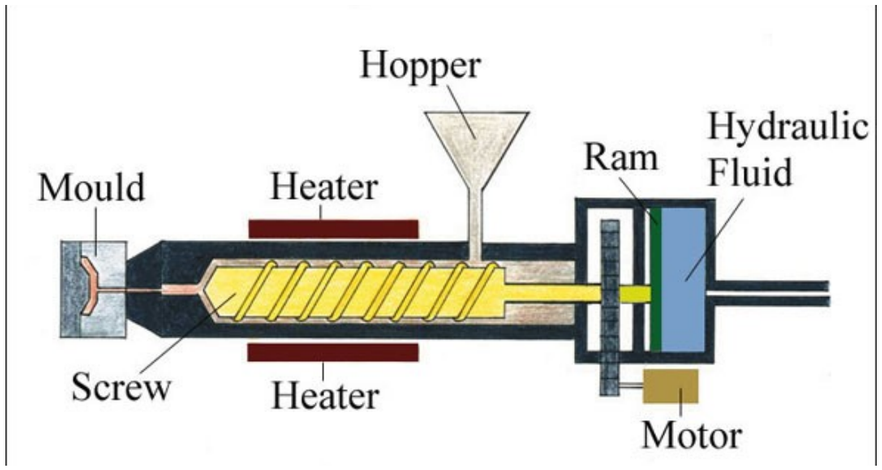
Injection Moulding

This is process is normally associated with thermoplastics and used to create complex 3D Shapes.

Image

Diagram



Example Product

The **Panton Chair** is an S-shaped chair first designed by the Danish designer Verner Panton in the 1960s. It is considered the world's first moulded plastic chair and to be a masterpiece of Danish design.

Today's Panton Chairs are manufactured by injection moulding out of polypropylene, which is fully recyclable. Injection moulding technology makes it possible to offer this design classic as an inexpensive version, thereby making it available to a wider market.

Step by step

- Granules of plastic powder or granules are poured or fed into a hopper.
- A motor turns a thread which pushes the granules along the heater section which melts then into a liquid. The liquid is forced into a mould where it cools into the shape.
- The mould then opens and the shape is removed.

Advantages

- Very complex 3D shapes can be produced.
- High volumes can be produced with consistent quality.
- Very fast compared to other moulding processes .
- Little labour costs.
- Little waste.
- Little to no finishing of the shapes produced.

Materials used in this process

- Polystyrene
- Nylon
- Polypropylene *(below)*

- Polythene
- ABS *(below)*

Disadvantages

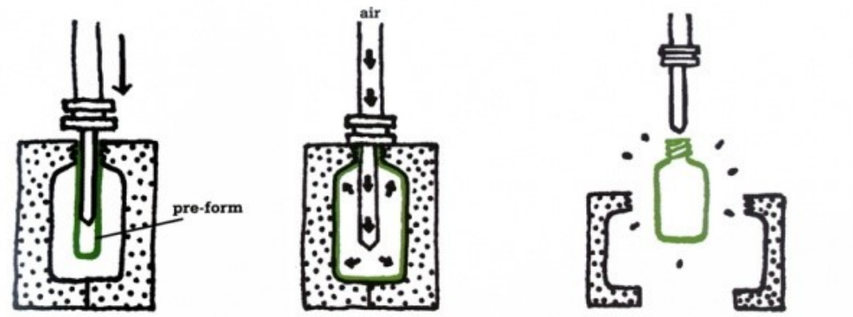
- High initial set-up costs.
- Moulds *(pictured)* are expensive.

Blow Moulding

This process is used in the manufacture of bottles and other containers. Objects produced are usually hollow.

Image

Diagram



1 An injection-moulded pre-form is placed in the mould.

2 Compressed air is injected, blowing the pre-form into the mould cavity to form the final shape.

3 The mould opens and the part is released.

Example Products

Although originally made of concrete, today's **traffic cones** are more commonly brightly coloured thermoplastic.
Recycled PVC from bottles can be used to create modern traffic cones. Blow moulding is ideal for traffic cones as they need to be mass produced, easily transported and hollow so they can be filled and weighted down with sand, water or concrete.

Step by step

- The plastic is fed in granular form into a 'hopper' that stores it.
- Heated plastic granules are injection moulded into a pre-form shape which is positioned into a mould.
- Air is forced into the mould which forces the plastic to the sides, giving the shape of the bottle.
- 5. The mould is then cooled and is removed.

Advantages

- Once set up, blow moulding is a rapid method of producing hollow objects with narrow necks.
- Well suited to low or high production scales.
- Many types of plastic can be used.
- Can be less expensive than injection moulding.

There are many different **kayaks** on the market made from different construction methods which all have their advantages and disadvantages. Blow moulding is the most inexpensive form of production, but has the poorest performance properties. It makes for great low prices but the finish and thickness of material may be thin where kayakers really need it thick, such as in the corners on the bottom of the boat. Also you will rarely find a long pointy kayak that has been blow moulded because of problems getting the plastic into the ends.

Materials used in this process

- HDPE
- LDPE
- PP
- PVC
- PET *(pictured)*

Disadvantages

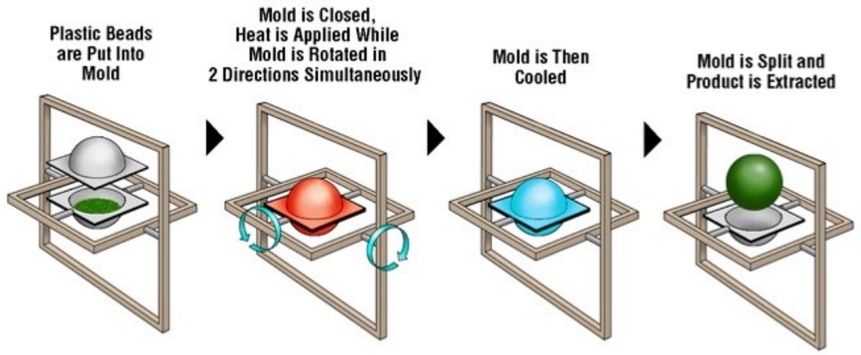
- Limited to hollow parts.
- Moulds can be expensive.
- It is difficult to produce ‘re-entrant shapes’ (shapes that do not allow easy extraction from the mould).
- Difficult to produce triangular shapes.

Rotational Moulding

Used in the manufacture of hollow plastic products.

Image

Diagram



Example Products

The **Q Drum** is the simple, durable, effective and user-friendly solution to trouble of fetching water invariably over long distances In disadvantaged and rural communities. The idea of the Q Drum originated in response to the needs of rural people in Southern Africa who struggle conveying adequate quantities of potable water from a reliable source.

The Q Drum is manufactured by means of rotational moulding, leaving a seamless finish. It is made from LLDPE (Linear Low Density Polyethylene) which is compatible to most dry foodstuffs or consumable liquids. The simplicity of the design ensures the ease of use - even a child can pull 50 litres of water without undue strain.

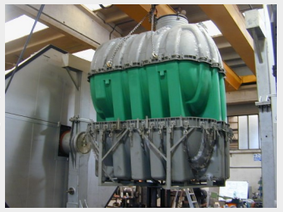
Step by step

- Moulds are loaded with a precise amount of thermoplastic powder *(pictured).*
- The mould is clamped together.
- The mould is then rotated in a heated chamber and the thermoplastic is melted. The continuous rotation ensures the thermoplastic covers all of the inside of the mould.
- The mould is cooled and then opened.
- The product is extracted.

Advantages

- A hollow part can be made in one piece with no seem lines or joints.
- Ideal for rigid, tough and flexible shapes.
- There is no material wastage as all the material is normally consumed in making the product.
- Different types of product can be moulded together on the one machine.
- Surface textures can be applied to the finished products by applying a texture to the mould.
- Moulds tend to be cheaper than injection moulding or blow moulding.

Polyethylene water tanks and chemical tanks are manufactured using rotation moulding. They are tough shapes, impact resistant and non-corrosive. The one piece seamless inner polyethylene construction these tanks to be used for the storage of most industrial chemicals, including a wide range of herbicides and fertilisers.



Unloading a moulded polyethylene tank from a large scale industrial rotational moulding machine.

Materials used in this process

More than 80% of all the materials used in rotational moulding are from the polyethylene family of plastics.

- Polyethylene
- Polypropylene
- Polyvinyl chloride
- Nylon
- Polycarbonate

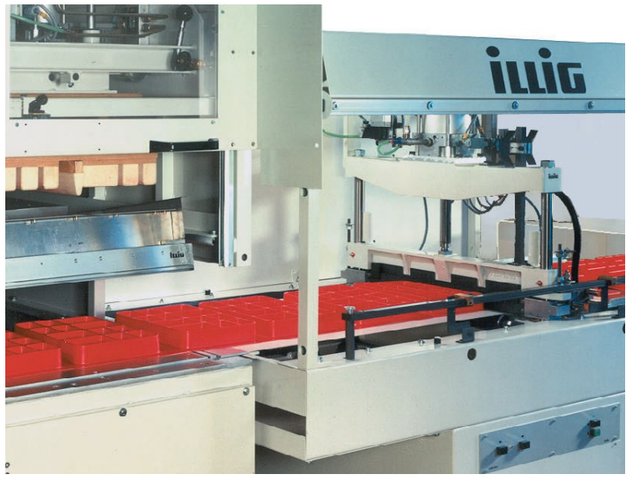
Disadvantages

- Only hollow shapes can be produced . More complex shapes need injection or blow moulding.
- The plastic used must be ground down into a fine powder, and in many cases there is need for special additive packages . This makes the manufacturing costs fairly high.

