AIRCRAFT PRODUCTION TECNOLOGY

III B. Tech V semester (Autonomous IARE R-18)

BY

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CO's	Course outcomes
CO1	Demonstrate different type of materials used in aircraft industry and study its properties
CO2	Understand the process of casting and inspection techniques used for production.
CO3	Explain sheet metal operations and its tooling operations used for aircraft industry.
CO4	Gain knowledge about the basic convectional and unconventional Machining
CO5	Understand the importance of composites and its manufacturing process.

AIRCRAFT ENGINEERING MATERIALS

MODULE - I

CLOs	Course Learning Outcome
CLO1	Choose a concept or idea of technical real time problems to form solutions for the same.
CLO2	Understand, Identify, Study and comprehend processes that lead to solutions to a particular production.
CLO3	Develop one- self to extend the outputs of research.

Classification of Engineering Materials –

- Engineering Materials
  - Metallic Materials
    - Ferrous
      - Steels
        - Plain
        - Carbon
        - Alloy
      - Cast iron
        - Grey
        - White
        - Malleable
        - Ductile
        - Nodular
    - Non-ferrous
      - Aluminium
      - Copper
      - Magnesium
      - Tin
      - Zinc
      - Lead
      - Nickel and their alloys
  - Non-metallic Materials
    - Organic
      - Plastics
      - Wood
      - Paper
      - Rubber
      - Leather
      - Petroleum
    - Inorganic
      - Minerals
      - Cement
      - Glass
      - Ceramics
      - Graphite

Iron Carbon Equilibrium Diagram

- Alloy of the Iron-Carbon system include steel and cast iron
- Alloys with a carbon content up to 2% are known as steels
- Alloys with a carbon content above 2% are called Cast Irons.
- The Iron-carbon system provides the most prominent example of heat treatment

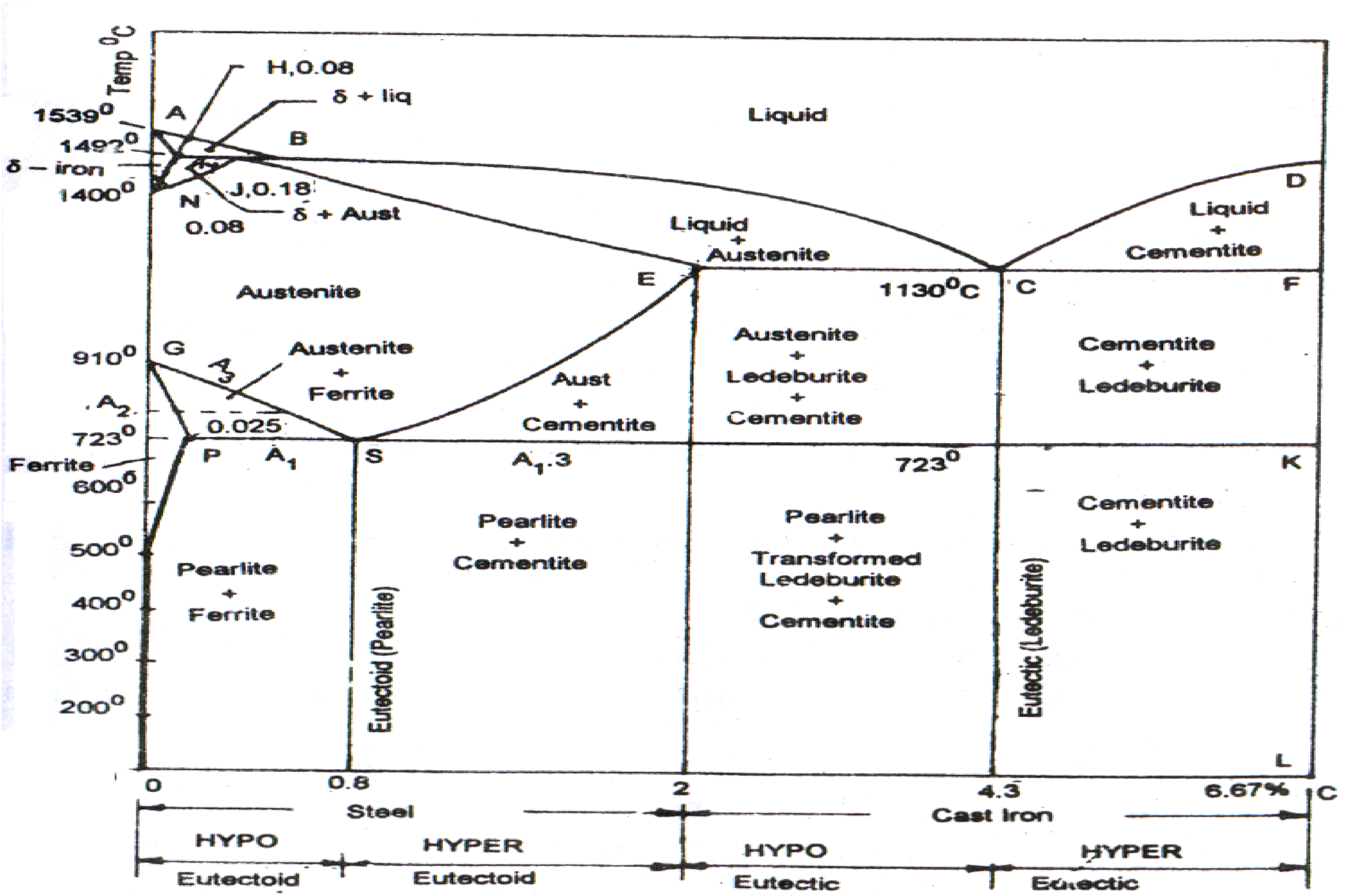
Eutectoid steels

- Steels with a carbon content from 0.008 to 0.8% are called hypo eutectoid steels
- Steels containing carbon from 0.8 to 2% are called hyper eutectoid steels
- Steel with a carbon content of 0.8% is known as eutectoid steel

Eutectic Steels

- Iron having carbon in the range of 2 - 4.3% is called Hypo eutectic steels
- Iron having carbon in the range of 4.3 to 6.67% is called Hyper eutectic steels

Iron Carbon Equilibrium Diagram



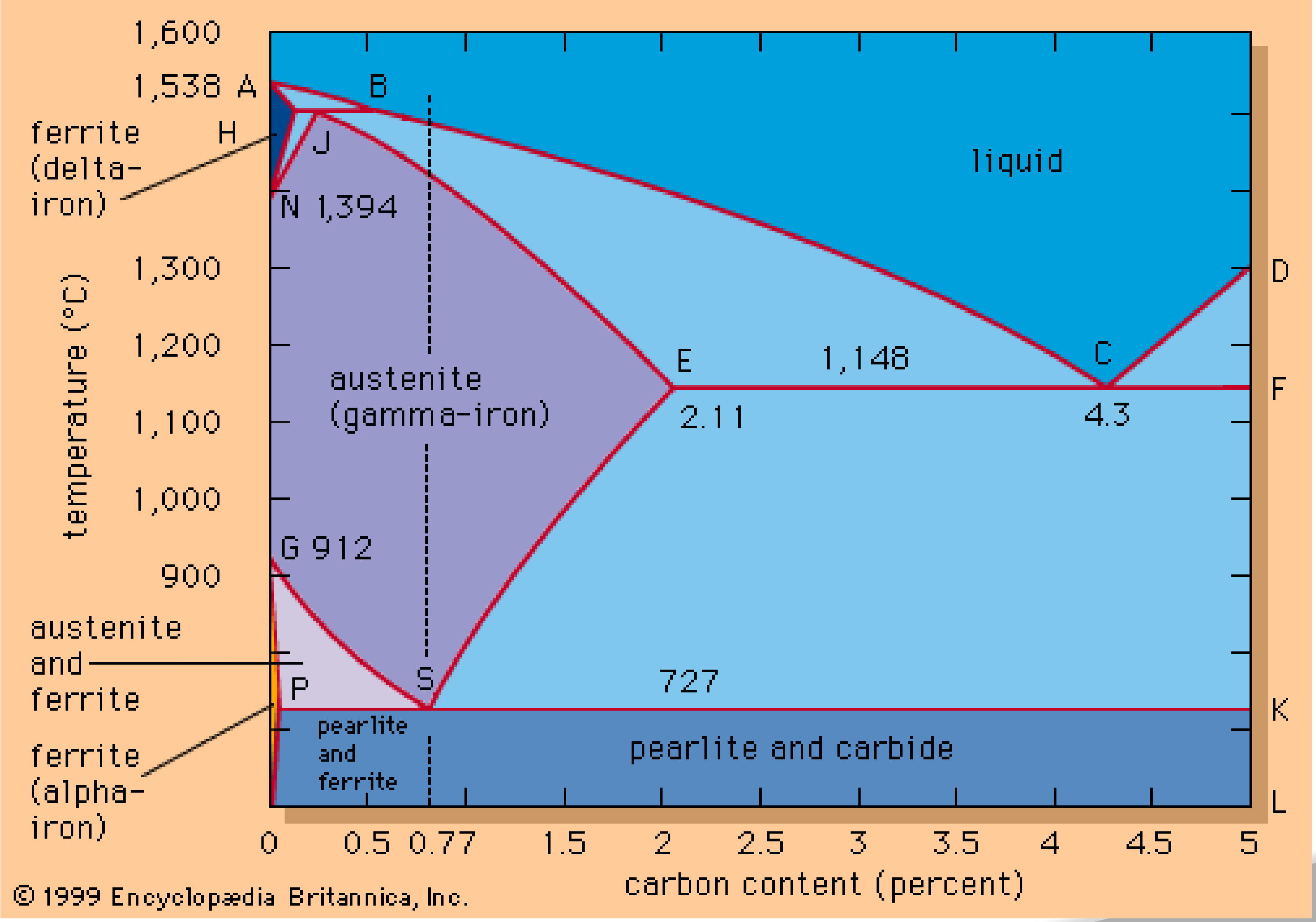
Iron Carbon Equilibrium Diagram

- From 11300 C Carbon precipitates from austenite
- At 7230 C the Austenite and the Austenite in Ledeburite contain 0.8 % C, and pearlite transformation takes place at that temp
- Ledeburite below 7230 C is a mixture of Cementite and Pearlite
- Pearlite is a mixture of ferrite and Cementite

δ Iron

This is a solid solution of carbon in iron and has a BCC crystal structure

- The maximum solubility or C in Fe is 0.09% at 14950C.
- This has no real practical significance in engineering.


1,600
1,538 A
B
ferrite
(delta-
iron)
H
J
N 1,394
1,300
1,200
1,100
1,000
900
temperature (°C)
liquid
D
E
1,148
C
F
austenite
(gamma-iron)
2.11
4.3
G 912
austenite
and
ferrite
S
P
727
K
pearlite
and
ferrite
pearlite and carbide
L
ferrite
(alpha-
iron)
0
0.5
0.77
1.5
2
2.5
3
3.5
4
4.5
5
carbon content (percent)
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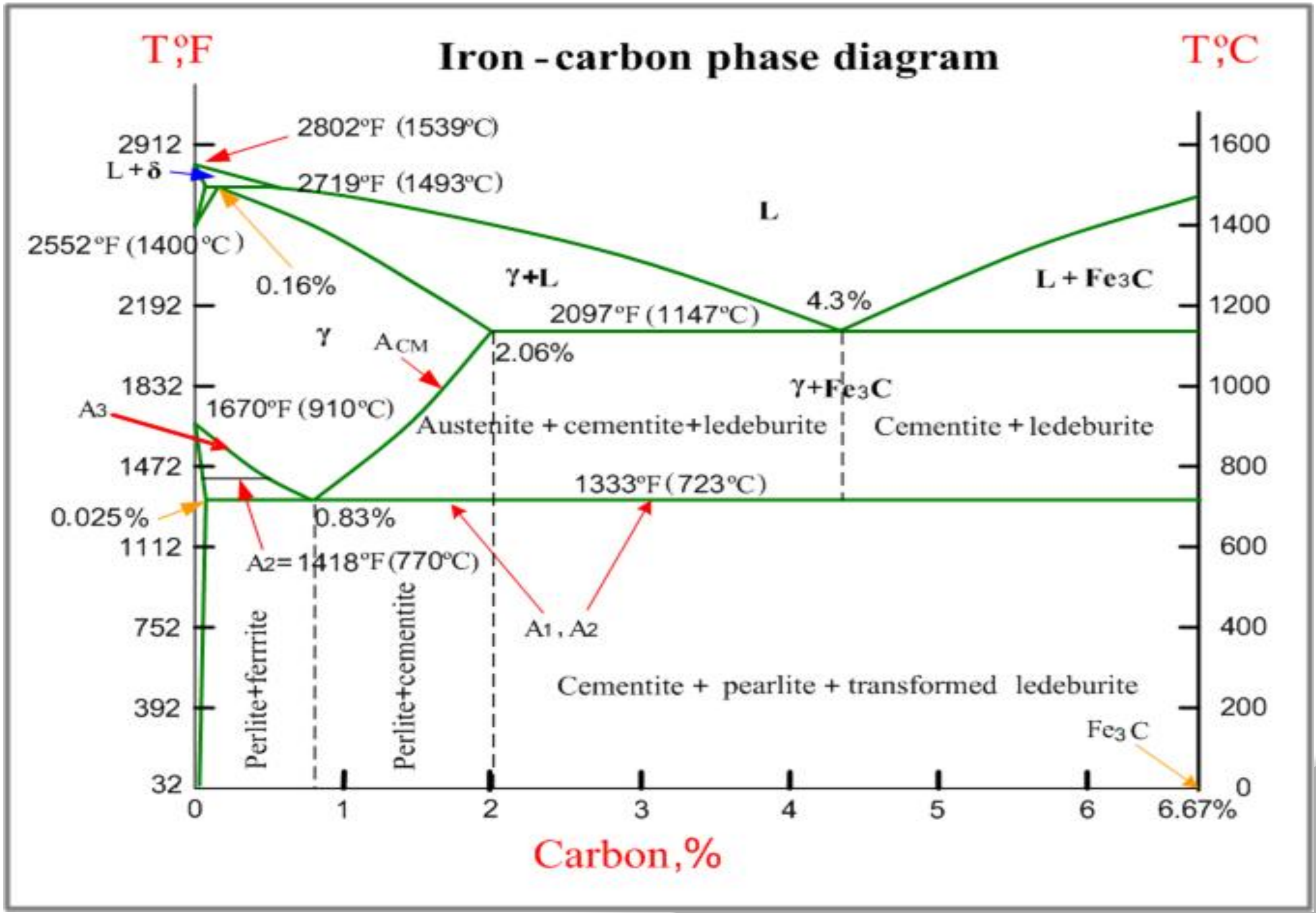
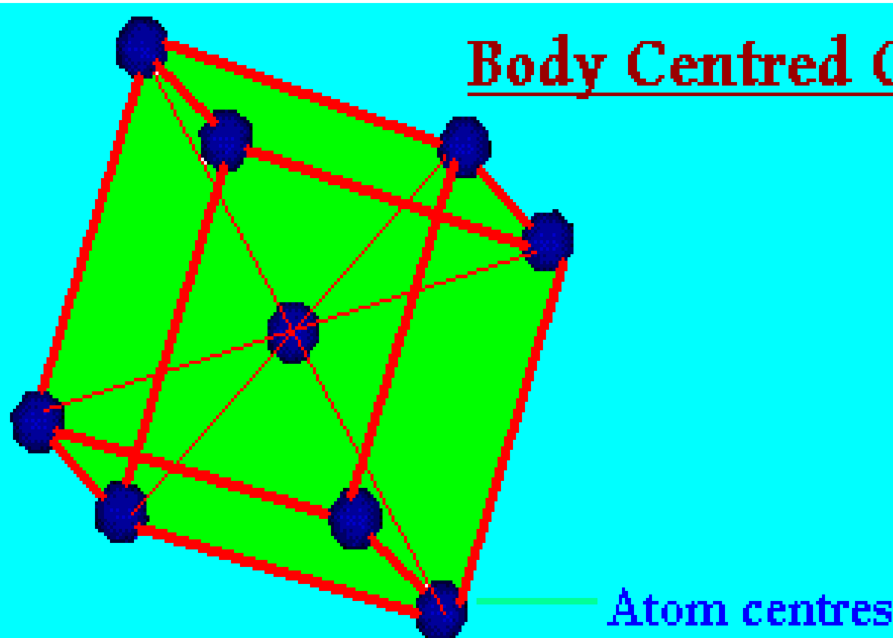
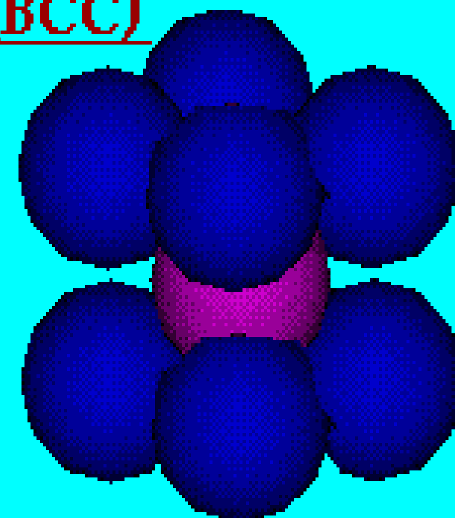


T,°F
Iron - carbon phase diagram
T,°C
2802°F (1539°C)
2719°F (1493°C)
2552°F (1400°C)
L + δ
L
0.16%
γ+L
L + Fe3C
2097°F (1147°C)
4.3%
γ
ACM
2.06%
γ+Fe3C
A3
1670°F (910°C)
Austenite + cementite+ledeburite
Cementite + ledeburite
1333°F (723°C)
0.025%
0.83%
A2= 1418°F (770°C)
Perlite+ferrite
Perlite+cementite
A1, A2
Cementite + pearlite + transformed ledeburite
Fe3C
2912
2192
1832
1472
1112
752
392
32
1600
1400
1200
1000
800
600
400
200
0
0
1
2
3
4
5
6
6.67%
Carbon,%

Body Centred Cubic (BCC)

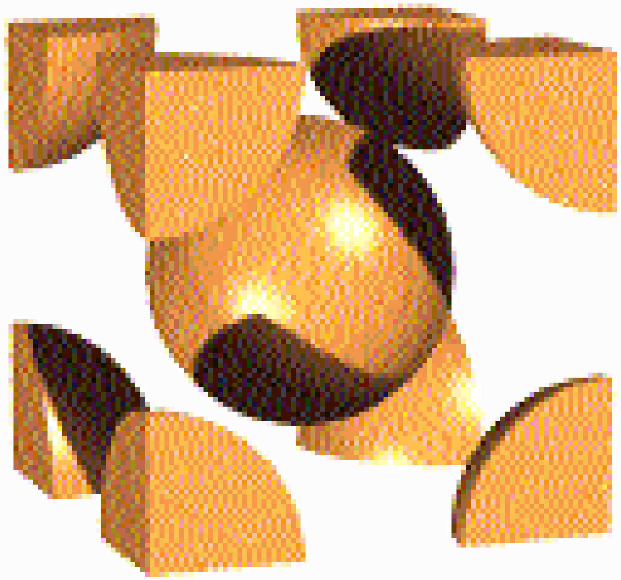


Stick model illustrates the centres of atoms in a BCC structure.

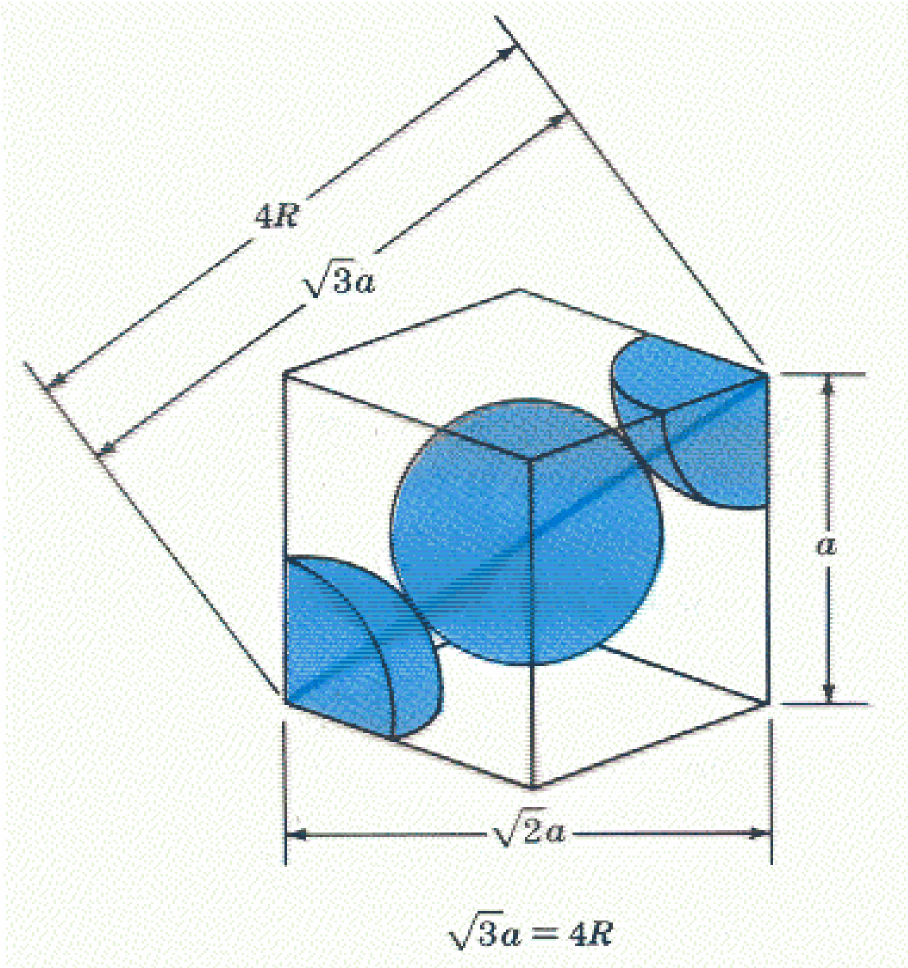


The body centred cubic packing sequence.

