Rosti

From concept to reality



Plastic Injection Molding 101:

From Design To Production

A COMPANY WITHIN

NORDSTJERNAN

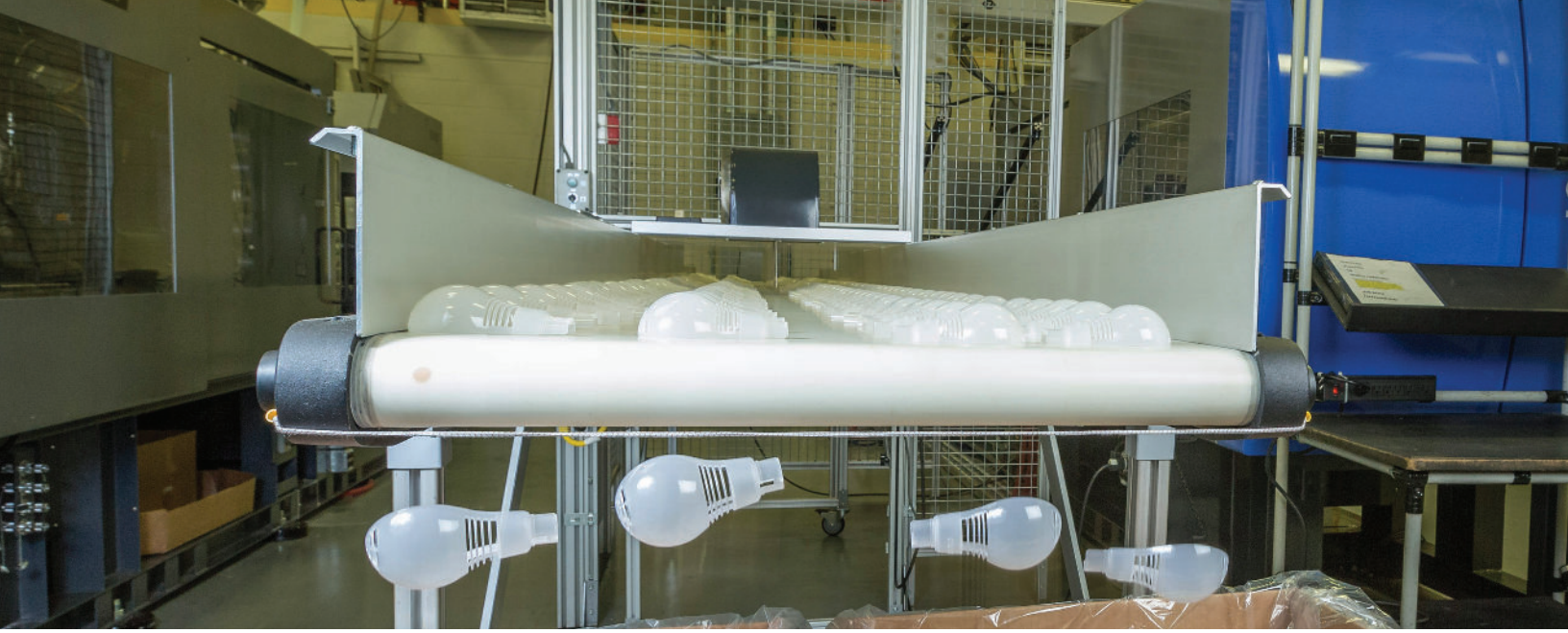


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What is plastic injection molding?

Plastic injection molding is the most commonly used manufacturing process for the production of small, medium, and large-sized plastic parts. The process utilizes an injection molding machine, raw plastic material, and a mold. The plastic is melted to molten heat in the machine and then injected into the mold, where it cools and solidifies into the final part.



Plastic parts are incorporated into products found in almost every industry, including automotive, medical, small engine, plumbing, industrial, agriculture, and more. Using the latest plastic injection molding technologies and production processes, manufacturers can produce ultra-high qualities of plastic parts with the highest level of precision and speed.

Like many manufacturing processes, plastic injection molding has evolved greatly over the last 20 years. Once driven by time and pressure, essential elements of molding are now position, peak pressure, and process repeatability. According to a feature in Plastics Today, scientific molding expert John Bozzelli, and Rosti partner RJG, were major pioneers in the development of decoupled and data-driven or "scientific molding." Plastic injection as an "art" gave way to plastics processing as a science of repeatability, standardization, and part success.

