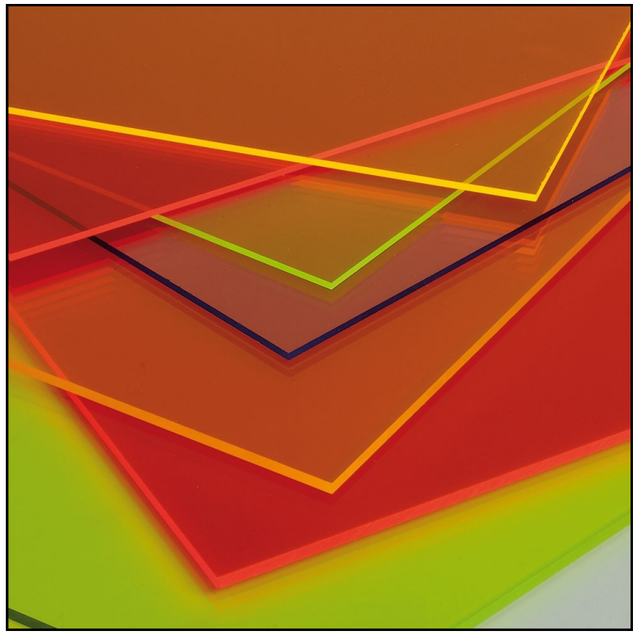
Recycling Identification Table

Plastic Identification Code (PIC)	Type of Plastic	Properties	Common Packaging Application
1 PETE	Polyethylene terephthalate (PET, PETE)	Clarity, strength, toughness, barrier to gas and moisture	Soft drink, water and salad dressing bottles; Nutella and jam jars.
2 HDPE	High-Density Polyethylene (HDPE)	Stiffness, strength, toughness, resistance to moisture.	Water pipes, hula hoop rings, buckets, water bottles, grocery bags, shampoo bottles.
3 V	Polyvinyl Chloride (PVC or V)	Versatility, ease of blending, strength, toughness	Cling film, cable insulation, rigid piping, vinyl records.
4 LDPE	Low-Density Polyethylene (LDPE)	Ease of processing, strength, toughness, flexibility, barrier to moisture	Frozen food bags, squeezable bottles, cling films, flexible container lids.
5 PP	Polypropylene (PP)	Strength, toughness, resistance to heat, chemicals, grease and oils. Versatile, barrier to moisture.	Kitchenware, yogurt containers, butter tubs, take-away containers, disposable cups, plates
6 PS	Polystyrene	Versatile, clarity, easily formed	Packing peanuts, disposable cups, plates, trays and cutlery.
7 OTHER	Other (often Polycarbonate or ABS)	Dependent of plastic.	Baby bottles, CDs, unbreakable glazing, electronic equipment, sunglass lens, car headlights, riot shield

Technical Department



Curriculum for Excellence

Knowledge & Understanding
in
Working with Plastic

Plastic

The basic raw materials used in the manufacture of plastics are oil, natural gas and coal, but contrary to popular belief, plastics are not a new "space age" material. Natural plastics such as shellac, wax horn, pitch and bitumen have been known for thousands of years.
Just as Timber is classified as either a softwood or a hardwood and metal as either a ferrous or a non-ferrous, so plastics are classified into two main groups; **Thermoplastics** and **Thermosetting** plastics.

Thermoplastics

Thermoplastics soften when heated, can then be shaped, and then harden as they cool. With this type of plastic the softening and hardening can be repeated many times over. When a thermoplastic has been re-heated it will return to it's original shape unless it has been permanently damaged be excessive heat or deformation. This characteristic of thermoplastics on re-heating is known as **Plastic Memory** (i.e. it remembers what its original shape was).

Thermosetting Plastics

As the name implies thermosetting plastics (or thermosets) set or solidify, when heated and cannot be returned to their original state by further heating.

Common Plastics

The following are descriptions of some of the more common types of thermo and thermosetting plastics in everyday use.

Acrylic

Acrylic materials are among the most commonly used thermoplastics in the school workshop and the material in which will most likely be the material used to manufacture any artefacts which are made. Often better known by it's trade name "Perspex", acrylic is available in clear or coloured sheets, rods and tubes. Acrylic is easily scratched and therefore sheets are usually covered on both sides by protective paper or thin polythene. As has been explained acrylic can come to the workshop in many forms.

Plastic Recycling

Plastic recycling is the process of recovering scrap or waste plastic and reprocessing the material into useful products, sometimes completely different in form from their original state. For instance, this could mean melting down soft drink bottles and then casting them as plastic chairs and tables.

Challenges of Recycling Plastic

Compared with other materials, such as glass and metal, plastics require a greater recycling process because of their polymers (chemicals that make up plastic). If two different plastics are melted together, they separate, much like water and oil. This reaction is called phase-separate. If these melted down plastics are to be made into a product, it will be structurally weak, therefore likely to break.

Plastic which have this symbol can be recycled.

Plastic wrapping will usually be sent to landfill. However, if recyclable, it can be washed, shredded and recycled into more plastic wrapping.

CDs and cases are usually sent to landfill, although they can also be ground up, washed in a caustic solution (acid) to remove the ink and foil, and then re-used.