BCC Structure



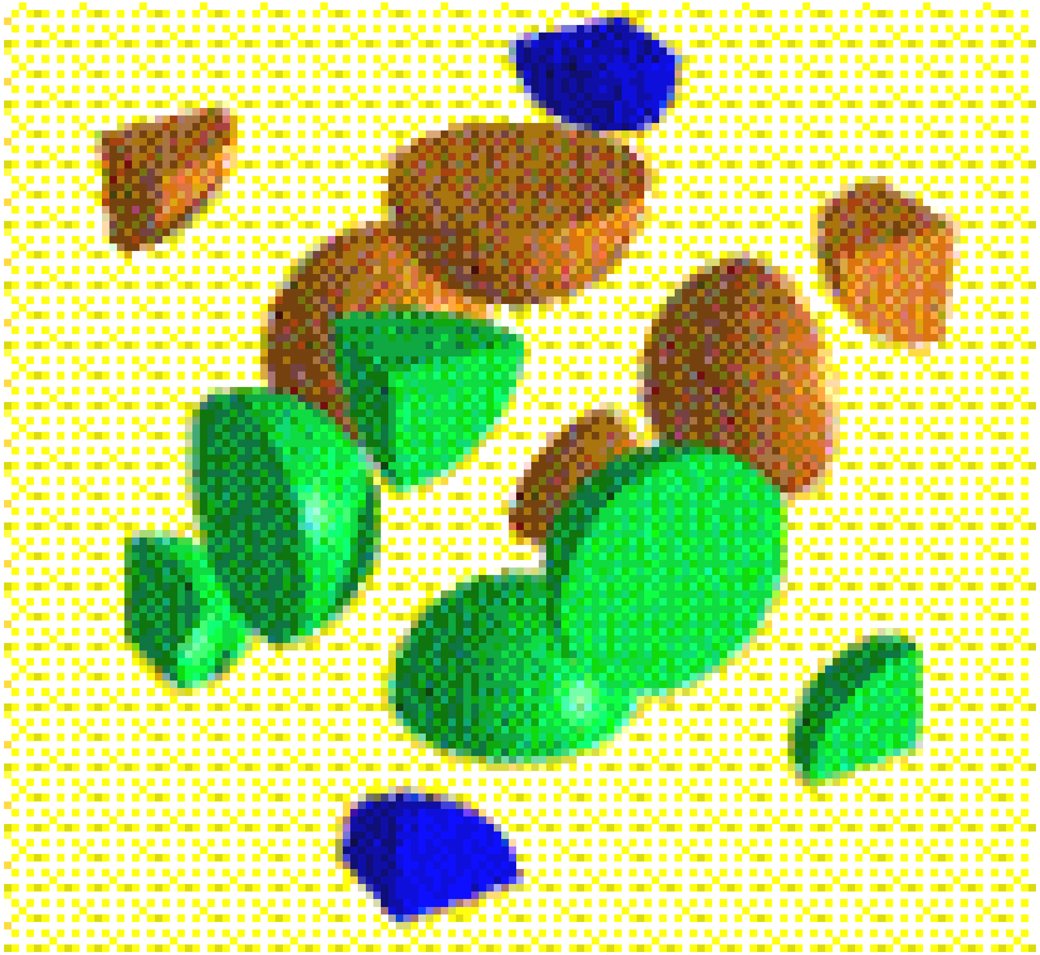
BCC Unit Cell



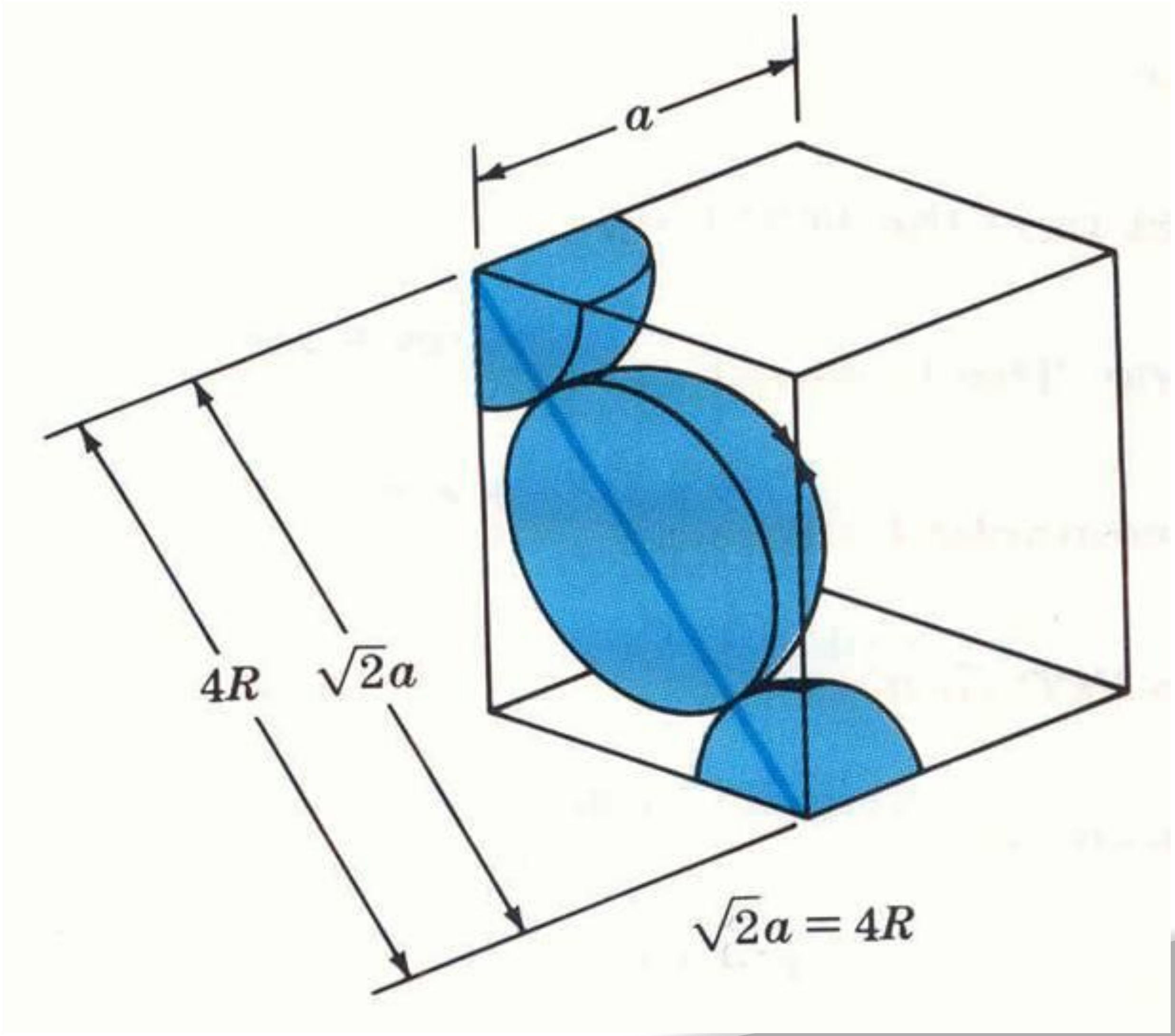
Austenite (γ iron)

- FCC, high formability, high solubility of Carbon, over 2%C can be dissolved in it
- At 1148º c most of heat treatments begin with this single phase

FCC Unit Cell



FCC Unit Cell



Pearlite

- Is an intimate mixture of ferrite and cementite.

- It has a distinct lameller structure and consists of alternate layers of ferrite and cementite

- It is an eutectoid phase transformation of austenite at 7230C having 0.83% carbon.

Ledeburite

- Is a mixture of austenite and cementite.
- It is obtain by eutectic phase transformation of liquid

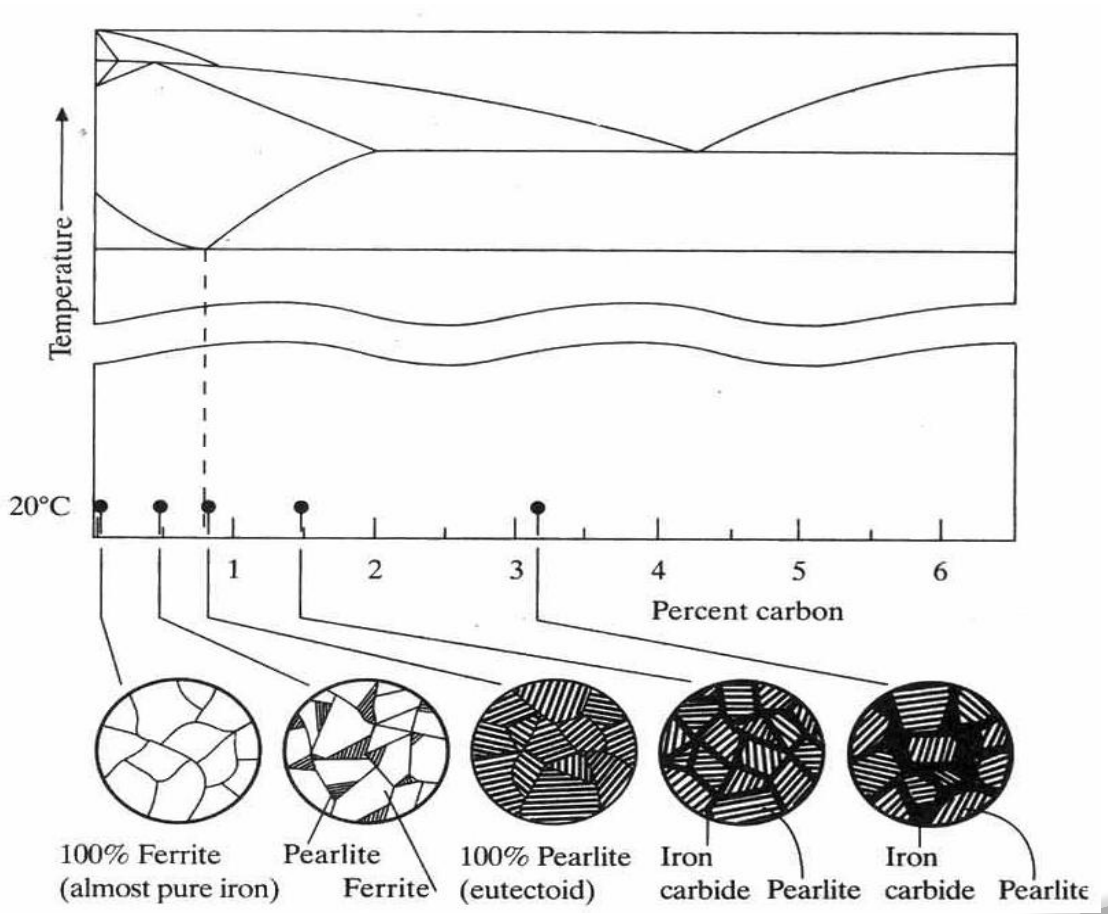
alloy

containing 4.3% carbon is cooled below 11480C.

- Below 7230 C ledeburite changes to pearlite.

Microstructures of Iron Carbon System at different compositions

Microstructures of Iron Carbon System at different compositions



HEAT TREATMENT

- HEAT TREATMENT can be defined as a process of changing the structure and the properties of the metals and alloys by controlled heating and cooling.

(HEAT TREATMENT is the heating and cooling of metals to change their physical and mechanical properties without letting it change its shape)

HEAT TREATMENT

- To relieve internal stresses.
- To soften the metal.
- To improve hardness of the metal surface.
- To improve machinability.
- To refine grain structure.
- To increase the resistance to wear, tear, heat and corrosion

Types of HEAT TREATMENT

Annealing

Normalizing

Hardening

Tempering

Annealing

- Annealing in which steels are heated to above the transformation range and holding the steel at the temperature for certain time.Then allow to cool slowly in the furnace.

Purpose

- To soften the steel
- To improve the machinability
- To increase ductility

Non -Ferrous metals and their Alloys

- Non Ferrous metals are those which have no iron in their composition
- The non ferrous metals are generally used in alloy form
- Non ferrous alloy consists of two or more materials, one of which must be a non ferrous metal
- Various Non- ferous metals are Cu, Al, Mg, Ni, Pb, Zn, etc

Few Components of Non Ferrous metals

Non -Ferrous Metals and their Alloys are preferred in Engineering Applications Beause of their

- High electrical conductivity
- High thermal conductivity
- Low specific gravity

- High Corrosion resistance
- High fatigue strength
- Good castability
- Good formability

Role of Non Ferrous metals

- A turofan jet engine for boeing 757 air craft contains the following Non ferous metals and alloy

  - 38% Titanium
  - 37% Nickel
  - 12% Chromium
  - 6% Cobalt's
  - 5% Aluminum
  - 1% Niobium (columbium)
  - 0.02% Tantalum

Copper and its alloys

- Due to their high electrical conductivity used in electrical industries.
- Due to their high thermal conductivity used as house hold utensils, etc.
- Copper posses good manufacturability
- The cupro - nickel alloy is superior in resisting erosion in high velocity salt water

Aluminium and its Alloys

- Due to their low specific gravity, it is used in manufacturing aircraft parts
- Due to their high resistance to corrosion, it is used in making refrigerator parts
- It possess high strength to weight ratio
- It has good machinability, formability, workability and castability
- Al- Si alloys are the most important Aluminum casting alloys because of high fluidity

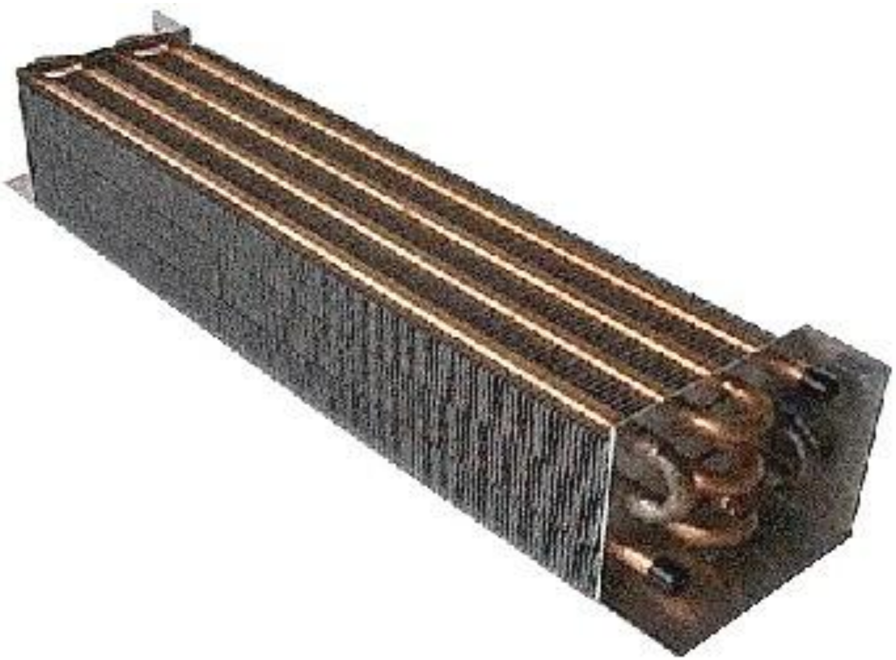
Copper and its alloys

Properties of Copper

- High electrical conductivity
- High heat conductivity
- Excellent resistance to corrosion
- High ductility and malleability
- Easily soldered, brazed or welded

Uses of Copper

- Due to its electrical conductivity copper is universal adopted for
  I. Electrical conductors
  II. Telegraph wires
  III. Telephone wires and cables
- Used in electroplating and electrotyping
- Making coins



Copper Alloys

Important copper alloys are

- Brass
- Bronze etc.,

Properties of Aluminium Bronze

- Resistance to corrosion
- Malleable
- Machinability (silicon improves)
- Hardness
- High strength (Fe & Ni increase strength)
- Good castability
- Yellowish brown alloy
- Light weight

Properties of Aluminium

- Low specific gravity (Aluminium weighs about one-third that of steel)
- High electrical and heat conductivity
- High resistance to corrosion specially after anodising it
- Becomes hard by cold working and, hence needs frequent annealing
- Low fatigue strength
- High light – reflectivity

Uses of Aluminium

- Unusual combination of lightness and strength, Al is used in aircraft field

- Best electrical conductor on an equal weight basis

- Due to corrosion resistance Aluminium is used
  I. In chemical apparatus and
  II. For coating other metal

Corrosion

- Corrosion is the deterioration or destruction of metals and alloys in the presence of an environment by chemical or electrochemical means

- Loss of valuable products: leakage due to corrosion, eg. slight losses of uranium compound or solutions are hazardous and can be very costly
- Effects on safety and reliability: Corrosion products could make sanitizing of equipment more difficult, eg. milk and dairy product plant.
- hip joints, screws, heart valves, etc – high reliability is of paramount importance.

Classification of corrosion

- Dry corrosion
- Wet corrosion

Dry corrosion

- Dry corrosion occurs when the metals are exposed to gaseous environment
- Corrosion processes involve reaction of metals with environmental gases.

Wet corrosion

- Wet corrosion occur when a metal or an alloy comes in contact with an aqueous solution of salt, acid or alkali by an electrochemical type of reaction.When a metal is immersed in an aqueous electrolyte,it dissolve / dissociate into metal ion + electron.

Paints

A paint is a cheap and convenient method but poor at wear resistance.

They deteriorate with time and surface will be repainted.

A paint Should have following qualities:

(i) It should be spread easily on the surface

(ii) It should form a tough, uniform film

(iii) The coating of paint should not crack after drying

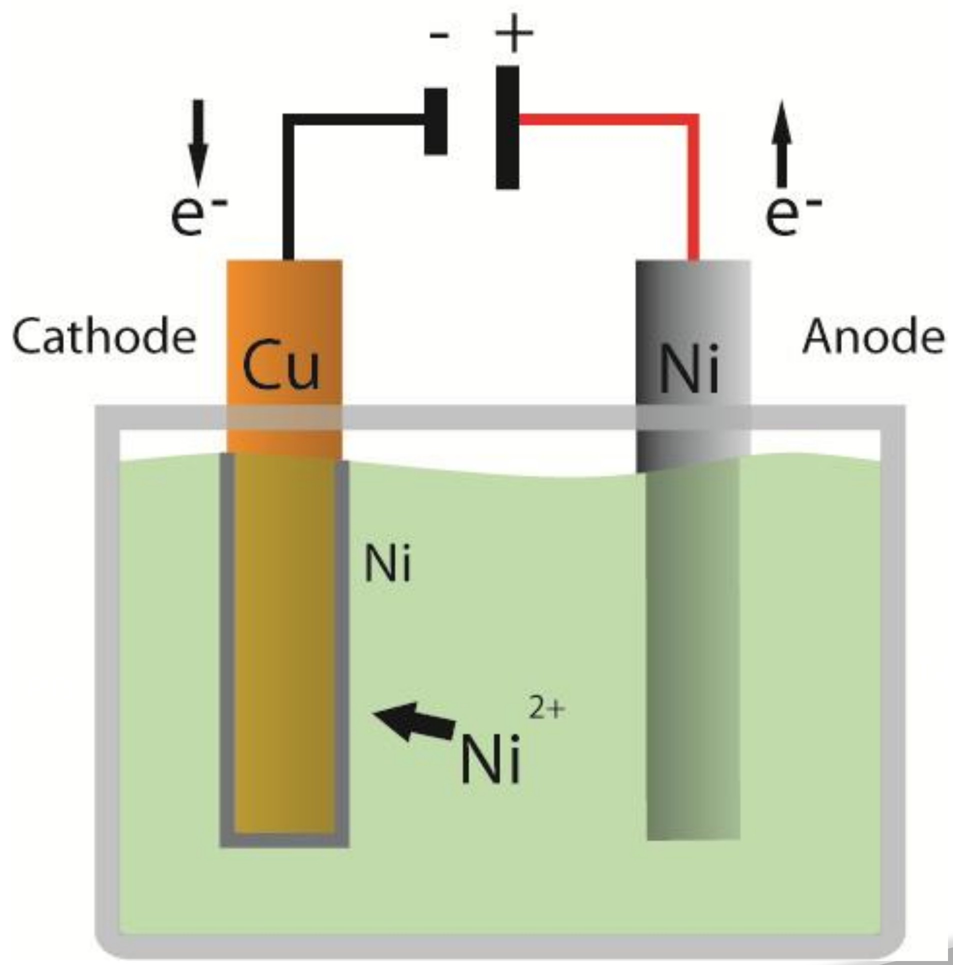
(iv) It should neither be oxidised nor reduced in environment

- Enamels are good at higher temperatures But these coatings are brittle in nature.
- A commonly adopted method to protect a metal is to cover it with a thin layer of another metal having good corrosion resistance.
- Cadmium, Chromium, Nickel, Aluminium, Tin, Zinc, Silver are used for coating Steel.

Electroplating

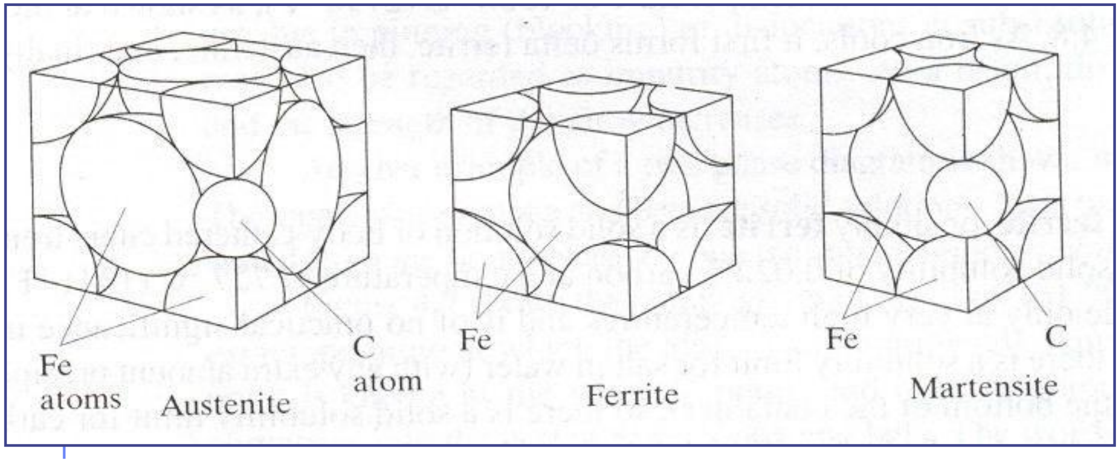
- Electroplating is the process of coating metals and protects them from corrosion, wear and chemical attack.
- Electroplating is the method of electro-deposition of metal by means electrolysis over surface of metals and alloys.
- The base metal is first subjected to acid pickling to remove any oxides etc.
- The base metal is made as cathode of the electrolytic cell and the coating metal is made as anode.
- Low temperature, medium current density, low metal ion concentration conditions are maintained for better electro-plating.

Electroplating

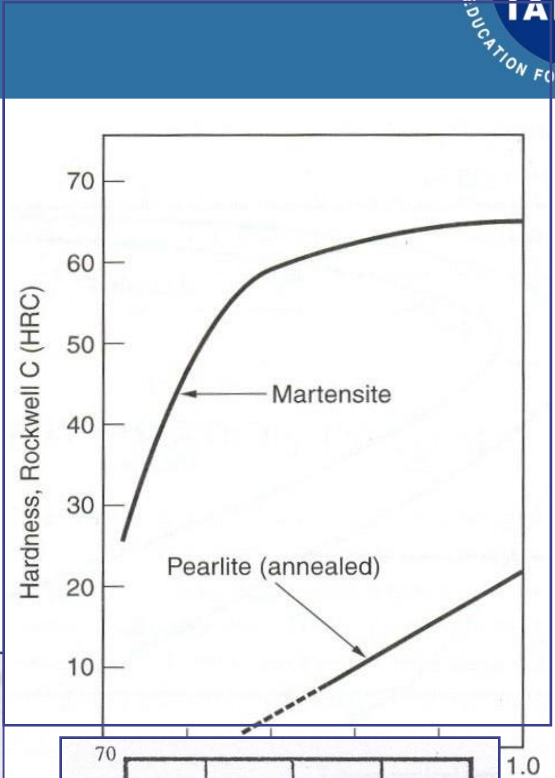


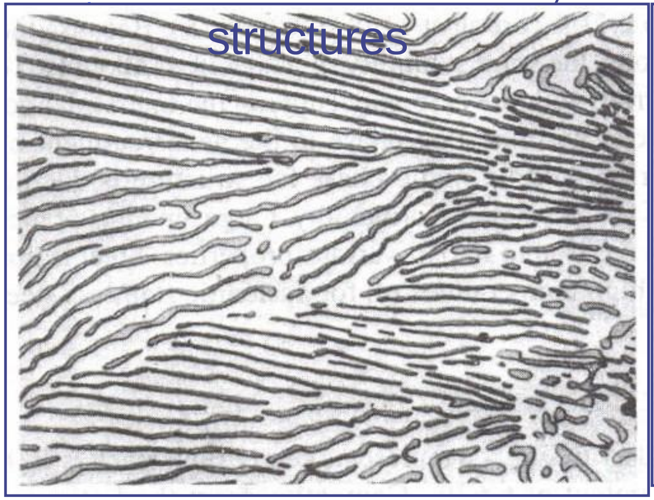
become attracted to Copper cathode

Microstructures

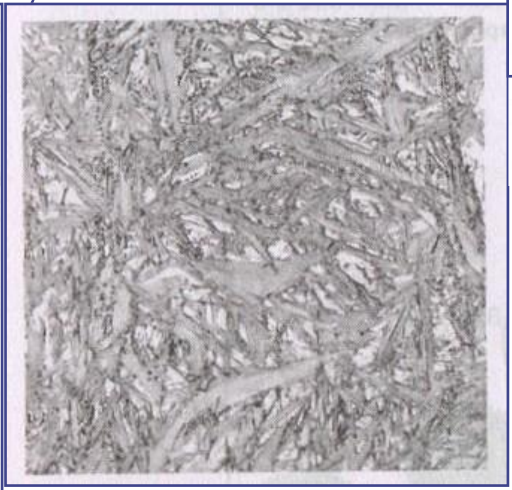


Unit cells of FCC, BCC, BCT structures

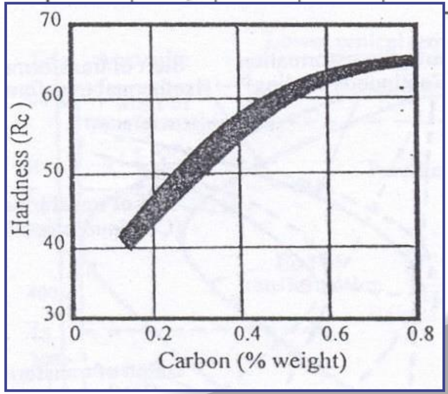




Pearlit
e



Martensit
e



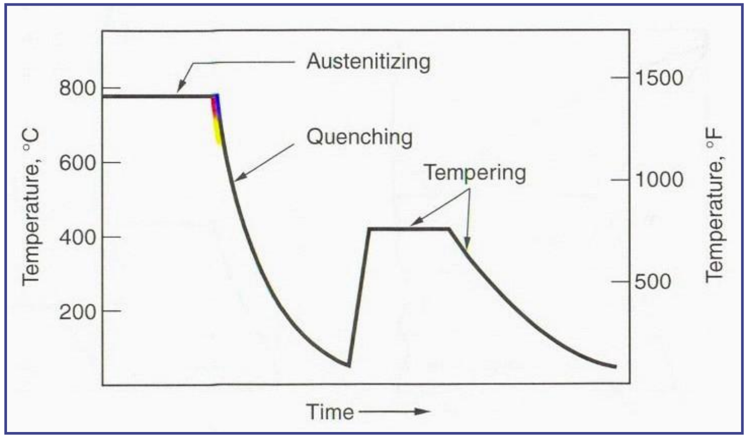
99% Matensite

Normalizing

- The process is similar to annealing and is carried out to avoid excessive softness in the material.
- The material is heated above austenitic phase and then cooled in air . This gives relatively faster cooing and hence enhanced hardness and less ductility.
- In this process, austenite is decomposed in ferrite and carbide at relatively lower temperature and fine pearlite is produced.
- Normalizing is less expensive than annealing.
- In normalization variation in properties of different sections of a part is achieved.
- The selection of heat treatment operations is strongly influenced by the carbon content in th esteel.