Make-up of an Injection Molding Machine:

An injection molding machine is made up of a material hopper, barrel, an injection ram/rotating screw, heating device, moveable pattern, ejectors, and mold inside the mold cavity. Generally, machines work in a horizontal manner.

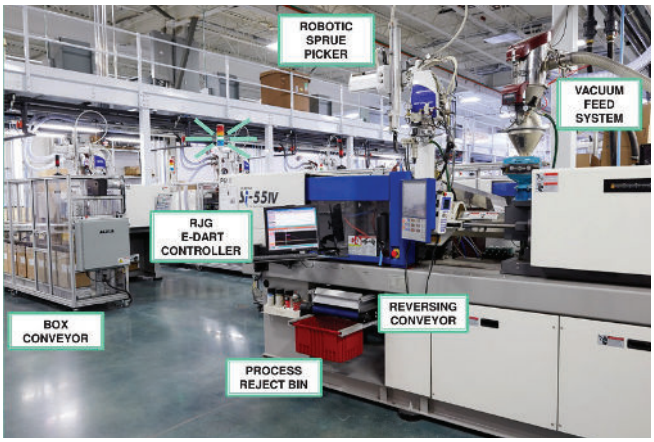
The function of the clamping unit is opening and closing a die, and the ejection of parts. There are two types of clamping methods - a toggle type shown and the straight-hydraulic type, which allows a mold to directly open and close with a hydraulic cylinder.

The hopper is located at one end of the barrel, and the hydraulic rotating screw runs by electric motor. The screw is rotated to melt plastic introduced from the hopper. After the required amount of molten plastic is accumulated, the injection process is started. On the other side of the barrel, a mold is attached.

While molten plastic is flowing in the mold, the injection molding machine controls the speed of the screw (or the injection speed). It also controls pressure as plastic fills the cavities. Speed control and pressure control is set where screw position and injection pressure reaches a certain value.

Make-up of an Injection Mold:

Molds for plastic injection consist of high-strength metal components that have been machined to operate in two halves. The molten plastic flows into a mold through a sprue and fills cavities by way of runners and gates. Then, the mold is opened after the cooling process and the ejector rod of the injection molding machine pushes the ejector plate of the mold to eject moldings.

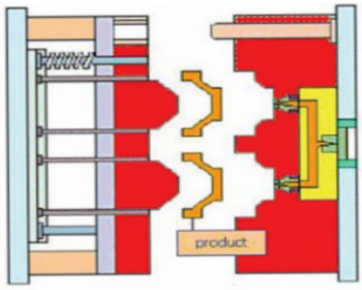


The composition of an injection mold is significant in order to function properly during the injection molding process. Although molds typically have two halves, a cavity side and a core side, there are often dozens of precision features that make up each half.

Almost all of the machined mold components that function to manufacture a custom-molded part are machined to tolerances of less than +/- 0.001″ or 0.025mm, one-third of the thickness of a piece of copy paper.

What is the plastic injection molding process?

The injection molding process cycle is quite short, usually lasting between six seconds and two minutes. The process consists of the following stages:



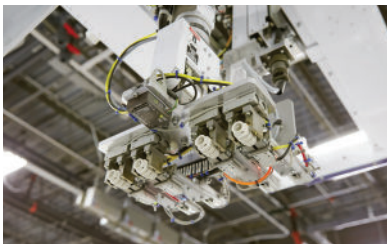
Clamping: Prior to the injection of the heated plastic material into the mold, the two halves of the mold must first be securely closed by the clamping unit. The tremendous force of the clamping unit pushes the mold halves together and keeps the mold securely closed while the material is injected. The time required to close and clamp the mold is dependent upon the machine - larger machines with larger openings require more time.

Injection: Raw plastic material, usually in the form of tiny pellets, is fed into the injection molding machine and conveyed or augered towards the mold by the injection unit. The plastic material heats up by temperature and compression as the screw conveys the plastic pellets through heated zones of the machine barrel. The amount of melted plastic that is conveyed to the front of the screw is an exact portion that will become the final part after injection. The amount of material that is injected is referred to as the shot, and once fully clamped, the machine injects the material into the mold. Injection time can be estimated by the shot volume, injection pressure, and part geometry.

