

Practical Workbook

MY-305 Metal Forming & Shaping Processes



Name _____

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Batch _____

Year _____

Department _____

**Department of Metallurgy Engineering
NED University of Engineering and Technology**

Practical Workbook

MY-305 Metal Forming & Shaping Processes



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**This is to certify that this practical book contains _____
pages.**

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Course Teacher

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Practical No. 1

Objective

To Study the general safety rules for metalworking operations

SAFETY IN COLD METALWORK

- .Keep the work area clean. Wipe up oil and grease spills immediately to prevent injuries caused by slipping and falling. Keep paths to exits clear.
- Use eye protection. When doing cold metalwork, wear approved safety glasses or a face shield.
- Store rags safely. Store oily and greasy rags in a fireproof metal container to prevent the spreading of spontaneous fires.
- Use the correct lifting method. Serious injury may result from straining due to incorrect lifting. Lift heavy objects with the leg muscles, not the back muscles. When lifting heavy objects, obtain assistance.
- Use proper tools. Always use the proper-sized tools and equipment for the job.
- Obtain the instructor's permission. Use equipment only with the instructor's permission. Notify the instructor immediately if you are injured.
- Wear proper clothing. Wear clothing that is not loose or bulky and wear hard-toed shoes with non-skid soles.
- Ground electrical equipment. Each electrical tool should be equipped with a three-prong plug and plugged into a grounded three-hole receptacle. When used outside, portable tools should be connected to ground fault circuit interrupter outlets.
- Restrain long hair. Restrain excessively long hair with a band or cap to keep hair from getting entangled in machines. When using a drill or drill press, be extremely careful with long hair.
- Secure stock. Be certain that stock to be cut, filed, or chiseled is securely fastened in a vise or by clamps to prevent tools from slipping.
- Mount holding devices securely. Mount vises, anvils, and clamps securely for cold metalwork

Safety Practices for Hot Metal Working

- Obtain the instructor's permission. Before using any tool or machine, you must obtain the instructor's permission. The instructor must be aware of all laboratory activities and will know if the equipment is in safe working order.
- Wear industrial-quality eye protection. To protect the eyes from sparks and metal chips, wear approved eye protection.
- Wear proper clothing. To protect against burns, wear clothing such as coveralls, high-top shoes, leather aprons, and leather gloves. Remove all paper from pockets, and wear cuff less pants.
- Protect hair and scalp. To protect the hair and scalp, restrain Excessively long hair and wear a cap.
- Know emergency procedures. In the event of an emergency, all students involved in or observing the emergency should call for help immediately as well as assist in correcting the situation. You should know the location of fire extinguishers and fire blankets and how to use them. You should also know the approved procedure for exiting the laboratory.
- Report all injuries or accidents to the instructor immediately, no matter how slight. The instructor will secure medical help.
- Keep work area and tools clean. Dirty, greasy, and oily tools and floors can cause accidents. Clean and put away all unneeded tools and materials. Clean up oil spills and scrap metal from the floor and equipment.
- Use correct tools. Always use the right size tool and only for its intended purpose. Use tongs or pliers for carrying hot metal.
- Avoid horseplay and loud talk. Loud talking as well as pushing, running, and scuffling while working with hot metal can cause serious accidents. Keep your mind on your work.
- Work in a well-ventilated area. Fumes and intense heat are part of hot metalwork and require that work be done outdoors or in a forced-ventilated area. This especially true when you are working with zinc (galvanized iron or pipe), cadmium, or beryllium.
- Use correct lifting methods. When lifting heavy objects, obtain help. Lift with the legs and not the back. Straining to lift heavy objects can cause serious injury.
- Store hot metal in a safe place. To avoid the possibility of accidental burns, keep hot metal in a safe place until it cools. Do not offer hot stock to the instructor for inspection.

- Never touch suspected hot metal. Test metal with moistened finger tips before actually touching it. Use tongs or pliers for handling hot metal.
- Turn off heat source before leaving work area. Before leaving the laboratory or work station, make certain the heat source is shut off and cool.
- Avoid using hot metalwork around flammable material. Do not perform hot metalwork on wood floors or near flammable material. Never work on containers that have been used for storage of combustible material without first having cleaned and safeguarded them.
- Protect welder cables and hoses when you are hot metalworking. Keep cables and hoses from coming in contact with hot metal and sharp objects. Never point a flame at cables or hoses.
- Use warm water instead of quenching oil for quenching. Quenching oil is easily confused with other oils. It is difficult to identify. If quenching oil is used, take it from new, previously unopened cans. Safety Practices for Using a Gas Furnace

Review Questions

Q1. What safety practices are used in your shop to promote general safety?

Q2. What equipment and machines in your shop must run, separate safety tests before you are allowed to operate them?

Q3. What personal safety protection devices or clothing must you wear while working in the shop?

Q4. What instructions are given for handling and storage of your job's material?

Q5. What procedure should you follow if you see an accident happen?