Tempering

- Martensite is very hard and brittle.
- Tempering is applied to hardened steel to reduce brittleness, increase ductility, and toughness and relieve stresses in martensite structure.
- In this process, the steel is heated to lower critical temperature keeping it there for about one hour and then cooled slowly at prescribed rate.
- This process increses ductility and toughness but also reduces hardness, strength and wear resistance marginally. Increase in tempering temperature lowers the hardness.



Surface Hardening

- Heat treatment methods in general change the properties of entire material.
- Hardening improves wear resistance of material but lowers impact resistance and fatigue life. Therefore sometimes there is requirement of surface hardening
- Two methods are used, first is heating and cooing to get required phase, and second is thermo-chemical treatment.
  - Induction heating Flame hardening
  - High frequency resistance heating Laser

MODULE - II

- **CASTING, WELDING AND INSPECTION TECHNIQUES**

MODULE – II

CLOs	Course Learning Outcome
CLO4	Outline performance of the output of research, development or design.
CLO5	Identify, solve new problems and gain new knowledge.
CLO6	Understand about the turning, milling, grinding and drilling of a specimen.

SAND CASTING

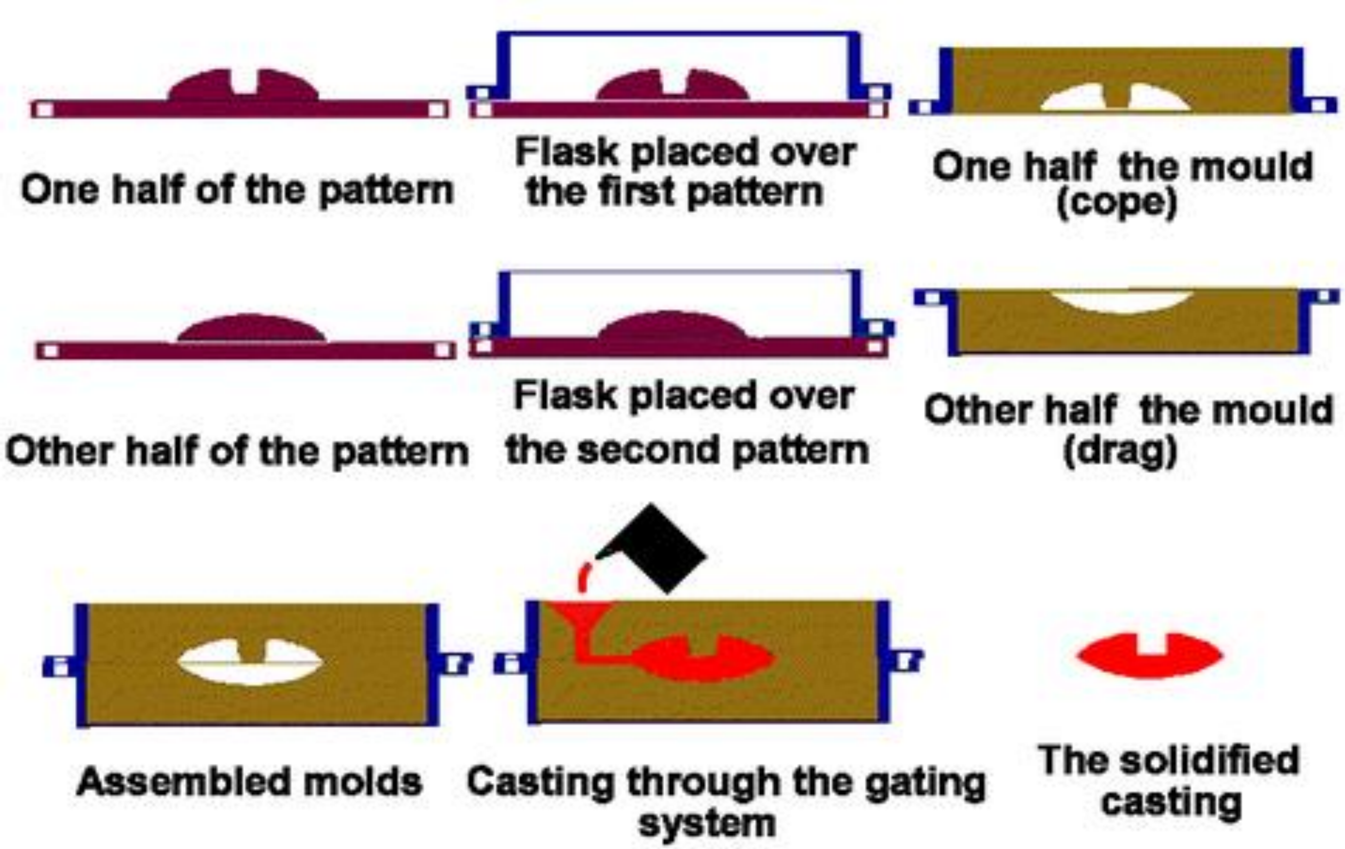
Sand casting, also known as sand molded casting, is a metal casting process characterized by using sand as the mold material.

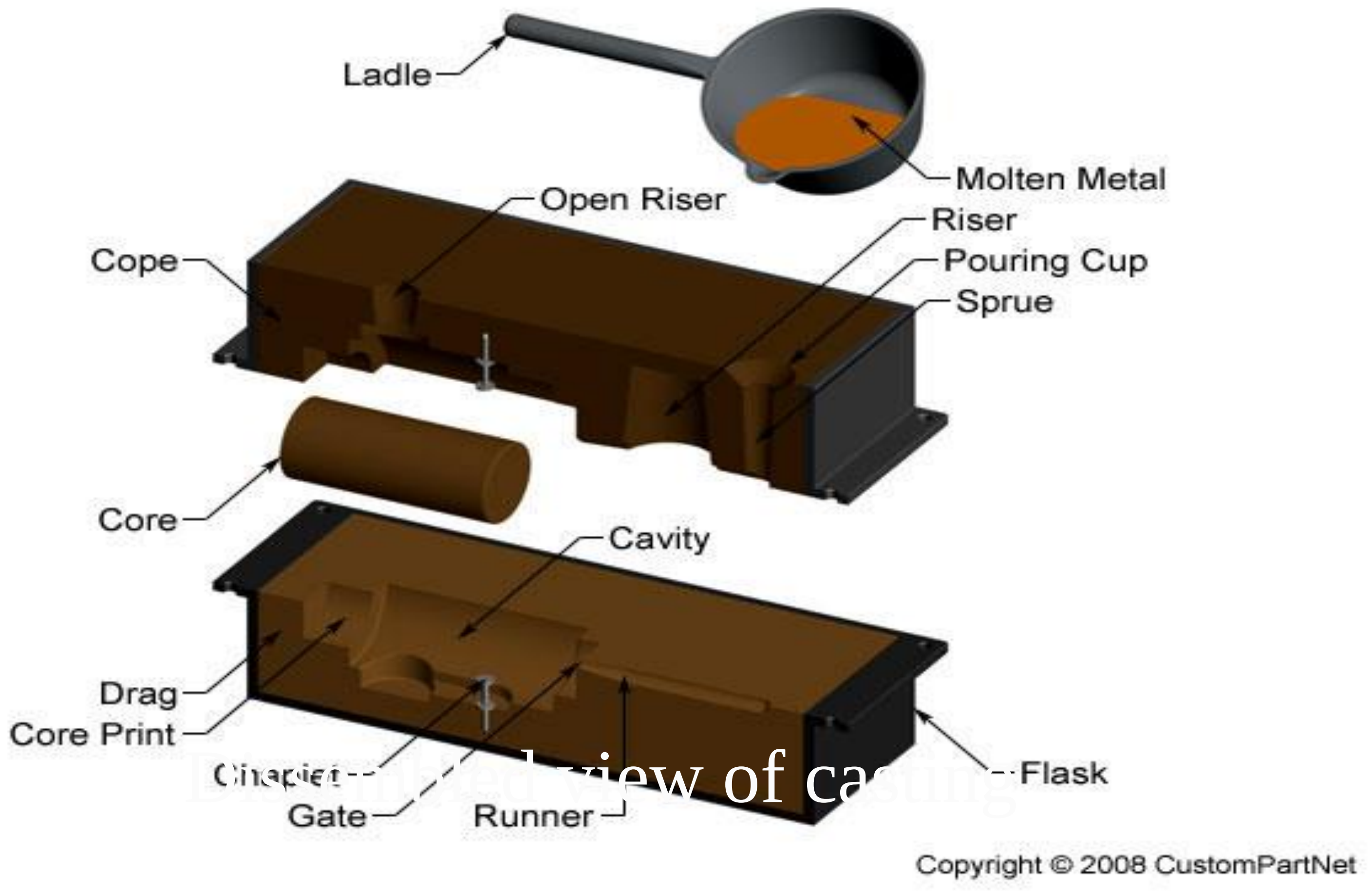
The term "sand casting" can also refer to an object produced via the sand casting process. Sand castings are produced in specialized factories called foundries.

Over 70% of all metal castings are produced via a sand casting process.

- Sand casting is relatively cheap and sufficiently refractory even for steel foundry use.
- In addition to the sand, a suitable bonding agent (usually clay) is mixed or occurs with the sand.

Plastic **Light weight Easy to make Light in weight Smooth glossary surface.**


One half of the pattern
Flask placed over the first pattern
One half the mould (cope)
Other half of the pattern
Flask placed over the second pattern
Other half the mould (drag)
Assembled molds
Casting through the gating system
The solidified casting


Ladle
Molten Metal
Open Riser
Riser
Cope
Pouring Cup
Sprue
Core
Cavity
Drag
Core Print
Flask
Gate
Runner
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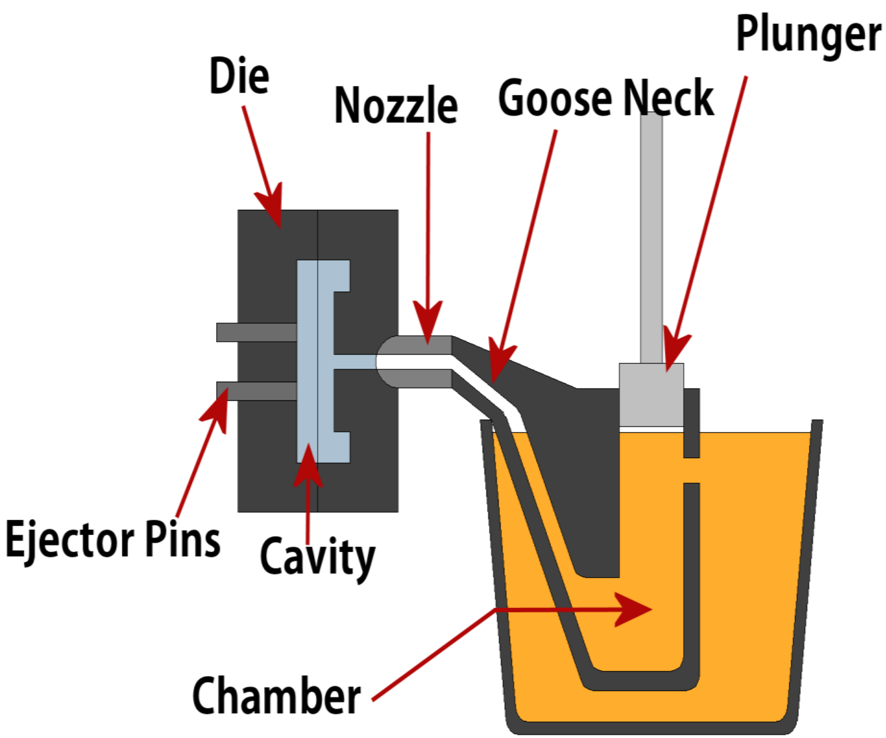
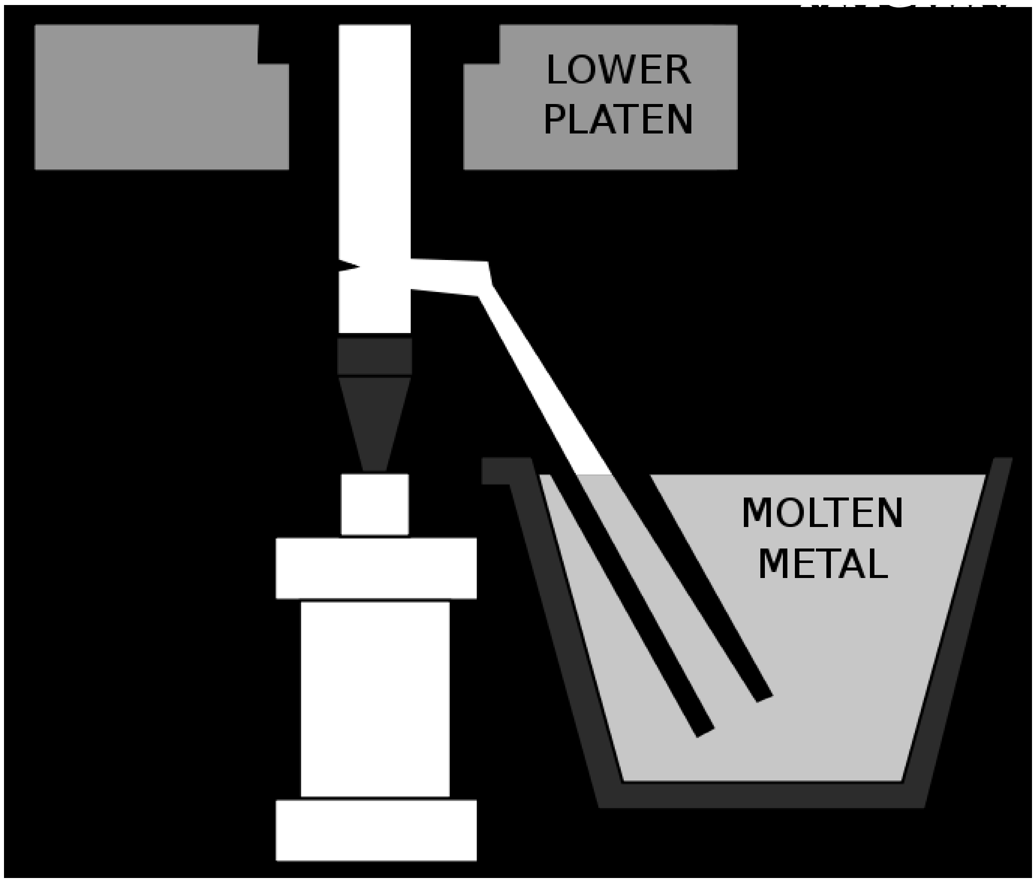
Casting products

DIE CASTING



- Hot-chamber die casting, also known as gooseneck machines, rely upon a pool of molten metal to feed the die.
- At the beginning of the cycle the piston of the machine is retracted, which allows the molten metal to fill the "gooseneck".



- These are used when the casting alloy cannot be used in hot-chamber machines; these include aluminum, zinc alloys with a large composition of aluminum, magnesium and copper.

ADVANTAGES OF DIE CASTING

1. Very high rate of production is achieved.
2. Close dimensional tolerances.
3. Surface finish of 0.8 microns.
4. Fine details can be produced.
5. Longer die life is obtained.

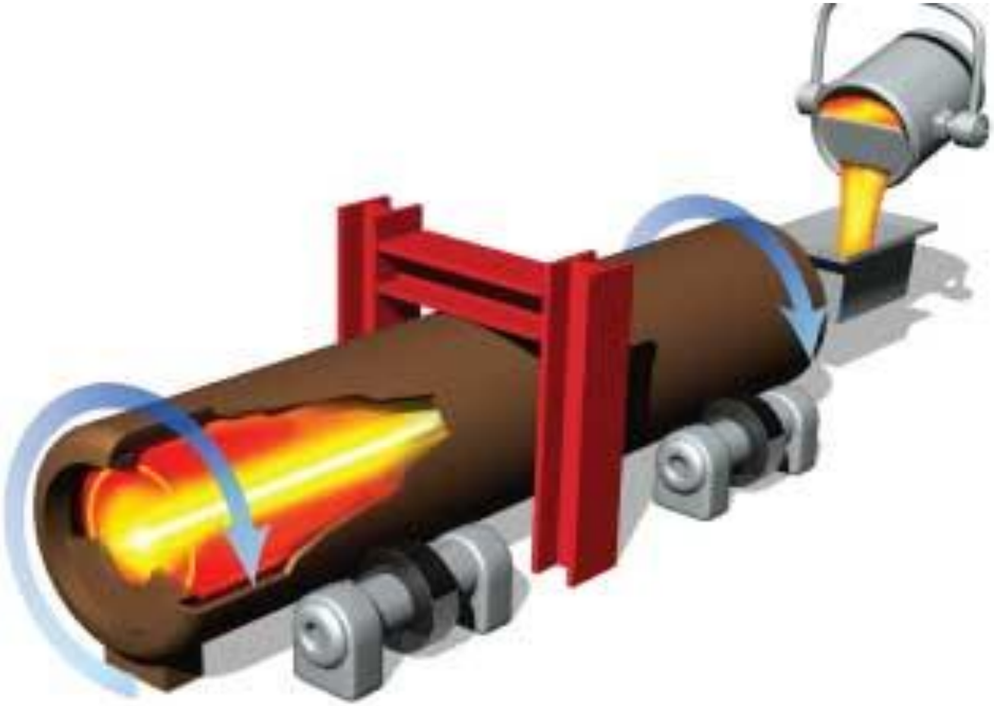
DISADVANTAGES

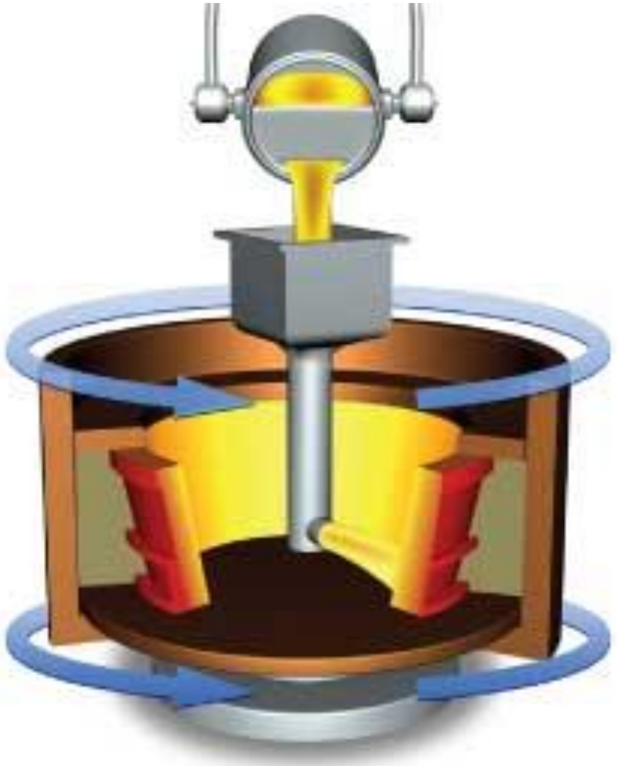
1. Not economical for small runs.
2. Only economical for nonferrous alloys.
3. Heavy casting cannot be cast.
4. Cost of die and die casting equipment is high.

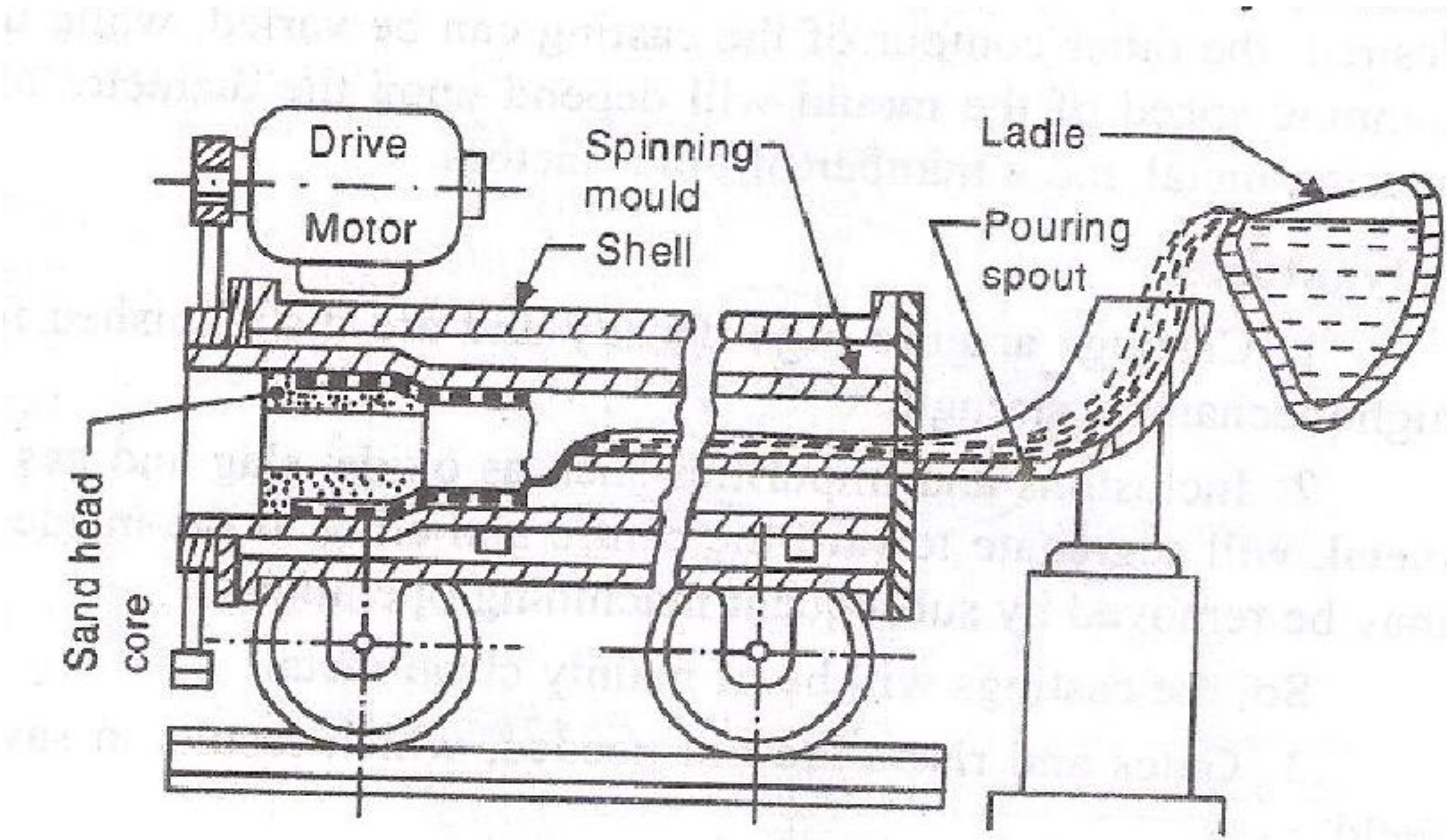
Casting products

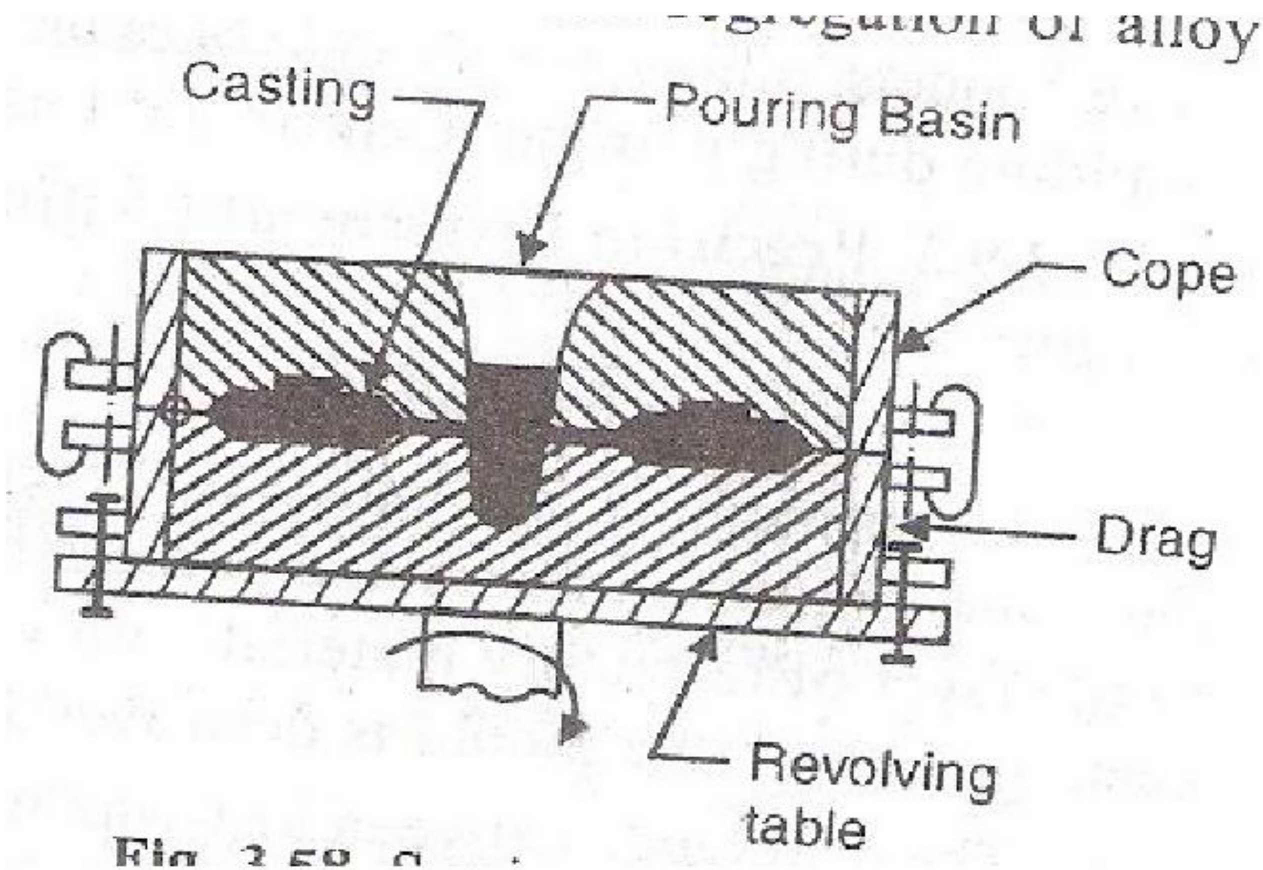
CENTRIFUGAL CASTING

- In centrifugal casting, a permanent mold is rotated continuously about its axis at high speeds (300 to 3000 rpm) as the molten metal is poured.
- The molten metal is centrifugally thrown towards the inside mold wall, where it solidifies after cooling.
- The casting is usually a fine-grained casting with a very fine-grained outer diameter, owing to chilling against the mould surface. Impurities and inclusions are thrown to the surface of the inside diameter, which can be machined away.






