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Manufacturing Process Primer

The Manufacturing Process

Developing a suitable manufacturing process can be a difficult task. Not only is the manufacturing process dependent on the geometry and features of the part being produced; It can also be affected by the volume of parts being manufactured and the material used in manufacturing.

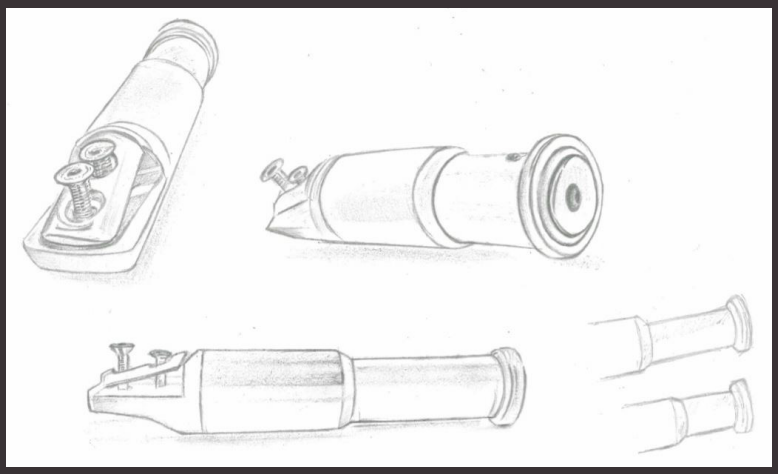
When should you start thinking about Manufacturing Processes?

Manufacturing processes should ideally be considered during the initial stages when designing a part. Typically, when you design a part there are five steps that can influence the final manufacturing process. These steps include the concept design, product design, prototyping, engineering, and production.

Parts produced with varying Manufacturing Processes.

Concept Design:

The concept design stage is important as many of the choices made concerning the features included in the part are made during this stage. Alternative ideas regarding the design can be easily assessed at this stage before anything is settled on.



Concept Design Sketches

The Manufacturing Process

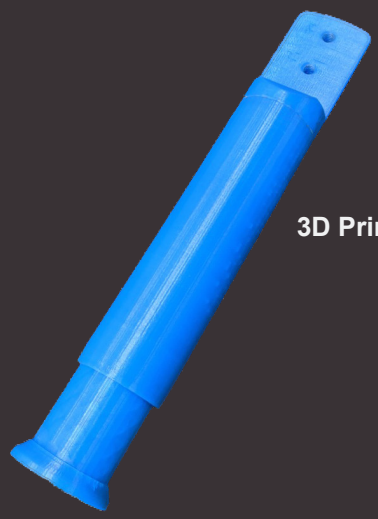
Product Design:

The next major step which affects the manufacturing process is the product design. By keeping the desired manufacturing process in mind, the design of certain features included in the product's design can be adjusted to improve efficiency of manufacturing processes when in production. Making these small changes will save time and money down the road as the product design will not have to be altered as often.

Computer Aided Design Model

Prototyping:

The prototyping stage is generally used to check the geometry of a part. Although, it can also identify issues that may become a problem during the manufacturing process, especially at high production rates. If the prototype is significantly complicated it may be a good idea to produce another prototype after the engineering stage so the manufacturing process selected can be refined.



3D Printed Prototype

Engineering:

After the product design is complete an analysis of the product and its features can be conducted to highlight any problems with the design, particularly points of failure. In some cases, the material initially relied upon may not be suitable. This could result with changes to the design or a change to a more suitable material that can handle the stresses. Both changes could potentially change the order or manufacturing technique utilized.

FEA Engineering Analysis

Production:

Even with all these preliminary steps it is possible that more issues with the design or process will appear during mass production. Processes can then be refined again to improve efficiency.

Final Production Part

Benefits of Optimised Processes

Keeping the Manufacturing Method in mind.

You may be questioning why keeping the manufacturing method in mind during the early stages is so important. Most manufactured parts rely on a number of processes to complete a single product. Often these parts will require a number of machines performing different tasks. The order of these processes is also extremely important, often required to ensure production is physically possible. If the manufacturing process is kept in mind during the initial stages, the number of machines and tool changes required can be reduced. In some cases it may be possible to design a part to be manufactured on one machine.

An example of this could be a small bracket milled on a 2.5D milling machine. The milling machine can only move in X and Y directions with limited movement in the Z direction. If the part is designed to accommodate these limitations it may be possible to perform most of the operations on the mill itself using minimal clamping adjustments and tool changes. By leaving the part clamped in one spot the milling machine offsets do not need to be reset every time a new operation is made. Instead of taking 5 minutes to setup every operation only the time taken to switch tools is required. If a part requires a considerable number of operations and tool changes, significant time can be saved on high production orders. This has a flow on effect, the machinist spends less time on the job overall, reducing the total cost significantly.

