

MACHINING

LEVEL – I

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Module Title: - Performing Hand Forging

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Table of Content

TABLE OF CONTENT	2
ACKNOWLEDGMENT.....	4
ACRONYM	5
INTRODUCTION TO THE MODULE	6
THIS MODULE COVERS THE UNITS:	6
LEARNING OBJECTIVE OF THE MODULE	6
MODULE INSTRUCTION	6
UNIT ONE: ANALYZE AND PLAN HAND FORGING WORK	7
1. ANALYZE AND PLAN HAND FORGING WORK	7
1.1. INTERPRET DRAWING FOR SWAGING, BENDING, UPSETTING, SPREADING, PUNCHING AND DRIFTING	7
1.1.1. <i>FORGING METHODS</i>	8
1.1.2. <i>Advantages of forging</i>	9
1.1.3. <i>Limitations of forging processes</i>	9
1.2. HAND TOOLS AND FORMERS FOR REQUIRED FORGING TECHNIQUES	9
1.2.1. <i>Types of Forging Tools</i>	9
1.3. FORGING TEMPERATURES AND HEAT SPECIFICATIONS	16
1.3.1. <i>Forging Temperature</i>	16
1.3.2. <i>The average temperature of a forge</i>	17
1.3.3. <i>The function of forging temperature</i>	18
1.3.4. <i>Forging temperature measured</i>	18
1.4. WORK PLAN ACCORDING TO SPECIFICATIONS	18
1.4.1. <i>The five steps of impression die forging</i> :.....	18
SELF-CHECK-1.....	20
UNIT TWO: PERFORM HAND FORGING TECHNIQUES	21
2. PERFORM HAND FORGING TECHNIQUES	21
2.1. SET UP AND OPERATE HEATING EQUIPMENT CORRECTLY.	21
2.1.1. <i>Heating equipment</i>	21
2.1.2. <i>Controlling Heat to specified areas</i>	25
2.2. APPROPRIATE FORGING TECHNIQUES	26
2.2.1. <i>Forging techniques</i>	26
2.2.2. <i>Forging Operations</i>	27
2.3. ALLOWANCE FOR MATERIALS SHRINKAGE AND OXIDIZATION	36
SELF- CHECK: -1	38
OPERATION SHEET-1 DRAWING.....	39
LAP TEST-1 DRAWING DOWN A CIRCULAR TAPER.....	39

LAP TEST-2 DRAWING DOWN A CIRCULAR TAPER.....	40
UNIT THREE: QUALITY ASSURE WORK.....	42
3. QUALITY ASSURE WORK	42
3.1. EQUIPMENT THAT MINIMIZES OXIDIZATION	42
3.1.1. Heating Devices (hearth and Furnaces)	42
3.1.2. MATERIALS USED IN FORGING:.....	44
3.1.3. FORGING TEMPERATURES	45
3.2. CONTROLLING HEAT TO SPECIFIED AREAS AS PER INSTRUCTION	46
3.2.1. HEAT TREATMENT OF FORGING	46
3.2.2. CONTROL OF HEATING DEVICES	47
3.3. STANDARD DEVICES MEASURE FORM AND SHAPE.....	48
3.3.1. TESTING OF METALS	48
3.3.2. Tensile test	48
3.3.3. Compression Test	49
3.4. OCCUPATIONAL HEALTH AND SAFETY (OHS) MEASURES AND PROCEDURE	49
3.4.1. SAFETY PRECAUTIONS.....	49
3.4.2. DEFECTS IN FORGED PARTS	50
3.4.3. Some of the causes of accident in forging shop are.....	50
SELF-CHECK-1.....	50
REFERENCE	53

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Acronym

Introduction to the Module

In machine filed; the basic skills, knowledge and attitude required using hand tools and formers, applying hand forging techniques and operating heat treatment equipment. for machine filed.

This module is designed to meet the industry requirement under the **Perform Hand Forging** occupational standard, particularly for the unit of competency: **Perform Hand Forging**

This module covers the units:

- Hand forging work
- Hand forging techniques
- Quality assure work

Learning Objective of the Module

- Analyze and plan hand forging work
- Perform hand forging techniques
- Assure quality work

Module Instruction

For effectively use this modules trainee are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit one: Analyze and plan hand forging work

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

- Interpret drawing for swaging, bending, upsetting, spreading, punching and drifting
- Hand tools and formers for required forging techniques.
- Forging temperatures and heat specifications
- work plan according to specifications

This unit will also assist you to attain the learning outcomes 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
- 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

1. Analyze and plan hand forging work

1.1. Interpret drawing for swaging, bending, upsetting, spreading, punching and drifting

Forging is an oldest shaping process used for the producing small articles for which accuracy in size is not so important. The parts are shaped by heating them in an open fire or hearth by the blacksmith and shaping them through applying compressive forces using hammers. Thus, forging is defined as the plastic deformation of metals at elevated temperatures into a predetermined size or shape using compressive forces exerted through some means of hand hammers, small power hammers, die, press or upsetting machine. It consists essentially of changing or altering the shape and section of metal by hammering at a temperature of about 980°C, at which the metal is entirely plastic and can be easily deformed or shaped under

pressure. The shop in which the various forging operations are carried out is known as the smithy or smith's shop. A metal such as steel can be shaped in a cold state but the application of heat lowers the yield point and makes permanent deformation easier. Forging operation can be accomplished by hand or by a machine hammer. Forging processes may be classified into hot forging and cold forgings and each of them possesses their specific characteristics, merits, demerits and applications.

Hand forging process is also known as black-smithy work which is commonly employed for production of small articles using hammers on heated jobs. It is a manual controlled process even though some machinery such as power hammers can also be sometimes used.

You will be expected to prepare for the hand forging activities by obtaining all necessary information, documentation, materials, tools and equipment, and to plan how you intend to carry out the required hand forging activities. You will be required to prepare the appropriate equipment to use, based on the hand forging operations required and the materials to be used. You will be expected to use the specified or appropriate techniques to prepare the materials and equipment in readiness for the hand forging activities. The forging activities will include operations such as bending, twisting, drawing down, upsetting, swaging, punching, cutting off and flame welding, as applicable to the task

1.1.1. 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 is 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.

1.1.2. 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.

1.1.3. 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. Hand tools and formers for required forging techniques.

Hand Forging is also called as Smithing or Blacksmithing. It is the simplest form of **forging** in which the metal to be heated to high temperatures in the fire of a forge, and then it is beaten into shape on a metal anvil with sledges or hammers in order to get the required shape

1.2.1. Types of Forging Tools

Page 9 of 55	Ministry of Labor and Skills Author/Copyright	Perform Hand Forging	Version -1 August, 2022
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The types of forging tools include anvil, chisel, tong, fuller, hammer, press, die, flatter, punch and drift, swage, swage block, clamping vice, and hearth.

Using appropriate forging tools and equipment leads to perfect forge work. This forge is sometimes called hearth because it uses hearth as a source of heating metal for easy deformation. The modern forging equipment is highly automated, made of high-tech machinery, and has made life easier for blacksmiths.

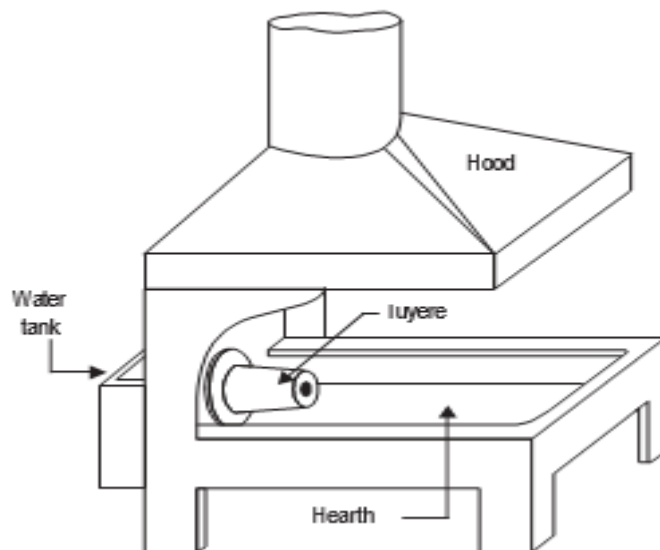


Fig. 1.1 Typical hearth



Fig .1.2. Types of hand forging tools

Anvil: Anvils are types of forging tools that serve as a workbench for blacksmiths. It is a large slab of metal usually made of steel. It is used to perform different operations like, flattening metal surfaces and obtaining shapes with the use of hammer. Some anvils contain hardy holes and punches holes. The hardy hole serves as a square shank for hardy and the punch hole provides clearance for punching a hole in the metal.

