Basic Metal Works

Level-I

Learning Guide#50

Unit of Competence: Perform Hand Forging

Module Title: Performing Hand Forging

LG Code: IND BMW1 M15 LO1-LG-50

TTLM Code: IND BMW M15 TTLM 1019v1

LO1: Analyze and plan hand forging work

Instruction Sheet	Learning Guide #50

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Interpreting drawing for swaging, bending, upsetting, spreading, punching and drifting techniques
- Selecting Hand tools and formers
- Applying forging temperatures and heat specifications
- Drafting Work plan

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Interpret drawing for swaging, bending, upsetting, spreading, punching and drifting techniques is in compliance with specification.
- Select *Hand tools and formers* for required forging techniques.
- Apply forging temperatures and heat specifications to for various materials requirement
- Draft work plan according to specifications

Learning Instructions:

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.

Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.

3. Accomplish the “Self-checks” in the information sheets.
4. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
5. If you earned a satisfactory evaluation proceed to “Operation sheets and LAP Tests if any. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.

6. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result;
7. Then proceed to the next information sheet.
8. If you earned a satisfactory evaluation in each self-check proceed to “Operation Sheets” in pages. However, if your rating is unsatisfactory, see your trainer for further instructions or go back to Learning Activities.
9. Read the “Operation Sheets” and try to understand the procedures discussed.
10. Do the “LAP test” in each page (if you are ready). Request your teacher to evaluate your performance and outputs. Your teacher will give you feedback and the evaluation will be either satisfactory or unsatisfactory. If unsatisfactory, your teacher shall advice you on additional work. But if satisfactory you can proceed to Learning Guide.

Information Sheet-1	Interpreting drawing for swaging, bending, upsetting, spreading, punching and drifting techniques

INTRODUCTION

- **Forging** is a type of metal Forming Processes by means of localized compressive forces exerted by manual or power hammers presses or especial forging machines. Forging is one of the oldest metal working operations known, dating back to 5000 (4000) B.C. and is used in making parts of widely varying sizes and shapes from a variety of metals. In forging, the shape of the raw material is changed by repositioning material rather than removing it.

  Among all manufacturing processes, forging technology has a special place because it can be used to produce parts of superior mechanical properties with minimum waste of material. During forging the atoms of the material will be packed so closely that some of them will be broken into pieces and this causes the material to be strong that is metal flow and grain structure can be controlled, so forged parts have good strength and toughness. The raw material for forging is usually a *bar, billet or blank.* Forging is generally employed for those components that require high strength and resistance to shock or vibration and uniform properties.

  Typical parts made by forging today are crankshafts and ***connecting rods, for engines, turbine disks, gears, wheels, bolt heads, hand tools,*** and many types of structural components for the machinery, transportation equipment and landing gear for aircraft.

FORGING METHODS

(1) Hand forging
(2) Drop forging
(3) Press forging
(4) Roll forging

- **Hand forging:** Hand forging is made by heating the metal until it is plastic state in an open hearth furnace and there by hammering is done on anvil by smith/sledge hammer with use of open face dies to get the desired shape and size by judgment of an individual.
- **Drop forging:** In this process of forming the desired shape by placing a heated bar or billet on the lower half of the forging die and hammering the top half of the die into the metal by means of a power hammer by repeated blows the impact of which compel the plastic metal to conform the shape of the die. This method is used to produce large number of small and medium sized forging of similar parts.
- **Press forging:** In this process the heated billet is squeezed between die. The pressure is applied by the forging press which completes the operation in a single stroke. Large forging are generally shaped by thin method.
- **Roll forging:** Rolling involves the passing of a heated bar between revolving rolls that contains an impression of the required shape. It is used to reduce short thick section to long slender pieces.

    - *Forging*

        ✓ *Forgings* the plastic deformation of metal by means of localized compressive forces exerted by manual or power hammers presses or especial forging machines.

        ✓ Forging is one of the oldest metal working operations known, dating back to 5000 (4000) B.C. and is used in making parts of widely varying sizes and shapes from a variety of metals.

    - The raw material for forging is usually

        ✓ *Bar i.e. flat bar or solid bar*

    - Forging is generally employed for those components that require

        ✓ High strength and

        ✓ resistance to shock or vibration and

        ✓ Uniform properties.

    - *Forgings* are metal parts that are given them shape by hammering or pressing.
    - Most forgings are made of

        ✓ Steel but,

- ✓ brass;
- ✓ bronze,
- ✓ copper, and
- ✓ aluminum are also shaped by forging

✓ Typical parts made by forging today are

- ✓ crankshafts and connecting rods, for engines
- ✓ turbine disks,
- ✓ gears,
- ✓ wheels,
- ✓ bolt heads,
- ✓ Hand tools, and many types of structural components for the machinery,
- ✓ Transportation equipment and landing gear for aircraft.

✓ Forgings must usually be machined in the machine shop after they are forged

Advantages & Limitations of Forging

- ***Advantages of forging***
  - ✓ Usually have better mechanical properties, especially if the fiber flow lines are directed.
  - ✓ Can be held to within fairly close dimensional tolerances
  - ✓ A wide range of forgeable metals is available.
  - ✓ Forgings are readily welded & incorporated in welded structures.
- ***Limitations* of forging processes**
  - ✓ Many intricate and cored shapes possible by casting processes can't be forged
  - ✓ Usually forgings cost more than castings
  - ✓ Closed impression dies for forgings normally cost more than patterns.
  - ✓ Permanent molds, or die equipment needed for casting processes
  - ✓ High tool cost and high tool maintenance

- ✓ Limitations in size and shape
- ✓ High tool cost and high tool maintenance and Limitations in size and shape

1.2. Safety procedures

- *Safety in Forging Shop*
- Safe work practices and safe work habits result when you use
  - ✓ Machines
  - ✓ Tools and
  - ✓ Materials correctly.
- You must follow commonly recognized safety rules and safety practices in order to avoid possible accidents or personal injury.
- In forging shop you are working with
  - ✓ Hot metal and there are so many moveable parts of machines used for shaping.
  - ✓ Also forging machines operate at high speed and repeatable glowing movement.
- Therefore in forging shop one must take safety precautions into consideration.
- Hammers, trimming and press machines must have a protector for their working zone.
- Some of the causes of accident in forging shop are
  - ✓ Fire: - burn might be caused by sparks.
  - ✓ Sharp and pointed materials that can be considered as waste.
  - ✓ Explosion: - sometimes the metal by itself explodes due to the presence of gas pockets inside it.
  - ✓ Noise: - Potential loss of hearing that can result from exposure to very high sound. Thus it contributes to reduced workers performance.

    Note: Most experts state that harmful effects can be expected from noise level above 100 dB (decibel). Sound around 140 dB is physically dangerous and increases muscular tension.

1.3. Safety Rules

- During forging operations,
  - ✓ Burning injury,
  - ✓ Damage of tools and equipment may occur due to lack of safe work habits.
- Safety habits must be developed to avoid or reduce accidents.
- Some of the safety rules of forging are:

a) Always use the tongs whose jaws fit to the shape of the forging piece.

b) Check that the heads of hand hammers and sledge hammers are fitted securely to their handles.

c) Remove any scale with a steel brush or scraper; never use to clean the anvil with hands; use protecting gauntlets.

d) Always clean the hot stock and anvil at interval of forging.

e) Observe that the anvil is free from wet and greasy materials.

f) Never try to forge cold or burnt metal.

g) Never allow any forging and waste materials to accumulate around the forging area.

h) Always keep the working area clean and tidy.

i) After completing the work, stop the air blast, and scrape the burnt coal (charcoal) from the forge and extinguish the fire.

j) Put all tools equipment, devices and forging pieces in their proper places.

1.4. Drawing

- **Drawing down**

  This process makes the metal thinner, by reducing its cross-section. Metal to be forged is first hammered on the back of an anvil. The process can produce tapers that arc Hat, circular, or square. Fig.1.1 shows the steps to follow in drawing down a circular taper:

  1. Hammer four sides to produce a short square (Fig.1.1 (a)).
  2. Lengthen the square taper (Fig.1.1 (b)).
  3. Hammer the corners of the long square in step 2 to produce an octagonal shape (Fig.1.1(c)).
  4. Continue round all the corners in step 3 to obtain a circular end (Fig.1.1 (d)).

  If the taper is fat or square go through either the first two or three stages above

- Avoid piping (hollow ends) when drawing down a taper.

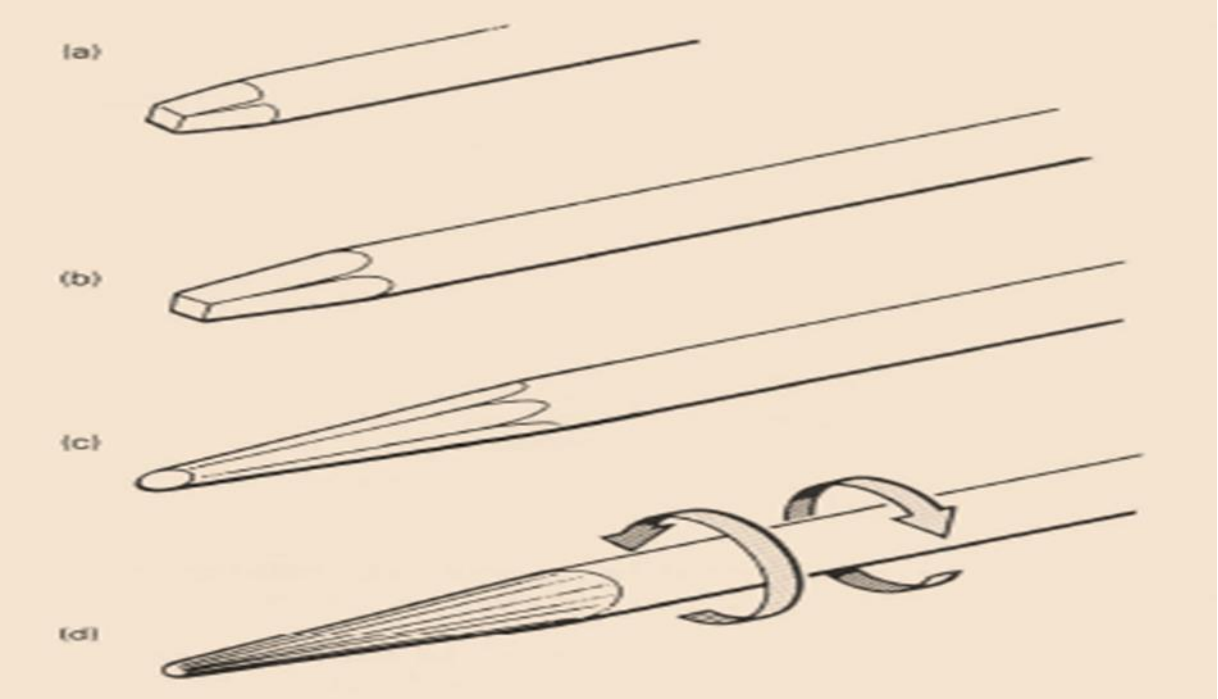


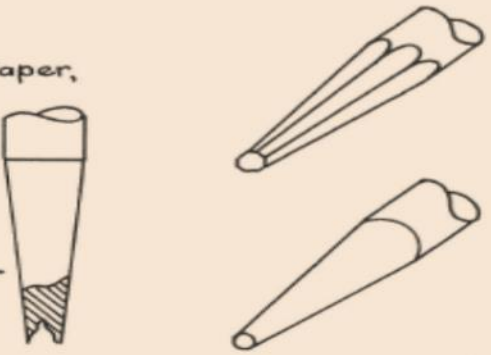
*Fig. 1.1.*Stages in drawing down: 4 **a)** first stage short- square; **b)** second stage-long square; **(C)** third stage- octagonal shape; (**d)** final stage- round shape.

FORGING PROCESSES

DRAWING DOWN A ROUND TAPER

1. Follow stages 1 to 3 for a square taper, then hammer octagonal and finally round.

Always draw square first or "piping" will result.

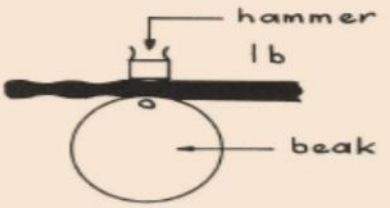


DRAWING DOWN PARALLEL

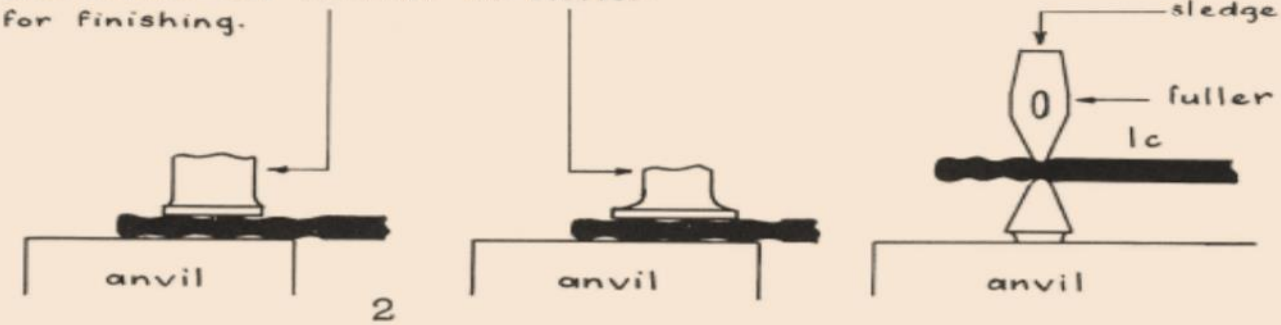
1. Draw down either
   a. single-handed, using straight pene hammer.

   or b. single-handed, using beak of anvil and flat face of hammer.

   or c. double-handed, using top and bottom fullers.



2. Use either set hammer or flatter for finishing.



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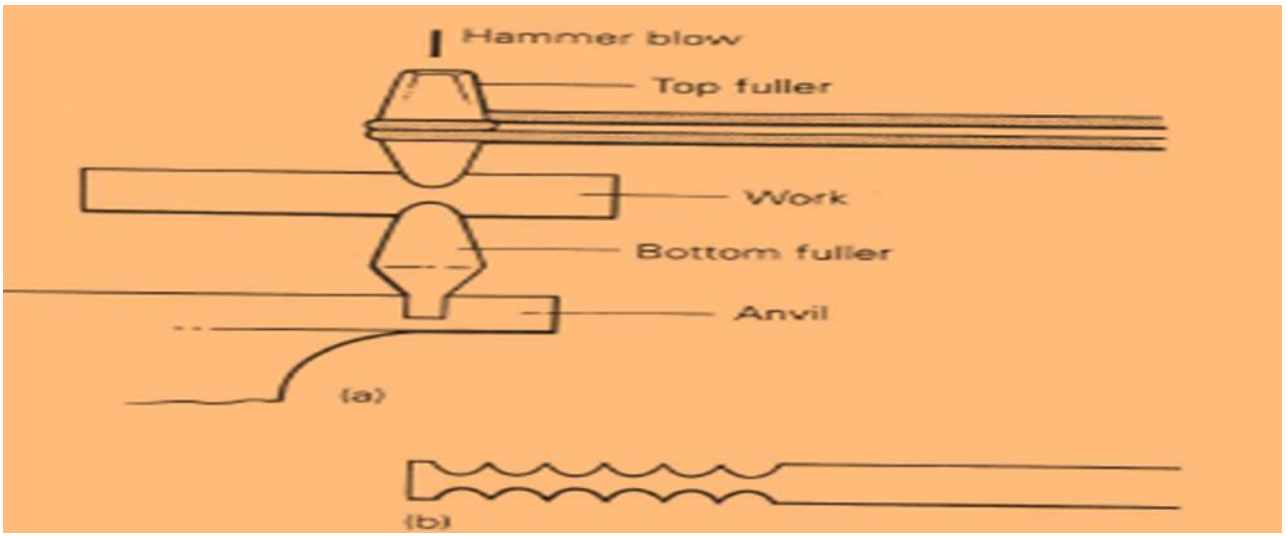


Fig:- 1.1.**Drawing down**

1.5. Twisting

- Twisting is one of the simple forge work operations.
- Which can be performed easily in the school workshop?
- It is essential to hear the metal properly for an effective

  1. Mark the length to be twisted (Fig. 1.2(a)).

  2. Heat the metal (nor very hot but red hot).

  3. Place the bar in the vice (Fig. 1.2(b)).

  4. Twist using specially prepared bars (Fig. 1.2.(c)).

  5. Turn the bar using the two hands.

  For a short sharp twisting, the metal must be very hot. However, a red hear along the length required gives a long regular twist.

