

AS LEVEL Section D

FACT FILES

Technology & Design

For first teaching from September 2011

For first award in Summer 2012

Processing



tech
nology
and
design



Learning Outcomes

In addition to those contained in parts 1.6 and 1.7 of Compulsory Section A of the specification students should be able to:

- demonstrate knowledge and understanding of the following processes:
 - laminating;
 - steam bending;
 - die cutting;
 - laser cutting;
 - CNC router, milling and lathes.



Course Content

Steam-bending timber

A bent twig, in its unseasoned 'green' state is springy because of its high moisture content. This effect can be recreated to bend solid wood by subjecting it to heat treatment - the supply of heat and moisture makes it soft, semi-plastic and compressible. A steam chest (Fig. 1) treats wood placed within it with saturated steam, maintaining a temperature of 100°C. The amount of time needed for steam bending varies from timber to timber – some timbers need up to one hour per 25mm of thickness before they can be bent. When the steam treatment is complete the work should be clamped in a jig or former as quickly as possible, while it is still pliable. It then needs to be held in its bent position to settle and dry out in a warm atmosphere. Wood that has been treated in this way can be prone to twisting.

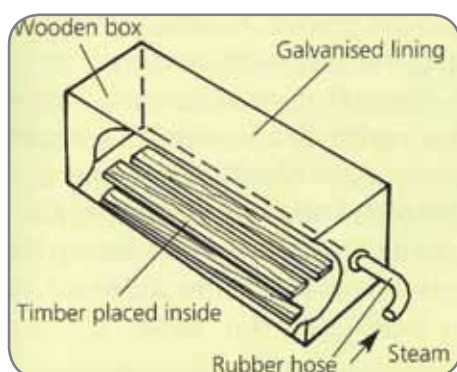
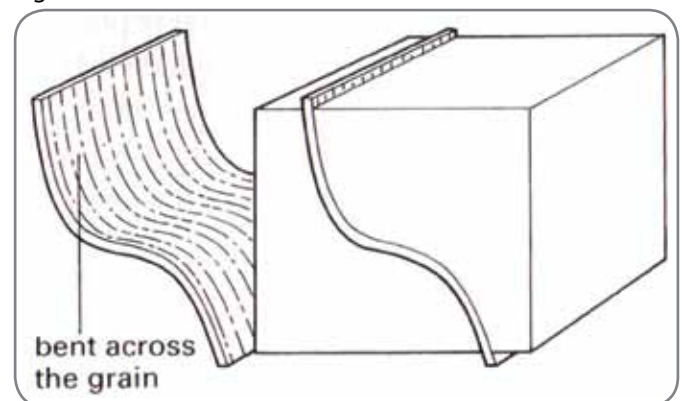


Fig. 1

Laminating timber

Improved precision is a major advantage of laminating timber in comparison with steam-bending. Timber can only be bent significantly in one direction, namely, at right angles to the grain flow because of its grain structure. Bending along the grain will tend to cause splitting at quite a low curvature. Consequently laminated timber is best bent across the grain as shown below.

Fig. 2



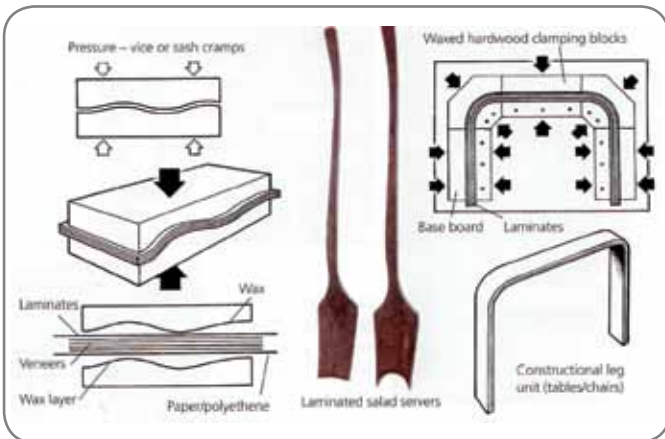
This will, of course, lead to a great difference in the strength properties of the completed lamination, and this must be taken into account by the designer.

