

# MULTIPLE MOULDINGS: DESIGN AND MANUFACTURE OF AN INJECTION MOULDED PRODUCT

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## WHAT YOU WILL LEARN

**After completing this project, you should understand:**

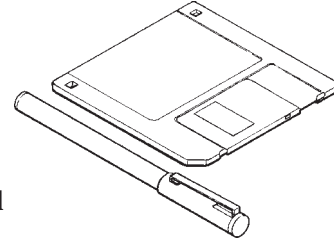
- The importance of injection moulding as a means of making things.
- How injection moulding works.
- Two methods for making an injection mould.
- How to mark out, cut out, and form materials for injection moulds.
- The reasons for faults such as “flash” marks on mouldings.

**After completing this project, you should be able to:**

- Work to a design brief and write a specification.
- Recognise design constraints when designing.
- Design and make an injection mould.
- Produce an injection moulded shape from a mould you have made.

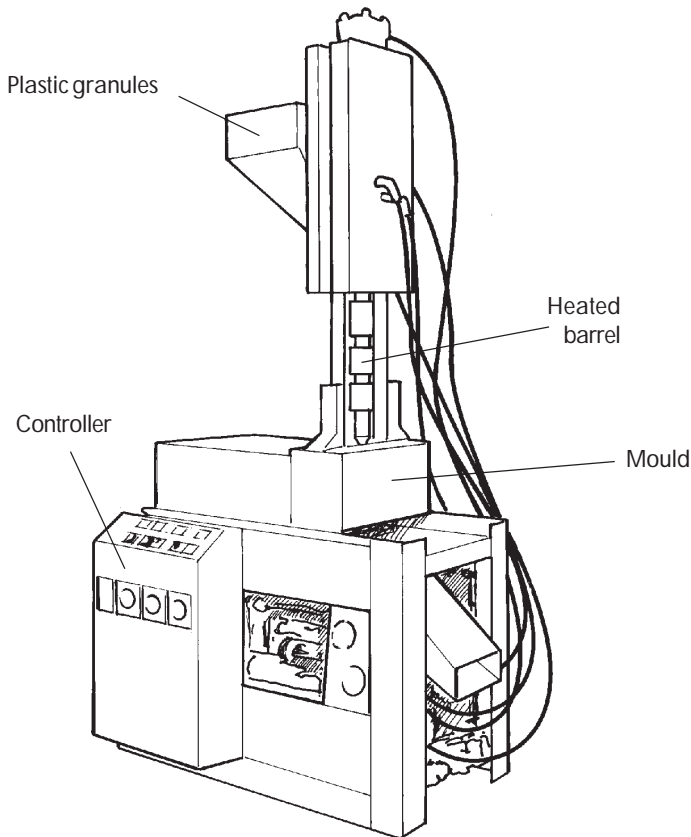
# MANUFACTURING - INJECTION MOULDED PRODUCT

Many of the things you own and come into contact with every day are made from plastics which have been **injection moulded** into shape. These things range in size from pens to computer and television cases. Many products have become very cheap and widely available because of the injection moulding 'revolution'. Injection moulding can produce very large or small products with great precision, in very large numbers, and at low cost.



## THE INJECTION MOULDING PROCESS

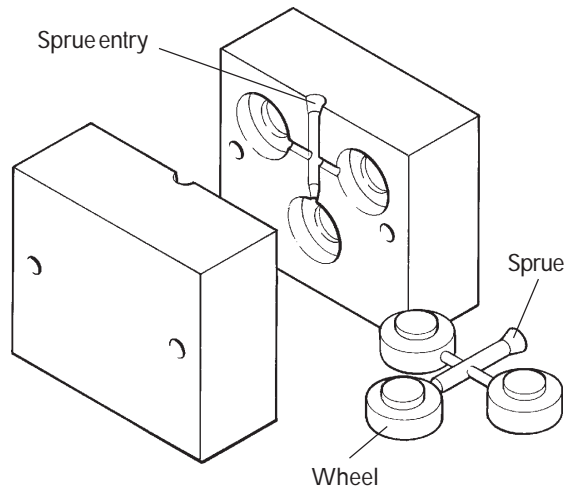
Injection moulding, as its name suggests, involves injecting fused (softened) plastic into a mould. In an injection moulding machine, plastic granules are fed into a heated barrel. They are forced through this barrel either by a piston or a screw (similar to one in a mincing machine). The granules fuse together into a mass like soft chewing gum and this is forced from the end of the barrel into a metal mould. An industrial injection moulding machine performs this whole operation automatically in stages:



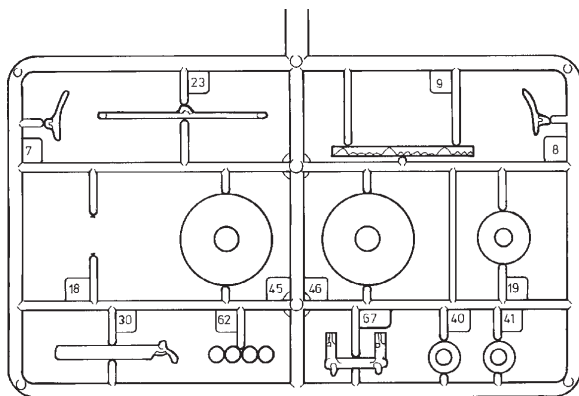
- Plastic is fed into a barrel and heated.
- The plastic is forced under pressure into the closed mould.
- The plastic remains for a time in the closed mould to cool down and harden.
- The mould opens and the plastic shape is ejected.
- The whole operation is then repeated.

## MANUFACTURING - INJECTION MOULDED PRODUCT

The mould itself is made from two or more metal parts which fit tightly together leaving only a small hole for the fused plastic to enter. This hole is called the sprue entry. If you look at an injection moulded product carefully, you may see the point at which the plastic entered the mould. It will be a small mark where the sprue has been broken or cut off the moulding.



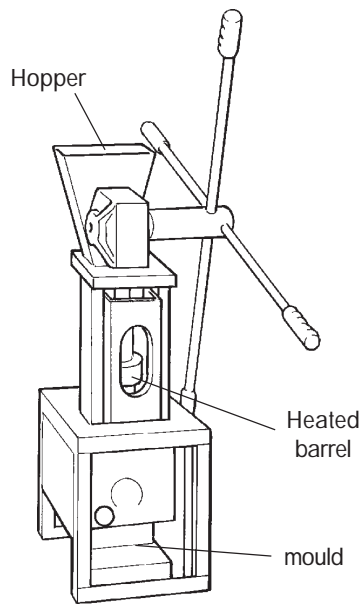
Sometimes a mould has a number of cavities which are connected by channels. When the plastic is injected, it passes through these channels to fill each cavity. Plastic model kits are made in this way, and when you take the parts out of the box they are joined to the plastic which has hardened in the channels.



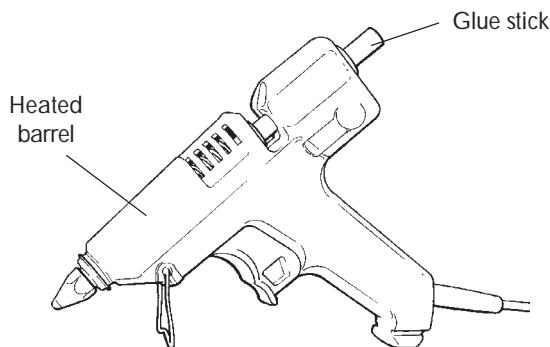
If you look carefully at such a moulding, you will probably see a fine line running all the way around which was where the mould parts came together. Sometimes in cheaper mouldings the plastic leaks out through a small gap between parts of the mould and produces a fault called 'flashing'. A 'flash' is unwanted plastic that becomes part of the moulded product.

## INJECTION MOULDING MACHINES

Large industrial injection moulding machines are expensive and not normally found in schools. Smaller hand-operated machines are used in school and also in industry for making prototypes (a moulding to see if an idea works) or for making the actual product where only a few have to be produced.



Hot-melt glue guns are sometimes used as injection moulding 'machines'. In a glue gun, hot-melt glue sticks are forced through a heated barrel and come out at the front nozzle as a sticky fused adhesive. Glue guns are not designed for injection moulding, but they can be used to make very precise identical mouldings if the hot-melt glue material is suitable for the product you want to make. Hot-melt glue is now available in a range of bright colours and although it is a flexible material, this is a very suitable property for some moulded products.



### ◀ NOTE

A sample or class pack containing glue gun, glue sticks and mould case is available.

# MANUFACTURING - INJECTION MOULDED PRODUCT

## INJECTION MOULDS

Injection moulds are normally made from steel. Where only a few thousand or even a few hundred mouldings are produced, softer metals such as aluminium is used.

