MORGAN
POLYMER SEALS

WHITE PAPER

Rubber Injection Molding

AN OVERVIEW OF COMMON MOLDING PROCESSES FOR HIGH-PRECISION GASKETS AND SEALS

MORGAN POLYMER SEALS

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INTRODUCTION

Many of the objects we see and use every day, from household goods to automotive parts and medical devices, are the result of injection molding manufacturing. Molding is the process in which a manufacturer uses a fixed frame, also known as a mold or tool or die, to shape liquid or pliable raw material into a finished product. It is most often used in mass-production processes to create part quantities in the thousands or millions.

Most people only associate injection molding manufacturing with plastic. After all, plastic bottles are one of the most common products manufactured by the billions each year. However, injection molding is not limited to plastic.

For the purposes of this white paper, we will focus on rubber injection molding, specifically the use of synthetic elastomers such as EPDM, NBR, ACM, and FKM. We will discuss the three most common molding methods for rubber and take a closer look at injection molding.

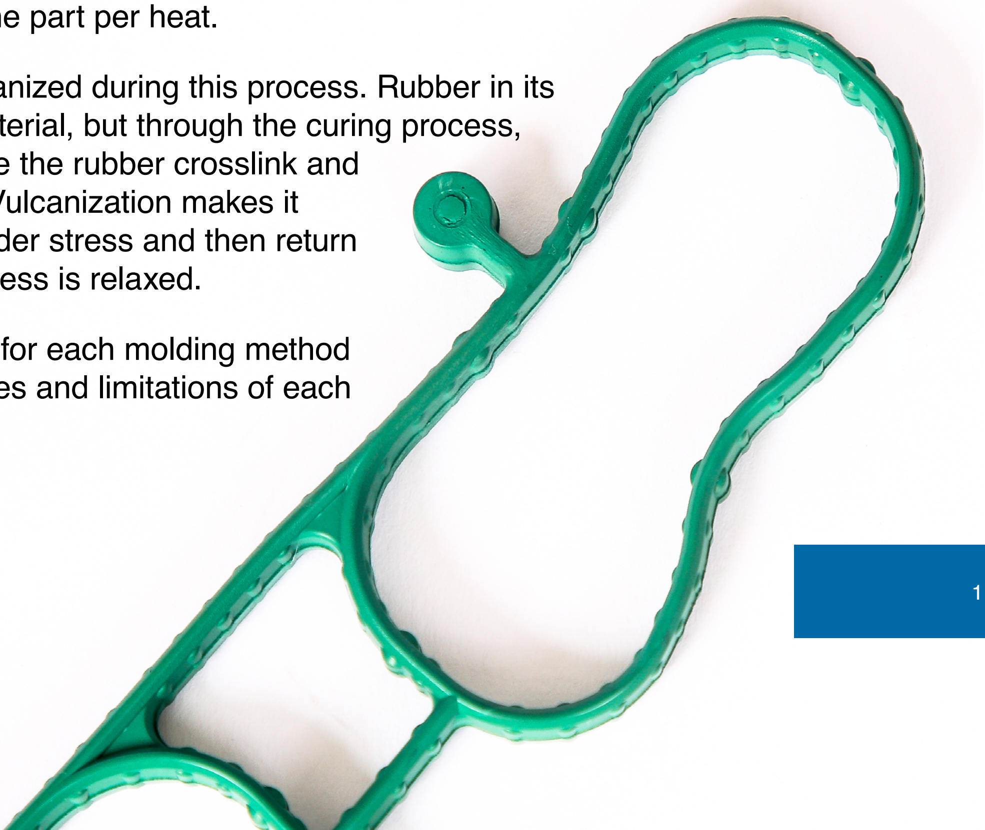
MOLDING PROCESSES

The three most common processes for rubber molding are compression, transfer, and injection molding.

From a high level, each method follows a similar workflow: rubber is heated, either before or during the process, and forced into a mold. It then conforms to a single mold cavity shape, producing only one part per "heat", or molding cycle, or multiple cavities, producing more than one part per heat.