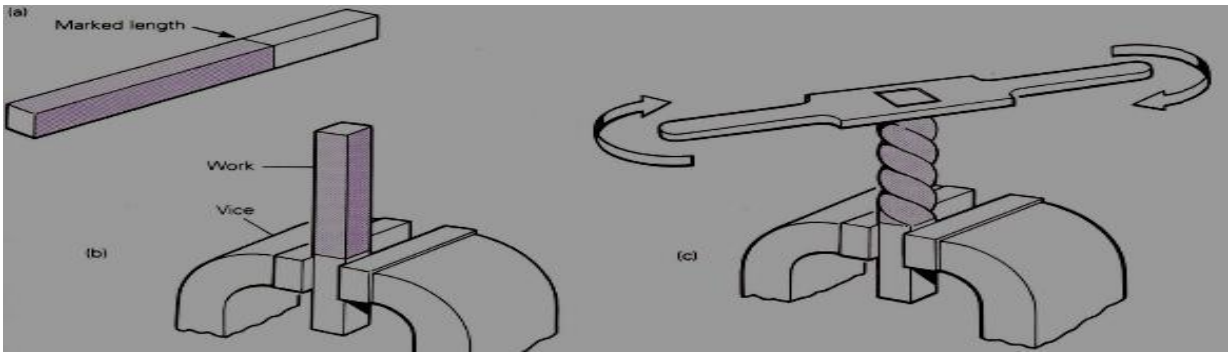
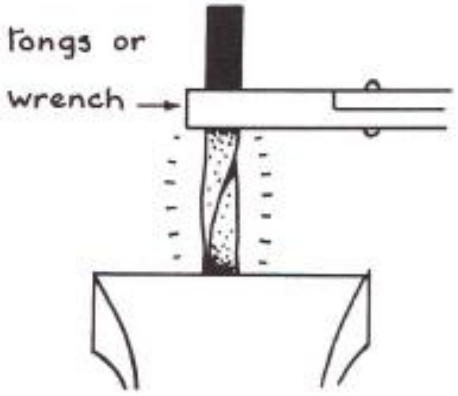


Fig.1.2. **Twisting**: (a) marked length; (b) holding work in vice (notice the position of the marked line); (c) Twisting using a specially prepared wrench

FORGING PROCESSES

TWISTING

1. Heat metal for a length a little more than the length of twist. An even heat is necessary. Uneven heating causes an irregular twist.
2. Grip in vice with lower limit of twist level with top of vice and hold with the under-face of the tongs (or wrench) level with the upper limit of twist. Pull through 90° or 180° before heat is lost.



FORGE WELDING

Hand welding is the joining of metal by hammering whilst the metal is very hot.

HEAT - Wrought iron - white heat - 1350°C
Mild steel - yellow-white heat - 1250°C

FLUX - W.I. - sand. M.S. - calcined borax.
Flux is used to dissolve oxide scale and prevent further oxidation.

Scarf weld

The ends to be welded must be -

1. Thickened to allow for hammering.
2. At the same temperature.
3. Hot enough to remove the slag.
4. Hammered and shaped to allow the slag to flow out of the joint.

Splice weld

Speed is essential so that the welding is completed before heat is lost. Once the weld has been made the hammering to final shape can be completed without haste.

1.6. Bending

Bending is flat stock. The question arises as to how long the flat stock is to be cut once the stock is bent; the finished part will meet the dimension requirements. Finding the lengths of the various parts when unfolded and laid- out in the flat is known as ***developing.***

It should be noted that bending should take place at right angles to the grain direction, as shown in fig. If the bending operation takes place parallel to the grain direction, separation will occur and cracking will develop. Stock may be bent safely at angles up to 45 with the grain direction. If there is any doubt whether a piece will bend without cracking, a test should be run on the material to be used.

Since the neutral axis is not affected during bending by deformation, as this line remains unchanged the length of the neutral bending line will give the true length of the piece after it has been bent.

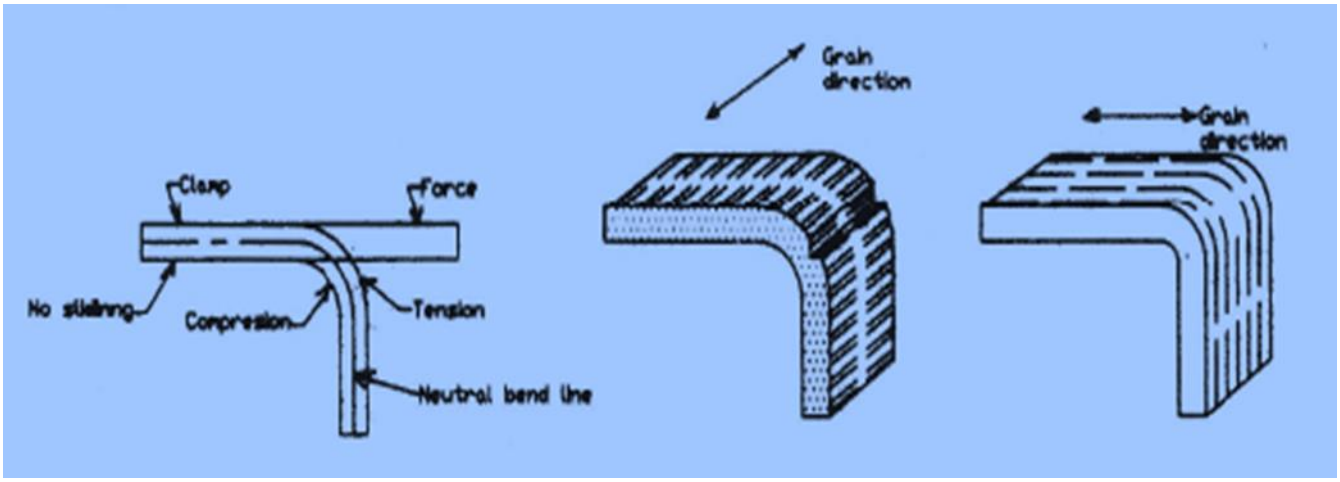


Fig.1.3. *Bends at right angle and parallel to the grain direction*

to have the exact size, the diameter of the neutral axis is usually taken with the internal dimensions it is good practice to make a sketch and to convert all external dimensions to internal dimensions before applying the equations.

Which follow the developed length on the neutral bending line for the bend shown in figure 1.3.is La+b+a2, Where a = length of leg at neutral line, b = length of arc at neutral bending line, a_l and a_2 are under for mend parts of the part.

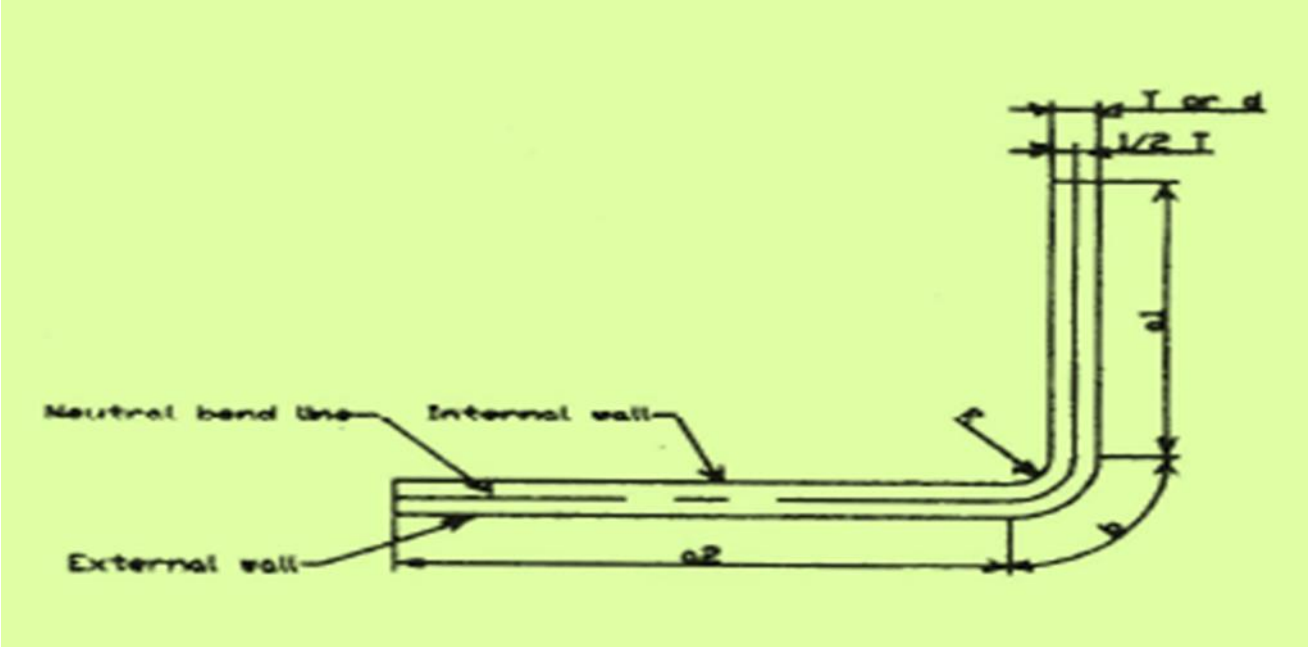


Fig.1.4. a 90° bend

The neutral bending line is sometimes taken as *one-third* or *half* the thickness of the material, applied from the inside of the bend.

The general equation for the length of the neutral bending line at a radius corner for any regular bend assuming 1/2 of the thickness of the material, applied from the inside bend is b = fl + tJ2) Where 0 = angle through which stock is bent 180 r = internal radius = 0.01745 (O) (r + t12) t = thickness or diameter of material b length of arc at neutral bending line If θ= 9O', then the value of (θΠ)/ 180 = 1.571 and the equation for a 90° bend becomes *b90= 1,571 (r+t /2) (1)*

Note that if the work piece is a rod t is replaced by d, diameter of the rod.

Examples *1) find the developed length in mm. of the part shown below.*

Solution The part should be redrawn and internal dimensions applied as shown The internal radius for the given rod with diameter equals 8mm is R = 50 - 8 = 42mm.

The lengths of the linear dimensions are: **N,** = 100-42 = 58mm & **N2** = 150-42 = 108mm. The length of a at the neutral bending line is calculated using *(1) as b 1.571 Fr+t'2)* = *1.571(42÷8.2)* = *7227mm .*

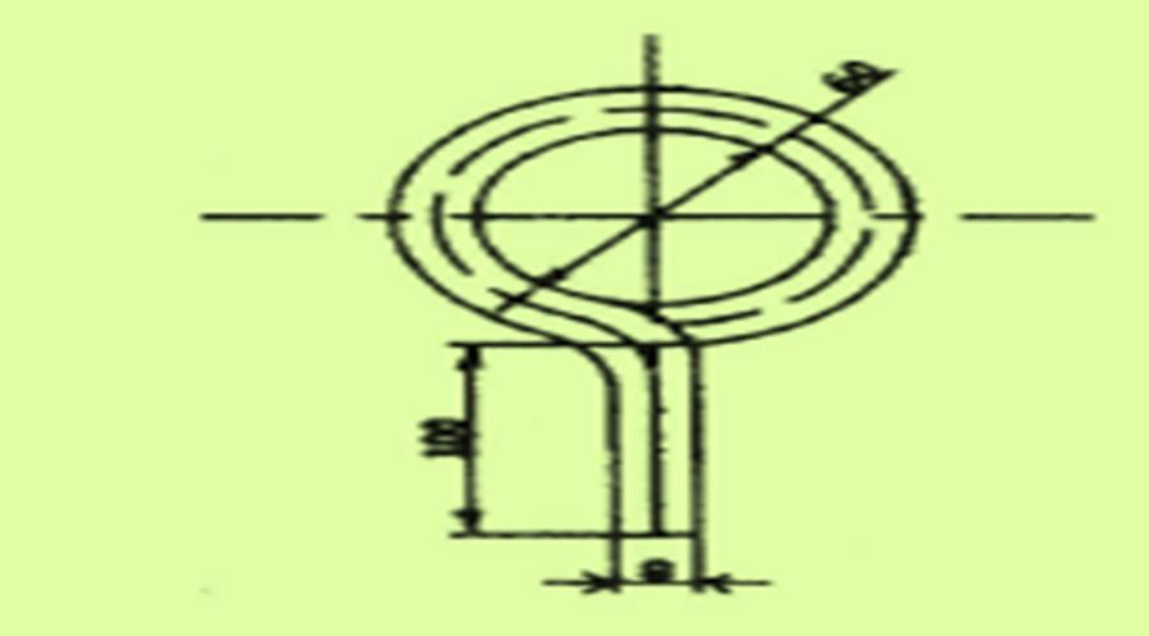
Similar result is also found using arc length formula for different angle bends. In this case for 90 degree bend *be D) =14* or [11x2(r+O.5t)J/4 gives the same blank length to the calculated one. Thus the developed length or the required blank length L is N1 + N2 + a = (58 + 108 +

72.27) mm = <u>238.27mm.</u>

2) *Calculate the length of the blank required to form the Coat hanger shown below.*

Assume that the diameter of the rod is 10mm also explain the procedures how this part is made in a smith forging shop.

The bend allowance AB = *nR (for semi* circle)
***3.14x** 35mm = 10990mm*
The bend allowance BC = =54, 95mm
2 .Length of flat ab = *52- (80—2) = 12* ***mm end*** length of flat be = ***70mm.***
Thus the total length of blank L = *ab+ cd + AB + BC =* ***12*** *+ 70 + 109.9* + 54.95 = ***264.85*** *mm (before bending)*
3) Find the *developed length to form an eye shown below.*



<u>Solution</u> *:* the length of material required to form the eye is calculated on the mean diameter, as the neutral axis is the middle line of the metal all the way round Using the blacksmith's formula; L of the eye at the neutral line = 3d + 4T where d1 = Inside diameter, T = Thickness diameter of metal used = (3x60 + 4X8)mm = <u>212mm.</u>
Therefore, the total developed length is the sum of L of eye and L of the flat which is 1 2mm. Like example (1) above, approximately the same result is found for the Length of the eye

applying the circumference of neutral line and following the steps it is possible to determine the blank length.

Bending is not a difficult process; it does not require much skill.

The stages involved are as follows:

1. Use chalk to mark the length that is to be bent.

2. Hear (pay attention to) the portion to be bent.

3. Place the marked line on an anvil.

4. Using the hammer (select the correct weight), bend the length to the angle required (Fig.1.5. (a)). If you are forming an eye, continue with the following stages:

5. Turn the work over on the hick and hammer i at the end (Fig.1.5 (b)).

6. Work backwards (Fig.1.5.(c)).

7. Turn it again and curve it round using the hick of the anvil (Fig. (d).

- Never attempt to form the eye directly; bend it at right angles first.

Determine the length of metal to be formed, which is equal to three times the mean diameter. For example to make a 24 mm external diameter eye from an 8 mm diameter rod, you will need 3 **X** (20 + 8) mm 84 mm of material.

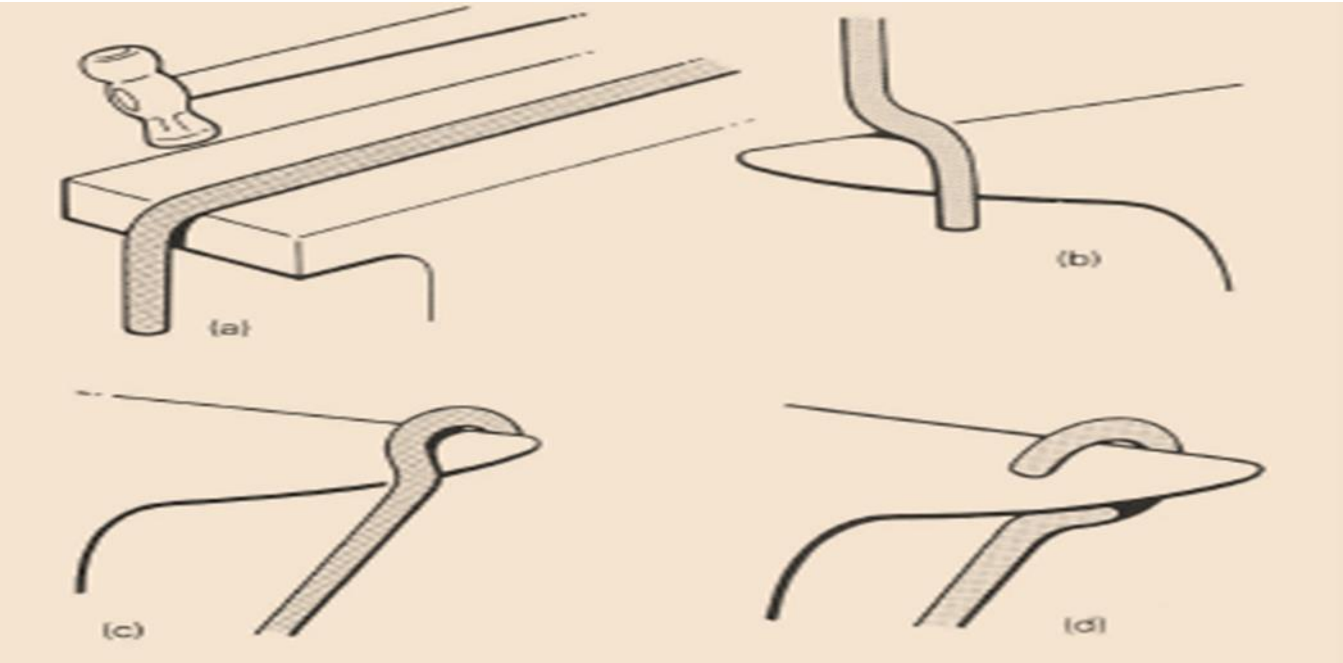
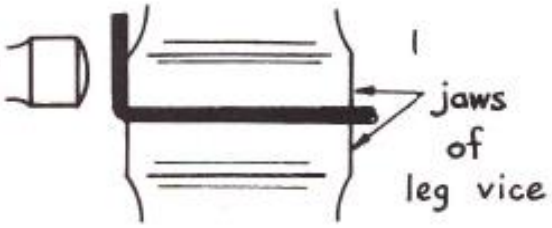


Fig.1.5. Bending/forming an eye: (a) first stage bending at right angles; (b) second stage; (C) third stage; (d) final stage.