An injection mould has to be made precisely so that its parts fit exactly and have to be well finished because the surface of the moulding is a 'mirror image' of the mould surface. Any imperfection or tool mark in the mould will show on the product.

Large moulds for products like television cases or dustbins cost thousands of pounds to make. Much of this cost results from getting a good finish on the inside of the mould.

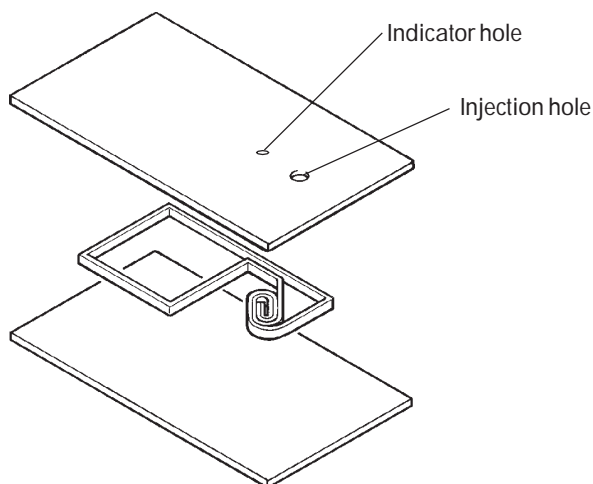
## MOULDS THAT YOU CAN MAKE

Two types of mould can be made quite rapidly for prototyping:

- Wire outline mould (for simple two dimensional shapes)
- Laminated mould

### Wire Outline Mould

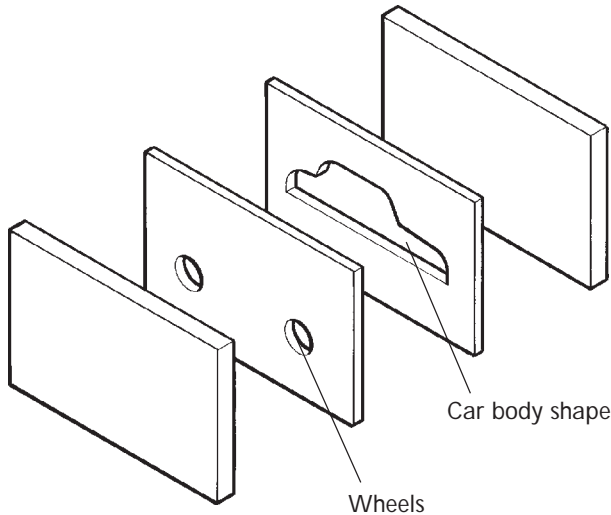
This mould uses metal wire which is trapped between two metal plates to form a cavity. The fused plastic is injected through a hole in the side of one of the plates. (A smaller hole near the injection hole is used to indicate when the mould is full.)



Wire moulds can be made in a matter of minutes but their use is limited to moulding flat products. Also, since plastic shrinks on cooling, a hole appears where the plastic has been injected. Either this is accepted or the wire has to be formed to allow for a sprue and gate that can be cut off the final product.

**Laminated Moulds**

Laminated moulds consist of three or more plates clamped together. In a three-plate mould, the centre plate is cut out so that when it is sandwiched between the other two a cavity is formed. In laminated moulds, more than one cut-out plate can be used so that a more complex shape can be built up. The example shows the outline of a car key ring fob. One of the middle plates has two holes drilled in it to form wheels.



DESIGNING AND MAKING AN INJECTION MOULDED PRODUCT

YOUR TASK

*A new sports shop has commissioned you to design and make a number of identical moulded products that it can give away as 'stickers' for the door of a refrigerator. These are to be small mouldings with either a moulded-in magnet or a self-adhesive sticky back. The size of the moulding should not exceed 30 mm × 30 mm and should be no thicker than 4 mm. You may decide on the outline of the shape but it must be kept simple and should suggest a leisure or hobby activity.*

◀ DESIGN BRIEF

DESCRIBING YOUR TASK

First, you need to draw up a design specification for your moulded product. A specification is a more detailed description of what a product will be like, what it will do, and who will use it. Here are some questions to help you produce your moulding specification:

◀ DESIGN SPECIFICATION

- Who are the mouldings for?*
- What theme will you use for the design?*
- What will be the overall size of the moulding?*
- What colour should the moulding be?*

## MANUFACTURING - INJECTION MOULDED PRODUCT

### MATERIALS AND COMPONENTS PROVIDED

Before you can start your design work you need to know what materials and equipment are available. To manufacture the product, you need to design and make either a wire or a laminated mould. (The notes below will guide you through each of these two options.) You will work with hot-melt glue as the moulding material and a glue gun as the injection moulder.

