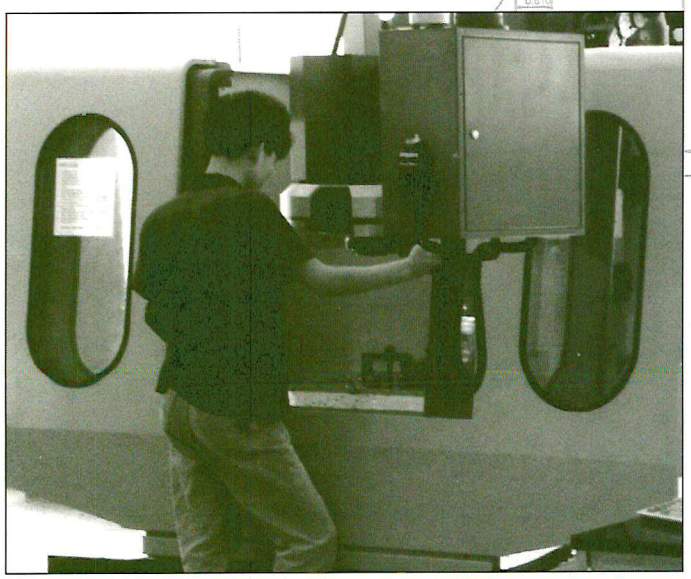
AMALGA
COMPOSITES, INC.

Engineering Problem Solving when Machining Thermoset Composites

▶ **Friction Heat**–Because composite materials are inherently thermal insulators, it is difficult to remove the heat that is generated by the friction of machining operations. Excessive heat build-up will damage the composite structure by degrading the epoxy matrix material. The use of a coolant, the appropriate cutting speeds and tool feed rates, and the proper selection of cutting tools will aid in the prevention of damage to the composite material resulting from frictional heating.

▶ **Abrasiveness**–Conventional tooling will wear rapidly because of the abrasive nature of fiberglass composites. If this tooling is used, periodic adjustments of the machine set are necessary as is a change-over of the cutting tools. Carbide or diamond tooling is recommended.

▶ **Delamination**–Composite structures are formed by the assembly of discrete layers of material called lamina. The assembly of lamina forms the composite laminate. Amalga Composites takes exceptional measures to prevent separating the lamina which results in a delamination of the composite laminate. Backing plates should be used when drilling through a structure, and excessive tool pressure should be avoided.



Complete Machining to Precise Specifications

The majority of the composite structures manufactured by Amalga Composites are machined to final engineering tolerances. Amalga has the production equipment to efficiently grind, cut, chamfer and mill composite material. Our machining capabilities allow us to deliver your part finished and ready to assemble, whether you require piston lead chamfers, milled snap ring grooves or any other secondary machining. Ask for a competitive quotation.

Conventional Machining Methods

▶ **Standard Metal Working Machining Equipment**– Excellent results are obtained when spindle speeds are high, material feeds are low and tooling is sharp. Machining techniques are similar to those used for marine brass.

▶ **Standard Cutting Tools**– suitable for low quantity production runs.

▶ **Tungsten Carbide or Diamond Tipped Tools**– used for large volume production runs.

▶ **Air or Liquid Cooling**– used to address low heat conductance and exceptional abrasiveness. Greater tool clearance is used to reduce friction.

▶ **Material Supports**– The greater resiliency of thermoset composites require greater support of the structure being machined.
- Use of I.D. plugs or O.D. rings may be necessary for chuck mounting.
- Metal shafts for internal support of long sections is recommended when machining center portions.
- Protection should be applied to the micro-finished inside diameter coating on cylinder tubing.

Operational Procedures for Safety and Efficiency

- **Control heat-up of the structure.**
  - –Use grind cutters similar to those used on brass.
  - –Use drills with slow twist, polished flutes and thin webs.
  - –Feed work at 100 to 150 surface feet per minute.
  - –Use light drill pressure.
  - –Replace tools when dull. Expect tools to wear faster than when machining metal.
  - –Coolants should be used to avoid softening of resin matrix.
- **Operate machinery at high speeds.**
- **Provide liberal clearance on cutting tools.**
- **Grind turning tools to provide rake angles that minimize cutting and thrust forces.**
- **Support the workpiece adequately to prevent distortion under cutting pressures.**
- **Allow for plastic memory to enhance machining accuracy.**