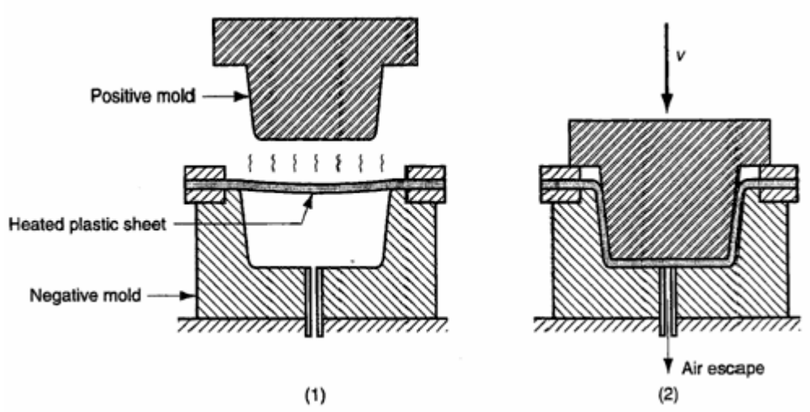
Thermoforming

This is a form of vacuum forming, where an additional female mould assists the moulding process so that greater detail can be achieved.

Image



Diagram



Example Products

Thermoforming is an important application for the manufacture of polypropylene **rigid food packaging**. The thermoforming process is used for producing mass parts of packaging products, but is also used in small production where injection moulding is not cost effective.

Step by step

- Sheet plastic is held securely between the two halves of the mould.
- The plastic is heated just above its softening point.
- The mould halves close and a vacuum is applied through the lower/negative mould.
- The upper/positive mould ensures the required amount of detail is achieved.

Advantages

- Low cost process.
- Works well when creating smooth shapes that need extra detail.

Disadvantages

- Deep moulds can result in thin and stretched of parts of the product.
- Limited to simple designs.
- Trimming is often required, creating some waste.

Materials used in this process

Most Thermoplastic sheet plastic.

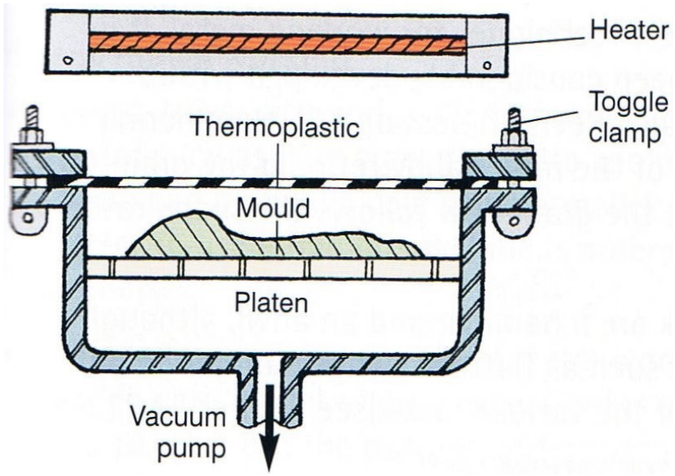
- ABS
- Polystyrene
- Acrylic
- Polycarbonate

Vacuum Forming

Sheet plastic is stretched onto or into a single-surface mould, and held against the mould by applying a vacuum.

Image

Diagram



Example Products

Australian designer Marc Newson has designed a **carrying case to hold a single bottle for champagne** for the brand Dom Pérignon. It is called **'The Black Box'.** The packaging is vacuum formed from poly-carbonate which is durable and is able to act as a good insulator. It is able to protect its precious contents from shock and temperature variations, thus preserving it and making a design statement.

Step by step

- A sheet of plastic is heated to a temperature suitable for forming.
- A mould is then pushed up into the plastic sheet.
- The 'vacuum' is turned on and this pumps out all the air beneath the plastic sheet.
- The sheet has the shape of the former pressed into its surface.

Advantages

- Available to schools *(pictured)*, colleges and industry.
- Simple process, easy to use.
- The mould can be made from a range of materials, including inexpensive materials, because the pressures involved are low.
- Suitable for one-off and large scale production.

Moulds used to create **garden ponds** are often vacuum formed. They can be produced quickly and on a large scale (sometimes one every five minutes) making them affordable and available across garden centres nationwide.

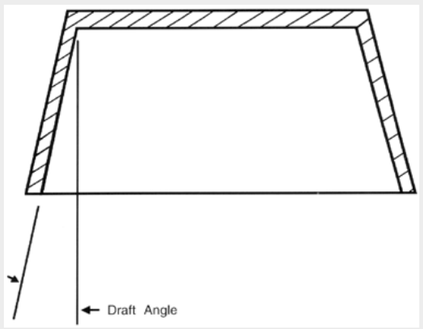
Materials used in this process

Most Thermoplastic sheet plastic.

- ABS
- Polystyrene
- Acrylic *(pictured)*
- Polycarbonate

Disadvantages

- Additional processing required is required to trim excess material which produces a lot of waste.
- Moulds must have no vertical sides—draft angles are needed *(pictured).*
- You can only have undercuts with special moulds.

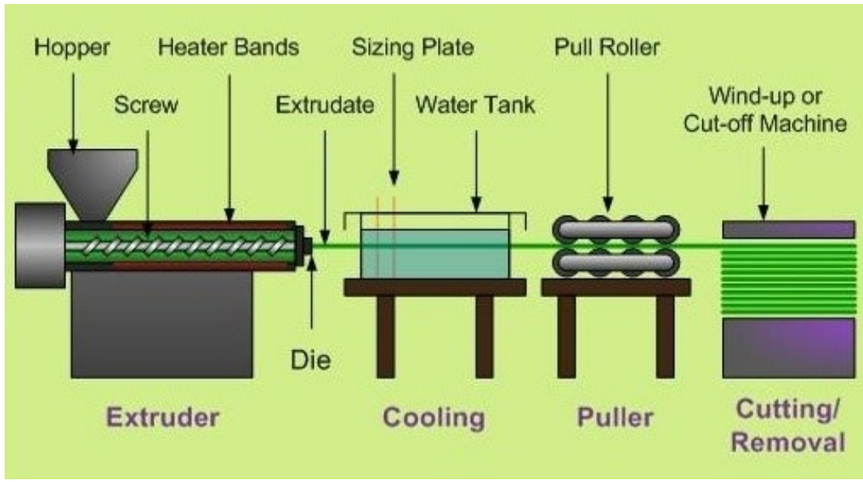


Plastic Extrusion

Plastic extrusion is the process where plastic is formed into a shape with a continuous profile.

Image

Diagram



Example Products

Plastic drinking straws are made from extruded polypropylene. During the extrusion process the heated polypropylene resin exits the die in a long string in the shape of a straw. This elongated tube is directed through a cooling stage—usually a water bath. Some operations run the plastic over a chilled metal rod, called a mandrel, which freezes the internal dimension of the straw to that of the rod. It is continuously moved along by a puller which helps maintain the shape of the straw as it is moved through the manufacturing process. Ultimately, the long tubes are cut to the proper length by a knife assembly.

Polypropylene has many properties which make it suitable for use in straw manufacturing. It is light-weight, has fair abrasion resistance, good dimensional stability, and good surface hardness. It typically does not experience problems with stress cracking and it offers excellent chemical resistance at higher temperatures. Most importantly for extrusion, it has good thermoplastic properties.
Another key attribute of this plastic is that it is safe for contact with food and beverage. Polypropylene is approved for indirect contact with food.

The major waste product from straw manufacturing is the plastic resin. Resin, which is contaminated, overheated, or otherwise ruined must be discarded. However, straws, which fail for other reasons, can be reworked. This process of reusing plastic is known as regrinding and involves pulverizing the straws and re-melting them. This can be done without loss of quality because of the thermoplastic nature of polypropylene

Step by step

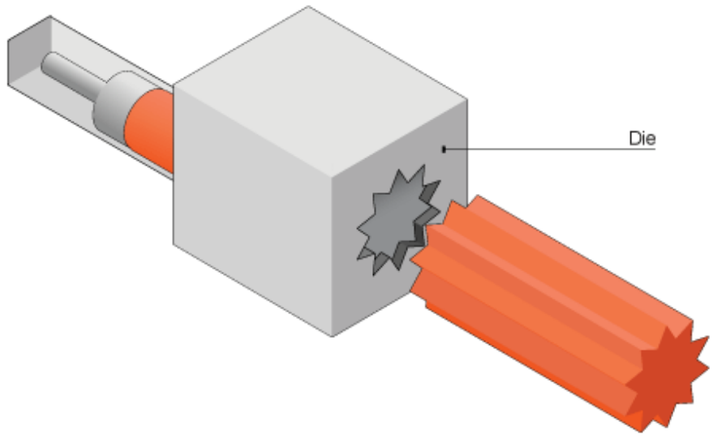
- Granules of plastic powder or granules are poured or fed into a hopper.
- A motor turns a thread which pushes the granules along a heater section.
- The heater softens the plastic which is then forced through a die.
- As the plastic leaves the die it is cooled.
- The extruded product is then cut to the required length.

Advantages and disadvantages

- The best way to make long products with the same profile.
- Only requires simple dies *(pictured below and right)*.
- Parts need to be cut to shape, assembled or drilled.
- Not suitable for one-off productions (unless your one-off is 50 meters long!).