For the sake of understanding some of the common terms, there are five main parts on anvils:

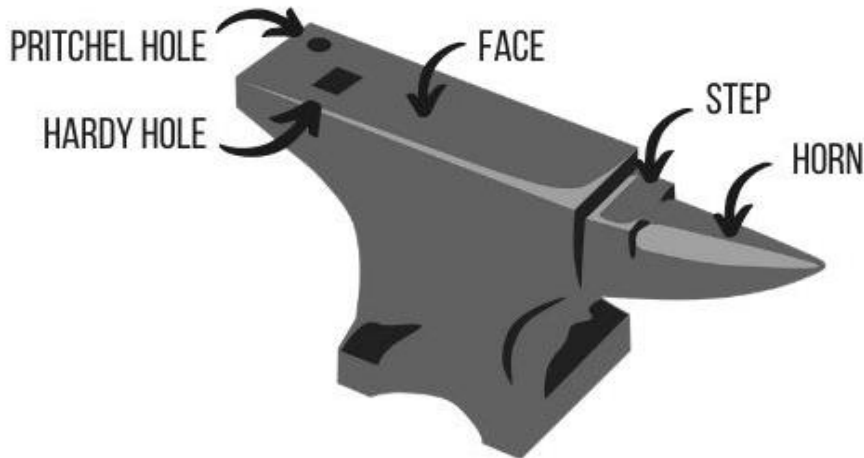


Fig. 1.3. Anvil

- **Chisel:** chisel is used for cutting and chipping out metal. It is made of high petroleum steel with an octagonal cross-section with a tapered cutting edge on one end. Chisel used in forging is of two types, Hot and cold chisel. Hot chisel is used for hot forging and cold chisel is used for cold forging.
- **Tong:** These types of forging tools are used in transporting the heated metal to the anvil. Tongs are available in different types and designs to provide adequate gripping of different metal shapes and sizes.

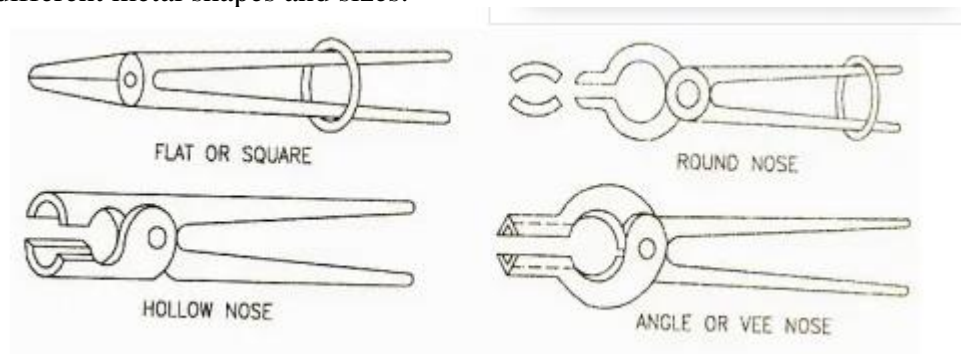


Fig. 1.4. Tongs

- **Fuller:** fuller helps to create groove or indentions in the forging process. It is also used to stretch the metal. Fuller works in pears, by placing one underneath the metal, and the other on top. This allows the indentation of both sides of the metal to occur simultaneously.

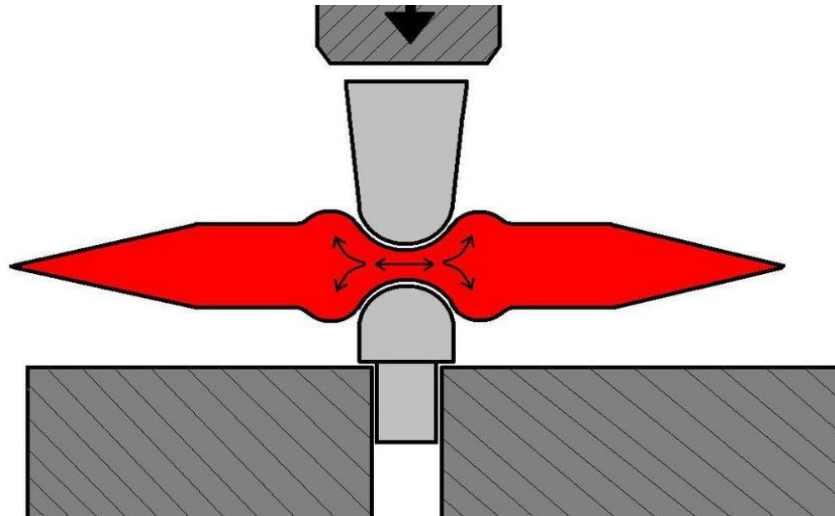


Fig. 1.5. Fuller

- **Hammers** are types of forging tools used in several ways, base on the type of forging needed to be performed, such as, hot forging, cold forging, closed die forging, upset forging, press forging etc. Hammer serves as a forging tool used in achieving shapes on work pieces. It is used as a striking tool and can be classified as, drop hammer and power hammer.
 - Drop hammer: heavy ram is falling onto the metal by gravity. It is used by the smith's hand power.
 - Power hammer: the power source is from hydraulics, compressed air, or electricity in driving the hammer. It is used when a large quantity of jobs is needed. The power works by placing the work piece on its anvil, level is used in controlling the heavy ram to fall on the work piece.

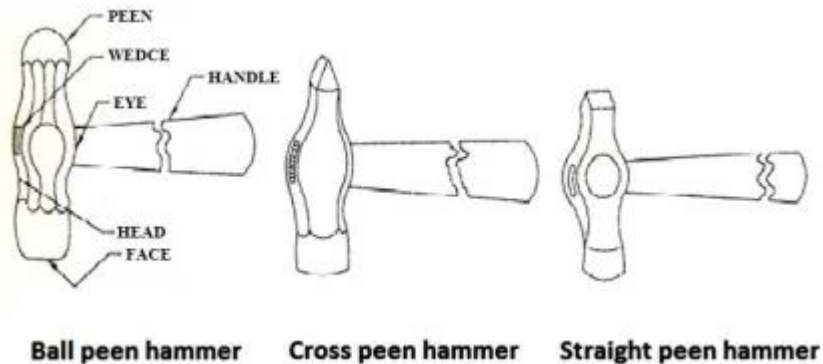


Fig. 1.6. Hammers

Punch and drift: These types of forging tools are made of high carbon steel which helps in making hot hole on hot metal pieces. This forging tool is available in different sizes and has a common shape. Drift is a large size of punch used in enlarging holes.

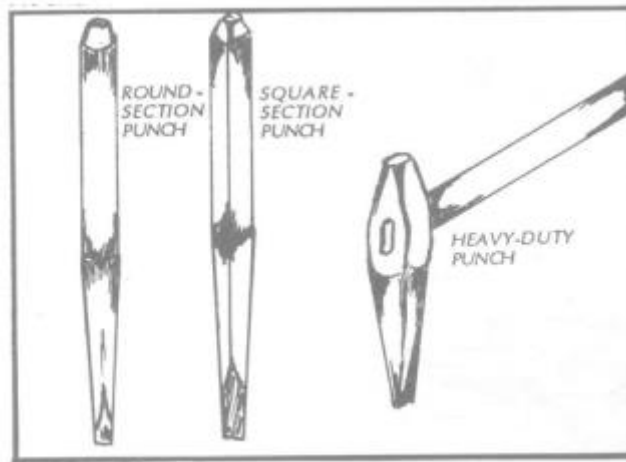


Fig. 1.7. Punch and drift

Flatter: this forging tool is used to flatten the surface of the work piece. It consists of a plane face joined with a straight shank. Flatters materials are high carbon steel.

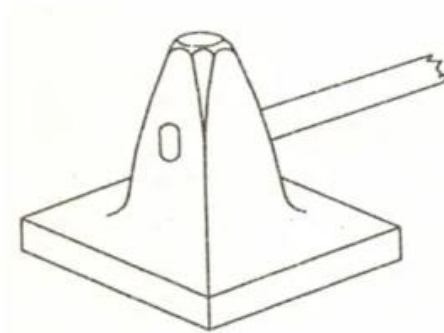


Fig 1.8. Flatter

Swage: Swage is a forging tool type that gives various shapes to the work piece. It is also made of high-carbon steel.

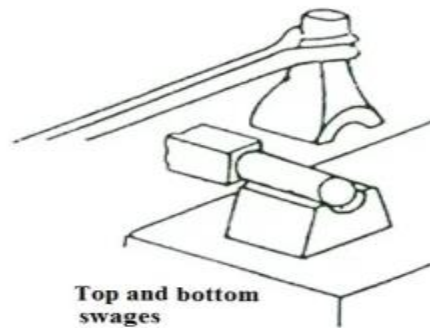


Fig 1.9. Swage

Swage block: this forging equipment is made of cast iron or cast steel rectangular block, having several holes in it. The holes are made of different sizes and shapes.

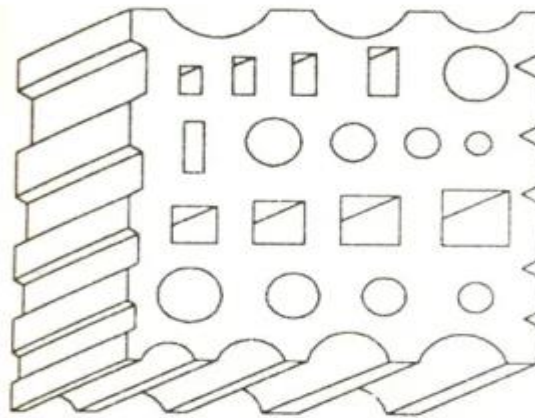


Fig 1.10 Swage block

Set hammer: set hammer is a forging tool used for making surface plane, forming and making corners. This forging tool has similar shapes with flatter. It is made of tool steel. The work piece must be placed on an anvil before a set hammer can be used.

