N4 N5

Design and manufacture

Plastics

Name: …… Class:…… Teacher:……

Plastics

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.
Plastics are classified into two main groups; **Thermoplastics** and **Thermosetting** plastics.

Plastics are ideal for mass production of quality products, and can duplicate or better the properties of most other materials, including aluminium, glass, rubber and steel.

Properties

General properties of plastics include:

- Light weight
- Resistance to corrosion
- Electrical resistant
- Easily formed
- Recyclable
- Available in various colours

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.

Plastic	Properties	Uses
Polyester Resin	Hard, rigid, brittle, tough when mixed with glass or carbon fibre.	Boats, car bodies.
Epoxy/Resin	Strong, good, chemical and heat resistant, sticks to other materials as well.	Adhesive glue, covering electronic components such as microchips

Plastic	Properties	Uses
Melamine Formaldehyde	Rigid, scratch resistant, water and stain resistant.	Tableware laminates, top coatings on products.
Urea Formaldehyde	Rigid, hard, strong, heat resistant, does not bend when heated, good electrical insulator.	Electrical plugs, sockets, door knobs.

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 by excessive heat or deformation. This characteristic of thermoplastics of re-heating is known as Plastic Memory (i.e. it remembers what its original shape was).

Material	Properties and working characteristics	Uses
Polythene (LDPE) (HDPE)	**Low density**: tough, common plastic, good chemical resistance, flexible, soft, electrical insulator, available in a wide range of colours. **High density**: Stiffer, harder, waxy feel.	Squeezy bottles, toys, packaging film, carrier bags and TV cable. Milk Crates, bottles, pipes, buckets and bowls
Polypropylene	Light, hard, impact resistant, easily joined, welded, bending, good mechanically	Medical equipment, syringes, containers, string, rope, nets, crates, chair shells, kitchenware.
Polystyrene (PS)	Light, hard, stiff, colourless, transparent, brittle, safe with food, good water resistance.	Model kits, packaging, disposable plates, cups , utensils.
Polyvinyl chloride (UPVC)	Good chemical resistance, weather resistance, stiff, hard, tough, lightweight, wide colour choice.	Pipes, guttering, bottles, shoe soles, roofing sheets, records, window frames.
Acrylic	Stiff, hard, brittle, very durable, scratches easily, polishes well, wide range of colours.	Light units, windows, car lights/reflectors.
Polymide (Nylon)	Creamy colour, hard, tough, resilient to wear,	Bearings, gear wheels, combs, hinges.
Acrylonitrile butadienestyrene (ABS)	High impact strength and toughness, scratch resistant, light and durable, good appearance, high surface finish.	Kitchen ware, camera cases, toys, safety helmets, car components, telephones.

Tools for use with Plastics (saws)

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 only to be used by the teacher.

Hacksaw

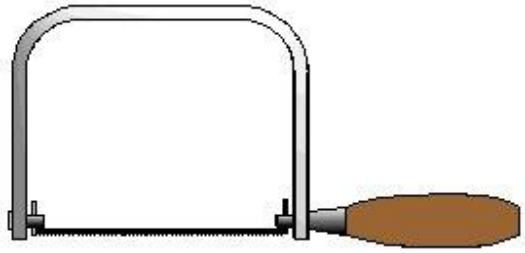
The hacksaw is used for general cutting of metal bar, tubes, etc. The blade is easily removed by slackening or tightening of the front wing nut.

Junior Hacksaw

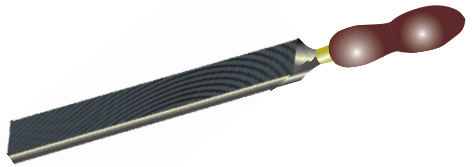
This type of saw is also used for cutting metal but is used for light work or where a hacksaw is too clumsy.

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 its 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.



Tools for use with Plastics (filing)



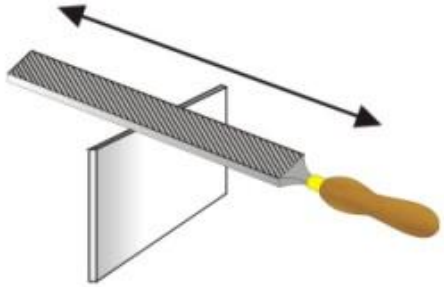
Files are used to shape metal or plastic.
They are available in a number of different shapes and degrees of roughness.