Practical No.2

Objective

To carry out cold rolling of non ferrous metal and study its effect on properties

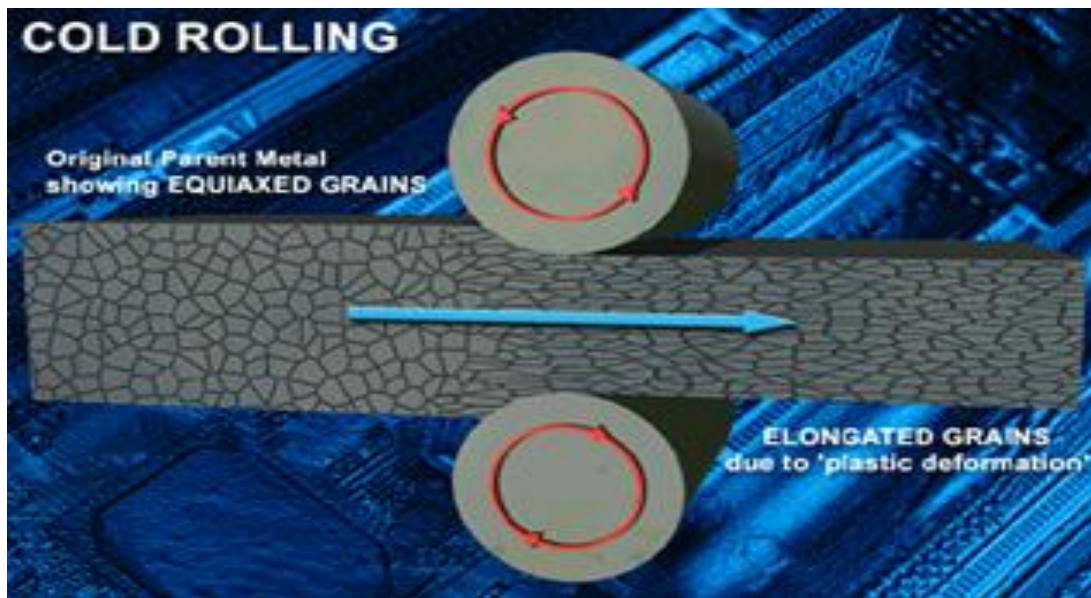
Apparatus

Rolling mill, nonferrous metal, hardness tester, metallurgical microscope

Theory

Cold rolling is a process by which the sheet metal or strip stock is introduced between rollers and compressed and squeezed. Cold rolling is done below recrystallization temperature. After cold working its grains are in a distorted condition. Plastic deformation or cold working affects all the properties of a metal that are dependent on the lattice structure. The amount of strain introduced determines the hardness and other material properties of the finished product. By cold rolling tensile strength, yield strength and hardness are increased, while ductility is decreased. Distortion of the lattice structure hinders the passage of electrons and decreases electrical conductivity in alloys. The increase in internal energy, particularly at the grain boundaries, makes the material more susceptible to intergranular corrosion, thereby reducing its corrosion resistance.

The advantages of cold rolling are good dimensional accuracy and surface finish. However, more power is required in cold rolling to deform higher strength starting material and overcome the additional resistance caused by strain hardening.



Cold rolled sheet can be produced in various conditions such as skin-rolled, quarter hard, half hard, full hard depending on how much cold work has been performed. This cold

working (hardness) is often called temper, although this has nothing to do with heat treatment temper.

Procedure:

Take the hardness of the material before rolling. Set the gap between the two rollers with the help of the adjusting knob. Turn on the mini rolling mill. Enter the material from the inlet side of the roller and collect the rolled material from the other side. Again measure the hardness of the rolled metal. The procedure is repeated at different reduction percentages.

Observations:

Material used

Initial dimension

Reduction (%)						
Hardness						

Results:

.....

.....

.....

.....

Advantages:

- High production rate.
- Suitable for production of plates, sheets and foils.
- Good dimensional accuracy and finish

Limitations:

- High equipment cost.
- Deformation limited to small reductions.

Review Questions

Q1. Discuss cold rolling process? Also describe the effect of roller size on the process and its disadvantages?

Q2. Discuss the straightening and roll bending process?

Q3. Discuss the problems in maintaining uniform thickness in a rolled product and some of the associated defects?

Q4. What is neutral point in rolling process?

Practical No.3

Objective

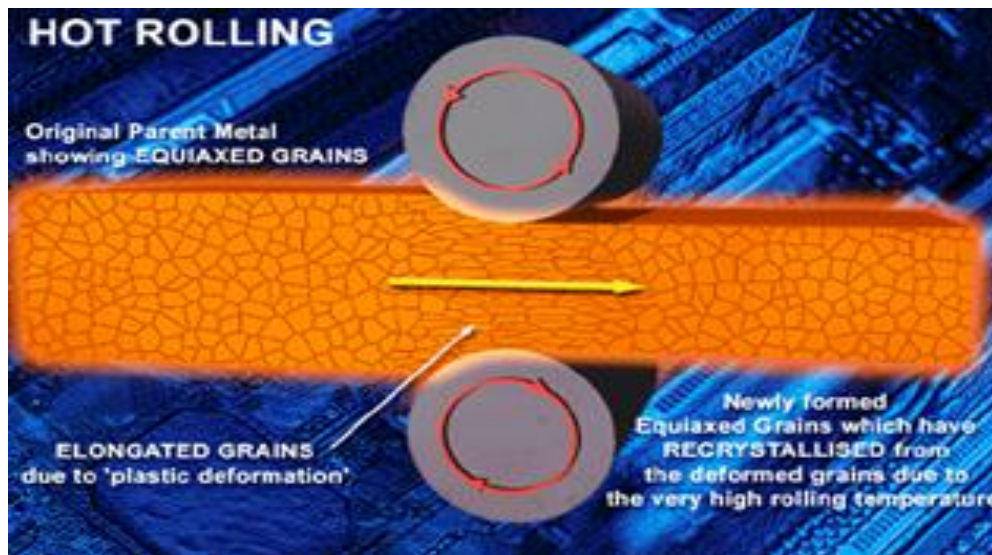
To carry out the hot rolling process

Apparatus

Hot rolling mill, reheating furnace, Billet/slab/ingot.