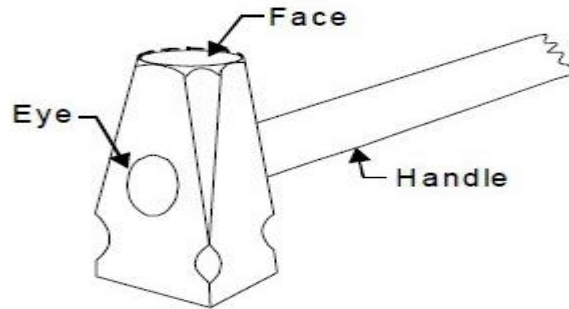


Fig 1.11. Set hammer

Clamping vice: this forging equipment is used in holding workpieces in the smithy show. It consists of two jaws, a spring, and a flat bottom. The work pieces are clamped between two jaws and tighten to hold it strongly.

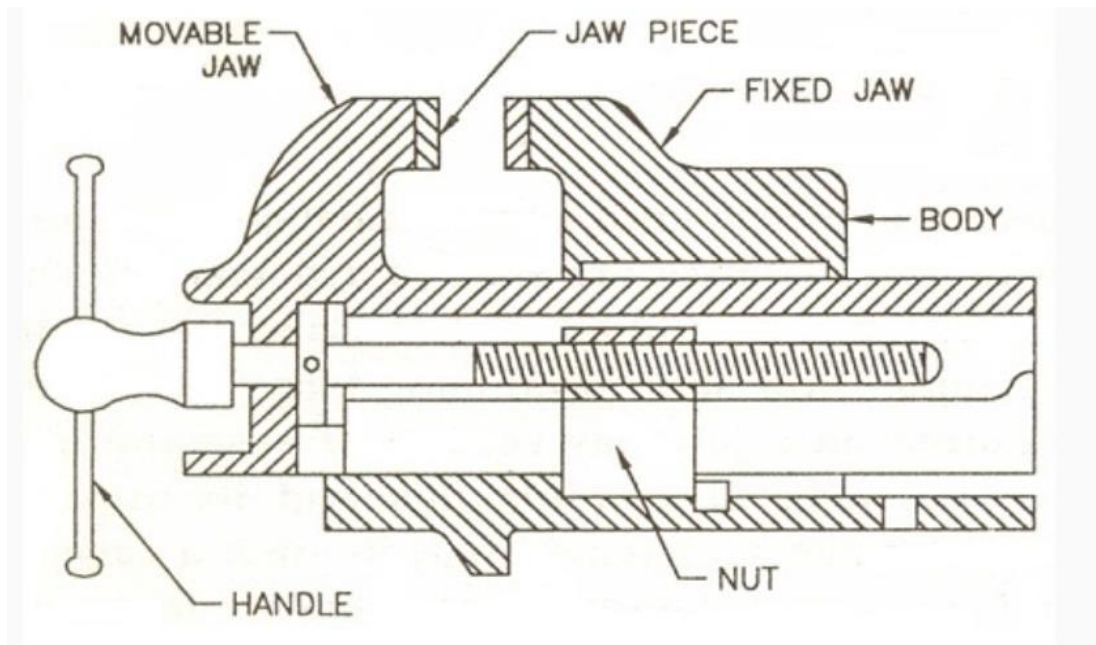


Fig 1.12 Clamping vice

Bick iron: this forging equipment is made of tool steel and it is hardened. It has a tapered tail at one side and the other portion is similar to the horn of an anvil. This forging equipment can also work on an anvil due to its taper shank.



Fig 1.13 Bick iron

Press: this forging equipment uses excessive pressure to fold metal into the desired shape. This forging equipment can forge the entire product at once. Presses are available in two types, mechanical and hydraulic press forging.

Mechanical press forging: this is a mechanical device, equip with a motor, crank, flywheel etc. it easily forces the ram against the metal. This forging equipment is not suitable for large or complex items, but it is useful when simple shaping effects is required.

- **Hydraulic press forging:** the operation is performed by high-pressure fluid propelled by hydraulic pumps in order to force ram against the metal. This forging equipment provides force while forging an item. It is used and preferred

This forging equipment is required to properly mold metal. It serves as molds into which malleable metals are pressed. The dies are important in all forging projects; it is used for large production and complex job. Dies are available in two types: open die and close die.

1.3. Forging temperatures and heat specifications

1.3.1. Forging Temperature

The calculation of the temperature distribution within the workpiece offers an optimal process planning (32). Based on this, the lowest possible forging temperature of the raw part can be determined depending on transport and storage times and the maximum available forming force in the design phase. In the production of near-net shape forging parts, the surface-to-volume ratio is higher than for conventional forgings. As this leads to a strong cooling in the thin-walled component regions, the temperature distribution has to be already taken into account in the

design phase. Considering the contact time, the choice of the forming machine has a high influence on the heat transfer into the tools and hence on the temperature distribution in the forged part (33,34). Therefore, the thermal coefficients in the creation of the simulation model are to be indicated as realistically as possible (35–37). Furthermore, the calculation of the workpiece temperature field is the basis for the design of a heat treatment out of the forging heat. The initial temperature before forging is 1200 °C; the temperature distribution of the gear shows a maximum temperature of 1210 °C in the center of the gear and a strong cooling in the teeth of about 400 °C (Figure 13). The reason for the strong temperature decreases in the teeth geometry is the heat transfer into the die during forming.

Steel forgings are regularly specified where strength, resistance to shock and fatigue, reliability, and economy are vital considerations. Forged materials also offer the desired degree of high or low temperature performance, ductility, hardness, and machinability. Advances in forging technology have expanded the range of shapes, sizes, and properties available in forged products to meet an increasing variety of design and performance requirements.

Broadly, the steel forgings go through: (a) hot forging, (b) warm forging, or (c) cold forging. These are briefly described as follows:

a. **Hot forging of steel:** The forging temperatures are above the recrystallization temperature, and are typically between 950°C–1250°C. Usually, one experiences good formability (i.e., filling of die-cavity in the context of forging), low forming forces, and an almost uniform tensile strength of the work-piece.

b. **Warm forging of steel:** Forging temperatures are still above the recrystallization temperature: between 750°C and 950°C. The scale-loss is lower at the work-piece surface and the tolerance is narrower compared to hot forging. One experiences limited formability and higher forming forces than in hot forging, but lower forming forces than in cold forging.

c. **Cold forging of steel:** Forging temperatures are around room conditions, adiabatic self-heating might bring the temperature up to 150°C. One experiences narrowest tolerances achievable and no scaling at work-piece surface. Further, an increase in strength and drop in ductility due to strain hardening might take place. The formability is rather low, and high forming forces are necessary.

Most importantly, your forge needs to be able to reach the right temperature to soften the metal, but not hot enough to melt it. The appropriate temperature for forging iron is 2500 degrees Fahrenheit or 1371 degrees Celsius

1.3.2. The average temperature of a forge

Heating The Metal

Page 17 of 55	Ministry of Labor and Skills Author/Copyright	Perform Hand Forging	Version -1
			August, 2022

Temperatures	Color	Description
900 °F	Red	
1,300 to 1,950 °F	Orange	
2,000 °F	Yellow	Typical forging temperature
2,100 to 2,500 °F	Bright Yellow to White	Hot enough to weld

1.3.3. The function of forging temperature

Isothermal forging

Adiabatic heating is used to assist in the deformation of the material, meaning the strain rates are highly controlled. This technique is commonly used for forging aluminum, which has a lower forging temperature than steels.

1.3.4. Forging temperature measured

The easiest way to tell what temperature a piece of steel is at is simply by seeing what color it's glowing. As steel begins to approach forging temperatures, it will start to glow red, then orange, and eventually yellow and white as it reaches higher and higher temperatures.

1.4. work plan according to specifications

A **work plan** represents the formal road map for a project. It should clearly articulate the required steps to achieve a stated goal by setting demonstrable objectives and measurable deliverables that can be transformed into concrete actions. An effective plan serves as a guiding document, enabling the realization of an outcome through efficient team collaboration.

1.4.1. The five steps of impression die forging:

1. Heating. Pre-forged metal starts with metal blocks called "ingots," which come in a variety of shapes and sizes depending on the part or component to be produced. ...
2. Preforming. ...

3. Finish Forging. ...
4. Cooling. ...
5. Finishing.

A. Heating.

Pre-forged metal starts with metal blocks called "ingots," which come in a variety of shapes and sizes depending on the part or component to be produced. These ingots are heated to a near molten state where the metal still retains its shape but can be altered easily with force.

B. Preforming.

In order to form a piece of the ingot to be pressed between the closed dies, the heated ingot is edged and blocked with a press or hammer. Edging is done to increase the working cross section and blocking is implemented to refine the shape for finish forging.

C. Finish Forging.

To complete the shape, the preformed metal is forced into an impression between two dies; this is where the metal takes on the general shape of the end product. Simple items may only need one press, but more complicated items may require multiple strokes at different pressures or even different dies to design the final product.