Drive
Motor
Spinning
mould
Shell
Ladle
Pouring
spout
Sand head
core


Casting
Pouring Basin
Cope
Drag
Revolving
table

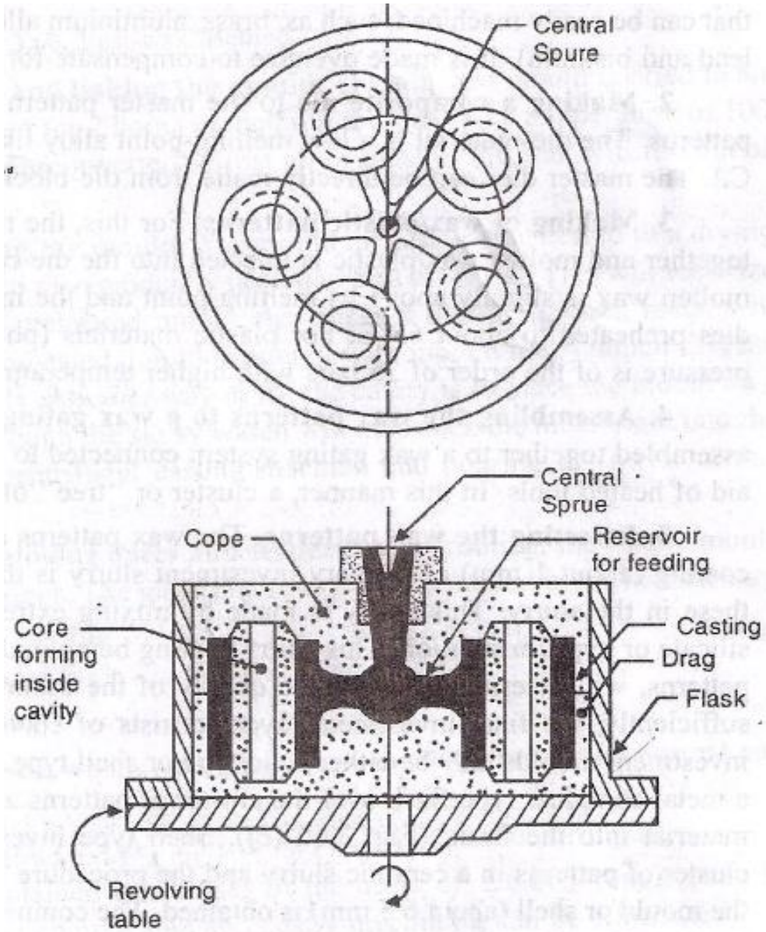
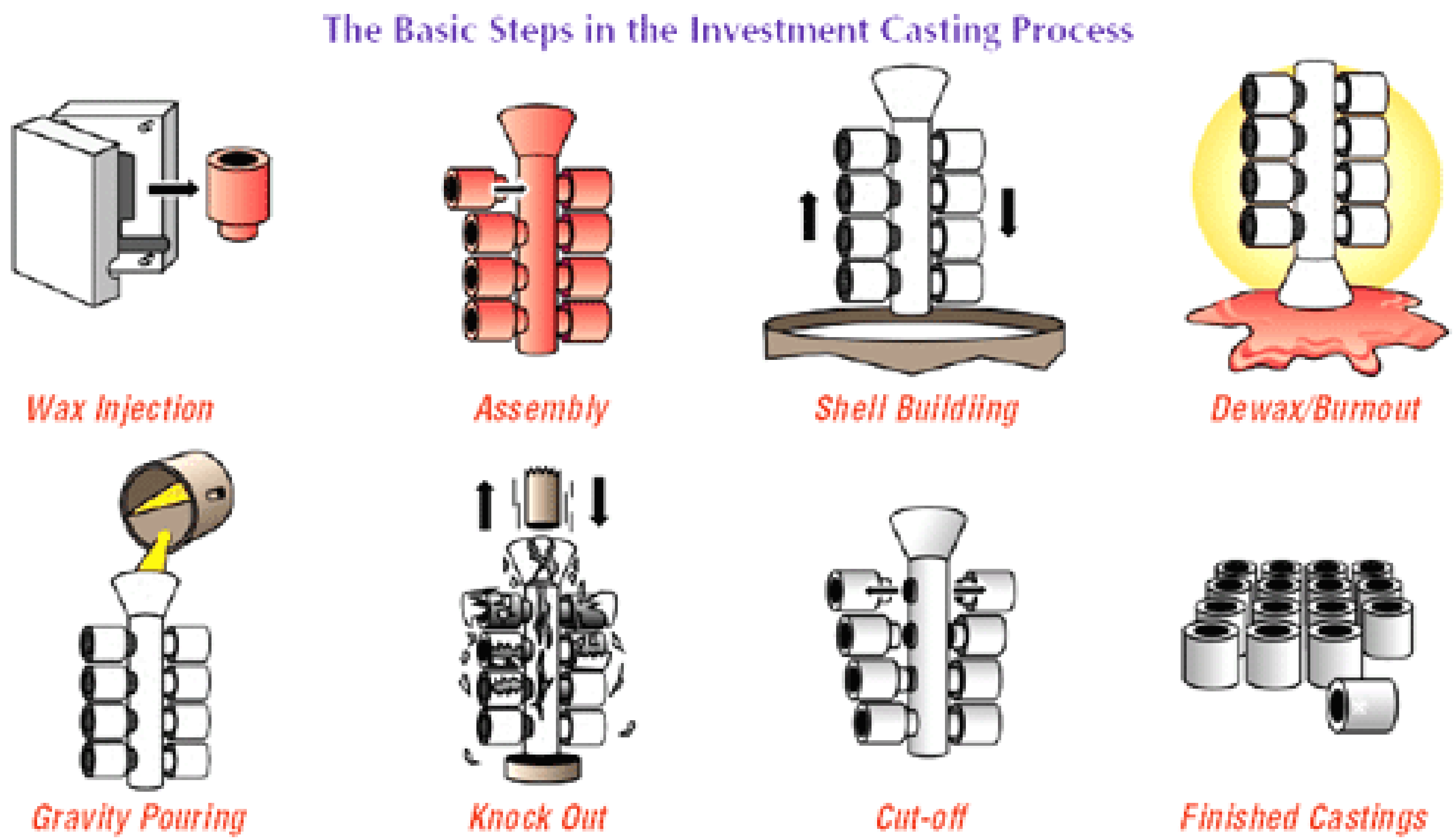


Fig. 3.59. Centrifuge Casting.

Investment casting

- Many Intricate forms with undercuts can be cast.
- A very smooth surface is obtained with no parting line.
- Dimensional accuracy is good.
- Certain un Machin able parts can be cast to preplanned shape.
- It may be used to replace die-casting where short runs are involved.

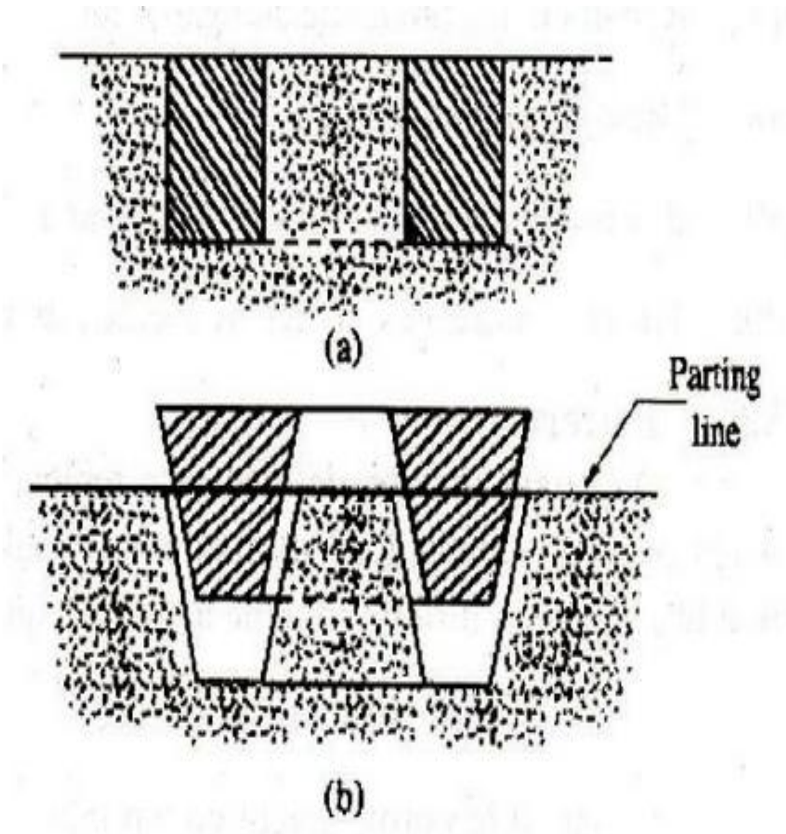

The Basic Steps in the Investment Casting Process
Wax Injection
Assembly
Shell Building
Dewax/Burnout
Gravity Pouring
Knock Out
Cut-off
Finished Castings

ALLOWANCS IN CASTING PROCESS

Patterns are not made the exact same size as desired casting for several reasons. Such patterns would produce castings which are under size . That is why allowance should be present in pattern.

Shrinkage allowance

When a metal solidifies and cools it shrinks and contracts in size.



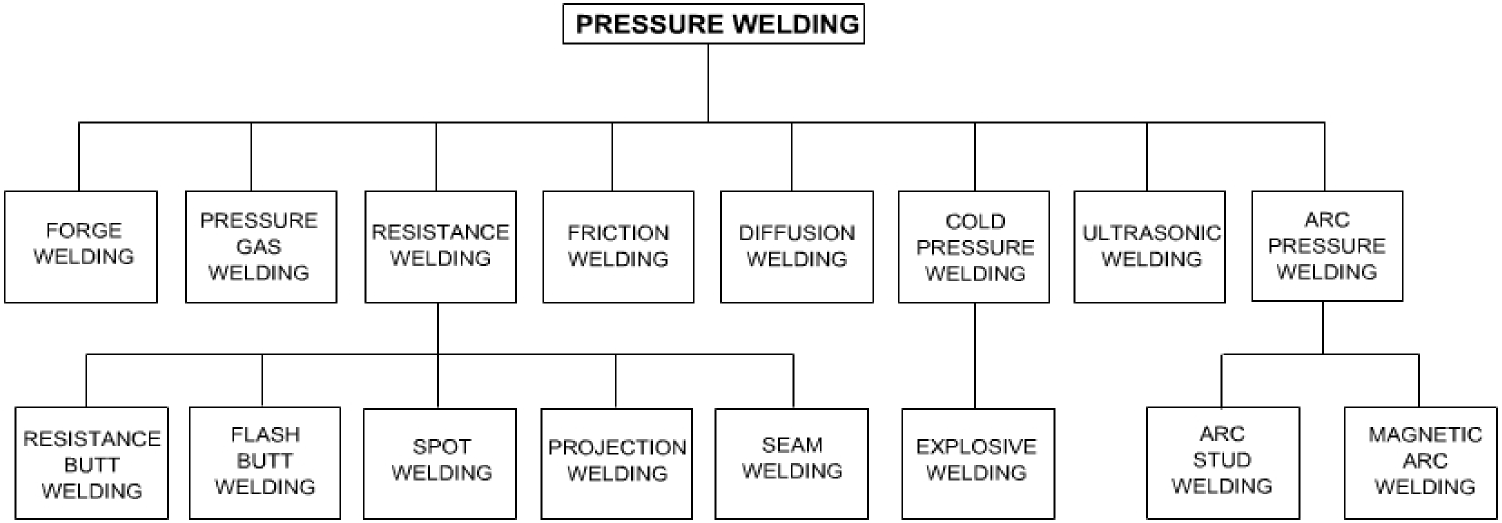
3. Draft allowance

When a pattern is drawn from the mould there is always some possibility of injuring the edges of the mould. This danger is greatly decreased when the vertical surfaces of the pattern are tapered inward slightly. This taper inward in the vertical surface is called Draft.

Welding is a process of joining similar metals by application of heat with or without application of pressure and addition of the filler material.

Weld ability is the capacity to be welded into inseparable joints and having specified properties such as definite weld strength , proper structure etc.

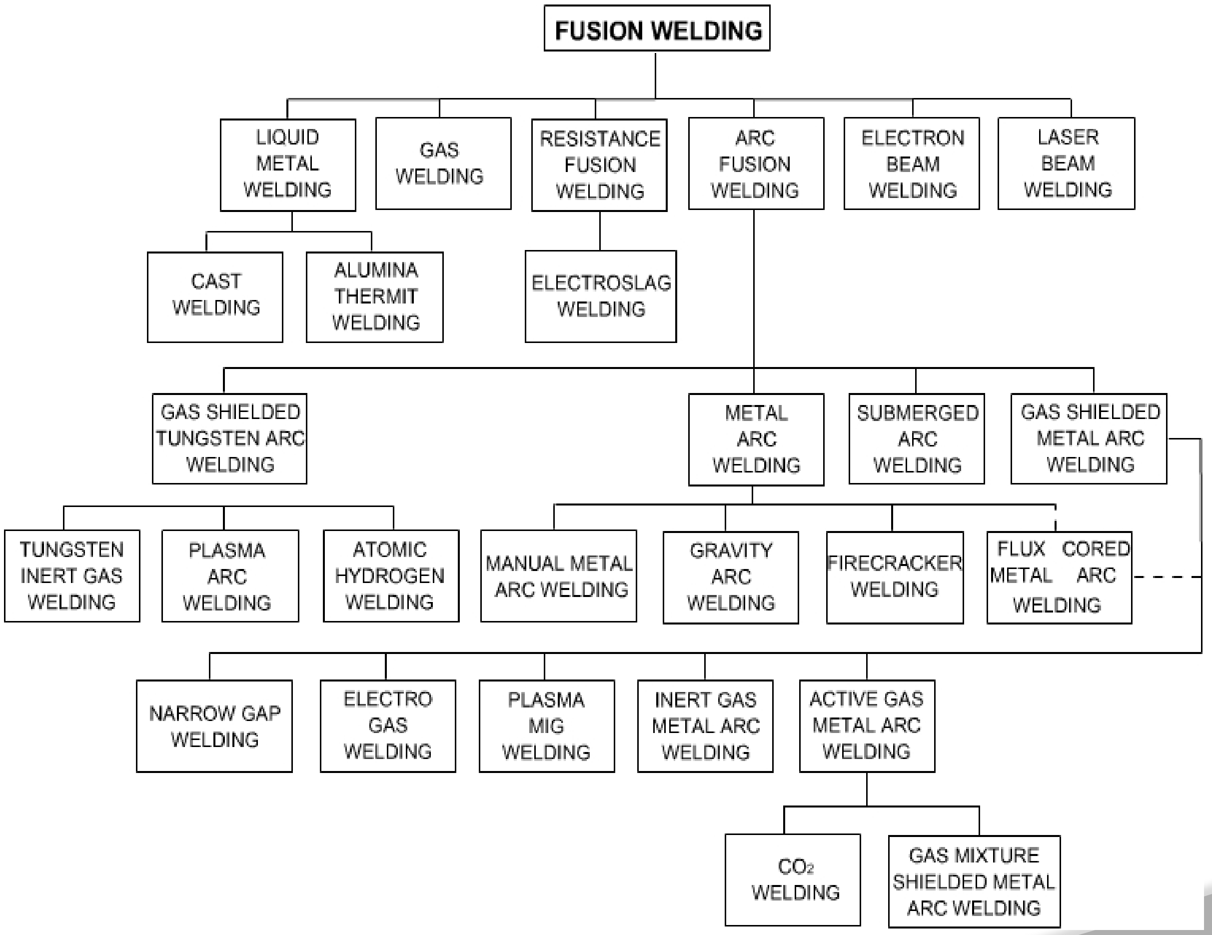
1.Thermal expansion
2.Thermal conductivity
3.Melting point
4.Surface condition
5.Change in micro structure

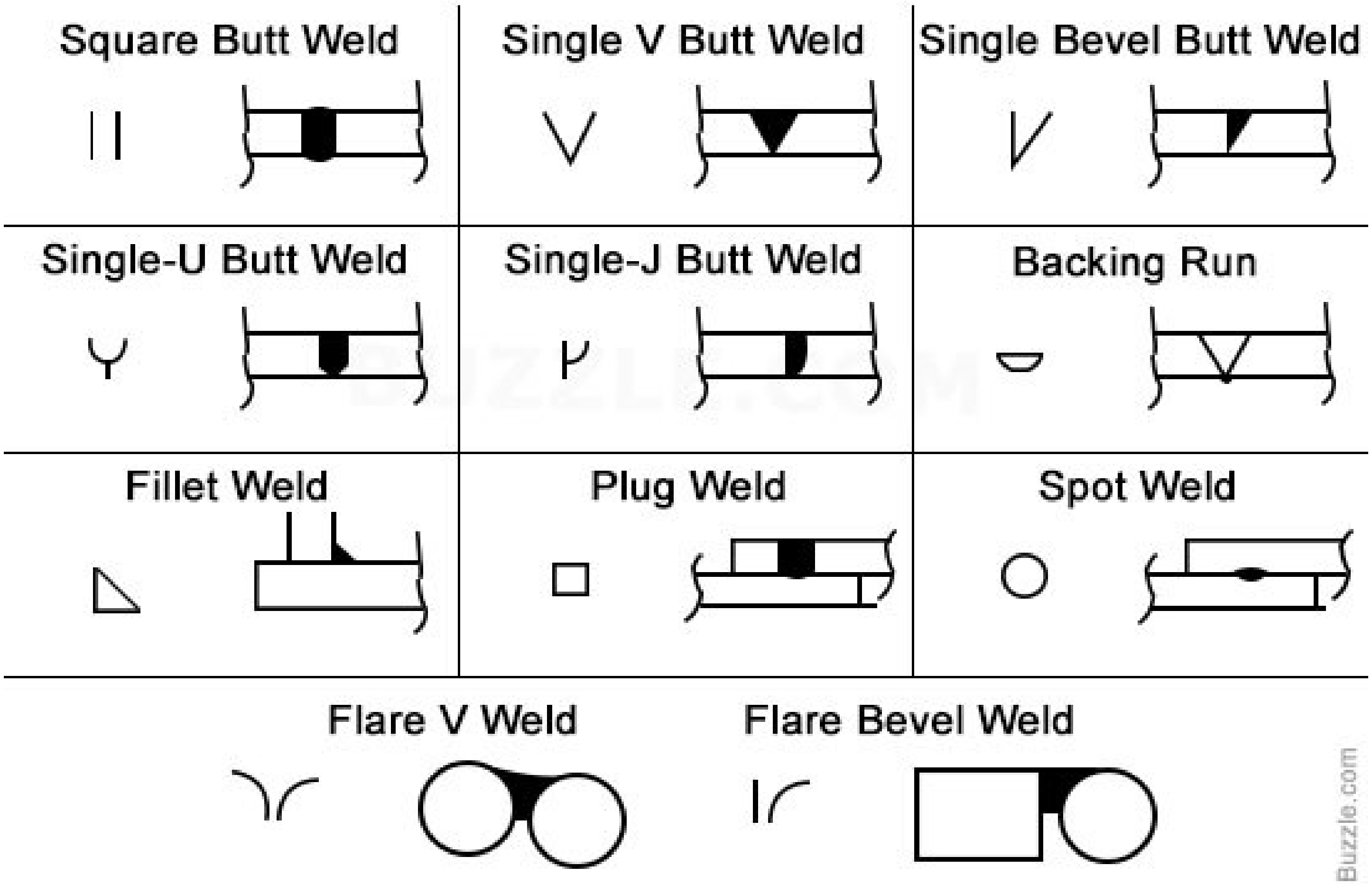

PRESSURE WELDING
FORGE WELDING
PRESSURE GAS WELDING
RESISTANCE WELDING
FRICTION WELDING
DIFFUSION WELDING
COLD PRESSURE WELDING
ULTRASONIC WELDING
ARC PRESSURE WELDING
RESISTANCE BUTT WELDING
FLASH BUTT WELDING
SPOT WELDING
PROJECTION WELDING
SEAM WELDING
EXPLOSIVE WELDING
ARC STUD WELDING
MAGNETIC ARC WELDING

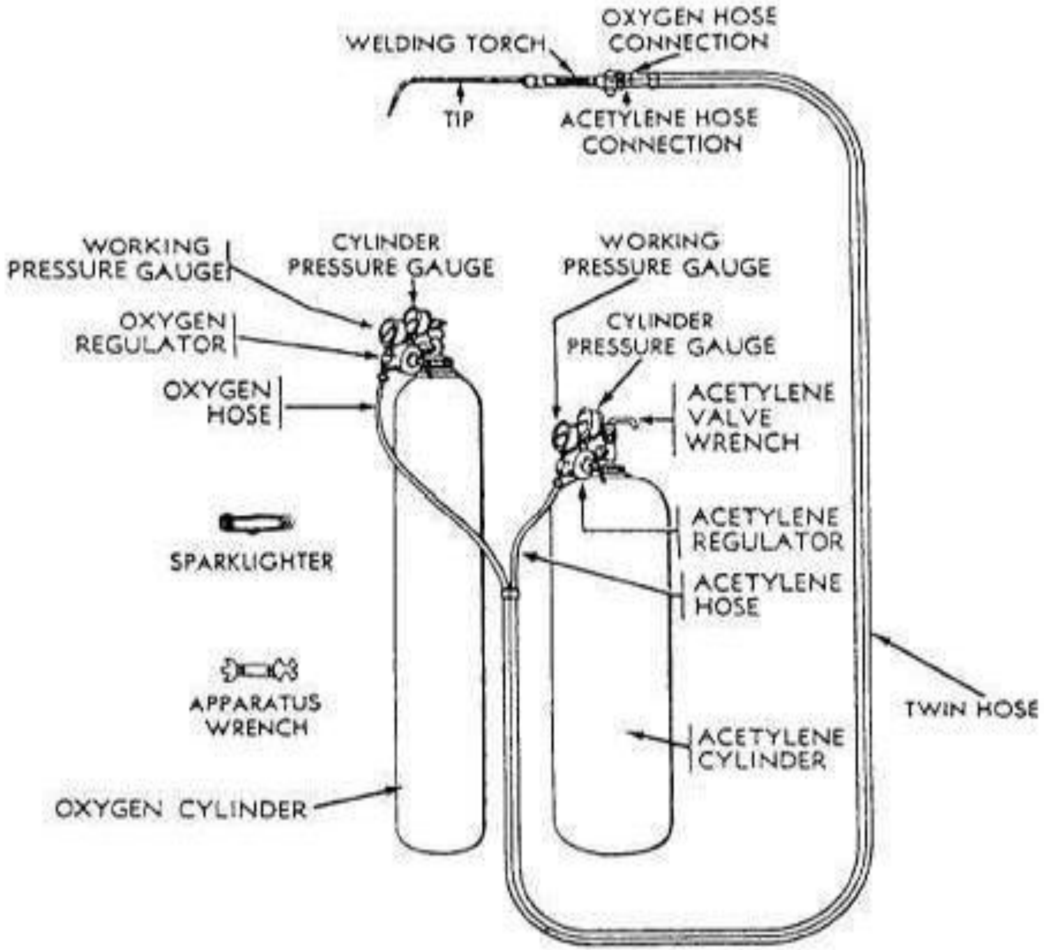
Fusion welding or non pressure welding the material at the joint is heated to the molten state and allowed to be solidified.