FORGING PROCESSES

FORMING ANGULAR BENDS

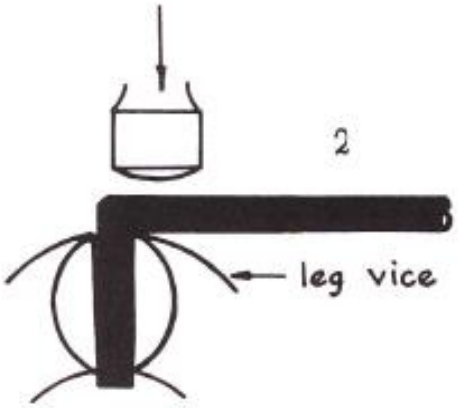
1. Narrow stock can be bent at the end of the vice or on the top of the leg vice.



2. Wide stock is best bent on the top of the vice.

3. All angular bends can be made on the anvil.

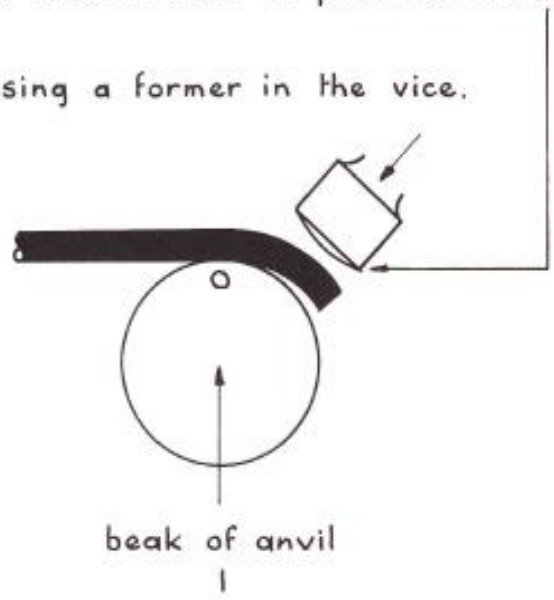
When metal is bent, the inside of the metal becomes compressed and the outside stretched. This leads to distortion. If a truly square bend is needed the metal must be upset first. See next page.

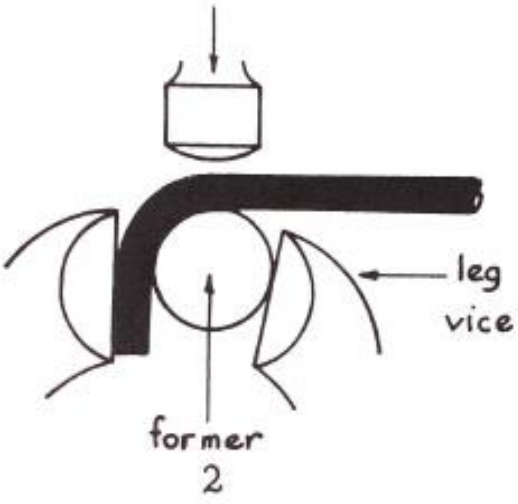


FORMING RADIUSED BENDS

1. Using beak of anvil. Hammer blow must be made in front of point of contact.

2. Using a former in the vice.





1.8. Upsetting or jumping up

- This process increasing the cross-section**.**

  - ✓ It is a difficult process and requires skills developed over the bars.
  - ✓ The end to be processed is heated **(it** must be very hot before it is jumped-up on the anvil.

- Upsetting involves the following stages:

  I. Heat the portion to be **jumped up.**

  2. Bounce the metal on the anvil face.

  3. Hold the bar in the vice and hammer the end.

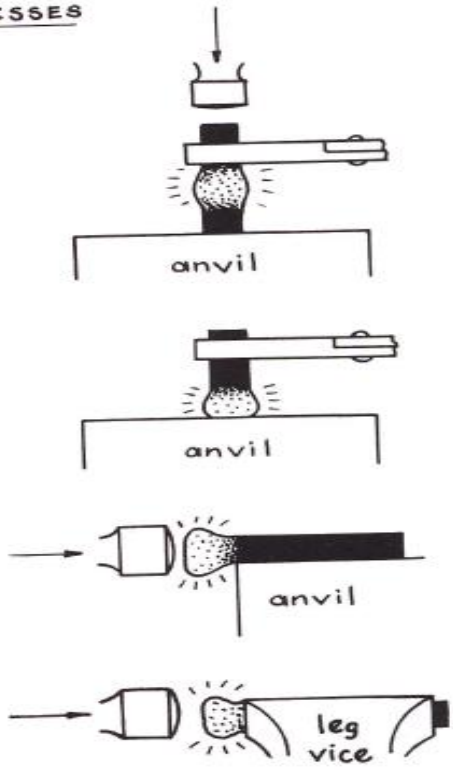
FORGING PROCESSES

UPSETTING or JUMPING-UP

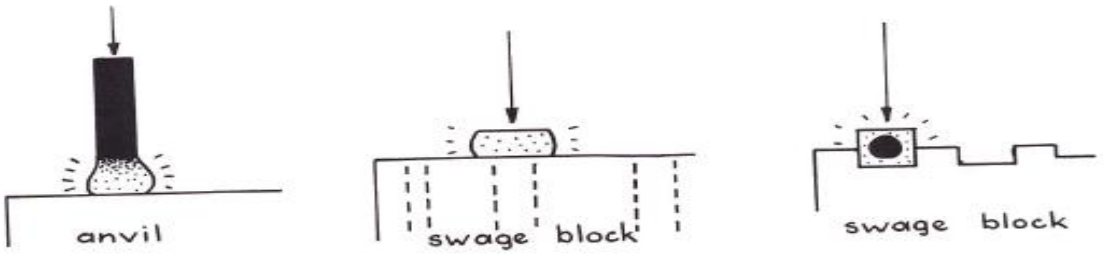
1. The thickness of the bar is increased at the expense of length.
A high heat is needed and localised if necessary by cooling either side to limit the extent of the spread.

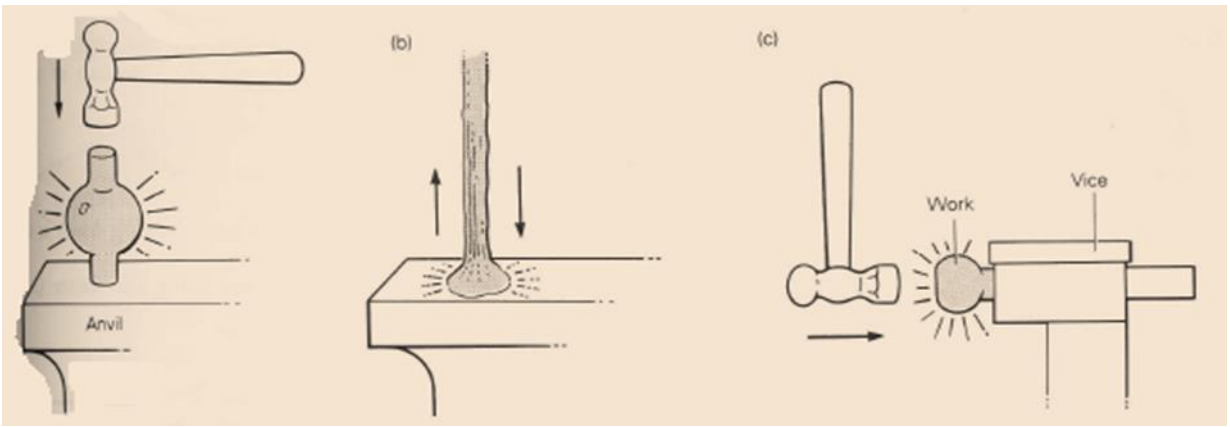
The necessary force can be obtained by –
1. Hammering on the anvil.
or2. Bouncing on the face of the anvil.
or3. Hammering on the face of the anvil, using the hammer sideways and the anvil for support.
or4. Hammering sideways with the metal supported in the vice.

The extent of the heating and the type of blow will depend on the nature of the work. Heavy blows are usually necessary.



FORGING A BOLT





1.8. Swaging

- Swaging is the process of finishing a round or hexagonal section of bar.

- It is made possible by the use of a pair of swages (Fig.1.6.). The process involves:
  1. hearing the metal;
  2. placing the metal between the top and bottom swages;
  3. striking the top swage while rotating the work.

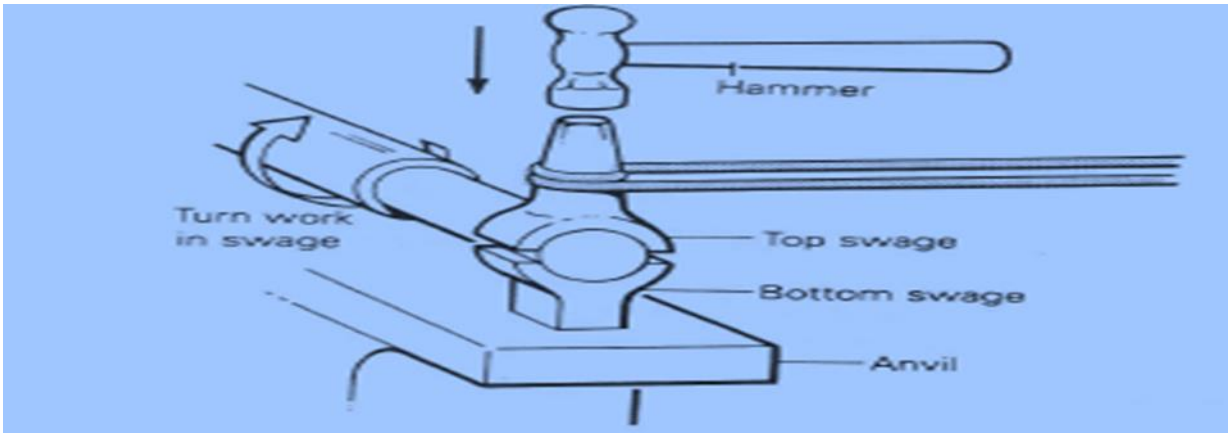


Fig.2.6. swaging process

1.9. Punching and drifting

- You use punches and drifts to make round or square hole in hot metals. The advantage of punching and drifting is that they do not remove any metal, unlike drilling, which does. The metal is left on each side of the **hole**

- **Punching therefore ensure that the** grain structure of the metal is not disturbed after forging. The procedure for punching and drifting is as follows:
  1. **Heat** the metal to near welding heat.
  2. Punch the hole first on the anvil.

  3. Turn the piece above the punch hole and punch through the dark underside of the piece.
  4. True up the punched hole using the drift,

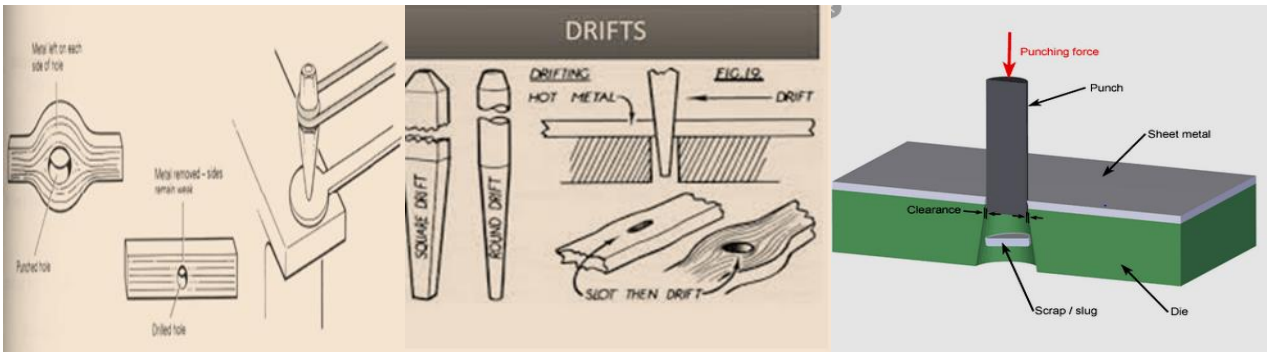


Fig.1.7. **Punching and drifting**.

Quench the end of the punched after use. to avoid splitting, upset the piece before punching

1.10. Fullering

As mentioned earlier, this process involves the use of fullers in pairs. Before drawing down fullers is carried out to produce shoulder. Fullers are not used to cut and therefore they only change the direction of the grains of the metal (Fig.2.8.).

In fullering:

1. Mark the length to be drawn down.
2. Hear the metal.
3. Notch or neck the point with arc drawing down is I start (Fig.2.8 (a)).
4. Finish off the rough surface using the flatter (see below).

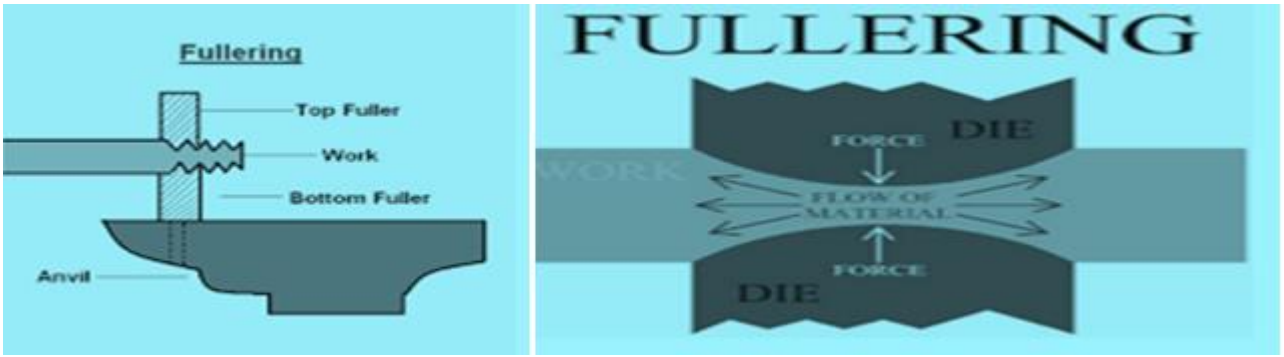


Fig.1.9. **Fullering**

1.11. Flattening

You use the flatter with the sledge hammer to flatten filtered piece (Fig.1.9.). Flattening enables you to finish off an undulating surface.

To flatten:

1. Hold the flatter on the surface.
2. Strike the end of the Hatter with the sledgehammer.
3. Move the Hatter to all areas and repeat step 2.