### ◀ DESIGN CONSTRAINTS

### WORKING OUT YOUR DESIGN

Having considered what is available to make it, you need to think about ideas for the moulding and the mould.

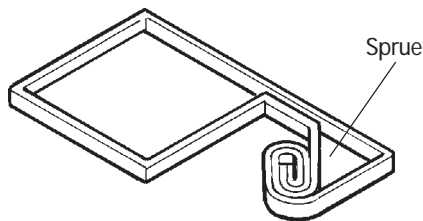
- Set your ideas down on paper.
- Play around with your ideas.
- Check your ideas against your specification.
- Decide which is the best design.
- Do a detailed full size drawing of your design on graph paper.
- This final drawing is a working drawing, i.e. a drawing that you work from to make the shape of the wire.

### ◀ NOTE

See Technology Study Files 3 and 4.

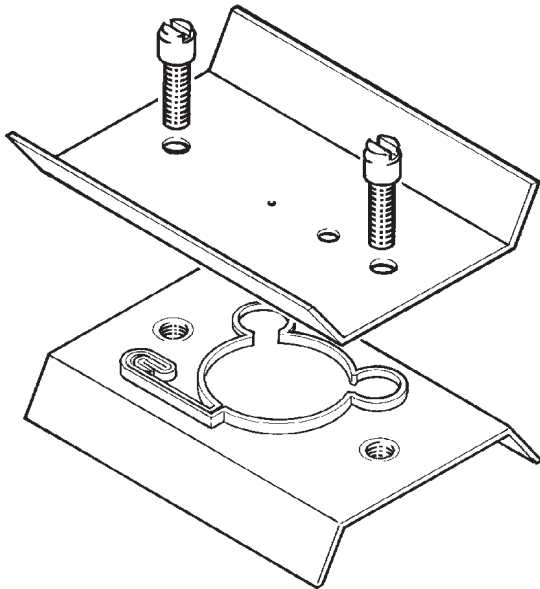
### HOW WILL THE MOULD BE CONSTRUCTED?

The 'wire' used to make the mould is 3.0 mm × 1.0 mm in cross-section. Alternatively, you can make a different size by cutting from a sheet on a guillotine. To make a complete enclosure, the wire is joined by folding it several times where the two ends meet.



## MANUFACTURING - INJECTION MOULDED PRODUCT

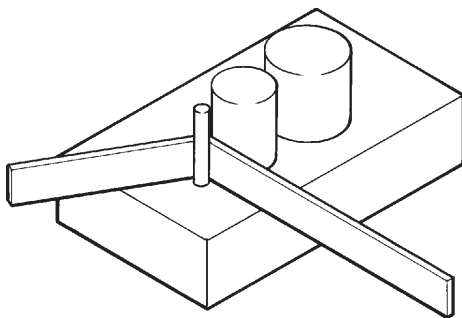
A mould case like the one below may also be provided. This has two screws which bring the top and bottom plates together and trap the wire. If you use the mould case, your wire shape must fit between the two screws. As an alternative to the mould case, two plates of aluminium may be used - held together by a small "G" cramp or tool makers clamps.



The squares on your drawing will help you to estimate the length of wire you need. You can check your estimate by bending a length of thin insulated connecting wire around the outline and then straightening it out and measuring its length. The length will be longer if you decide to build in a 'sprue' - and remember the total length must include an extra 4 cms to make the folded joint.

## MANUFACTURING - INJECTION MOULDED PRODUCT

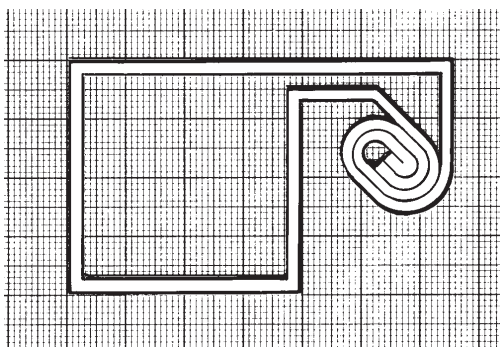
The wire can be bent to shape using a jig. This is a special tool made - (often from scrap materials) - to help with a manufacturing process. The diagram shows a simple jig for bending the wire. A very sharp bend can be made around the small pin and bends of different radii can be made around the pieces of dowel. There is a certain amount of 'spring-back' from the original shape when you are bending the metal. This must be allowed for by bending the wire slightly more than is needed. You can place the wire over the drawing as it is bent to check for accuracy.