Theory

A slab, billet, or ingot is passed or deformed between a set of work rolls revolving at the same speed, but in opposite directions. The distance between the work rolls is slightly less than that of the passing metal which allows for thinning as shown in the fig:1. The temperature of the metal is generally above its recrystallization temperature, as opposed to cold rolling, which takes place below this temperature. Hot rolling permits large deformations of the metal to be achieved with a low number of rolling cycles. As the rolling process breaks up the grains, they recrystallize maintaining an equiaxed structure and preventing the metal from hardening. Hot rolled material typically does not require annealing and the high temperature will prevent residual stress from accumulating in the material resulting better dimensional stability than cold worked materials.



Hot rolling is primarily concerned with manipulating material shape and geometry rather than mechanical properties. This is achieved by heating a component or material to its upper critical temperature and then applying controlled load which forms the material to a desired specification or size. the degree of change to the metal is directly related to the heat of the metal, high heats allowing for greater thinning.

Review Questions

Q1. Why is it desirable to have uniform temperature when hot rolling a material?

Q2. Why is the important to control the finishing temperature of a hot rolling operation?

Q3. Why are hot rolled products generally limited to standard shapes and sizes?

Practical No.4

Objective

To carry out the Extrusion process

Apparatus

Extruder, extrusion dies, feed system, Billets, Height gage, lubrication, safety glasses

Theory

In the extrusion process the material is compressed in the chamber and the deformed material is forced to flow through the die. The opening corresponds to the cross-section of the required product. Products having constant cross-section can be produced by this method since the die geometry remains the same during the entire operation. The cross-sections that can be produced vary from solid round, rectangular, to L shapes, T shapes, Tubes and many other different types. Extrusion is done by squeezing metal in a closed cavity through a tool, known as a die using either a mechanical or hydraulic press.

Extrusion produces compressive and shear forces in the stock. No tensile is produced, which makes high deformation possible without tearing the metal. The cavity in which the raw material is contained is lined with a wear resistant material. This can withstand the high radial loads that are created when the material is pushed the die.

Extrusions, often minimize the need for secondary machining, but are not of the same dimensional accuracy or finish as machined parts. Surface finish for steel is $3\ \mu\text{m}$ ($125\ \mu\text{in}$), and Aluminum and Magnesium is $0.8\text{-}\mu\text{m}$ ($30\ \mu\text{in}$). However, this process can produce a wide variety of cross-sections that are hard to produce cost-effectively using other methods. Minimum thickness of steel is about 3 mm (0.120 in), whereas Aluminum and Magnesium is about 1 mm (0.040 in). Minimum cross sections are 250 m² (0.4 in²) for steel and less than that for Aluminum and Magnesium. Minimum corner and fillet radii are 0.4 mm (0.015 in) for Aluminum and Magnesium, and for steel, the minimum corner radius is 0.8mm (0.030 in) and 4 mm (0.120 in) fillet radius.

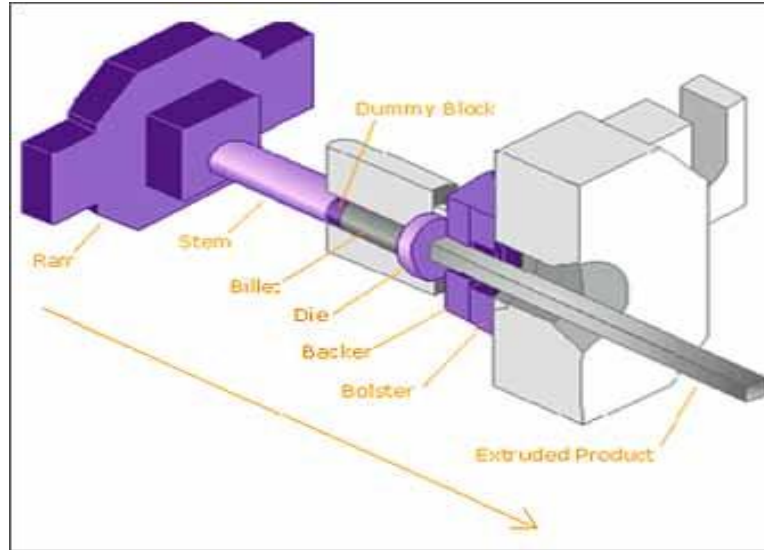


Fig. 1 Extrusion process

Cold Extrusion:

Cold extrusion is the process done at room temperature or slightly elevated temperatures. This process can be used for most materials-subject to designing robust enough tooling that can be withstand the stresses created by extrusion. Examples of the metals that can be extruded are lead, tin, aluminum alloys, copper, titanium, molybdenum, vanadium and steel. Examples of parts that are cold extruded are collapsible tubes, aluminum cans, cylinders and gear blanks. The advantages of cold extrusion are:

Hot Extrusion:

In Hot extrusion, a round billet which has been heated above the recrystallization temperature is compressed inside a cylindrical chamber by moving a ram and forced to flow through a die. The die opening may be round, or it may have other shapes. Hot extrusion is usually carried out by direct or indirect extrusion methods also called forward and backward/reverse extrusion.