The rubber is also cured or vulcanized during this process. Rubber in its natural state is not an elastic material, but through the curing process, the polymer chains that compose the rubber crosslink and no longer move independently. Vulcanization makes it possible for rubber to deform under stress and then return to its original shape when the stress is relaxed.

We will define how the workflow for each molding method differs and explain the advantages and limitations of each process.



COMPRESSION MOLDING

Compression molding is accomplished in a compression press consisting of a top and bottom platen that are forced together via a hydraulic cylinder or ram. In this process, an operator places a rubber preform in an open, heated mold, most often made up of a top and bottom plate containing the part geometry. The mold is closed in the press and the press compresses the mold and forces the rubber to conform to the shape of the mold cavities. Heat and pressure are maintained until the rubber has vulcanized to create the final product.

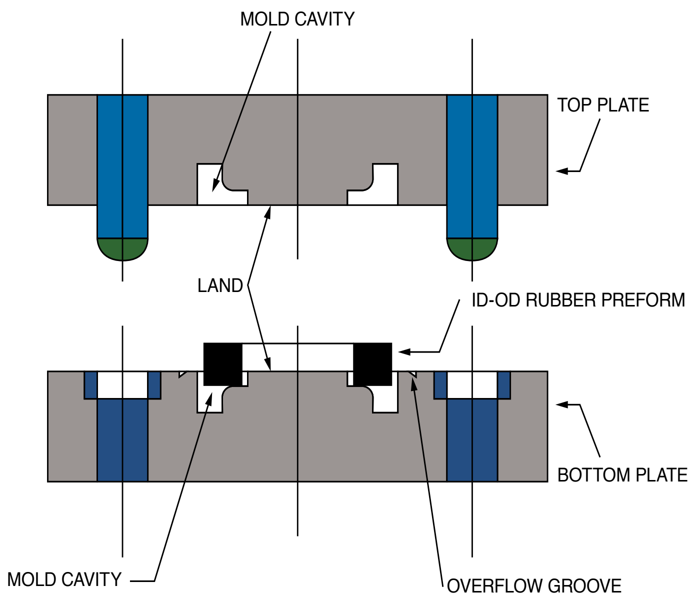


Figure 1: Open Compression Mold

The advantage of compression molding is its ability to mold relatively simple parts with comparatively low mold and equipment costs and fast setup times. Compression molding is one of the lowest-cost molding methods with regard to tooling and equipment. However, compression molding is primarily limited to compact parts with generally simple geometries. Also, production costs can climb higher due to slower cycle times and the need to utilize an excess of raw material to assure the part is complete.

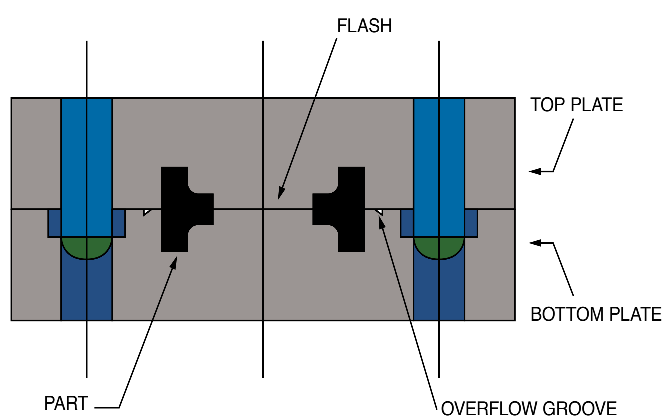


Figure 2: Closed Compression Mold

TRANSFER MOLDING

Transfer molding is a hybrid process between compression molding and injection molding where pre-heated rubber is forced into a heated mold, which, unlike compression molding, is closed. As the compression press closes, it forces the material from a chamber, known as the pot, though sprue or feed holes in the top of the mold into the mold cavity. Once filled, the rubber cures inside the mold cavity. Transfer molding can be performed utilizing a “hot” pot, where the excess material in the pot is completely cured in each cycle. It can also be performed utilizing a “cold” pot where the rubber is warmed to promote flow, but not heated to the point where it cures in the pot. The rubber waste in a hot pot process is much greater than in a cold pot process.