Cooling: The molten plastic inside the mold cools as soon as it makes contact with the interior mold surfaces. The cooling process solidifies the shape and rigidity of the newly molded plastic part. It's important to note that part shrinkage may occur during the cooling process.



The mold can not be opened until the required cooling time has elapsed. The cooling time requirements for every plastic molded part depend on the thermodynamic properties of the plastic, wall thickness of the part, and the dimensional requirements for the finished part.



Ejection: Once the part has cooled inside the mold, it may be ejected from the mold via the ejection system. Mechanical features of an injection molding machine push the part out of the mold using the necessary force for ejection. During this process, the machine has prepared a new shot of plastic, and once the part is fully ejected, the mold is ready for the next part.

What occurs during plastic injection molding post-processing?

Following the injection molding process, post-processing applications are often required. This may include secondary processes for decorative or functional purposes. With injection molding, there are six common types of injection molding post-processing applications.

- Gate Trimming
- Painting
- Laser Marking
- Pad Printing
- Heat Staking
- Ultrasonic Welding



What are plastic injection molding machine classifications?



Knowing the approximate size of the press size required to produce your precision parts is essential in determining the best injection molding partner based on the press capacity available. For example, larger presses cannot accommodate smaller molds because they have far too much shot capacity.

Injection molding machines are classified or rated based on tonnage, or more specifically, the clamping pressure or force. Presses can run in size from less than 5 tons of clamping pressure to over 4000. The higher the press ton rating, the larger the machine. A machine rated for 400 tons can deliver 400 tons of clamping pressure. This pressure keeps the mold closed during the injection process, and too much or too little pressure can cause quality issues.

Plastic Components, Inc. offers press sizes ranging from 35-ton up to 500-ton in Wisconsin and up to 1250-ton in North Carolina.

Want to learn more about material shrink rate calculation?

View Rosti's Material Shrink Rate Guide here.

What are the advantages of plastic injection molding?

The aesthetic and functional versatility of plastic injection molding makes it an excellent choice to manufacture a vast array of parts and products. Key advantages include:

Speed and cost-effectiveness

Injection molding is a very simple process that can be highly automated, so it is very efficient. This reduces production time, which may result in greater revenue as well as cost savings.

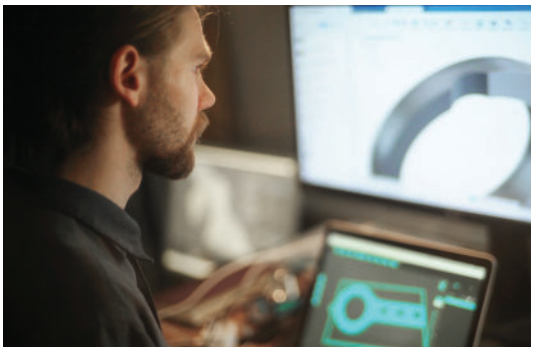
Lightweight

Plastic is strong, yet it is considerably lighter than metal or other common parts materials. For this reason, many manufacturers consider metal to plastic conversion as a beneficial option for replacing metal or steel parts with plastic parts.

Superior quality

Injection molding produces parts that are precise and consistently uniform. In fact, injection molded parts have very good dimensional consistency compared to other plastics manufacturing processes. There are also many data-driven injection molding practices and resources that support the overall quality of a part. Examples include the use of SolidWorks software for up-front design validation, RJG eDart process controls, automation and robotics, and more.





Design compatibility

Injection molding easily integrates with computer-aided design (CAD, computer-aided manufacturing (CAM), and SolidWorks. So, while this process is a good choice for producing uncomplicated items, it is equally valuable for producing highly complex or finely detailed parts, as well as when precise specifications for a component need to be met.

Customizable colors

Colorant providers are capable of producing a broad spectrum of colors to produce virtually any shade or visual effect.

Compliance

When needed, resins are available that comply with FDA, NSF, REACH, and RoHS requirements.

Customizable product traits

Over 15,000 variations of plastics are available on the market to achieve desired functional results. In addition, fillers such as glass fibers are added to increase strength, or UV protection can be added to increase the durability of products that will be exposed to the sun.