D. Cooling.

By coordinating the cooling of the metal, forgers can increase the strength of the final product by deforming and optimizing the grain flow within the metal. A unique aspect of impression die forging is the "flash," which is the excess metal that flows outside of the dies. The flash cools and hardens rapidly causing it to be stronger than the metal in the dies. This forces the metal in the dies to completely fill any cavities.

E. Finishing.

Once a forged product has gone through the pressing process, trimming and other surface treatment operations are performed in order to improve the dimensional accuracy of the forged product. Surface treatment can be completed to enhance corrosion resistance and improve the appearance of the finished forged product.

Self-check-1

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

PART ONE: -True /false (each have 2point)

1. In Hand forging process the forgings are made with the help of repeated blows in an open die.
2. The necessary tools and equipment's used for hand forging is Flatters, set hammers, ball peen hammer, welding machine.
3. The raw material for forging is usually a *bar, billet or sheet metal*.
4. *Forging* is the plastic working of metal by means of localized compressive forces
5. Pre-forged metal starts with metal blocks called "ingots," which come in a variety of shapes and sizes depending on the part or component to be produced.

PART TWO: – GIVE the Short answer and blank space (each has 2 point)

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

Unit Two: Perform hand forging techniques

This unit to provide you the necessary information regarding the following content coverage and topics:

- Set up and operate heating equipment correctly.
- Appropriate forging techniques
- Allowance for materials shrinkage and oxidization

This guide will also assist you to attain the learning outcomes stated in the cover page.

Specifically, upon completion of this learning guide, you will be able to:

- Set up and operate heating equipment correctly.
- Apply and carry out appropriate forging techniques
- Make allowance for materials shrinkage and oxidization

2. Perform hand forging techniques

2.1. Set up and operate heating equipment correctly.

2.1.1. Heating equipment

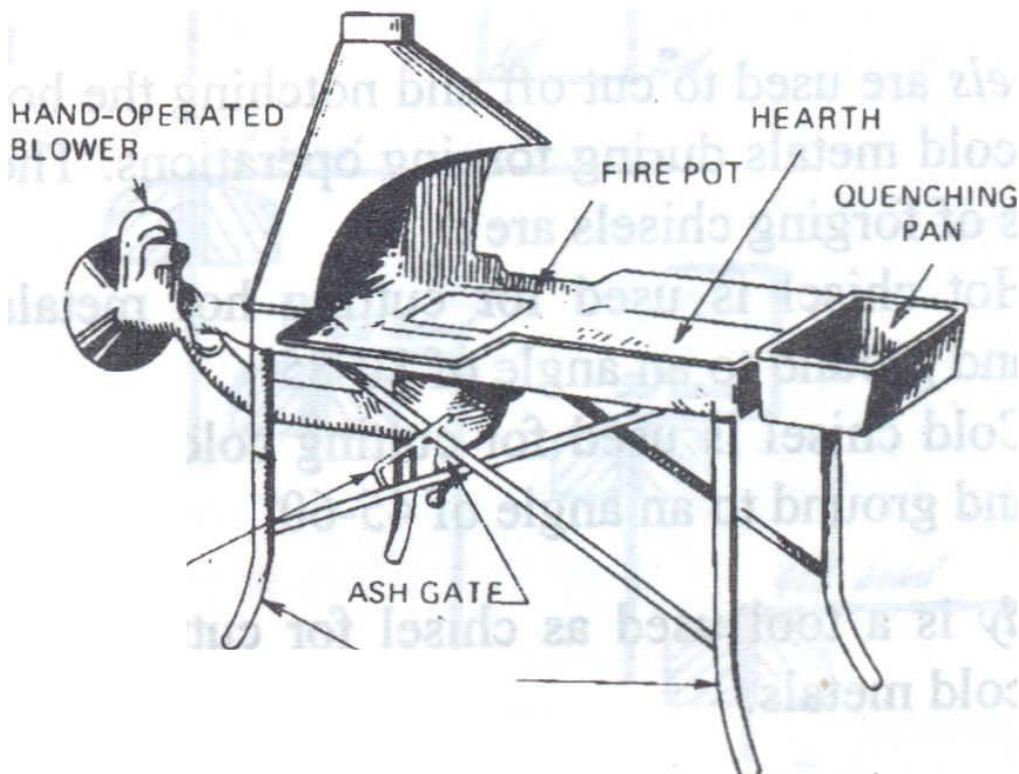


Fig. 2.1 Heating Procedure of Metal Setting for Fire

Setting up heating equipment

- i) Clean out the old fire from the forge hearth and remove the ash.
- ii) Put some wood shaving over the tubers and light.
 - iii) Turn on a little air using litter by hand or power blower to get the fire started.
 - iv) Keep a forging fire neutral throughout the heating of metal as shown in fig 39.

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

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,

- (a) **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.1 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.

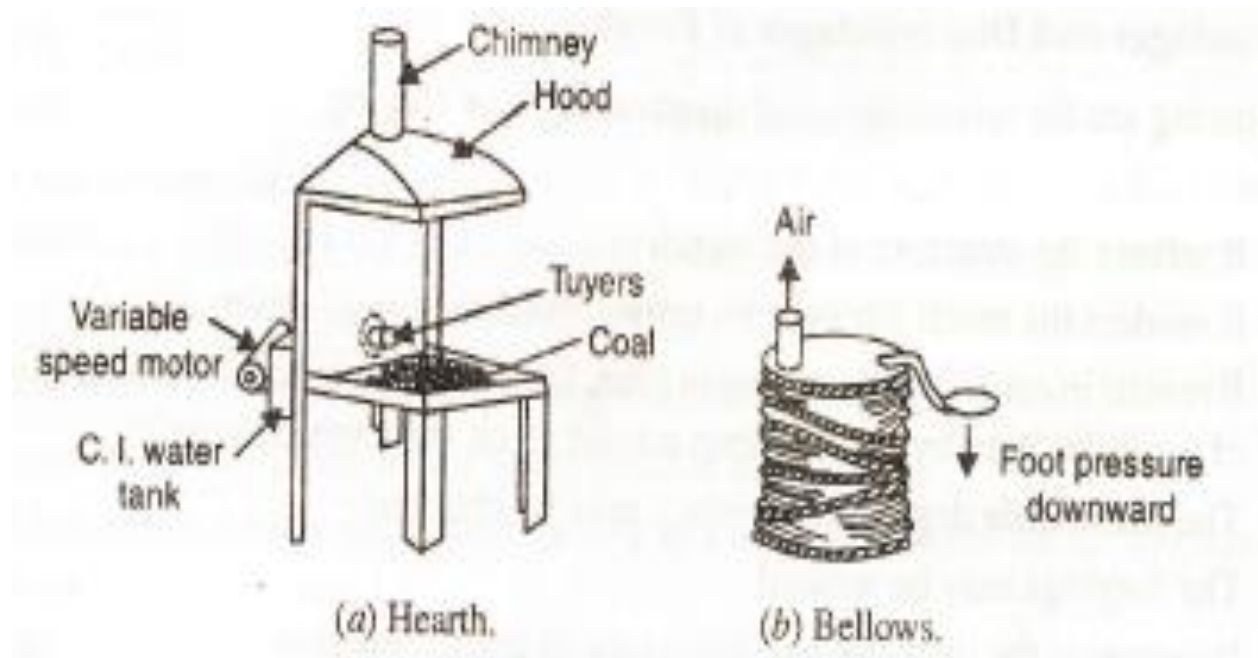


Fig.2.2. common form of the hearth

The fuel used in a hearth may be

- coke,
- coal or charcoal.

(b)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.

1. 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.



Fig 2.3 Box or box type furnaces

(b) Continuous type furnaces: -These furnaces are provided with mechanical pusher and are used 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.

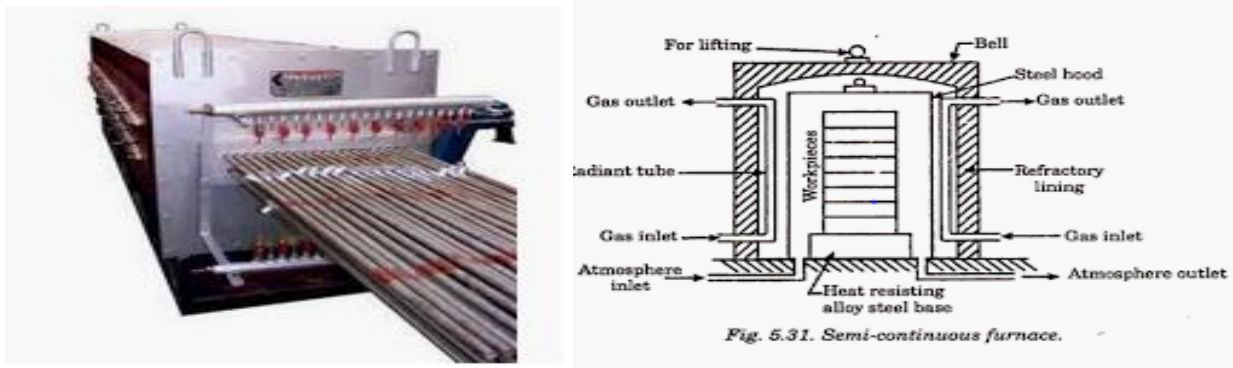


Fig 2.4. Continuous type furnaces

(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.



