

Trade of Sheet Metalwork

**Module 1: Sheetmetal
Fundamentals**

**Unit 4: Folding and Joint
Allowance**

Phase 2

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Document Release History

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22/06/06	First draft	
04/03/14	2.0	SOLAS transfer

Module 1 – Sheetmetal Fundamentals

Unit 4 – Folding and Joint Allowance

Duration – 7 Hours

Learning Outcome:

By the end of this unit each apprentice will be able to:

- Describe the use and care of the box and pan folders
- Fold simple sheet metal blanks within specified tolerance ($\pm 1.0\text{mm}$)
- Calculate groove allowance and form grooved joint as per drawing

Key Learning Points:

P	Work Unassisted.
Rk	Safety/housekeeping/maintain due care in handling and forming sheet metal.
Sk Rk	Use and care of tools, machinery and equipment especially the box and pan folders.
Rk	Edge treatment of sheet metal - terminology.
Sk	Form bends using box and pan folders.
Sk	Form and close grooved joint.
D	Parallel line development.
P Rk	Work planning, quality control, surface defects, problem solving.
M	Calculation of allowances for various hems and edges.
M	Calculation of bend allowance - inside and outside dimensions.
M	Calculation of groove allowances.

Training Resources:

- Tool kit
- Hand groover
- Safety equipment and protective clothing
- Tools and machinery/equipment
- 0.6 mm galvanised mild steel

Exercise:

Set up and adjust the box and pan folding machine.

Use blanks from exercises 2.1.2A and 2.1.2.B.

Fold blanks as per drawing numbers 2.1.3A and 2.1.3B.

Groove blanks as per drawing number 2.1.3C.

Key Learning Points

M = Maths **D** = Drawing **RK** = Related Knowledge **Sc** = Science

P = Personal Skills **Sk** = Skill **H** = Hazards

Safety

Always wear the appropriate protection at all times i.e.

- Goggles when grinding and drilling
- Safety shoes and tight-fitting overalls at all times; gloves when needed; also ear protection

Good housekeeping is an important element in accident prevention. Good housekeeping begins with planning ahead. Materials should be neatly stacked and any spillages of oil or grease should be cleaned up immediately.

Each person should pay attention to his own work area. A neat work area reflects a worker's approach to his work and equipment.

The apprentice should always think safety. There are too many hazards in the work area to list. The apprentice should cultivate a positive attitude towards safe working habits.

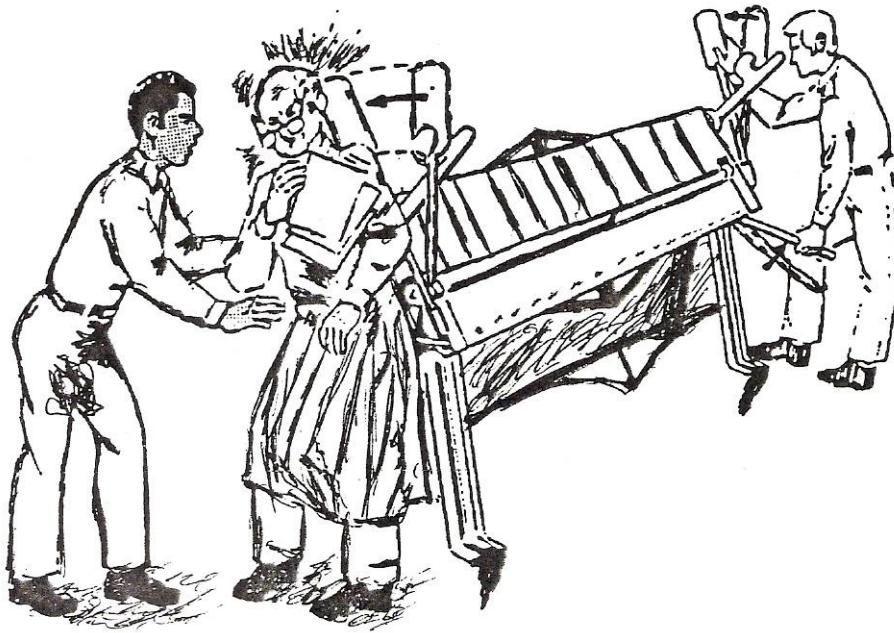
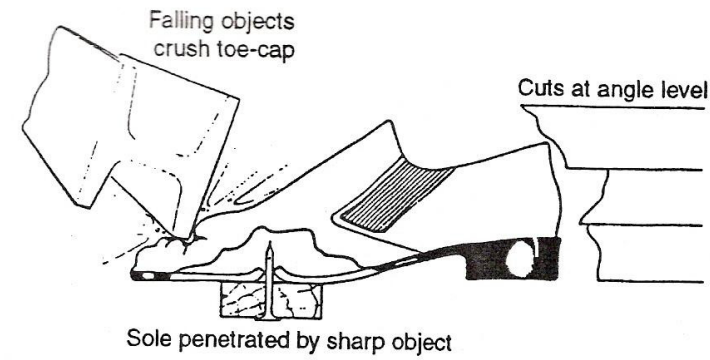
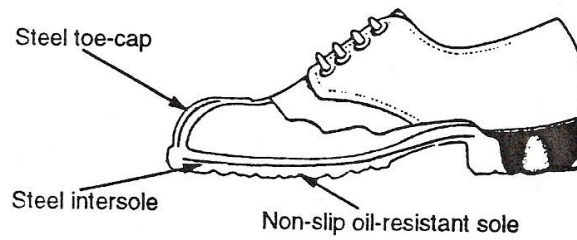


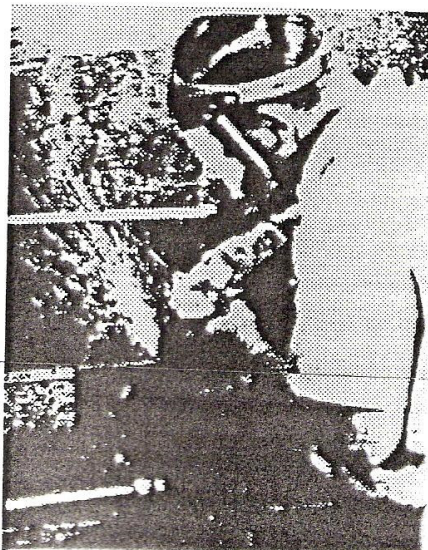
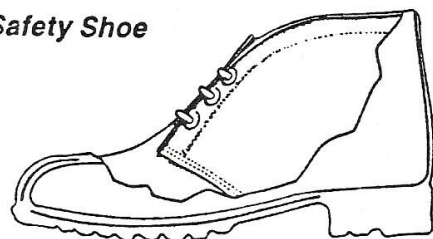
Figure 1 - Safe Work Area



Light-weight shoes offer NO protection



Industrial Safety Shoe



Always wear a face shield or goggles when grinding.