1. Direct Extrusion:

In this the metal flow is in the same direction as that of the ram and is the most extensively used extrusion method. Because of relative motion between the heated billet and the chamber walls, friction is sever and this is generally reduced by using molten glass as lubricant – Particularly during extrusion of steels. At lower working temperatures, a mixture of oil and graphite is often used. The main components of direct extrusion are shown in fig.2.

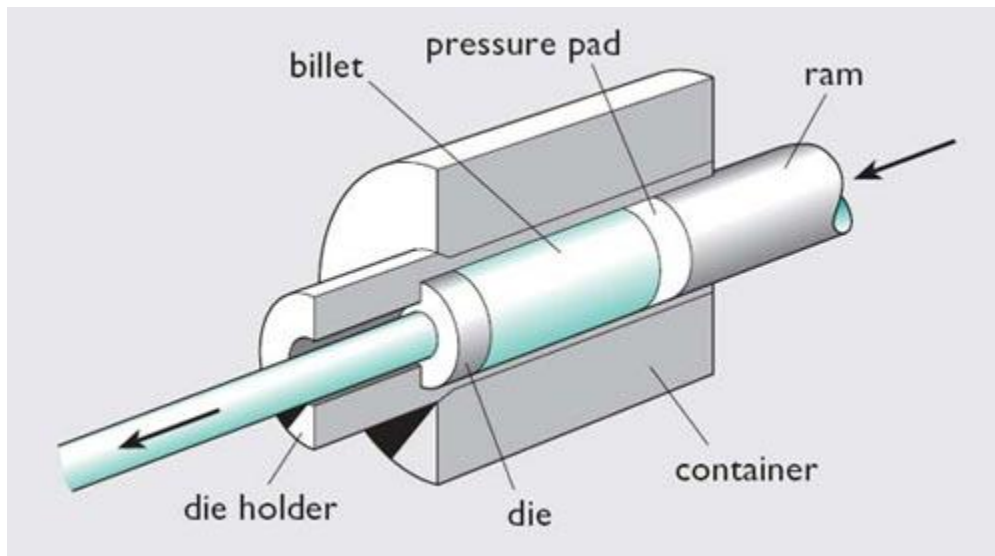


Fig. 2 Direct Extrusion

2. Indirect Extrusion:

The process where metal flow is in the opposite direction to that of ram movement, is relatively more energy efficient since it reduces friction considerably because there is no friction to overcome along the chamber walls. The process however is not used extensively because it restricts the length of extruded components. Also, handling of extruded products through a moving ram is not very convenient.

Typical parts produced by extrusions are trim parts used in automotive and construction applications, window frame members, railings, aircraft structural parts, etc. Fig. 3 shows the indirect extrusion process.

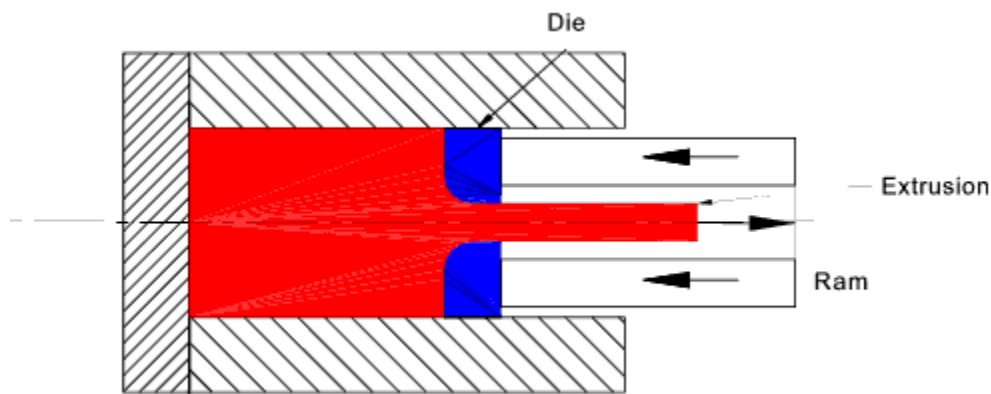


Fig. 3 Indirect Extrusion

Procedure:

1. Billets must be heated to approximately 800-925 ° F.
2. After a billet reaches the desired temperature, it is transferred to the loader where a thin film of smut or lubricant is added to the billet and to the ram. The smut acts as a parting agent (lubricant) which keeps the two parts from sticking together.
3. The billet is transferred to the cradle.
4. The ram applies pressure to the dummy block which, in turn, pushes the billet until it is inside the container.
5. Under pressure the billet is crushed against the die, becoming shorter and wider until it has full contact with the container walls. While the aluminum is pushed through the die, liquid nitrogen flows around some sections of the die to cool it. This increases the life of the die and creates an inert atmosphere which keeps oxides from forming on the shape being extruded. In some cases nitrogen gas is used in place of liquid nitrogen. Nitrogen gas does not cool the die but does create an inert atmosphere.
6. As a result of the pressure added to the billet, the soft but solid metal begins to squeeze through the die opening.
7. As an extrusion exits the press, the temperature is taken with a True Temperature Technology (3T) instrument mounted on the press platen. The 3T records exit temperature of the aluminum extrusion. The main purpose of knowing the temperature is to maintain maximum press speeds. The target exit temperature for an extrusion is dependent upon the alloy. For example, the target exit temperature for the alloys 6063, 6463, 6063A, and 6101 is 930° F (minimum). The target exit temperature for the alloys 6005A, and 6061 is 950° F (minimum).
8. Extrusions are pushed out of the die to the lead-out table and the puller, which guides metal down the run-out table during extrusion. While being pulled, the extrusion is cooled by a series of fans along the entire length of the run-out and cooling table. (Note: Alloy 6061 is water quenched as well as air quenched.)
9. Not all of the billet can be used. The remainder (butt) contains oxides from the billet skin. The butt is sheared off and discarded while another billet is loaded and welded to a previously loaded billet and the extrusion process continues.
10. When the extrusion reaches a desired length, the extrusion is cut with a profile saw or a shear.
11. Metal is transferred (via belt or walking beams systems) from the run-out table to the cooling table.
12. After the aluminum has cooled and moved along the cooling table, it is then moved to the stretcher. Stretching straightens the extrusions and performs 'work hardening' (molecular re-alignment which gives aluminum increased hardness and improved strength).
13. The next step is sawing. After extrusions have been stretched they are transferred to a saw table and cut to specific lengths. The cutting tolerance on saws is 1/8 inch or greater, depending on saw length.