Fig 2.5. Slot type furnaces

(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.



Fig 2.6. Rotary hearth furnaces

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.

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

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 center 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.

2.1.2. Controlling Heat to specified areas

Heat during forging is controlled by the color of the metals.

Heating the metal

- i) . Never put the metal from the top with one end at the bottom of the fire. This heats the

metal unevenly.

- ii). Always place or put the metal in the center in a horizontal position.
- iii) . Remove the metal from the fire at intervals to see how hot it is.
- iv). Heat the metal to its proper color and temperature.
- v). Poorly heated metal will be difficult to forge and is liable to cracks.

2.2. Appropriate forging techniques

Forging techniques are essential elements of the blacksmithing and metalworking industries introduces the underpinning knowledge and forging skills that are the basis of all blacksmithing production in the forge environment.

The **forging company** uses different types of forging techniques to shape up the metal. Although these techniques are different from each other, they all provide the same kind of benefits. The pounding action used in forging deforms and shapes the metal in the way you want. The said process also leads to an unbroken grain flow.

2.2.1. Forging techniques

The process of forging enables the metal to retain its strength and durability. Forging is relatively affordable when compared to other metal fabrication processes. Here are the different kinds of forging techniques available with many forging companies:

A. Hot Forging

This forging process includes heating the metal beyond its recrystallization temperature. The metal gets heated up to 2,300 degrees Fahrenheit. The advantage of hot forging is that it decreases the energy required to form the metal. The excessive heat used in hot forging cuts down yield strength, thereby improving ductility

B. Cold Forging

As opposed to hot forging, the concept of cold forging shapes at metal at room temperature. Cold forging includes many forging techniques such as extruding, bending, cold heading, and cold drawing. This versatile method of metal reshaping requires the use of more powerful equipment. You may have to pay more to the forging company for this kind of metal forging.

C. Open Die Forging

The metals that do not have any precut profile when engaging in forging constitute open die forging. The open design in this process lets the metal flow everywhere except where it touches

the flat die. This type of metal reshaping is extremely popular in the field of art smithing. It is also used for shaping ingots before secondary shaping measures.

D. Closed Die Forging

This concept of forging is also known as impression die forging. It makes use of molds. The molds are connected to the anvil. There is a hammer that forces the molten metal that further flows into the cavities of the die. Closed die forging is a cost-effective option to choose. It also offers exceptional strength to the metal over other alternative methods.

E. Press Forging

This method of forging relies on the concept of compression. The metal is allowed to sit on a stationary die. After it, many compressions are applied with continuous pressure, which helps it attain the desired shape. The process of forging is time-consuming, but the results are incredible. You can also pair up press forging with hot or cold forging.

F. Roll Forging Process

Roll forging includes increasing wires or rods in terms of length. Heated bars of metal are then placed between two cylindrical rolls. These rolls then rotate and apply the desired pressure that eventually shapes the metal. This forging process has many benefits. It eliminates flashing and offers a superior grain structure.

2.2.2. Forging Operations

Forging is the oldest metal working process. Because it just requires heating and hammering of metals, man found it easy. The following forging operations are performed

Drawing down or swaging: Drawing out is used to reduce the thickness of a bar and to increase its length. It may be carried out by working the metal over the horn the anvil as shown in Fig. 14.17, then by hammering it on the anvil face. The rounded horn of the anvil acts as a blunt edge, which forces the metal to flow lengthwise when struck by the hammer. For drawing down very heavy work, fuller may be used for drawing down a bar over the horn (round portion) of anvil.

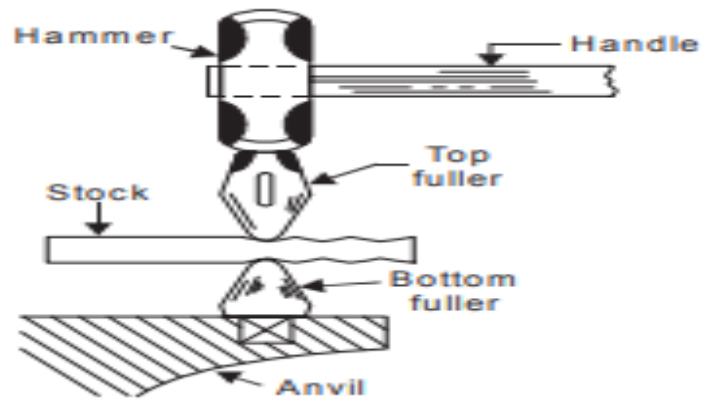


Fig. 2.7. Drawing out

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 are flat, circular, or square. Figure 2.3. shows the steps to follow in drawing down a circular taper:

1. Hammer four sides to produce a short square (Figure 2.3.(a)).
2. Lengthen the square taper (Figure 2.3.(b)).
3. Hammer the corners of the long square in step 2 to produce an octagonal shape (Figure 2.3.(c)).
4. Continue round all the corners in step 3 to obtain a circular end (Figure 2.3.(d)).

if the taper is flat or square go through either the first two or three stages above

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

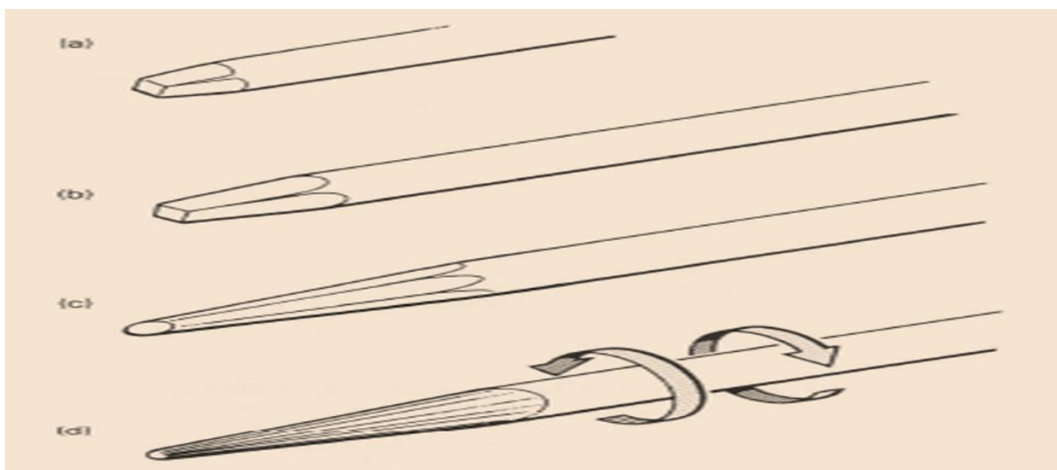


Fig 2.8. Drawing down or swaging

Figure 2.3 Stages in drawing down: 4a) first stage - short square; b) second stage -long square; (C) third stage-octagonal shape; (d) final stage - round shape. Avoid piping (hollow ends) when drawing down a taper

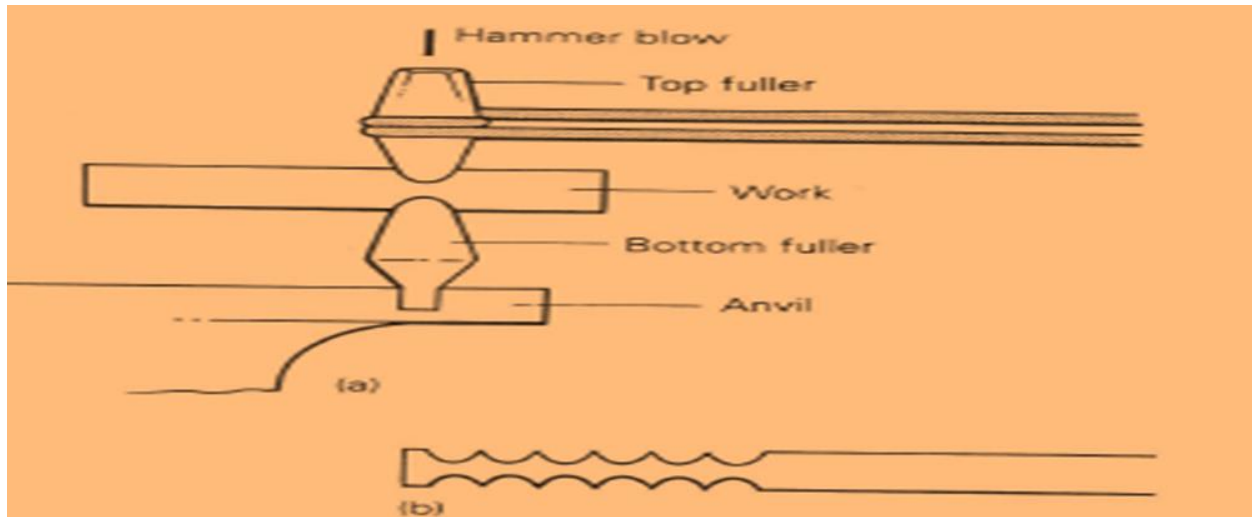


Fig: - 2.9. Drawing down

Upsetting: It is just reverse of drawing. The cross-sectional area of the work piece is increased and length decreases. For it, the compressive forces are applied along the length axis of the metal piece.

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 figure. 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.