Figure 2 - Safety Wear

Sheet Metal Tools and Machinery

Sanding Machine

This is a machine which can be either electrically or air driven. It has a hard rubber flexible pad onto which the actual sanding disc is fastened by means of a centre nut. It is used in the sheet metal shop for weld removal on panels, cabinet corners etc. prior to painting.

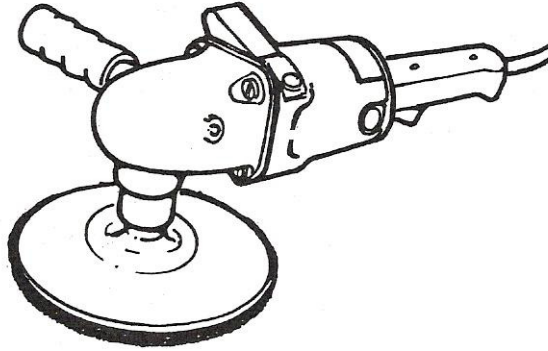


Figure 3 - Sanding Machine

Bench and Floor Grinder

Grinding is the process of removing material by the cutting action of countless numbers of hard and sharp abrasive particles of a revolving grinding wheel as they come in contact with the surface to be ground.

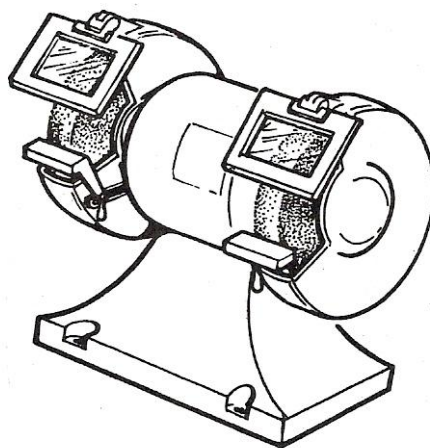


Figure 4 - Bench Grinder

Grinding machines are made in a variety of types and sizes depending upon the kind of work to be ground. The motor driven bench or floor grinder is the type most commonly used in the sheet metal shop.

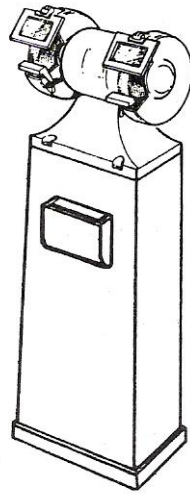


Figure 5 - Floor Grinder

These grinders are used for all kinds of general off-hand grinding and for the sharpening of centre punches, chisels, drills and other small tools.

Electric Angle Grinder

The main use of the angle grinder in the sheet metal shop is for removing excess weld metal on welded joints, flanges, frames and general fabrication work prior to painting. With the aid of a cutting disc, sheets, angles, flat bar etc. can be cut to size.

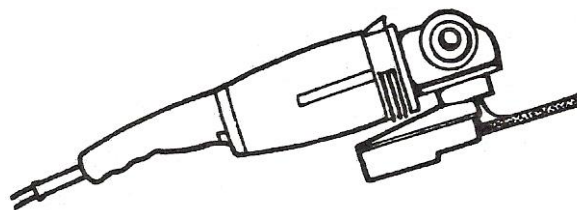


Figure 6 - Electric Angle Grinder

Power Flanging Machine

This is a production machine and is used in the sheet metal shop for turning the single edge on cheeks of curved elbows prior to completion of the Pittsburgh lock.

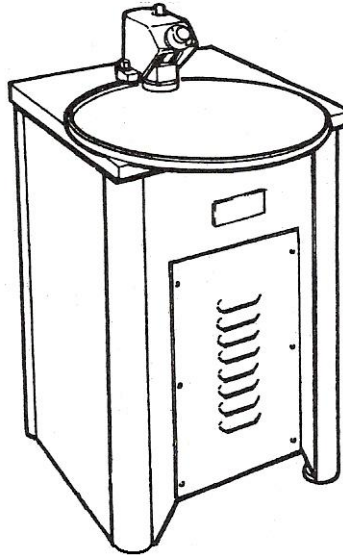


Figure 7 - Power Flanging Machine

Corner Notching Machine

This is another production type machine. This machine removes metal from the corners of the blank size. A typical example is notching the four corners from a blank before it is bent into shape to produce a one piece box.

See DVD of machine for further information.

Circular Saw

This is a production type machine yet it is also suitable for one-off cuts. It can cut virtually any material in their many different shapes, e.g. mild steel, copper, brass and with tougher blades stainless steel may be cut. Solid bar as well as hollow tubing can be cut.

Bench Shears

Bench shears is used in almost every sheet metal shop. The operating principle of these shears is the same as snips except they are built stronger and have a compound leverage system for greater power. The blades are designed to cut curves and circles as well as straight lines.

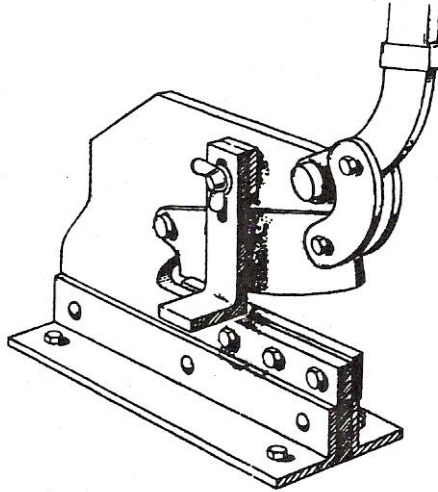


Figure 8 - Bench Shears

Belt Sander

Hazards:

- Ensure tool rest is as close as possible to belt
- Material to be sanded should be at least 6 mm
- Always wear eye protection and hold the workpiece securely
- Wear ear protection as most belt sanders are noisy

Swaging Machine (Jennys)

Hazards:

- Wear gloves as raw edge of metal may cut hands
- Be careful clothing does not get entangled in machine
- Jewellery is dangerous on this machine i.e. rings

Use of different rolls permit the machine to do the following: swaging, wiring, flanging, crimping and joggling.