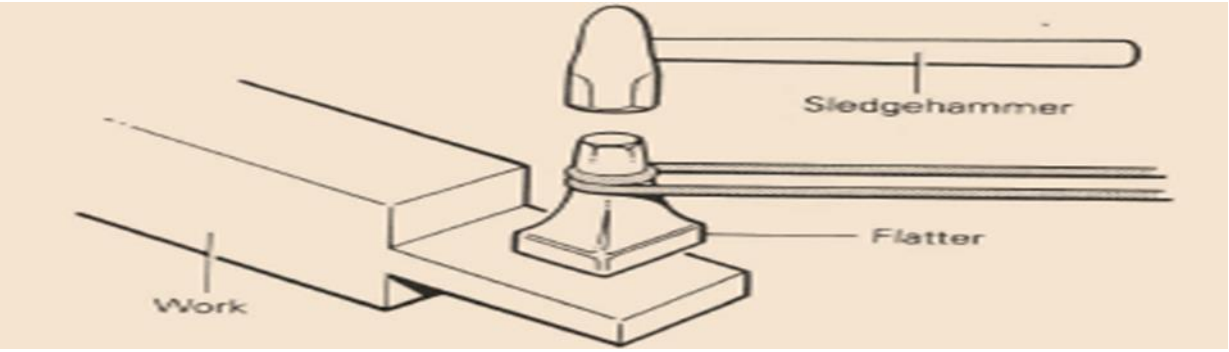


Fig.1.10. **Flattening**

Information Sheet-2	**Selecting Hand tools and formers**

2. Use hand tools and formers

- **Occupations in forging**
  The main kinds of workers in the forging shop includes

  - ✓ *Heaters:* -workers who heat the metal to the correct temperature.
  - ✓ *Blacksmiths:* -worker who forge by hand.
  - ✓ *Hammer smith:*- uses power hammers equipped with unshaped dies to hammer metal in to shape.
  - ✓ *Hammer operators:* -use forging machines in which the heated metal is poured into shape between accurately machined dies called closed dies.
  - ✓ *Inspectors*- check the forgings.
  - ✓ *Finishers:* -remove burrs, chip imperfections from the finished forgings.
  - ✓ *Ornamental-iron worker:*- makes and installs wrought-metal decorations for buildings and homes, This worker heats metal and shapes into artistic designs

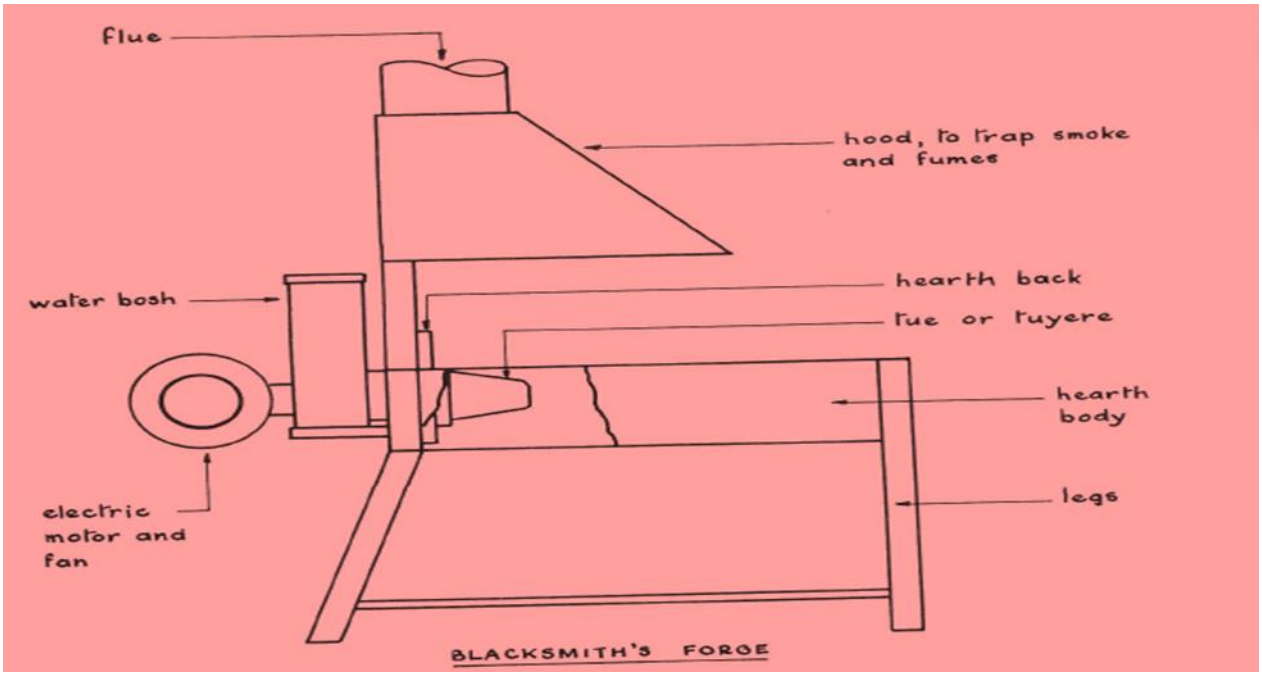


Fig.2.1

HEARTH BODY, of heavy gauge M.S. supported on legs of angle iron and usually lined with firebrick for protection.

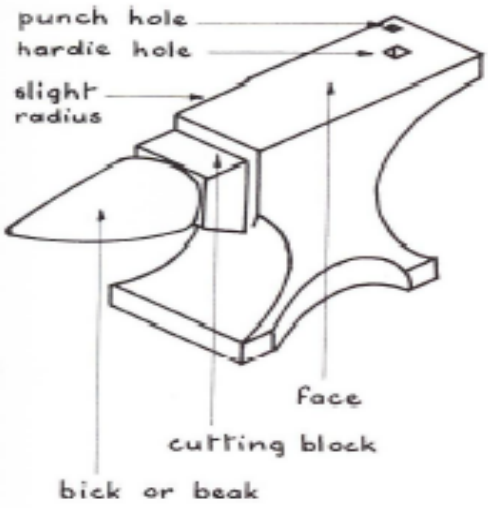
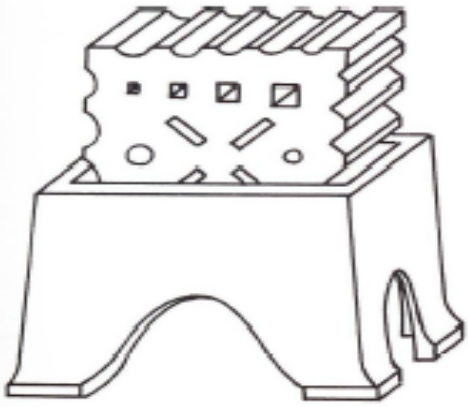
TUE or TUYERE, of C.I. bolted to the hearth back and cooled by means of a water bosh.

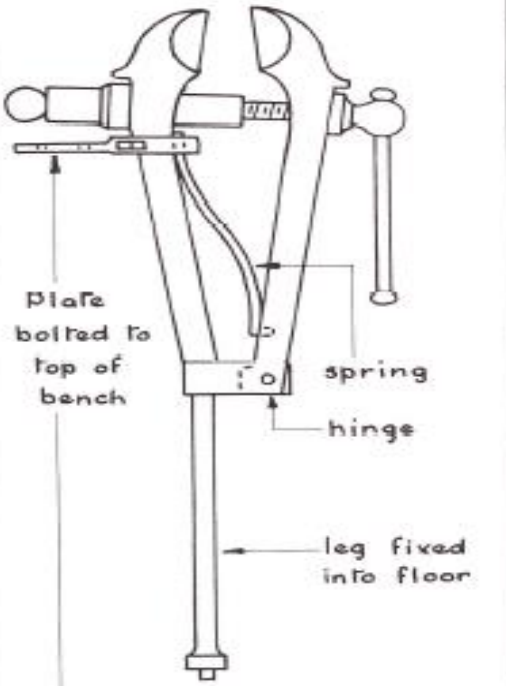
BOSH, of C.I. filled with water to keep the tuyere cool.

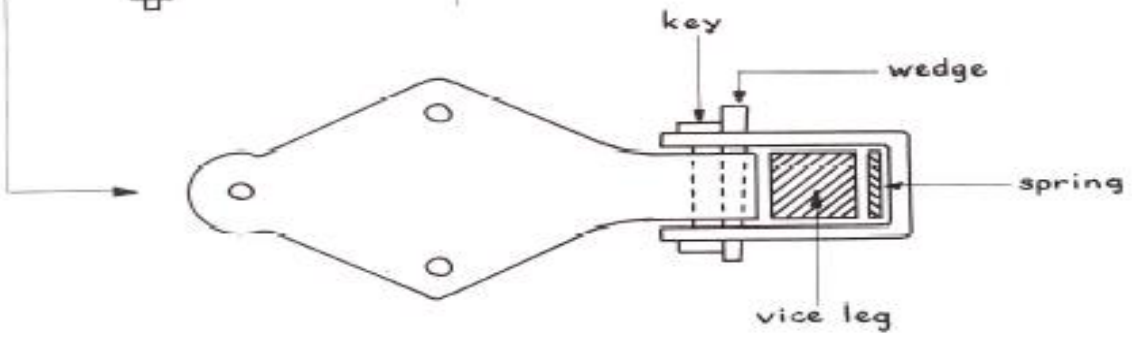
HEARTH BACK, of C.I. detachable, to protect the M.S. back.

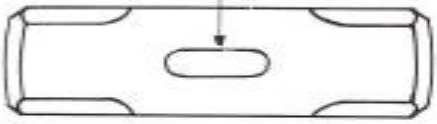
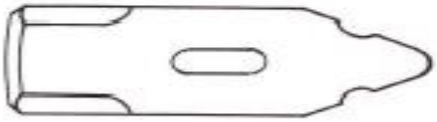
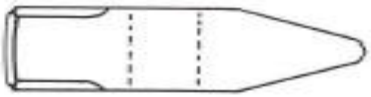
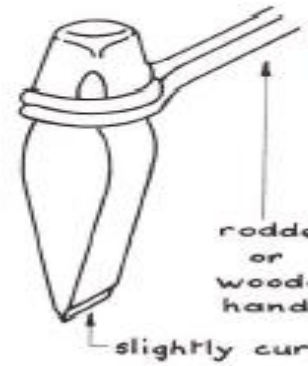
ELECTRIC MOTOR, of variable speed to control the blast and fitted with fan.

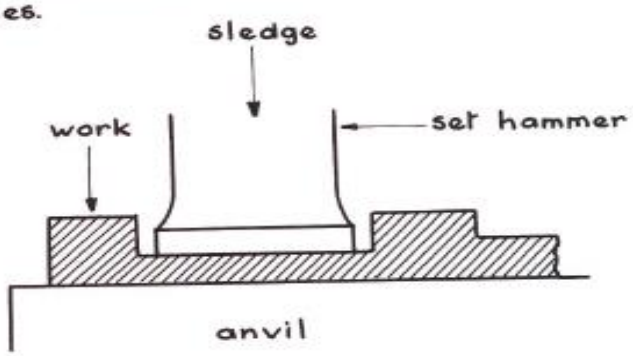
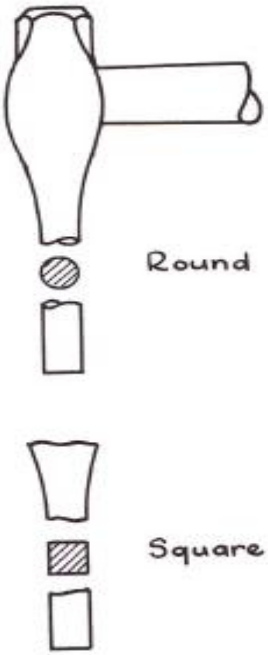
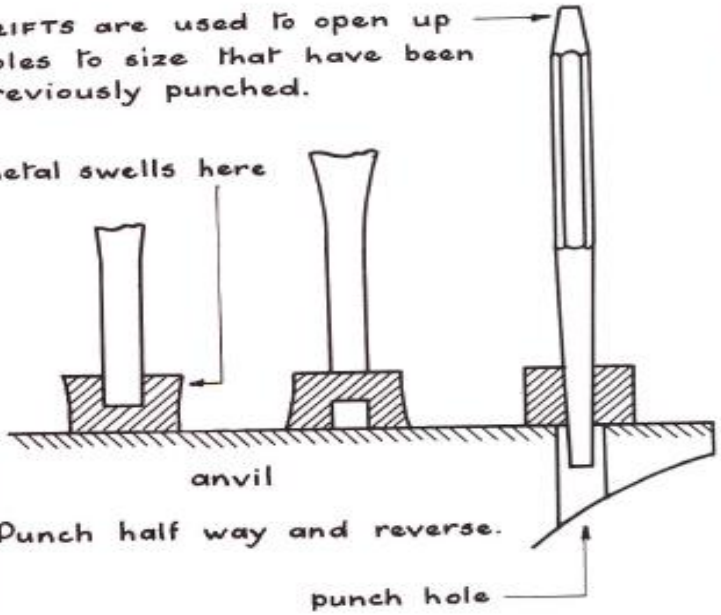
FUEL, coke "breeze", a crushed gas coke or soft coal free of sulphur

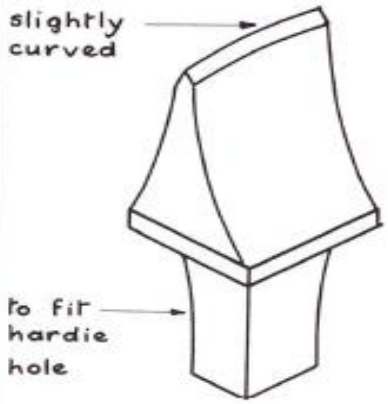
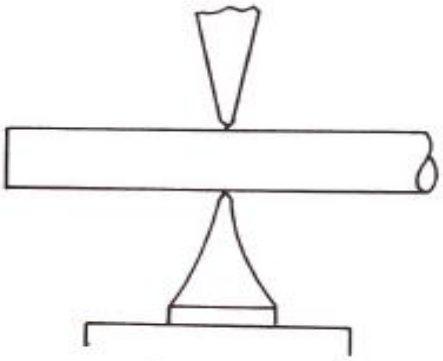
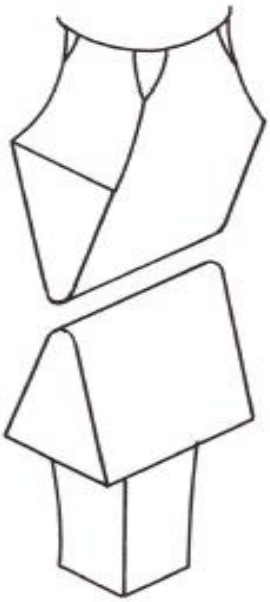
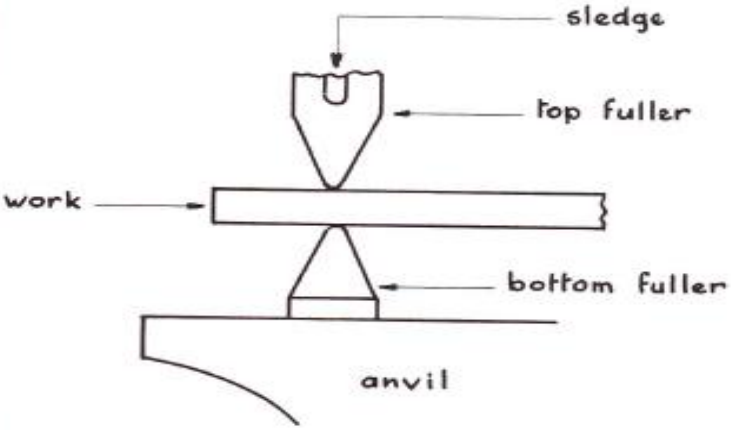
TOOL	DETAILS and USES
ANVIL  	BODY, of M.S. with a top face of H.C.S. approx 20 mm thick, welded on. A short length of one edge of the face is slightly rounded. CUTTING BLOCK, left soft. Used for resting metal on for cutting with a chisel. Being soft it will not damage the chisel. BEAK, left soft. Used for bending metal to a radius, forming rings and for drawing down. PUNCH HOLE. Used as a clearance when punching holes in hot metal. HARDIE HOLE, a square hole to take the shank of bottom tools, eg. fullers etc. WEIGHT, up to 150 kg.
SWAGE BLOCK 	ANVIL STAND, of C.I., with a seating for the anvil base. Similar in shape to the swage block stand. Many blacksmiths prefer a wooden stand, usually part of a tree trunk because wood absorbs the force of the hammer blows better than metal. SWAGE BLOCK, of C.I., with a series of holes of various sizes and shapes. Used for forming hot metal usually with the help of top tools. SWAGE BLOCK STAND, of C.I., which will hold the swage block in a flat position or on its end.

