CNC Prototyping VS Injection Molding ProtoTyping for ThermoPlastics

ProLean

Thermoplastics are a class of plastic that can be repeatedly melted and reconfigured. They are commonly utilized for prototyping across several sectors. There are various reasons behind using thermoplastics in mechanical prototyping. It offers excellent mechanical strength, wear resistance, corrosion resistance, electrical insulation, chemical stability, machinability, and cost-effectiveness. In addition, the particular type of thermoplastic holds some unique characteristics that make it suitable for many applications.

Some of the common thermoplastics used in prototyping include **Polyethylene (PE), Polypropylene (PP), Polystyrene (PS), Polycarbonate (PC), and Acrylonitrile-butadiene-styrene (ABS).**

CNC machining and injection molding are popular manufacturing techniques in prototype development with thermoplastic materials. This article ***will discuss several aspects of both approaches to conclude why CNC machining is better than injection molding for prototyping.***

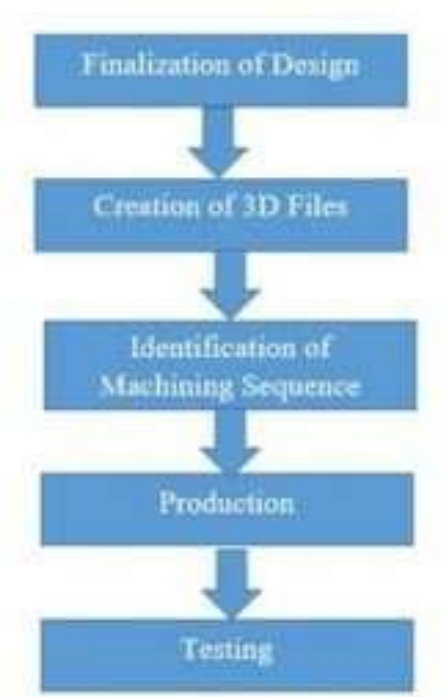
What is meant by Prototyping in Manufacturing?

Prototyping refers to creating a physical model of a product or part to test and evaluate its design and functionality. It is a crucial step in developing mechanical parts and products that allows engineers to identify and solve any flaws with the product design before it goes into mass production. Prototyping ensures the optimum quality of final products and economic competency.

Developing thermoplastic prototypes involves two primary techniques: ***CNC machining and injection molding.***

Thermoplastic Prototypes from CNC Machining

CNC machining is a popular choice for prototyping thermoplastic parts because it offers design complexity, accuracy, quality as-machined finish, quick lead time, and many other advantages. It involves the creation of a 3D model, generating commanding programs, machining with various tools, and testing for improvement.



It is an efficient way to produce prototypes and is often used in various industries, including aerospace, automotive, medical, home appliances, and electronics.

Thermoplastic Prototypes from Injection Molding

Injection molding involves injecting liquid plastic into a mold to create the desired shape. It is a popular prototyping approach because it offers repeatability with good dimensional accuracy.

The creation of mold is the first step, which is made with hard materials like hardened steel, aluminum, and brass. The mold is designed to produce a specific shape and has a cavity that is the negative of the desired part. The molten form of thermoplastic is injected into the mold with high pressure, which creates the desired shape after solidifying.

So, the fundamental differences between these techniques are mold creation and the change in the physical state of thermoplastic material. The CNC machining approach starts the actual manufacturing right after the development of 3D models. In contrast, injection molding involves the mold creation and liquidity of thermoplastic before moving into the manufacturing process.

Reasons: Why CNC Machining is a Better Option for Thermoplastic Prototypes

We already discussed the basics of thermoplastic prototyping with CNC machining and injection molding. Now, let's overview the fundamental reasons why CNC machining is the better choice.

1. High production speed

CNC machining produces prototypes in a short time compared to injection molding. It can create the physical parts from design within a matter of hours. After finalizing the design for prototypes, tool path selection and machining with various tools are further steps to create the prototypes.

On the other hand, Injection molding requires the preparation of a custom mold, which can take several days to manufacture. Only after the creation of mold the manufacturing of prototypes begin.

Reducing lead time is crucial in prototyping, as it allows product developers to create prototypes quickly and spend more time on testing and modification. This can also give them an advantage in the market competition, allowing them to bring their products to market faster. Quick prototyping allows more time to be spent on developing and refining the final product, leading to a higher-quality result.

2. CNC produces more precise parts than injection molding

CNC machining can achieve very tight tolerances, with tolerances as low as ± 0.005 inches possible. Computer control and automation in CNC machining allow the creation of accurate thermoplastic parts for prototypes (Vosniakos, 2001). However, injection molding is unable to achieve that precision level. The high

temperature, pressure, and accuracy of mold affect the tolerances and make it hard to achieve a high level of precision.
Another thing is that obtaining tight tolerances with injection molding depends on many variables. It is difficult to control a large number of variables perfectly so that the molded parts will be precise as desired.

