COMMERCIAL PRODUCTION METHODS

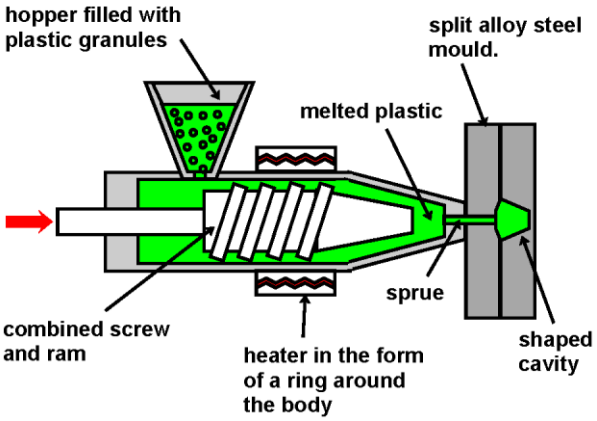
Over the past forty years plastics have replaced traditional wood and metal materials for making products and parts of products. Some advantages of using plastics are:

- They do not rot or corrode
- They are light in weight
- They are easy to use in mass production
- They come in a vast range of colours
- They can be clear and transparent
- Lubrication is not required for moving parts
- Moving parts work more quietly

Injection Moulding

In industry, injection moulding is one of the most common methods of producing products in thermoplastic plastics. e.g. school chairs, TV cases, toothpaste tube caps etc. Thermoset plastics cannot be injection moulded because any plastic left in the machine would set hard permanently and block the nozzle.

Section view of an Injection Moulding machine



1. Plastic granules from the hopper are forced by the combined screw and ram into the heated area.

2. The plastic melts and is then forced under high pressure through the sprue hole into the split mould.

3. The mould is cold and the plastic cools and sets quickly.

4. The mould is opened and the product is ejected.

5. The sprue is cut away. The product is now ready for use.

Glass Reinforced Plastics (GRP)

Fibres of glass are mixed with the thermoset plastic called **Polyester**, in liquid (resin) form. The resulting material, after the resin has set, is very tough because any crack that starts in the polyester stops getting longer and larger when it reaches a glass fibre.

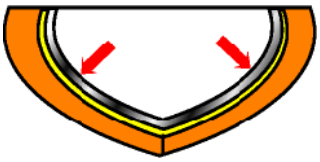
Making a model boat hull in GRP (the lay-up process)

Plan view

enlarged section view of split mould

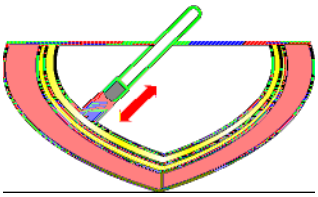
A. A layer of release agent is applied to the inner surface to stop the new GRP from sticking to the mould. The release agent can be in wax form.

B. A thick layer of coloured gellcoat resin is painted over the release agent.



C. A sheet of glassfibre is laid by hand over the dry but sticky gell coat layer.

D. Polyester resin, the same colour as the gellcoat, is stippled onto the glassfibre until it is covered with resin. This is then allowed to set before the hull is taken out of the mould.

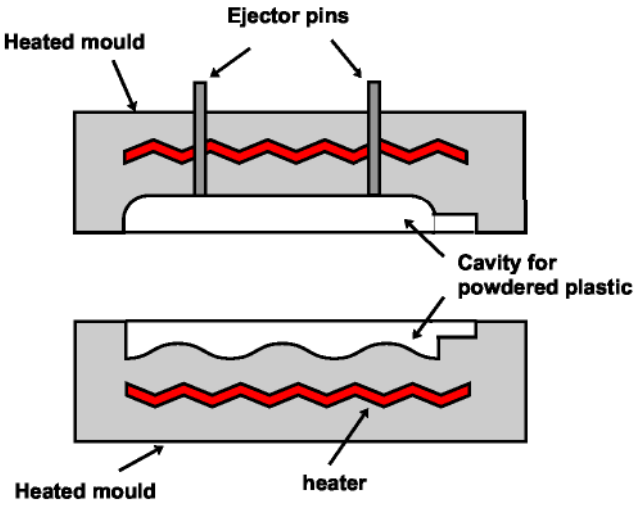


1. Why cannot thermoset plastics be used in an injection moulding machine?
2. How does an injection moulding machine work?
3. Explain the stages used in the lay-up process, when making a product from GRP