Advantages:

- Moderate cost of equipments and tooling.
- Suitable for large reduction.
- Complex sections and long products can be produced.

Limitations:

- Only constant cross-section can be produced.
- Components with thin walls are difficult to produce.
- Lubrication is necessary.
- Dimensional accuracy and finish achieved are not good.

Review Questions

Q1. Describe various extrusion methods of making hollow shapes?

Q2. List the common ways of extruding metals.

Q3. What is the primary shape limitation of extrusion process?

Q4. What are some of the attractive features of the extrusion process?

Q5. Why is lubrication often a major concern in metal forming?

Practical No.5

Objective

To carry out the Forging process

Apparatus

Forging press, dies and punches, reheating furnace, trimming and piercing, metal to be forged

Forging

Forging is the process by which metal is heated and is shaped by plastic deformation by suitably applying compressive force. Usually the compressive force is in the form of hammer blows using a power hammer or a press. Forging refines the grain structure and improves physical properties of the metal. With proper design, the grain flow can be oriented in the direction of principal stresses encountered in actual use. Grain flow is the direction of the pattern that the crystals take during plastic deformation. Physical properties (such as strength, ductility and toughness) are much better in a forging than in the base metal, which has, crystals randomly oriented.

Forgings are consistent from piece to piece, without any of the porosity, voids, inclusions and other defects. Thus, finishing operations such as machining do not expose voids, because there aren't any. Also coating operations such as plating or painting are straightforward due to a good surface, which needs very little preparation.

Forgings yield parts that have high strength to weight ratio-thus are often used in the design of aircraft frame members.

A Forged metal can result in the following

- Increase length, decrease cross-section, called drawing out the metal.
- Decrease length, increase cross-section, called upsetting the metal.
- Change length, change cross-section, by squeezing in closed impression dies. This results in favorable grain flow for strong parts

Common Forging Processes

The metal can be forged hot (above recrystallization temperatures) or cold (below recrystallization temperatures).

Open Die Forgings / Hand Forgings:

Open die forgings or hand forgings are made with repeated blows in an open die as shown in the following fig: a. where the operator manipulates the work piece in the die. The finished product is a rough approximation of the die. This is what a traditional blacksmith does, and is an old manufacturing process.



Fig.1 Open-die Hot Forging Operation

Impression Die Forgings / Precision Forgings:

Impression die forgings and precision forgings are further refinements of the blocker forgings. The finished part more closely resembles the die impression. Fig: b clearly shows how impression die forging is to be carried out.

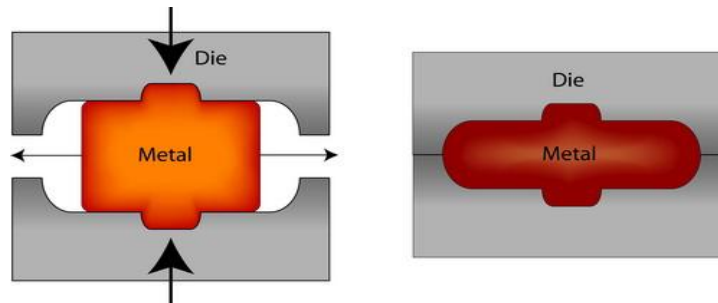


Fig.2 Impression Die Forgings

Press Forgings: Press forging use a slow squeezing action of a press, to transfer a great amount of compressive force to the work piece. Unlike an open-die forging where multiple blows transfer the compressive energy to the outside of the product, press forging transfers the force uniformly to the bulk of the material. This results in uniform material properties and is necessary for large weight forgings. Parts made with this process can be quite large as much as 125 kg (260 lb) and 3m (10 feet) long.

Design Consideration:

- Parting surface should be along a single plane if possible, else follow the contour of the part. The parting surface should be through the center of the part, not near the upper or lower edges. If the parting line cannot be on a single plane, then it is good

practice to use symmetry of the design to minimize the side thrust forces. Any point on the parting surface should be less than 75° from the principal parting plane.

- As in most forming processes, use of undercuts should be avoided, as these will make the removal of the part difficult, if not impossible.
- Recommended draft angles are described in the following table.

Material	Draft Angle ($^\circ$)
Aluminum	0 - 2
Copper Alloys (Brass)	0 - 3
Steel	5 - 7
Stainless Steel	5 - 8

- Generous fillets and radius should be provided to aid in material flow during the forging process. Sharp corners are stress-risers in the forgings, as well as make the dies weak in service. Recommended minimum radiuses are described in the following table.