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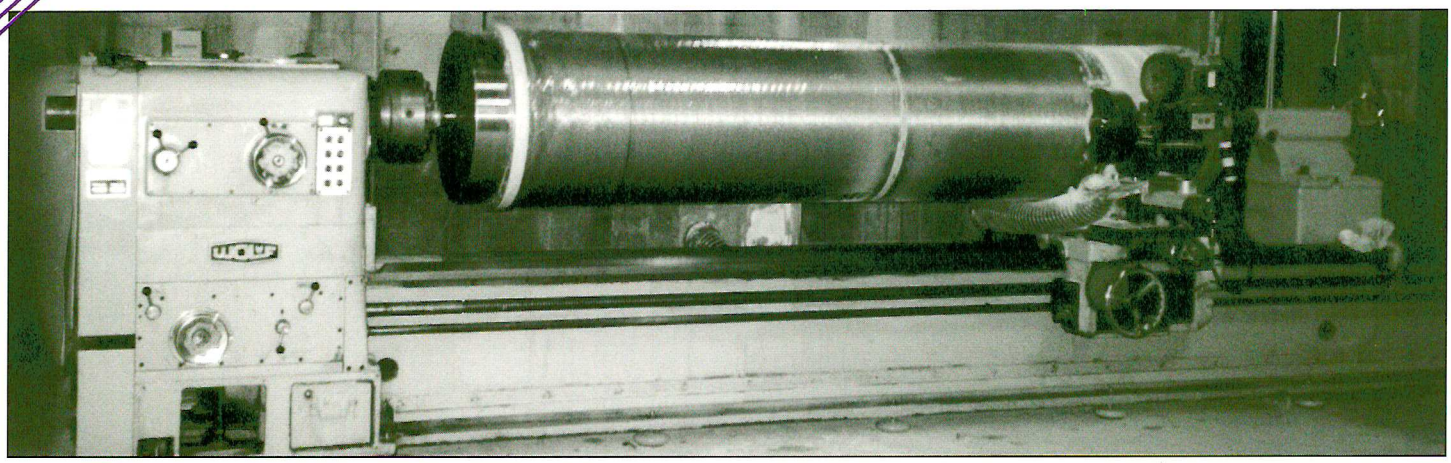


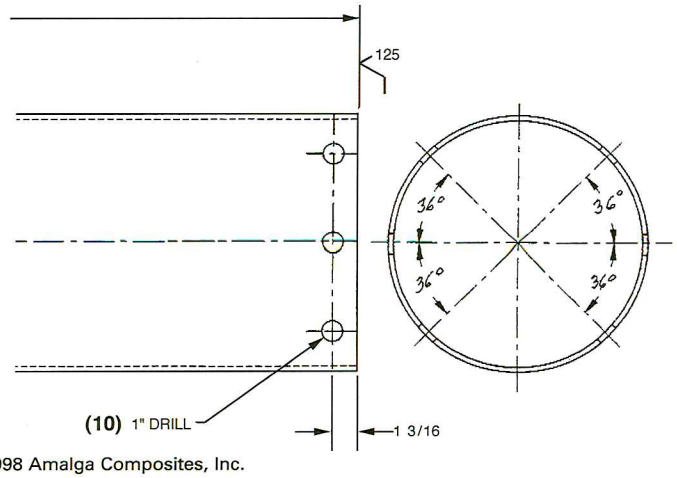
CONVENTIONAL MACHINING PRINCIPLES APPLY TO COMPOSITES. CALL US FOR INFORMATION ON TOOLING SPECIFICATIONS FOR MACHINING COMPOSITES.

Beveling & Drilling

Beveling the cut-off can be achieved by several methods, depending on quantities and tolerances.
Short production runs require hand files or a shaped block sander using carbide chips brazed to metal.
Large volume production necessitates the use of a carborundum burr in an 8,000 RPM air motor.

Critical Production Details

- Forstner drill bits designed for composites provide the best results.
- Drill bits with specific helix angles, wide polished flutes and point angle for fiberglass reinforced thermosets limits chip packing and overheating.
- Helix angles of 10° to 50°, clearance of 9° to 20° and point angles of 60° to 120° are required.
- Vary drill speed with the size and depth of the hole.
- Carbide and diamond tipped tools are more responsive when operating at higher speeds and slower feeds, and will produce a smoother hole.
- A bit that is approximately .002" oversize is recommended.
- Support the backside of laminate with wood or plastic to prevent delamination and splintering.



Grinding, Milling and Turning

Standard metal working lathes and milling machines are sufficient for machining thermoset composites. High speed steel tools can be used effectively if maintained sharp, although carbide or diamond tipped tools will prove more economical for large production runs.

Composite structures can be finished to close tolerances by sanding and/or grinding. Belt and drum type sanding machines have been employed successfully with grit sizes from 30 to 240. Using coolants on conventional sanding and grinding machinery will prevent clogging and glazing of the abrasive. Grinding with silicone carbide or aluminum oxide grit wheels will require free flowing coolants to prevent the workpiece from overheating.

Speeds, feeds and tools sharpened for brass machining will work effectively. Honed cutters will extend service life. Cooling with water or air will increase cutting rates and lathe tools should maintain a high clearance–between 10° and 20°. Setting the rake at zero or negative will improve performance. Tool sets should be 1° to 2° above center. A surface speed of approximately 600 feet per minute is recommended.

Cutting

Fiberglass reinforced thermoset composites can be cut with hand saws, band saws and circular saws. Precautions should be taken to keep parts from overheating due to the material's low thermal conductivity. Vibration should be avoided to prevent delamination. Because of the abrasive nature of fiberglass, maintaining the tool's sharpness requires diligence. Cutting with 1/32" to 3/32" thick abrasive wheels containing carbide abrasive with a 36 to 60 grit range on an 8" diameter and rotating a 4,000 RPM is a proper method for thermoset composites. Band saw blades should be diamond tipped or fine tooth to reduce deformation of composite materials. Circular or radial arm saws should utilize diamond tipped or carbide edged blades. Spray mist, water or air jets with a vacuum pick-up is recommended for cooling and dust removal.