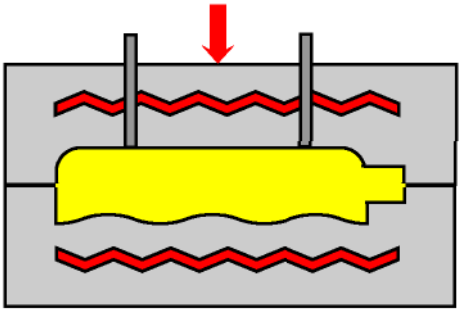
Compression Moulding

This method is used for thermoset plastics and produces products that need to resist heat, such as saucepan handles, hairdryer casings, mains electric sockets, etc. **A)** The exact amount of powdered or granular plastic is placed in the mould. **B)** The two halves are then closed and great pressure is applied. **C)** The combination of the heat from the moulds and the pressure melts the plastic and it fills the cavity without any waste. **D)** The mould opens and the plastic product cools and sets. **E)** The product is then ejected from the mould by ejector pins.

Split mould for a saucepan handle



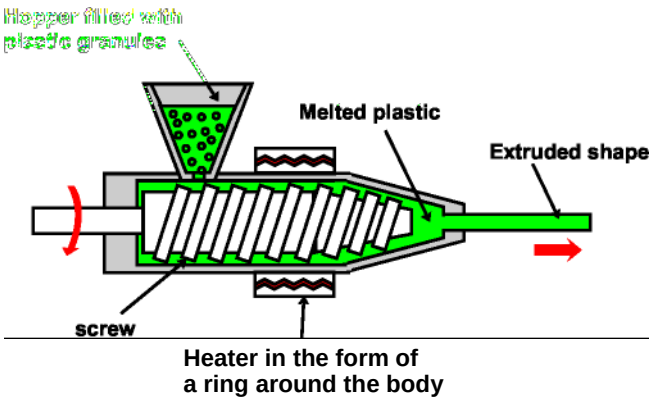
The mould closed and filled with plastic



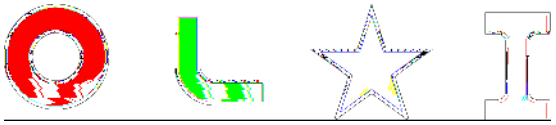
Extrusion

This process is similar to squeezing toothpaste from a tube, the paste comes out with the same circular crosssection shape as the hole in the tube.

The machine is very similar to an injection moulding machine, except that the ram is replaced by a screw system that continuously feeds plastic granules through the machine. This means that very long lengths of plastic can be produced.

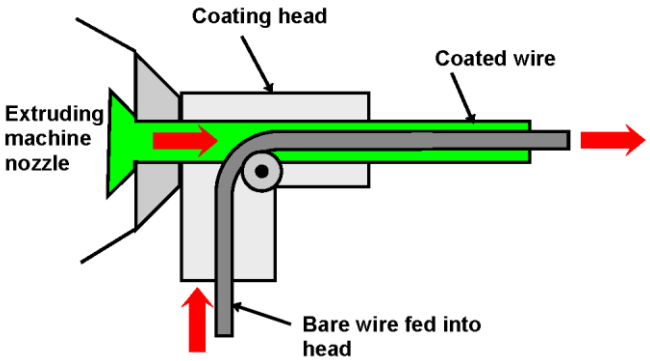


Typical extruded cross-sections



Extrusion Coating

Extrusion is used for covering electric wires. A special head is attached to the nozzle of the extruder. Bare wire is fed in and turned 90°, to be coated with PVC.