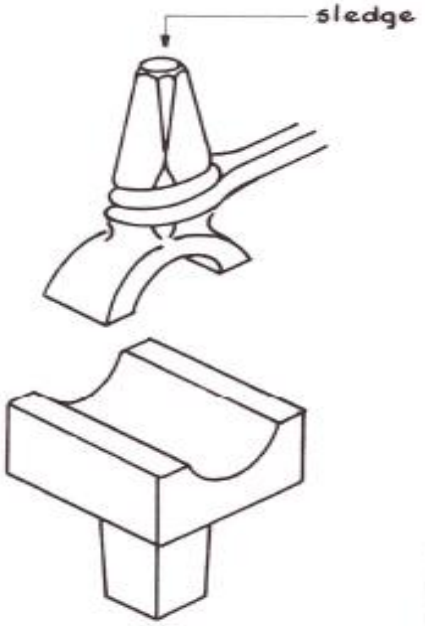
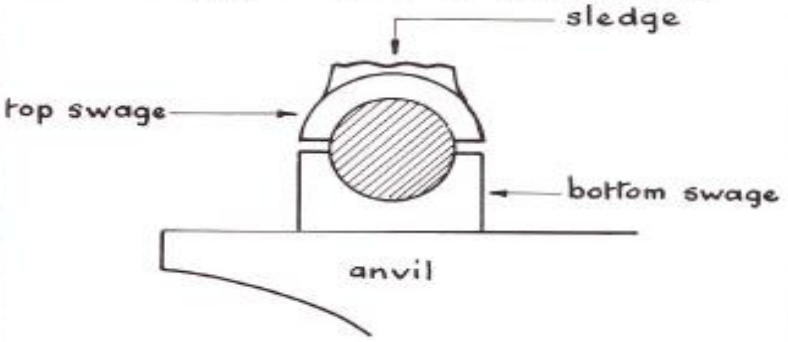
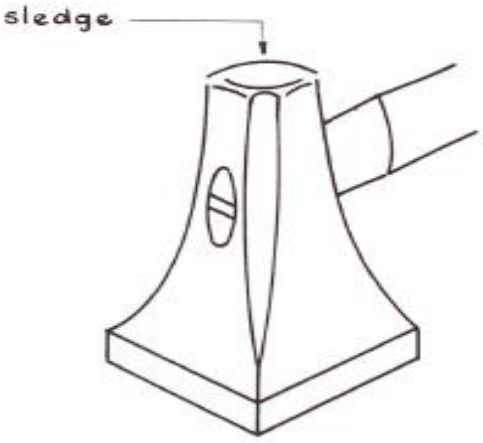
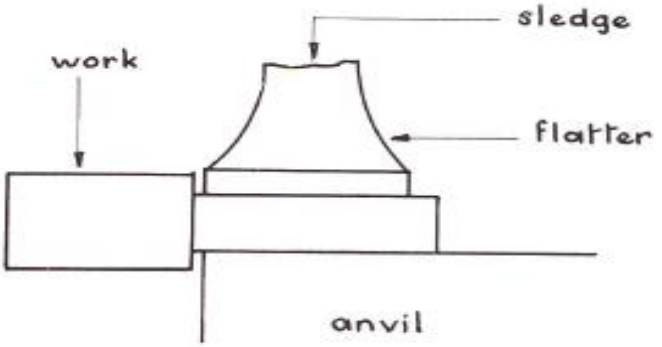
TOOL	DETAILS and USES
LEG VICE 	Made of wrought iron with steel-faced jaws. When the vice is opened the outer jaw swings along the arc of a circle so that a parallel grip is possible only when the jaws are opened to one position.  Parallel grip for neither thin nor thick metal. The leg vice is clumsy but it will stand up to rough usage. It is suitable for holding cold or hot metal for working such as bending. No quick release mechanism is provided.

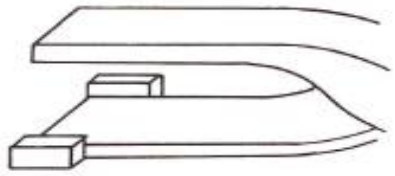
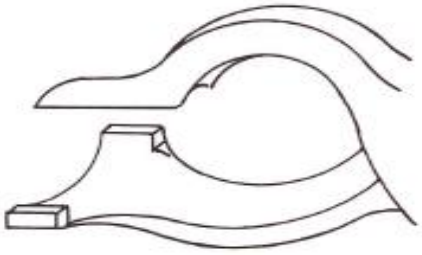


TOOL	DETAILS and USES
FORGING HAMMERS eye  Double-Face Sledge  Straight Pein Sledge  Smith's Hammer	Hammer heads are made of H.C.S. with the ends hardened and tempered and the eyes left soft for strength. The striking faces are slightly convex to prevent the corners digging in to the metal. SLEDGE HAMMERS. In addition to the two shown, there is a cross pein sledge which has the pein at right angles to the shaft. Weights vary from 0·9 to 6·5 kg. The handles or shafts are made of hickory or ash. Sledge hammers are usually used by a striker working in conjunction with a smith. SMITH'S HAMMER. The head has the face slightly convex and the other end has a cross pein which is used for drawing down, etc. Weights vary from 0·9 to 1·3 kg and the shafts are made of knot-free hickory or ash.
HOT and COLD SETS  	HOT SET, of H.C.S., left soft. Cutting angle 30°. Used for cutting hot metal.  COLD SET, of H.C.S., hardened and tempered. Cutting angle 60°. Used for cutting cold metal.

TOOL	DETAILS and USES
SET HAMMER  	Similar to the flatter but smaller in size. Used in confined places or on small surfaces. 
PUNCHES and DRIFTS  	Available with rodded or wooden handles. PUNCHES are used for making round or square holes in hot metal. DRIFTS are used to open up holes to size that have been previously punched. 

TOOL	DETAILS and USES
HARDIE 	The HARDIE fits in the hardie hole of the  anvil. Used as a bottom chisel with a set chisel for cutting hot metal.
TOP and BOTTOM FULLERS 	Made in pairs, the bottom tool fitting in the hardie hole and upper tool handled and held by the smith while it is struck by the striker. Specified according to the dia. of the end.  Used for necking, often before drawing down, or for drawing down itself.

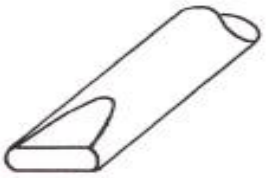
TOOL	DETAILS and USES
TOP and BOTTOM SWAGES 	Supplied as a pair with a curvature of definite radius. The top swage is struck with a sledge whilst the bottom swage rests in the hardie hole. Used for finishing work round that has been roughly shaped by hammering.  Single-handed swages have the top and bottom halves joined together with a flat spring.
FLATTER 	Obtainable with either rodded or wooden handles. The flat face is square with a very slightly convex surface. Used for the finishing of flat surfaces. 

TOOL	DETAILS and USES
TONGS  Square mouth	Used for rectangular, square and irregular stock.
 Round mouth	Used for round stock and work of irregular shape. A circular clamping ring can be pushed over the handles to hold the tongs tightly to the work and so relieve the smith of much of the grip that is necessary.

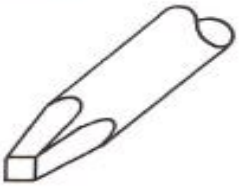
FORGING PROCESSES

DRAWING DOWN A SQUARE TAPER.

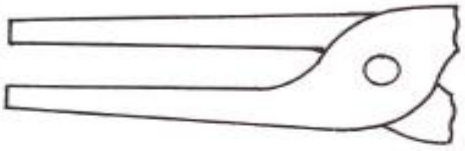
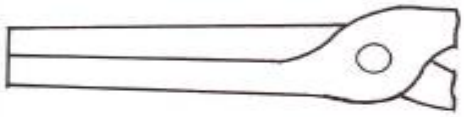
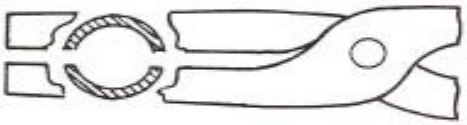
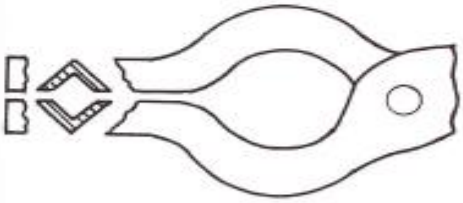
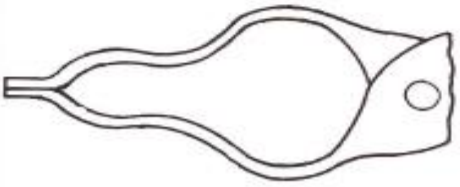
1. On the face of the anvil, hammer a short two-sided taper down to the required thickness at the end.



2. Rotate the metal through 90° and hammer two more short tapers, making four sides in all.



3. Whilst rotating the metal, make the taper the required length.

TOOLS	DETAILS and USES
TONGS	The smith needs a range of tongs of various shapes to hold the metal securely.
 Open mouth	Flat tongs - open mouth - are used for gripping flat stock that is relatively thick. They should grip along the whole length of the jaws.
 Close mouth	Flat tongs - close mouth - are used for holding flat stock that is relatively thin. They should grip along the whole length of the jaws.
 Hollow bit	Hollow bits are used for holding round stock. Size is specified by diameter.
 Vee-bit	Vee-bits are used for holding square stock. Size is specified by the size of the square.
 Pick-ups	Pick-ups are not used for holding metal for working but for picking up awkward shapes.

2.1. Using hand tools and formers correctly and in accordance with safety procedures.

There are five basic rules that apply to all hand tools used either hand or power.

- ✓ Keep all tools in good working order
- ✓ Use the tool only for what it is designed to do
- ✓ Examine the tool for damage before each use
- ✓ Always follow the manufacturer's instructions when operating any tool
- ✓ Always wear the appropriate PPE when operating any tool.

- **SAFETY RULES for SPECIFIC Hand Tools**

Hammers

- ✓ Use a claw hammer for pulling nails
- ✓ Do not strike a hardened steel surface with a claw hammer
- ✓ Do not strike one hammer against another hammer
- ✓ Do not use a hammer as a wedge or pry-bar

Fig.2.2

CHISELS

- ✓ Use only chisels that are sharp
- ✓ Do not use chisels with a mushroom head
- ✓ Use only hammers that are designed for use with chisels

Fig.2.3

Swage block

It is usually a block of cast steel or cast iron carrying a number of slots of different shapes and sizes along its four side faces and through holes from its top face to bottom face.

This is used as a support in punching holes and forming different shapes. The job to be given a desired shape is kept on a similar shaped slot, which acts as a bottom swage, and then the top swage is applied on the other side of the job.

The holes in the top and bottom face are used in punching. Their use prevents the punch from spoiling by striking against a hard surface after the hole has been punched.


Fig.2.4

Tongs

They are used to hold the jobs in position and turning over during forging operation. they are made of mild steel.

Tongs are usually made in two pieces, riveted together to form a hinge. Smaller length on one side of the hinge carries the holding jaws, which are made in different shapes and sizes to suit the corresponding shapes and sizes of the jobs, and the longer portions on the other side of the hinge form the arms which are held in hand by the smith.

Over all sizes of the tongs vary according to the size and shape of the job to be held, but the commonly used lengths of the tongs in hand forging vary from 400 mm to 600 mm with the jaws' opening ranging from 6mm to 55 mm.

Tongs are usually named after the inside shapes of the jaws.

Flat tongs are used for gripping thin section and small flat pieces.

Round hollow tongs, with curved surface inside, are used for holding round work.

Hollow tongs with square jaws are used to hold square or hexagonal work. Pick up tongs have their jaws so shaped that even small sections can be easily picked up. They are not used for holding the work.

Fig.2.5

- **Punches**

Punches are tapered tools made in various shapes and sizes. They are used for producing holes in red hot jobs. A larger tapered punch is called a drift.

The job is placed on the anvil and the punch is hammered through it up to about half its depth. In is then turned over and the punch made to pass through it. Completion of this operation in two stages prevents the job from splitting and full to bursting.

Fig.2.6

- **Flatters**

These are also known as smoothers. They are made of high carbon steel and consist of a square body, fitted with a handle, and a flat square bottom. They are used for leveling and finishing a flat surface after drawing out or any other forging operation.

Fig.2.7

- **Anvil**
  - ✓ To carry out the forging operations successfully, a proper supporting device is needed which should be capable of withstanding heavy blows rendered to the job.
  - ✓ An anvil stands as the most appropriate choice for this purpose.

Its body is generally made of cast steel, wrought iron or mild steel provided with a hardened top, about 20 to 25 mm thick.

This hardened plate is welded to the body on the top.

- ✓ The horn or beak is used in bending the metal or forming curved shapes.
- ✓ The flat step provided, between the top and the horn, is used to support jobs during cutting and is known as chipping block.
- ✓ The flat projecting piece at the back of the anvil is known as tail.
- ✓ It carries a square hole to accommodate the square shank of the bottom part of various hand tools like swages, fuller. It is called a hard die hole.
- ✓ The circular hole provided near the hard die hole is known as pitcher hole.

- ✓ The commonly used size of an anvil weighs approximately 50-150 kg although it is manufactured in various sizes.

- ✓ The top face of the anvil should stand at about 0.75 m from the floor.

Fig.2.8

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page

PART ONE: - GIVE the Short answer and blank space (each has 2 point)

1. what is the advantage and disadvantage of forging
2. List down the types of forging
3. Forging is one of the oldest metal working operations known, used in making parts of widely varying sizes and shapes from a variety of metals.

PART TWO: – True /false (each have 2point)

1. In Hand forging process the forgings are made with the help of repeated blows in an open die. (T)
2. The necessary tools and equipment's used for hand forging is Flatters, set hammers, ball peen hammer, welding machine. (F)
3. The raw material for forging is usually a *bar, billet or sheet metal.* (F)
4. *Forging* is the plastic working of metal by means of localized compressive forces. (T)

Note: **Satisfactory rating - 30 points** **Unsatisfactory - below 15 points**

You can ask you trainer for the copy of the correct answers.

Score = _____

Rating: _____

Answer Sheet

1.Part One

1.

1. Usually have better mechanical properties, especially if the fiber flow lines are directed.
2. Can be held to within fairly close dimensional tolerances
3. A wide range of forgeable metals is available
4. Forgings are readily welded & incorporated in welded structures.

2.

1. Many intricate and cored shapes possible by casting processes can't be forged
2. Usually forgings cost more than castings
3. Closed impression dies for forgings normally cost more than patterns.
4. Permanent molds, or die equipment needed for casting processes
5. High tool cost and high tool maintenance
6. Limitations in size and shape
7. High tool cost and high tool maintenance and Limitations in size and shape

3. Forging

1. True

2. False

3. False

4. True

Name: _____ Date: _____

Basic Metal Works

Level-I

Learning Guide #51

Unit of Competence: **Perform Hand Forging**

Module Title: **Performing Hand Forging**

LG Code: **IND BMW1 M15 LO2-LG-51**

TTLM Code: **IND BMW M15 TTLM 0919v1**

LO2: **Perform hand forging techniques**

Instruction Sheet	Learning Guide #51

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Setting up and operating Heating equipment
- Applying and carrying out forging techniques
- making allowance for materials shrinkage and oxidization

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Operate ***Heating equipment*** set up a correctly.
- Apply and carry appropriate ***forging techniques*** with safety procedures
- Make allowance for ***materials*** shrinkage and oxidization

Learning Instructions:

1. Read the specific objectives of this Learning Guide.

3. Follow the instructions described below.

4. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.

5. Accomplish the “Self-checks” in the information sheets.

6. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

7. If you earned a satisfactory evaluation proceed to “Operation sheets and LAP Tests if any”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.

8. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result;

9. Then proceed to the next information sheet.

10. If you earned a satisfactory evaluation in each self-check proceed to “Operation Sheets” in pages. However, if your rating is unsatisfactory, see your trainer for further instructions or go back to Learning Activities.

11. Read the “Operation Sheets” and try to understand the procedures discussed.

12. Do the “LAP test” in each page (if you are ready). Request your teacher to evaluate your performance and outputs. Your teacher will give you feedback and the evaluation will be either satisfactory or unsatisfactory. If unsatisfactory, your teacher shall advice you on additional work. But if satisfactory you can proceed to Learning Guide.

Information Sheet- 2	Setting up and operating Heating equipment

2. Perform Hand forging techniques.

2.1 Setting up heating equipment

✓ *Heating Procedure of Metal Setting for fire*

✓ Clean out the old fire from the forge hearth and remove the ash

✓ .Put some wood shaving over the tubers and light.

✓ Turn on a little air using litters by hand or power blower to get the fire started

✓ Keep a forging fire neutral throughout the heating of metal.

2.2. Operating Heating equipment.

✓ Heating Devices (Hearths and Furnaces)

✓ .The heating of metal is done either in a smith's hearth or in a furnace.

✓ .The hearths (commonly known as forges) are used for heating metals for hand forging.

✓ .It is a very old method of heating still it is used.

✓ .The furnaces are used for heating metals for heavy forging

1. ***Hearths****: - the* hearths *may be classified as* open or closed hearths, the blacksmith forges may have one or two hearths which are called single hearth or double hearth. Respectively.

- **A common form of the hearth**

✓ **Single hearth** open type consists of a shallow dish or tray made of heavy gauge mild steel or cast iron sheets. Its size varies from 1.5 m to 2.5m square and 0.8 m to 1.2 m deep. Look at Fig.2.10 below.

✓ It is provided with a lining of fire clay or other refractory material to withstand the excessive heat produced due so the combustion of fuel.