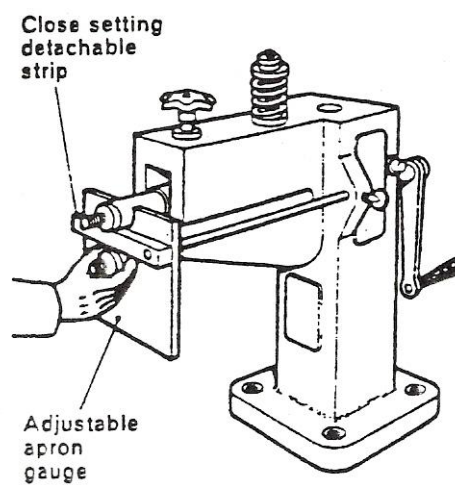


Figure 9 - Swaging Machine (Jennys)

Pittsburgh Lock (Lock Former)

Hazards:

- Wear gloves as metal has hard edges
- Make sure metal going through machine will not hit off anything
- Ensure material is long enough to be picked up by three rollers, if not it may jam in machine and also cause injury

Lock Forming machines are commonly used in the manufacture of ducting. The wheels which shape the lockform can be changed to enable a wide variety of shapes to be produced.

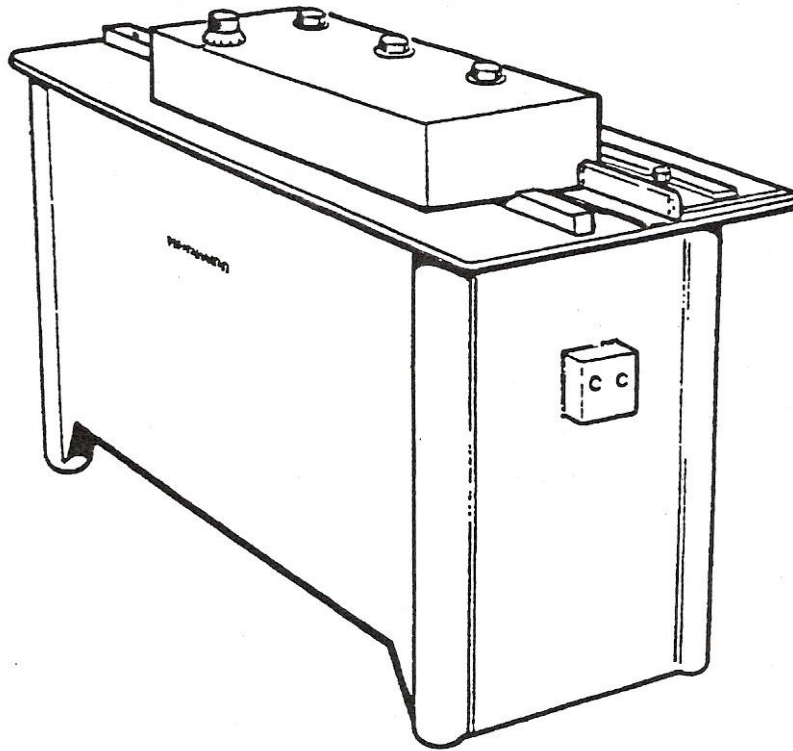


Figure 10 - Pittsburgh Lock (Lock Former)

Double-Ended Polisher

Hazards:

- Flying particles – a full-face shield and dust mask is required
- Gloves, if worn, should be tight-fitting
- Use the bottom front quarter only for polishing
- If there is an opening in the workpiece, polish away from opening and not towards

The machine is normally found in the craft side of the metal industry. Copper, brass and stainless steel are the most common metals used on this machine.

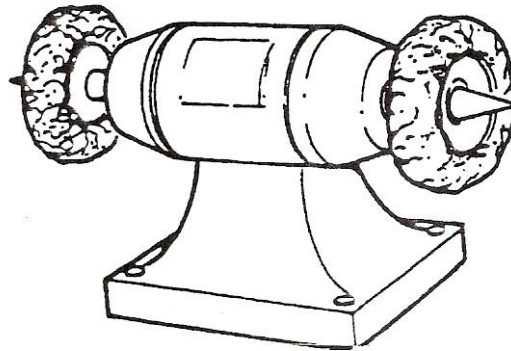


Figure 11 - Double-Ended Polisher

Radial Drill

Hazards:

- Exercise caution as hands and hair can become entangled in drill
- Ensure metal is gripped securely as metal may pull when drill penetrates workpiece
- Ensure correct speed is used
- Drill pilot hole first if large hole is required
- Wear safety glasses

There are floor mounted and bench-mounted types. Each type should be securely bolted down.

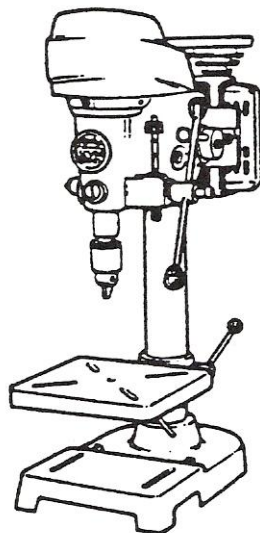


Figure 12 - Radial Drill

Bending Rollers

Hazards:

- Loose clothing e.g. cuffs may get caught up in machine. Always wear tight-fitting overall.
- Exercise caution as fingers may also get caught.

The two types of bending rolls used in sheet metal are the plain bending and slip bending rolls. These machines are for curving sheet metal. On the slip bending rolls the upper roll can be released and this facilitates the removal of the workpiece. This can't be done on plain rolls. There are power and manually operated types available.

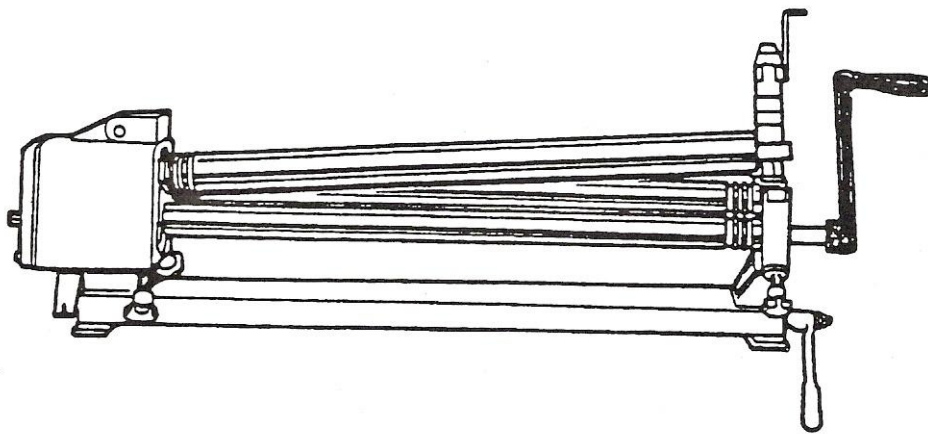


Figure 13 - Bending Rollers

Spot Welder

Hazards:

- Sparks may cause eye injury. Safety glasses are essential.
- Hot tips may burn hands, care and gloves are required.
- Footwear, well insulated, should be worn in case of electric shock.