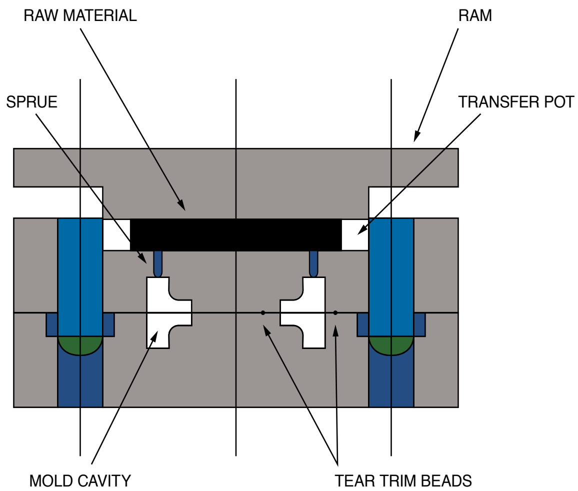


Figure 3: Open Transfer Mold

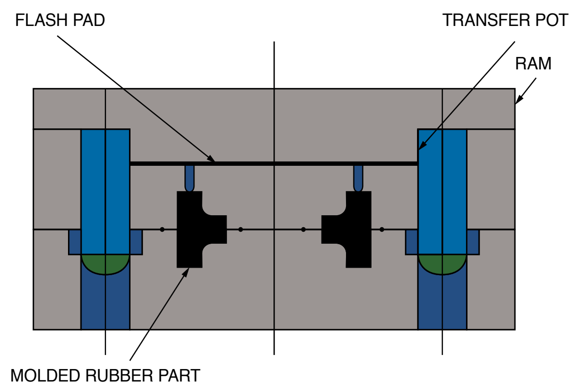


Figure 4: Closed Compression Mold

Examples of transfer molding applications are vibration isolator grommets for engine fastening systems and electrical connector seals.

Compared to compression molding, transfer molding offers many benefits, such as shorter production cycle times, the ability to mold more complex parts, less material waste, and better heat-to-heat product uniformity. Transfer molding can also lend itself to tools with a higher number of cavities since it does not need to place individual preforms into each cavity, thereby creating a much faster cycle time. However, the tooling costs for transfer molding are higher than those for compression molding due to the more complex mold and equipment. So, while transfer molding may deliver shorter production cycle times than compression molding, it may be slower than injection molding.

INJECTION MOLDING

Injection molding is a manufacturing process for producing parts by injecting pre-heated material into a mold using an injection unit consisting of a screw and piston. Injection presses offer significantly more control over all process parameters, including the material's temperatures at various points in the process and the speed and volume of the material introduced into the mold. It is a more advanced iteration of transfer molding, utilizing special equipment, and offers unique benefits, especially forthose looking to produce a high volume of complex precision parts.