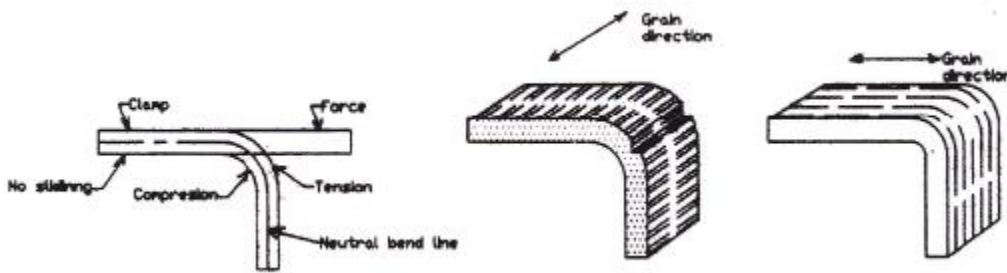


Figure 2.10. Bends at right angle and parallel to the grain direction

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 2.5 is $L = a_1 + b + a_2$,

Where a = length of leg at neutral line, b = length of arc at neutral bending line, a_1 and a_2 are under for mend parts of the part.

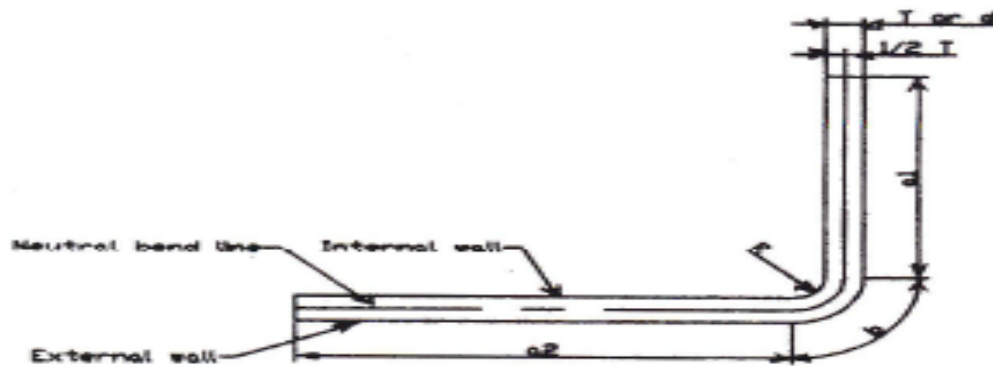


Figure 2.11. a 90° bend

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 $b = f l + tJ2$
Where θ = angle through which stock is bent 180° r = internal radius = $0.01745 (\theta) (r + t/2)$ t = thickness or diameter of material b length of arc at neutral bending line If $\theta = 90^\circ$, then the value of $(\theta \pi) / 180 = 1.571$ and the equation for a 90° bend becomes $b_{90} = 1.571 (r + t/2) (1)$

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

$$R = 50 - 8 = 42\text{mm.}$$

The lengths of the linear dimensions are: $N_1 = 100 - 42 = 58\text{mm}$ & $N_2 = 150 - 42 = 108\text{mm}$. The length of a at the neutral bending line is calculated **using (1) as b** $1.571 \text{ fr} + t'2)$

$$= 1.571(42 \div 8.2)$$

$$= \underline{7227\text{mm}}$$

Similar result is also found using arc length formula for different angle bends. In this case for 90-degree bend $be D) = 14$ or $[11 \times 2(r + 0.5t)] / 4$ gives the same blank length to the calculated one.

Thus, the developed length or the required blank length L is

$$N_1 + N_2 + a = (58 + 108 + 72.27) \text{ mm} = \underline{238.27\text{mm.}}$$

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 $AB = n R$ (for semi-circle)

$$\underline{3.14 \times 35\text{mm}}$$

$$= 10990\text{mm}$$

The bend allowance $BC = 54.95\text{mm}$

Length of flat $ab = 52 - (80 - 2) = 12 \text{ mm end}$ length of flat $be = 70\text{mm.}$

Thus the total length of blank $L = ab \text{ cd} + AB + BC$

$$= 12 + 70 + 109.9 + 54.95$$

$$= \underline{264.85 \text{ mm (before bending)}}$$

3) Find the developed length to form an eye shown below.

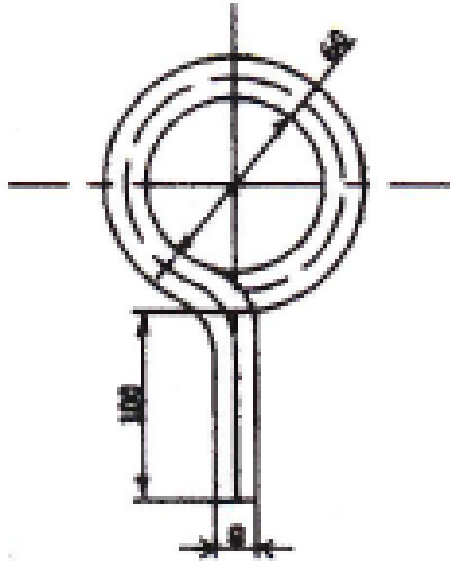


Fig 2.12. Coat hanger

Solution. ‘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 d = Inside diameter, T = Thickness diameter of metal used = $(3 \times 60 + 4 \times 8)$ mm = 212mm.

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 (Figure 5.13(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 (Figure 5.13(b)).

6. Work backwards (Figure 5.13(c)).
7. Turn it again and curve it round using the hick of the anvil (Figure (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.

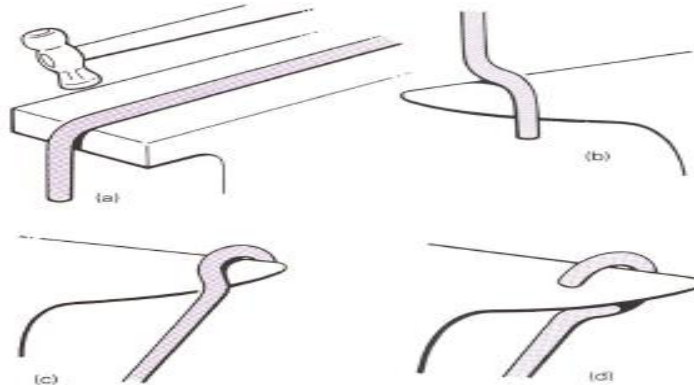


Figure 2.13. Bending/forming an eye: (a) first stage bending at right angles; (b) second stage; (C) third stage; (d) final stage.

Upsetting: - This process increasing the cross-section. It isa difficult process and requires skills developed over the pars. 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:

1. 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.

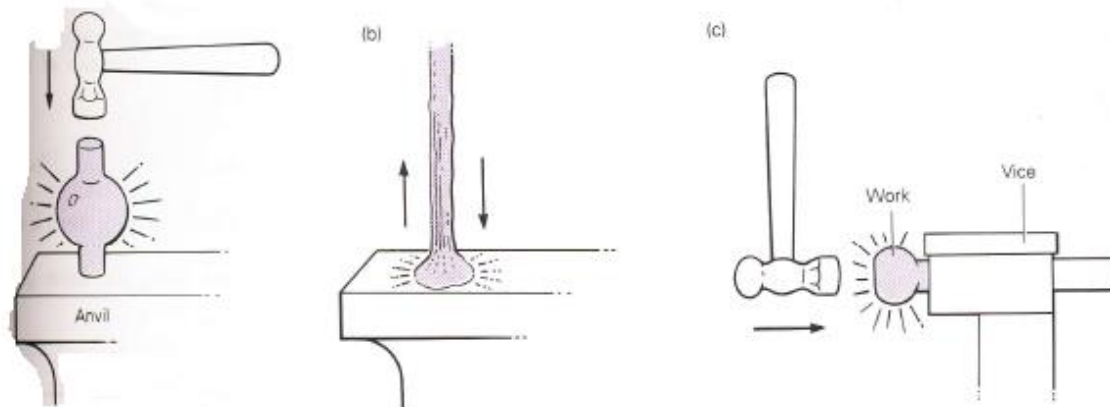


Fig 2.14.: - Upsetting

Punching is a main forging operation used for producing hole in metal plate by using a tool known as punch. The metal plate is placed over the hollow cylindrical die and punch is placed above it at required location where hole is being made. For punching a hole, the metal job must be at near welding heat and the punch is driven part way through the job with hammer blows. The work is then turned over and the hole is completed from the other side. The above said practice is adopted for thicker jobs.