Stages in finishing an edge of acrylic

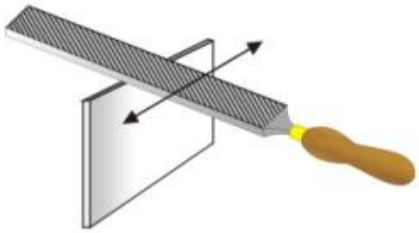
When acrylic plastics are cut they tend to have very rough edges, this is due to the fact that it is a very brittle material. Brittle means that although it is very hard, it tends to break easily especially when sawing. To ensure the plastic is finished with a clean smooth edge it is essential that the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

1 **Cross file** the edges to remove the majority of blemishes.
2 **Draw file** the edges to remove the marks left from cross filing.
3 Use **wet and dry** paper to get an overall smooth finish.
4 Use acrylic or metal **polish** (Brasso) to achieve the final finish.

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.



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.



Tools for use with Plastics (drilling)

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. It is also essential that you **drill into the acrylic slowly**.

Twist Drill

Twist drills are generally made from a carbon steel and are used for **drilling circular holes** in metal, plastic or wood. Twist 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.

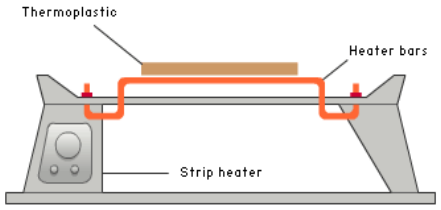
Processes for shaping plastic

Bending

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 oven or strip heater.

The Strip Heater

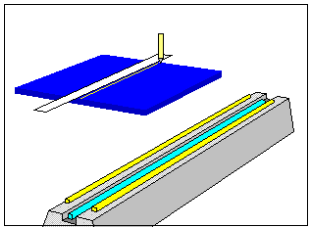
The purpose of the strip heater is to **heat only a narrow strip of acrylic** to allow local bending. Before bending the acrylic the protective coating is removed and then area to be bent is marked with a pen. After heating it sufficiently the acrylic can be shaped, preferably using a suitable former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



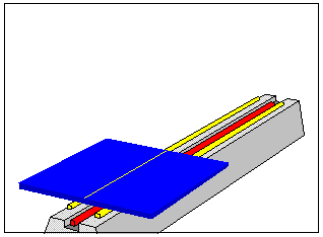
The Oven

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.

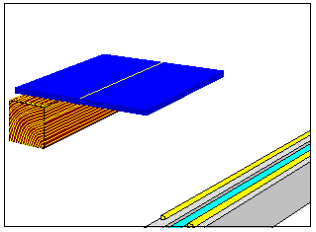
Stage 1
The first stage is to **mark the line** where the bending will take place.



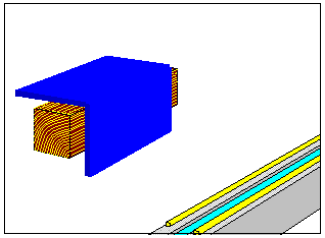
Stage 2
The second stage is to **place the acrylic over the heating element**, turning regularly to avoid burning.



Stage 3
The third stage is to **remove the soft heated acrylic** and place it on a suitable **JIG** or **FORMER**.



Stage 4
The last stage is to **bend the acrylic** to the desired shape.