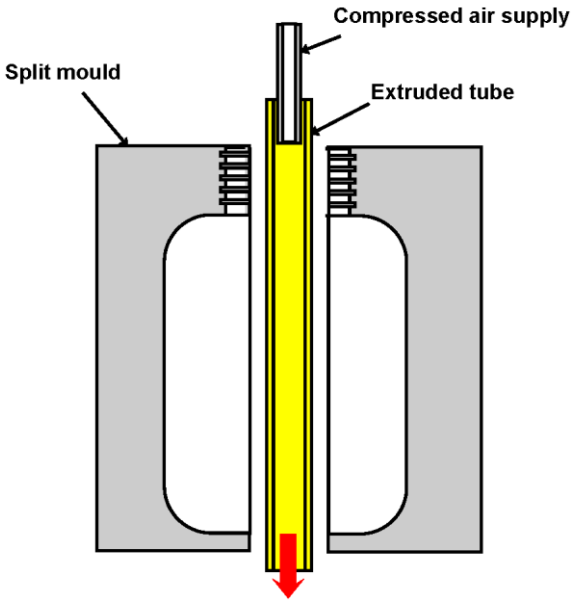


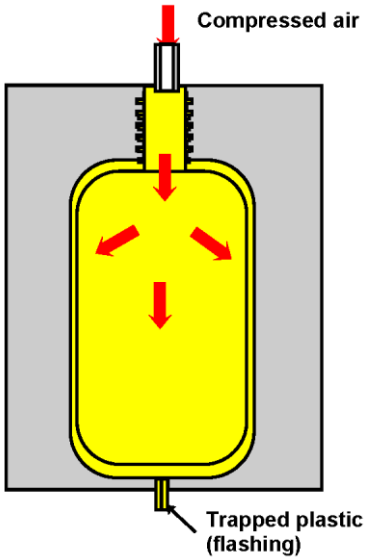
A short length of coated wire.

Extrusion Blow Moulding

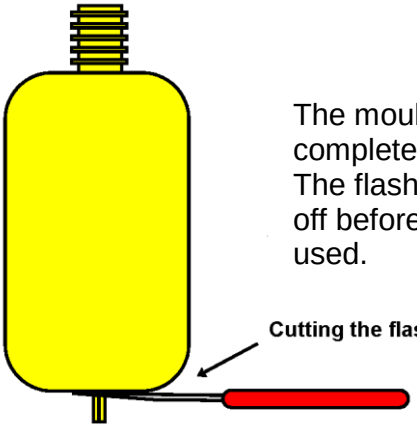
This process is used for producing plastic bottles. An extruding machine is placed vertically above the moulding machine and extrudes a tube of hot, soft plastic directly into the bottle mould.

A typical plastic used for this process is HDPE (High Density Polyethylene).





The mould is closed and compressed air blows the trapped tube of plastic to the sides of the mould. The air is cold and cools the plastic so that it sets quickly.



The mould is opened and the completed bottle is ejected. The flashing needs to be cut off before the bottle can be used.

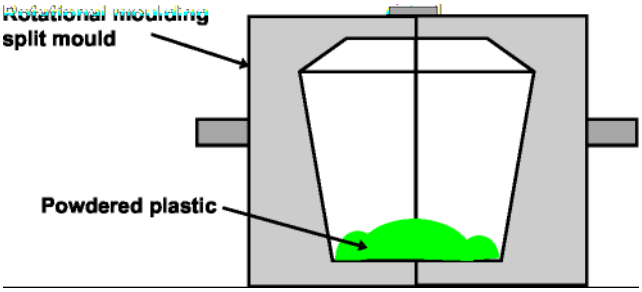
Rotational Moulding

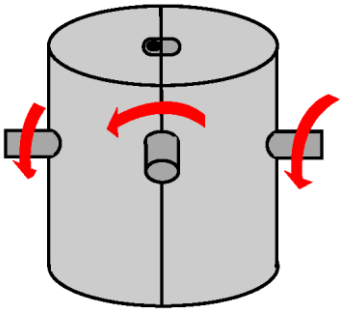
This process is used to make thick walled, hollow products like dustbins, water tanks and oil tanks.

1. The correct amount of powdered plastic e.g. High Density Polythene, is put inside the mould.

2. The mould is closed, heated and slowly rotated in two directions at the same time. The powder melts and evenly coats the walls of the mould.

