Flexural** test: Tests how much a material can bend before it breaks.
- Tensile test: Tests how much a material can stretch before it breaks.
- Izod impact test: Tests how much energy a material can absorb before it breaks.
- Lap shear test: Tests how strong the bond is between the resin and the material.

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Physical Properties

- Specific gravity: Determines the density of a material relative to water.
- Fiber volume fraction: Determines the glass content of a material (fiberglass adds strength).
- Water absorption: Determines how much water a sample can absorb.

The results from the above tests were compared against particleboard and are detailed in Tables 3 and 4 below.

Table 3. Mechanical Properties

Material (thickness)	Flexural Stress (psi)	Tensile Stress (psi)	Tensile Strain(in/in)	Izod Impact (lb-ft/in)	Lap Shear (psi)
Jacobson[1] (114')	4,625 "	2,278	0.0038	1.87	235.6
Rapid[2] (1/4")	5,200	2,619	0.0042	1.5	205.4
Particleboard (1/4")	3,106	2,009	0.0357	1.47	
Particleboard (7/16')	1,944	1,138	0.0296		298.4[3] 150.2[4]
'Odd-Lot' Resin (1/4")	10,780	6,457	0.0245		

[1]Made from FRP scrap ground by Jacobson Companies
[2]Made from FRP scrap ground by Rapid Granulator
[3]7/16" particleboard, smooth sides bonded together
[4]7/16" particleboard, rough sides bonded together

Table 4. Physical Properties

Material (thickness)	Specific Gravity	% Glass Fiber Volume	24 hr. Water Absorption (% wt. included)
Jacobson (1/4")[1]	1.33	3.6	0.43
Rapid (1/4")[2]	1.35	4.2	0.26
Particleboard (1/4")	0.78		39.9 .
Particleboard (7/16")	0.65		39
Odd Lot Resin (1/4')	1.17		

[1]Made from FRP scrap ground by Jacobson Companies
[2]Made from FRP scrap ground by Rapid Granulator

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Summary

The intern successfully demonstrated that Astoria's FRP scrap waste could be ground and reused to make panels that generally meet or exceed the required mechanical and physical properties of the particleboard currently used to divide and reinforce module compartments. Only the lap-shear strength of the panels showed to be slightly weaker than the bond between the smooth side of the particleboard and the resin (see Table 3).

The cost per square foot of each panel made with recycled FRP was determined to be about five cents less than that of particleboard, when savings from diverted FRP landfilling costs were considered.

Currently only about 25 percent of the total cured FRP waste generated by Astoria is needed to generate enough FRP waste boards to replace the amount of particleboard used. In order to recycle all of its cured FRP waste, Astoria needs to produce a marketable product.

The estimated cost savings from substituting FRP waste boards for particleboard would be approximately $2,300 annually, and would reduce the amount of solid waste going to the landfill by approximately 33,000 pounds annually.

Capital costs for purchasing the grinding equipment necessary for manufacturing FRP waste boards ranges from $30,000 for one grinder to $180,000 for two grinders (Note: the second, more expensive grinder may be needed to reduce the particle size). Because of these high costs, recycling cured FRP waste was not found to be economically feasible at this time.

Future Goals

Since the conclusion of the project, the intern's project supervisor at Astoria has met with representatives from other FRP manufacturers to determine if a joint FRP scrap recycling venture was feasible. They are interested in pursuing options that may: 1) improve the economic feasibility of recycling, 2) prevent landfilling the scrap by reusing it in their own shops, and 3) develop a new marketable product from the excess waste.

Though Astoria and the other companies do not want to develop a new product line themselves, they felt it maybe a feasible business opportunity for entrepreneurs. Important technical, financial, marketing and liability issues will need to be resolved before a significant amount of FRP waste can be recycled.

More Information

MnTAP has variety of technical assistance services available to help Minnesota companies manage and reduce their industrial waste. If you would like assistance or more information about MnTAP's Intern Program, call 612/627-4646 or 800/247-0015 in greater Minnesota.