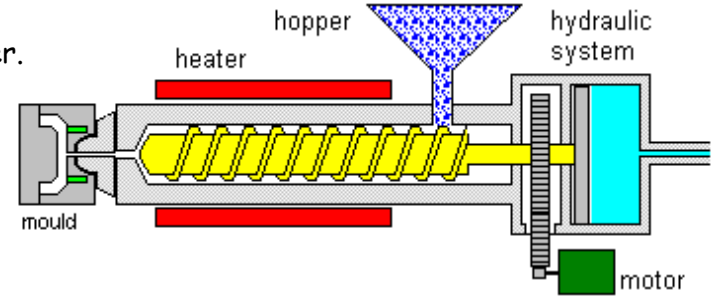
Industrial Processes for shaping/forming plastic

Injection moulding

Injection Moulding is a process which allows large quantities of plastic components to be made quickly. Thermoplastic granules are heated until they soften. Then the material is forced under pressure into a mould. When cooled, the mould is opened and a component, which is the exact shape of the cavity is taken out. Injection Moulding is one of the most important industrial processes in the mass production of plastic goods. The cost of producing the moulds can be very high, therefore it is necessary to manufacture and sell large quantities of the product being manufactured to recover costs.

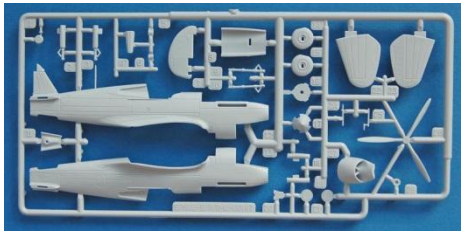
The Process

1. A fee hopper if filled with thermoplastic granules.
2. A rotational screw mechanism passes the granules through a heater.
3. The heater causes the granules to plasticise.
4. The soft plastic is injected into the mould where it is cooled.
5. The mould is opened automatically.
6. The finished component is ejected.
7. No further finishing is required. The quality of the product is identical to the surface of the mould.



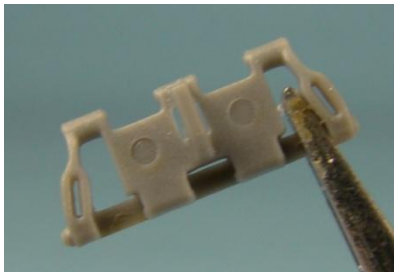
Uses

Components produced by injection moulding vary from golf tees, spoons, wash basins, buckets, airfix models to product casings.

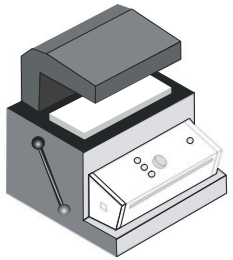


Identifying Features

A way of telling if a product has been injection moulded is to look for ejection pin marks on the surface of the product. These are normally circular marks left when the pins force the product out of the mould.



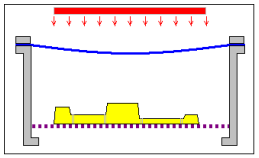
Industrial Processes for shaping/forming plastic



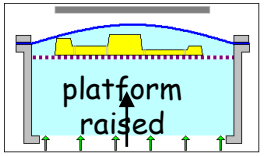
Vacuum Forming

In Vacuum Forming, a sheet of thermoplastic is held in a clamp and is heated until it is 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.

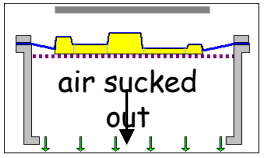
Stage 1
The first stage of vacuum forming is to **clamp the sheet** across the top of the machine and heat it until **the plastic is soft and flexible**. This can be judged by watching the material, **which will start to sag** under its own weight when soft. If touched with a stick it will feel soft and rubbery.



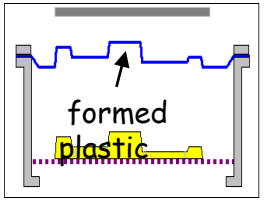
Stage 2
The **pattern is then raised up** to meet the hot soft plastic.



Stage 3
At this stage the **air has been sucked out** from beneath the plastic **pulling it onto the pattern**.

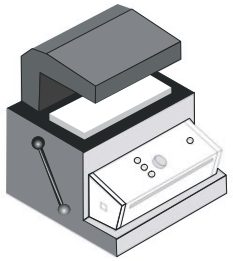


Stage 4
The final stage is to **remove the pattern** from the plastic leaving the finished article.



http://www.youtube.com/watch?v=1t39xX6fjt0

Industrial Processes for shaping/forming plastic



Vacuum Forming

In Vacuum Forming the shape of the pattern is very important for a number of reasons.