Simple bending jig

Finally, when the two ends of the wire are folded round, they should be 'crimped' (nipped tightly together) with a pair of pliers.

You can calculate quite accurately the volume of plastic needed to fill your mould. Count the squares on 1 mm graph paper within the wire outline and multiply by the height of the wire in mm.



◀ MATHS OPPORTUNITY

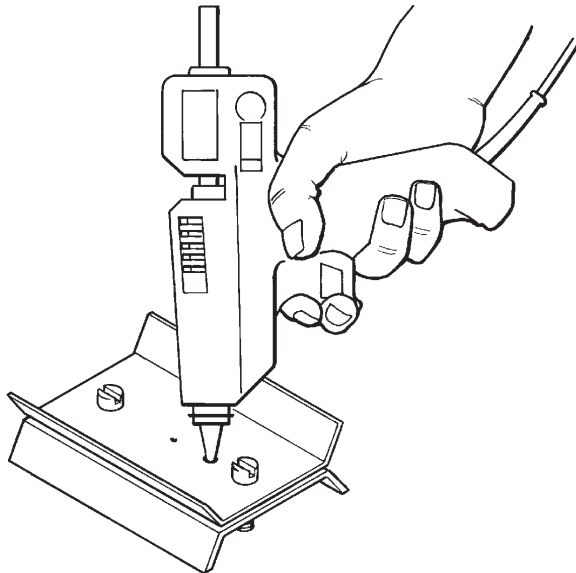
e.g.  $310 \text{ squares} \times 3 \text{ mm}$   
 $= 930 \text{ cubic millimetres (mm}^3\text{)}$   
or  $0.93 \text{ cubic centimetres (cm}^3\text{)}$ .

What length of a 10 mm diameter glue stick would you need to fill your mould?

## MANUFACTURING - INJECTION MOULDED PRODUCT

When the wire shape is complete, your product is ready for moulding. The mould case (or aluminium plates) and the wire should both be sprayed lightly with silicon release agent. This prevents the hot plastic sticking to the surfaces.

The wire is then put in position and the mould tightened (or the plates clamped). Remember to make sure that the sprue hole is within the cavity formed by the wire! Place the nozzle of the glue gun in the hole and insert the plastic by repeatedly pressing the glue gun's trigger. It also sometimes helps to press the glue stick into the rear of the glue gun with your free hand. When the cavity is full, a small spot of plastic appears from the 'warning' hole, and you should stop injecting plastic at this point. If you continue, there is a danger that the pressure built up inside the cavity will push the wire outwards and destroy its shape.

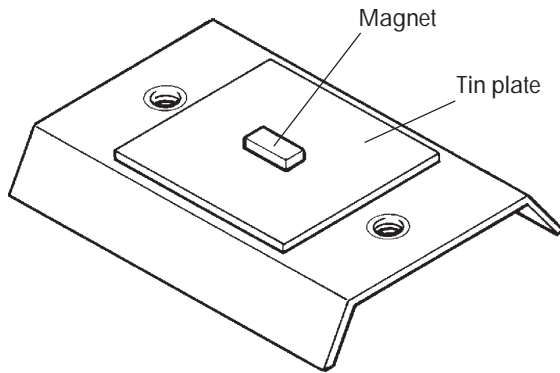


The metal mould conducts heat away from the plastic inside very quickly so the mould can be opened almost immediately. If a large quantity of plastic is injected, however, the mould will get very hot and may need to be cooled in water before opening. (The moulds used in industry get hot as plastic is injected and these are cooled by a continuous supply of water that runs in specially machined channels.)

◀ SCIENCE OPPORTUNITY

## INSERT MOULDING

One way of attaching your product to a refrigerator door is to incorporate a small magnet within it. When something like a magnet is moulded in and trapped, the process is known as insert moulding.



The plastic covered strip used for magnetic wall planners etc. can be used for insert moulding. The strip is cut into lengths of about 1 cm and one of the pieces is put into the mould before the plastic is injected. To ensure the magnet does not move during moulding, it can be placed on a sheet of tinfoil cut to fit inside the mould case (or between the aluminium plates). The hot plastic forms around the magnet and holds it securely in place after hardening.

