Exploring Exotic Materials and Technologies in Medical Device Injection Molding

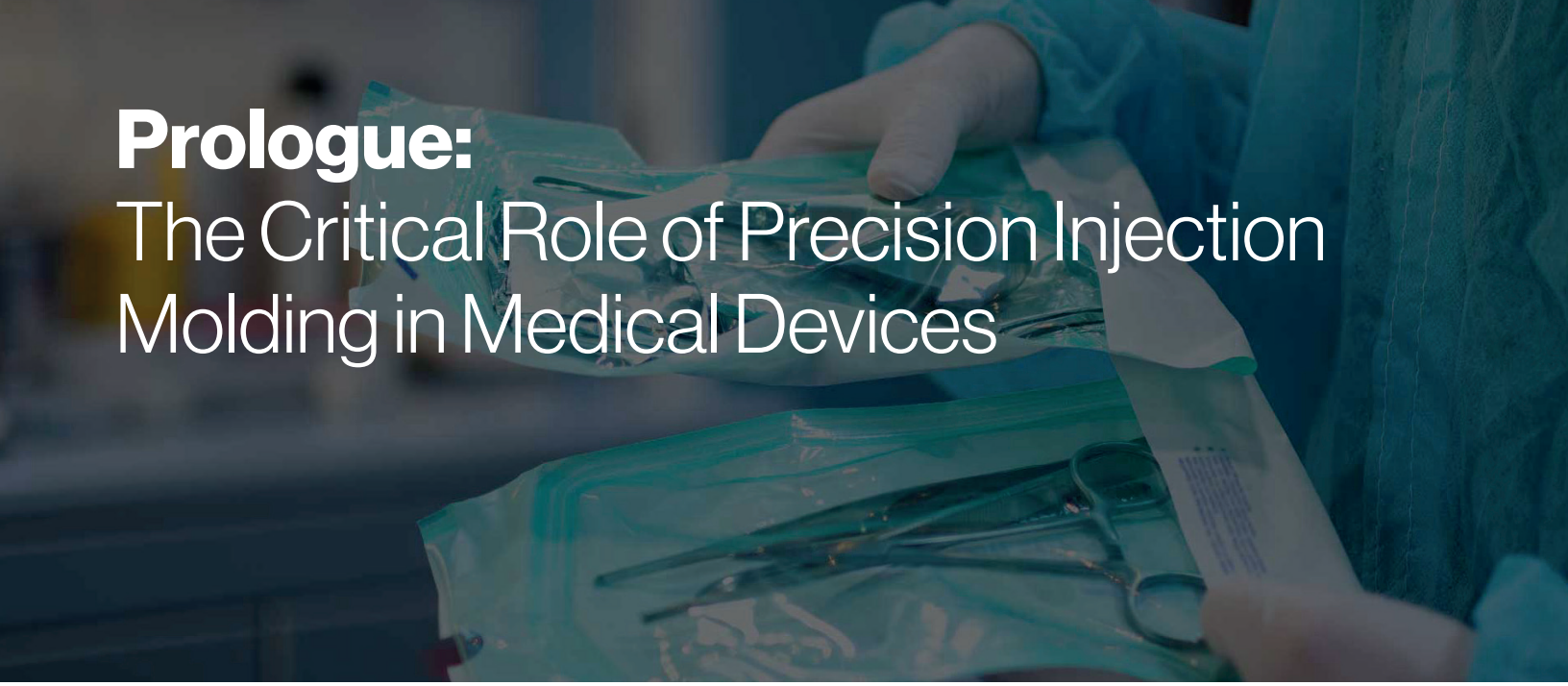
vantiva

Introduction

As science marches on, the manufacturing industry marches with it. Staying on the bleeding edge of the medical device industry demands constant attention to the latest developments in thermoplastic materials as well as injection molding technology.

New developments in thermoplastics provide new avenues for medical device manufacturers to explore—but also require an understanding of their unique requirements.

From optically transparent Cyclic Olefin Polymers and Copolymers to sustainable Polyhydroxyalkanoates, set off on an adventure to explore the advanced and exotic thermoplastics of tomorrow and their applications in the medical device market—as well as the unique technological considerations and demands that come part and parcel with injection molding these exotic materials.



Prologue: The Critical Role of Precision Injection Molding in Medical Devices

Precision injection molding plays an essential role in the manufacturing of high-quality, reliable medical devices. Through the use of the latest in cutting-edge technology, precision medical injection molding enables medical device designers to consistently and reliably produce parts with intricate and complex features on a microscopic level with extremely tight tolerances out of a wide range of materials.

Precision injection molding provides the ability to choose materials based on a wide range of desirable characteristics and specific medical characteristics, all the while ensuring batch-to-batch consistency and minimizing material waste. Ultimately, injection molding capabilities provide medical device manufacturers with a cost-effective, efficient way to achieve high throughput for rapid prototyping and final production at any scale.