3. The still rotating mould is cooled with a cold water spray until the plastic inside has set. The mould is then split open and the product removed.





The heated mould rotates in two directions at the same time, rather like some fairground rides.

KEY WORDS **Compression moulding: Extrusion: Blow moulding: Rotational moulding:**

1. Give **five** reasons why plastics have replaced traditional materials in product design.
2. Explain how it is that thermosetting plastics can be used for compression moulding, but not for injection moulding.
3. What device is used to remove plastic mouldings from a mould?
4. What process would you choose to make a plastic curtain rail and why?
5. Explain, with the aid of a diagram, how an electric wire is coated in PVC.
6. Draw an annotated diagram showing the main features of extrusion blow moulding.
7. In the rotation moulding process, why does the mould have to be rotated in two directions at the same time?

A. Identify **five** plastic products or parts of products from home or school and suggest which commercial process you think was used for making them. Give reasons for your choices.

SMART MATERIALS

A smart material is a material that can be controlled. It can be made to change its colour, size or shape and be returned to its original form at will.

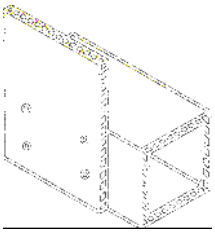
The control input can be changing the temperature of the material, applying an electric current through the material or by applying pressure to the material.

Shape-Memory Alloys

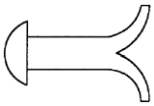
Shape-memory alloys (SMAs) have two distinct molecular structures at different temperatures. If they are reshaped when cooled, they will return to their original shape when heated back to room temperature.

The nickel-titanium alloy, Nitinol, is used for medical and space components, fasteners, water sprinklers and pipe connections.

e.g. Nitinol can be used to make a self-opening split rivet. The diagram below shows sheet metal riveted to square tubing. You cannot easily get inside the tube to open the split rivet.

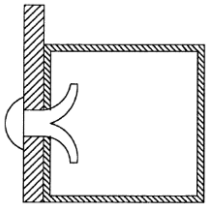


At room temperature the split rivet is in its open position.



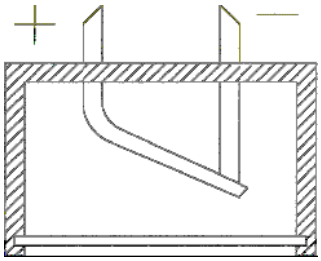
When cooled to below freezing, the rivet becomes straight.

When cold and straight the rivet is placed through the hole and is allowed to heat up to room temperature. The rivet then opens up inside the tube and holds the sheet and tube firmly together.



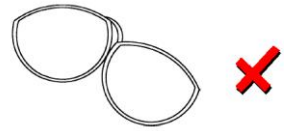
The diagram shows an artificial hip joint. When it is cooled the teeth lie flat and allow it to be inserted into the top of the thighbone .

When the temperature of the joint rises to that of the body, the teeth curve out and grip the inside of the hole in the bone and stop the joint from moving.



The diagram shows a detector for a fire alarm sprinkler system. When a fire raises the temperature, the positive (+) contact straightens and breaks the circuit, this will trigger the sprinklers.

Glasses frames that remember their shape are made from a SMA. If the glasses are sat upon and the frames are twisted, the alloy remembers its room temperature shape and returns to it.



Shape-memory Plastics

Shape-memory plastics (SMPs) are also being developed. Different plastics have different recovery temperatures. There are currently five grades that change shape between 40°C and 80°C. These can be used to sense temperature change because they change shape when a certain temperature is reached.

1.	What is special about a smart material?
2.	What are the methods used to control smart materials?
3.	What do SMA and SMP stand for?
4.	Which metals make up the alloy Nitinol?
5.	Explain, with diagrams, how you use a Nitinol split rivet.
6.	How can Nitinol be used to prevent fire damage?
7.	How can a person with a hip problem be helped by an SMA?
8.	Give an example of how an SMA can self-repair damage.
A	Describe fully three possible uses for SMP material.
B	Design a household or garden product that might make use of SMA or SMP materials.