Sustainability

The process of injection molding produces minimal waste because it is so accurate and efficient, and any excess material can often be recycled.

Is metal to plastic conversion a process that could benefit your product?

Get our comprehensive guide here.

What are the types of plastic injection molding?



Plastic injection molding is not a one-size-fits-all process. Different techniques can be used to achieve different types of end results.

Standard molding

This basic technique uses a single color and material to produce the part. It is commonly used to manufacture everything from beverage containers and caps to auto parts and toys.

Two-shot (dual-shot) molding

This is also a two-step injection molding technique, but it is done in one molding press and it allows you to create a part or product using multiple colors and plastic types simultaneously, without having to use a multi-stage assembly process. For instance, you might want to create a power tool housing with a branded-color handle.

First, a substrate is injected by the primary press barrel. Then, mold steel is exchanged and a second injection unit molds the second shot. The bond between the materials can be chemical or mechanical.

Insert molding

Insert molding is an application in which a prefabricated part is used as the substrate. This substrate may be made of an alternative material to plastic (often it's metal).

Knobs and dials that have a plastic exterior over a metal interior are examples of insert molding. The substrate is inserted into the mold, then plastic is injected onto it. Typically this process uses thermoplastic resin as the overmolding material.

Overmolding

This is a two-step process used to produce items that require two different types of plastic – for example, a shaped handle with a soft outer material that makes it easier to grip.

First, the substrate part is produced; then each part is individually moved to another mold where another thermoplastic is molded over the substrate. The bond between the two materials can be mechanical or chemical.

What is a thermoplastic?



Polymer resins become molten when heated, so they can be molded as desired and then allowed to harden. The resulting plastic is called a thermoplastic.

There are several types of thermoplastic, each with distinct characteristics that make it especially useful for certain applications and budgetary requirements. Thermoplastics can be highly resistant to temperature extremes, and corrosive materials or environments.

Common types of thermoplastic materials include:

- Acrylic (PMMA)
- Acrylonitrile butadiene styrene (ABS)
- Polyamide (PA)
- Polylactic acid (PLA)
- Polycarbonate (PC)
- Polyether ether ketone (PEEK)
- Polyethylene (PE)
- Polypropylene (PP)
- Polyvinyl chloride (PVC)
- High Impact Polystyrene (HIPS)

Let's dive a little deeper into a few of the materials listed above…



Acrylonitrile Butadiene Styrene (ABS) combines the three monomers in its name to create a plastic that is opaque, lightweight, and versatile. Molded using high temperature, it becomes shiny and heat-resistant; low-temperature molding makes it strong and impact-resistant. ABS is used for drain pipe, small kitchen appliances, auto parts, and LEGOs.

Polyamide (PA/nylon) is not only very strong but is also highly resistant to impacts, abrasion, and harsh chemicals. It is commonly used for everything from auto parts and industrial components to medical devices, clothing, shoes, and sports equipment.

Polycarbonate (PC) is transparent and extremely impact-resistant, so it is valuable for DVDs, eyeglass lenses, coverings for cell phone faces, auto dashboard gauges, medical devices, and protective partitions.

Polyethylene (PE) is commonly used in both high density (HDPE) and low density (LDPE) variations for products ranging from plastic bags and films to beverage containers.

High Impact Polystyrene (HIPS) is polystyrene to which rubber has been added to increase strength. It is an inexpensive choice for applications that require rigidity and dimensional strength. There are optional variations that meet FDA food-grade standards as well as high-gloss and flame-retardant options.

Polypropylene (PP) is extremely tough, resisting high heat, stress, impacts, harsh chemicals, and water. It is food-safe so it's used to make plastic utensils, but it is also used for clothing, rugs, and car batteries.

Aligning with your injection molding partner to choose the best resin early in the design for manufacturability process, is crucial to a part's production success. A good place to start is to have a general understanding of the main types of resins.

What industries utilize plastic injection molding?