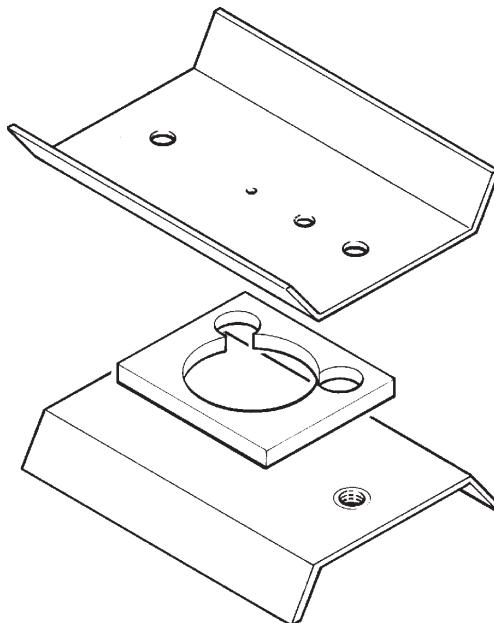
### ◀ NOTE

The flexible ferrite material is available at good stationers.

## USING THE LAMINATED MOULD METHOD

A laminated mould can be manufactured by substituting a cut-out metal plate for the wire described above. This fits either into the mould case as shown below or between two plates of a similar thickness.

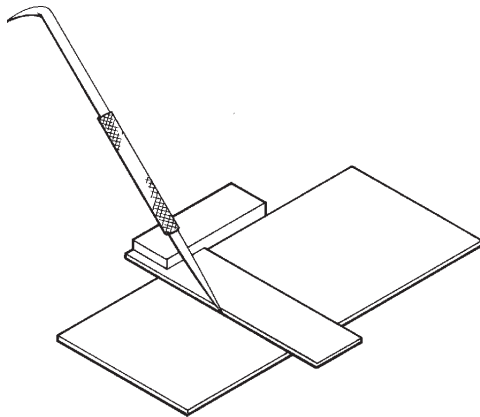
For a simple flat product, the mould is designed and drawn as described previously. Remember that your final idea should be drawn and dimensioned so that another person can 'read' the drawing and make what it describes.



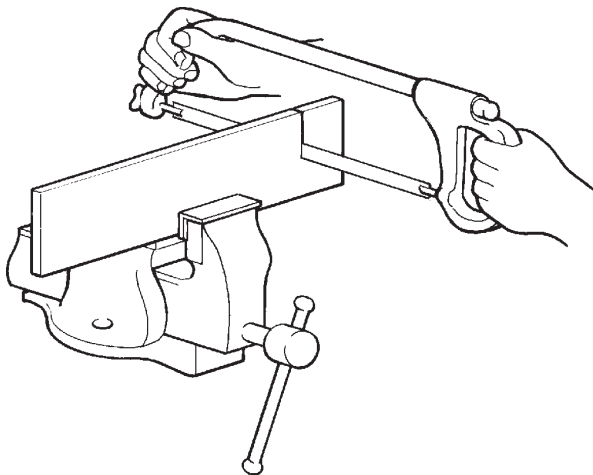
### MAKING THE CUT-OUT PLATE

It is likely that the material for making the mould plate will be supplied as aluminium strip of the correct thickness and width. This has to be marked out to length and cut off with a hacksaw as follows:

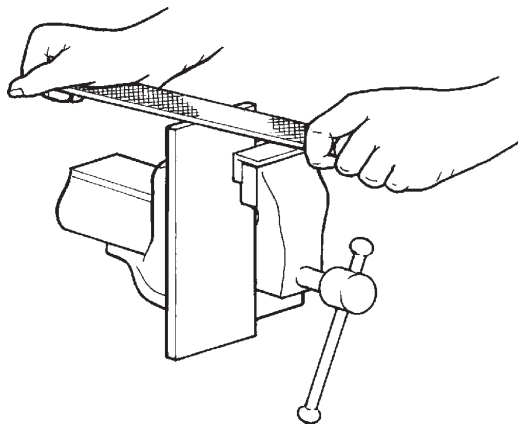
- Place a try-square across the strip at 90° and mark a line with a scriber. (A scribed line shows up much more clearly if the metal surface is first painted with 'engineer's blue' or a spirit-based felt-tip pen.)