3. It is possible to achieve a better surface finish with CNC machining.

If we compare the surface finishing results between CNC machining and injection molding, thermoplastic parts from CNC machining offer better results. The precise machining and finest cutting tools cause a high-quality as-machined surface finish. In contrast, injection molding results in a slightly rougher surface finish because of melting and intense pressure inside the mold. The surface finish is also affected by the roughness of the mold cavity.
CNC machining can achieve an average roughness value (Ra) as low as 0.4 μm (Kumar, 2014). However, it is almost impossible to obtain this level of finish with injection molding.

4. It is easy to change the prototype design with CNC.

After the evaluation of manufacturing feasibility, design improvement has always been an essential part of prototyping. Since the manufacturing process is controlled by a computer numerical control (CNC) system, CNC machining allows for easy design changes. It is a matter of updating the CNC code if any changes are required in features, dimensions, tolerances, and other aspects.
On the other hand, injection molding requires the customization of mold and a completely new mold in many cases, even for a minor design change of prototypes.

5. CNC machining can create complex geometries

Because the machining process enables the creation of a broad range of shapes and features, CNC machining is ideally suited for generating prototypes with complicated geometry. The custom mold design includes restrictions on injection molding, making it unsuitable for creating prototypes with intricate forms.

The CNC machining processes can create curves, contours, undercuts, interior features (holes, channels, and cavities), threaded features, tapers, chamfers, free-form surfaces, deep pockets, rotational symmetries, thickness variable parts, irregular holes, and many more.

6. The cost of prototyping is less with CNC machining.

There is a common misconception about injection molding that it is cheaper technology than CNC machining. It is not valid in all cases. The mass production of parts is more cost-effective than the CNC machining approach since a single mold can be useful for thousands of pieces. Nevertheless, the Prototyping process is costlier because of the high cost of mold creation.

For example, if the cost of manufacturing a mold is $1000 and you need to produce 10,000 identical parts. The cost of the mold will be distributed among all the parts, and the share of the mold cost for each piece will be $0.1. While in prototyping, it is unlikely that you would need to produce 10,000 items. If you only need to create 100 identical parts, the share of the mold cost for each piece would be $10.

This example demonstrates how the cost of the mold significantly impacts the cost-per part, especially with low-volume production.

7. Consistency of thermoplastic properties

Injection molding involves using thermoplastic materials in molten form; the raw material's physical state changes from solid to liquid. This phenomenon might not retain all the physical & mechanical properties of thermoplastics after creating the desired shape. Properties like strength and hardness could be altered because of changes in state & intense pressure.

In contrast, CNC machining involves using machining tools to shape the raw material and retains all the original properties after manufacturing.

8. All the thermoplastics are not well-suited for injection molding

Some thermoplastics can shrink, break down, or degrade at the high temperatures required for injection molding. It leads to problems with the quality

of the finished parts. It is because of their physical or chemical properties. Some of the thermoplastics that are not well-suited for injection molding, include ***PVC and LDPE.***

So, all thermoplastics cannot be used in prototyping with injection molding. CNC machining can shape all thermoplastics with high precision and without degradation in any properties.

Summing Up

CNC machining and injection molding are popular manufacturing techniques in prototype development with thermoplastic materials. CNC machining is a better choice for prototyping thermoplastic parts because it offers design complexity, accuracy, quality as-machined finish, quick lead time, and many other advantages. One of the most significant drawbacks of injection molding is the high cost of mold manufacturing, which is ineffective for small-volume production.

If you plan to create thermoplastic parts with injection molding, it is generally better to use CNC machining for prototyping. This allows you to produce prototypes quickly and test their design and functionality before moving on to mass production. Once the prototypes have passed all necessary tests, you can later switch to injection molding for high-volume production.

ProleanTech is the CNC manufacturing service provider for the prototyping of thermoplastics and other various materials. We offer prototyping for almost every industry, including ***automotive, aerospace, energy, electronics, and robotics.*** Upload your design and request the quote to begin your prototyping project.

FAQ's

What are the significant advantages of CNC machining compared to injection molding?

CNC machining offers design complexity, accuracy, quality as-machined finish, quick lead time, and many other advantages. It is also well-suited for producing prototypes with complex geometry and tight tolerances.

What are the disadvantages of injection molding?

Some disadvantages of injection molding include the need for a custom mold, which can take several days to manufacture, and the more significant variability of the process due to the high temperatures and pressures involved.

What are the most common thermoplastic materials used in prototyping?

Some of the most common thermoplastic materials used in prototyping include Polyethylene (PE), Polypropylene (PP), Polystyrene (PS), Polycarbonate (PC), and Acrylonitrile-butadiene-styrene (ABS).

Is it appropriate to switch from CNC machining to injection molding for mass production?

Once the prototypes produced with CNC machining have passed all necessary tests, you can switch to injection molding for high-volume production. Injection molding is typically more economical for producing large quantities of parts.