For OEMs in industries of all types, plastic parts are an essential and economical option in product design and production. In most circumstances, it makes sense to find the lowest cost, lowest weight, and most durable material to produce the product needed. Plastic injection molding is an incredibly versatile manufacturing process that plays a critical role in developing products from medical devices to automotive components to appliances and more. In fact, plastics can reduce the weight of parts by 50%, produce less scrap, and be formed into more complex shapes and geometries. Let's review some of the top applications for injection molding and the valuable characteristics of plastic parts for each.

Automotive: Many plastic parts in automobiles require a range of intricate design features to function correctly. Typical injected molded components used in automobiles include bumpers, dashboards, and smaller parts, such as cup holders, mirror housings, and many more. Common characteristics of plastic parts for the automotive industry include:

- Weather and wear-resistant
- High-heat plastic parts maintain integrity in high-temp scenarios
- Certain polymers stable from the degradation of chemical exposure
- Effective alternative for discontinued parts
- Lightweight for reduced emissions/energy saving
- Noise and vibration reduction
- Reduced cost and weight



Medical: The use of plastics has been widely used for medical device manufacturing. Offering superior quality and precision, custom plastic parts are used in a variety of medical components and offer exceptional mechanical properties. Common characteristics of plastic parts for the medical industry include:

- Variety of various colors, shapes, and sizes
- High level of design & application flexibility
- High tensile strength
- Resistant to high temperatures
- Reduced cost and weight

Construction: Manufacturers use injection molded parts to produce cost-effective construction parts and products, including tools, fasteners, and accessories. Common characteristics of plastic parts for the construction industry include:

- Great stability and durability when exposed to environmental elements
- Cost-effective compared to metal or wood
- Energy efficient
- Lightweight
- Many finish options

Plumbing: There was a time when metal, ceramic, or concrete materials were predominantly used in industrial and residential plumbing. Today, while metal pipes, including copper and galvanized steel, are still commonly used, plastic plumbing components have been found to offer superior qualities and offer many valuable characteristics, including:

- Corrosion resistance
- Low heat conductivity
- Non-reactive to chemicals
- Reduced cost and weight



Appliance: Appliance manufacturing is another industry that favors the high-volume, highly repeatable process of creating plastic components for product production. Components such as gears, pulleys, pumps, shelves, and trays are a few examples of plastic parts incorporated into refrigerators, dishwashers, kitchen gadgets, and more, which offer greater durability and value. Common characteristics of plastic parts for the appliance industry include:

- Resistance to heat, chemicals, and corrosion
- Added durability and longevity
- Decreased weight
- Design flexibility
- Ability to incorporate complex processes, such as overmolding

Electronics: When you think of electronics, it's most likely you think of wires and metal. Although, corrosion-resistant plastic can help improve the performance of electronic components. When compared to other materials, plastics have a superior ability to improve safety and provide insulation. Your television, computer mouse, and many other devices often incorporate parts created with the plastic injection molding process. Common characteristics of plastic parts for the electronics industry include:

- Withstand high voltages and high temperatures without degradation
- Design flexibility
- Superior insulating properties, dielectric strength, and thermal performance
- Reduced cost and weight



When creating a component for a product, the cost-effectiveness and design flexibility of plastic injection molding should always be taken into consideration. Plastics can reduce the weight of parts by 50-percent, can be formed into complex shapes, and produce less scrap material (of which is typically recycled). The industry examples listed above are just a few among an extensive list of others that may benefit from injection molded parts. Whenever repeatability, consistency, affordability, and reliability are essential for a medium to high volume thermoplastic component, injection molding is an ideal solution.

How is automation used in plastic injection molding?

Just like many other industries, the world of plastics is continuously changing and growing. Companies are continually investing in automation to improve productivity and increase capacity and efficiency.



Plastic injection molding processes are fast, efficient, and precise when conducted by experienced technicians utilizing advanced automated machinery. Automation helps ensure each manufactured component will be identical to the validated design.

Taking automation a step further, lights-out manufacturing describes processes, innovative machinery, and technology that is put into place within facilities to conduct tasks that would normally need constant oversight by on-site technicians. Essentially, an automated production facility can run "lights-out" – or without substantial assistance from human labor, lights, heat, and other costly factors for a business. However, most highly automated facilities still require the supervision of highly skilled laborers and technicians. Lights-out manufacturing processes allow companies to keep facilities running 24 hours a day, seven days a week, with a scaled-back workforce or virtual technician oversight.