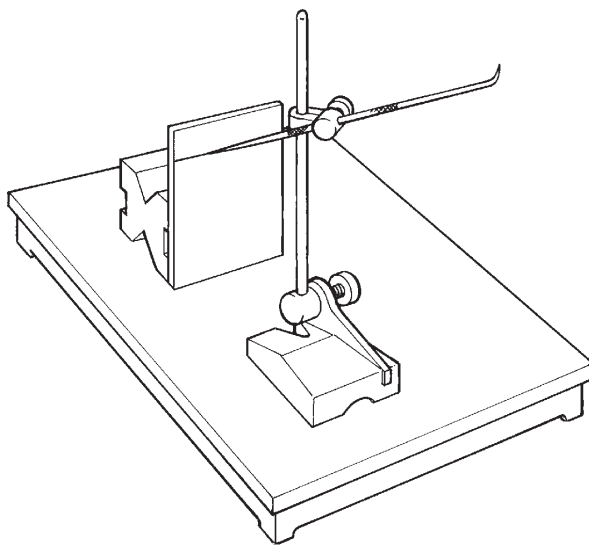
- If you use a try-square to mark out other details on the plate, do this before the plate is cut off because the stock of the try-square can rest along the full length of the strip.
- Make sure the material is held in the vice between 'soft jaws'. Make the cut on the 'waste side' of the scribed line.



- Finish off the ends of the plate with a file so they are at 90° to the sides. Put a small mark on one side and one end. These are your datum edges - places from which you mark out.



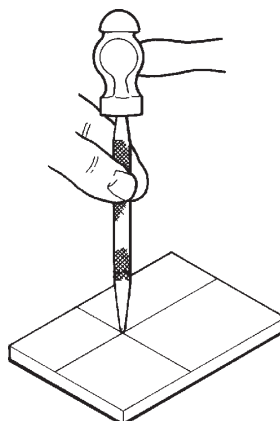
- Mark out the shape of the cut-out from the two datum edges. Any lines at 90° to these edges can be ruled across using a trysquare, but a more accurate method is to use a scribing block on a surface plate.



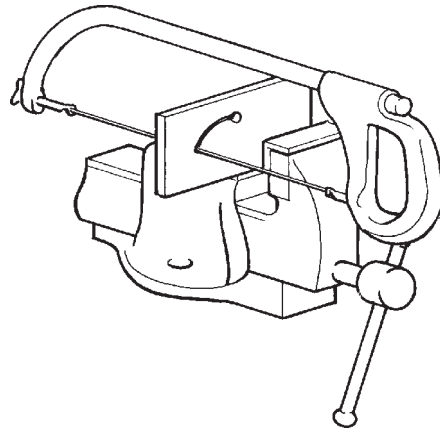
◀ MATHS OPPORTUNITY

Datum surfaces

Mark out the centres of any holes to be drilled by centre-punching the intersection of two crossing lines. The same method is used to obtain the centres for any compass work. A very light centre punch mark helps locate one leg of the compass.



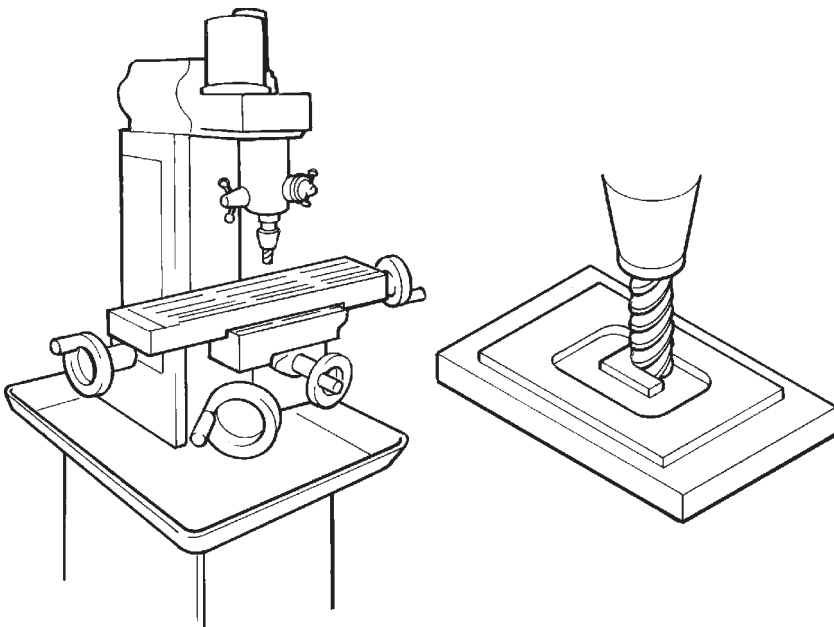
Cut out the plate using an abrafile saw which has to be inserted through a small drilled hole. Smooth the cut edge using a combination of files and abrasive paper such as emery cloth. Professional tool makers wrap abrasive paper around small wooden sticks to help them.