If strength is required both along and across the grain, then it is possible to laminate sheet material with the grain in alternate layers perpendicular to one another. It is also possible to bend plywood with the grain in front and back veneers lying perpendicular to the bend. It should be remembered when ordering plywood that the first dimension gives the strength along the grain – i.e. 2440 x 1220mm indicates a normal board and 1220 x 2440 mm indicates a cross-grained board. The designer should consider carefully which is the best choice, and be sure to use it economically. It is important that the designed shapes fit conveniently on to standard sheets to avoid waste, in just the same way as sheet metal blanking must be carefully planned.

A more accurate method of shaping wood is laminating. This involves building up the curved form with layers ('lamina'). The layers may be thin veneers, thicker constructional veneers, or saw cuts strips. They are assembled so that the grain of each layer is running in the same direction, following the curve (unlike plywood, which has interlocking grain).

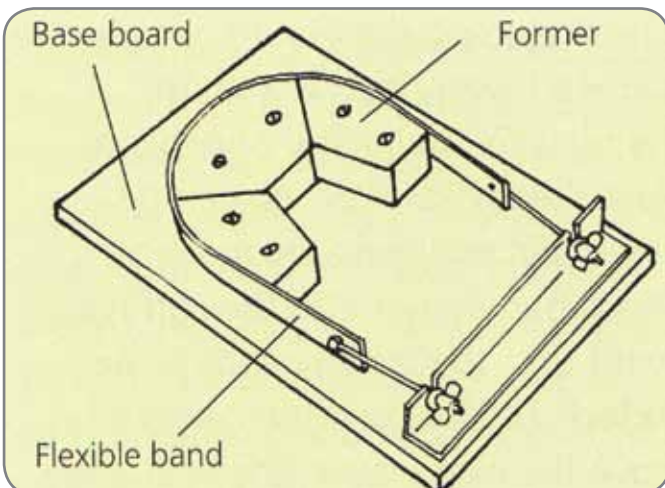
The layers are glued together with a strong adhesive (e.g. Aerolite306) and are sandwiched between the waxed faces of a former or a jig using clamp pressure (Fig. 3). The layers bend to the shape of the jig and 'set' together.

Fig. 3



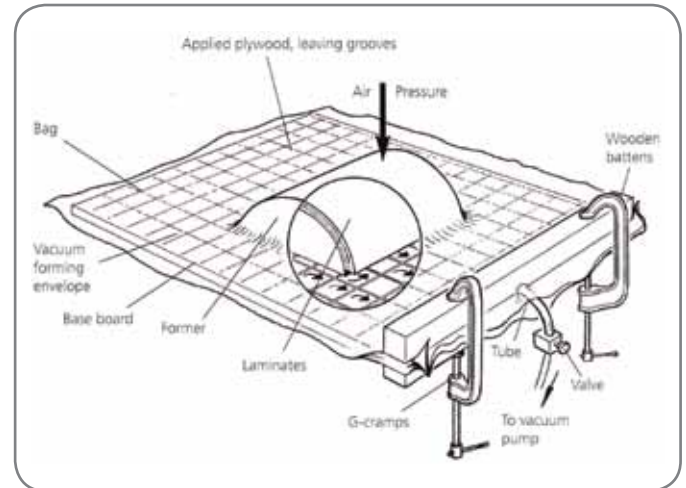
If the curve you want to make is suitable, you can use a flexible band in place of one of the formers. The band follows the shape of the former and pressure is exerted by means of a screw (Fig. 4).

Fig. 4



Another method of applying pressure is by using a bag press (Fig. 5). This technique is most useful for forming small curves with thin lamina. The glued layers are taped to a former and placed on to a prepared base board, which is inserted into a bag. The bag is then sealed and the air extracted using a vacuum pump. The consequent atmospheric pressure acts on the lamina and presses them together.