Lights-Out Manufacturing

Rosti's Bunsen Drive facility ensures the maximum amount of efficiency out of every square foot of space. Since the opening of the Bunsen facility, the United States Government issued Rosti a patent to validate the processes that take place within the facility. Every detail from the lighting to the part conveyance system has been meticulously planned. This attention to the little nuances of a manufacturing plant is what separates this facility from others in the world. Additionally, infrastructure expansions have set the stage for the additional production presses that have already been added, and more that will come in the future.

The advancements in automation and "lights-out" manufacturing processes have impacted the plastics industry at a high level. It allowed businesses to improve in the areas of cost and turn-around time. It has also allowed plastic part producers to lower the likelihood of defects and increase the overall quality of products created.

Five critical ways lights-out manufacturing has transformed injection molding include:



1. It has helped U.S. manufacturers gain a globally competitive advantage.
2. It allows large orders to be completed quickly without the higher costs associated with running additional shifts.
3. It provides a greater ability to meet quality control, delivery, and cost containment requirements.
4. It requires a highly trained and dedicated workforce to manage and maintain state-of-the-art automation equipment and processes.
5. It creates an added level of protection for intellectual property.

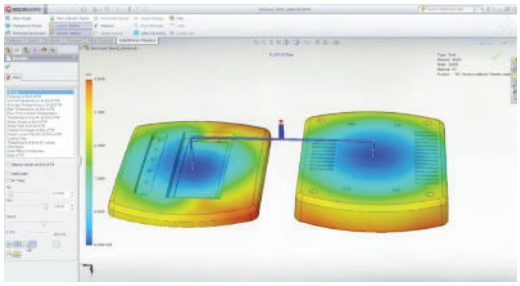


What are the steps of developing a plastic part?

Creating custom plastic parts does not need to be complicated and is now more accessible than ever. When you align with a knowledgeable plastic injection molder, you will work together to develop a clear plan of action, optimized design and will soon have the precision parts needed to get your product to market fast and on budget. Below are the high-level steps in the plastic part development process.

1. Design for Manufacturing in Plastic Injection Molding (Designing the Part)

One of the most important aspects of the plastic part development process is taking the necessary steps to avoid delays and reduce the risk of costly design changes. Your injection molder should have the necessary resources to lead you through a comprehensive design for manufacturability (DFM) process.



Did you know that manufacturers rank design as the top factor in reducing overall manufacturing costs? DFM involves designing a product that optimizes manufacturing efficiencies for the equipment and/or process used in its production in order to realize the lowest possible unit costs at the highest possible quality. The most important reason for integrating DFM into manufacturing a plastic injection molded product is that design decisions can determine 70% of its manufacturing costs.

- Design for Manufacturing
- Design for Functionality
- Design for Assembly
- Design for Sustainability

While production checklists are still critical components of the process, the work that happens earlier in the development cycle is what creates real efficiencies in regard to time and budget. When a tool-maker / injection molder is involved early in the design and development cycle, customer objectives are understood and unexpected surprises are avoided. It's all about taking this 4-pronged approach:

Establishing a collaborative effort early on and working together to develop a true understanding of what it will take to achieve the successful molding of a part, will create efficiencies for your part development process in a number of ways.

2. Determine the Molding Process



There are different molding processes used in manufacturing plastics. Custom injection molding is one of the most popular techniques used to produce high-volume plastic parts using an open-and-close mold function.

However, the process you choose will depend on different variables. These include your initial design, the quantity of the parts needed, and the overall use of the products. Additionally, working with an injection molder that offers post-molding capabilities can help streamline your process, create efficiencies, and reduce costs. Whether you're looking for post-molding services including hot stamping, inserting, heat staking, or more, some injection molders are equipped to provide turn-key solutions.

3. Prototyping



Working with a plastic prototype molding partner to create custom injection mold tools and components built with a production mentality will support the overall efficiency of your project.

Many OEMs consider prototype molds before going directly to the manufacturing process for a lot of reasons. These are low-cost molds that are typically different from production mold because they are meant for short-term use only. In many ways, prototype molds are useful for reviewing specifications, seeing how the part functions or behaves, and overall validation of performance.