Precision injection molding can make use of a vast range of thermoplastic and thermosetting resins. Choosing the right materials for a given application demands a deep knowledge of the properties of a given material, its costs, and ease of use—as well as any unique manufacturing requirements.

In the following chapters, we will explore three such advanced resins that are seeing an explosion of use in the modern medical device market.

Chapter One:
Taking Medical Precision Molding Into Warp Speed With COP

Cyclic Olefin Polymer (COP), the first of three materials we'll be exploring in this book, is a transparent polymer that stepped up to be the hero the world needed in a time of crisis.

During the COVID-19 pandemic, the US federal government's Operation Warp Speed had its work cut out for it—pouring tens of billions of dollars to fund vaccine development and distribute them in one of the world's largest vaccine rollouts in history.

Operation Warp Speed had many challenges to overcome—including developing the materials necessary to distribute and deliver the vaccines to the American populace. Most vaccines are administered using pre-filled syringes in glass vials. However, glass vials were in short supply due to massive demand, and medical manufacturers found COP to be more than an effective substitute.

What You Can Make With Injection Molded COP

Aside from its transparency, COP has many other glass-like properties, including strength, clarity, and inertness. Unlike glass, though, it can be processed and shaped like any other thermoplastic. While glass containers and COP can both be shaped using blow molding, manufacturers can also use a wide range of other methods to shape it into intricate and complex designs.

COP's high dimensional stability means it retains its shape extremely well even when exposed to fluctuations in temperature and humidity, and it can withstand various sterilization methods, including gamma irradiation, ethylene oxide sterilization, and autoclaving. It is also chemical resistant and biocompatible.

As a result, COP and its related thermoplastic polymers, including COC, are extremely useful for a wide variety of medical devices. While it proved itself a hero in supplying suitable vials for vaccine delivery, its other uses included syringes, vials, diagnostic consumables, surgical instruments, and drug delivery systems.

As a result of its stellar performance during Operation Warp Speed, the appetite for COP as a glass substitute for medical devices and equipment is growing. As the regulatory environment broadens, we expect the coming years to see greater and greater demand for medical devices made from injection-molded COP.

Chapter Two: Molding Better Medical Optics With COC

Cyclic Olefin Copolymer (COC) is a thermoplastic in the family of COP with its own useful properties, most notable being its transparency and low birefringence.

Birefringence refers to a material's refractive index depending on the polarization and propagation direction of light. In other words, when an optically transparent material has a high birefringence, polarized light seen through it will appear distorted.

Sometimes this can be a desirable property, since materials with a high birefringence can be used in many types of scientific research. However, high birefringence is less desirable when you need to see clearly through a material. For example, the low birefringence of COC makes it ideal as a replacement for glass in many optical devices used in the medical field.

In addition, like many other new and advanced thermoplastic polymers, COC is highly resistant to chemicals and solvents. It also boasts low water absorption properties, high heat resistance, and biocompatibility.

What You Can Make With Injection Molded COC

COC's unique properties make it ideal for many types of medical devices, equipment, and products where optical clarity is highly desirable. Some of these include:

- Sterile packaging for medical devices and pharmaceutical products
- Microfluidic devices used in medical diagnostics and analysis
- Laboratory consumables, including Petri dishes, well plates, and other disposable labware
- Test kits and assay devices
- Single-use surgical instruments
- Dental devices
- Lenses for endoscopes or medical cameras

While COC, like most advanced and exotic thermoplastic polymers, has its own demands for more specialized injection molding equipment (to be discussed in a later section), it is easy to mold into complex shapes with intricate details on incredibly small scales using various manufacturing processes—which is one of the properties that makes it ideal for a wide range of microfluidic chips.

Chapter Three: Feeding the Demand for Sustainable Medical Devices With PHAs

Medical waste is a significant issue across the global healthcare industry. While medical waste is inevitable—you would not want to reuse certain pieces of equipment or materials once they've been used—the medical industry has a responsibility to minimize waste and prioritize sustainability wherever possible.

Polyhydroxyalkanoates, or PHAs, are a type of thermoplastic that are notable for being not only biocompatible but also biodegradable—a factor that makes them significantly desirable as a material for more sustainable medical devices.

PHAs, unlike other thermoplastics, can be produced from natural or organic materials, such as plant sugars or vegetable oils. As a result, medical devices and equipment made from PHAs can also be broken down into harmless natural byproducts by microorganisms once they reach the end of their service lifetimes.

Due to being produced from renewable resources, PHAs result in a smaller carbon footprint compared to traditional petroleum-based plastics and promote a circular economy by providing a sustainable end-of-life option for medical devices. Proper disposal and composting of PHA-based products can contribute to waste reduction and environmental conservation.

What You Can Make With Injection Molded PHAs

Just because it is a sustainable material does not entirely explain the utility of PHAs in the medical industry. There are plenty of sustainable materials that are not suitable for use in the medical industry. However, PHAs are not only sustainable, but biocompatible, sterilizable, and generally non-toxic—all ideal properties for medical devices.

