The top 8 questions about plastic injection moulding

Plastic injection moulding is a manufacturing process used to create parts for numerous electronic and electro-mechanical products across all market sectors, including industrial, medical, and transportation. It is a reliable and high-quality process in which resin is injected into a mould to produce thousands or even millions of identical items.

Injection moulding is widely regarded as a flexible, efficient, cost-effective way of producing quality pieces. However, it's a complex topic, and multiple considerations and questions must be asked to ensure the right solution. If you're new to injection moulding or looking to start a design partnership, here are eight questions we recommend you consider to achieve the best results.

1. What is the end use of your product?

Injection moulding can be a cost-effective and accurate way of manufacturing many types of products in bulk. However, the purpose of your product will have a massive effect on all the plastic injection moulding decisions you make.

For example, on one side of the scale, if you are manufacturing a medical device, there may be critical biosafety and chemical stability considerations, as the materials used can cause harm or excrete toxic substances. Or on the other side of the scale, there may be aesthetic considerations if you produce

consumer electronic devices.

Therefore, during the design and manufacturing phases, careful thought should be given to several areas, including the following.

- Which is the best material to use for the specific product? Choosing the right one will depend on the device's use and application and whether the parts have functional, aesthetic, or mechanical requirements.
- Does the product need to be robust? If certain devices break, they can often become hazardous; therefore, materials should be selected carefully to avoid breakages.
- Does the product need to be used in an extreme environment? For example, will the device be exposed to corrosive substances, heat, liquids, or vibration?
- Does the final product have any aesthetic requirements? Correct decisions about material selection, mould design, and process parameters must be made if the product needs to look a certain way.
- Does the product need to be sterilised? If so, it must be able to resist contaminants to be safe for human use.

Each type of product has its own set of specific considerations, which must be reviewed in the design phase and when the project is being costed.

2. What volume do you need to manufacture?

What volume do you expect to manufacture: a high-volume product, or is your product intended for a niche market? You will have to decide what type of tool you require based on the answer.

Low-volume plastic injection moulding

Low-volume plastic injection moulding uses a Master Unit Die mould, also known as Modular Unit Die or a MUD tool (and more generically as soft tools). These tools generally produce fewer than 10,000 parts and are suitable for projects that do not require the production of hundreds of thousands or even millions of products. This technology uses easily machined aluminium instead of steel and eliminates the need for an expensive mould base because it only involves product-specific inserts.

There are several benefits of low-volume injection moulding using a MUD tool. First, this type of production offers greater design flexibility as the tooling can be made quickly, which means new moulds can be created to adapt to changes in the design. Second, it is cheaper to manufacture aluminium tooling inserts than complete steel tooling; thus, there are shorter turnaround times.

This type of plastic injection moulding is ideal for prototyping, market testing, clinical trial runs, and pilot production. However, there are better methods to use if you need to produce a low volume of products over a long period (between five to seven years).

High-volume plastic injection moulding

Conversely, using a hard tool, high-volume plastic injection moulding can produce hundreds of thousands to millions of products. Depending on your project's requirements, this method has several advantages over low-volume injection moulding.

First, high-volume injection moulding can produce more pieces at faster speeds and is therefore reducing costs due to a higher equipment utilization. Second, it is better suited to automation, once again increasing production capacities and reducing costs. Third, high-volume injection moulding can lower the unit cost as the more-durable steel creates more pieces before it

needs to be replaced. However, the operation does have a higher initial cost, and as such, there are likely to be minimum order requirements to cover the significant upfront tooling investment.

The project requirements also influence tool choice

In addition to expected manufacture volume, the product requirements also dictate the type of tool you need to create a successful end product. For example, if your product has optical requirements (no imperfections permitted), you will need to choose a more expensive steel rather than an aluminium MUD tool.

It is a common misconception that the volume of products to be manufactured is the only variable in tool choice: product requirements, specifications, and complexity must all be considered if the final product is to function correctly. While some OEMs (original equipment manufacturers) design the complete product themselves and outsource only the manufacturing, others see the benefit of working with an EMS (electronics manufacturing services) partner starting from the design phase. Regardless of your route, discussing your project's specifications with your outsourcing partner from the beginning will ensure that the correct tool is chosen.

3. What is the expected lifecycle of the mould?

How long an injection mould lasts depends on whether the tool is made from hardened steel or aluminium, what type of plastic is used, the part geometry and how the tool is designed. Depending on these factors, one mould can last between one hundred thousand to one million cycles. And if the mould is well looked after, it will last even longer, making it even more cost-effective.

The most important consideration is having a clear idea of how many parts are required for the product. At the beginning of the project, OEMs and their EMS

partner should discuss whether the best option would be to replace the tool during the product lifetime or whether it would be a better option for the tool to last the whole product lifetime.

There is also a third option: to refurbish the tool, which could be a cost-effective choice. However, as the tool will be out of service for a while, planning is required to avoid completely ceasing production.

4. What is the expected lifecycle of the part?

While some plastics degrade relatively quickly when exposed to heat and light, most parts that have been injection moulded will last indefinitely. However, parts being used for functional purposes will eventually reach a point of failure, depending on how they have been treated.