Rosti ensures injection mold tools are built to specification, allowing the customer to have full confidence that the prototype component is capable of being tested, marketed, or even used for short-term or low-volume production needs. Rosti values our strategic partnership with plastic prototype development resources to provide our customers with:

- Single-cavity prototype tools which replicate the design characteristics of production caliber tools (i.e. similar tools design process, material selection, gating, parting line configuration, water line design, etc.)
- Collaboration with our plastic prototype development partners on business development efforts, particularly for new programs, part development, and metal to plastic conversion projects
- Fulfillment of the "project manager" role with respect to development work, third-party contracts for prototype tooling, and low-volume molding

4. Plastic Part Manufacturing



In our section above on the injection molding process, we walked you through the makeup of a mold, the basic description of a molding machine, and the process cycle. This cycle is short, using high-pressure injection of material into the mold, where it is shaped. This is a process implemented by the majority of injection molders. Factors that will determine the best plastic part manufacturing scenario for your unique component include:

- Adequate production space
- Molding machines size appropriate for your unique part
- Scientific molding practices, data-driven analysis, and automated processes
- A facility focused on the volume of parts that best fits your needs
- Mold maintenance support
- Assembly capabilities
- Advanced metrology equipment to support PPAP requirements

Learn about Rosti's scientific molding practices in our Complete Guide to Scientific Molding.

What are important considerations when selecting an injection molder?

Above, we talked about the best manufacturing environment for your plastic part. But there are other crucial attributes of an injection molder that should be evaluated when selecting the best resource. When you need thousands of parts produced on time and under budget, how do you achieve peace of mind that you are working with a true partner that will keep your needs in mind? Here are a few considerations:



- **Quality Standards:** Do your parts need to pass strict inspections or meet high safety and quality standards? If so, it is imperative that you partner with an injection molder that is ISO certified, which guarantees that parts will be molded with correct and specified materials.
- **Customer Service & Communication:** Long-term business-to-business relationships require the extra element of exceptional customer service and communication. Especially when working with complex parts or projects that include a high level of intellectual property sensitivity, working with an on-shore partner that is responsive to your needs is essential.

  Particularly if your needs are specialized or unique, finding a supplier that understands your industry, materials, and challenges is crucial to the success of the project.
- **Available Resins:** Material/resin selection is a critical element to the design and production process for a successful product. Working with an experienced injection molder will help you ensure that the end-use will be kept in mind throughout the design and material selection process. In addition to the base material that is determined to be the best option for your product, filler materials, and other additives can be included to enhance the properties of the part.
- **Value:** Price is always a top factor for a manufacturer when determining the best injection-molding partner. Budgets and ROI calculations are a part of doing business. However, consider the process of buying a car. Sometimes a “bargain” deal may result in costly repairs a few months later. Many elements come into play when considering the overall price for part production, and more goes into a long-term relationship than just choosing the lowest quote. While the lowest-priced option may seem like the best solution, it could cost you more money in the long run.

Why choose Rosti for your next plastic injection molding project?

Plastics manufacturing is a highly competitive, global industry where businesses are presented with both time and cost challenges. Avoiding delays and reducing risk for costly design changes will mean that your product gets to market faster and within budget.

Over the years, best practices for tooling and part manufacturing have changed substantially. While production checklists are still critical components of the process, the work that happens earlier in the development cycle is what creates real efficiencies. Working with an experienced and knowledgeable injection molder that keeps DFM and scientific molding at the forefront of a project, as well as one that has a diverse understanding and accessibility to resin experts, will ensure your objectives are met, and unexpected surprises are avoided.

All metal to plastic conversion processes at Rosti involve our engineering team, who will work closely with you to understand all of the part requirements. From there, we collaborate on all design for manufacturability elements, including part design, material selection, mold design, and process engineering.

If you're considering moving forward with a metal to plastic part conversion, we encourage you to discuss your options with one of our experienced engineers to determine if such a transition is applicable for your product.

We're happy to share metal to plastic conversion examples that are applicable to your industry and unique application.

CONNECT WITH ROSTI

Are you looking for an injection molder that can provide expert consultation from the design of your metal to plastic conversion project - straight through to production completion?

Connect with Rosti's knowledgeable team members who will focus on all areas of design, development, and production.

Rosti
From concept to reality

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