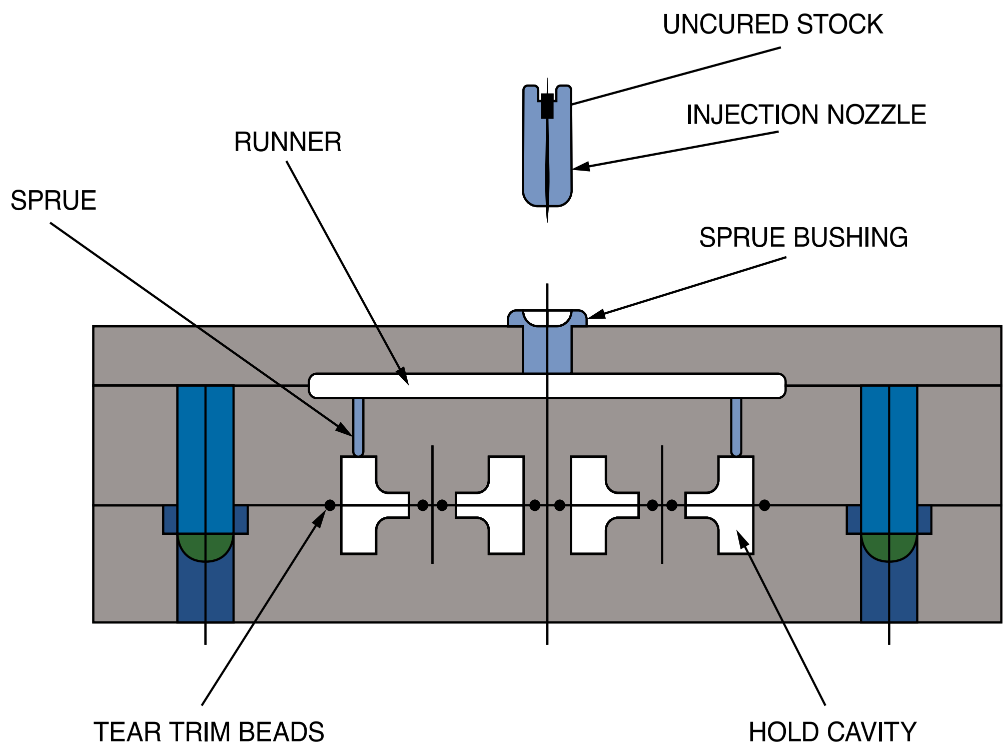


Figure 5: Open Injection Mold

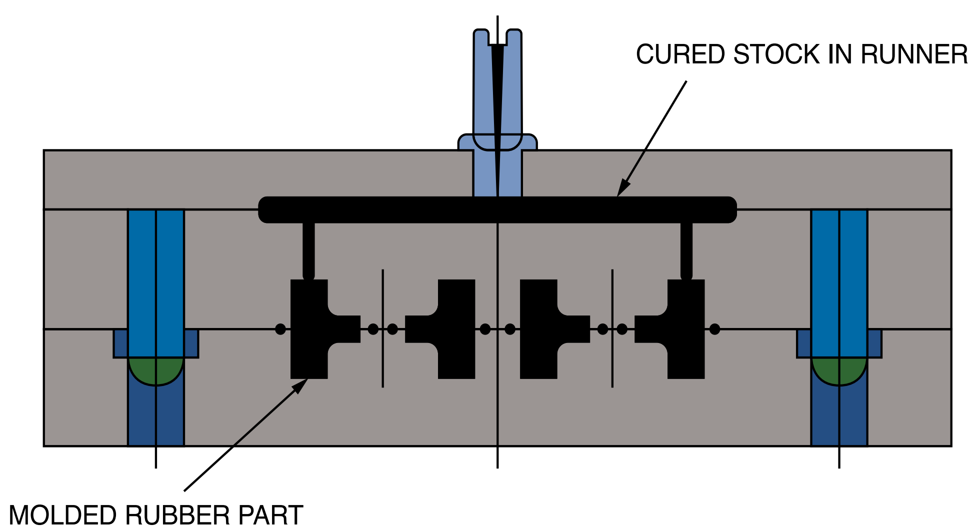


Figure 6: Filled Injection Mold

WHAT IS INJECTION MOLDING?

Injection molding is one of the most popular processes used to achieve high quality and cost-effective parts. As stated previously, parts are produced by injecting material into a mold. Specifically:

Step 1: A rotating extruder screw automatically feeds a ribbon of raw material into a heated barrel where the rubber is pre-heated to the optimum temperature. With silicone rubber, a secondary ram known as a "stuffer" introduces a bulk quantity of material into the injection unit.

Step 2: A hydraulic piston injects the pre-heated and masticated material into a hot mold cavity.

Step 3: Now, inside the mold cavity, the material cures quickly due to the heat produced while quickly entering the mold cavity, combined with the mold temperature and pressure.