Recycling Symbols

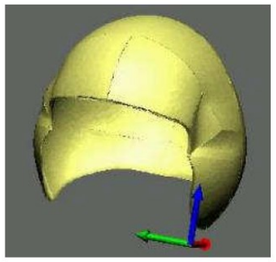
There are 5 groups of plastics, each with their own specific properties and are used for packaging worldwide. Each group of plastic can be identified by its Plastic Identification Code (PIC) which is usually a number or an abbreviation of letters. An example of this would be Low Density Polyethylene which can be identified by the number "4" or the letters "LDPE". The PIC code appears inside a three-chasing-arrow recycling symbol which is used to indicate whether the plastic can be recycled into new products.

Manufacturers of plastic products are required to use PIC labels on all of their plastic products. PIC labels can be found on the base or side of plastic products such as food packaging and containers.

Rapid Prototyping (RP)

Rapid Prototyping (RP) is a quick method of producing an extremely accurate 3D models directly from a Computer Aided Drawing (CAD) file of the component. The rapid prototyping machine converts this CAD (Inventor Models) image into a control program which builds up the 3D model of the component layer upon layer in just a few hours.

3D Printing is the most common RP process due to its relative low cost (around £20 000). A layer of powder is spread over a table and a printer-type inkjet then passes over the powder spraying a water-based adhesive. This bonds the powder together in the desired shape. The table drops slightly and another layer of powder is deposited. The process repeats itself until the desired model is built.



The Computer Aided Drawing (CAD) image of the product is created (fighter pilot helmet)

The 3D Printer converts the CAD image into a control program for the movement of the printer head across the powder.

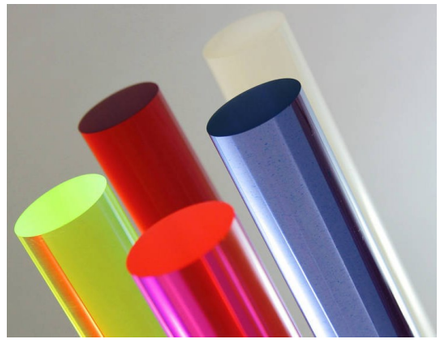
Layer-by-layer the finished model is built-up. It can include holes, texture and hollow sections

Advantages of RP

- People prefer to evaluate and test a real-life model rather than just a sketch or computer image.
- Complex forms can be manufactured in one piece which may be impossible otherwise.
- RP enables exceptionally accurate models to be made from CAD files very quickly.
- Models made by some RP techniques can be used as masters

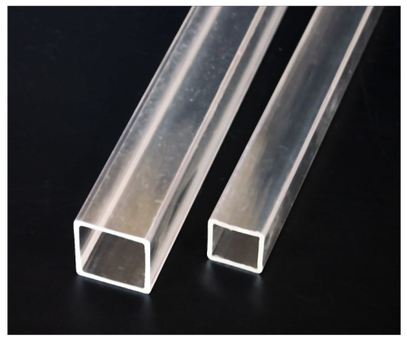
Supply Form

Round tube used as Pipes.

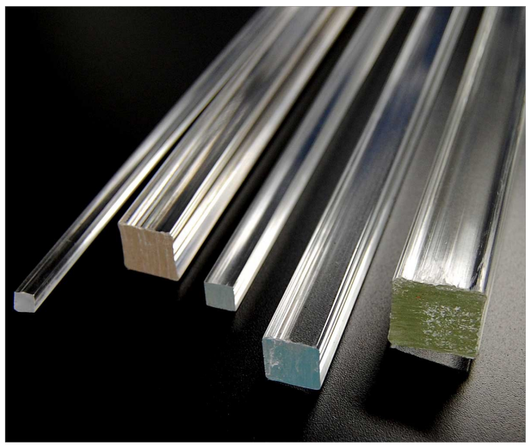


Round Bar used for the handle of a screwdriver.

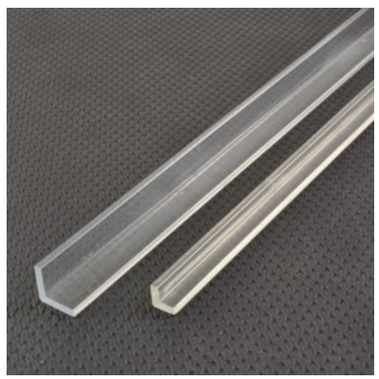
Sheet used for shop signs.



Square Tube



Square Bar



Extruded strip used for curtain rails

Table of Commonly Used Plastics

	Thermosetting			Thermo		
Plastic	**Phenolic Resin**	**Epoxy Resin**	**Polyester**	**Acrylic**	**Polystyrene**	**PVC**
Properties →	Hard, Heat Resistant	Hard, Heat Resistant	Hard, Heat Resistant	Stiff, Hard, Clear, Easy Cut, Glued, Polished, Scratches Easily	Stiff, Hard, wide Range of Colours OR very light and buoyant	Good colour range, stiff, hard OR soft and flexible
Forms →	Powder granules	Liquid Paste	Liquid Paste	Rod, tube and sheet in a wide range of colours	Powder granules and sheet OR slabs and beads	Powders, pastes and sheets
Uses →	Electrical appliances saucepan handles	Bonding, gluing	GRP boats, car bodies, embedding	Car light units, shop signs, watch lenses	Model kits, disposable cups OR insulation and floats	Pipes, guttering OR dip coating, floor tiles