2.5D Milling Operation

Manufacturing Processes

Common Manufacturing Processes for Metal and Plastic

There are quite a few options when it comes to manufacturing processes for metal and plastic parts. Having a good idea of the more common manufacturing methods available will make it easier to understand how your products features affect which manufacturing process will be appropriate for you.

Plastic Manufacturing Processes

There are quite a few options when it comes to producing plastic parts as they can be easily formed due to the relatively low melting temperatures required. Below are a few of the processes that can be used to successfully form plastic parts.

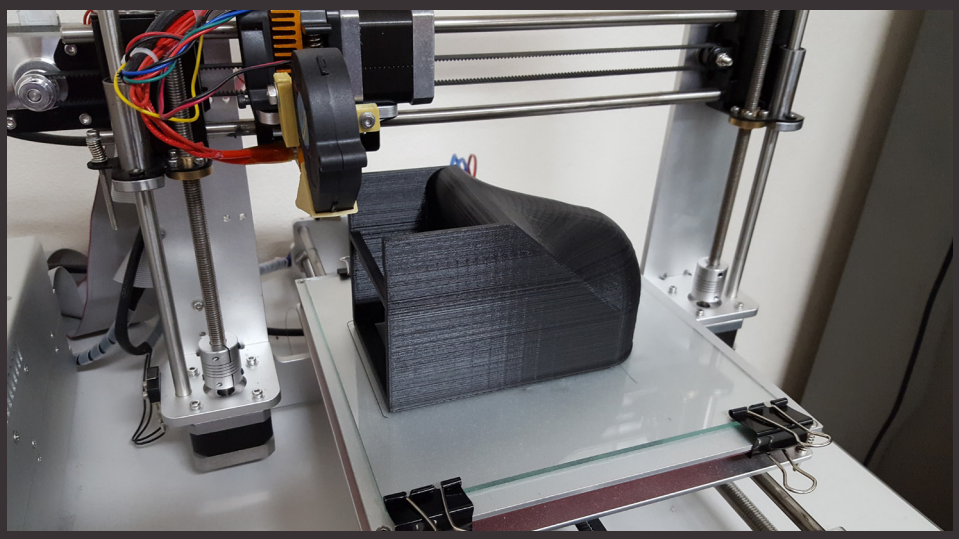
- 3D Printing
- Blow Moulding
- Plastic Extrusion
- Plastic Injection Moulding
- Milling and Turning
- Vacuum Forming

These processes make use of a thermoplastic or thermoset plastic that has not yet been baked. The plastic is heated and then worked to reach the final shape. The only exception to this is milling and turning.

3D Printing/Additive Manufacturing:

In 3D printing, thermoplastic is fed into the hot-end and melted. The pressure from more material being fed in causes the molten plastic to flow out of the nozzle where it is deposited on a heated bed using computer numerical control and stepper motors.

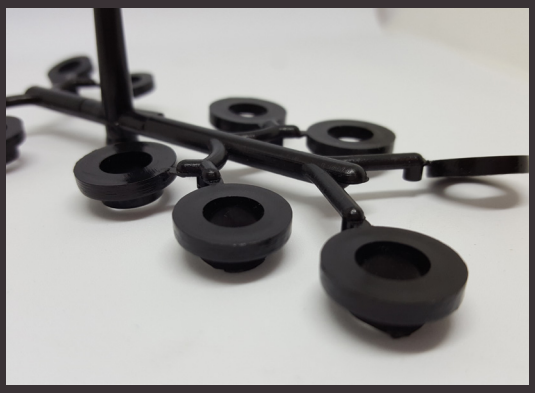
Plastic 3D Printing



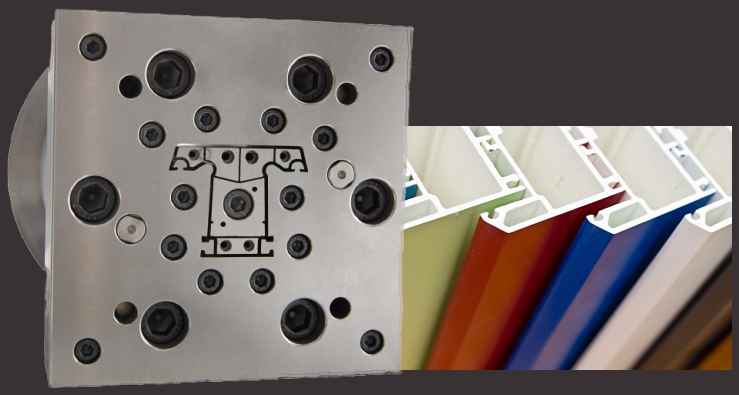
Manufacturing Processes

Plastic Extrusion and Plastic Injection Moulding:

Plastic extrusion involves feeding plastic through a hopper into a corkscrew where it is heated and melted. The corkscrew forces the plastic through a shaped die forming the desired part. A similar process is used for plastic injection moulding where plastic is melted and forced into a mould. Once the plastic has cooled sufficiently the mould is opened and the injection moulded part is ejected.