Spot welding is used as an alternative to riveting when joining light-gauge metal. The basic principle of spot welding is two pieces of metal to be joined are clamped between two copper electrodes, which are connected to a power source. As electricity is passed from one electrode to the other, metal clamped between them acts as a resistor. This causes a build-up of heat and melts the metal thus welding them together.

Tips should be filed regularly and the cooling system always used.

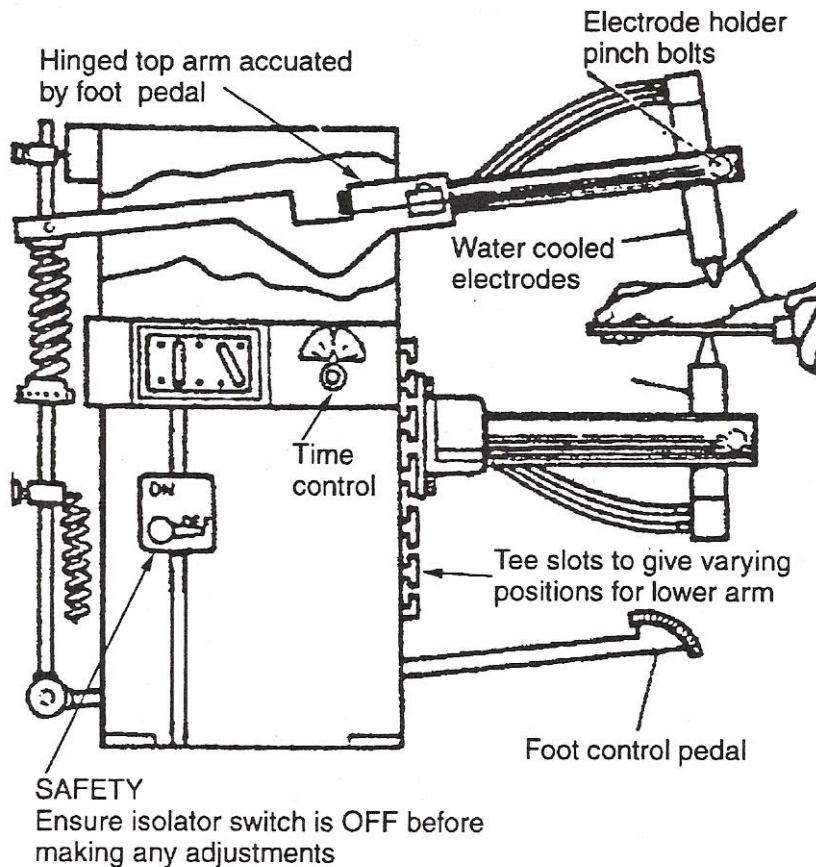


Figure 14 - Spot Welder

The Press Brake

Hazards:

- Hands may get squashed between top and bottom tooling
- Workpiece may fly up when bending and strike operator
- Hands may get trapped between machine and workpiece
- Use correct manual lifting techniques when operating machine

The press brake is another machine for bending metal. This machine is quite different from the standard machine or the box and pan folders because it bends and forms the metal by pressing it into special dies. The dies of the press brake are changed to fit the operation being done. The press brake is more of a production machine than the hand folders. That is, it is better suited to doing a large number of the same operations rather than doing many different operations. Press brakes come in various sizes, with the ten-foot model being the most common one.

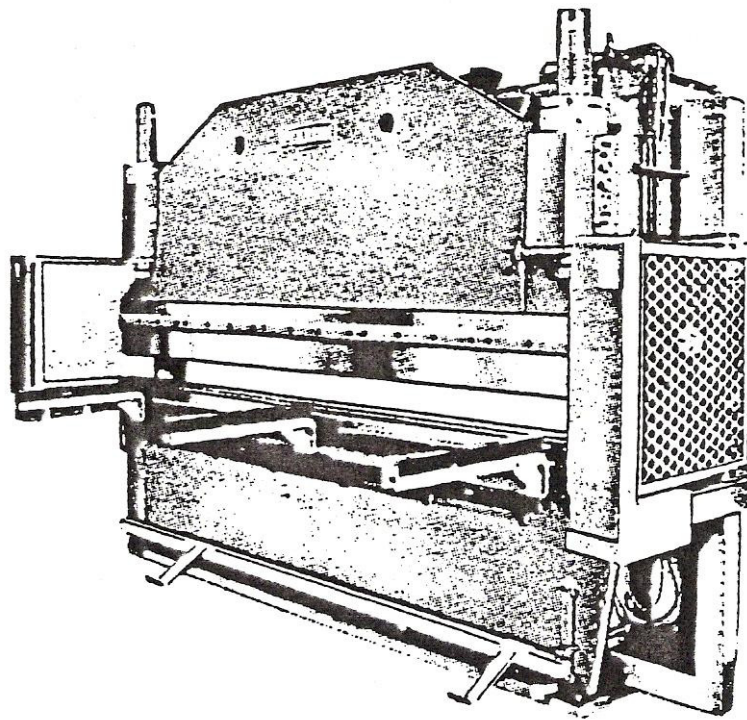


Figure 15 - The Press Brake

Treadle Guillotine

Hazards:

- Ensure nearby people are clear of foot pedals
- Do not over-exert in trying to cut metal
- Do not exceed capacity of machine
- Ensure your own feet and legs are clear of the foot pedals
- Take care in handling the sheet itself
- Only one sheet should be cut at a given time
- Never cut wires, rods or seams