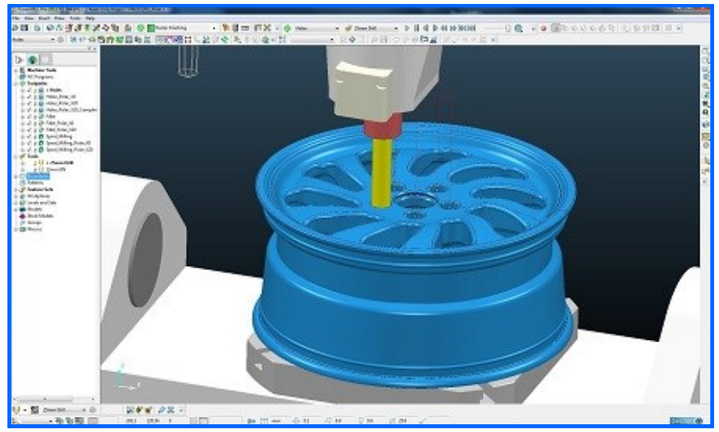
Marking Out Acrylic

As has been stated acrylic sheet is supplied covered with paper of polythene film to prevent scratching of the finished surface. Whilst the paper covered sheets can be marked with a pencil the polythene covered sheets, and unprotected sheets are best marked with a felt pen.

CAM (Computer Aided Manufacture)

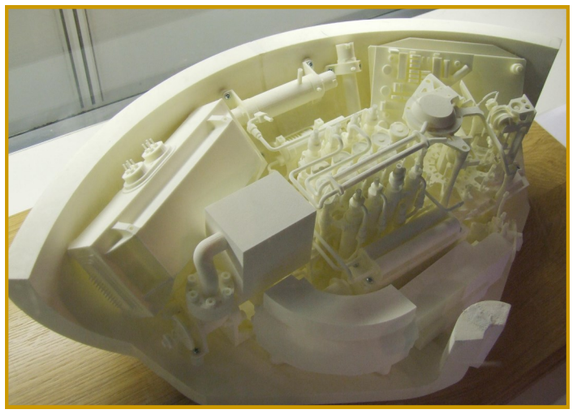
Computer Aided Manufacture (CAM) allows complicated products or components to be manufactured very accurately and at speed using Computer Numerical Controlled (CNC) machines. These machines often perform many different operations and allow components to be cut, shaped, turned, drilled and milled, while all the operator has to do is to change the material and maintain the tools.

The example shown opposite shows the animation of a car wheel being made by a CNC machine.



CNC (Computer Numerical Control)

Almost all manufacturing companies have changed over from manual to Computer Numerical Controlled (CNC) versions of lathes and milling machines etc. This enables components to be designed on a Computer Aided Drawing (CAD) system and then automatically converted into a Computer Aided Manufacture (CAM) program for the control of the CNC machine. This software program will control the entire process and allow the machine to produce identical components quickly and accurately:



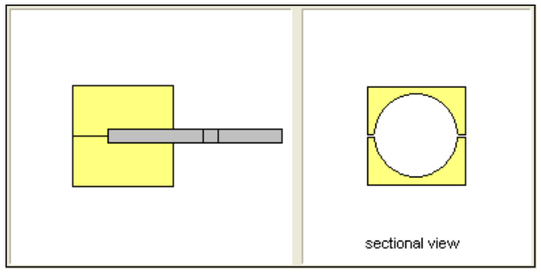
This example has been made using a similar type of software program. In the example above the various tools such as the drills, etc, remove the material but on this example the material has been added layer by layer until it is made. It allows very intricate models to be made.

This method is called;……..

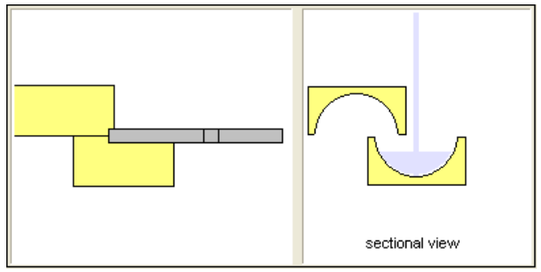
Rotational Moulding

This plastics process is used to create objects such as balls.

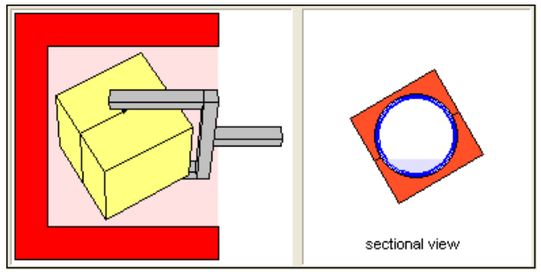
The picture opposite shows the rotational mould.



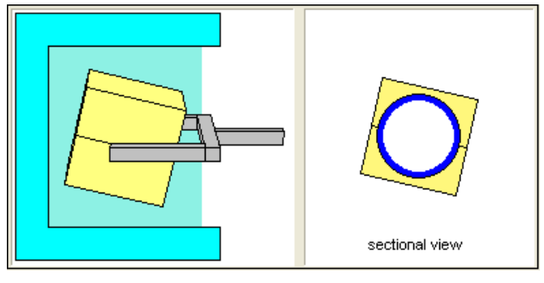
At this stage the liquid plastic is poured into the mould. The mould is then sealed and the process of rotating it begins.