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,

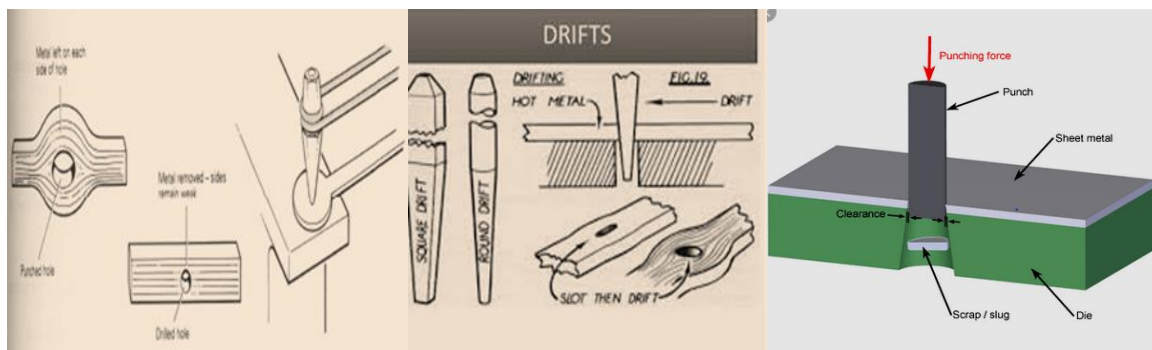


Fig.2.9. Punching and drifting

Fullering operation generally used in forging shop is shown in Fig. 2.8. It involves heating the stock in the black smith hearth. Then heated stock is placed on the fuller fixed on anvil. A fuller is put over the sock and hammering is done to reduce the cross section of job at required point.

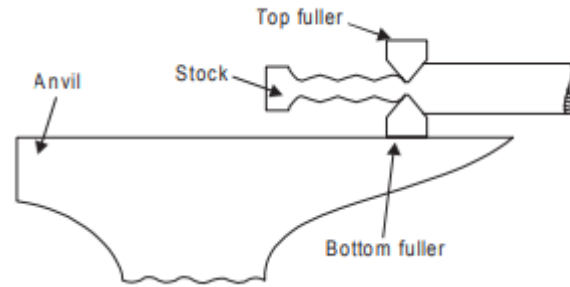


Fig. 2.10. Fullering

Cutting is a main forging operation to cut out a metal rod or plate into two pieces with the help of a chisel and hammer when the metal is in red hot condition. A hot or cold cut (chisel) is used for cutting heated metal bars in a smithy shop. The hot set does not require hardening and tempering. Its cutting edge is keener than that of a cold set. Hot sets are manufactured from a tough variety of steel in order that they may cut through relatively soft red-hot metal with ease. While cutting, it is best to cut half through the workpiece to turn it over and cut through from the other end.

Forge Welding It is a process of joining two metal pieces to increase the length by pressing or hammering them when they are at forging temperature. It is performed in forging shop and hence sometimes it is called as forge welding.

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

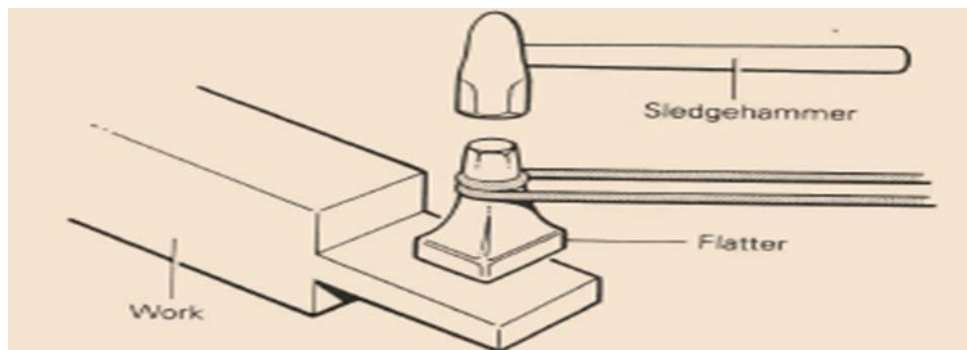


Fig.2.11. Flattening

Piercing: - Metal flows around the die cavity as a moving die pierces the metal

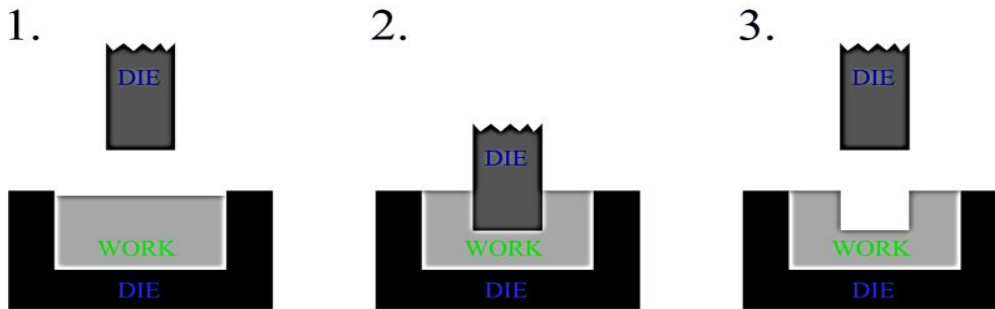


Fig 2.12

Roll forging → In this process, the bar stock is reduced in cross-section or undergoes change in cross-section when it is passed through a pair of grooved rolls made of die steel. → This process serves as the initial processing step for forging of parts such as connecting rod, crank shaft etc.

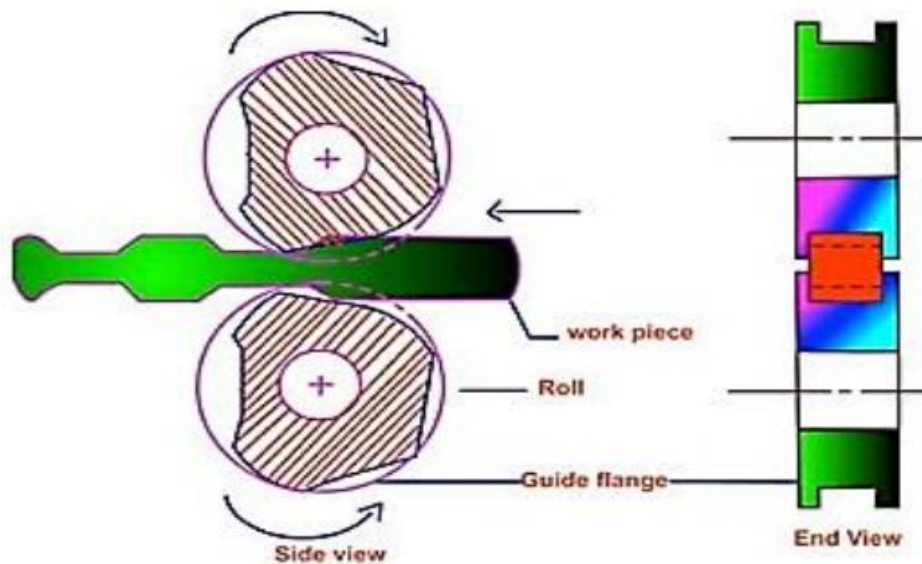


Fig 2.13 Roll forging

2.3. Allowance for materials shrinkage and oxidization

Allowance for Shrinkage. In doing work in the blacksmith shop it must be constantly remembered that the work is larger when being worked than it is when cool. Allowance must, therefore, always be made for shrinkage. As the pattern -maker allows for the contraction of the molten metal to the cold casting, so the blacksmith must allow for the contraction of the hot iron or steel to the cold forging. From the scale of iron heats at the several colors, given in Table

before, it will be seen that the temperature at which forgings are finished under the hammer, should be at about 900 ° Fahrenheit. When these same forgings are cold their temperature will be from 60 ° to 70 ° Fahrenheit. There is, therefore, a difference of at least 840 ° between the working and the finished temperature. The expansion of iron may be taken to average about .00000662 of its length for each increase of one degree Fahrenheit in its temperature. If a bar of machine steel exactly 2 feet long when cold is heated red hot and measured, it will be found to have increased nearly 1 inch in length. Taking the temperature of the red heat as 1370 ° Fahrenheit, and that of the cold bar as 70 ° Fahrenheit, the increase in length would be $X \frac{24}{1}$ (length in inches) inches. This expansion must be allowed for when measuring forgings red hot. In precision forging, die components are subjected to high loads in a very short period of time. Components must withstand to high static and impact pressures, friction forces between surfaces, and both mechanical and thermal fatigue. Although the workpiece is plastically deformed under compressive load, forging stresses in the dies are a complex combination of tension, compression and shear. In order to increase the resistance of the die insert against internal pressure, the die insert is shrink fitted into one or more shrink rings. Interference between mating diameters of adjacent rings imposes a compressive hoop (tangential) pre-stress on the die insert. The compressive hoop stress imposed by shrink ring has a cumulative effect at the bore of the die insert. Consequently, resultant tensile hoop stress on the bore, caused by the forging loads transmitted through the forging part, can be substantially reduced. Thus, allowing for maximum stress differences particularly at the bore makes it possible for higher forging pressures to be sustained.

The usual way to shrink fit design for precision forging of gear dies is to use thick wall cylinder theory (analytical approach) assuming that bore diameter is equal to pitch diameter by neglecting actual gear tooth shape. For more accurate determination, finite element method (FEM) can be used. The actual stresses predicted by FEM are much higher than the analytical approach, so that the design of the gear shaped die is beyond the capability of the analytical approach. In this paper, analytical approach for dies with gear teeth is modified using FEM solution sets. FEM analyses results are verified by experiments. During experiments cylinder approach is observed to be inadequate for forging loads. An easy-to-use set of formula and nomograms for determination of sizes of die and ring, and radial interference are presented. The solution set is verified with experiments.