Materials used in this process

Extrusion can be used with a range of materials . As well as plastics aluminium, wood-plastic composites and ceramics are commonly extruded.

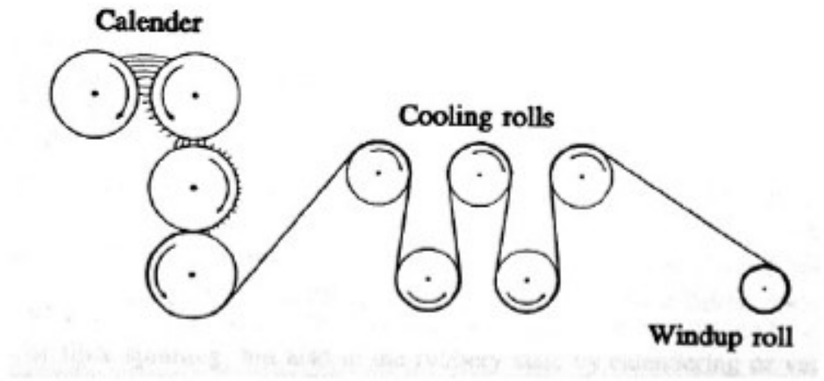


Calendaring

A process used to manufacture thermoplastic sheet, film and coating materials

Image

Diagram



Example Products

Products made from calendaring include:

- floor coverings *(pictured below)*
- continuous flooring
- rainwear
- shower curtains
- table covers
- pressure-sensitive tape
- automotive and furniture upholstery
- wall coverings
- luminous ceilings
- signs and displays

Step by step

- Pre mixed thermoplastic material is fed into rollers.
- Rollers are heated to just above the softening point of the thermoplastic.
- The plastic is forced through a gap roller to determine the thickness of the final product.
- The final roller chills the material.

Advantages

- Produces long continuous rolls without joins.
- Excellent for producing large quantities of flat sheets.
- Can be combined with printing or with laminating a layer of fabric or paper.
- Calendering is very good at handling polymers that are heat sensitive as it causes very little thermal degradation.

Disadvantages

- Suited to large scale production only.

(above) PVC rolls produced by calendaring.

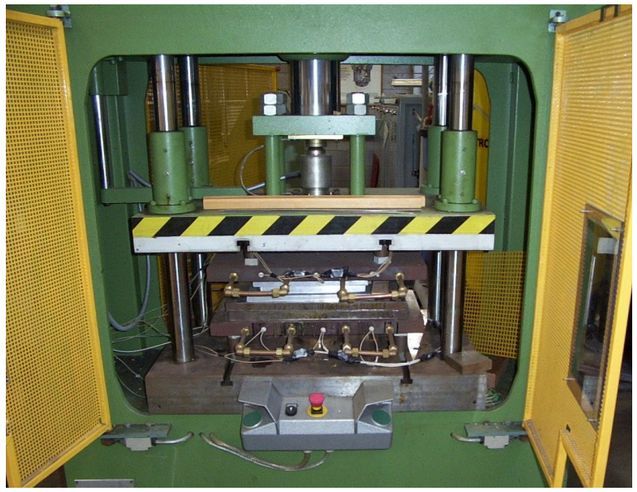
Materials used in this process

- PE
- PVC
- ABS
- Cellulose acetate
- MDPE

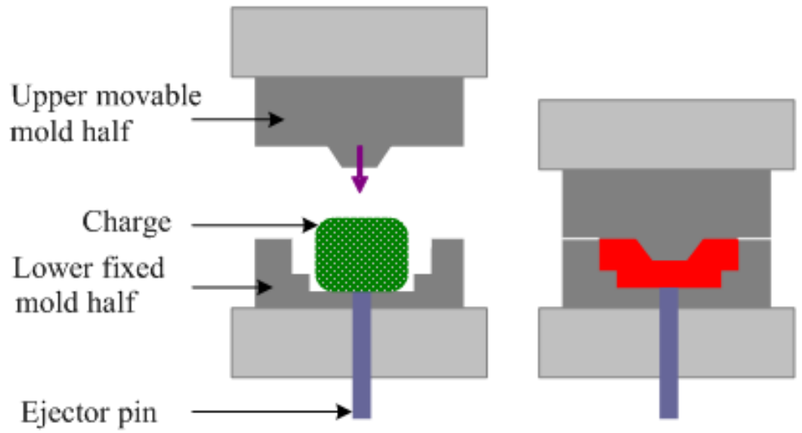
Compression Moulding

Possibly the most important process for manufacturing with thermosetting plastics.

Image



Diagram



Example Products

The thermosetting plastic urea formaldehyde is stiff and a good electrical insulator making it a good choice of material for a **plug socket**. Its solid shape with thick walls makes compression moulding the only really suitable manufacturing process.

Step by step

- A performed charge (compressed plastic powder) is placed between the two halves of the mould.
- The mould is heated to a temperature that will allow the long chain molecules of the thermosetting plastic to fix together (this is called cross-link).
- The mould is closed and held together for a period of time that will allow all cross-links to be formed.

Advantages

- Idea for thermosetting plastics.
- Long production runs.
- Low set-up and mould costs compared with injection moulding.
- Little waste material.
- Idea for creating solid parts with thick walls.

Melamine is combined with formaldehyde to produce melamine resin, a very durable thermosetting plastic. **Melamine kitchenware** is often made by compression moulding.

Materials used in this process

Thermoset Plastics and ceramics.

Disadvantages

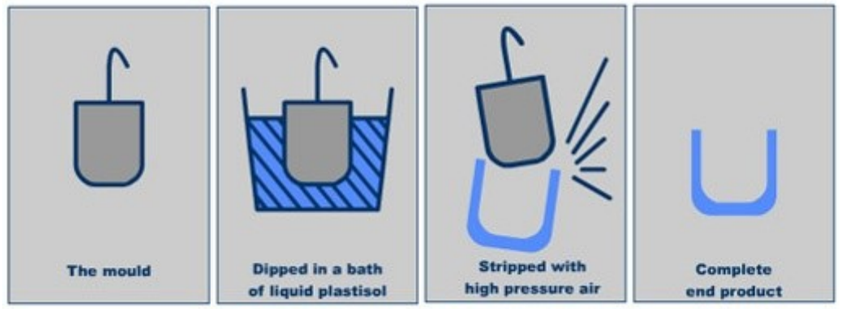
- Limited complexity of shapes produced.

Dip Moulding

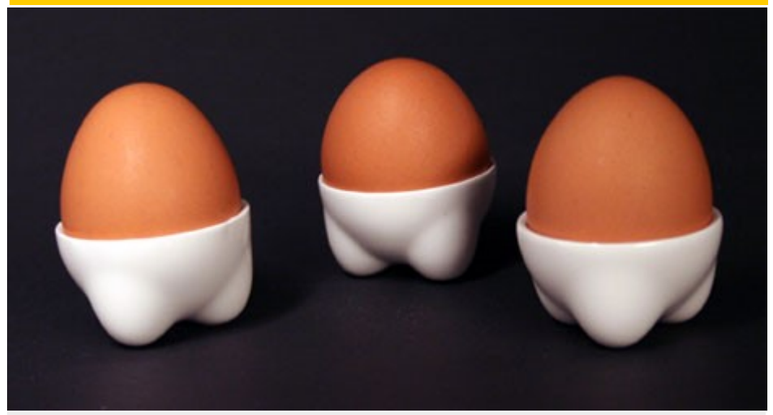
Simple and cheap method of manufacturing shapes where a shape is dipped into a melted plastic.

Image

Diagram



Example Products



Dip-moulding is usually used for cheap, industrial applications. Only the inside of the product is controlled by tooling. The exterior finish is affected by gravity, which causes the material to form little drips on the bottom of your product. Designer Liz Kinnmark challenged, herself to design a product with a form that embraces drips on the bottom. **Egg pants** (above) are what emerged. The product is a cute, flexible egg cup, which won't shatter and which is easy to clean.

Balloons are mass produced using dip moulding.

Step by step

- A mould is dipped into a bath of liquid/molten plastic.
- The mould is removed from the plastic having been coated with a layer of the plastic.
- The mould is cooled.
- The end product is removed from the mould.

Advantages

- Highly cost effective for short production runs.
- Prototypes and formers can be produced very quickly.
- No split lines in final product.
- Suitable for very large production runs.

Disadvantages

- Limited to simple shapes.

Materials used in this process

Soft materials that can be stretched over the moulds including:

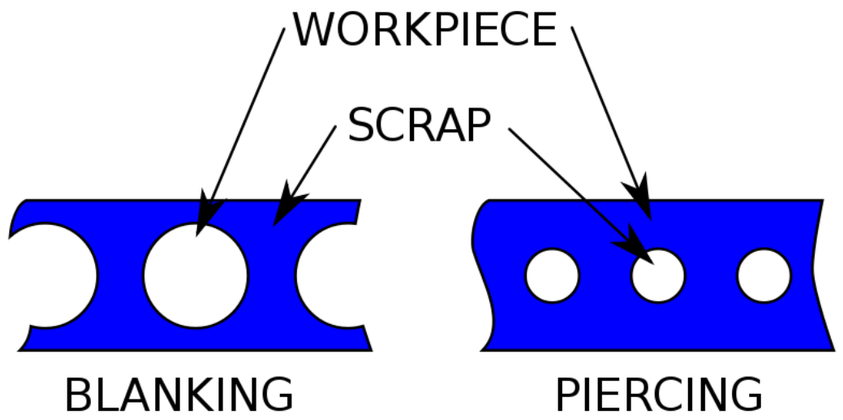
- PVC
- Polyurethanes
- Latex
- Elastomers
- Silicones

Blanking and piercing

When a sheet of metal has a hole punched through it, it has been pierced. When a part to be used is punched out of sheet metal it is called a blank.