BENEFITS OF USING INJECTION MOLDING

The popularity of injection molding is due, in part, to several unique advantages, which include:

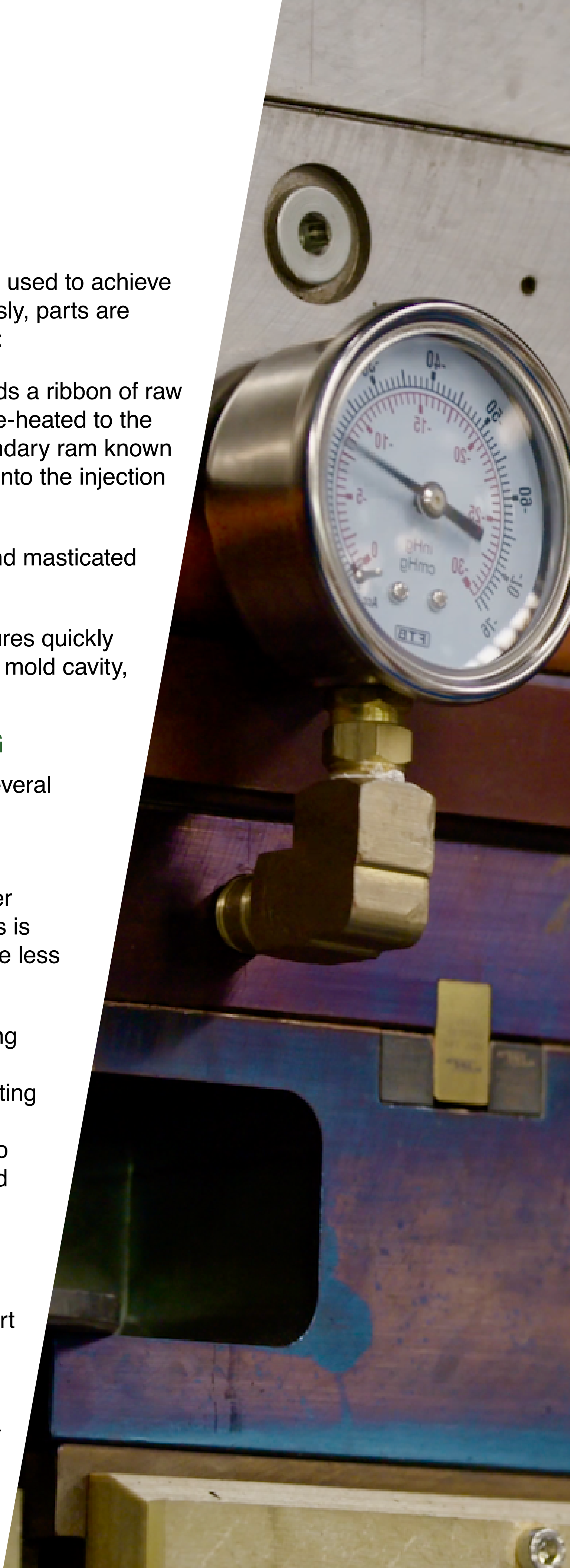
HIGH PRECISION

Injection molding can achieve more complex and tighter tolerance geometries than other molding methods. This is because an injection press forces heated, and therefore less viscous, raw material into a mold under high pressure.

Material handling also plays an integral part in improving product precision. Instead of an operator handling the material, the charging of the injection barrel by the rotating screw is automated, and therefore, the volume of the injected material is exact. Material feed automation also contributes to more consistent cycle times with reduced shot-to-shot size variation.

REPEATABILITY

When performed by experts, the injection molding process is highly controlled and repeatable. Once a part is successfully produced, the following parts will be nearly identical to the original. And because injection molding is a more automated process, there is no manual handling of materials or molds, removing many of the process variables caused by press operators.



Moreover, the faster cycle times for injection molding means that the molding tool spends less time open. Keeping the tool closed creates a more stable heat profile within the tool and results in better cycle-to-cycle consistency.

MINIMAL MATERIAL WASTE

Some forms of injection molding can further reduce material waste by employing a “cold runner” system. In basic injection molding, the rubber is introduced through a central injection point in the middle of the tool and fed through a gallery of hot runners to various points of the part geometry. Depending upon the complexity and size of the part, this can lead to a significant amount of waste rubber in these cured runners.