1.Arc welding

2.Thermit welding




Square Butt Weld
Single V Butt Weld
Single Bevel Butt Weld
Single-U Butt Weld
Single-J Butt Weld
Backing Run
Fillet Weld
Plug Weld
Spot Weld
Flare V Weld
Flare Bevel Weld
Buzzle.com


WELDING TORCH
OXYGEN HOSE CONNECTION
TIP
ACETYLENE HOSE CONNECTION
WORKING PRESSURE GAUGE
CYLINDER PRESSURE GAUGE
WORKING PRESSURE GAUGE
OXYGEN REGULATOR
CYLINDER PRESSURE GAUGE
OXYGEN HOSE
ACETYLENE VALVE WRENCH
SPARKLIGHTER
ACETYLENE REGULATOR
ACETYLENE HOSE
APPARATUS WRENCH
TWIN HOSE
ACETYLENE CYLINDER
OXYGEN CYLINDER

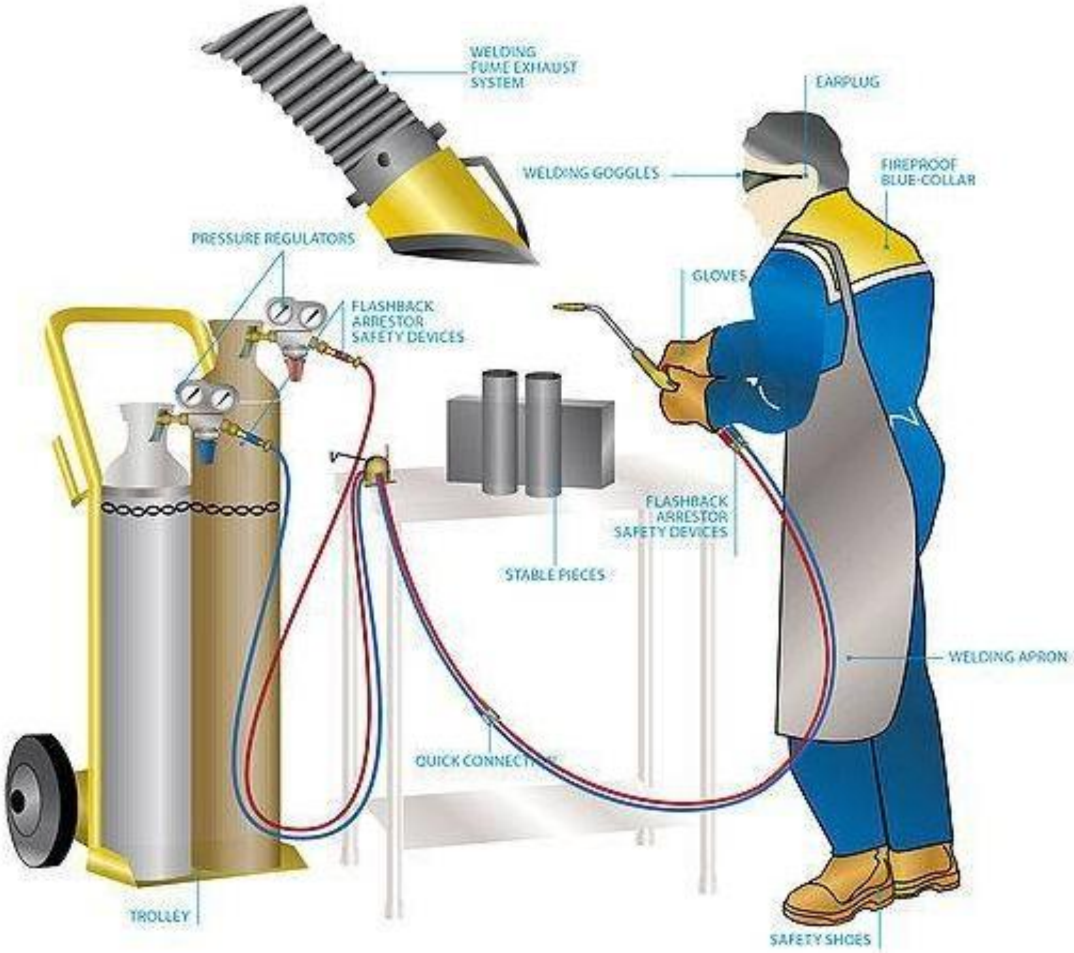
ARC WELDING

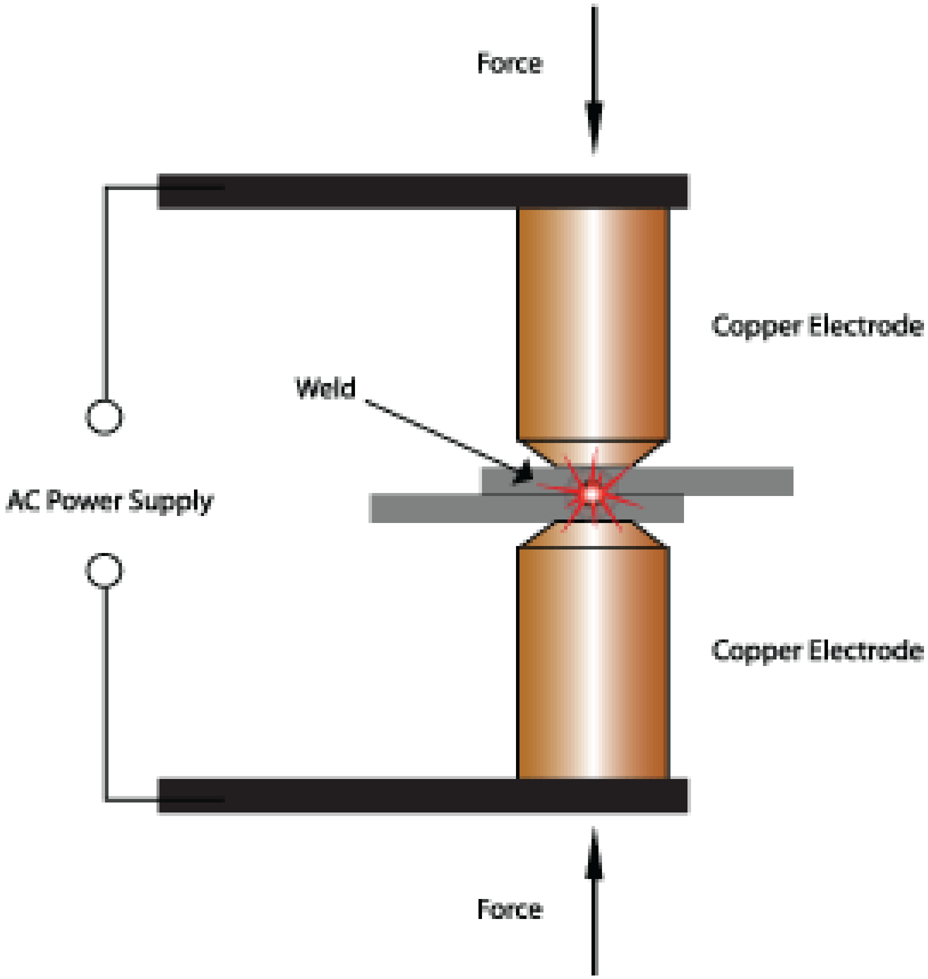
This type of welding is used to join metal sheets and plates having thickness of 2 to 50 mm.

With metal thicker than 15 mm filler metal is used. The composition of the filler rod is almost same as the part being welded .

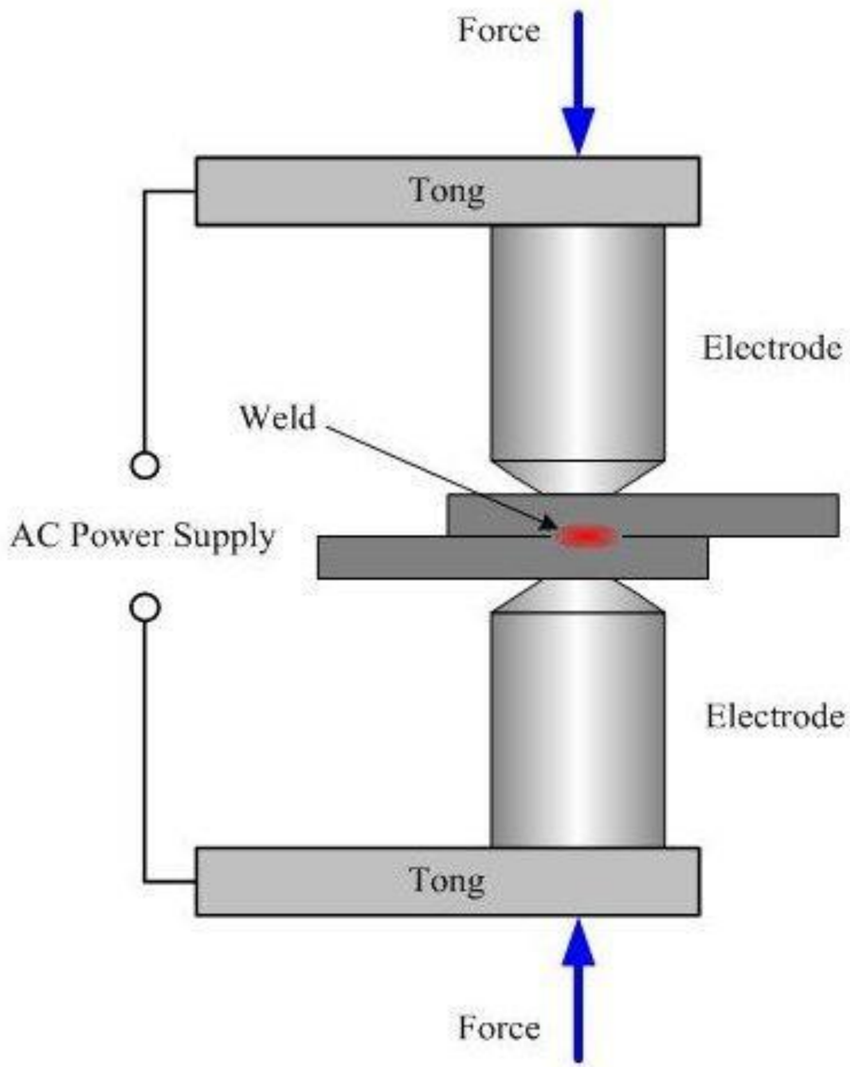
To remove the oxides and impurities present on the surfaces of the metal and to obtain satisfactory bonding FLUX is employed during the welding .

GAS WELDING

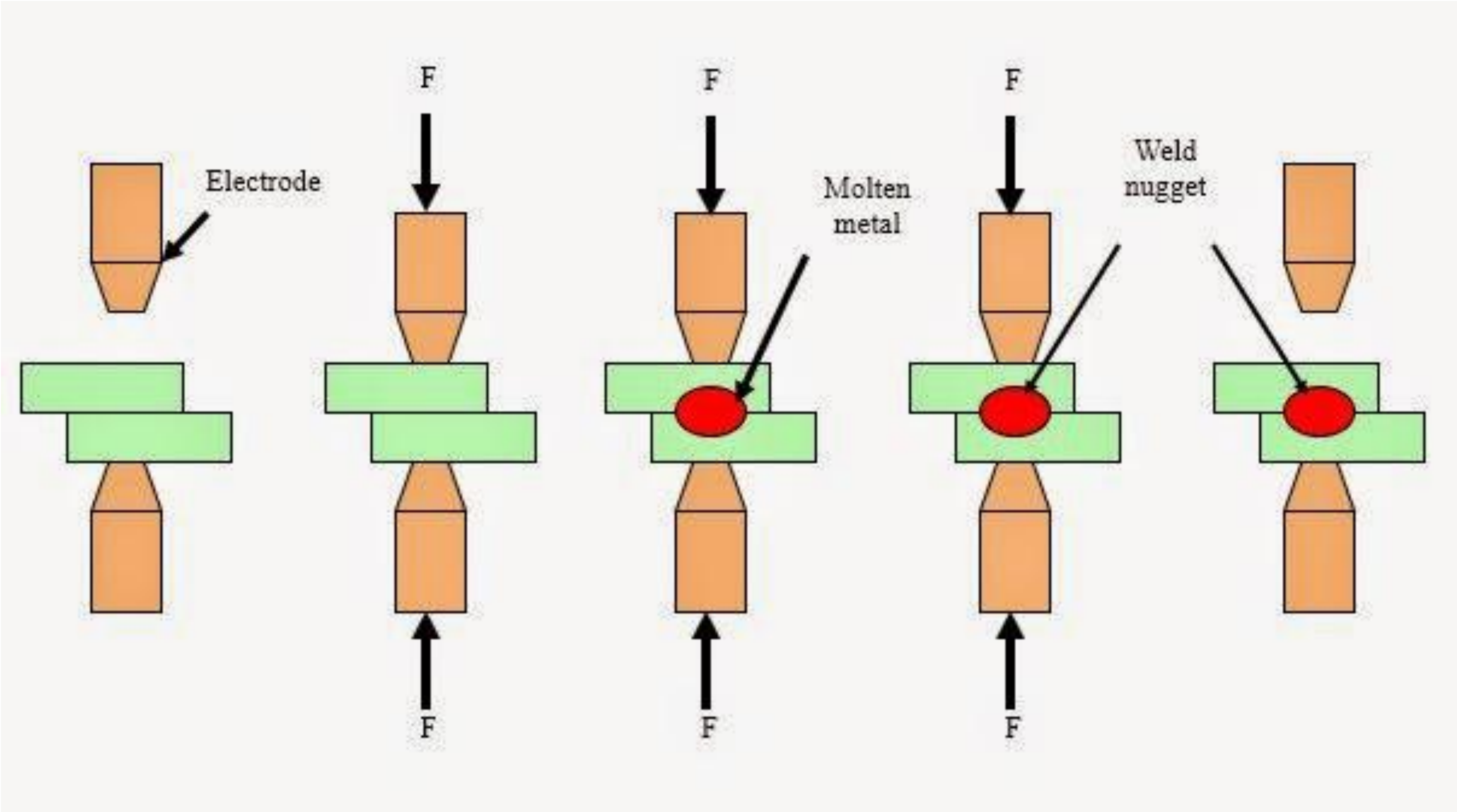

WELDING FUME EXHAUST SYSTEM
EARPLUG
WELDING GOGGLES
FIREPROOF BLUE-COLLAR
PRESSURE REGULATORS
GLOVES
FLASHBACK ARRESTOR SAFETY DEVICES
FLASHBACK ARRESTOR SAFETY DEVICES
STABLE PIECES
WELDING APRON
QUICK CONNECT
TROLLEY
SAFETY SHOES



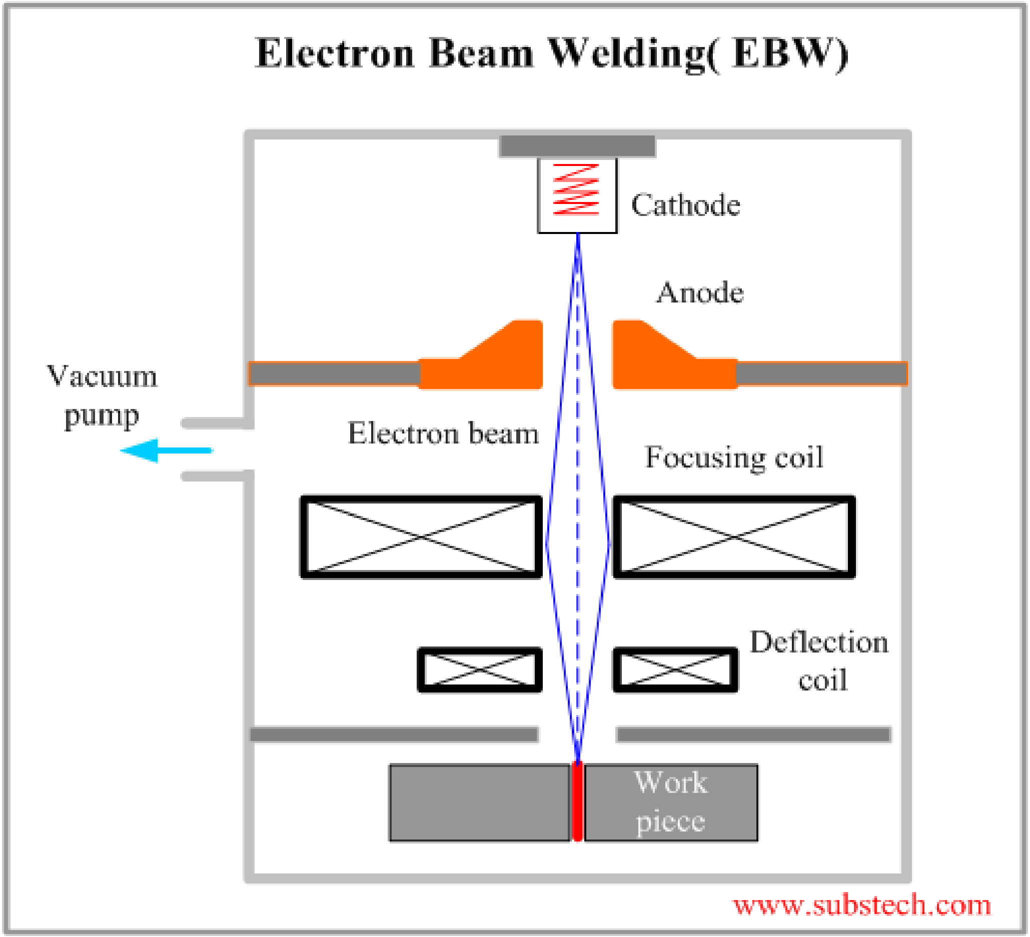
RESISTANCE WELDING

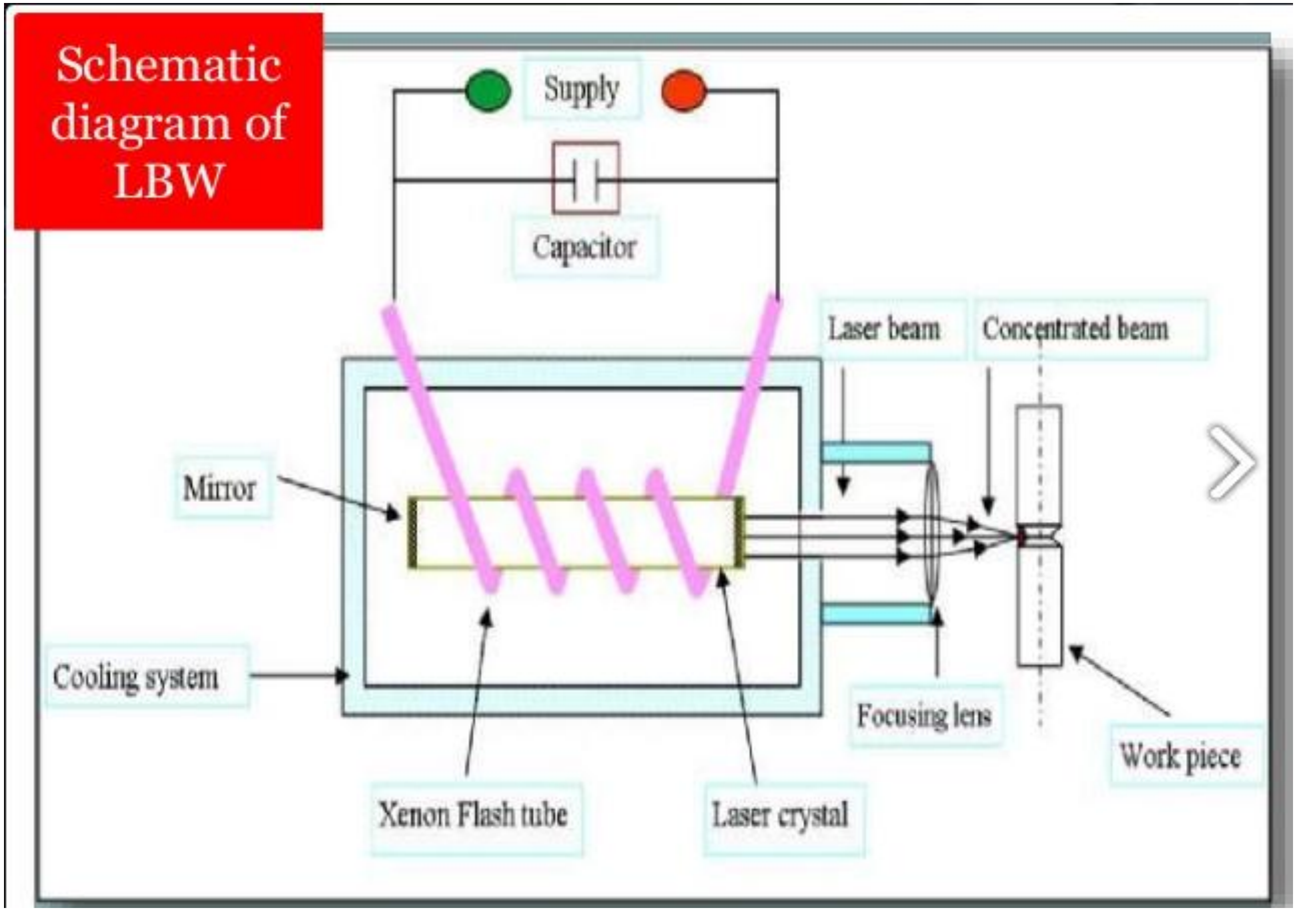


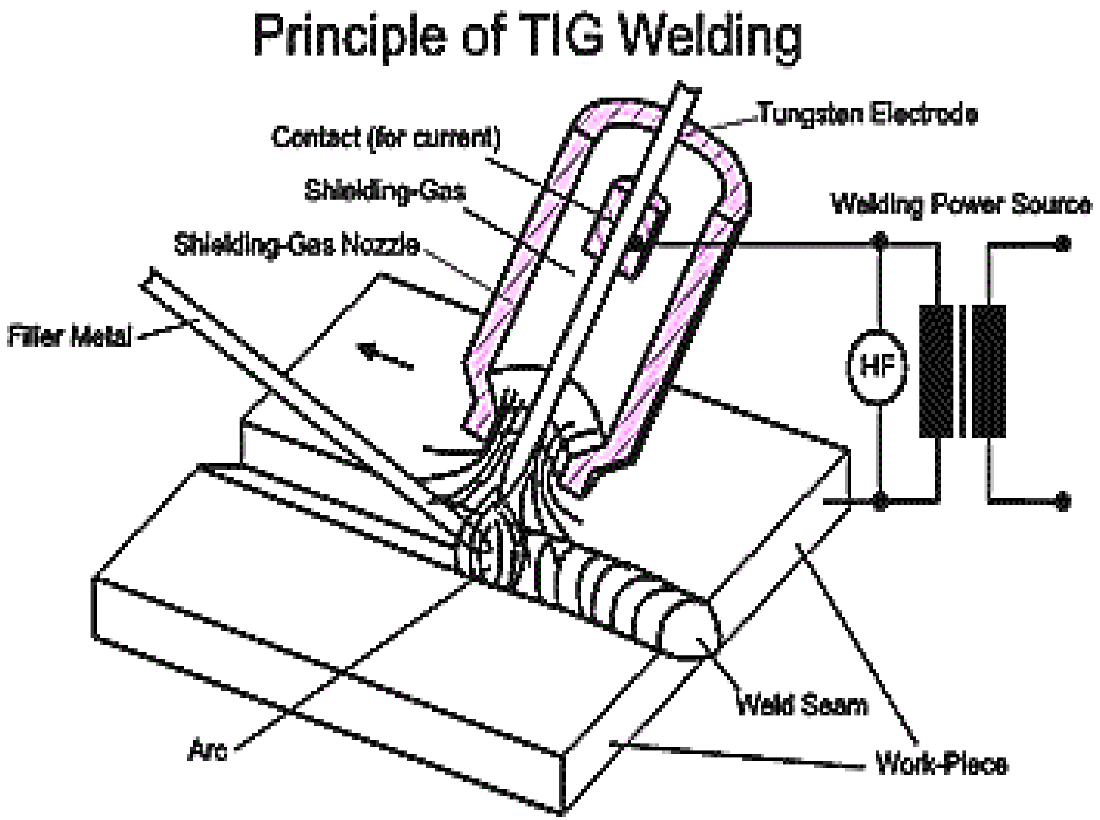
Resistance welding is one of the oldest of electric welding process in use by industry today. The weld is made by a combination of heat, pressure and time. As the name resistance welding imlies, it is the resistance of the material to be welded to causes current to flow and localized heating in the part. The pressure exerted by the tongs and electrode tips, through which the current flows, hold the parts to be welded in intimate contact before, during and after the welding current time cycle. The required amount of time to current to flow in the joint is determined by material thikness and type, the amount of current flowing and the cross-section area of the welding tip contact surfaces.