Image

Diagram



Example Products

Blanking is a way of making simple components like washers

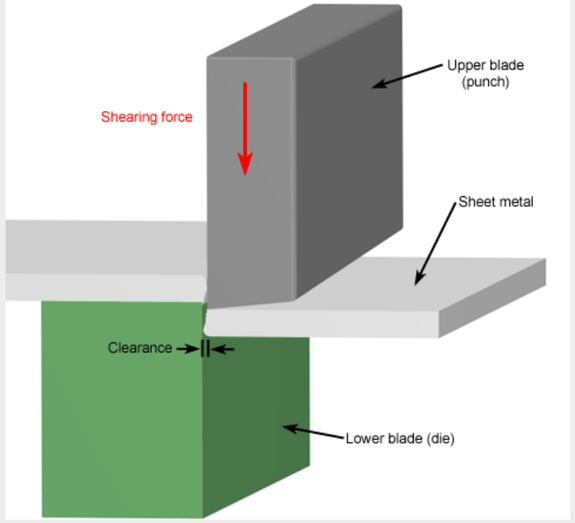
punching lots of holes into something, like the computer casing pictured above, is called perforating.

Perforated circles can be formed into bowl shapes to create a colander *(pictured).*

Products such as soft drinks cans are made by punching disc-shaped blanks from sheet aluminium. This is an everyday product that has to be cost effective, work all the time and be safe when used. The process is set-up to maximise manufacturing efficiency with as little waste as possible.

Step by step

- Piercing and blanking sheet metal requires punches. These punches use a shearing action.



Advantages and disadvantages

- Can produce many different shapes *(pictured).*
- Can be used for any sheet metal.
- High level of accuracy.
- Limited to size of stock materials.
- If the material is not fully utilized there can be a fair amount of wastage.
- Restricted to sheet metal.

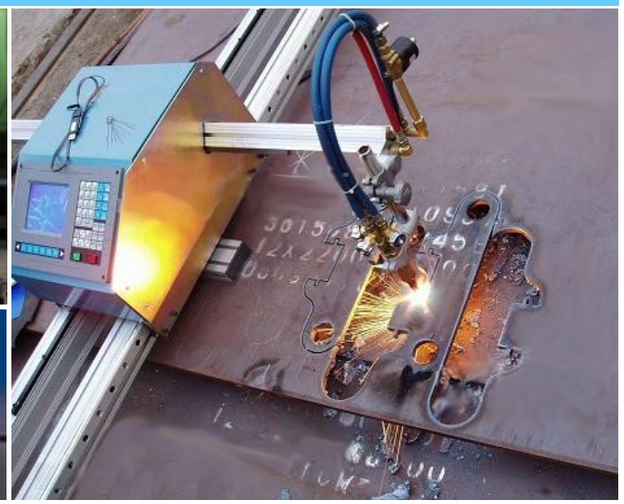
Materials used in this process

Sheet metal. Aluminium is common.

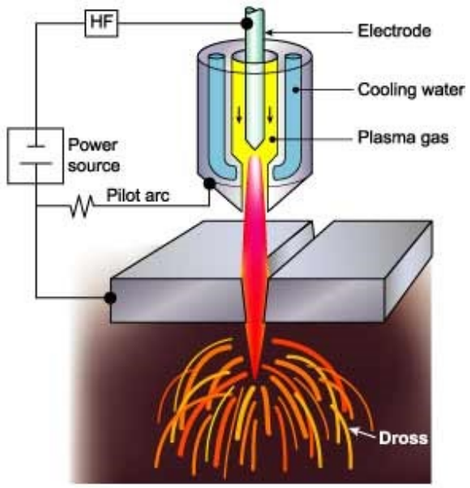
Plasma Cutting

Plasma cutting is a stream of ionised gas which becomes so hot it vaporises the metal that is being cut.

Images



Diagram



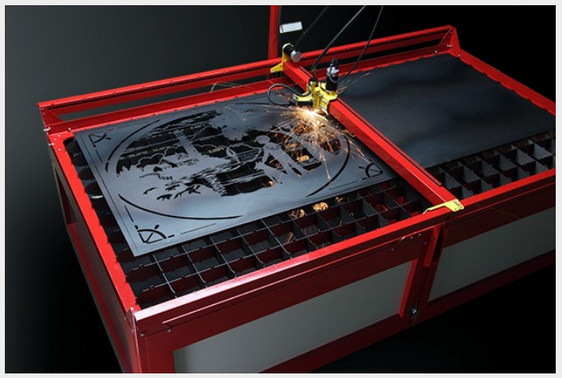
Example Products

Plasma cutting is used in heavy construction including ship building aircraft building and the manufacture of machine components. It can be also used artistically.

The red trim for the interior of this car (below) has been plasma cut.

Step by step

- Plasma cutting can be done handheld/manual or controlled by CNC *(pictured).*



Advantages and disadvantages

- Economical process when creating small batches.
- Provides smooth, clean cuts.
- Sheet material thinner than 8mm may distort. Plasma cutting is not suitable for sheets under 2mm thick.
- Very energy intensive.
- Often a high amount of wastage, especially with handheld cutting.
- A large range of materials can be cut.

Materials used in this process

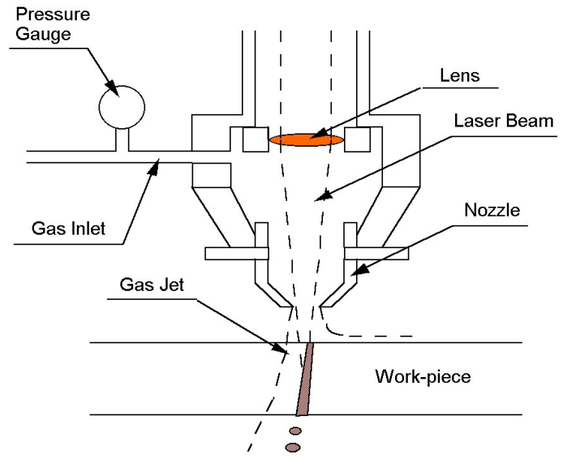
Any electrically conductive metallic material. Most commonly stainless steel and aluminium.

Laser Cutting

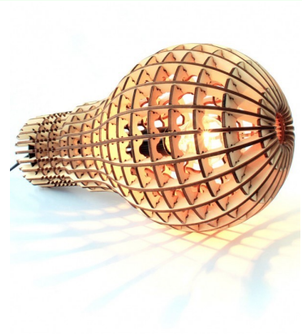
A highly accurate form of cutting and decorating materials using a fine beam of light controlled by a CNC machine.

Images

Diagram



Example Products



Designer Barend Massow makes interesting laser cut **lighting** pieces inspired by traditional lighting forms. These examples (above) were cut from plywood and acrylic.

The great level of accuracy that can be achieved from laser cutting plywood allows for easy, no glue, assembling **toy kits** that can be easily flat packed.

Because of the high level of accuracy and finishing quality that can be achieved laser cutting is often used in the production of intricate batch produced products such as **jewellery**. Pictured is some acrylic earrings.

A laser cut acrylic **shop sign.**

Advantages

- Can engrave and cut materials by adjusting the power output.
- Highly complex shapes can be produced.
- Suited to batch production.
- Gives a clean edged cut on acrylic and metals.
- A much broader range of materials can be cut compared to plasma cutting.
- Low maintenance/no tool wear.

Disadvantages

- Can leave burn marks on wood and paper materials.
- Highly polished or reflective surfaces decrease the effectiveness of the laser.
- Very energy intensive.
- Slow when working with thicker materials.
- Material wastage is often high.
- Not suitable for large scale production.
- There is an optimum thickness from which materials can be cut.