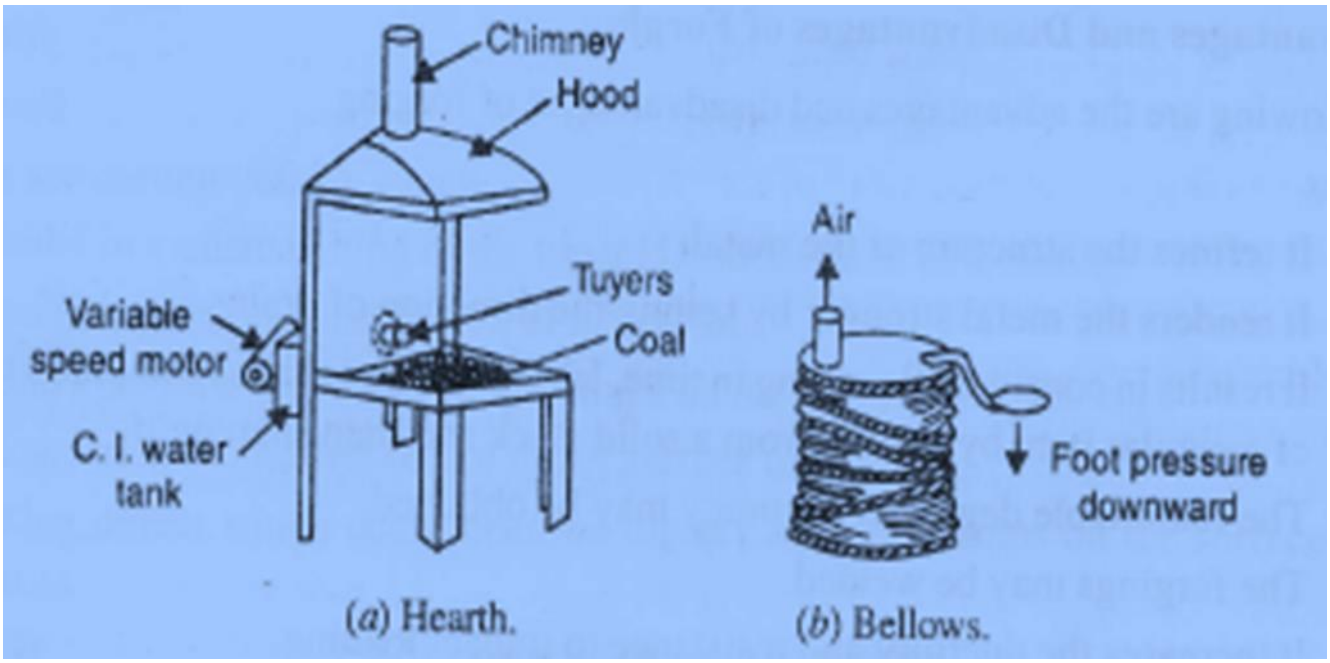


Fig.2.10.

- The fuel used in a hearth may be
    - ✓ coke,
    - ✓ Coal or charcoal.

✓ The smoke and gases produced due to the burning of fuel is escaped through hood and chimney.

✓ Water tank is provided for the purpose of quenching the work.
The closed type hearths are employed in mass production for heating small parts.

The hearths may be made of bricks especially for heavy work.

2. ***Furnaces****:* - The furnaces of refractory type are mostly used for heating large work to be forged under power hammers.

- ✓ Since the work, in the furnaces, is heated by the flames produced from the combustion of fuel, therefore these furnaces may be called as flame furnaces.
- ✓ The gas and oil mostly used as fuels as these are economical and easily controlled.

- ✓ The work does not come in direct contact with the fuel.
- ✓ The following are the various types of furnaces used for heating steel.

a).Box or box type furnaces:- These are widely used in forging shops for heating small and medium size work; these furnaces are usually made of steel frame lined with insulating and refractory bricks.

b) .Continuous type furnaces: - These furnaces are provided with mechanical pusher and are tad for mass production of articles. In these furnaces, the pieces of steel are charged at one end and pushed to the furnace for heating at correct temperature.

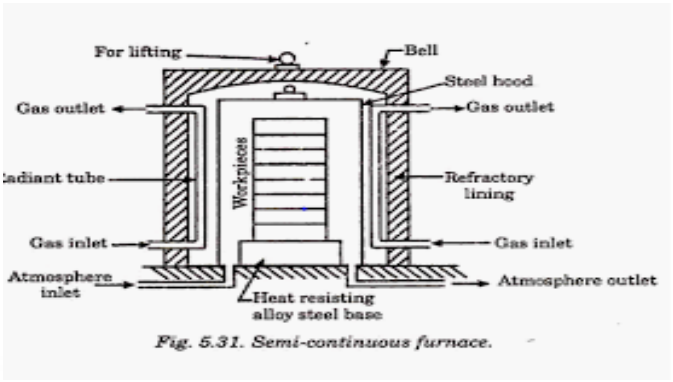


Fig. 5.31. Semi-continuous furnace.

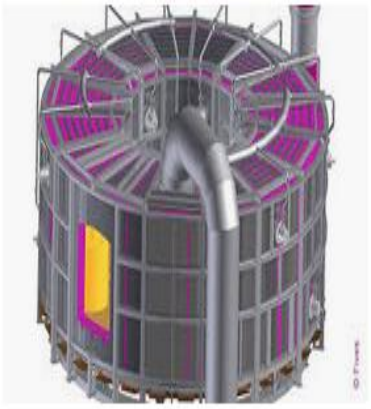
c)***Slot type furnaces: -*** These furnaces are commonly used for heating bars at one end for forging or other forging operation, in these furnaces, a slot is provided at the front through which the bar is inserted for

heating



d).Rotary hearth furnaces*:* - These furnaces are sometimes used for heating large number of pieces steel for forging. In these furnaces, the speed of rotation is adjusted in such a way that the ink is heated to the required temperature after one or two revolutions.






e). ***High frequency induction furnaces:-***these furnaces are quite popular with the availability (cheap electric power).

The work produced by induction heating is free from oxide scale, have uniform temperature and takes less time,

f) Resistance *furnaces*:- These furnaces are faster than induction furnaces are often automated in these furnaces; the work is connected to the circuit of a step down transformer. The simple fixtures made to hold the work of different shapes and sizes.

F). **Blowers**: - the supply of air at proper pressure is always necessary for the combustion of fuel in the hearth or furnace

- **Open Fire**

1. ***Open fire***:-The open fire (also called loose fire), as shown in Fig. 1(a), is used for 'all general work. It is made in the hollow space with coke left from the last fire, covered with green coal. At the fire burns away. Coke from the top and sides is thrust into the centre and its place is taken by green coal from the supply maintained on from plate of the forge. the ash and clinkers clean at regular intervals of time.

2.3. Controlling Heat to specified areas

- **Heat during forging is controlled by the color of the metals.**
- ***Heating the metal***
  - ✓ Never put the metal from the top with one end at the bottom of the fire. This heats the metal unevenly.
  - ✓ Always place or put the metal in the center in a horizontal position.
  - ✓ Remove the metal from the fire at intervals to see how hot it is.
  - ✓ Heat the metal to its proper color and temperature.
  - ✓ Poorly heated metal will be difficult to forge and is liable to cracks.
- **The temperature of steel for forging is determined by temperature color.**

Temper Color	Temperature (0C)	Temper Color	Temperature (0C)
Brown	500	Orange Yellow	1000
Dark Purple	550	Straw Yellow	1100
Dark Red	650	Very Light Yellow	1200
Cheery Red	700	White	1300
Light Cheery Red	800	Bright White	1400
Dark Orange	900		

- **Allowance for Forged material**

Shrinkage allowance		
Length or width, mm	*Commercial.* or - *mm*	*Close* + or - *mm*

Up to 25	008	0.05
26 to 50	0.15	0.06
51 to *75*	0.23	0.13
76 to 100	0.30	0.15
101 to 125	0.38	0.20
126 to 150	0.45	0.23
each additional 25	add 0.075	0.038
For example 400	1.200	0.830

- **Shrinkage allowance**

  The forgings arc generally made at a temperature of 1150 t0 1300 C. At this temperature, the material gets expanded and when it is cooled to the atmospheric temperature, its dimension would be reduced. it is very difficult to control the temperature at which forging process would be complete, therefore to precisely control the dimensions. Hence a shrinkage allowance is added on all the linear dimensions given in Table 19.4.

- **Die wear allowance**

  The die wear allowance it added to account for the gradual wear of the die which takes place with the use of the die. The suggested values are presented in Table following table:

- **Finish allowance**

  Machining allowance is to be provided on the various forged surfaces which need to he further

Table 19.5 Die wear tolerance

Net mass of forging (kg)	*Commercial + or − (mm)*	*Close + or − (mm)*
up to 0.45	0.80	0.40
0.46 to 1.35	0.88	0.45
1.36 to 2.25	0.95	0.48
2.26 to 3.20	1.03	0.53
3.21 to 4.10	1.11	0.55
4.11 to 5.00	1.18	0.60
Each additional 1 add	0.083	0.041
For example 15.00	2.010	1.010

machined. The amount of allowance to be provided should account for besides the accuracy, the depth of the decarburised layer. Also, the scale pits that are likely to form on the component should also be removed during machining. A guideline for finish allowance is provided in Tables 19.6 and 19.7.

Table 19.6 Finish allowance for drop forgings

Greatest dimension (mm)	*Minimum allowance per surface (mm)*
up to 200	1.5
201 to 400	2.5
401 to 600	3.0
601 to 900	4.0
above 900	5.0

Table 19.7 Finish allowance for upset forgings

Greatest diameter (mm)	*Minimum allowance per surface (mm)*
up to 50	1.5
51 to 200	2.5
above 200	3.0

The component as affected by the various allowances is shown in Fig. 19.10.

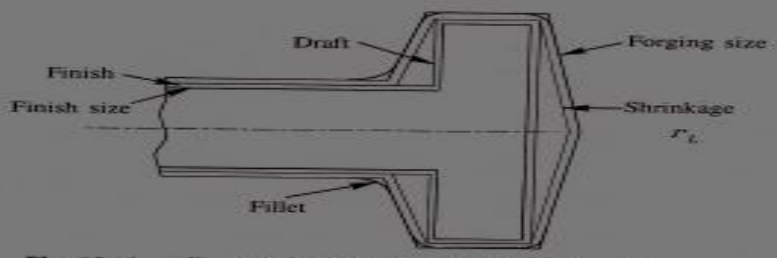


Fig. 19.10 Allowances shown on forged component

2.4. Applying appropriate forging technique

- **Defect in Forgings**

  The following are some of the reasons for forging defects:

  (**I)** .Faulty original metal,

  (II). Incorrect die design.

  (III). Improper heating, and

  (IV) .improper forging operation.

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

❖ PART ONE – CHOOSE

1. ------ process involves the use of fullers in pairs, before drawing down fullers is carried out to produce shoulder.

A. heating B. punching C. fuller D. smith E. none

2. ---------- is the process of finishing a round or hexagonal section of bar.

A. bending B. Swage C. upsetting D. punching

3. _____process increasing the cross-section of a at the expense of its length.

A. upsetting B. Punching C. bending D. Swage

4. The forging operation of "upsetting" is…….

(*a*) Reverse of drawing down process (*b*) it is a bending operation

(*c*) It is a drifting operation (*d*) none of these.

❖ Part III short answer Matching

Column A	Column B
1. ___Internal crack	A. reducing cross sectional area
2. ___Punching	B. producing a bar with a smaller diameter
3. ___Fullering	C. due to secondary tensile stress
4. ___Swaging	D. producing hole
5. ___Drawing	E. increasing diameter &cross sectional area
6. ___Upsetting	F. reducing cross section area &increasing in length.

II.PART ONE (self-check-2)

1. C

2. B

3. A

4. A

1. C **5.F**

2. D **6.E**

3. A

4. B

Note: **Satisfactory rating - 30 points** **Unsatisfactory - below 15 points**

Name: _____ Date: _____

Basic Metal Works

Level-I

Learning Guide#52

Unit of Competence: Perform Hand Forging

Module Title: Performing Hand Forging

LG Code: IND BMW1 M15 LO3-LG-52

TTLM Code: IND BMW M15 TTLM 1019v1

LO3: Quality assure work

Instruction Sheet	Learning Guide #52

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Equipment is operated in a manner that minimizes oxidization in accordance with operational procedures.
- Heat is controlled to specified areas as per instruction.
- Form and shape are measured by applying standard devices.
- Occupational Health and Safety (OHS) measures and procedures are followed throughout the process.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Operating Equipment in minimizes oxidization with operational procedures.
- Controlling Heat specified areas
- Measuring Form and shape applying standard devices.
- Following Occupational Health and Safety (OHS) measures and procedures throughout the process.

Learning Instructions:

Learning Instructions:

1. Read the specific objectives of this Learning Guide.

2. Follow the instructions described below.

3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.

4. Accomplish the “Self-checks” in the information sheets.

5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

6. If you earned a satisfactory evaluation proceed to “Operation sheets and LAP Tests if any”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.

7. After you accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result;

8. Then proceed to the next information sheet.

9. If you earned a satisfactory evaluation in each self-check proceed to “Operation Sheets” in pages. However, if your rating is unsatisfactory, see your trainer for further instructions or go back to Learning Activities.

10. Read the “Operation Sheets” and try to understand the procedures discussed.

11. Do the “LAP test” in each page (if you are ready). Request your teacher to evaluate your performance and outputs. Your teacher will give you feedback and the evaluation will be either satisfactory or unsatisfactory. If unsatisfactory, your teacher shall advice you on additional work. But if satisfactory you can proceed to Learning Guide.

Information Sheet-3	Following Occupational Health and Safety (OHS) measures and procedures

3. SAFETY PRECAUTIONS

- Some safety precautions generally followed while working in forging shop are given as under.

1. Always avoid the use of damaged hammers.
2. Never strike a hardened surface with a hardened tool.
3. No person should be allowed to stand in line with the flying objects.
4. Always use the proper tongs according to the type of work.
5. The anvil should always be free from moisture and grease while in use.
6. Always wear proper clothes, foot-wears and goggles.
7. The handle of the hammer should always be tightly fitted in the head of the hammer.
8. Always put out the fire in the forge before leaving the forge shop.
9. Always keep the working space clean.
10. Proper safety guards should be provided on all revolving parts.
11. Head of the chisel should be free from burrs and should never be allowed to spread.
12. During machine forging, always observe the safety rules prescribed for each machine.
13. One must have the thorough knowledge of the working of the forging machine before operating it.

- **DEFECTS IN FORGED PARTS**

Defects commonly found in forged parts that have been subjected to plastic deformation are as follows.

- ✓ Defects resulting from the melting practice such as dirt, slag and blow holes.
- ✓ Ingot defects such as pikes, cracks scabs, poor surface and segregation.
- ✓ Defect due to faulty forging design.
- ✓ Defects of mismatched forging because of improper placement of the metal in the die.

- ✓ Defects due to faulty design drop forging die.
- ✓ Defects resulting from improper forging such as seams cracks laps. etc.
- ✓ Defects resulting from improper heating and cooling of the forging part such as burnt metal and decarburized steel.

Information Sheet-4	Controlling heat to specified areas

4. HEAT TREATMENT OF FORGING

Heat treatment is carried out for releasing the internal stresses arising in the metal during Forging and cooling of work piece. It is used for equalizing the granular structure of the forged Metal and improving the various mechanical properties.

The following are the purposes of heat treatment:

i. To remove internal stresses set-up during forging and cooling.

ii. To normalize the internal structure of the metal.

iii. To improve mach inability.

iv. To improve mechanical properties, strength and hardness.

Generally forged parts are annealed, Normalized and tempered to obtain the desired results

4.1. Annealing of forged metals

One of the most important processes of heat treatment of steel is employed for the following purpose:

1. To soften the steel so that it may be more easily machined or cold worked
2. To refine the grain size & structure to improve mechanical properties like strength & ductility
3. To relieve internal stress which may have been caused by hot or cold working or by unequal contraction in casting
4. To alter electrical, magnetic or other physical properties
5. To remove gases trapped in the metal during initial casting

4.2. Normalizing of forged metals

Normalizing is done for the following purpose

1. To refine the grain structure of forged metals to improve machine ability, tensile strength and structure of weld.
2. To remove strains caused by cold working process like hammering, rolling, bending etc, this makes the metal brittle and reliable.
3. To remove dislocations caused in the internal structure of forged metal due to hot working.
4. To remove certain mechanical and electrical properties.

- **The process of normalizing consists of heating 30^0c-50^0c above its critical temperature**.

4.3. Hardening of forged metals

It is defined as the heat treating process in which the forged metals are to 20^0c above the transformation range soaking at this temperature for considerable period to ensure through penetration of the temperature inside the component, followed by continuous cooling to room temperature by quenching in water oil or brine solution.

4.4. Tempering forged metals

Forged metals hardened by rapid quenching are very and brittle. It also contains internal stresses which are severe and unequally distributed to cause cracks or even rapture or hardened steel (the tempering is known as drawing) is done for the following reasons:

1. To reduce brittleness of the hardened forged metals and to increased ductility.
2. To remove the internal stresses caused by rapid cooling
3. To make forged metals to resist shock and fatigue

• Operate heating equipment

Heating Devices (hearth and Furnaces)

The heating of metal is done either in a smith's **hearth or in a furnace**. The hearths (commonly known as forges) are used for heating metals for hand forging. It is a very old method of heating still it is used. The furnaces are used for heating metals for heavy forging.