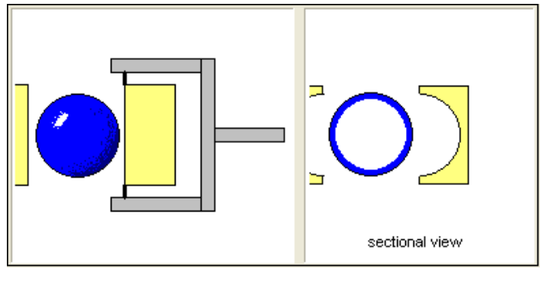
This stage shows the plastic being heated as it is rotated around the mould



The completed plastic mould is now cooled before ejection from the mould.



The moulded shape is ejected from the mould.



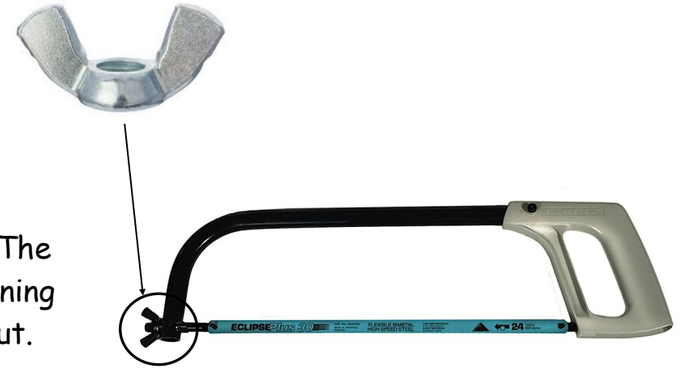
Cutting Acrylic

In the school workshop the most common method of cutting acrylic is by sawing. Fine toothed saws like the coping saw, hacksaw and junior hacksaw are the most suitable. Sawing must be done carefully and steadily to avoid chipping and splintering the material.

The band saw can also be used but is generally only to be used by the teacher.

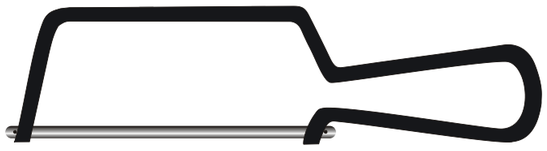
Hacksaw

The hacksaw is used for general cutting of metal bar, tubes, etc. The blade is easily removed by slackening or tightening of the front wing nut.



Junior Hacksaw

This type of saw is also used for cutting metal but is used for light work or where a hacksaw is too clumsy.



Coping Saw

The coping saw is used to cut curves and other awkward cuts in plastic or wood. It is also unique as it is one of only a few saws which has it's teeth facing backwards. In normal sawing the cut is made in the forward stroke but with the coping saw the cut is made on the backward stroke.

Files

Files are used to shape metal or plastic. They are available in a number of different shapes and degrees of roughness.

Files must not be used without a handle.

Stages in Finishing an Edge of Acrylic

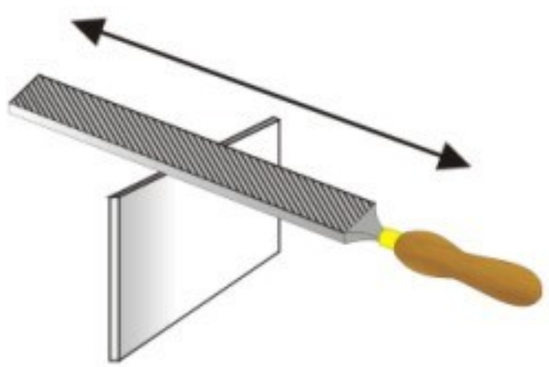
When acrylic plastics are cut they tend to have very rough edges, this is due to the fact that it is a very brittle material. Brittle means that although it is very hard, it tends to break easily especially when sawing. To ensure the plastic is finished with a clean smooth edge it is essential that the edges are finished in the following sequence.

A Cross file the edges to remove the majority of blemishes.
B Draw file the edges to remove the marks left from cross filing.
C Use wet and dry paper to get an overall smooth finish.
D Use acrylic or metal polish (Brasso) to achieve the final finish.
E Buff with a clean cloth.

Always finish the edges of the acrylic prior to any bending.

Cross Filing

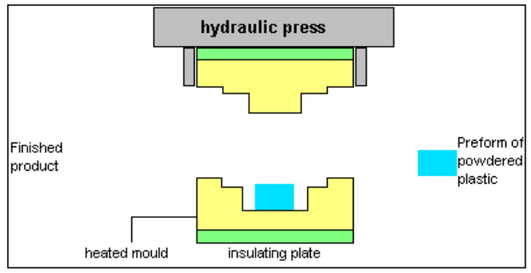
In this type of filing the file is moved across the work piece using the full length of the blade. This method of filing is used for removal of a lot of material with every stroke applied.



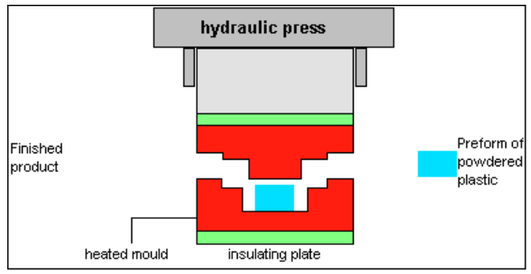
Press Forming

If you require to make a simple dish shaped object then the best process to use is press forming. Press forming uses a two part mould, the male former and the female former. The male former will consist of the 'replica' of the dish shape to be formed, the surface finish of this former must be good if a quality moulding is required.

