Fabricating and Machining UHMW-PE

Ultra High Molecular Weight polyethylene (UHMW-PE) is an engineering thermoplastic with a molecular weight of greater than 3.1 AMUs (atomic mass units). The high molecular weight enhances a number of important physical properties, not the least of which are outstanding abrasion resistance, high impact strength and a low coefficient of friction. In addition, the polymer has good chemical resistance, excellent sound dampening characteristics, superior dielectric and electrical insulating properties and it doesn't absorb moisture.

These properties, in combination with ease of machining, make UHMW-PE, a cost-effective material that meets FDA and USDA requirements for direct food contact, it is used extensively in the food, beverage, medical and pharmaceutical industries. The non-porous quality of UHMW-PE inhibits the growth of fungus or bacteria. UHMW-PE is also widely utilized in the textile, chemical processing, pulp and paper, mining, maritime, steel, water and sewage treatment, bulk material handling and agriculture industries.

UHMW-PE properties can be enhanced through the use of additives such as colorants, UV and heat stabilizers, anti-static agents, wear-resistant fillers and friction-reducing lubricants. Metals or ores can be used to increase the weight and make the polymer magnetically detectable, while other filler increase the environmental operating temperature.

Because UHME-PE is a semi-crystalline polymer, it must be sintered by either compression molding or ram extrusion. Annealing, prior to machining, helps remove the processing stressed caused by sintering. Finished machined parts can also be annealed, but such parts must be fixtured during the cooling process to allow for shrinkage during annealing. Rough machining should be done prior to stress-relieving so dimensional changes can be accommodated during final machining.

Available in standard sheets, rods, and tubes for producing dimensionally stable parts, UHMW-PE can be sawed, milled, turned, planed, drilled or punched. Cutting tools should have high rake angles and sufficient ship clearance to prevent clogging. Feed rates should be high so that minimum time is allowed for the cutting tool to heat the material by friction. Care should be taken to keep tools sharp because UHMW-PE can rapidly dull tool cutting edges, causing part distortion. High Quality surface finishes can be obtained by using proper cutting tools, although attempts to improve poor finishes by filing or sanding will generally result in worsening the appearance.

Most machining processes hold tolerances of between +/-.005 and +/-.010. Saw cutting strips to length, however, would more typically be +/-.030 since the fairly high rate of linear thermal expansion and contraction UHMW-PE makes the length of a piece vulnerable to environmental changes.

Machining Processes

Sawing: For circular sawing, carbide-tipped blades give the best results. A 12-14" diameter blade should have approximately 24 teeth. Feed speeds can range from 10 to 40 feet per minute. For band sawing a blade with three teeth per inch, raker set and positive rake angel are recommended. Feed speeds range from 10 to 40 feet per minute.

Turning: Use high-speed steel tool bits with 10" front and side clearance and 15-30" rake. Lower cutting speeds of between 600 and 1,000 feet per minute are required. However, it is often necessary to run at a higher rpm to keep chips clear of the machine. Cutting fluids should not be necessary, but a blast of compressed air will sometimes aid in chip removal. When trying to achieve close tolerances or a very thin walled part in UHMW-PE, machine in passes. Remove most of the material on the first pass, then let the piece sit and rest overnight.

Milling: Cutters designed for machining aluminum give the best results. Cutting speed of 600 to 1,800 feet per minute are suggested, with a fed rate of approximately 0.01 inches per revolution. Router bits work well for slotting and light milling.

Planing: Wood planers readily reduce the thickness and true-up the surface of UHMW-PE. A rigid machine with sharp blades will give very efficient stock removal and good surface finish. To minimize the potential to warp when machining UHMW-PE, plane half of the desired thickness from each side of the sheet.

Drilling: Conventional high-speed drills are adequate for most drilling applications. For optimum performance, use special low helix drills with polished flutes. Drilling pilot holes prior to drilling a large hole is not recommended for UHMW-PE, because its properties cause the drill to grab and pull itself into material.

Grinding/Sanding: Due to UHMW-PE's abrasion resistant properties, grinding and sanding are usually ineffective. In fact, grinding may cause the material to melt and smear, resulting in a clogged grinding wheel.

UHMW-PE modified with additives such as glass or metallic oxides will result in shorter tool life. Although carbide tools will add life to the tool, it requires higher speeds and feeds. Some materials with a very high percentage of abrasive additives are impractical to machining by any method.

Forming and Welding

UHMW-PE can be hot-formed on the job to make simple bends and angles that facilitate installation. No matter which method is chosen – torch, electric heater, oven or bath – caution should be used and every effort made not to overheat the material. UHMW-PE, like any plastics, will burn under improper conditions. In addition, the complete cooling cycle will be somewhat longer than the heating cycle due to the high heat retention characteristics of UHMW-PE. Cooling should not occur on concrete or metal surfaces because the process will be too rapid and may introduce additional stress into the material. An additional recommendation is to cover the material with an insulation blanket made from a material such as fiberglass.

Cold-forming UHMW-PE is often used when there is a need to fit curves and angles. Whether using a brake press, rolling, hand-forming or using bolts to draw and form the piece in place, the angle and curves must be over-bent by as much as 75 to 100 percent to compensate for the springback effect of UHMW-PE. The potential for stress cracks can be reduced by using sheets 3/8" or thinner when cold-forming.

Spin or frictional welding can be achieved using a standard machine lathe capable of 550 to 560 rpm with the ability to stop turning the instant the brake is applied, and a metal backup plate of ¼" steel, with a diameter of slightly less than the flange OD. This kind of weld needs 48 hours of fully crystallize before the pipe can be put into service.

Butt, or hot plate wilding to join flat sheets into long pieces or coils, requires the use of a metal heating tool, coated with a non-stick agent, capable reaching the necessary temperature to bring the polymer to a molten state. This process requires the use of special wilding equipment to achieve uniform welds with a strength of between 85 and 100 percent of the original material strength.

Adhesives

The low coefficient of friction, non-porous surface of UHMW-PE makes it difficult for any adhesive to penetrate into the polymer and form a bond. Consult your adhesive supplier for recommended procedures to bond UHMW-PE to various substrates, although mechanical fasteners are recommended for most applications.

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