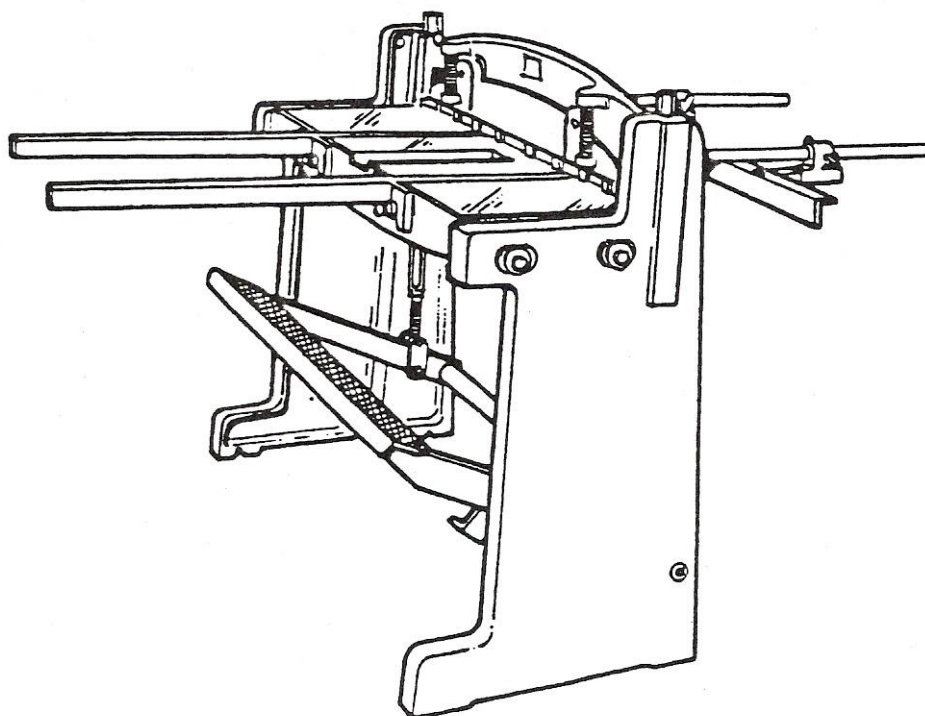


Figure 16 - Treadle Guillotine

Box and Pan Bending Machine

Hazards:

- Beware of swinging counter-balance weights and bottom leaf (bed) of machine.
- Do not use improper manual handling techniques when using machine or moving metal in or out of benders. This machine can put great strain on your back.
- Beware of blade crush when using machine or especially changing blade.

This type of machine, while suitable for all types of bending operations, has special provision for folding pans, trays or boxes. No rods, wires or metal beyond the capacity of the machine should be bent on this machine.

Always adjust for metal thickness.

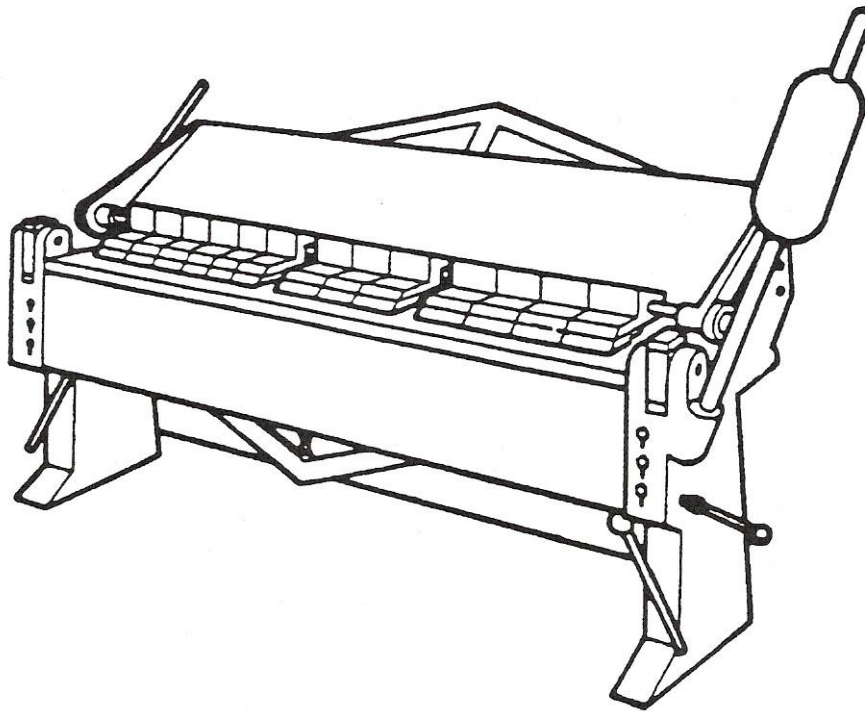


Figure 17 - Box and Pan Bending Machine

Fly Press

Hazards:

- Beware of swinging counter weights
- Watch fingers or loose clothing – do not get caught between punch and die

The Fly Press is suitable for blanking, forming, perforating and bending operations.

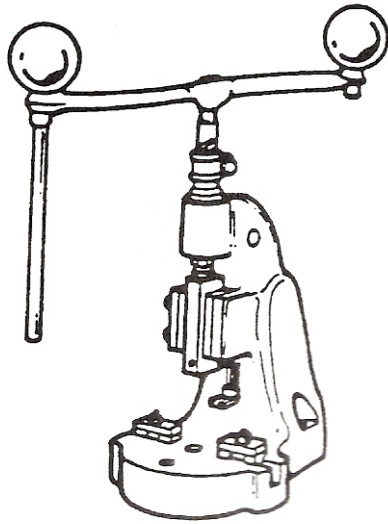


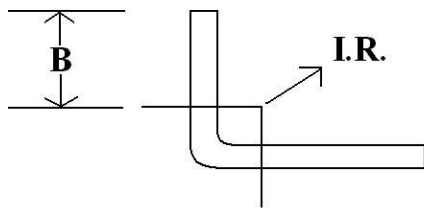
Figure 18 - Fly Press

Box and Pan Folders

1. The most important points when using this machine is to set the machine to suit the metal thickness which we are bending.
2. Never bend beyond the capacity of the machine. This strains the machine and will shorten the life-span and quality of the folders.
3. Never bend round bar etc. in the machine.
4. When removing or inserting the fingers (of machine) take care not to get your own hand or fingers squashed.

The main specifications of folding machines are as follows:

1. The maximum length and thickness to be bent. For example, the capacity of the machine may be 1.5 m times 1.62 mm. This means that the machine is capable of folding a sheet of metal 1.5 m wide and of 1.62 mm (16 s.w.g.) thickness.
2. The lift and shape of the clamping beam.
The smallest width of bend is 8 to 10 times the metal thickness.
The minimum inside corner radius of the bend is 1 ½ times the metal thickness.



B refers to the smallest width which will clamp securely in the machine. If **B** is smaller than 8 to 10 times metal thickness it may slip out.