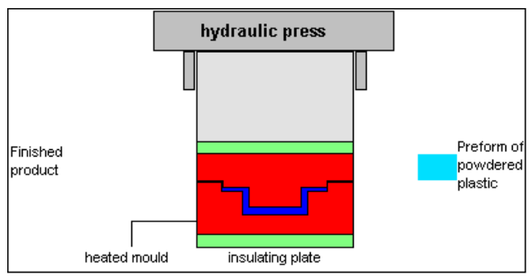
The piece of acrylic to be pressed is placed between the two formers ready to be heated.



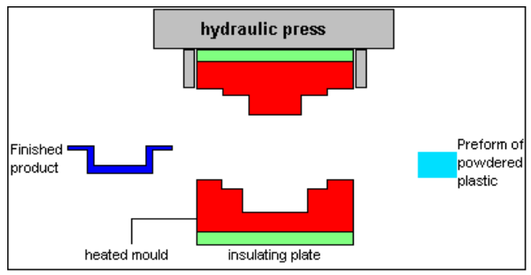
The acrylic is now heated by the formers.



The male former is then **'pressed'** over the female former.



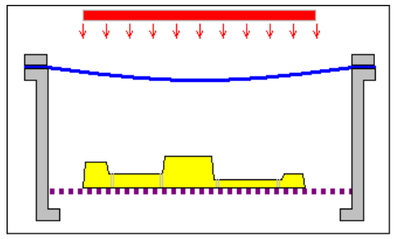
The final pressed bowl is then ejected from the mould as can be seen from the drawing.



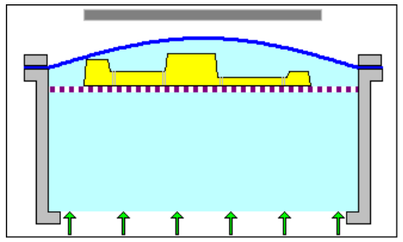
Vacuum Forming

In Vacuum Forming, a sheet of thermoplastic held in a clamp is heated until soft and flexible. Air is sucked out from underneath the sheet so that air pressure pulls the sheet down onto a specially made mould. This process enables thermoplastics to be formed into complicated shapes such as packaging, storage trays and seed trays.

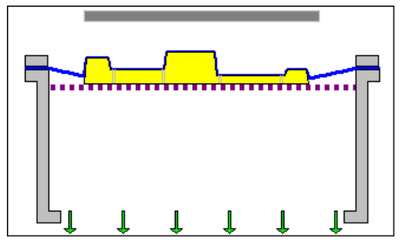
The first stage of vacuum forming is to clamp the sheet across the top of the machine and heat it until the plastic is soft and flexible. This can be judged by watching the material, which will start to sag under its own weight when soft. If touched with a stick it will feel soft and rubbery.



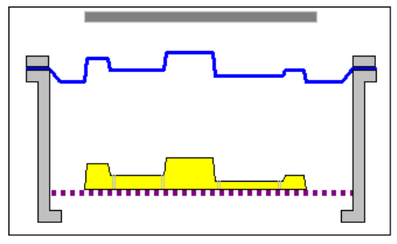
The pattern is then raised up to meet the hot soft plastic.



At this stage the air has been sucked out from beneath the plastic pulling it onto the pattern.

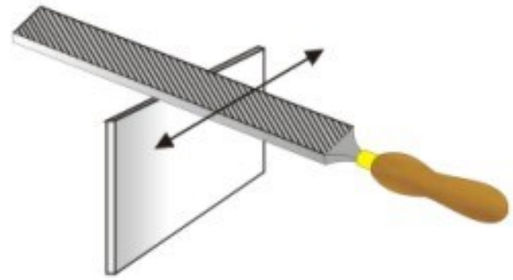


The final stage is to remove the pattern from the plastic leaving the finished article.



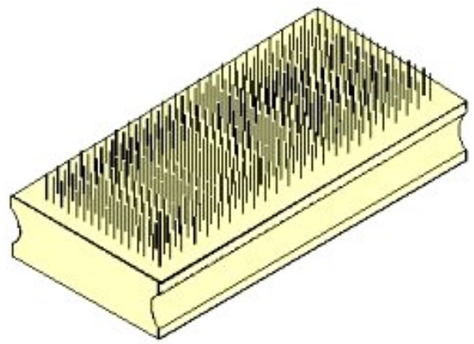
Draw filing

In this method of filing, the file is moved sideways along the work piece and is used to obtain a smooth finish after cross filing. This method does not remove much material.



Cleaning the file

Small pieces of plastic can get trapped in between the teeth of the file. This is called **PINNING**.
A **FILE CARD** can be used to clear the file of the excess material. The file card looks very similar to a wire brush except the teeth are very short.