Injection Moulded Washers

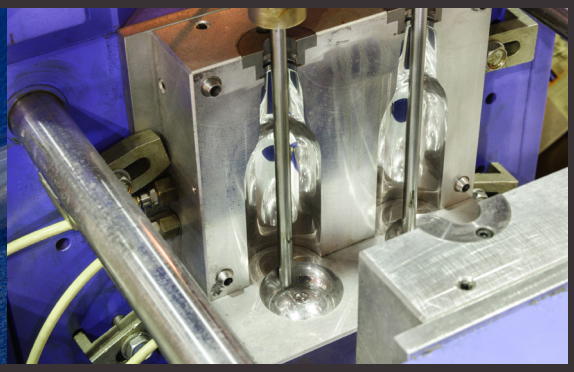


Plastic Extruder Die and Extruded Parts

Blow Moulding:

Blow moulding is used frequently for the production of PET bottles. The plastic blank is heated and then shaped using high pressure air. The air physical deforms the soft blank to conform to a mould. This process follows a similar concept as glass blowing.

Blow Moulding Blanks



Blow Moulding Die

Vacuum Forming:

Vacuum forming is used on products requiring thin walls that conform to the shape of a mould or die. The plastic is heated before being pulled over the mould by mechanically lowering it. The mould sits on a permeable surface that allows air to flow through. As the plastic is lowered over the mould a vacuum is used to remove any air between the plastic and mould's surfaces.

Milling and Turning:

Unlike the rest of these processes milling and turning achieves the desired shape by removing material. This process is significantly slower than those mentioned above but may offer a good solution to producing a prototype or to take a near net process to completion.

Metal Manufacturing Processes

Casting and Forging:

Casted Parts

Investment Casting: Investment casting utilizes a wax pattern of the part being produced. The wax pattern is formed using an injection moulding machine. Multiple patterns can be joined onto one sprue allowing for efficient production. The pattern is coated in a ceramic slurry, fired, and dewaxed leaving an empty mould. Metal can then be cast into the remaining ceramic mould. Once complete the mould is shattered and the part can be cleaned up. Investment casting is typically used for items requiring high detail.

Pressure Die Casting: Molten metal is forced into a mould under high pressure to help achieve complex shapes with high precision and accuracy. Pressure die casting is typically used for parts requiring smooth surface finishes and where precision is required. Pressure die casting requires a high initial investment for precision tooling.

Sand Casting: The sand-casting process makes use of a carefully manufactured pattern that is packed into a mould with sand. The pattern is then carefully removed leaving a cavity in the tightly packed sand. Metal is then poured into the cavity to produce the final part. Once cooled sufficiently the sand forming the mould is broken down and reused. Sand casting is relatively inexpensive and is used frequently on low volume parts ranging from small to large.

Metal Forging: Metal forging can be described as the process of changing the shape of a metal material either hot or cold with the use of two dies. The metal being forged can be worked open, with impression dies or with a flash-less die. The metal forging process is one of the cheapest shaping processes while also being suitable for mass production. The final product although limited in terms of detail can be exceptionally strong.

CNC Machining:

Milling: Milling is a subtractive manufacturing process that is frequently used to produce parts requiring exceptionally smooth surfaces and features. It relies on specialized tooling matched to the metal being operated on.

Turning: Turning is a subtractive manufacturing process that is used to produce parts with rotational symmetry. The CNC Turning process can be used to produce highly detailed parts of high precision with extremely fine tolerances.

Manufacturing Processes

Fabrication:

Fabrication processes involve a range of smaller process designed to convert stock material and specialty manufactured parts into a final product. These processes include:

Welding Fabrication: Parts can be physically fused together.

Sheet and Plate metal Fabrication: Sheet and Plate metal fabrication involves the production of products such as storage tanks, metal ducts, housings, enclosures, and other products such as screens and grills.

CNC Laser cutting and Turret Punching: Turret punching is a process that uses a punch and a die to mechanically shear sheet metal based on the shape of the punch and die being used. The shape used is generally simple but can be repeated over and over again. Laser cutting can be used in a similar way to remove sections of material or to cut out the perimeter of an object.

Pipe and Section Bending: Pipe and section bending allows for the production of parts such as arches, structural supports that spread weight more effectively as well as custom piping systems.

Wire Cutting:

EDM Wire Cutting: Wire cutting electrical discharge machining (EDM) is a process that utilizes spark erosion to melt small bits of material and remove it from an object. The process works even on extremely hard metals such as tool steel. The thin wire allows for the production of high tolerance parts with difficult tapers and internal geometry that would otherwise be difficult to achieve on standard milling machines.

EDM Wire Cut Part

Most metals are available for the above processes. Due to the wildly different properties between some metals the difficulty of producing parts using some processes may vary greatly.

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