The **three main steps** in folding work are:

1. Clamping
In clamping, the amount of lift of the clamping beam is important. It should be sufficient to allow the fitting and use of special clamping blades, or to give adequate clearance for previous folds.
2. Folding
Care must be taken to see that the folding beam will clear the work, particularly when making second or third folds. Some folding machines are designed to fold radii above the minimum, either by the fitting of a radius bar or by adjustment of the folding beam.
3. Removal of the work
Care must be taken in folding to ensure that the work may be easily removed on completion of the final bend. The sequence of folding must be carefully studied. The lift of the clamping beam is important here. Some folding machines known as **universal folders** have a swing beam. The work may be completely folded around this beam, which is then swung out to allow removal of the work.

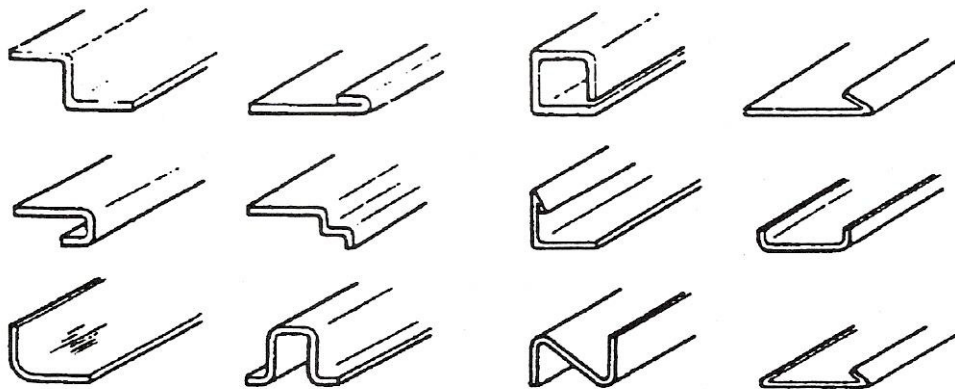


Figure 19 - Examples of Work Produced on a Folding Machine

Sharpness of Folded Edge

The sharpness of the folded edge is controlled by lowering or raising the wing. The cross-section view of the bar folder illustrated in Figure 20 shows the wing raised for a sharp fold and then lowered for a thick, heavy edge.

Allowance for Metal Thickness

When making various types of seams from metal of 26 gage or lighter, allowance for the thickness of the metal is not necessary. However, when heavier materials are to be used and accuracy is required, the actual amount of material taken up by the bend or fold must be considered.

The wing must be at least the thickness of the metal being bent lower than the bed of the machine. If we bend 3 mm thick material, we lower the wing 3 mm.

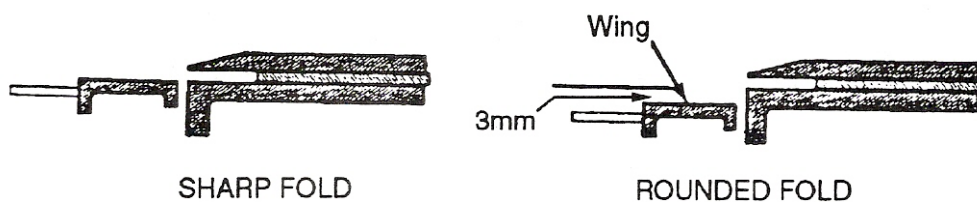


Figure 20 - Bar Folder Adjusted for Sharp Fold and Rounded Fold

Bend Allowance

When making a bend or fold in a sheet of metal, the bend allowance must be calculated. Bend allowance is the length of material required for the bend. This amount of metal must be added to the overall length of the layout pattern, to assure adequate metal for the bend. Bend allowance depends on four factors:

- a) The degree of bend
- b) The radius of the bend
- c) The thickness of the metal
- d) The type of metal used

The radius of the bend is generally proportional to the thickness of the material. Bending a strip compresses the material on the inside of the curve, and stretches the material on the outside of the curves.

However at some distance between these two extremes lies a space which is not affected by either force. This is known as the “Neutral Line” or “Neutral Axis”, and occurs at a distance approximately 0.445 times the metal thickness ($0.445 \times T$) from the inside of the radius of the bend (see Figure 21).

A fundamental formula, as shown below, can be used to determine the bend allowance:

$$\frac{\pi D}{4} = \text{Allowance for bend only}$$

Where:

$$D = \text{Neutral line diameter} = 2(R + 0.445T)$$

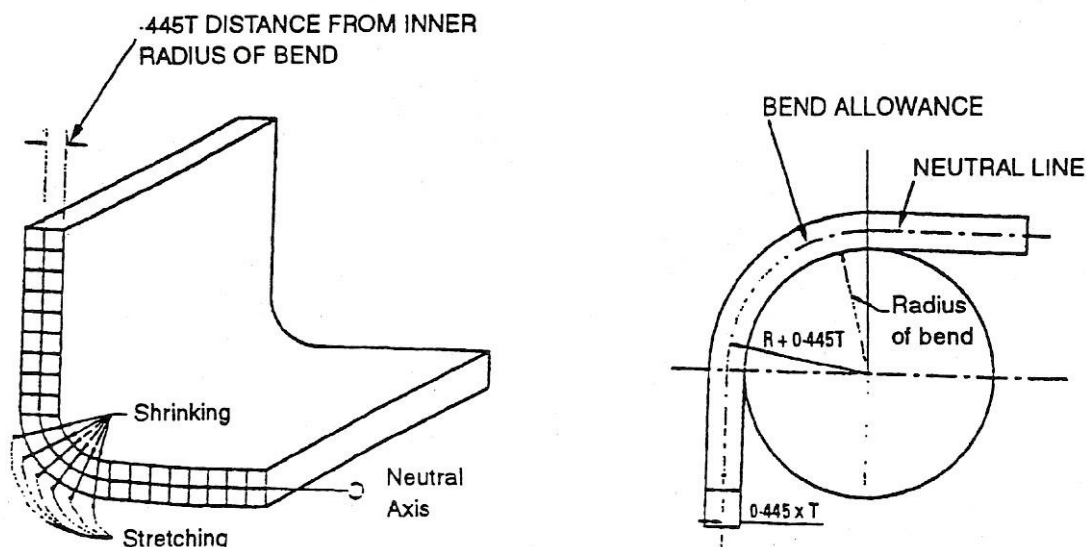


Figure 21 - Calculating Internal/External Dimensions

If given inside dimensions of box we simply add up given dimensions.