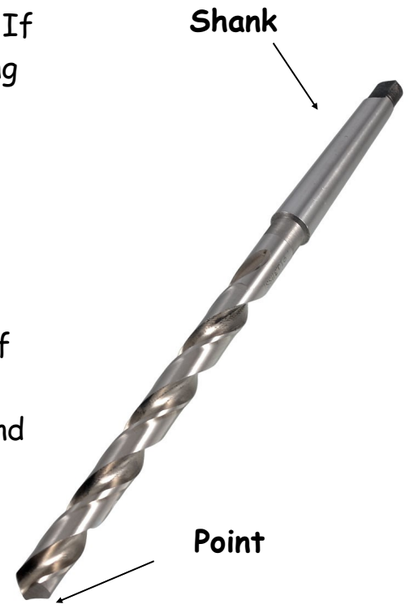


Drilling Acrylic

Holes can be drilled or cut in acrylic using standard drilling equipment, twist drills or hole saws. Prior to drilling it is very important to ensure the bottom of the acrylic is supported with a piece of wood. If it is not the most likely result will be the cracking of the acrylic.

Twist Drill

Twist drills are generally made from or carbon steel and are used for drilling circular holes in metal, plastic or wood. The most common type of drills used are the TWIST DRILLS. These drills have three basic parts, a point, a parallel body and a shank which can be either parallel or tapered.



Hole Saw

This tool is used to drill big holes in wood or plastic and is generally fitted to an electric drill. The hole saw has a centre drill attached which is called the PILOT drill. It is called the pilot drill as it pilots the larger diameter cutter to exactly the right location.

Epoxy Resin (Araldite)

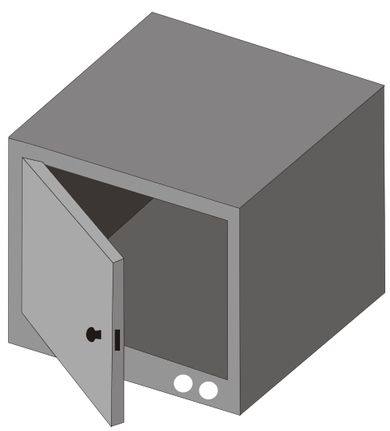
In the table on page three it was seen that epoxy resin comes as a liquid paste. The picture opposite shows the form in which it generally purchased.

Bending and Forming Acrylic

Acrylic becomes soft and pliable when heated to approximately 150 °C. In this state it can be easily bent and formed to shape. On cooling to room temperature the formed shape is retained. The most convenient method of heating, prior to bending and forming, is to use the strip heater or oven.

The Oven

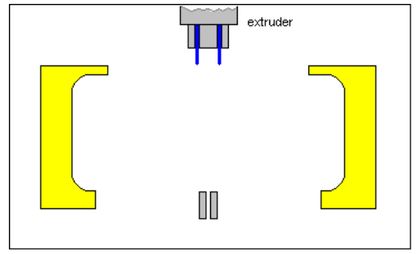
Where more complex shaping of acrylic is required it is necessary to use an oven for heating. For a 3mm thick sheet of acrylic the oven should be set to a maximum temperature of 170°C and the sheet heated for about 15 - 20 minutes before forming to the required shape.



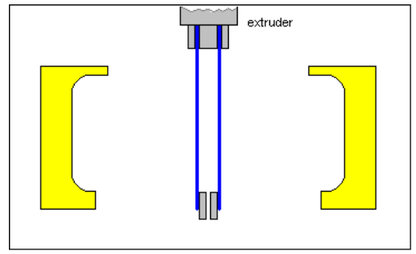
Blow Moulding

Blow moulding is the process of producing plastic bottles or similar type artefacts.

The first stage is to introduce an extrusion of plastic from a circular shaped injector at the top as shown.

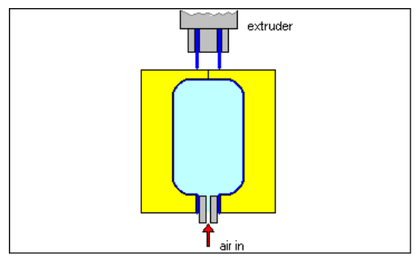


In the second stage the extrusion is held in place by the device at the bottom.

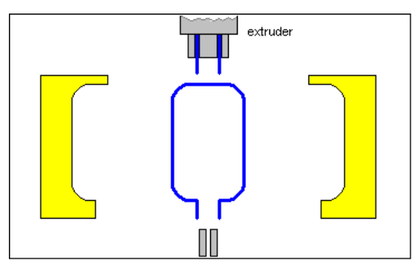


This stage involves bringing the circular split moulds together.

Air is now blown into the mould expanding the plastic to the size and shape of the mould.



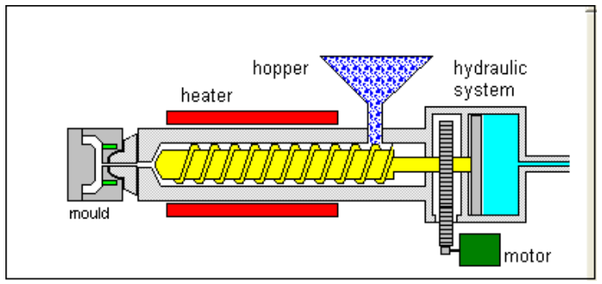
The split moulds are now released and the resultant bottle ejected from the mould.