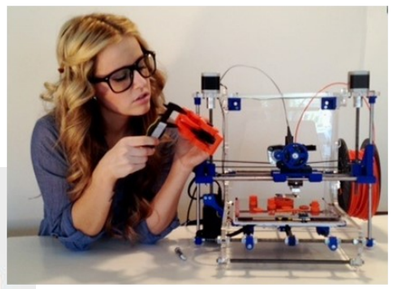
Materials used in this process

- Paper
- Card
- MDF
- Plywood
- Acrylic
- Copper
- Stainless steel
- Aluminium
- Gold
- Silver

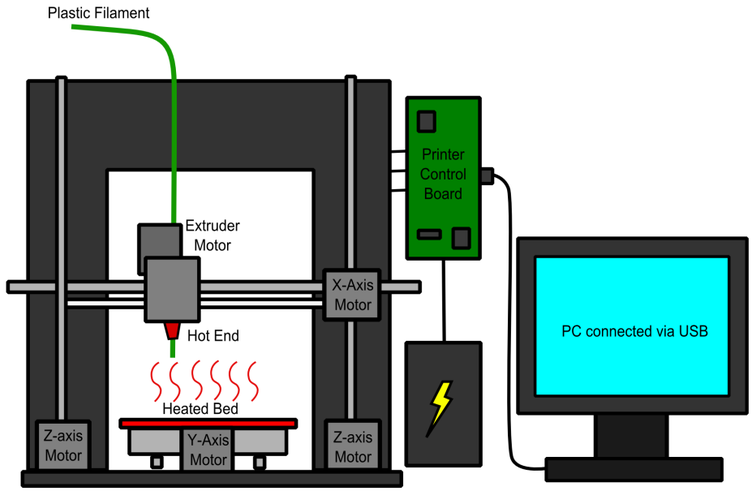
3D Printing

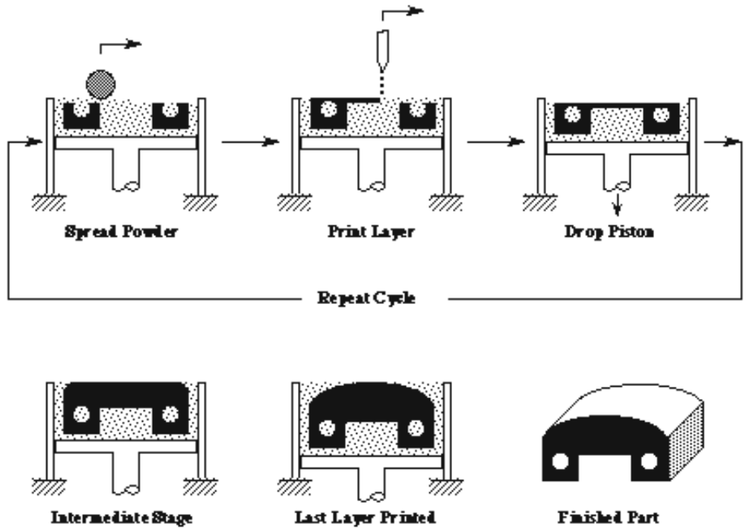
Additive manufacturing or 3D printing is a process of making a three-dimensional solid object of virtually any shape from a digital model.

Images



Diagram





Example Products

Architectural models were previously made by hand and the scaled-down buildings produced in foam, plastic or wood finish. But the advent of 3D printing technology now allows architects to design their work in 3D and print physical models overnight.
The picture above shows two singular architectural models of football stadiums, one of Old Trafford and one of rival Manchester City's Etihad Stadium. Both of these replicas show the iconic grounds in remarkable detail

Aerospace giant BAE Systems says his company has test flown a Tornado Fighter Jets equipped with parts made with 3D metal printing equipment. The parts included a protective cover for the radio, a landing-gear guard and air-intake door support struts. This test is a demonstration of how, maintenance crews will be able to make replacement parts quickly – and cheaply – at any air base hosting the Tornado. Predictions suggest that the 3D printing process could ultimately lead to potential cost savings to BAE of more than £1.1 million between 2014 and 2017.

The McDonald's IT director in Britain said in 2013 that the mega-chain is considering placing a 3D printer in each of their thousands of restaurants which would allow them to 3D print Happy Meal toys at will. Considering that McDonald's distributes more toys per year than Toys-R-Us, includes a toy in more than 20% of all its sales and spends more than £42 million a year advertising Happy Meals alone, and you might begin to understand what it would mean for the company to be able to cut costs on those meals.

Materials used in this process

- A range of thermoplastics, metal alloys and plasters.

Advantages and Disadvantages

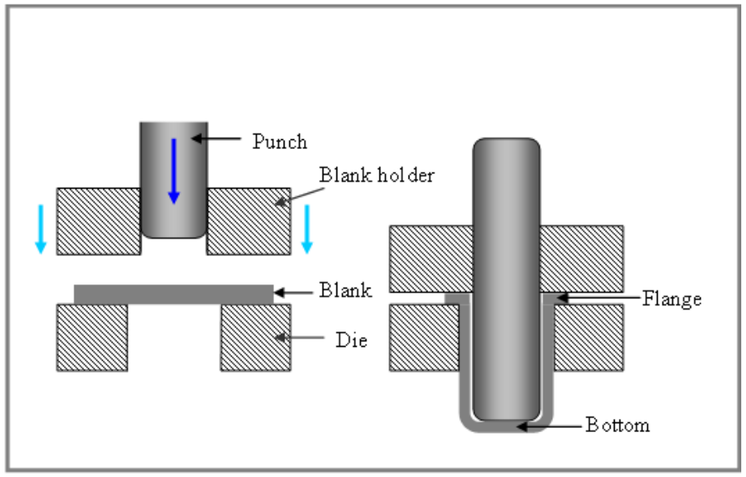
- Any object can be easily printed. It does not matter how complex the design, 3D printing has opened the door to an infinite possibility of shapes and sizes that can also be customized to the customer's needs.
- Designers can instantly improve their prototypes, increasing efficiency and the effectiveness of an organisation. Perfection can be achieved in a matter of hours .
- Technology such as this can be misused resulting in the rise of many ethical concerns. As any desired object can be printed, an owner of a 3D printer can print objects that are protected by copyrights or could be used in fraud or even weapons.

Press-forming / Deep Drawing

A process of pressing sheet metal into 3D shapes.

Image

Diagram



Example Products

Products of all shapes and sizes, can be economically created through this process, including items such as aluminium cans, cookware, and **kitchen sinks**.

The picture above shows the sequence of **can** body production from circular blanks beginning with deep drawing.

Step by step

- Sheet metal materials/blanks are loaded into a hydraulic press and clamped into the blank holder.
- The punch forces the material through the die so it takes the shape of the punch.

Advantages

- Pressing sheet metal into more 3D shapes can increase stiffness.
- Can be carried out at room temperature.
- Suitable for medium and high volume production.
- Seamless parts created from single sheets of metal.

Materials used in this process

Sheet metals with sufficient ductility.

They may include:

- Steel
- Copper
- Brass
- Aluminium

Disadvantages

- Very high level of stresses needed to overcome the resistance of the metal being pressed.
- High tooling costs.

The picture (left) shows formed fire extinguishers before finishing (right).

Sand Casting

A low cost method of casting metal in sand moulds. Used for one-off or low volume production.

Image

Step by step

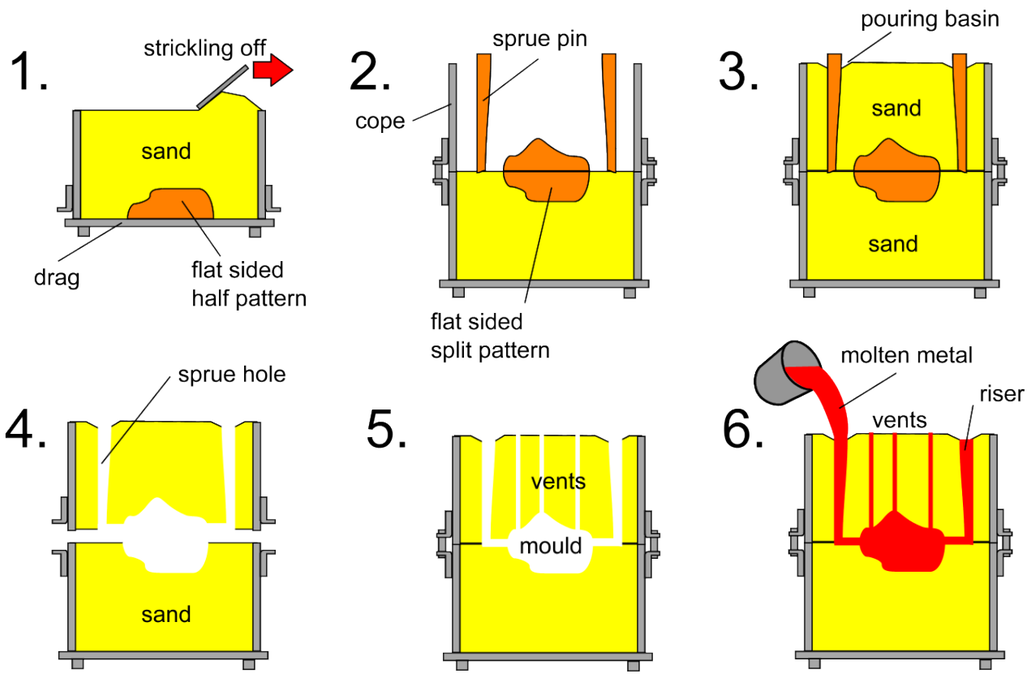
- A pattern is made.
- Each part of the pattern is placed on a base board. A mould box half is placed over it.
- Sand is packed around the pattern forcing it into contact with the pattern.
- The pattern is removed from the mould half.
- The mould halves are fitted together with locating pins ensuring correct alignment.
- Molten metal is poured into the running gate.
- Once the metal has solidified the mould is broken open.

Materials used in this process

Metals with a low melting point. These include:

- Copper alloys
- Lead
- Zinc
- Aluminium
- Tin
- Certain steels

Diagram



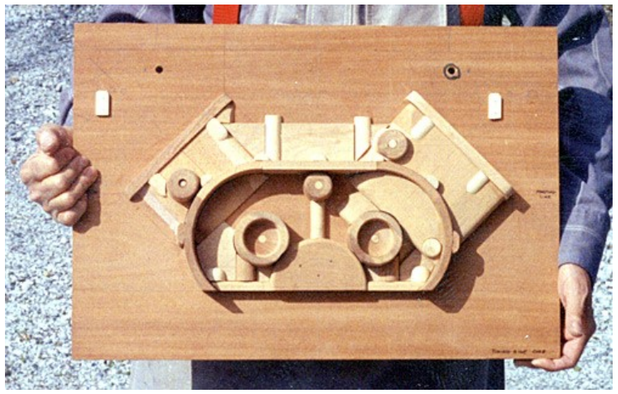
Advantages

- Low cost process.
- Easy to operate.
- Advanced sand casting can produce very detailed and intricate parts.
- Flexible levels of production.