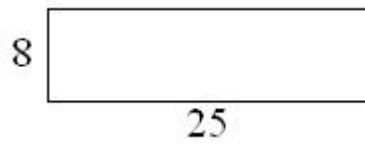
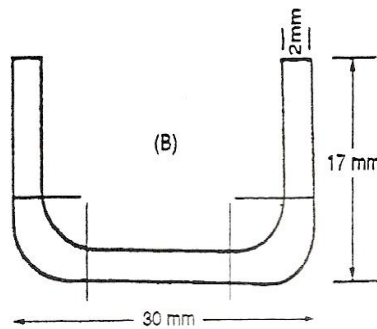


Figure 22 - Example of Calculating Dimensions

Depth of Box = 8 mm, Width = 25 mm, Total cutting size: $8 + 8 + 25 = 41$.



Examples:

O/S	Dim	=	30 mm
I/S	Dim	=	30 mm – 2 MT
		=	26
O/S	Dim	=	17 mm
I/S	Dim	=	17 – 1 MT = 15
	MT	=	2 mm

Blank size = $15 + 15 + 26 = 56$

Self-Secured Joints

These joints, as the name implies, are formed by folding and interlocking thin sheet metal edges together in such a manner that they are made secure without the aid of any additional jointing process. Their use is confined to fabrications or components constructed with light gauge sheet metal less than 1.6 mm thick.

A selection of these joints is shown in Figure 23. Of these the following are the most widely used:

- The grooved seam
- The paned-down joint
- The knocked-up joint

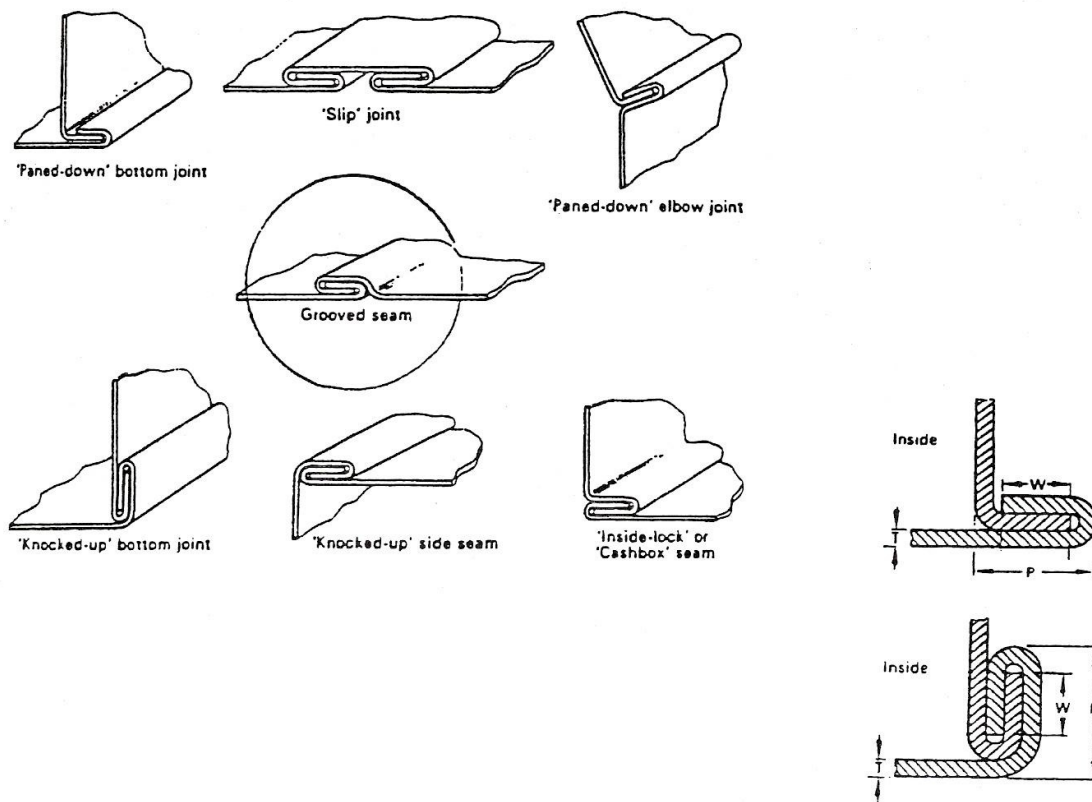


Figure 23 - Self-Secured Joints

Grooving Formula

Width of Groove $\times 1\frac{1}{2} - 2T$

T being metal thickness

This implies that if groove is 8 mm wide, the formula is:

$8 \times 1\frac{1}{2} - 2T$ *We will put T at 1 mm*

$= 12 - 2(1)$

$= 12 - 2$

$= 10 \text{ mm}$

So we add 10 mm to both ends of the job being assembled.

However, we bend on a line which will be $2T$ (thickness) lesser than the width of groove, e.g. $8 - 2T = 6$.

So we add 10 mm to both ends of the job but we bend on the 6 mm line.

This applies to an 8 mm groove only. For a 10 mm groove we put 10 in place of 8 in the formula, for example:

$10 \times 1\frac{1}{2} - 2T$ *where T = 1 mm*

$= 15 - 2(1)$

$= 13 \text{ mm}$

So we add 13 mm to both ends.

But we bend on 8 mm because $10 \text{ mm} - 2T = 8 \text{ mm}$.

Method 1

The joint edges may be folded over and slightly closed (the gap being a little wider than the thickness of the metal it has to accommodate). Edges prepared in this manner present no interlocking problems when making seams on ‘flat surfaces’, as shown at (d) in Figure 24.

Method 2

The joint edges may be folded over to an approximate angle of 60° . Edges prepared in this manner are an advantage when interlocking seams on cylindrical articles of small diameter, as shown at (e) in Figure 24.

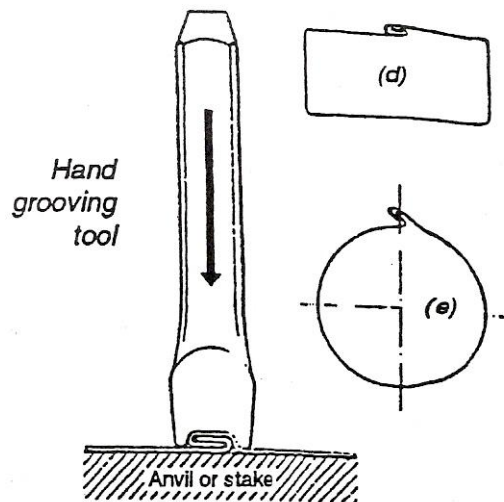


Figure 24 - The Grooved Seam

Various Edges

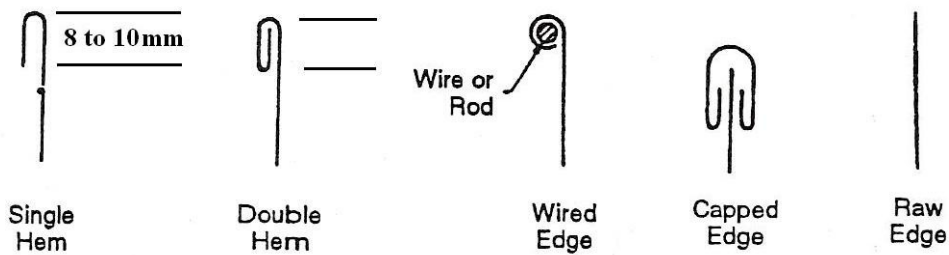


Figure 25 - Various Edges

The single hem is usually 8 to 10 mm in size.