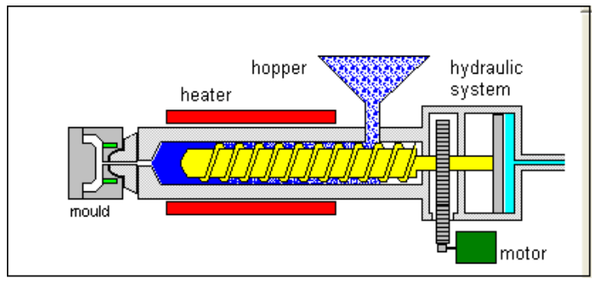
Injection Moulding

The process of injection moulding is very similar to that of Extrusion as it injects hot soft plastic through an injector into a mould rather than into long shaped strips.

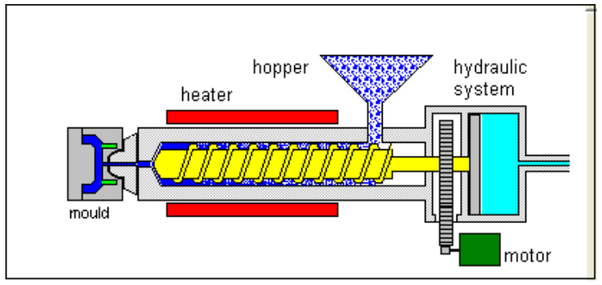
As with extrusion the first stage in the process is to place plastic granules into the HOPPER. The granules are then carried along the auger towards the injector.



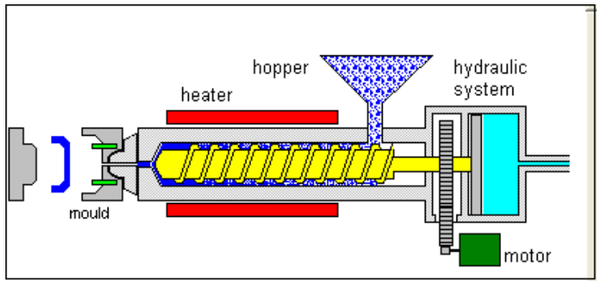
As the granules are pushed along the auger they are heated at the same time making them into a hot soft plastic paste.



The hot soft plastic paste is then pushed out the end through an injector into the mould.



As the plastic paste is pushed out the injector into a mould/ pattern it is held here for a short time while it cools. It is then ejected. Examples of articles which are injection moulded are mobile phone covers, buckets etc.



Safety with Plastics

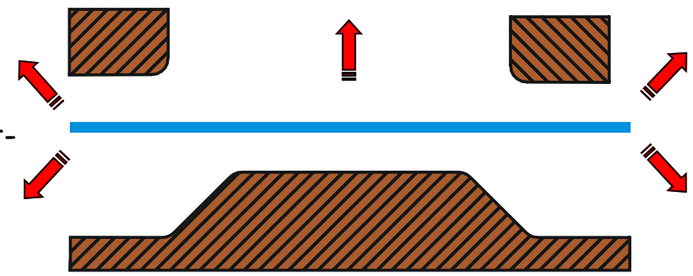
Working safely with plastics, like most other materials, requires sound common-sense and the observation of safe working practices. The following is a list of the more obvious safety precautions that should be noted.

1. When machining acrylic (i.e. sanding, sawing, drilling, etc.) eye protection and dust masks should be worn. Sheet material should be securely held in suitable vices or jigs.

2. On no account must hot thermoplastics be allowed to touch skin or clothes. When plastic dip coating, for example, stout leather gloves must be worn.

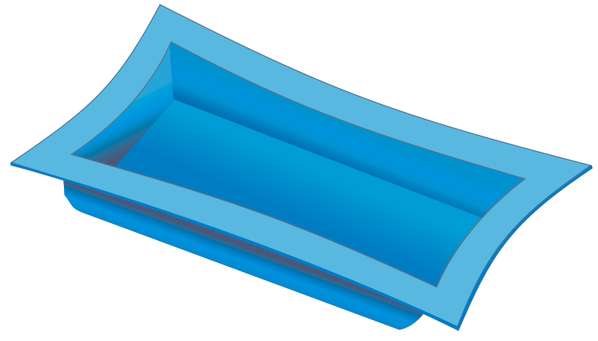
Press Forming

In the diagrams opposite a piece of acrylic has been heated in an oven, it is therefore very hot and very soft. It is then placed above the former and pressure is applied onto it. The acrylic readily takes the shape of the former.



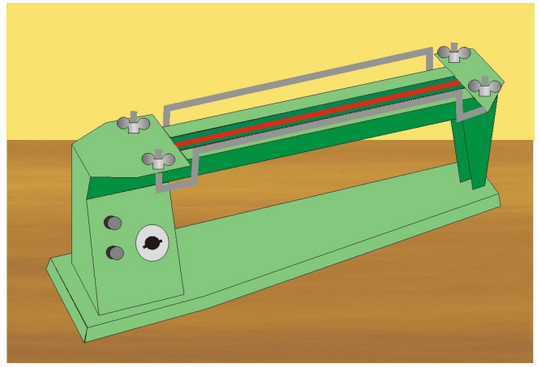
It is then left to cool. If the acrylic was to be reheated it would return back to its original flat state. This is called **Plastic Memory**.

The plastic tray opposite is an example of the type of results which can be achieved using the above formers. It can be noticed that the edges are slightly curved, this is due to the plastic being drawn in by the former.