One way to mitigate this waste is by using a “cold runner” system where a cooled manifold splits the central flow of material into multiple streams kept at a temperature below the cure point. These multiple streams can then feed the raw material into several points in the part cavity, significantly reducing or, in some cases eliminating the waste of cured sprues. To further advance a cold runner system, valve gates systems can be employed to introduce the raw material directly into the part cavity and then shut off the rubber flow through the use of a pintle valve.

These methods reduce material costs but also increase the complexity and cost of the tooling. So a valve-gated cold runner system is primarily considered for high-volume programs where the material cost savings justify the substantial tooling investment.

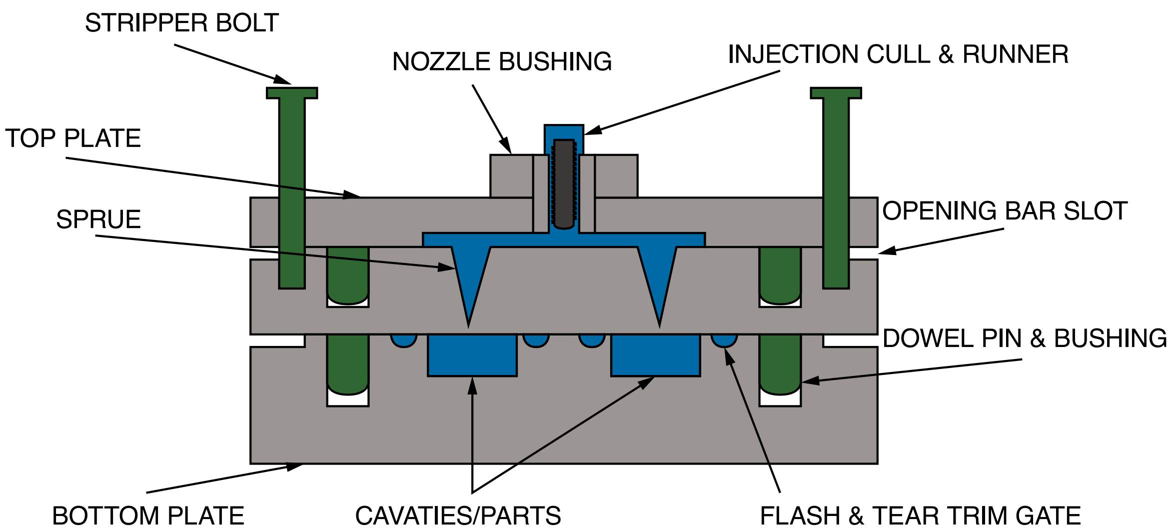


Figure 7: Injection Molding Equipment

INJECTION MOLDING EQUIPMENT

Of significant importance in the effectiveness of the injection molding process are the capabilities of the injection press itself. A well-designed injection press should have some key features that promote satisfactory injection molding such as:

ENERGY EFFICIENCY

With their collection of pumps, heaters, motors, and control systems, large injection presses consume significant amounts of electricity. So manufacturing with quality machines that run efficiently can help mitigate energy costs.