Height of Protrusion mm (in)	Min. Corner Radius mm (in)	Min. Fillet Radius mm (in)
12.5 (0.5)	1.5 (0.06)	5 (0.2)
25 (1.0)	3 (0.12)	6.25 (0.25)
50 (2.0)	5 (0.2)	10 (0.4)
100 (4.0)	6.25 (0.25)	10 (0.4)
400 (16)	22 (0.875)	50 (2.0)

- Ribs should not be high or narrow, this makes it difficult for the material to flow.

Tolerances:

- Dimension tolerances are usually positive and are approximately 0.3 % of the dimension, rounded off to the next higher 0.5 mm (0.020 in).
- Die wear tolerances are lateral tolerances (parallel to the parting plane) and are

roughly +0.2 % for Copper alloys to +0.5 % for Aluminum and Steel.

- Die closure tolerances are in the direction of opening and closing, and range from 1 mm (0.040 inch) for small forgings, die projection area < 150 cm² (23 in²), to 6.25 mm (0.25 inch) for large forgings, die projection area > 6500 cm² (100 in²).
- Die match tolerances are to allow for shift in the upper die with respect to the lower die. This is weight based and is shown in the following table.

Material	Finished Forging Weight		
	Trimmed kg (lb)		
	< 10 (< 22)	< 50 (< 110)	> 500 (> 1100)
	Die Match		Tolerance
	mm (in)		
Aluminum, Copper Alloys, Steel	0.75 (0.030)	1.75 (0.070)	5 (0.200)
Stainless Steel, Titanium	1.25 (0.050)	2.5 (0.100)	6.5 (0.260)

- Flash tolerance is the amount of acceptable flash after the trimming operation. This is weight based and is shown in the following table.

Material	Finished Forging Weight		
	Trimmed kg (lb)		
	< 10 (< 22)	< 50 (< 110)	> 500 (> 1100)
	Flash		Tolerance
	mm (in)		
Aluminum, Copper Alloys, Steel	0.8 (0.032)	3.25 (0.125)	10 (0.4)
Stainless Steel, Titanium	1.6 (0.064)	5 (0.2)	12.5 (0.5)

A proper lubricant is necessary for making good forgings. The lubricant is useful in preventing sticking of the work piece to the die, and also acts as a thermal insulator to help reduce die wear.

Procedure

A typical forging operation involves the following sequence of steps.

1. Prepare a slug, billet, or perform by shearing (cropping), sawing or cutting off, either cold or hot. If necessary, clean surfaces by such means as shot blasting.
2. For hot forging, heat the work-piece in a suitable furnace and, if necessary, descales it after heating with a wire brush, a water jet, or steam or by scraping. The scaling may also occur during the initial stages of forging. The scale, which is usually brittle, falls off during plastic deformation of the part.
3. For hot forging, pre heat and lubricate the dies; for cold forging, lubricate the blank.
4. Forge in appropriate dies and in the proper sequence. If necessary remove, remove any excess material, such as flash, by trimming, machining or grinding.
5. Clean the forging, check its dimensions, and, if necessary, machine it to final dimensions and tolerances.
6. Perform additional operation, such as straightening and heat treating, for improved mechanical properties. Perform any finishing operations that may be required.
7. Inspect the forging for external and internal defects.

Advantages of Open Die Forging:

- Inexpensive tooling and equipment.
- Simple to operate.
- Wide range of work piece sizes can be used.
- Suitable for low production volume.

Limitations:

- Can be used for simple shapes only.
- Fairly skilled operators are required.
- Production rate is low.
- Dimensional accuracy and surface finish achieved are poorer
- Finishing required for achieving final shape.
-

Advantages of Closed-Die Forging:

- Suitable for high production rate.
- Can be used for production of complex shapes.
- Good dimensional accuracy and reproducibility

Limitations:

- High equipment and tooling cost.
- Appropriate die set for production of each component.
- More than one step required for each forging.
- Finishing required for achieving final shape.

Review Questions

Q1. Describe the factors to be considered during the designing of a die for forging?

Q2. What would happen to a brittle metal such as white cast iron, if it were formed by closed die forging?

Q3. Explain the flash-less forging process?

Q4. What attractive features are offered by counterblow forging equipment?

Q5. Discuss the importance of lubricant in forging process?

Practical No 6

Objective

To draw an Aluminum wire of $\text{Ø } 3.35\text{mm}$ from $\text{Ø } 9.50\text{mm}$ Rod

Apparatus

Dies (of required sizes), Pure Aluminum drawing Oil, Nose Pliers, Pair of Hand Gloves, Safety Goggles, Wire Drawing Machine, Pointing Machine.

Theory

In a typical wire drawing operation one end of the wire is reduced and passed through the opening in the die, gripped and pulled to reduce its diameter. Drawing wire gets wrapped round a power driven-capstan which provides the required frictional drag to pull the wire through the die. By successive drawing through dies of reducing diameter the wire can be reduced to a very small diameter. Annealing before each drawing operation permits large reduction in area and de scaling treatments prolong the life of the dies. Tungsten carbide dies are generally used for drawing of hard wires, and diamond dies is the choice for fine wires