PHAs can be injection molded to produce a wide range of medical devices and equipment with intricate shapes and complex geometries. Some of these include:

- Surgical instruments, such as clamps, forceps, and scalpel handles
- Disposable syringes and needles, as well as other disposable medical devices or labware
- Catheters and tubing
- Implantable medical devices, such as drug delivery systems or even orthopedic implants
- Orthodontic devices

While PHAs offer several unique advantages, it's important to consult with experts about their performance and safety in specific medical device applications, since there is a wide range of PHAs with varying chemical properties.

Chapter Four:
Processing Exotic Thermoplastics With Cutting-Edge Technology

The aforementioned advanced new thermoplastics—COC, COP, and PHAs—are incredibly useful for medical device manufacturing in their own ways, but making use of them isn't quite as simple as it is with traditional thermoplastics. While these exotic thermoplastics can easily be shaped into complex and intricate small parts with the right injection molding tools, they also demand additional equipment.

In order to injection mold thermoplastics, their temperatures must be raised to their melting point, changing them from solids into liquids. The liquids must then be injected into a mold and cooled throughout the molding process. The need for cooling equipment is essential for injection molding operations that use traditional thermoplastics.

However, some exotic thermoplastics not only have higher melting points than traditional thermoplastics, but also need to be kept hot through the entire molding process and cooled afterward. This need calls for ancillary equipment—heating equipment that maintains a desirable temperature as the thermoplastics are molded.

Many exotic thermoplastics also have unique demands for post-molding drying and precise processing to ensure stability and avoid the potential negative effects of excess moisture or unwanted crystallization. They also often require unique post-processing considerations.

Making the most of these advanced materials to produce cutting-edge medical devices requires strategic partnerships with injection molding experts. These experts can significantly de-risk the long and often challenging process of bringing new medical devices to market. Contract manufacturers in the medical injection molding space are committed to maintaining advanced and specialized equipment and a vast and deep knowledge of medical industry concerns and requirements.

Epilogue:
Vantiva Precision BioDevices – A Long Legacy of Precision and Innovation

With a legacy that traces back to Technicolor's founding in 1921, Vantiva Precision BioDevices builds its precision injection molding capabilities on a solid foundation of manufacturing expertise for audiovisual duplication and data storage.

Technicolor SA, a highly successful film processing and video and audio duplication firm, produces over 90% percent of the world's supply of CDs, DVDs, Blu-ray discs, and other optical discs, building extensive high-volume manufacturing and global distribution logistics capabilities. This same foundation of video and audio storage media innovation forms the basis of Vantiva Precision BioDevices's current capabilities.

Optical discs are manufactured in much the same way as precision injection molded parts—assembled in multiple layers from polycarbonate with nanometer-scale tolerances for the peaks and valleys that store digital data, in much the same way grooves on a record store sound. The utmost in consistent and reliable precision molding, manufacturing, and polymer bonding capabilities are required to ensure uniform disc thickness and maximum flatness.

Similarly, many medical devices consist of molded parts that have been assembled, UV-cured, and hermetically sealed. By leveraging decades of existing precision molding technology and distribution expertise, we are capable of bringing high throughput manufacturing capabilities, cutting-edge technical knowledge, and worldwide supply chain logistics to our customers seeking to break into the market of medical devices at any scale.

Vantiva Precision BioDevices's century-long legacy of pushing the envelope of optical disc manufacturing, digital video processes, and technological solutions enables us to help our customers take their ideas for innovative medical products to market at any scale, while staying mindful of regulatory compliance requirements every step of the way.

Quality Control in Medical Device Manufacturing

One of the most significant factors that set Vantiva Precision BioDevices apart from other strategic manufacturing and distribution partners is our focus on maintaining high standards of cleanliness throughout the entire manufacturing process, from injection molding to assembly to distribution.

In most other industries, especially when dealing with the exotic materials we've explored thus far which require heating through the molding process, the cleaning of injection molded parts is handled in post-processing. Post-process cleaning adds another stage to the development of medical equipment, for which cleanliness, as the saying goes, is next to godliness.

However, our facilities make extensive use of controlled clean room environments throughout the entire process of molding, assembling, curing, packaging, and handling, with production processes certified to rigorous ISO 13485:2016 standards.

The extensive use of clean room facilities throughout the development process eliminates one particular post-processing step, improving efficiency and quality control and ensuring adherence to strict regulations and standards for medical products.

Bring your device to market with precision, accuracy, and global logistics expertise.

From microfluidics to other applications for injection molding in the medical industry and other scientific fields, Vantiva Precision BioDevices leverages a firm commitment to maintaining deep industry knowledge, manufacturing expertise, and logistics expertise to help you bring new products from back-of-a-napkin designs to products on the shelves at any scale without risk.

To get started, contact our engineers today.

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