Self- check: -1

PART ONE – Choose the best answer

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.
5. **Roll forging** → In this process, the bar stock is reduced in cross-section or undergoes change in cross-section when it is passed through a pair of grooved rolls made of die steel.
A. upsetting B. **Roll forging** C. bending D. Punching

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 |

Part IV Explain the following

1. Explain the various types of furnaces used in forging work?
2. Write Short notes on:
 - 2.1. Drop forging

2.2. Press forging

2.3. Flattening

Operation sheet-1 Drawing

Operation Title: - Drawing down a circular taper

PURPOSE: Exercising how to make different forging techniques

Equipment tools and materials:

1. Anvil
2. Straight pen hammer
3. Flat face hammer
4. Tong
5. PPE

PROCEDURE:

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

Precautions: -Use all safety regulations, safe working habits

Quality criteria: - Wright operation steps

Lap Test-1 Drawing down a circular taper

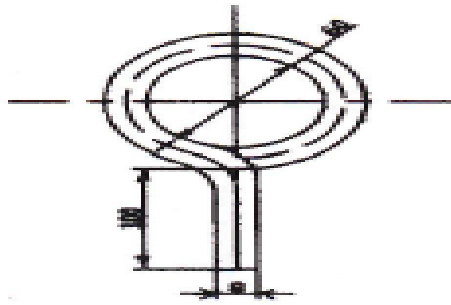
Tsk 1. Mansion the process that can produce tapers

Operation sheet-2 Bending & forming the Coat hanger

Operation Title: - forming the Coat hanger

Instruction: - Calculate the length of the blank required to form the Coat hanger shown below.
Assume that the diameter of the rod is 10mm

PURPOSE: Exercising how to make bending operation



Equipment tools and materials:

1. Anvil
2. Straight pen hammer
3. Flat face hammer
4. Tong
5. PPE

PROCEDURE:

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

If you are forming an eye, continue with the following stages:

5. Turn the work over on the hick and hammer it at the end
6. Work backwards
7. Turn it again and curve it round using the hick of the anvil

Precautions: -Use all safety regulations, safe working habits

Quality criteria: - specific dimension

Lap Test-2 Drawing down a circular taper

Task 1. Calculate the length of the blank required to form the Coat hanger shown above. Assume that the diameter of the rod is 10mm

Page 40 of 55	Ministry of Labor and Skills Author/Copyright	Perform Hand Forging	Version -1
			August, 2022

Task 2. Explain the procedures how the above coat hanger is made in a smith forging shop.

Task 3. Explain with neat sketches the following forging operations: (i) Upsetting, (ii) Drawing down, (iii) Bending, (iv) Drifting, (v) Punching, (vi) Welding (vii) Fullering

Unit THREE: Quality assure work

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

- Equipment that minimizes oxidization.
- Controlling heat to specified areas as per instruction
- Standard devices measure form and shape
- Occupational Health and Safety (OHS) measures and procedure

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

- Operate equipment that minimizes oxidization.
- Control heat to specified areas as per instruction
- Measure form and shape by applying standard devices
- Follow Occupational Health and Safety (OHS) measures and procedure

3. Quality assure work

3.1. Equipment that minimizes oxidization.

3.1.1. 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.

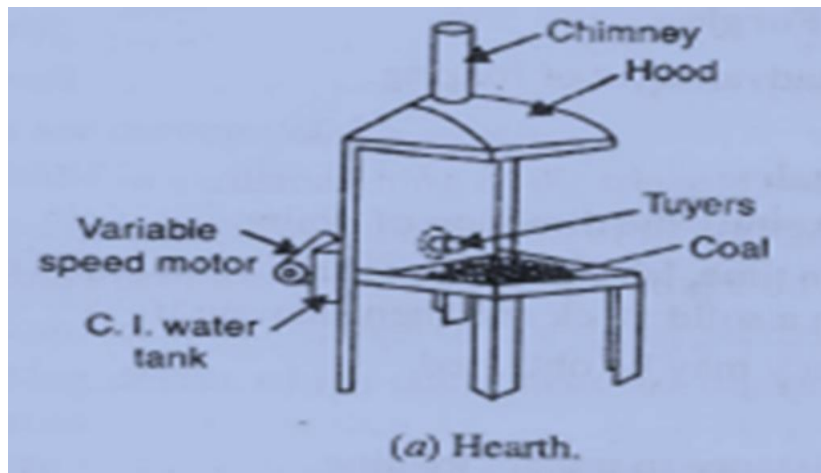


Fig 3.1. Heating Devices (hearth)

The fuel used in a hearth may be 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 motorized 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

3.1.2. 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

3.1.3. 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:

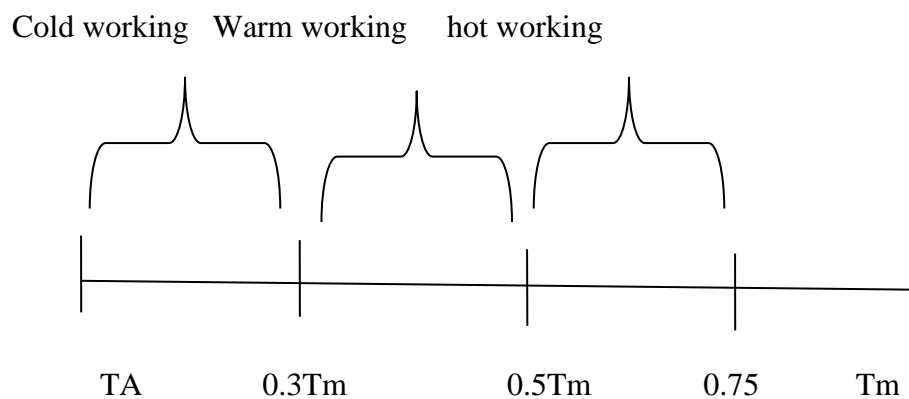


Fig 3.2. three temperature ranges

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.

3.2. Controlling heat to specified areas as per instruction

3.2.1. HEAT TREATMENT OF FORGING

What is heat treatment in forging?

Heat treating is used to alter and improve the physical properties of a given material using a heat treat furnace. Typical heat treatment techniques applied to steel forgings include **annealing, normalizing, quenching, and tempering**. Precipitation hardening applies to superalloys, titanium and some PH stainless steels.

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

What are the major points depending upon the forging temperature?

The forging temperature of an alloy will lie between the temperatures of its component metals. For most metals, forging temperature will be approximately 70% of the melting temperature in kelvins

Table 3.1. Forging temperature.

Material	Forging Temperature	
	Celsius	Fahrenheit
Aluminum	300 – 480	600 - 900
Zinc	419.53	787.154
Lead	327.46	621.428

3.2.2. 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 center of the hearth is called the tuyere 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 tuyere opening, therefore, the tuyere 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 these 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 center of a sufficiently large fire with additional fuel above to reduce the heat loss and atmospheric oxidation

3.3. Standard devices measure form and shape

3.3.1. TESTING OF METALS

Metal testing is accomplished for the purpose of for estimating the behavior of metal under loading (tensile, compressive, shear, torsion and impact, cyclic loading etc.) of metal and for providing necessary data for the product designers, equipment designers, tool and die designers and system designers. The material behavior data under loading is used by designers for design calculations and determining whether a metal can meet the desired functional requirements of the designed product or part. Also, it is very important that the material shall be tested so that their mechanical properties especially their strength can be assessed and compared. There fore the test procedure for developing standard specification of materials has to be evolved. This necessitates both destructive and non-destructive testing of materials.

Destructive tests of metal include various mechanical tests such as tensile, compressive, hardness, impact, fatigue and creep testing. A standard test specimen for tensile test Non-destructive testing includes visual examination, radiographic tests, ultrasound test, liquid penetrating test and magnetic particle testing.

3.3.2. Tensile test

A tensile test is carried out on standard tensile test specimen in universal testing machine.

Fig. 7.3 shows a schematic set up of universal testing machine reflecting the test specimen gripped between two cross heads. Fig. 7.4 shows the stress strain curve for ductile material. Fig. 7.5 shows the properties of a ductile material. Fig. 7.6 shows the stress strain curves for wrought iron and steels. Fig. 7.7 shows the stress strain curve for nonferrous material.

3.3.3. Compression Test

Compression test is reverse of tensile test. This test can also be performed on a universal testing machine. In case of compression test, the specimen is placed bottom crossheads. After that, compressive load is applied on to the test specimen. This test is generally performed for testing brittle material such as cast iron and ceramics etc. Fig. 7.8 shows the schematic compression test set up on a universal testing machine. The following terms have been deduced using figures pertaining to tensile and compressive tests of standard test specimen.

3.4. Occupational Health and Safety (OHS) measures and procedure

3.4.1. 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.

3.4.2. 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.

3.4.3. 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.

Self-check-1

DIRECTION: Answer all the questions listed below.

PART ONE – Choose the best answer for the following

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.

4. Destructive tests of metal include various mechanical tests such as

(a) tensile, compressive (b) hardness, impact, (c) fatigue and creep testing (d) all

5. Forging temperature of Aluminum is _____ Celsius

(a) 327.46

b) 300 – 480

c) 120

(d) 419.53

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- Shape Analysis & Measurement Michael A. Wirth, Ph.D. University of Guelph Computing and Information Science Image Processing Group © 2004

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