The lifespan of the thermoplastic part produced by the mould depends on the type of plastic used to create it, the application of the part, the part's geometry, how it is stored, stress levels, and temperature. If the part is functional, it will also be subject to wear and tear and tear. Conversely, if the part serves an aesthetic function, its colour and surface will be affected over time. Last, UV light is also a stress factor, so any plastic left outside will, over time, become brittle and break.

Understanding how these factors influence plastics over time enables making accurate predictions regarding the part's lifecycle.

5. Do you need to create a prototype?

Using a MUD tool may be the best option to create second-stage prototypes as they have been proven to be a good intermediate step between 3D printing and a final steel tool. It can create up to 10,000 pieces, highlighting any problems that may need to be resolved. Also, you can test for form, fit, and function.

The advantage of using a MUD tool over a 3D-printed prototype is that it has the final material, mechanical properties, precision and surface finish of the mass-produced product. Even vacuum casting in a silicone mould is unlikely to meet these requirements if you are conducting a clinical trial or want to impress initial customers in a field study.

6. What is the correct type of resin to use?

One of the most critical considerations for a plastic injection moulding project is the correct resin type. As with all the other questions, there is no one-size-fits-all answer, but the right choice depends on a combination of factors relating to function and aesthetics. Choosing the correct resin for the end product will ensure it meets the market needs.

Five considerations will help guide the type of resin used in the project:

1. Final part appearance, including surface texture, gloss, and colour
2. The part's strength, flexibility, or rigidity
3. Chemical or environmental resistance
4. Any regulatory requirements
5. The part's life expectancy

There are many different types of plastic with properties relating to flexibility and durability as well as resistance to heat, cold, and chemicals. Various resins are suitable for diverse types of products; for example, some resins are more transparent, others have a high mechanical stability, others are more resistant to chemicals, and others have better capabilities to reproduce the desired geometry accurately and without distortion. In addition, you can add fibres, fillers and other additives to improve mechanical strength, warpage, flammability, and other properties. Finally, choose the right masterbatch to get the colour you want.

Thermoplastics comprise most manufactured polymer resins and are used in injection moulding. There are three main categories of thermoplastics: commodity resins, engineering resins, and speciality resins.
Commodity resins are easy to process and cheap, which is why they are generally used in everyday, mass-produced items such as packaging and low-end consumer products.

Engineering resins are expensive; however, they are more resistant to chemicals and environmental exposure and very strong.
High-performance resins are for high-end parts and are also expensive.

7. What is the best type of tool to use?

Whether to use a MUD tool with aluminium inserts or a complete steel tool is one of the most pivotal (and probably most misunderstood) questions in plastic injection moulding. While there are some instances when there is a correct type of tool to use, most projects are not so clear cut; factors such as prototyping, budget, the purpose of the product, and the market play an

important role.

Previously, when considering what type of tool to use, the question was focused on whether to use a hard tool or a soft tool. However, recent technological developments mean that the choice is no longer between steel and aluminium.

The industry needed to develop, move away from this dichotomy, and invent something that could produce more than just a 3D-printed part and less than a final part. The change was driven by price, speed, and product requirements; for example, it is not possible to create complicated mould structures using a soft tool.

It is beneficial to use different types of tooling for different phases in the product cycle:

1. Prototype tooling: to ensure the product is correctly designed or for testing
2. Rapid tooling: to create inserts for injection moulding tools in a short amount of time, typically within a few weeks
3. Final tooling: to produce the final product

MUD tools are typically used for points one and two and complete steel tools for point three.

8. Are you working on a timescale?

Time to market is an important consideration; the quickest time to market will result from an efficient and cost-effective process—not going straight to production without first ensuring the product functions correctly.

For example, directly going to the final production tool can lead to a longer process in certain situations, as design faults or required modifications need to be promptly recognised. For the quickest time to market, all lessons must be learnt by first using a MUD tool to create a prototype before using the final tool. MUD tooling can also improve the efficiency of plastic part output, and software can review the part's design to facilitate quick production. Depending on the project, it is also possible to use SLA or SLS 3D printers to obtain a mix of suggestions for the prototype. However, if you chose this prototyping option and there is a gap as you used parts that are not made with 3D-printed simulated resins, you might want to use a MUD tool with the final chosen resin before using the final tools.

There should always be a bridge between prototyping and production, and MUD tooling can manufacture a feasible prototype for a lower cost and commitment level. Some OEMs can overestimate the number of manufactured units required in the early stages—this is especially true with medical devices—so beginning production with a MUD tool can save time and money before committing to manufacturing.

Choosing the correct tool at the right project stage will optimise timing and cost. Using a MUD tool (or a 3D printer) at the beginning will enable you to establish the best design—once you have done this, you can invest in the right tool for the design. Skipping this process will likely increase time to market as making adjustments after the design has been finalised is more expensive and time-consuming than it is to make changes during the prototyping phase. Focusing on a timeline rather than following a correct process will likely lead to delays at later stages of the project.

Conclusion

Plastic injection moulding is a cost-effective and efficient process to produce parts for electronic and electro-mechanical products. However, there is no one-size-fits-all or 'best' solution for every product type. Each project is different and requires the eight questions above (as a minimum) to be carefully considered so a unique process can be established that observes multiple factors: from budget to the product's end use to how many units need to be produced and when. One way to get the correct answer to all the above questions is to speak to an expert plastic injection moulding engineer as soon as possible and work together to find the right solution for your project.