CAPACITY EFFICIENCY

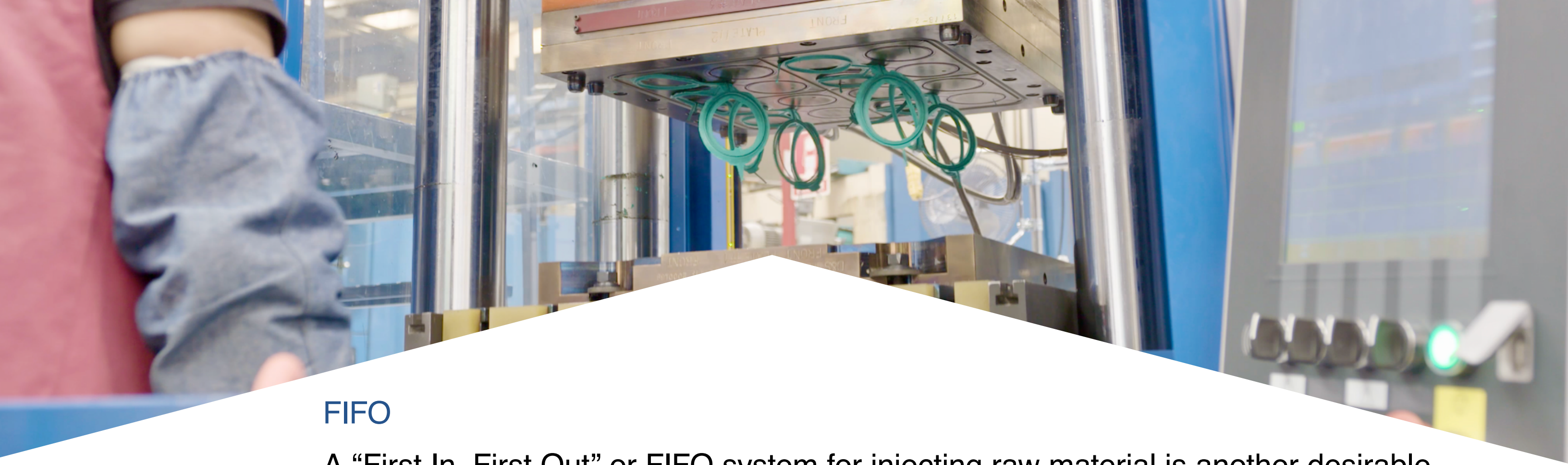
Injection presses can also take up large amounts of space in a manufacturing plant, especially horizontal presses. When choosing an injection press, vertical presses should be considered to help reduce the physical footprint of the machine and leave more space on the manufacturing floor.

PRESS MAINTENANCE

Injection presses require maintenance by expert engineers to ensure continued quality output. To reduce maintenance costs across a line of multiple presses, a molder should consider sourcing all its machines from a single press manufacturer. This practice allows the rubber molder to stock fewer spare parts than molders who maintain equipment from multiple press makers.

FULL-SIZE RAM

The main hydraulic piston or ram applies the force to close and apply the full clamping pressure to the mold. A press that utilizes a full-sized hydraulic ram will more evenly distribute the clamp tonnage to the platen/mold surfaces mitigating any bending that would lead to tool wear and flashing. A full-size ram will help to maximize the life of the mold, ensure satisfactory parts over the long term, and protect customers' tooling investment.



FIFO

A "First In, First Out" or FIFO system for injecting raw material is another desirable attribute for injection molding equipment. The ability for an injection unit to take up raw material into the injection barrel and then inject that material into the mold in a FIFO order ensures the press injects only fresh material for each heat. A FIFO system prevents the potential introduction of old compounds that can lead to part defects and production delays.

WHEN TO USE INJECTION MOLDING

As mentioned previously, deciding which molding process is ideal for achieving quality rubber parts is complex. However, there are some generalizations for when injection molding is the best choice.

HIGH-VOLUME PRODUCTION

Injection molding is primarily ideal for producing part quantities in the hundreds of thousands or millions. While the setup costs and lead times are substantial, injection molding becomes a largely automated process with short cycle times once the upfront work is complete.

COMPLEX PRODUCTS

Injection molding can achieve a higher degree of product complexity compared to compression and transfer molding. This is because injection machines feed the rubber into the tool in a precise, automated manner. In contrast, compression and transfer molding rely on the manual placement of rubber into the tool.

DETERMINING WHICH MOLDING PROCESS TO USE

There are numerous factors to consider when deciding on which of these three molding processes to use: part size and design, material selection, product quantity, setup cost, and more. However, there is no decision matrix or if-then algorithm that can identify which process is ideal. Ultimately, this decision should be made only by experienced manufacturers who have the substantial technical skill and capabilities required to mold high-precision parts.

At Morgan Polymer Seals, we understand that choosing the proper molding process is both a science and an art. Our company founder, Kevin Morgan, is an engineer with more than 40 years of molding experience, and we employ a team of technical experts and design engineers who understand the benefits and limitations of each process. Since 1997, we have manufactured quality rubber products for OEMs like Ford, and GM, delivered across the globe from our headquarters in Baja California, Mexico.

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