The double hem is similar with the inside edge being 1 mm smaller to facilitate a neat fit.

The formula for a wired edge is $1\frac{1}{2} \times$ diameter of wire minus 1 or 2 metal thickness approximately.

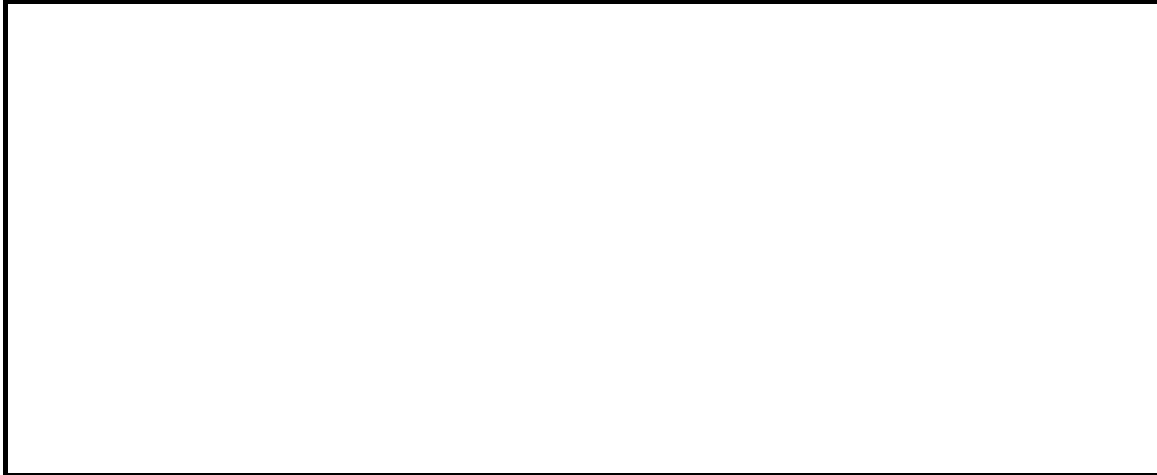
Self Assessment

Questions on Background Notes – Module 1. Unit 4

1. Explain Annealing.

2. Why do we temper steel?

3. What % of carbon is in: a. Low Carbon
 b. Medium Carbon
 c. High Carbon



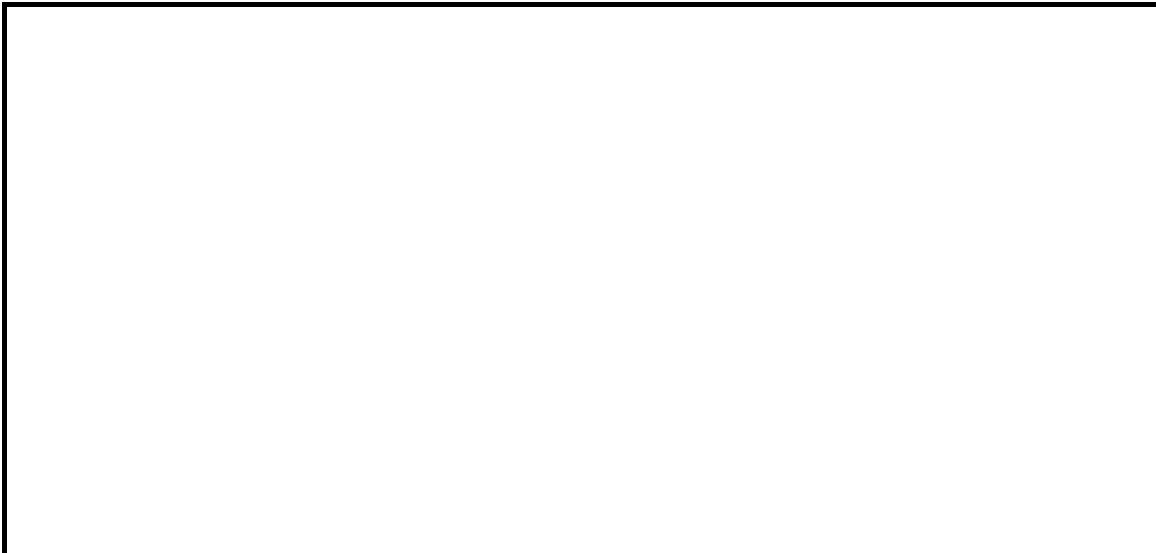
4. Define and name three important properties of metal.



5. State the Theorem of Pythagoras.



6. For a state of Equilibrium to exist what is necessary?



Answers to Questions 1-6. Module 1. Unit 4

1.

Annealing:

Annealing softens and removes stresses in ferrous and non ferrous metals. Ferrous metals are heated above their critical point and held at this temperature for a short period, they are then allowed to cool in hot ashes which protects the metal from rapid cooling and oxidisation by the air.

2.

Tempering:

Tempering takes some of the hardness and brittleness out of hardened steel and gives it the necessary toughness to make it suitable for tool making.

3.

Low Carbon Steel	=	is up to 0.3%
Medium Carbon Steel	=	0.5 - 0.7 %
High Carbon Steel	=	0.8 – 1.2%

4.

Properties of metal:

- a. **Hardness** is the property of a metal to resist penetration or scratching.
- b. **Malleability:** The extent to which a metal can be extended in all directions by hammering or rolling without causing the metal to crack. Metals are more malleable when hot.
- c. **Ductility:** The degree to which a metal can be expanded in the direction of its length. Ductile metals are easily hammered to shape and will yield to pressure.
- d. **Fusibility:** Capable of being melted by heating.
Fusibility is the relative ease with which they may be melted.

5.

Pythagoras Theorem:

Pythagoras states that the square on the hypotenuse (longest side) of a right angled triangle is equal to the sum of the squares of the other two sides.

6.

For a State of Equilibrium to Exist (balance):

The sum of the total clockwise moments = sum of anti clockwise moments.

This is called the Principle of Moments.

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