1. Hearths: - the hearths may be classified as open or closed hearths, the blacksmith forges may have one or two hearths which are called single hearth or double hearth respectively.

A common form of the hearth, as shown in Fig (a), is a single hearth open type forge. Its size varies from 1.5 m to 2.5m square and 0.8 m to 1.2 m deep. It is provided with a lining of fire

clay or other refractory material to withstand the excessive heat produced due so the combustion of fuel.

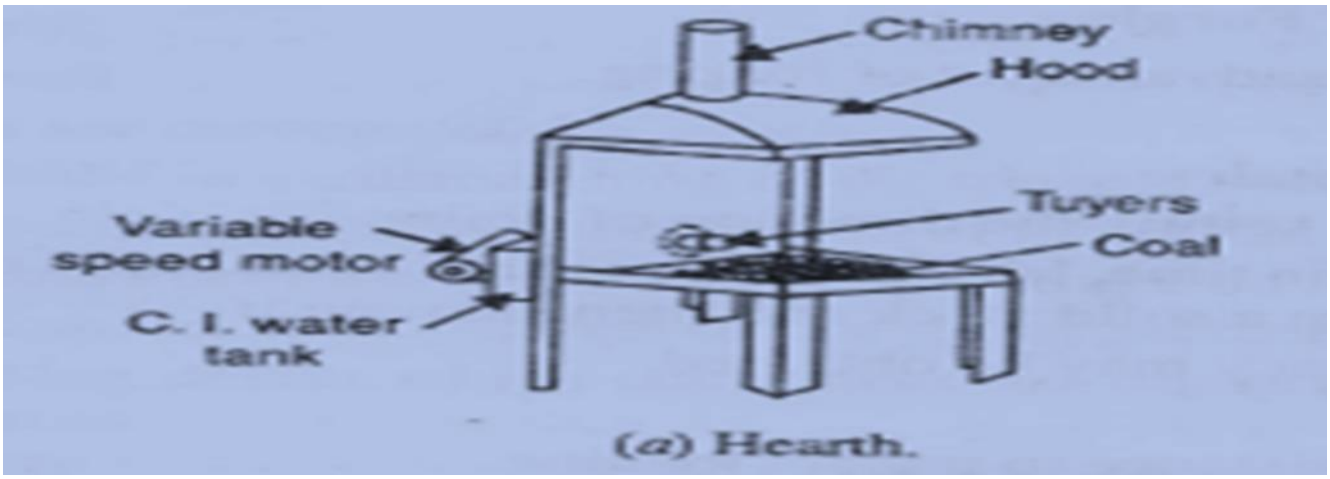


Fig 4.1. Heating Devices (hearth)

The fuel used in a hearth may he coke, coal or charcoal. For general work, low sulphur is used. There is an inlet for blowing air either through the back or bottom. The air is generally applied through a motorize fan blower. The motorized fan is generally fitted with a series-wound variable speed motor.

Heating controls allow you to easily regulate the temperature of your home. The **controls** automatically turn the **heating** on and off based on settings input by the user, to ensure maximum comfort. ... The latest technology allows you to automatically **control** your **heating** to work around your daily schedule.

Temperature is the **most important** one because it provides a critical condition for combustion, chemical reaction, fermentation, drying, calcinations, distillation, concentration, extrusion, crystallization, and air conditioning. Poor **temperature control** can cause major safety, quality, and productivity problems.

If your **temperature** is above 250°F, close down the vents to reduce the amount of oxygen in order to reduce the **temperature**. If your **temperature** dips below 225°F, open up the vents fully to allow more oxygen in to increase the **temperature**. Learn more about **temperature control**.

- **No-Cost Ways to Improve Air Conditioning Efficiency**

1. Clean around outdoor condenser unit

2. Vacuum indoor vents and keep vents unblocked.
3. Increase your thermostat by a few degrees.
4. Keep lamps and other heat producing appliances away from your thermostat.
5. Keep curtains and blinds closed in the heat of the day.
6. Clear your drain line

- **MATERIALS USED IN FORGING**:

Mostly in forging, Ferrous & Non-Ferrous metals are used in manufacturing purpose.

- **Ferrous metals:** these contain iron as a main constituent, these are stronger. Some of them are low and medium carbon steels, alloy steels, stainless steels, titanium, die-steels.

FERROUS METAL FORGING TEMP.IN ◦C

1. Low carbon steel 1250◦C

2. Medium carbon steel 850-1100◦C

3. Stainless steel 1200◦C

- **Non-Ferrous metals:**

Non-ferrous metals do not contain iron as the main constituent. Generally they are weaker than ferrous metals but have other important properties such as corrosion resistance, high electrical and thermal conductivity, good formability and special electrical & magnetic properties the chief non-ferrous metals used in the industrial purpose are copper, aluminum, zinc, lead, tin, magnesium and their alloys.

- **NON-FERROUS METALS FORGING TEMP IN ◦C**

1. Brass 650-800◦C

2. Bronze 825-900◦C

3. Aluminum alloys 350-450◦C

4. Copper 900◦C

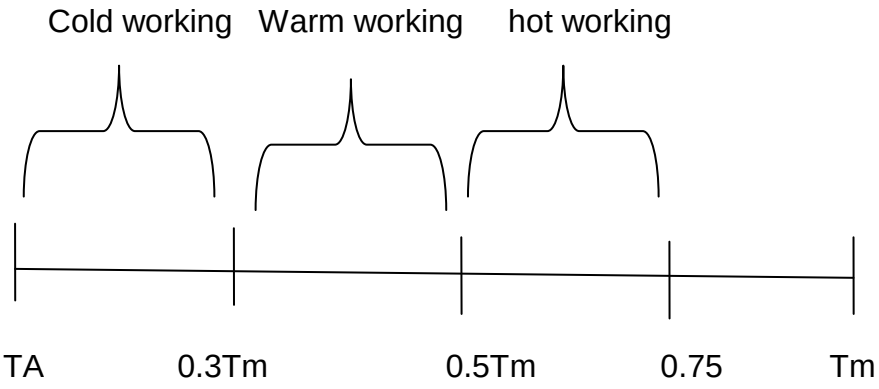
FORGING TEMPERATURES

• **Forging temperature** is a temperature at which a metal becomes soft like clay or its shape can be changed by applying a relatively small force without creating cracks in metal.

• **Note: -** Temperatures for alloys (combination of metals) will lie between the temperatures specified for the metals utilized.

When heating a piece of steel on a forge the blacksmith must always watch the flame of the fuel. Metal is best heated a bright slightly smoking flame, because such a flame excludes all possibility of overheating the metal. *the difference* between *the initial and final forging temperature* is *called the forging temperature interval.*

There are three temperature ranges-cold, warm, and hot working:



TA is the ambient (room) temperature, and Tm is the work metal melting temperature

- **Cold working** is metal forming performed at room temperature.
  - ✓ **Advantages**: better accuracy, better surface finish, high strength and hardness of the part, no heating is required.
  - ✓ **Disadvantages**: higher forces and power, limitations to the amount of forming, additional annealing for some material is required, and some material are not capable of cold working.
- **Warm working** is metal forming at temperatures above the room temperature but bellow the recrystallization one.
  - ✓ **Advantages**: lower forces and power, more complex part shapes, no annealing is required.
  - ✓ **Disadvantages**: some investment in furnaces is needed.

- **Hot working** involves deformation of preheated material at temperatures above the Re-crystallization temperature.
  - ✓ Advantages: big amount of forming is possible, lower forces and power is required, forming of materials with low ductility, no work hardening and therefore, no additional annealing is required.
  - ✓ Disadvantages: lower accuracy and surface finish, higher production cost, and shorter tool life.

Chart:- 1.for forging temperature

Material	Celsius	Fahrenheit
Carbon steel	1230	2246
Stainless steel (Magnetic)	1095	2003
Stainless steel (Nonmagnetic)	1150	2102
Nickel	1095	2003
Titanium	955	1751
Copper	900	1652
Brass	815	1499
Commercial bronze	900 to 419.53	1652 to 787.154
Aluminum	540	1004

- ***Color of Metals in Forging***

  The temperature of steel for hand forging is generally determined by temperature color in the following four general ranges.
  - ✓ ***Red heat (about 470 C)*** is used for making easy bends in mild *steel* and for forging the HCS as in Loop making.
  - ✓ ***Cheery- Red heat (about 790* °C)** is used for simple forging operation such as for hot cutting and light punching of mild steel and HCS.

    Note. HCS must not be raised above cherry red. They will loosen their especial property.
  - ✓ ***Bright cherry red heat (about 1100*** All principal forging operations are carried out at this heat on mild steels, Drawing down, upsetting, fullering, punching, etc are performed at this temperature.

    White heat (welding heat, *about 1260-1400* °c). As the metal approaches white heat it becomes plastic.

4.5. CONTROL OF HEATING DEVICES

For good control of heating devices such as hearth or forging furnace, the following points are should always be considered.

1. The nozzle pointing into the centre of the hearth is called the tuyre and is used to direct a stream of air into the burning coke. The air is supplied by centrifugal blower.

2. As the hottest part of the fire is close to the tuyre opening, therefore, the tuyre is provided with a water jacket to prevent it from burning away.

3. The hood provided at the top of hearth collects smoke, fumes etc., and directs them away from the workplace through the chimney in form of exhaust.

4. The fuel for the fire may be either black-smiting coal or coke. To light the fire, either use paper and sticks or preferably a gas poker.

5. Impurities will collect as clinker and must be removed from the bottom of the fire when the fire cools.

6. The blowers are used to control the air supply using forced draught. Regulators control the draught and the temperature of the fire.

7. Blower delivers to forge adequate supply of air at proper pressure which is very necessary for the combustion of fuel.

8. A centrifugal blower driven by an electric motor is an efficient means of air supply

in forging hearth.

9. Fire tools such as rake, poker and slice are generally used to control or manage the fire and theses tools are kept nearby the side of the hearth. Rake is used to take heated work piece out of the fire. Poker is a steel rod which is used to poke (stir) fire in the hearth.

10. The place of the metal to be heated should be placed just above the compact centre of a sufficiently large fire with additional fuel above to reduce the heat loss and atmospheric oxidation

- **Making preventive maintenance**

Maintenance is a broad definition concerned with controlling the condition of equipment.

The trainees should detect the overhaul preventive maintenance (PM) action of Forge hand tools & hammers, formers & heating equipment.

This moderate approach begins with an attempt to plan on preventive maintenance of a forge work.

1. Cleaning, repairing hand tools, formers, heating equipment
2. Select preventive maintenance task
3. Choose preventive maintenance interval with normal life span
4. Determine normal life span before defect
5. Prevent hand tools, formers, hammers & forging machines from deterioration
6. Lubricating forging machine
7. Checking daily surveillance of forging machine

Self-Check -3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

❖ PART ONE – CHOOSE

1. Advantage of cold working is

(*a*) Better dimensional accuracy (*b*) better surface finish

(*c*) Higher strength (*d*) all of these.

2. Typical hot working temperature range for steel is

(*a*) 650–1050°C (*b*) 650–723°C

(*c*) 500–910°C (*d*) none of these.

3. The forging operation of “upsetting” is

(*a*) Reverse of drawing down process (*b*) it is a bending operation

(*c*) It is a drifting operation (*d)* none of these.

III.PART ONE (self-check-3)

1. D **3. A**

2. A

Operation sheet-1

OPERATION TITLE:-Upsetting or jumping up

PURPOSE: This process increasing the cross-section of a at the expense of its length

CONDITIONS OR SITUATIONS FOR THE OPERATIONS:

EQUIPMENT TOOLS AND MATERIALS: - Tong, Forge, Round bar Charcoal, PPE

PROCEDURE:

1. Heat the portion to be jumped up.

2. Bounce the metal on the lower die.

3. Hold the bar with tong and hammer the end.

PRECAUTION: use PPE and tongs

QUALITY CRITERIA: Dimensional accuracy and Surface finish

OPERATIONTITLE:-Drawing down

PURPOSE: This process makes the metal thinner, by reducing its cross-section. Metal to be forged is first hammered on the back of an die. The process can produce tapers that arc, Hat, circular, or square. Fig. shows the steps to follow in drawing down a circular taper:

EQUIPMENT TOOLS AND MATERIALS:- Tong ,Hearth ,Round bar Charcoal, PPE, drop Hammer

PROCEDURE:

I. Hammer four sides **to** produce a short square (Fig.a)

2. Lengthen the square taper (Fig.b)).

3. Hammer the corners of the long square in step 2 to produce an octagonal shape (Fig. (c)).

4. Continue round all the corners in step 3 to obtain a circular end (Fig. (d)). if the taper is fat or square go through either the first two or three stages above.

- Avoid piping (hollow ends) when drawing down a taper.

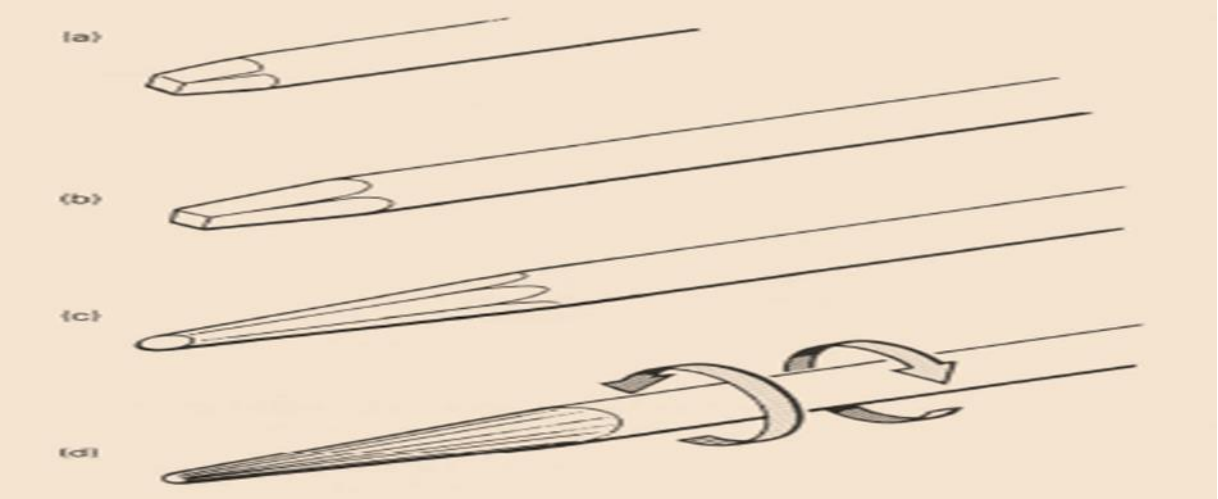


Fig.*1.1.* Stages in drawing down: a) first stage -short square; b) second stage- long square; (C) Third stage-octagonal shape; (dl final stage-round shape.

PRECAUTION: use PPE and tongs

QUALITY CRITERIA: Dimensional accuracy and Surface finish. Roundness.

OPERATIONTITLE: - Flattening

EQUIPMENT TOOLS AND MATERIALS: - Tong, Hearth, Round bar Charcoal, PPE, drop Hammer

PROCEDURE: You use the flatter with the sledge hammer to flatten filtered piece Flattening enables you to finish off an undulating surface.

To flatten:

1. Hold the hot metal on lower die.
2. Strike the work piece with the drop hammer
3. Move work pieces them to all areas and repeat step 2.

PRECAUTION: use PPE and tongs

QUALITY CRITERIA: Dimensional accuracy and Surface finish. Roundness

Operation sheet-2

OPERATION TITLE:- S-Hook

PURPOSE: This process increasing the cross-section of a at the expense of its length

CONDITIONS OR SITUATIONS FOR THE OPERATIONS:

EQUIPMENT TOOLS AND MATERIALS: - Smith's forge**,** Anvil**,** 500gm and I kg ball-peen hammers, Flatters, Swage block, Half round tongs, Pick-up tongs, Cold chisel.

PROCEDURE:

Aim: To make an **S-hook** from a given round rod, by following hand forging operation.

Tools required:

Sequence of operations:

1. One end of the bar is heated to red hot condition in the smith's forge for the required length.
2. Using the pick-up tongs; the rod is taken from the forge, and holding it with the half round tongs, the heated end is forged into a tapered pointed end.
3. The length of the rod requires for S-hook is estimated and the excess portion is cut-off, using a cold chisel.
4. One half of the rod towards the pointed end is heated in the forge to red hot condition and then bent into circular shape as shown.
5. The other end of the rod is then heated and forged into a tapered pointed end.
6. The straight portion of the rod is finally heated and bent into circular shape as required.
7. Using the flatter, the S-hook made as above, is kept on the anvil and flattened so that, the shape of the hook is proper.