Fig. 5



Laminating as a Finishing Process for Paper and Board

Laminating applies a transparent plastic film to the surface of paper and board. Commercial laminating uses a polypropylene (PP) film that is glued to the paper as it is fed through a heating wedge under high pressure. Lamination provides a wide range of uses across the whole spectrum of printed products due to its properties of good gloss and strength and advantages of low cost.

Die Cutting

While the die-form is being made the cartonboard sheets for the job are selected and cut to size on a power guillotine. The cartonboard is then printed using the appropriate printing process, such as offset lithography.

After the die-form is mounted on the machine, a test sheet is cut and adjustments and corrections made. Once satisfied, each printed sheet is fed onto a platen, directly below the die-form. The platen is then forced upwards, pushing the cartonboard hard against the rulers. The cutting rules cut right through the cartonboard, the creasing rules push the card into the groove formed by the matrix strips. Once cut, the sheets are pulled to the next stage to be stripped of their waste. Ejector pins on the die-form push the waste away onto a conveyor belt for disposal while the nets leave the machine and are stacked ready for gluing.

Laser Cutting

Surface decoration using CAD/CAM

Laser cutting and Engraving

Laser cutting is a technology that uses a high powered laser to cut materials, and is usually used in industrial manufacturing to produce features that otherwise would be problematic or even impossible to die-cut. It also eliminates the need for expensive tooling as the laser is directly controlled by computer using a CAD/CAM system. The laser either melts, burns, or vaporises away the material leaving an edge with a high-quality surface. This process is ideal for manufacturing signage, for example, from sheet acrylic. Laser cutters usually work much like a milling machine would for working in sheet materials. The laser (equivalent to the mill) enters from the side of the sheet and cuts through the axis of the beam. In order to be able to start cutting from somewhere other than the edge, a pierce is made before every cut. Piercing usually involves a high-powered pulsed laser beam that slowly makes a hole in the material.

In the printing industry, lasers are used in the following ways:

- **Direct laser imaging** of lithographic printing plates using carbon dioxide laser imaging head to burn away unwanted material and form negative printing plate directly from digital data.
- **Direct laser engraving** of flexographic and gravure printing plates and cylinders using a high-power carbon dioxide laser head to form sharp relief images with steep, smooth edges to give a high standard of process colour reproduction.

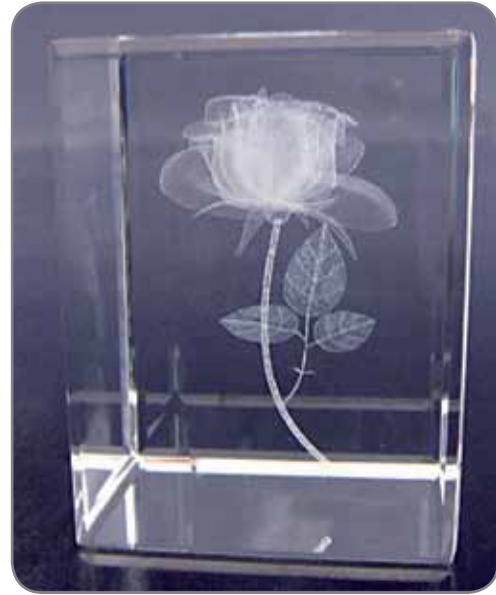
Advantages of laser cutting over mechanical cutting:

- Lack of physical contact with the material produces a clean edge
- Precision, as there is no wear on the laser and it is computer controlled
- Reduced chance of warping the material that is being cut, as laser systems have a small heat affected zone
- Some materials or features are very difficult or impossible to cut by more traditional means.

Disadvantages include:

- Very expensive machinery
- High energy consumption required to power lasers.

Fig. 6



CNC router, milling machines and lathes

Computer-aided manufacture (CAM) is a process that converts drawings that have been produced using a CAD system into actual products. CAM can involve a range of machines, but the most common are lathes, routers, milling machines and laser cutters. These machines are controlled by a computer that guides the machine through an entire manufacturing process – computer numerical control (CNC).