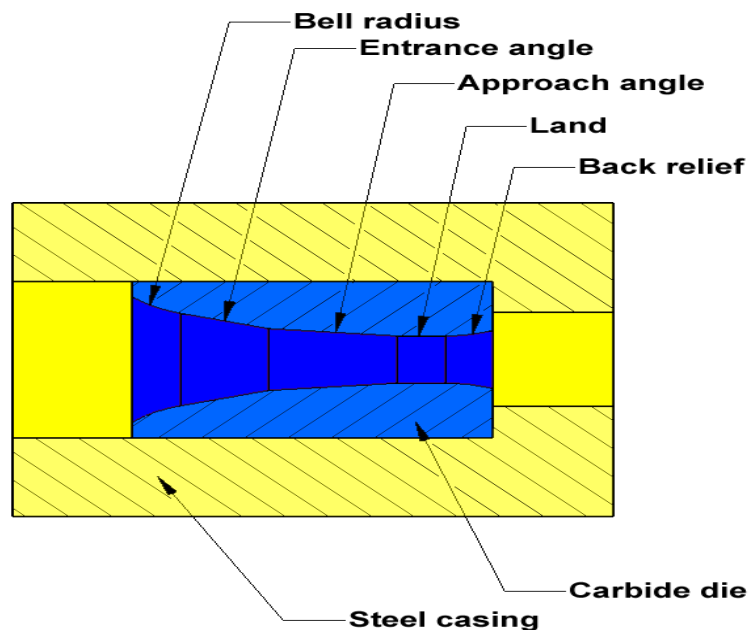


Figure Wire drawing Die

Procedure

1. Check all the connections of machine including Electrical and Drawing oil pipes and valves, and capstan surface.
2. Switch On the main of the wire drawing machine and Pointing Machine.

3. Now take 9.50mm Aluminum Rod and make a point in pointing machine by passing between the rollers cavity (first pass it from largest cavity then to the smaller cavity and so on).
 4. After sufficient reduction of wire diameter, fix the first die(9.30mm) in the die holder and pass the wire from it and pull it from die by the help of nose pliers.
 5. Then Pull the wire by the help of capstan 6 to 10 m long.
 6. Take another die and do the same process for all the other dies (do pointing further again if needed).
 7. Take wire and make a round to the capstan or pass it from capstan of the shortest diameter stage.
 8. Place the die in the die holder and pass it from another capstan then place a second die in the die holder and pass it to the capstan (Do it for the remaining dies).
- Note: As the wire reduces it should pass from the greater diameter stage of capstan.
9. Check the wire diameter of the wire coming out from the final die with the help of micrometer screw gauge.
 10. When all the dies are set in place, “inch” the machine so that the wire come outside the machine to the block and then to the take-up of the machine.
 11. Load spool on the take up of the machine and fix the wire in it by passing it from a hole given in the flange of the spool.
 12. Now turn On the take-up and Wire Drawing machine.
 13. When spool is filled with Al. wire stop the take up and Wire drawing machine at the same time.
 14. Unload the spool from the take-up. Now you have a wire of required diameter.

Review Questions

Q1. How many dies required to draw the aluminum wire from 8mm to 3.5mm if we do reduction in each die 14%.

Q2. How many types of wire drawing machine on the basis of process?

Q3. Which lubricant we use in copper, aluminum and steel wire drawing?

Q4. Can we do heat treatment after aluminum wire drawing?

Q5. What is the function of capstan in wire drawing machine?

Industries that rely on deep drawing include aerospace, automobile, dairy, lighting, pharmaceuticals, and plastics. Companies that manufacture deep drawn parts require engineer-designed operations and deep drawing presses are relatively expensive.

Accessories such as molds, tooling plates and columns are required to manufacture deep drawn parts. While a mold is needed for stretching the material over the mold's edge to produce the required shape, a tooling plate or column is needed as a surface for holding work pieces.

Lubrication lowers forces in deep drawing, increase drawn ability and reduces defects in the parts and wear on the tooling. In general, lubrication of the punch should be held to a minimum, because the friction between the punch and the cup improves drawn ability by reducing tensile stresses in the cup. For general, applications commonly used lubricants are mineral oils, soap solutions, and heavy-duty emulsions. For more difficult applications, coating, wax, and solid lubricant are used.

Review Questions

Q1. What will happen to the blank if blank holder force increased and decreased?

Q2. In deep drawing why lubrication is kept minimum?

Q3. Why is important the corner radii of the punch and die?

Practical No 8

Objective

To examine the microstructure of rolled, forged, extruded and drawn parts

Apparatus

Specimens to be examined, abrasive cutting machine, mounting machine, grinder, polisher, etchants, metallurgical microscope

Theory

What is Metallography?

- **Metallography:** is the science and art of preparing a metal surface for analysis by grinding, polishing, and etching to show microstructural component.
- **Microstructure:** is the geometric arrangement of grains and the different phases present in a material.



Fig. A simple Microstructure

- **Grain Boundaries:** is the interface between two grains in a polycrystalline material where the crystal is disordered due to rapid change in crystallographic directions.

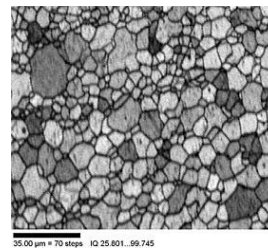
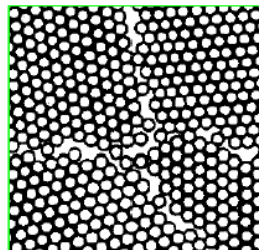


Fig. Polycrystalline Material

- Most engineering alloys are polycrystalline this means that each piece of a metal is made up of a great number of single crystals, or grains, each having a regular crystal structure (for example, FCC, BCC, or HCP).
- Materials specialists are interested to see the grain boundaries in order to estimate the grain sizes. The average grain size in metals is usually in the order of several to tens of micrometers, which can be measured only by the use of an optical or light microscope

Sample Preparation

- **Sampling:** The preparation starts by cutting a small representative piece of the metal to be studied.
- **Mounting:** Small samples can be difficult to hold safely during grinding and polishing operations, and their shape may not be suitable for observation on a flat surface. They are therefore mounted inside a polymer block or mount.