The Strip Heater

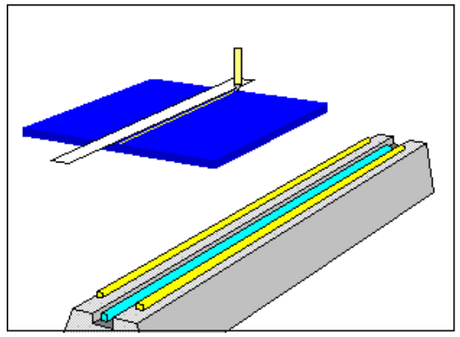
The purpose of the strip heater is to heat only a narrow strip of acrylic to allow local bending. Before bending the acrylic the protective coating is removed and then area to be bent is marked with a pen. After heating it sufficiently the acrylic can be shaped, preferably using a suitable former or



The sequence diagrams shown below illustrate the four main stages of bending a piece of acrylic

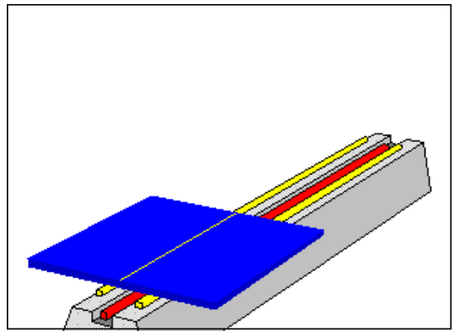
The first stage is to mark the line where the bending will take place.

1

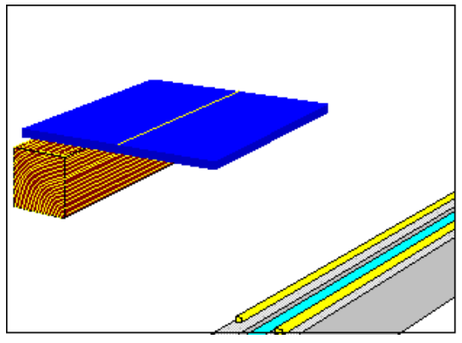


The second stage is to place the acrylic over the heating element, turning regularly to avoid burning.

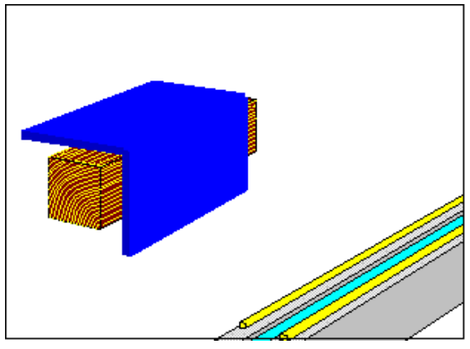
2



The third stage is to remove the soft heated acrylic and place it on a suitable JIG or FORMER.



4

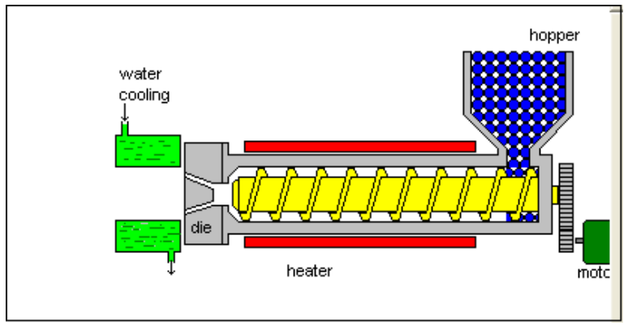


The last stage is to bend the acrylic to the desired shape.

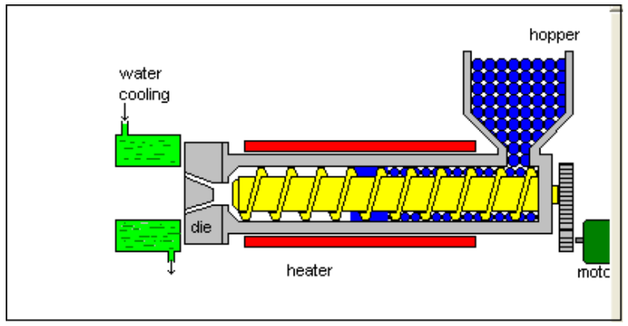
Extrusion

Extrusion is the process of extruding plastic generally into long strips such as round tube, curtain rails, etc.

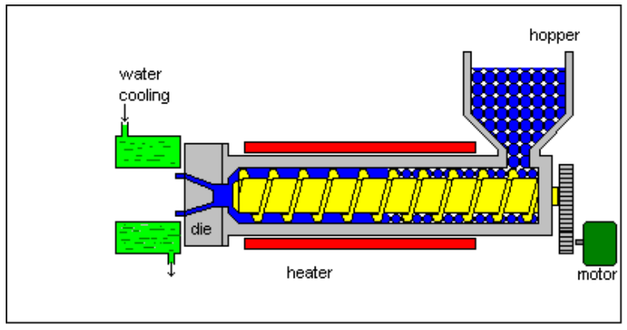
The first stage in the process is to place plastic granules into the HOPPER. The granules are then carried along the auger.



As the granules are pushed along the auger they are heated at the same time making them into a hot soft plastic paste.



The hot soft plastic paste is then pushed out the end through a specially shaped injector.



As the plastic paste is pushed out the injector in its new shape it is still very hot therefore to cool it down it is surrounded by a cold water which cools the plastic back to its original temperature.