The principles of CAD/CAM are the same irrespective of the scale. Software is used to create vector based drawings, whether these are parametric drawing packages such as ProDESKTOP or SolidWorks. Vector based drawings are based upon lines and points that are linked to each other mathematically by the software. This means that they can be used to generate coded information that can be transmitted to the machine. Sometimes additional software is needed to ensure the compatibility between the CAD program and the machine tool.

Types of CNC machines

Routers and engravers for normally light work, producing grooves and profiles

Milling centres This classification includes some of the most versatile machine tools able to produce the most complex contours an internal and external profiles.

Lathes for all turning and cylindrical contouring operations

Laser cutters Co2 Laser Systems only used in schools. In industry cuts with an intense beam of light.

Programming CNC Machines

In order to help both users and suppliers of machine tools an international system of standard codes has been developed to describe machining operations. The codes appear as 'G' and 'M' codes. On a lathe the 'G' codes are to do with the movement of the tool, and on a milling machine, the movement of the work. 'M' codes are concerned with other functions such as starting, stopping and turning on the coolant. For example, code G01 means, 'straight line between two points' and is common to all CNC machine tools.

CNC machines cut by moving either the work piece or the cutting tool, or most commonly through a combination of both. The direction in which movement of the tool on a lathe or the work on a milling machine takes place is defined by a letter and a + or - sign. The letters used are 'X', 'Y' and 'Z'. The Z axis is the axis of the machine that rotates. In the case of a lathe, this is the workpiece and on a milling machine this is the tool.

On the lathe the other axis is X. Fig.7 shows the relationship between the 2 axes X and Z and the directions + and -. When turning a solid bar on the lathe - indicates the direction that cuts. For example -X will reduce the diameter of the work and -Z will make it shorter.

Fig. 7

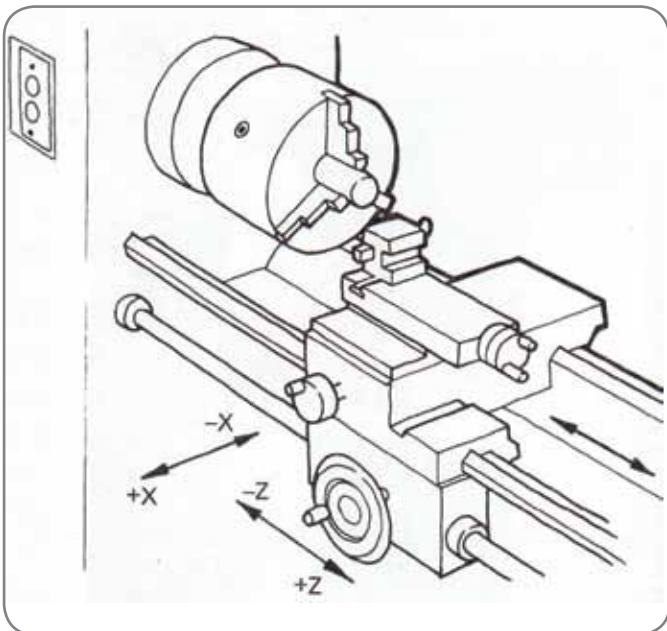


Fig. 8



Fig. 9

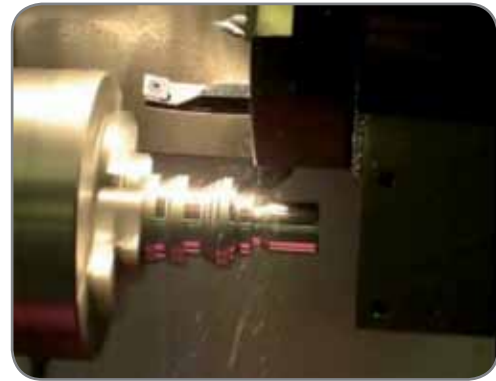


Fig. 10 shows the three axes of a vertical milling machine. The Z axis is the one parallel to the rotation of the tool, on most small machines this is not controlled by the programming and has to be adjusted by hand or it may just be a plunge down and a lift up. (If the up and down movement is the table rather than the tool, then this is regarded as an additional axis defined as 'W'.) The X and Y axes are the movements of the table at right angles to each other like the axes of a graph.