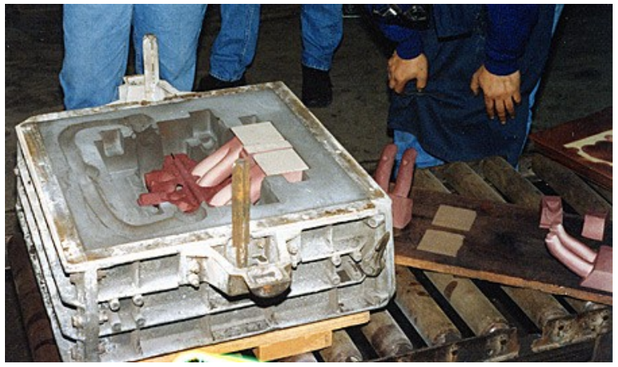
Disadvantages

- Can be labour intensive.
- Unit costs can be high when used for one-off production.
- Parts may require a lot of finishing.

Example Products



Above is an example of a pattern produced to create a mould for an **engine part**. The images below show the mould and casting.

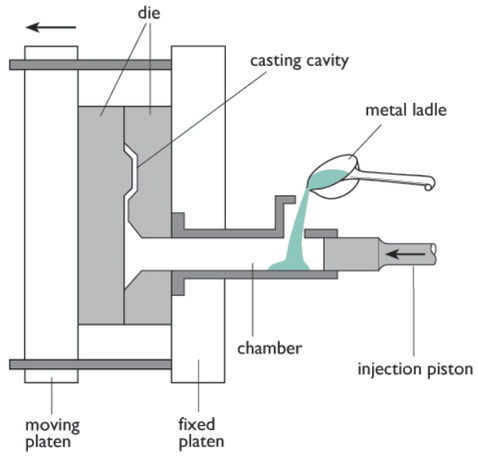


High Pressure Die Casting

High pressure die-casting is one of the most economical methods of producing metal components with complex shapes.

Image

Diagram



Example Products

Die cast metal toys have been popular for decades. Die-casting allows fine and complex details as can be clearly seen in the example pictured above.

Step by step

- Molten metal is poured into a chamber.
- An injection piston or plunger forces the molten metal under high pressure into the casting cavity.
- The pressure is maintained until the metal solidifies.
- Injector pins are used to push the components out of the die.

Advantages

- Suitable for metals with low metaling points.
- Ideal for complex shapes.
- A high level of detail can be achieved.
- Excellent surface finish.
- Highly accurate.
- Can produce small and thin parts.
- Fast process.

(above) A die-cast one-piece calliper brake leaver for a bicycle.

Materials used in this process

Metals with a low melting temperature such as

- Aluminium
- Zinc

Disadvantages

- Expensive, so only suitable to high volume production.
- Parts produced are not guaranteed to have high structural strength.
- Excess material requires additional trimming which adds to energy use and waste.

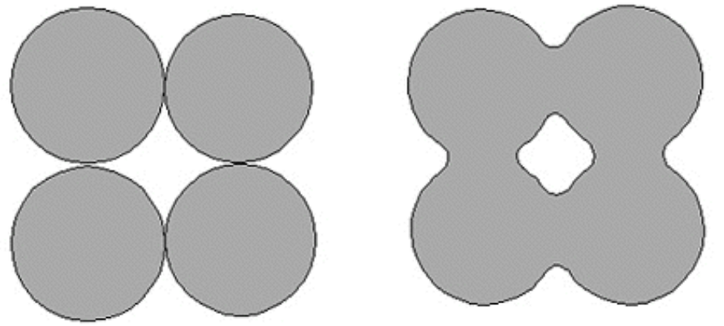
The Chair One designed by Konstantin Grcic is formed of polished die-cast aluminium or in die-cast aluminium treated with fluorinated titanium and painted in polyester powder. The Chair One can be stacked and there is a seat cushion also available to order if required. The black or white polyester painted version is suitable for outdoor use.

Sintering

Discription

Image

Diagram



Representation of the initially unsintered powder particles.

Represention of Sintered Powder Particles

Example Products

There are 2 main types of bicycle disc brake pads: Sintered (or metallic), and Resin (or organic). Both types of pads have their pros and cons, and choosing the right pad depends on many things such as the rider weight, weather/trail conditions and type of riding.

Sintered pads are made up of hardened metallic ingredients, which are bound together with pressure and temperature. Their advantages are that they perform better in wet conditions and last longer, but unfortunately they are louder, take longer to break in and do not have as much initial bite

These pads will be better for heavier riders and are recommended for riding in wet, muddy, or dusty conditions. Riders notice increased performance at the end of their rides. This happens because the heat is put back through the brake calliper, rather than thedisc where you would get brake fade. Since these pads are made of a harder compound they will last longer than resin pads.

Step by step

- Materials are crushed into a powder.
- The powder is compacted into a die, which will give the product being made its final shape.
- The compacted shape is then heated so that the powder particles bond.

Advantages

- A good process for using materials that are difficult to process in any other way.
- Good surface finish.
- No wasted material.
- Not suited for making products with thin walls.
- Can produce complex shapes.

Materials used in this process

- A variety of metals, glass, plastics and ceramics.

Disadvantages

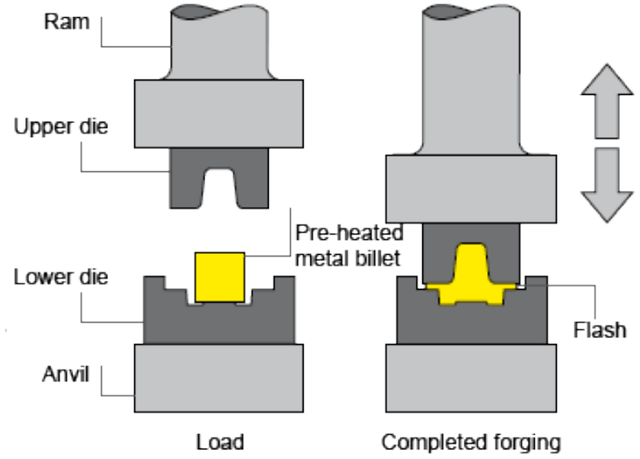
- There can be problems with shrinkage.
- Allows use of some recovered waste materials.
- Requires a number of different stages.

Drop Forging

Used as a refining process when large numbers of similarly shaped objects are required.

Image

Diagram



Example Products

The words "drop forged" are often stamped on **drop forged tools**. Why do manufacturers want you to know that a tool is drop forged? The reason is because this tells you something about the strength and durability of the tool. The other two ways to make a tool would be casting it from molten metal or machining it (cutting material away) from a larger block of metal. The advantage of drop forging is that it improves the strength of the metal by aligning and stretching the grain structure. A forged part will normally be stronger than a casting or a machined piece.

Step by step

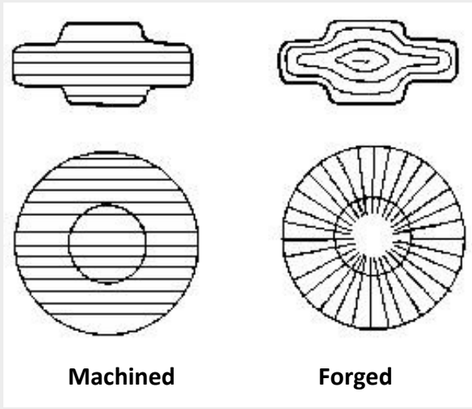
- Very large forces are exerted onto a pre-heated metal billet between the die halves.

Materials used in this process

- Most ferrous metals, including stainless steel and alloys.
- Non ferrous metals including titanium, copper and aluminium are suitable.

Advantages and disadvantages

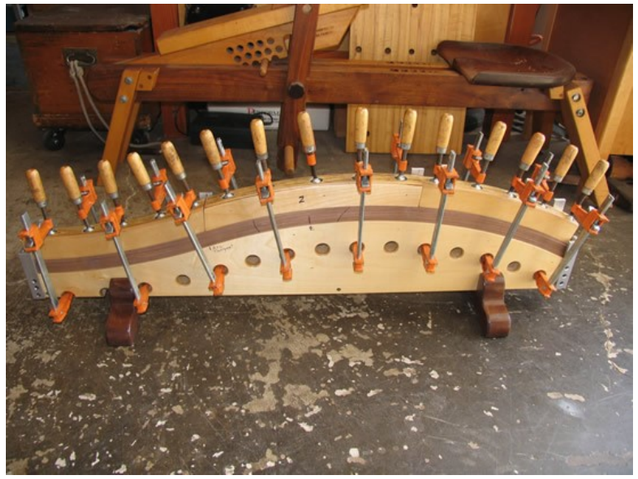
- Forging can produce a piece that is stronger than an equivalent cast or machined part. As the metal is shaped during the forging process, its internal grain deforms to follow the general shape of the part. As a result, the grain is continuous throughout the part, giving rise to a piece with improved strength characteristics *(see diagram below).*
- Some metals may be forged cold, but iron and steel are almost always hot forged. Hot forging prevents the work hardening that would result from cold forging, which would increase the difficulty of performing secondary machining operations on the piece.
- It can be very expensive.
- There are significant dangers working with the hot metal.