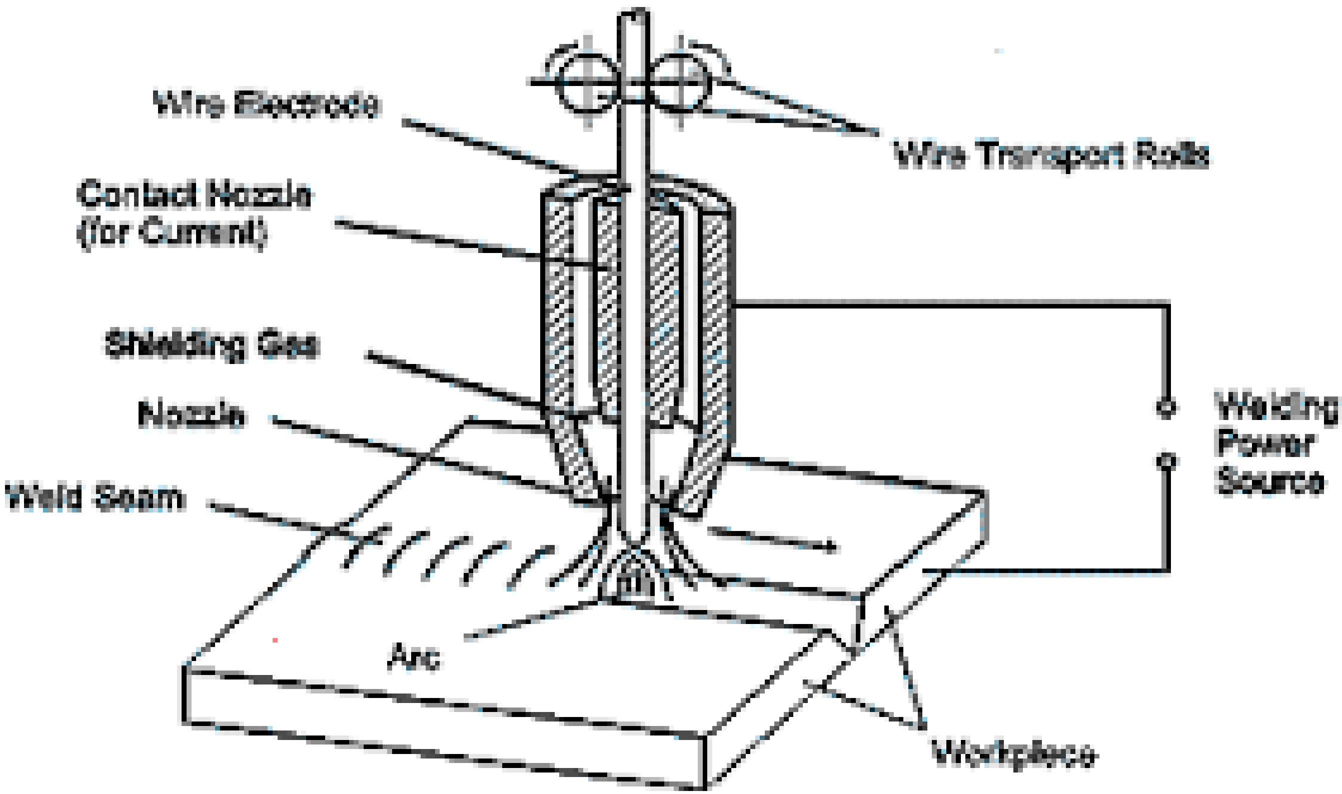


Spot welding

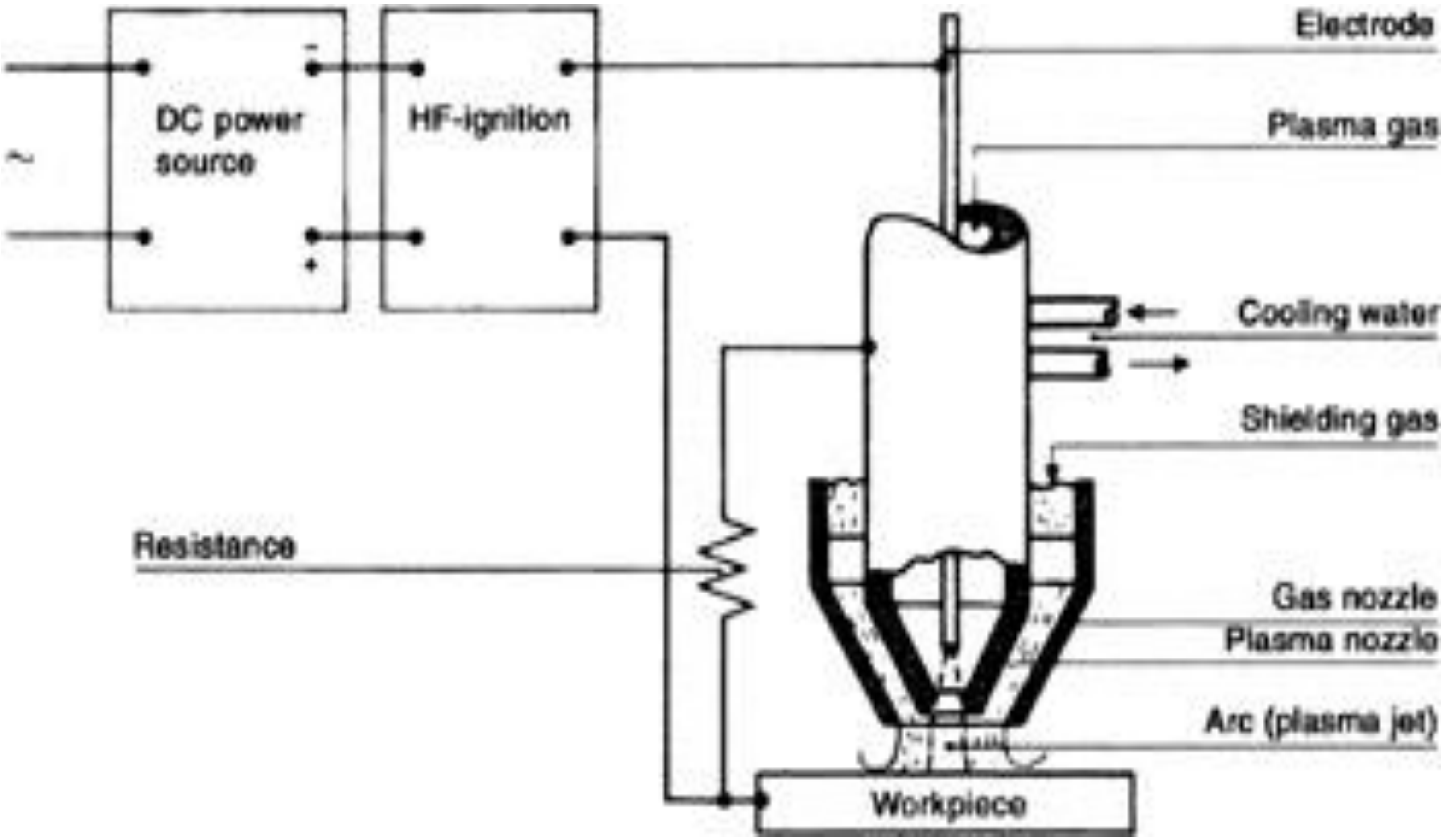

Electron Beam Welding(EBW)
Cathode
Anode
Vacuum
pump
Electron beam
Focusing coil
Deflection
coil
Work
piece
www.substech.com


Schematic diagram of LBW
Supply
Capacitor
Laser beam
Concentrated beam
Mirror
Cooling system
Focusing lens
Work piece
Xenon Flash tube
Laser crystal

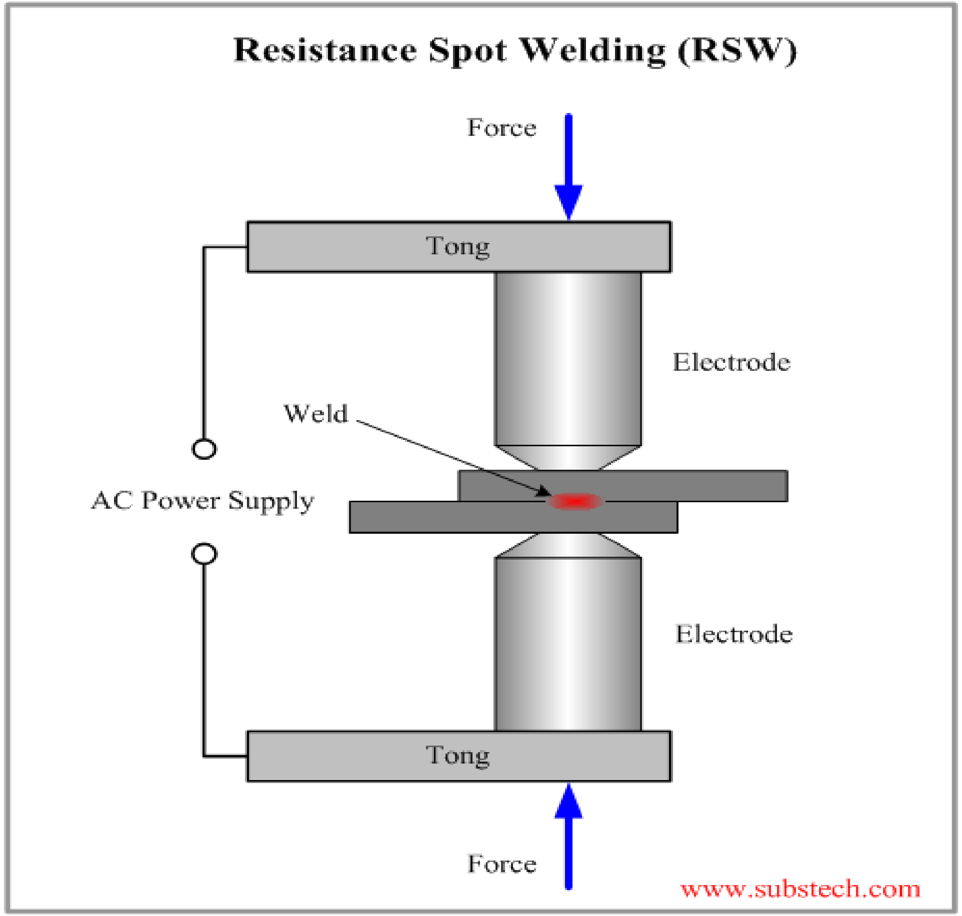

Principle of TIG Welding
Tungsten Electrode
Contact (for current)
Shielding-Gas
Welding Power Source
Shielding-Gas Nozzle
Filler Metal
HF
Weld Seam
Arc
Work-Piece


Wire Electrode
Wire Transport Rolls
Contact Nozzle
(for Current)
Shielding Gas
Nozzle
Weld Seam
Welding
Power
Source
Arc
Workpiece

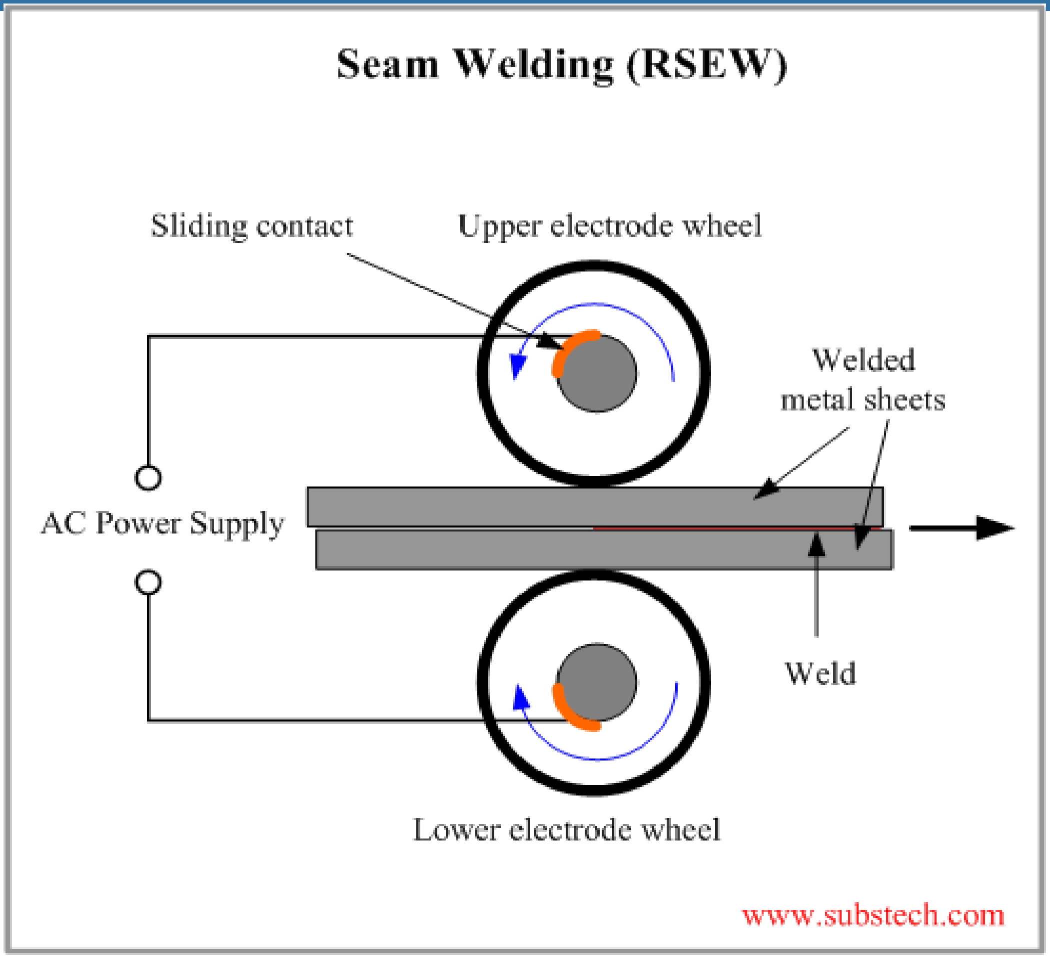
MIG Welding

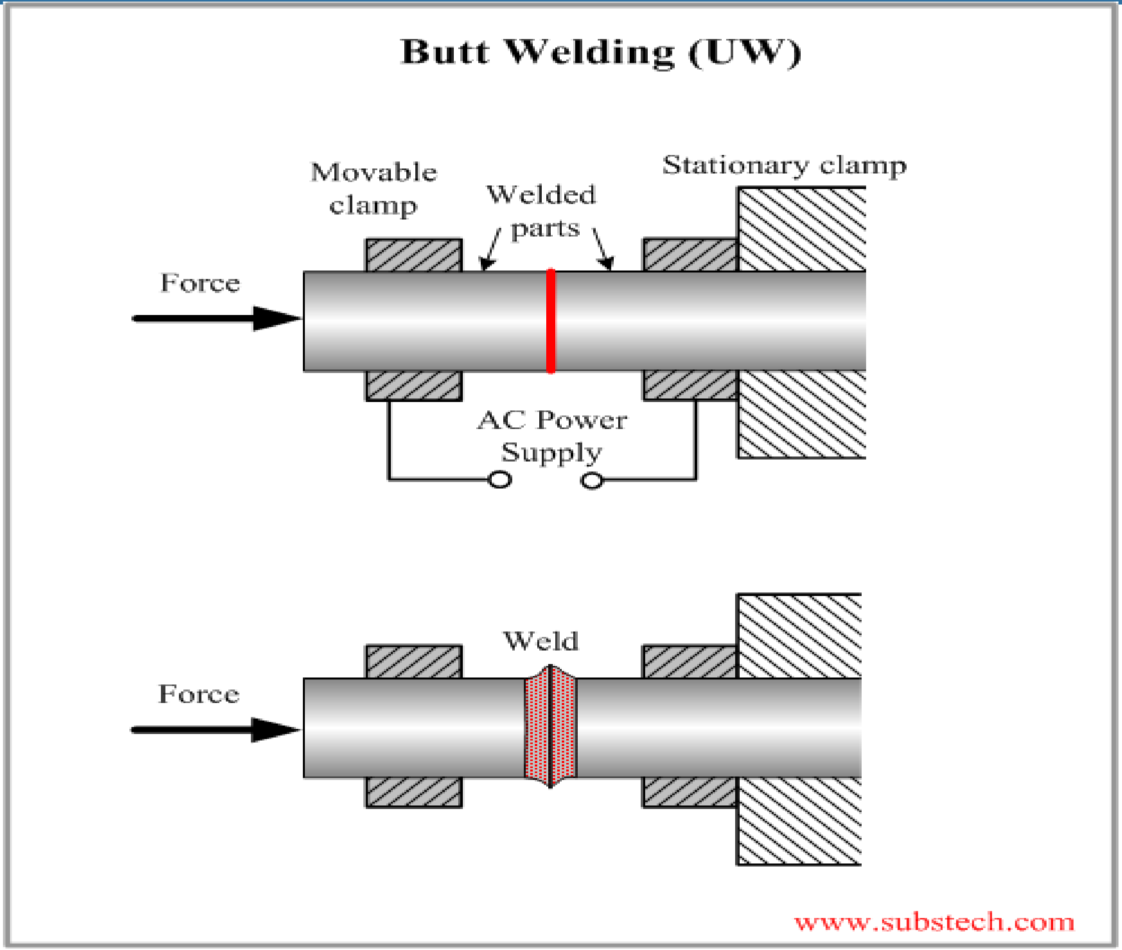


PLASMA ARC WELDING



Resistance Spot Welding (RSW)
Force
Tong
Electrode
Weld
AC Power Supply
Electrode
Tong
Force
www.substech.com


Seam Welding (RSEW)
Sliding contact
Upper electrode wheel
Welded
metal sheets
AC Power Supply
Weld
Lower electrode wheel
www.substech.com


Butt Welding (UW)
Movable clamp
Welded parts
Stationary clamp
Force
AC Power Supply
Weld
Force
www.substech.com

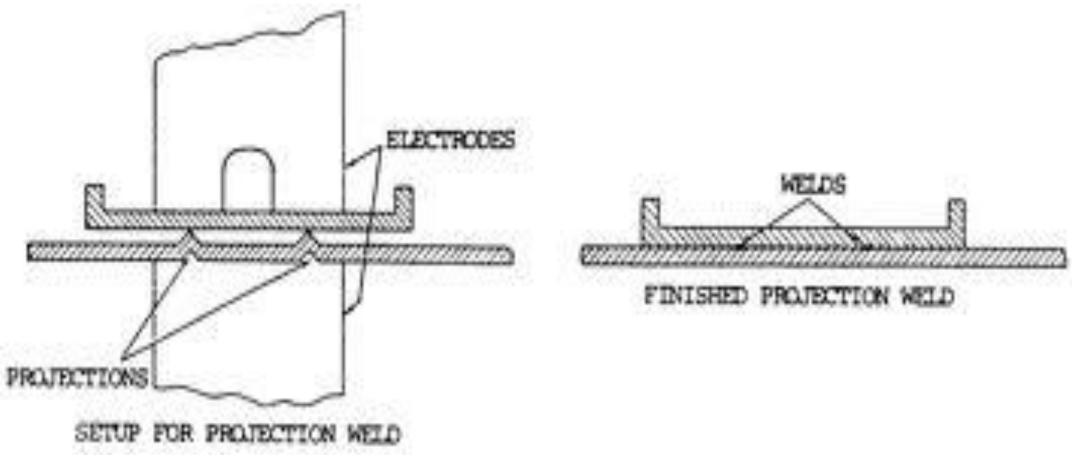
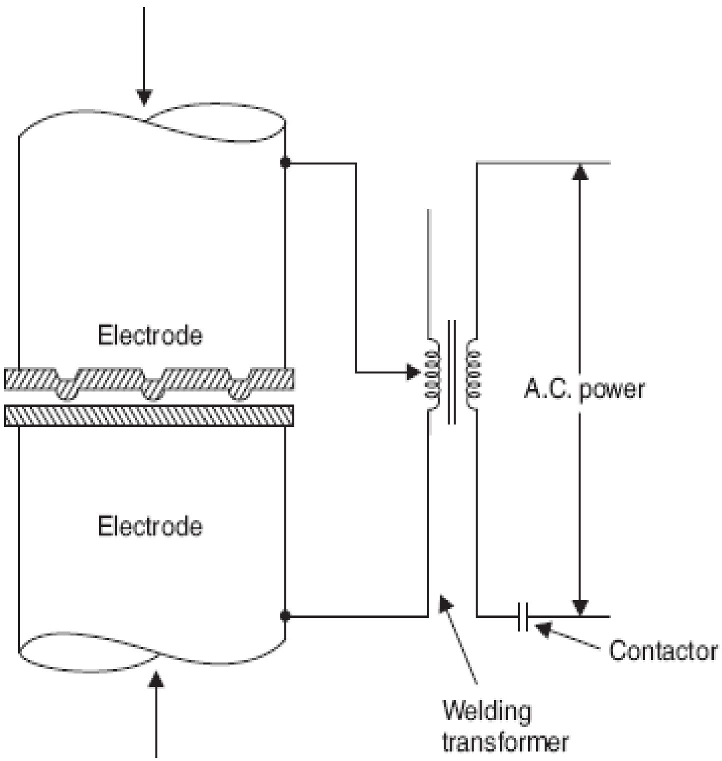


Figure 5-40. Projection welding.