CNC milling machine

Fig. 10

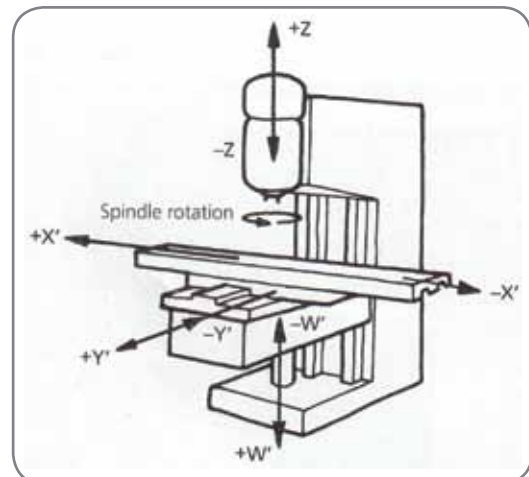


Fig. 11



CNC laser

Fig. 14



CNC router

Fig. 12



Fig. 15

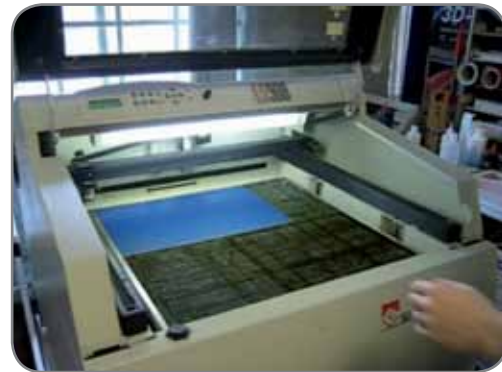


Fig. 13



CNC machine	Materials cut	Applications
Lathes	<ul style="list-style-type: none"> Metals 	<ul style="list-style-type: none"> Produce accurate and complex shapes that would be difficult to produce on hand operated lathes
Routers	<ul style="list-style-type: none"> Wood Foam 	<ul style="list-style-type: none"> Similar to milling machine but using softer materials Used for block modelling Can cut 2D and 3D shapes
Milling machines	<ul style="list-style-type: none"> Metals 	<ul style="list-style-type: none"> Produce flat and complex curved shapes In industry work to fine tolerances
Laser cutters	<ul style="list-style-type: none"> Plastic Wood Card 	<ul style="list-style-type: none"> Cuts with intense beam of light Material does not require clamping Can cut both simple and complex shapes

Table 1 Computer-aided machining

There are many advantages to CAM. The cost of setting up CAM systems can be high, but once the initial costs are made and the system is programmed the advantages are considerable. The machines are able to work 24 hours a day with little human intervention. They ensure that the products they produce are consistently accurate. They are reliable and, because they can be reprogrammed, are very flexible.



Revision questions

1. (a) What are the advantages and disadvantages of steaming timber in order that it can be bent to a predetermined curve?
(b) How does the steaming enable the bending to take place easily?

2. The rockers of a modern rocking chair are to be made of laminated strips of beech that have been steamed, glued and clamped around a former to produce the desired curve.
(a) Why is lamination a good choice for chair rockers?
(b) What problems would you be watching for in manufacturing the two rockers in this way?

3. Explain what the initials CNC stand for and describe its principle of operation. Explain the advantages and disadvantages of manufacture by a CNC machine compared to manufacturing by other types of machine tools.

4. Name a material that is suitable for machining with a small CNC milling machine that might be found in a school Technology and Design department. State, giving your answers in full, why your selected material is suitable.