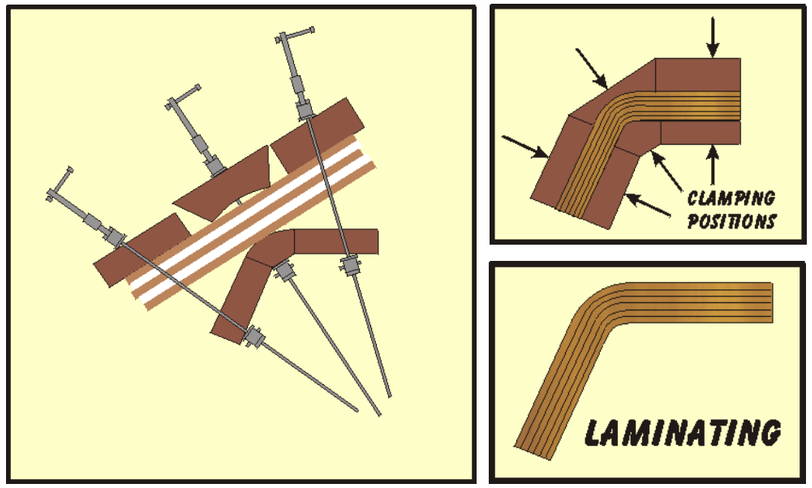
Wood Laminating

Multiple sheets of wood veneer are formed using moulds and bonded together using strong adhesives, to produce rigid, light weight structures.

Image



Diagram

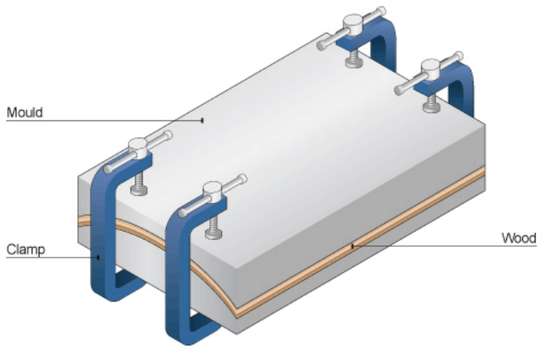


Example Products

The **Eames Lounge Chair and ottoman**, was released in 1956 after years of development by designers Charles and Ray Eames. It was designed for a high-end market. It is made of laminated plywood and leather. Examples of this design are part of the permanent collection of New York's Museum of Modern Art.
The chair has become iconic with Modern style design. The chair is composed of three curved plywood shells. In modern production the shells are made up of seven thin layers of wood veneer glued together and shaped under heat and pressure. The design is considered to be one of the first to make use of moulded plywood, which was devised during WWII for leg and arm splints. The original (vintage) chairs made use of luxurious materials such as rosewood faced plywood, cast aluminium and leather to create organic shaped seating shells .

Step by step

- Adhesive is applied to the face of each veneer.
- Each veneer is stacked on top of the other (lay-up).
- The veneers are clamped into position in a die *(pictured below and above).*
- The adhesive is dries and the shape is formed.



Advantages

- Suitable for one-off, batch and mass production.
- Can accommodate a range of thicknesses.
- Creates strong and lightweight products and components.
- Can be combined with other materials to enhance properties such as in snowboards *(pictured).*

Disadvantages

- Involves many steps.
- Restricted to bends in a single direction.

Supplies of birch veneers *(above)*

Materials used in this process

Wood veneers.

- Birch is used in majority of mass produced furniture.

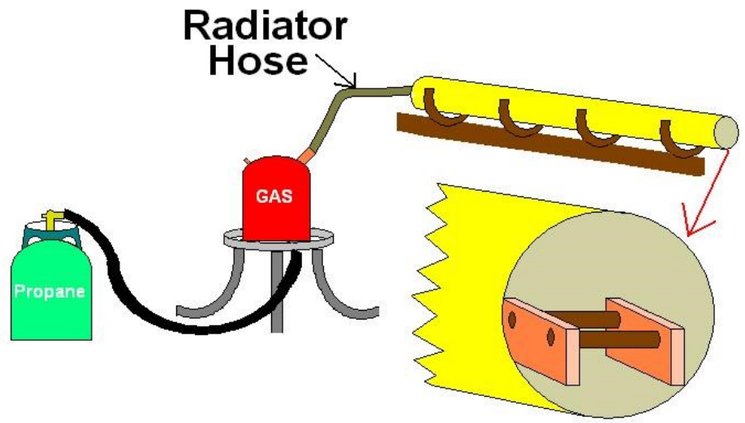
This elegant **stackable stool** designed by Shin Azumi is formed from a single sheet of plywood. The seat and the body of the stool merge seamlessly. The wide spread of the base helps to disperse pressure.

Steam Bending

The moistening of certain woods to a point where it becomes more pliable.

Image

Diagram



Exam- ple

Step by step

- Tools used for the steaming process include: a steam box, a steam or heat generator, a thermometer and a hose.
- Steam boxes may be constructed from PVC pipe and must completely encase the wood so that the steam may saturate the entire length of the material.
- The wood is steamed and softened.
- Once the wood is becomes flexible it can become manipulated.

Materials used in this process

- Hardwoods are more suitable than softwoods and some hardwoods are more pliable than others.
- Beech and oak are common in furniture making.
- Oak is common in construction.
- Elm, ash and willow are traditionally used in boat building.
- Maple is suitable for musical instruments.

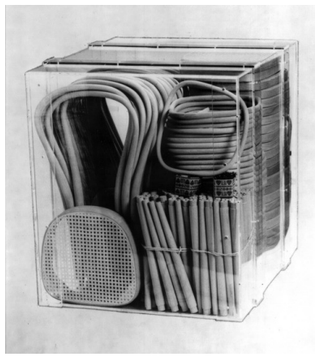
Advantages

- Has good aesthetic appeal.
- The most effective technique for bending solid wood.
- Can be done with simple equipment.
- Parts with strong weight to strength ratio can be produced.
- Steam bent wood parts can be individually shaped and joined to produce almost any shape *(pictured).*

Disadvantages

- Only high quality hard wood timbers should be used.
- Not suitable for applications that require precision.
- The bend radius is dependant on the type of wood used.

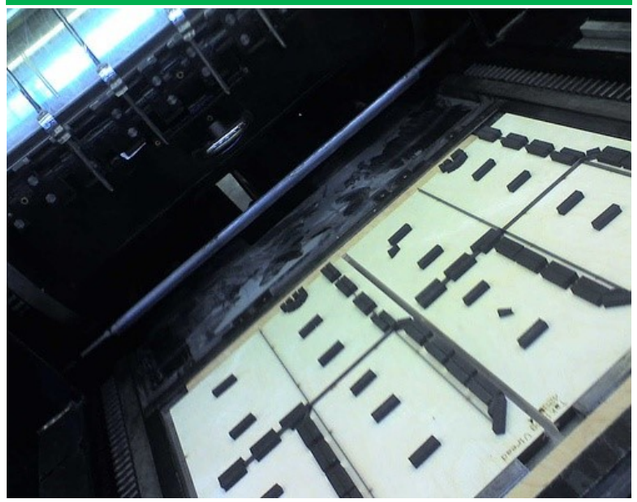
The **No. 14 chair** is the most famous chair made by the Thonet chair company. Also known as the bistro chair, it was designed by Michael Thonet and introduced in 1859. It is made using steam bending technology. With its affordable price and simple design, it became one of the best-selling chairs ever made. Some 50 million No. 14s were sold between 1859 and 1930, and millions more have been sold since. Thonet's No. 14 was made of six pieces of steam-bent wood, ten screws, and two nuts. The wooden parts were made by steam heating beechwood slats to 100 degrees Celsius, pressing them into curved cast-iron molds, and then drying them at around 70 degrees Celsius for 20 hours. The chairs could be mass-produced by unskilled workers and disassembled to save space during transportation.
The design was a response to a requirement for cafe-style chairs. The seat was often made of woven cane or palm, because the holes in the seat would let spilt liquid drain off the chair.
Chair No 14, today known as 214, is still produced by Thonet.
While CNC machining and wood laminating can be used to produce similar shapes, steam bending is specified for applications that require the aesthetic appeal and structural benefits of solid wood.



Die Cutting

A process for cutting, perforating and creasing thin sheet materials.

Image

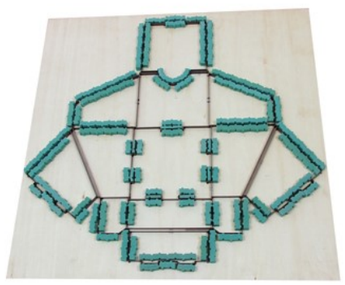


Step by step

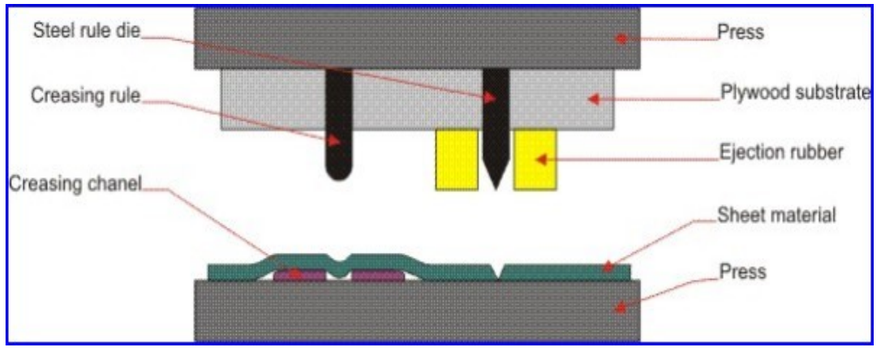
- The sharp edges of the cutting die are brought down onto a thin sheet material.
- The material can be cut, creased and perforated all on one single step.