S- HOOK

NOTE: In-between the above stage, the bar is heated in the smith's forge, to facilitate forging operations.

Result:

The S-hook is thus made from the given round rod; by following the stages mentioned above.

Precautions:

1. Hold the job carefully while heating and hammering

2. Job must be held parallel to the face of the anvil.

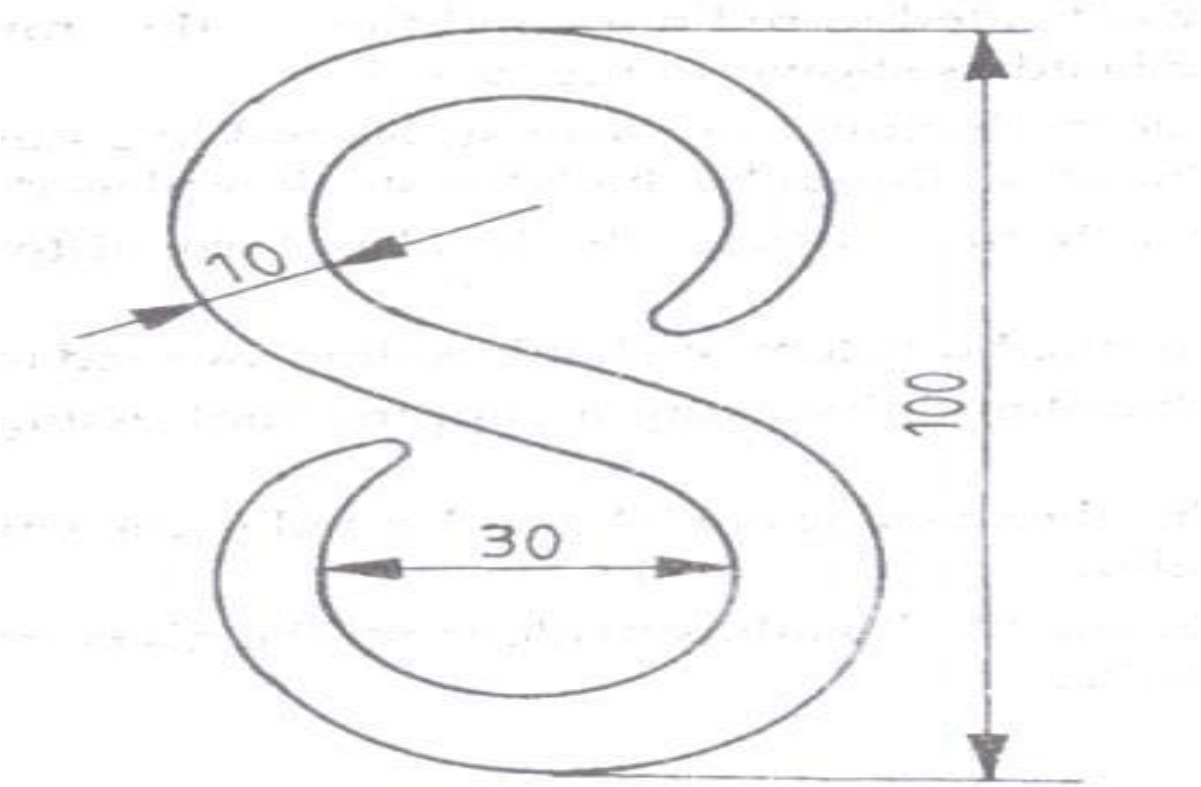
3. Wear steel-toed shoes.

4. Wear face shield when hammering the hot metal

5. Use correct size and type of tongs to fit the work.

6. Use PPE and tongs

QUALITY CRITERIA: Dimensional accuracy and Surface finish S-hook.



Operation sheet-3

OPERATION TITLE:- Square Rod

PURPOSE: This process increasing the cross-section of a at the expense of its length

CONDITIONS OR SITUATIONS FOR THE OPERATIONS:

EQUIPMENT TOOLS AND MATERIALS: - Smith's forge**,** Anvil**,** 500gm and I kg ball-peen hammers, Flatters, Swage block, Half round tongs, Pick-up tongs, Cold chisel.

Aim: To make a Square rod from a given round rod, by following hand forging operation.

Sequence of operations:

1. Take the raw material from stock i.e., mild steel 10 mm round shaped, cut the length of 50 mm.
2. Handle specimen with round tong and heat in blacksmith's forge up to the part appears as red cherry color code.
3. The required piece heated up to it gets the recrystalization temperature.
4. The part is taken out from the forge and blow with sledge hammer for obtaining the square shape on all edges.
5. The hammering is done on the anvil.
6. The above mentioned all steps are done, after the specimen bent in required shape.
7. Check the dimensions after cooling the job by quenching process.

NOTE: In-between the above stage, the bar is heated in the smith's forge, to facilitate forging operations.

Result:

The square rod is thus made from the given round rod.

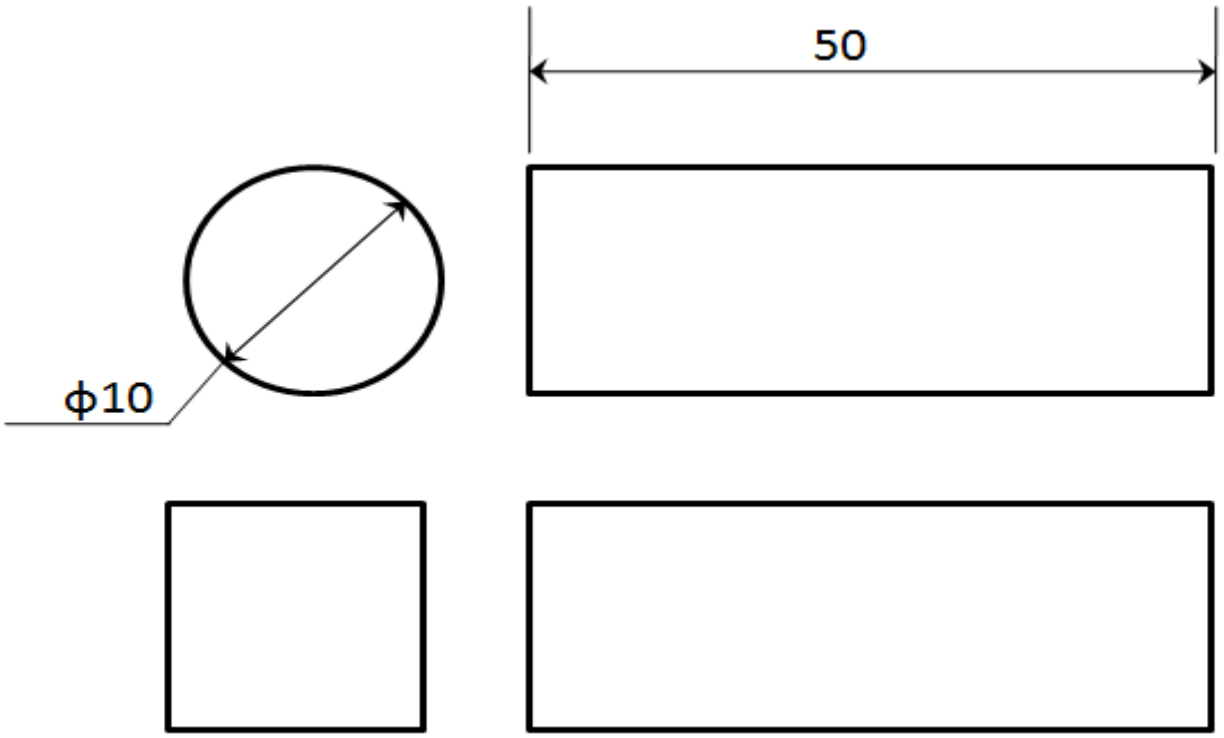
Precautions:

1. Hold the job carefully while heating and hammering
2. Job must be held parallel to the face of the anvil.
3. Wear steel-toed shoes.

4. Wear face shield when hammering the hot metal

5. Use correct size and type of tongs to fit the work.

QUALITY CRITERIA: Dimensional accuracy and Surface finish. Square ness.



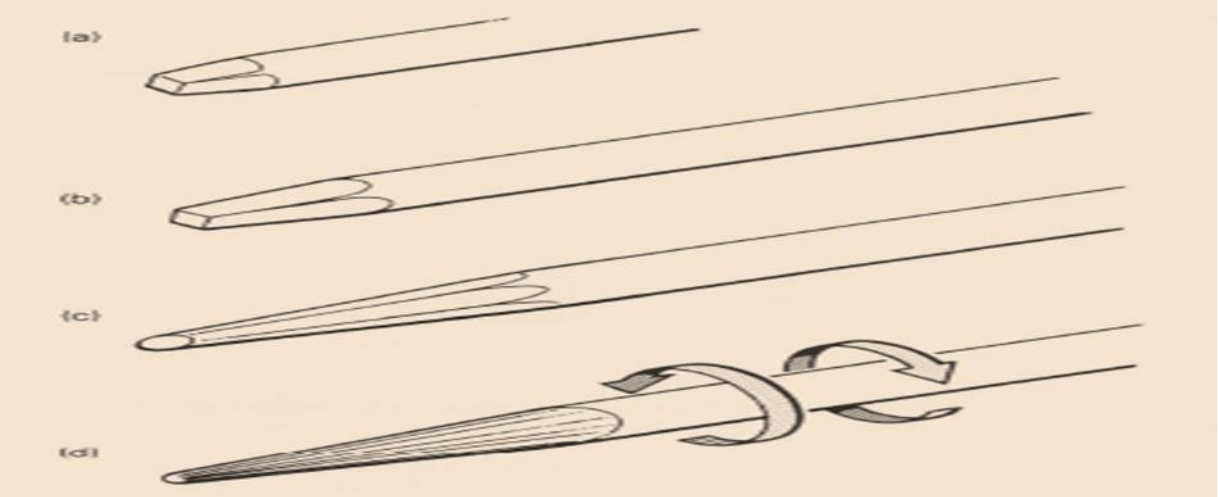
LAP Test	Practical Demonstrations

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within --- hour.

Task 1. Drawing down



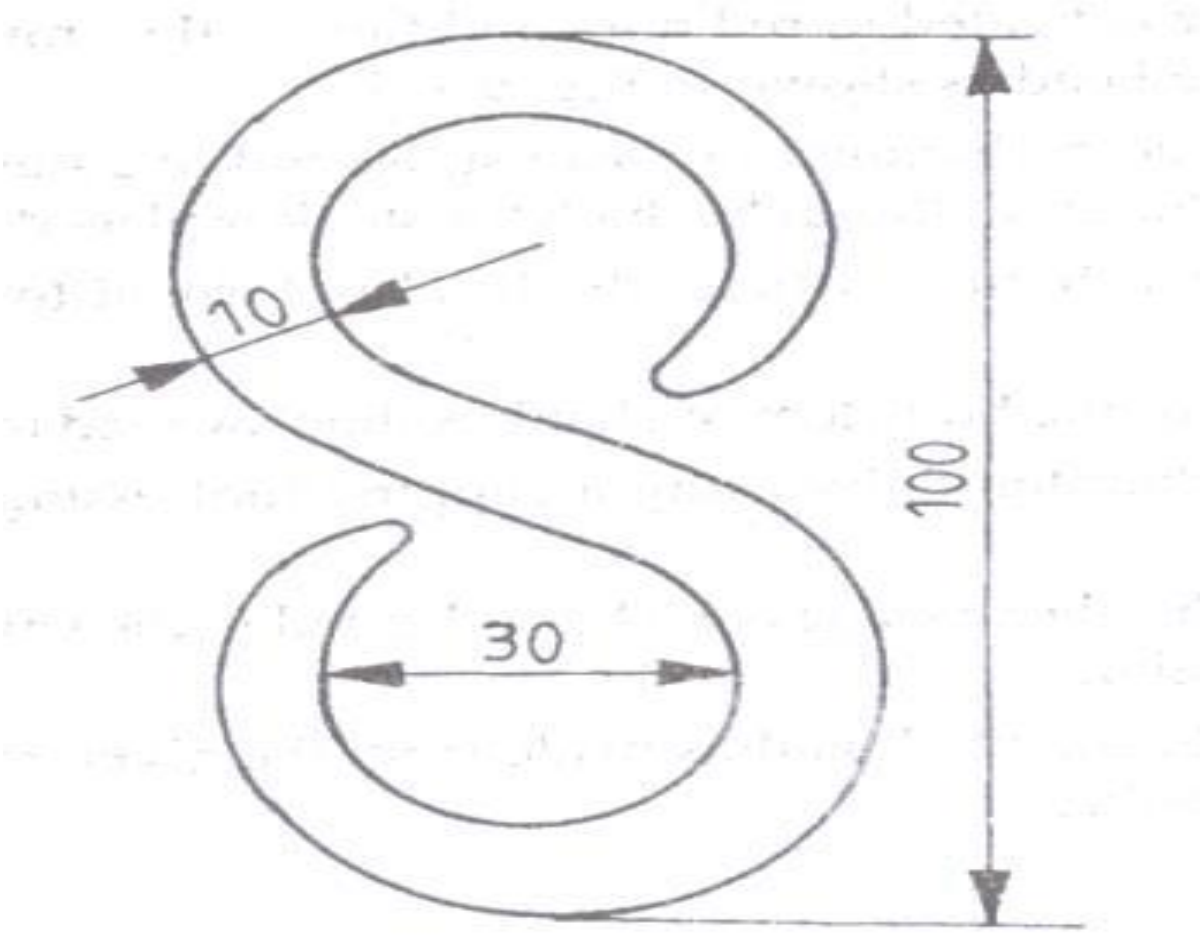
LAP Test	Practical Demonstrations

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within --- hour.

Task 2. S-Hook



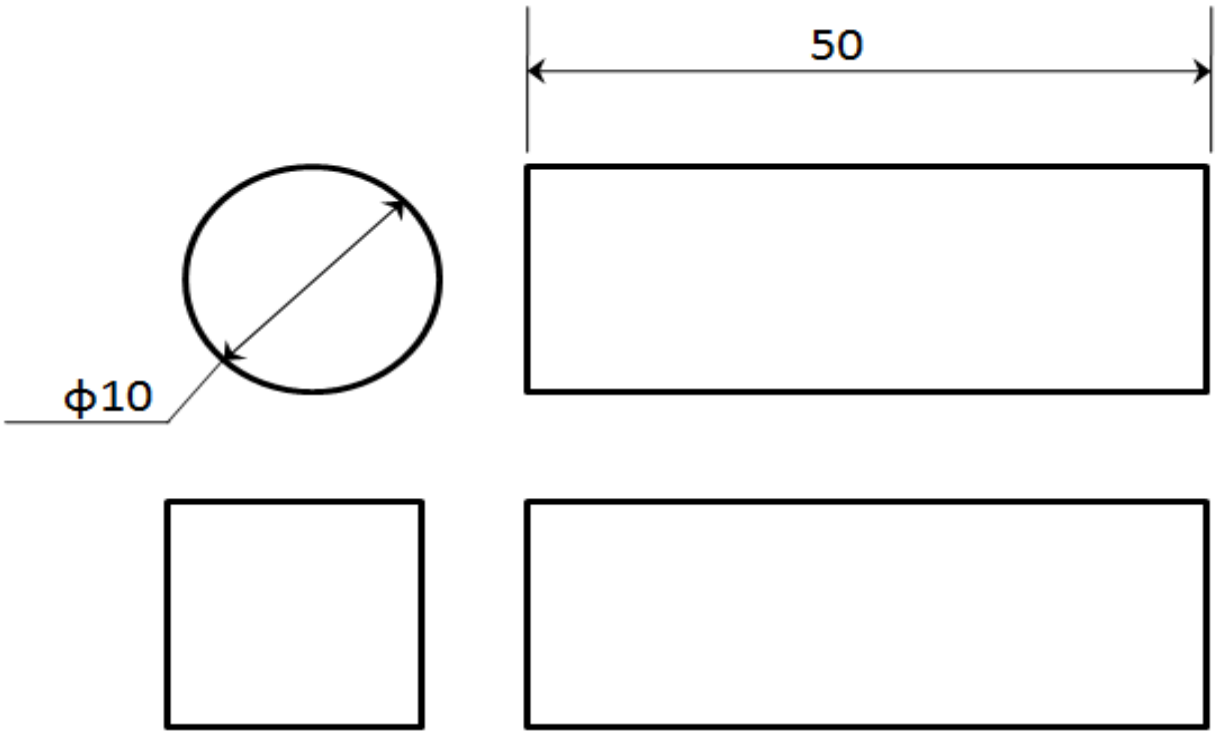
LAP Test	Practical Demonstrations

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within --- hour.

Task 3. **Square Rod**



List of reference materials

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2- Introduction to Basic manufacturing processes and work shopTechnology, Rajender Singh.
3- Web. set .www.Google.com