Machining of GRAFOAM® Carbon Foam

This document should be used as a general guideline for machining GRAFOAM® carbon foam.

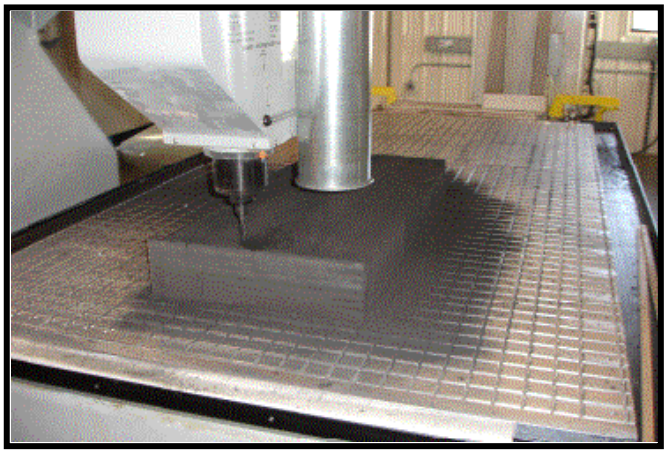
Machining Facility Requirements

A. Enclosed Environment – This is a preferred setup when possible.

1. Use dust extraction system to maintain a slight negative pressure in the enclosure in order to prevent air-borne carbon dusts from escaping the enclosure.
2. Remove carbon dusts and carbon foam chips collected at the bottom plate.

B. Non-Enclosed Environment – This is a less preferred setup.

1. Have suction close to point of machining (dust generation).
2. Suction volume should be adequate commensurate to the rate of dust generation. Maintain air velocity in suction pipe equal to or greater than 20 meters per second.
    i. ~20m/s air velocity for dust only.
    ii. ~25m/s air velocity for medium-high density carbon foam chips.
    iii. ~30m/s air velocity for large carbon foam chips.



An example of a non-enclosed environment with a dust collection pipe attached near the tool point.

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Machining Guide

GRAFOAM® carbon foam, similar to monolithic graphite, machines about as easily as aluminum or hardwood. Most of the common machining processes from sawing to turning can be used. Successful machining of a carbon foam work piece does require some familiarity with the material.

Carbon foam, although machines easily, is abrasive and could cause a high rate of tool wear. **It is recommended to use carbide or diamond tools for better tool life.** Carbon foam is normally machined dry. Carbon dust generated during machining should be extracted using a vacuum system at the point of the cutting tool.

Generally, it is recommended to use a high positive rake angle on the cutting tool.

Sawing

For FPA-02 and FPA-5 grades, satisfactory results can be obtained with standard band saws and standard carbon-steel blades of ½ inch wide with four teeth per inch to ten teeth per inch. Blades specially designed for cutting carbon and graphite are available. For FPA-10 and higher density grades, carbide grit/tipped or diamond grit blades should be used.

Turning

Carbon foam, although abrasive, is easy to turn. Chuck the work piece tightly, but not to the point of crushing or chipping the material. It is also important to use a lathe that has good bearings in the headstock. Use high-quality tungsten-carbide insert tooling with a positive rake angle and a nose radius of 1/64 inch or larger for general turning.

Note: When turning foam on a lathe you will find the density of some foam to be too fragile to place into the chuck. In most cases it works best to sandwich the material between sacrifice materials and turn it between centers. You can also place the martial into a collect fixture to hold on the outside surface for boring.

Milling

For facing cuts, use a diamond grit facing wheel with medium grit, medium grade, and medium open structure with a 1/4-inch radius or larger on the edge of the cup. Recommended surface speeds for the specific tool type should be used as guidelines. A face mill with round inserts can also be used.

Use high-quality carbide or diamond-coated end mills. Use ball nose end mills for cutting contours.

Grinding

Any standard surface grinder can be used. Dress the wheel often to keep it sharp. On larger, repetitive, close-tolerance jobs use diamond grinding wheels to maintain sharp corner radii. A good, overall surface grinding wheel is usually composed of silicon carbide medium grit, medium grade, medium open structure and vitreous bond.

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Drilling and Boring

A standard high-speed steel drill is satisfactory for drilling only a few holes and will wear relatively rapidly at the point and cutting edges. Inspect frequently for lip geometry.

For drilling holes smaller than 1/16 inch in diameter in low volume production, a HSS drill is preferred because of its toughness. For high volume drilling of holes over 1/16-inch-diameter, a high quality carbide tipped drill is preferred.

Use high-quality carbide inserts in a chatter-free boring bar. For core drilling, use diamond-faced tools with about an 80-psig pressure to flush the inside of the core.

Tolerance

Although it's possible to machine carbon foam (depending on the grade) to fairly tight tolerance, the general rule is that the closer the tolerance, the more costly the part. The following table summarizes the tooling and conditions recommended for machining graphite and indicates the tolerances that are achieved for ordinary shop work at reasonable cost. **Trials should be conducted on carbon foam to better determine the parameters and tolerance.**

Machining Summary[1]

				Tolerance	
Process	**Tool Recommendation**	**Speed**	**Feed**	**Size (inch)**	**Finish (RMS μ inch)**
Band Sawing -Long density	½-inch-wide carbon steel blade, four teeth/inch to ten teeth/inch	3100 ft/min	Hand	0.06-0.19	500-1000
-High density	Tungsten-carbide-grit blade	6800 ft/min	Hand	0.06-0.19	500-1000
Drilling	Tungsten carbide or HSS drill	500 to 4000 rpm	Hand	0.033-0.016	100-250
Grinding	Silicon carbide medium grit	1700 rpm	56 ft/min	0.001-0.003	100-250
Planning/Shaping	Tungsten carbide blade	2800 rpm	216 in/min	0.008-0.03	100-250
Turning (O.D.)	Tungsten carbide or ceramic tool	28-1500 rpm	0.0025 to 0.0035 in/r	0.003-0.125	100-250
Conventional Milling or CNC Machining	Carbide or diamond-coated ball-end cutting and milling tools	800-1000 sfpm		chip load 0.001-0.015 per tooth	

[1] Machining summary is approximated, based on graphite machining. Trials should be conducted on carbon foam to better determine the parameters and tolerance.

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Electrical Standards
The following gives a brief overview of required electrical standards and preferred equipment, if applicable, for a machining facility that handles GRAFOAM® carbon foam.

- Equipment needs to meet IP 54 (NEMA 12) or better (5 – dust protected, 4 – protection against splashing water).
- All motors need to be TEFC (totally enclosed fan cooled).
- Panels need to meet IP 54 (NEMA 12) or better.

Product Caution

Engineering controls are to be employed when machining GRAFOAM® carbon foam to avoid generating carbon dust as it is electrically conductive and can cause shorting of electrical equipment if emitted to the atmosphere. High concentrations of carbon dust can be irritating to eyes, skin, mucous membranes, and respiratory tract and inhalation of high concentrations for prolonged periods may cause pneumoconiosis. Read the Material Safety Data Sheet (MSDS #4289) carefully prior to working with the material.

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