The plate can also be cut out using a vertical milling machine. The aluminium is secured to the table of the machine and the cut is controlled by moving the machine table along or across. The amount of movement of the table in these two directions can be controlled very accurately by the dials on the feed wheels.

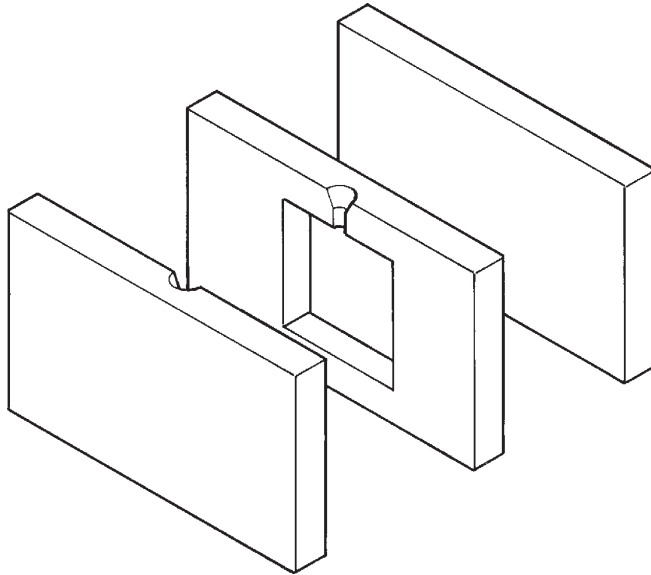
If it is available, a CNC (computer numerically controlled) milling machine can be used for cutting out the plate. With some software packages the shape you need is drawn on a computer screen and then automatically converted into a set of instructions to operate the milling machine.

◀ IT OPPORTUNITY



### SELF-CONTAINED LAMINATED MOULDS

The simplest self-contained mould has three plates of identical size with the cut-out plate in the centre. In such a mould, it is normal to inject the plastic through a sprue drilled between two of the plates. Because of this, it is necessary to add at least two location pins in the plates so they always fit together precisely the same way. (A good size for the location pins in your mould would be 5 mm diameter.)



To drill the holes for the location pins, mark out and centre-punch one outer plate and then clamp all three plates together and drill.

Finally, with the location pins in place, the three plates are clamped together again and a sprue hole drilled between the centre and one outer plate. The top of this sprue hole is countersunk to accommodate the moulding machine or glue gun nozzle.

For a more complex moulding, it may be necessary to have more than one centre plate with a cut-out. These plates can have different cut-out shapes and be of different thicknesses.

## MANUFACTURING - INJECTION MOULDED PRODUCT

### MANUFACTURING IN QUANTITY

If you wish to make more than one moulding - e.g. as part of a mini-enterprise project - you need to think about the production process. If it takes you four hours to make one moulding, it should be possible to make 10 identical mouldings in far less than 40 hours. This is because once the injection mould has been made, it is a relatively fast operation to repeat the actual moulding process.

Injection moulding is capital intensive. This means it is relatively costly and time consuming to make moulds. However, once the mould is available, it can soon pay for itself by producing thousands of mouldings!

◀ MATHS/BUSINESS OPPORTUNITY

### QUALITY CHECKING

Checking for quality is very important when products are manufactured in quantity because a manufacturing fault could be repeated many times. You need to check your first moulding very carefully for any unwanted details or flashmarks. If you are producing a batch of identical mouldings, check one or two at random to ensure they remain consistent.

### EVALUATING YOUR MOULDING (AND MOULD)

There are a number of things to consider when evaluating the success of your moulding.

1. Was the mould successful and did it enable you to make what you intended?
2. Does the moulding meet the requirements of the brief and your specification?
3. Costs. What do you estimate the moulding cost to make? How much would it cost to make ten as opposed to just one?
4. Check your product against the competition by comparing quality, unique features, possible selling price, etc.

◀ NOTE

See Technology Study File 12.