Materials used in this process

- Paper
- All sorts of card
- PVC
- PET
- Polypropylene *(pictured)*



Diagram



Advantages

- Low set up costs.
- Cost effective for batches.
- Can easily be combined with printing.
- Many shapes can be cut in a single cutting action.
- Large batches can be produced very quickly.

Disadvantages

- 3D products need to be assembled by hand.

Example Products

Die Cut **Alphabet Book**. All Pages are die cut to show the interest of alphabet shapes.

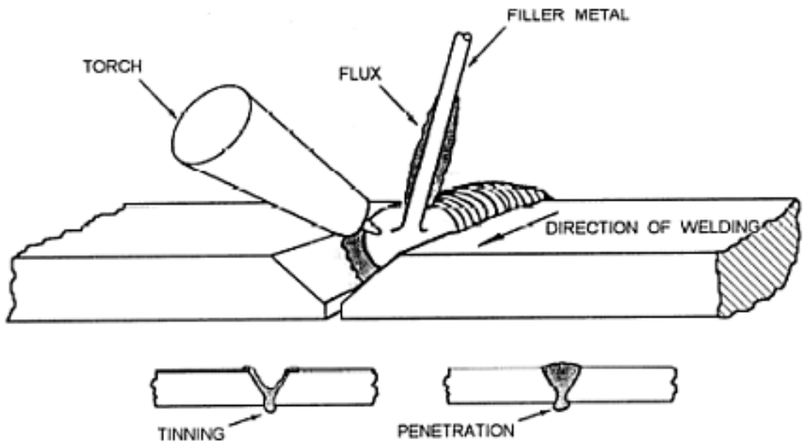
Stickers are often either kiss cut or die cut. Kiss Cuts are cuts that go only through the vinyl and not the backing material. Die Cuts are cuts that go through both the vinyl and sticker backing paper.
In the photo above you'll notice that the left image is a kiss cut sticker which still has the rectangle backing behind it. However, once the sticker is removed from the backing it appears as if it were die cut. The image on the right shows a die cut that is around the image so there isn't excess material. The price of the sticker will go up with the complexity of the shape around it.

Brazing

A way of forming permanent joints in metal by melting a brazing rod at 880°C between two parts.

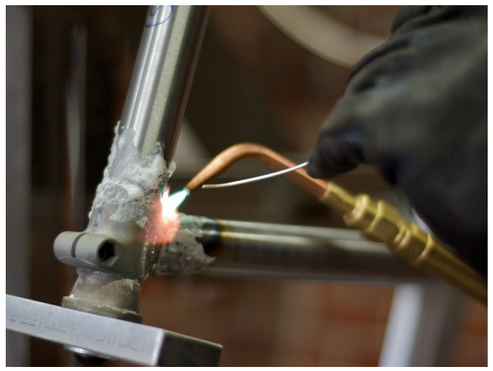
Image

Diagram



Example Products

The stainless steel **Alessi Bombe Milk Jug** was designed by Carlo Alessi in 1945 and is still in production today. Brazing is used to join the spout and handle. Brazing is used to maintain the integrity of the original design.
An overlap has been created between the spout and body to maximize the surface area being joined.
The wok is done in a jig and the whole process lasts about 30 seconds. Very little finishing is required, the brazed part is removed from the jig and lightly polished.



Brazed bicycle parts.

Step by step

- The metal to be joined must first be cleaned so that grease and dirt is removed.
- Flux is brushed along the joint to prevent oxidation taking place on the metal surfaces.
- Pressurised gas and air is fed through a nozzle and ignited.
- The joint is heated with the flame until eventually it becomes so hot that it becomes red in colour.
- A brazing rod (copper-zinc alloy) is then pushed gently against the joint and if the temperature is right the end of the rod will melt and begin to run along the joint. The rod is fed into the joint until a brazed joint is complete.

Materials used in this process

- Copper
- Steel (particularly mild steel).

Advantages

- Low costs.
- Does not affect the properties of the materials being grazed.
- Suitable for one-off through to mass production.
- Depending on size of joint and technique this process takes little time.
- The bond is very strong—close to the strength of the parent material.
- Can produce a clean joint without the need for secondary finishing
- Complex and intricate joints can be achieved.
- Very few rejects as faulty joints can be dismantled and re-joined.

Disadvantages

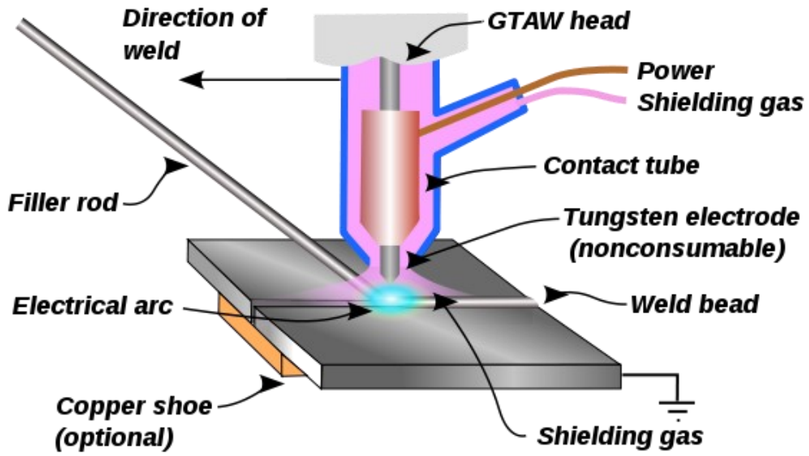
- Requires a high degree of cleanliness.
- The joint colour is often different from that of the base metal, creating an aesthetic disadvantage. Although this can be changed or the materials painted.
- Not as strong as a welded joint.

TIG (Tungsten Inert Gas) Welding

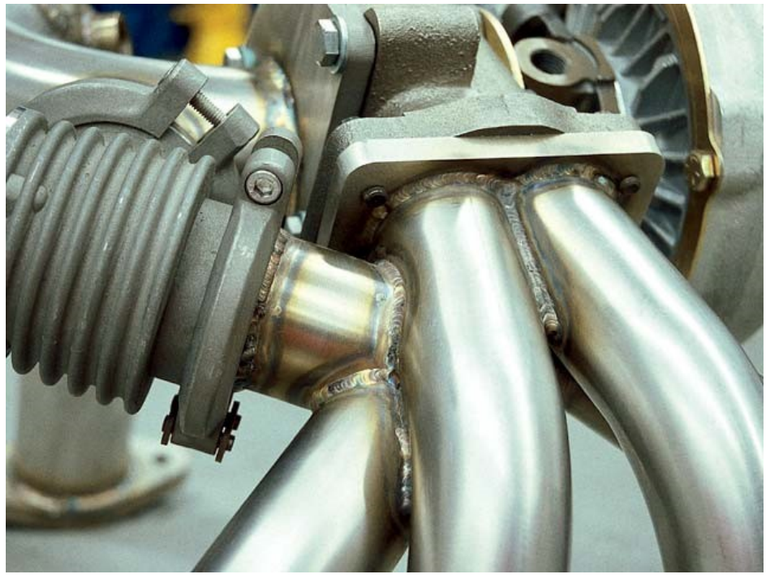
A precise and high quality form of electric arc welding that uses a non-consumable tungsten electrode.

Image

Diagram

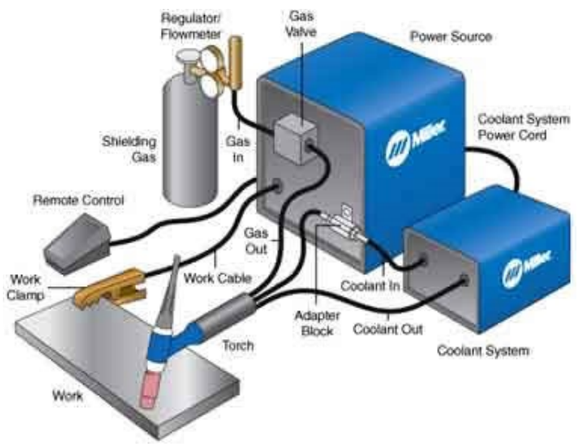


Example Products



Step by step

- TIG generates heat via an arc of electricity jumping from a (tungsten metal) electrode to the metal surfaces you intend to weld .
- The heat is sufficient to melt the joint edges.
- The electrode is coated in flux which when melted, prevents the joint becoming oxidised.



Advantages

- Using Tungsten to provide its electrical current, TIG welding decreases the amount of sparks, smoke and fumes produced.
- TIG welding has less contamination in its weld, providing more precise and higher quality welds.
- No tooling costs.

Disadvantages

- TIG welding requires more setup time than MIG welding and is not as user-friendly.
- TIG welds tend to be more expensive and take longer than MIG welding, especially in thicker metals.
- TIG welding is more complex and requires more skill than the MIG welding process.

Materials used in this process

TIG is widely used on:

- Carbon Steel
- Stainless Steel
- Aluminum.

It is the main process for joining

- Titanium.