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ONLINE EXCLUSIVES**The Value of High-Performance Plastics in Medtech**

Their lightweight, corrosion-resistant, and heat-resistant properties enable more efficient, reliable, and durable medical components.

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In the search for materials that can advance medical device manufacturing, high-performance plastics (HPPs) excel where traditional materials fall short. These polymers provide superior performance for applications requiring high chemical resistance, excellent biocompatibility, and the option for overmolding to metal components. From cardiovascular implants to orthopedic

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This article explores the unique properties of HPPs, the complex processes required to manufacture them, and their transformative impact on modern medical engineering. It highlights how these materials solve critical challenges, the benefits they provide over alternatives like metal, and the specialized expertise needed to unlock their full potential.

What Are High-Performance Plastics?

HPPs are a category of polymers known for their exceptional ability to maintain their mechanical, thermal, and chemical properties when subjected to harsh operating conditions. The term can refer to specific polymer families, like polyetheretherketone (PEEK), or to standard polymers engineered with additives to boost their capabilities.

For instance, adding carbon fiber to polyphthalamide (PPA) significantly increases its strength, while incorporating polytetrafluoroethylene (PTFE) into PEEK reduces friction and improves wear resistance. The key is achieving the perfect balance between the base resin and the right fillers to create a material tailored for a specific application's demands. This customization allows HPPs to deliver targeted solutions where off-the-shelf materials cannot.

Key Advantages Over Traditional Materials

The shift from traditional materials like metal to HPPs is driven by significant functional benefits. These plastics aren't just substitutes; they're upgrades that enhance performance, efficiency, and longevity in demanding medical environments.

1. Lighter Weight and Improved Ergonomics

A primary advantage of HPPs is their lower density compared to metals. Replacing a steel component with a polymer alternative can reduce the overall weight, improving the ergonomics of handheld medical devices and reducing the load of implantable components.

2. Superior Durability and Performance

Unlike metal, HPPs are resistant to corrosion, which is a critical factor for implantable devices. This avoids issues like bio-toxicity and material degradation over time. They also offer excellent chemical resistance, withstanding the increasingly aggressive cleaning agents and disinfectants used in sterilization processes.

3. Customizable Properties with Fillers

Additives and fillers can be incorporated to tailor materials for specific needs. Some reduce friction and stiction, making devices easier to operate. Others enhance wear resistance or biocompatibility. Specialized fillers can even introduce thermal or electrical conductivity, enabling unique device functions like overmolded printed circuit board components.

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Common HPPs in Medical Applications

Many HPP materials can be used in various medical applications, depending on device requirements. Each offers a unique profile of properties suited for specific challenges.

- **Polyetheretherketone (PEEK):** Stands out for its exceptional mechanical properties, which closely mimic those of cortical bone. This material is biostable, radiolucent, and has received U.S. Food and Drug Administration (FDA) clearance for use in various implant types.
- **Polyphenylsulphone (PPSU):** Favored for its excellent toughness, high chemical resistance, and outstanding steam

- **Polysulfone (PSU):** Offers a blend of toughness and rigidity, biostability, transparency, and resistance to bodily fluid absorption.
- **Polyetherimide (PEI):** Recognized for its high heat resistance and robust mechanical performance.
- **Polyurethanes (PU):** Highly elastic and biostable materials with a proven track record in applications like lead insulation and vascular reconstruction.
- **Radiopaque Compounds:** Materials like barium sulfate (BaSO_4) are often incorporated into device components to provide contrast for medical imaging.
- **Custom Compounds:** Formulations with high-filler content are often developed to meet specific functional or performance requirements in advanced medical devices.

Overcoming Manufacturing Challenges

Creating parts from HPPs, especially those enhanced with additives, involves overcoming several technical hurdles related to tooling, temperature control, and shrinkage management.

Because HPPs can be extremely abrasive, specialized screw and barrel systems are often required to protect machinery. Their unique molecular structure can also make achieving optimal material flow difficult in multi-cavity molds. This necessitates precise temperature management throughout the molding process.

Unlike standard polymers that melt between +392°F and +527°F/+200°C and +275°C, HPPs have much higher melt temperatures, sometimes reaching up to +797°F/+425°C. Maintaining consistent temperatures across all mold components is challenging. Advanced programmable thermal control systems are needed for reliable operation. Careful control of tool temperatures is key to ensuring proper mechanical properties, cycle efficiency and part crystallinity.

Additionally, robust cooling strategies are essential to minimize warping, especially in flat, high-precision parts. As molded parts cool, they shrink in volume. Designing molds that account for this shrinkage while optimizing cooling requires substantial expertise and hands-on experience.

The Importance of an Expert Partner

Successfully producing HPP components requires more than just the right equipment. It demands a partnership with a supplier that brings deep expertise in tooling design, process simulation, and advanced material formulation.

We have invested in these capabilities, combining infrastructure—such as all-electric machines with AI-driven controls and advanced process monitoring—with deep engineering knowledge. This allows us to deliver high-volume, tight-tolerance HPP components that meet demanding industry standards.

Case Study: A Redesigned Minimally Invasive Device

A customer sought to enhance a minimally invasive device used to treat nerve damage. The goal was a complete redesign focused on improving ergonomics, reliability, and surgical precision, which required a new handle and refined locking mechanisms based on direct feedback from physicians.

The project involved a sophisticated mix of thermoplastic materials—including polycarbonate (PC), acrylonitrile butadiene styrene (ABS), nylon, and PEEK—across fifteen unique molded components. Our experts leveraged specialized techniques like overmolding on metal and plastic substrates, ultrasonic welding, and precise pin insertion. By taking on complex kitting and assembly responsibilities, we streamlined the production process and helped bring the validated device to full production.

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HHPs represent a significant leap forward in material science. Their ability to reduce weight, resist corrosion, and withstand extreme temperatures allows medtech engineers to design more efficient, reliable, and durable life-saving components.

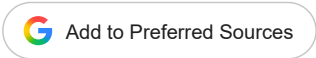
While the manufacturing challenges are substantial, they can be overcome with specialized expertise, advanced technology, and a collaborative partnership approach. As medtech OEMs continue to push the boundaries of what's possible, HPPs will be an essential tool for turning ambitious designs into reality.

Vincent Etchen is an expert at Trelleborg's River Falls, Wis. facility, which specializes in advanced engineering capabilities, custom material formulations, and partnerships with tooling and material suppliers to deliver high-volume, tight-tolerance products from highly engineered polymers. He helps manage material conditioning with centralized drying and conveying systems supporting consistent part quality at high processing temperatures.



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