PROJECTION WELDING

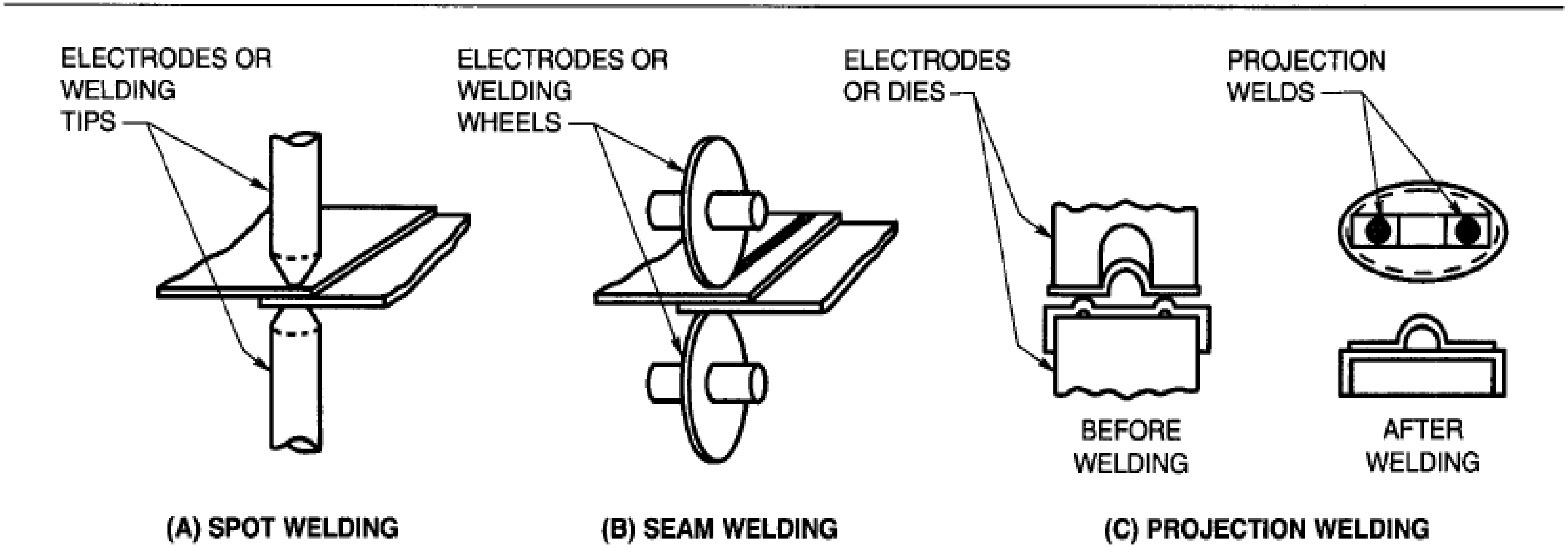


Figure R-7—Simplified Diagrams Showing the Basic Processes of Spot, Seam, and Projection Welding

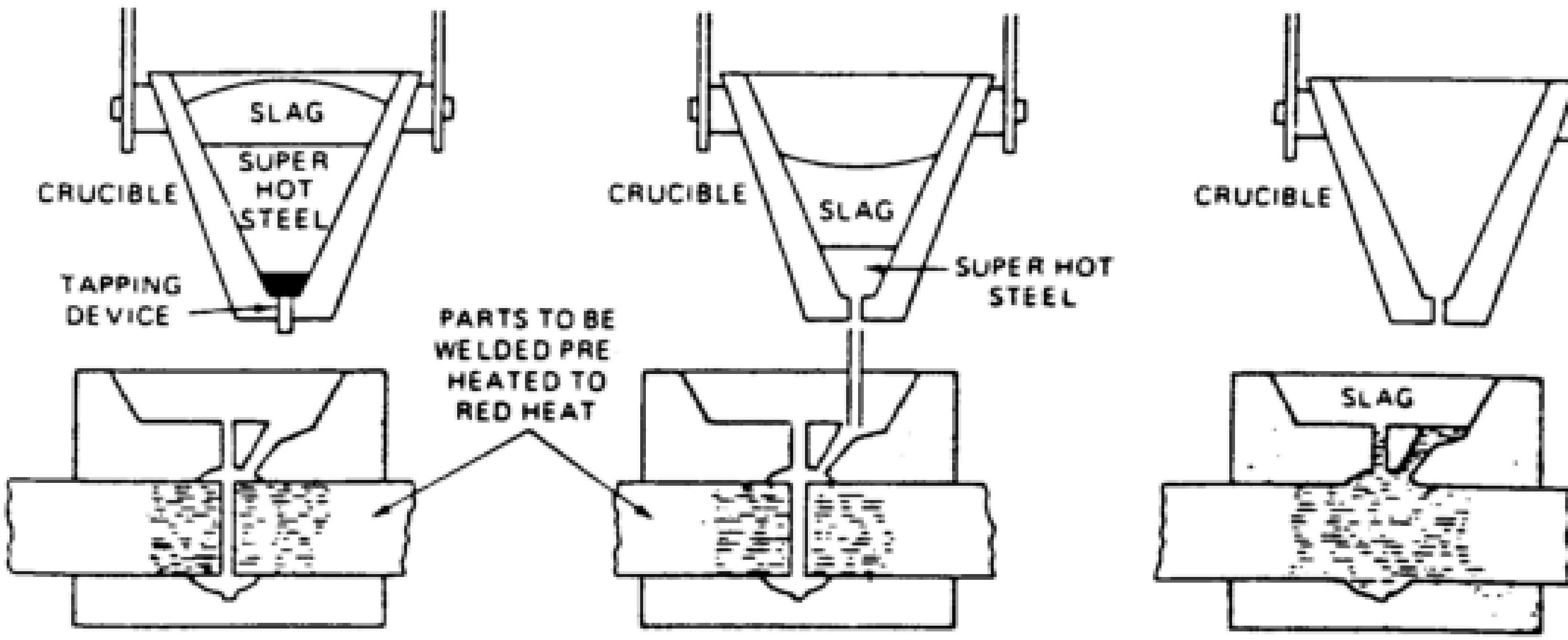
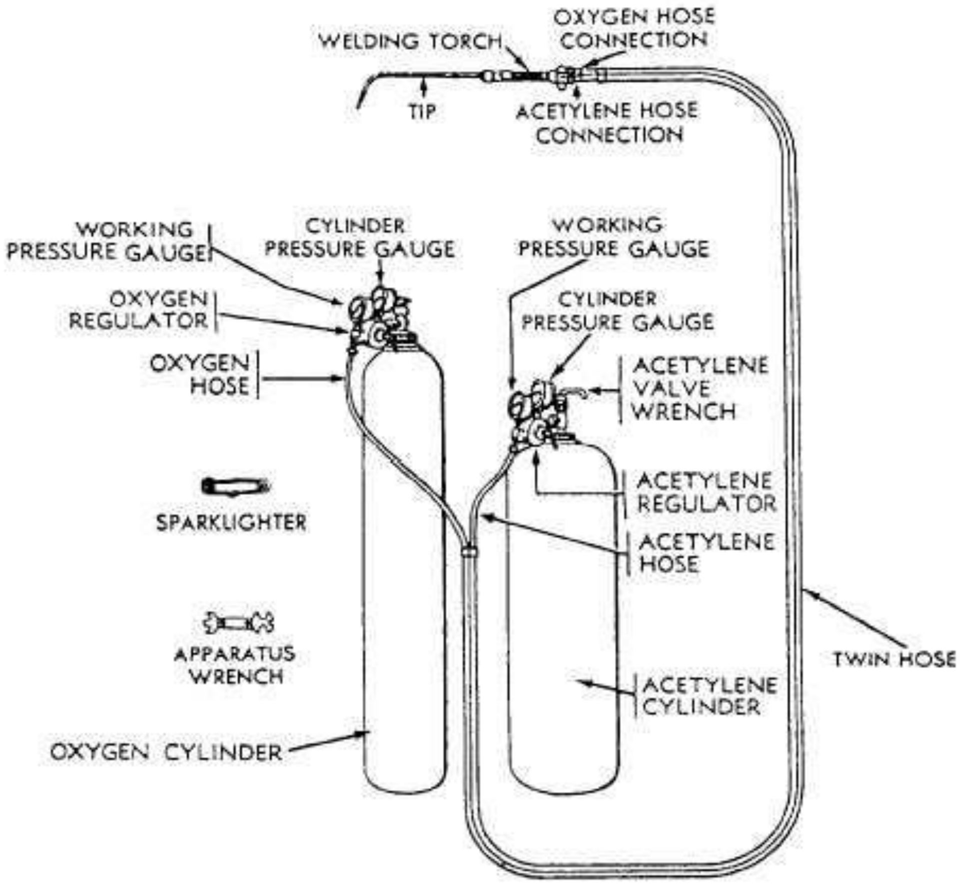


Figure 6-12. Steps in making a thermit weld.

THERMIT WELDING



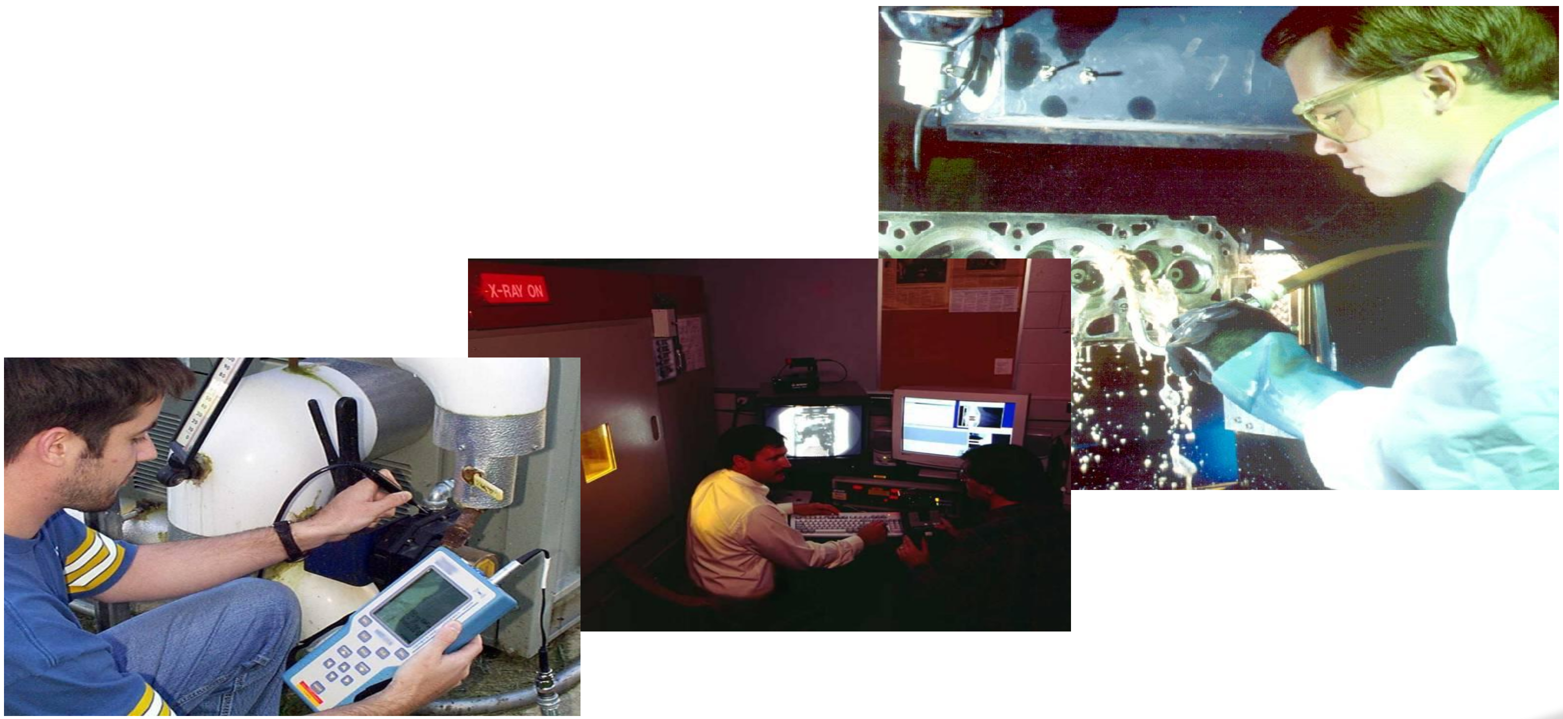
OXY ACETLYNE GAS WELDING

Introduction to Nondestructive Testing

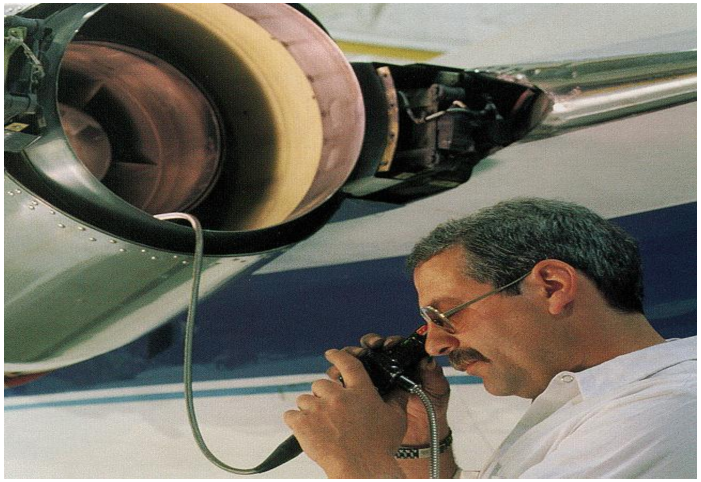
Outline

- Introduction to NDT
- Overview of Six Most Common NDT Methods
- Selected Applications

Six Most Common NDT Methods



Visual Inspection



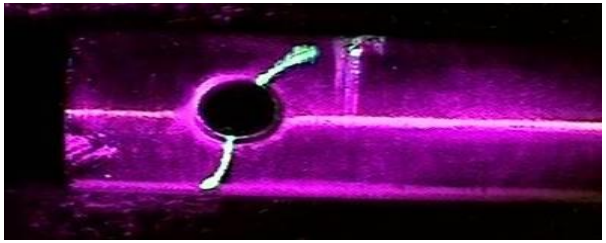
Most basic and common inspection method.

Tools include fiberscopes, borescopes, magnifying glasses and mirrors.

Liquid Penetrant Inspection

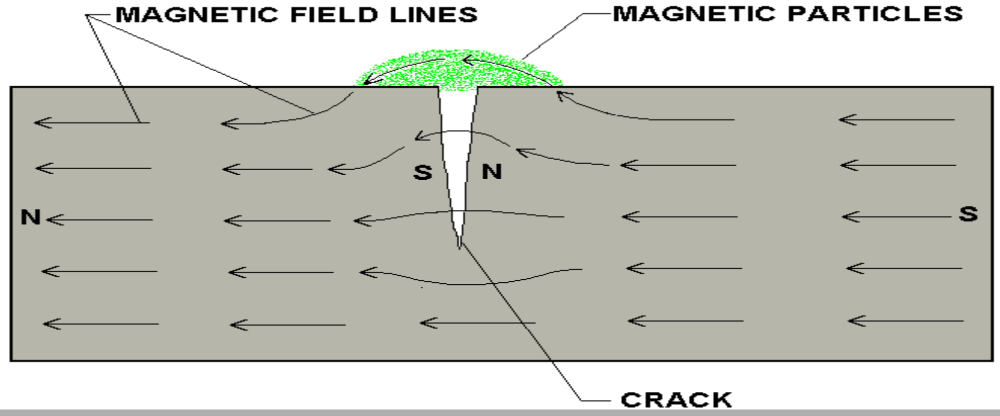
- A liquid with high surface wetting characteristics is applied to the surface of the part and allowed time to seep into surface breaking defects.
- The excess liquid is removed from the surface of the part.
- A developer (powder) is applied to pull the trapped penetrant out the defect and spread it on the surface where it can be seen.
- Visual inspection is the final step in the process. The penetrant used is often loaded with a fluorescent dye and the inspection is done under UV light to increase test sensitivity.



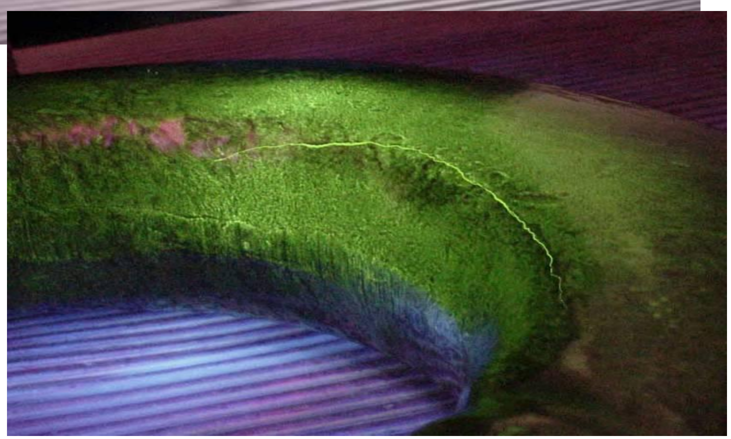



Magnetic Particle Inspection

- The part is magnetized. Finely milled iron particles coated with a dye pigment are then applied to the specimen. These particles are attracted to magnetic flux leakage fields and will cluster to form an indication directly over the discontinuity. This indication can be visually detected under proper lighting conditions.

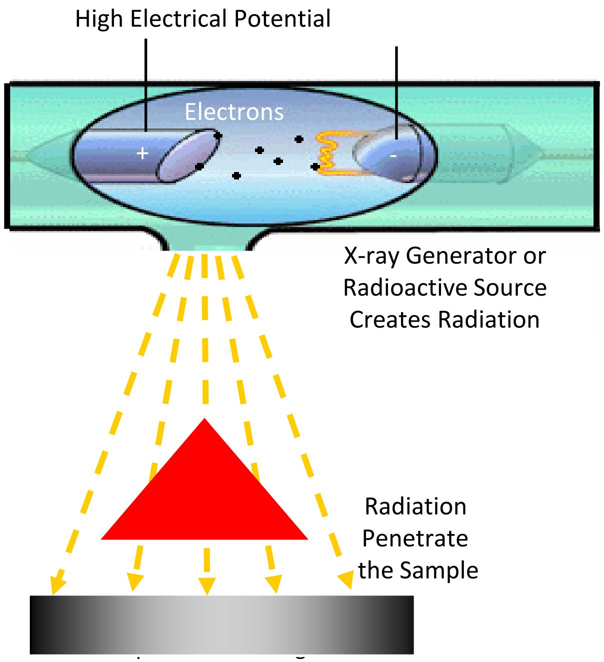


Magnetic Particle Crack Indications

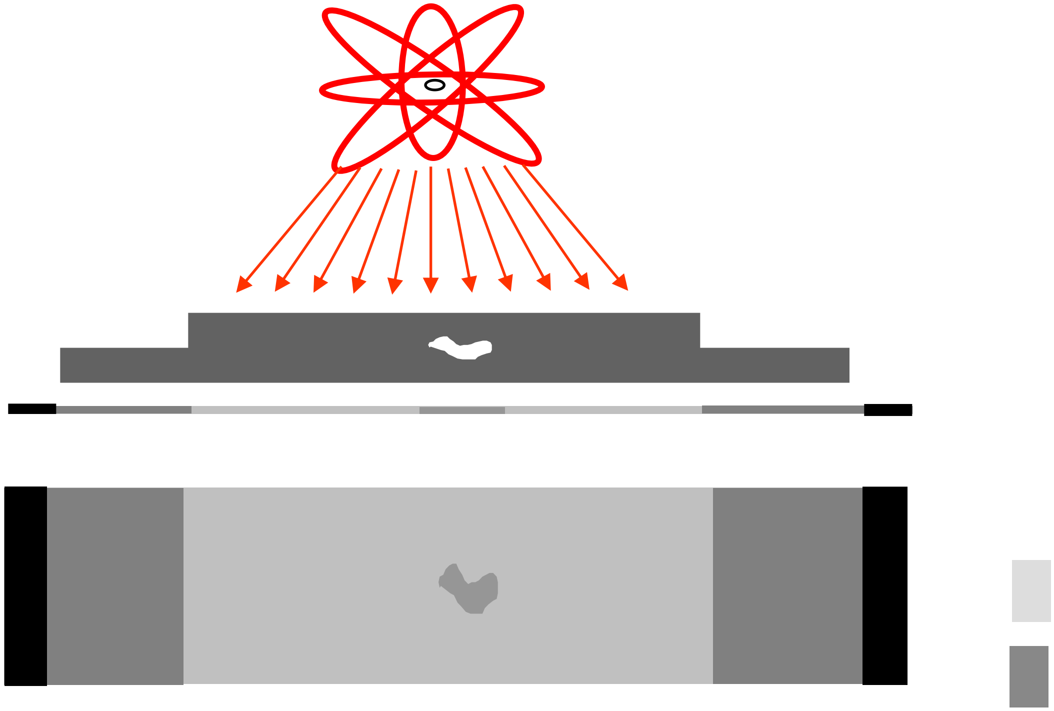


Radiography

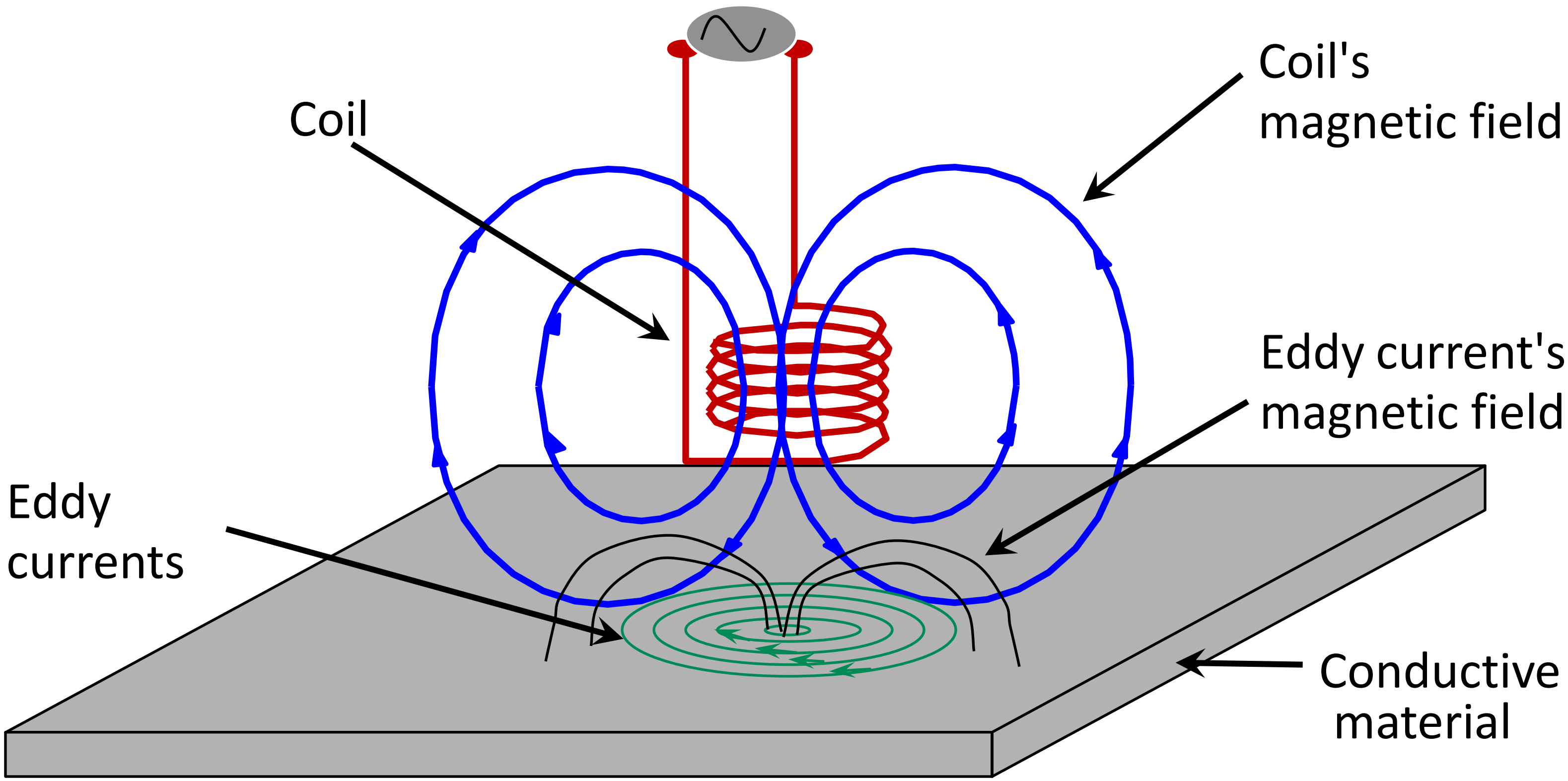
The radiation used in radiography testing is a higher energy (shorter wavelength) version of the electromagnetic waves that we see as visible light. The radiation can come from an X-ray generator or a radioactive source.



Film Radiography



Eddy Current Testing



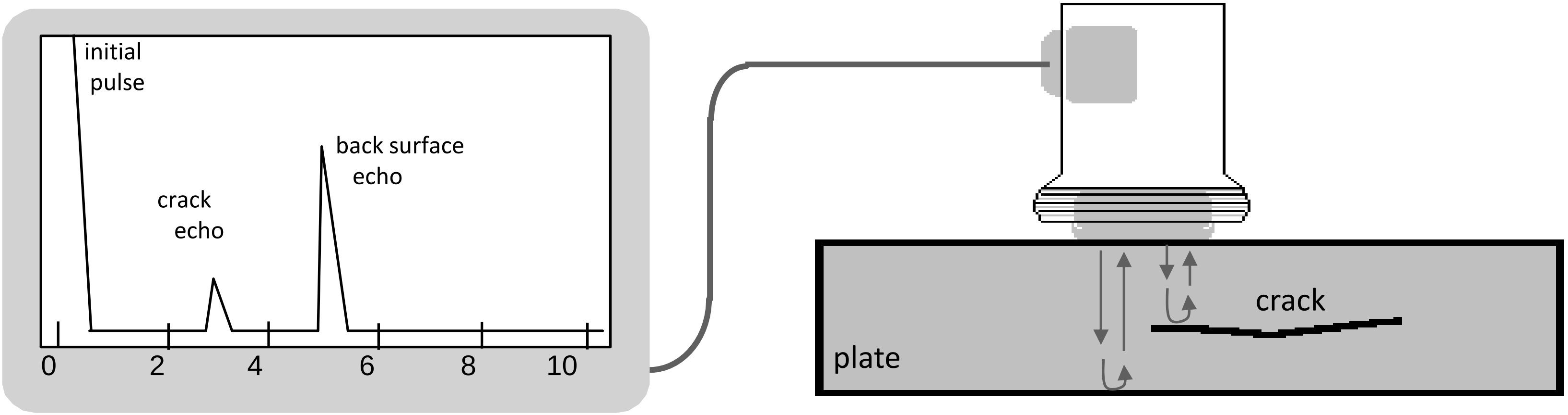
Eddy Current Testing

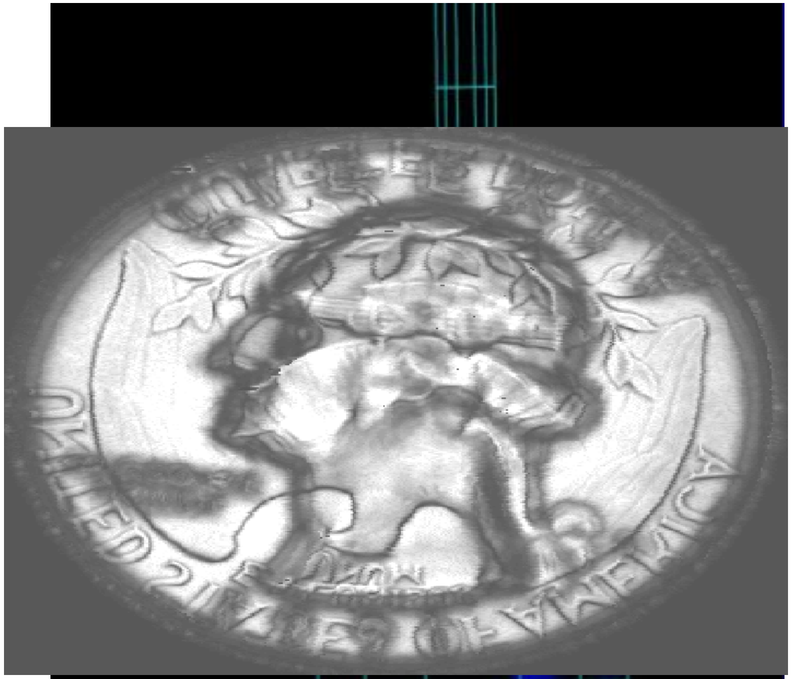
Ultrasonic Inspection (Pulse-Echo)

High frequency sound waves are introduced into a material and they are reflected back from surfaces or flaws.