Fig. Sampling



Fig. Mounted Sample

Mounting

- **Cold mounting** can be done using two components resins (epoxies) which are liquid to start with but which set solid shortly after mixing. It requires very simple equipment consisting of a cylindrical ring which serves as a mould and a flat piece which serves as the base of the mould. The sample is placed on the flat piece within the mould and the mixture poured in and allowed to set. Cold mounting takes few hours to complete.
- **Hot-mounting** the sample is surrounded by an organic polymeric powder which melts under the influence of heat (about 200 C). Pressure is also applied by a piston, ensuring a high quality mould free of porosity and with intimate contact between the sample and the polymer.



Fig. Hot Mounting Press

Grinding

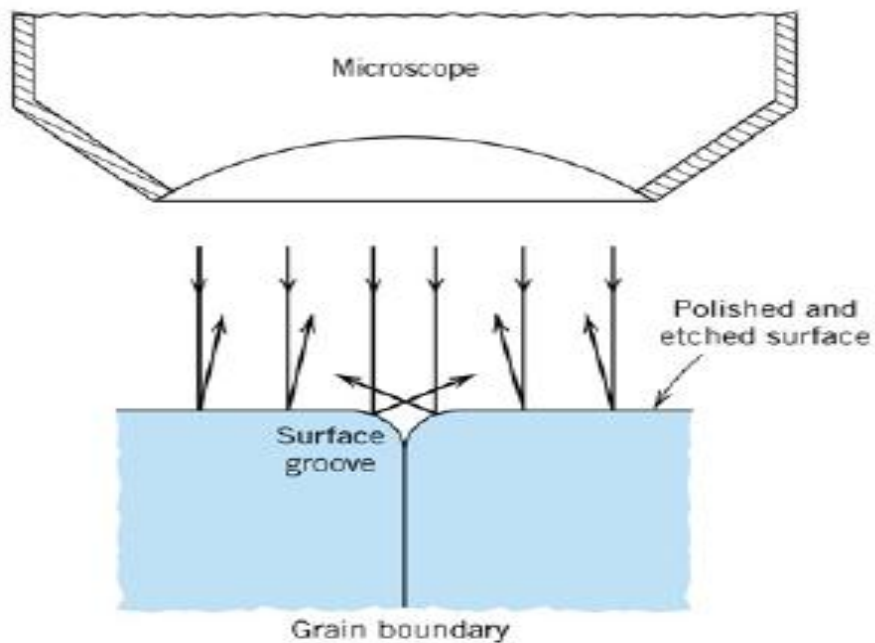
- Grinding is done using rotating discs covered with silicon carbide paper and water.
- There are a number of grades of paper, with 180, 240, 400, 1200, grains of silicon carbide per square inch. 180 grade therefore represents the coarsest particles and this is the grade to begin the grinding operation. *Always use light pressure applied at the centre of the sample.*
- Continue grinding until all the blemishes have been removed, the sample surface is flat, and all the scratches are in a single orientation.
- Wash the sample in water and move to the next grade, *orienting the scratches from the previous grade normal to the rotation direction.* This makes it easy to see when the coarser scratches have all been removed.
- After the final grinding operation on 1200 paper, wash the sample in water followed by alcohol and dry it before moving to the polishers.

Polishing

- The polishers consist of rotating discs covered with soft cloth impregnated with a pre-prepared slurry of hard powdery alumina particles (Al_2O_3 , the size ranges from 0.5 to 0.03 μm).
- Begin with the coarse slurry and continue polishing until the grinding scratches have been removed. *It is of vital importance that the sample is thoroughly cleaned using soapy water, followed by alcohol, and dried before moving onto the final stage.* Any contamination of the final polishing disc will make it impossible to achieve a satisfactory polish.
- Examining the specimen in the microscope after polishing should reveal mirror like surface.

Etching

- The purpose of etching is two-fold.
 - Grinding and polishing operations produce a highly deformed, thin layer on the surface which is removed chemically during etching.
 - Etchant attacks the surface with preference for those sites with the highest energy, leading to surface relief which allows different crystal orientations, grain boundaries, precipitates, phases and defects to be distinguished in reflected light microscopy as demonstrated in following figure.



- Etching should always be done in stages, beginning with light attack, an examination in the microscope and further etching only if required.
- If you over-etch a sample on the first step then the polishing procedure will have to be repeated.
- The table below gives the etchants for alloys that will be examined in this experiment.

Sample	Etchant
Al alloys	Keller's (2ml HF + 3ml HCL + 5ml HNO ₃ + 190ml water)
Cu-Zn alloy (brass)	10ml HNO ₃ + 90ml water
Steel and cast irons	Nital (2% HNO ₃ + 98% ethanol)

Microscopic techniques

- Optical microscopy used to obtain an enlarged image of a small object. In general, a compound microscope consists of a light source, a condenser, an objective, and an ocular or eyepiece, which can be replaced by a recording device such as a photoelectric tube or a photographic plate. The optical microscope is limited by the wavelengths of the light used and by the materials available for manufacturing the lenses.



Fig. Optical/Metallurgical Microscope

Results

Average grain size

The number of phases present

Sketch of the microstructures

Review Questions

Q1. Briefly describe the microstructural information you got from different samples.