•Rounded Corners – The pattern should have rounded corners and not sharp edges so that the plastic does not rip or tear as it forms round the pattern.

•Tapered Edges - The pattern should have tapered edges or sloping sides so that the pattern can be easily removed from the plastic after forming.

•Internal curves – The pattern should not have internal curves as these cause folds in the plastic to occur during the Forming process.

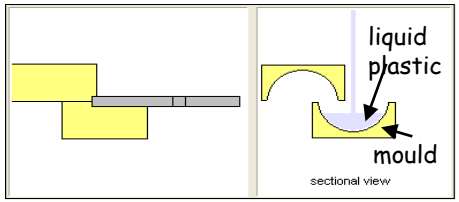
Pattern with rounded corners and sloping/tapered sides.

Industrial Processes for shaping/forming plastic

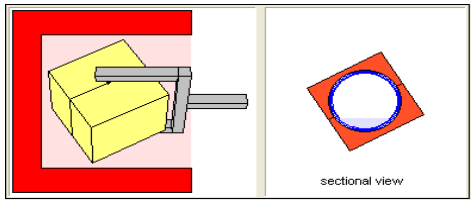
Rotational Moulding

Rotational moulding is a method of creating medium to large sized hollow components from plastics. It involves melting plastic inside a closed mould which is rotated so the plastic coats the inside of mould. The plastic is then cooled and solidifies in the shape of the mould.

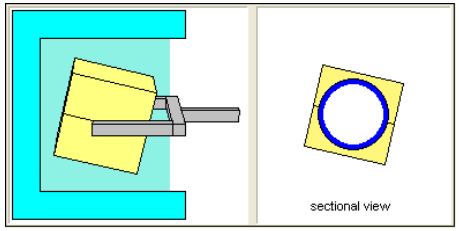
Stage 1
At this stage the **liquid plastic** is poured into the mould. The mould is then sealed and the process of rotating it begins.



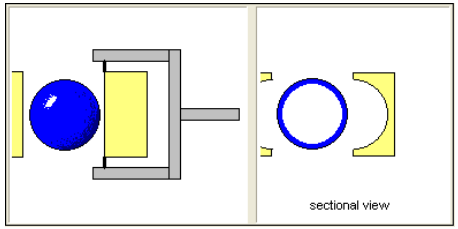
Stage 2
This stage shows the plastic being **heated as it is rotated** around the mould. The heated plastic coats the inside wall of the mould.



Stage 3
The completed **plastic mould is now cooled** before ejection from the mould.



Stage 4
The **moulded shape is ejected** from the mould. The picture here shows a hollow sphere.



http://www.youtube.com/watch?v=CcGSKJxLfj8

Joining Plastics (permanent)

The main method of a permanent joining for plastic is adhesives.

Adhesives

Adhesives, or glues, are designed to bond material together. As there are many different types of material to be bonded, a wide range of adhesives have been developed. The strength of a glued joint depends on three things: the area to be bonded; the strength of the glue when set; and the bond between the material and the glue. To achieve a strong glued joint the area to be glued should be as large as possible, the correct glue should be used and the surfaces to be glued should be as clean as possible.

Here are some adhesives commonly used with plastics:

Epoxy resin (Araldite) – comprises two parts, a resin and a hardener. They are mixed in equal amounts and can be used on most materials.

Acrylic cement (Tensol) – thick clear liquid with unpleasant fumes, specially made for acrylic.

Contact adhesive – thick brown rubbery glue commonly used to stick down plastic laminates. when brought together the surfaces cannot be moved for adjustment.

Super glue – bonds on contact and is used on small surface areas.

The outer casings of the two products shown below have been injection moulded.

(*a*) (i) State **three** features which would confirm that injection moulding is the manufacturing process used for the outer casings.

(ii) State **two** advantages to the manufacturer of using injection moulding to produce the outer casings.

(*b*) State how the designer could find out the correct sizes for the handles of the two products **without** referring to anthropometric data tables.

Both products were designed with *planned obsolescence*.
(*c*) (i) State an advantage of planned obsolescence to the manufacturer.

(ii) State **two** reasons why planned obsolescence is harmful to the environment.