Reflected sound energy is displayed versus time, and inspector can visualize a cross section of the specimen showing the depth of features that reflect sound.

f





y scale image produced using the sound reflected
n the back surface of the coin (inspected from
ads" side)

Common Application of NDT

- Inspection of Raw Products
- Inspection Following Secondary Processing
- In-Services Damage Inspection

Inspection of Raw Products

- Forgings,
- Castings,
- Extrusions,
- etc.

Special Measurements

CASTING, WELDING AND INSPECTION TECHNIQUES

- **SHEET METAL PROCESSES IN AIRCRAFT INDUSTRY**

MODULE - III

CLOs	Course Learning Outcome
CLO7	Getting knowledge about the techniques to produce a safe, effective, economic final product.
CLO8	Understand the theoretical knowledge behind the design and development of aircraft components.
CLO9	Gain knowledge about the basic convectional, unconventional riveting and welding for knowledge based exams.

Introduction

- Sheet metal is simply metal formed into thin and flat pieces. It is one of the fundamental forms used in metalworking, and can be cut and bent into a variety of different shapes.
- Countless everyday objects are constructed of the material.
- Thicknesses can vary significantly, although extremely thin thicknesses are considered foil or leaf, and pieces thicker than 6 mm (0.25 in) are considered plate.

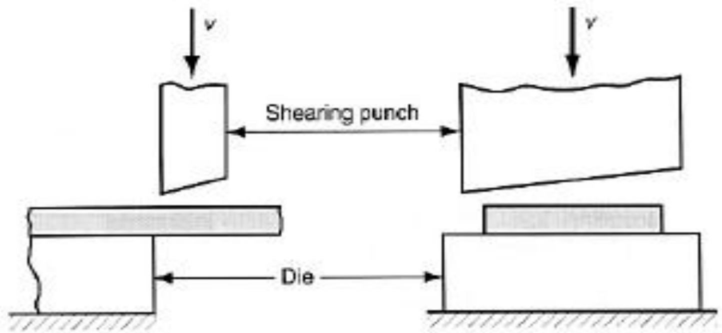
Sheet metal processing

- The raw material for sheet metal manufacturing processes is the output of the rolling process. Typically, sheets of metal are sold as flat, rectangular sheets of standard size.
- If the sheets are thin and very long, they may be in the form of rolls. Therefore the first step in any sheet metal process is to cut the correct shape and sized ‘blank’ from larger sheet.

- **Sheet Metal Forming processes**

- Introduction
  1. Sheet metal processes involve plane stress loadings and lower forces than bulk forming
  2. Almost all sheet metal forming is considered to be secondary processing
  3. The main categories of sheet metal forming are
     - Shearing
     - Bending
     - Drawing

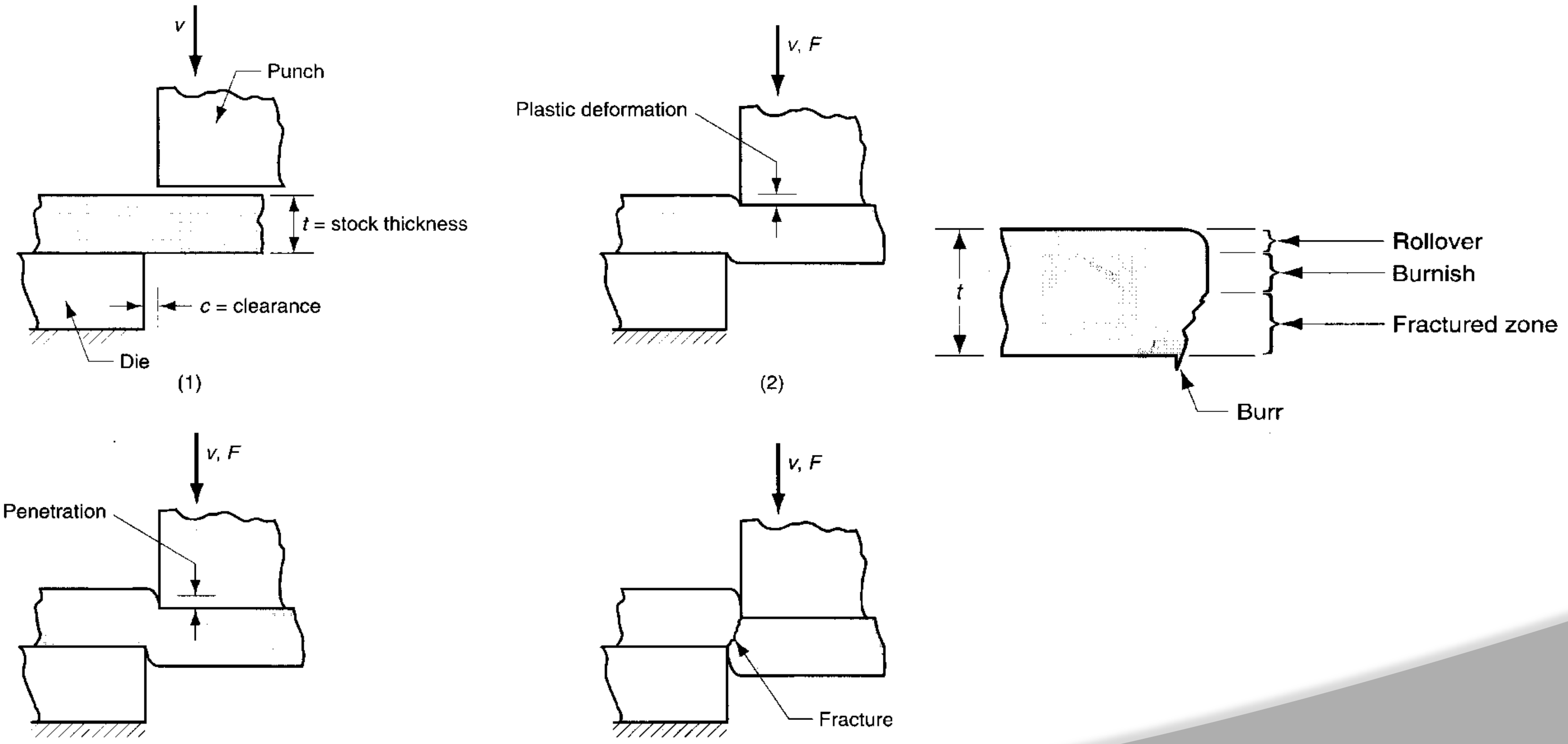
- Shearing
- Shearing is a sheet metal cutting operation along a straight line between two cut-ting edges by means of a power shear.



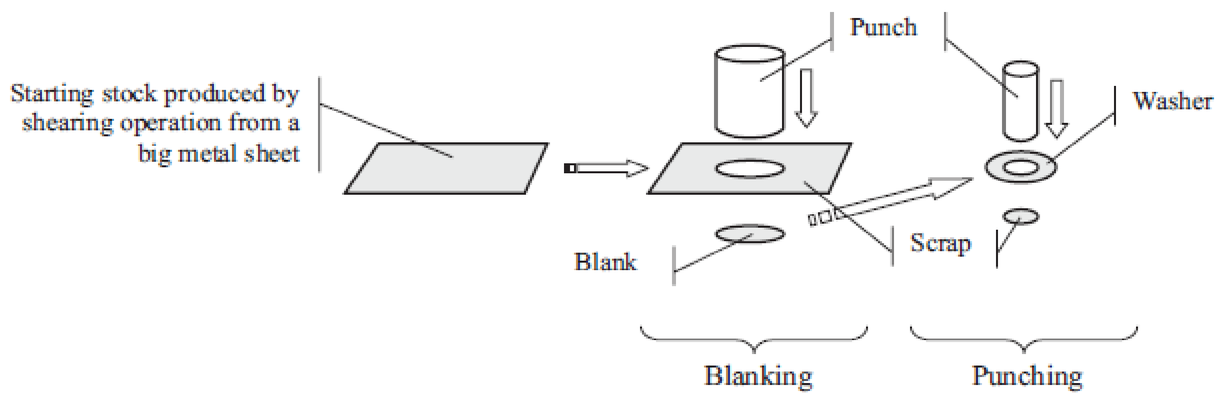
Shearing operation

Shearing by two sharp cutting edges.

Plastic deformation to penetration to fracture

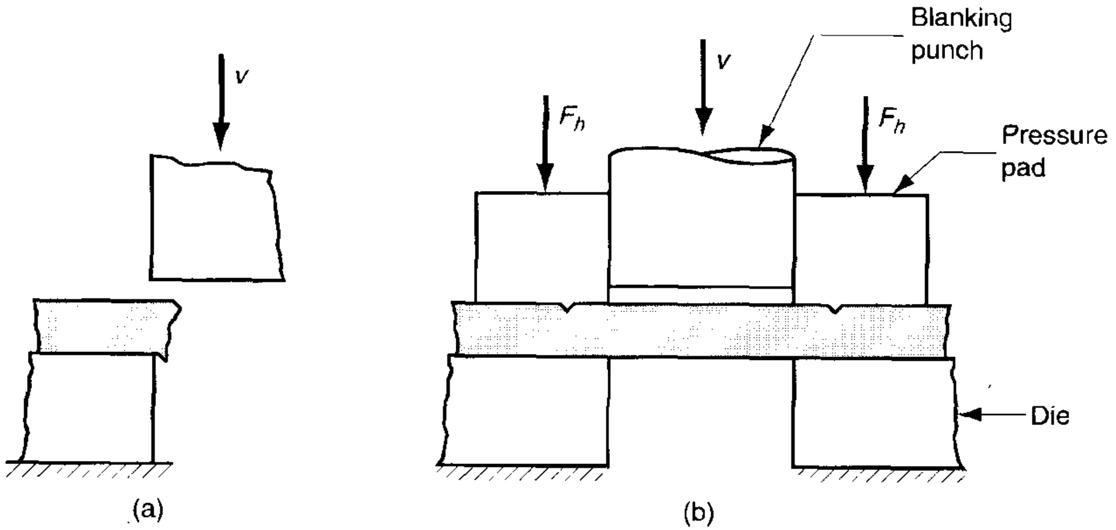


- Blanking and punching
- Blanking and punching are similar sheet metal cutting operations that involve cutting the sheet metal along a closed outline. If the part that is cut out is the desired product, the operation is called blanking and the product is called blank. If the remaining stock is the des … g. Both ope … ducing a was…



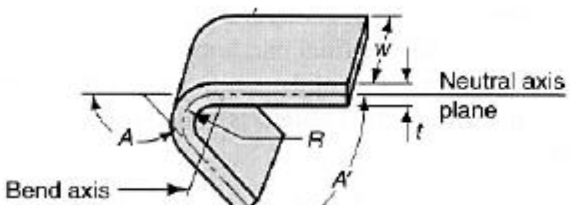
Steps in production of washer

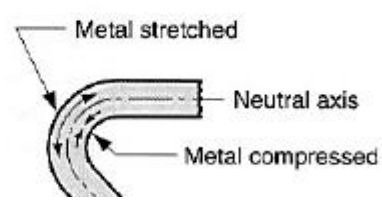
Sheet-metal Cutting Operations

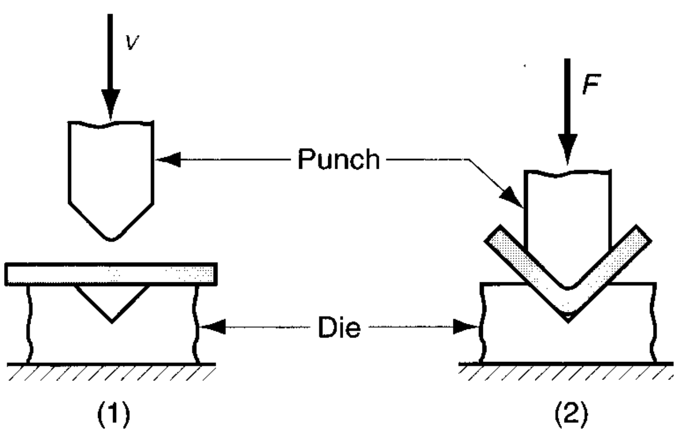


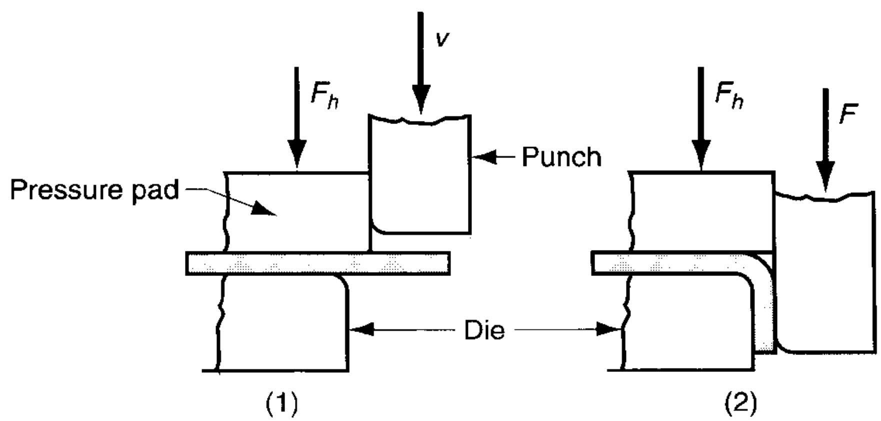
Bending

Bending is defined as the straining of the sheet metal around a straight edge



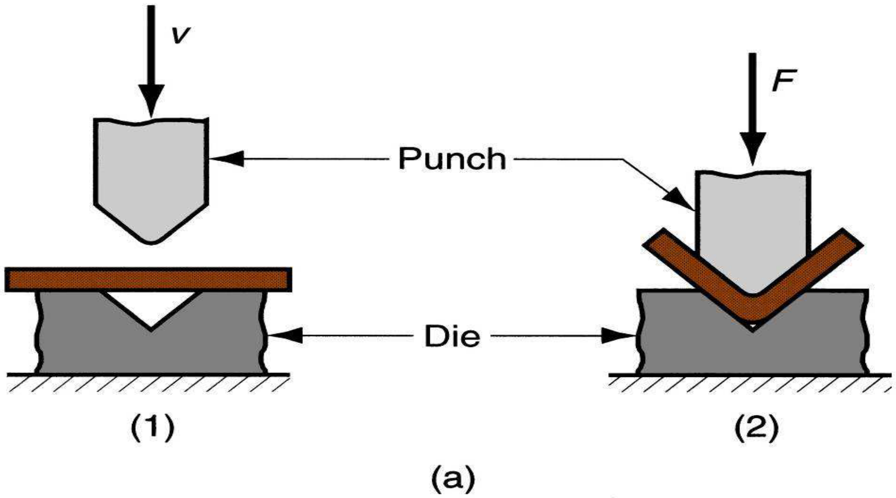






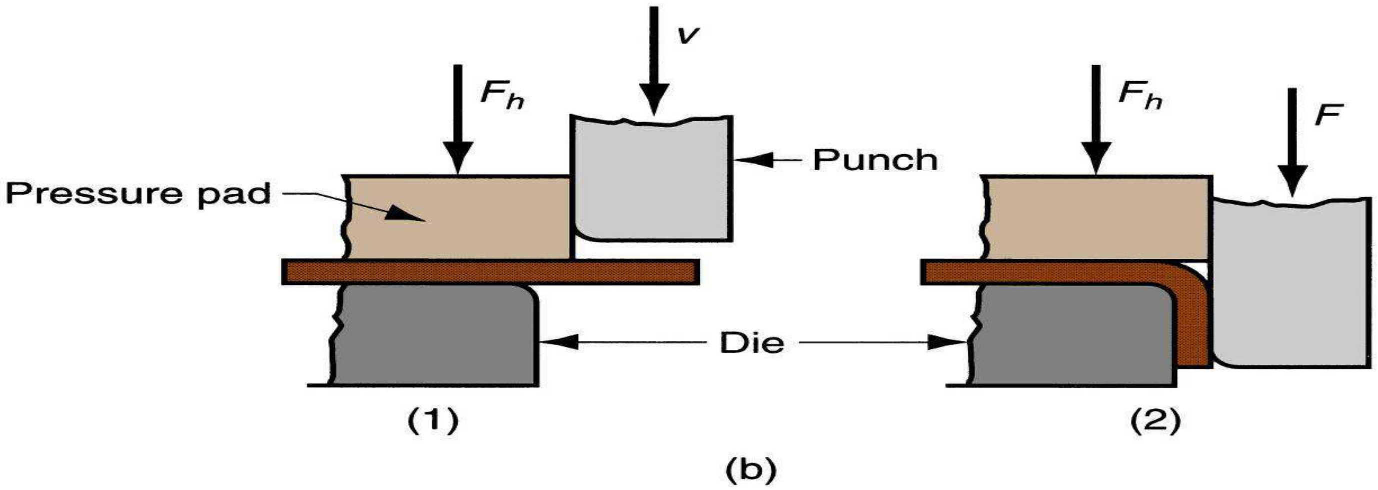
V-Bending

- For low production
- Performed on a press brake
- V-dies are simple and inexpensive

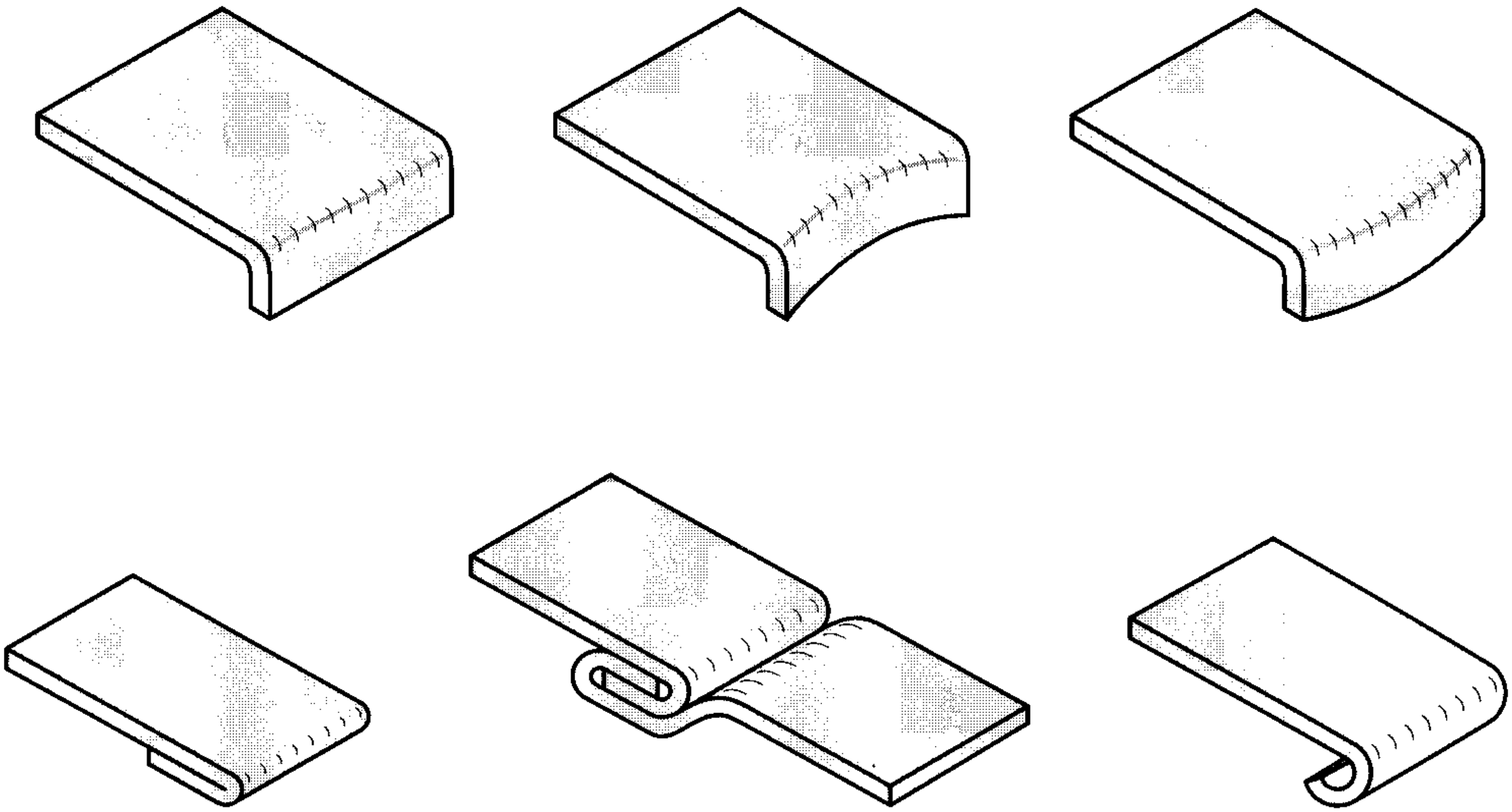


Edge Bending

- For high production
- Pressure pad required
- Dies are more complicated and costly

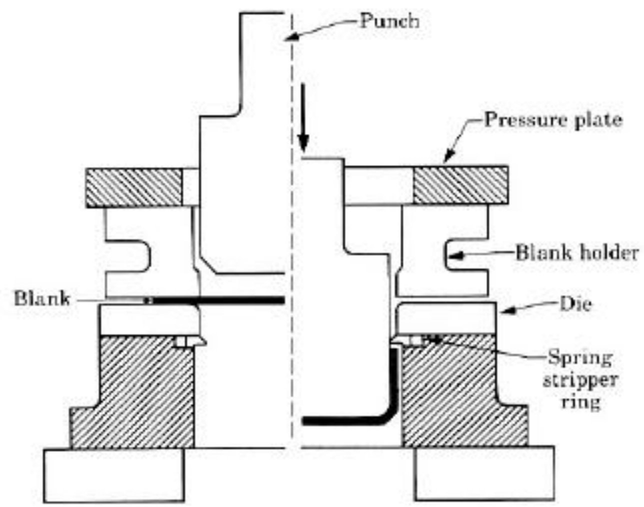


Bending Operations



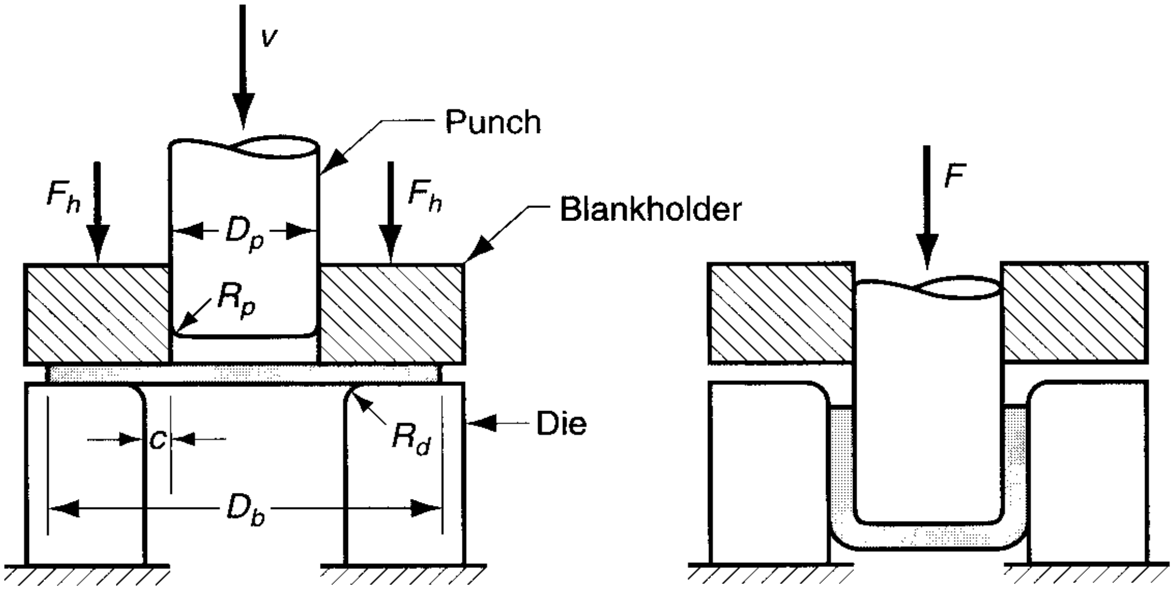
Drawing

Drawing is a sheet-metal operation to make hollow-shaped parts from a sheet blank

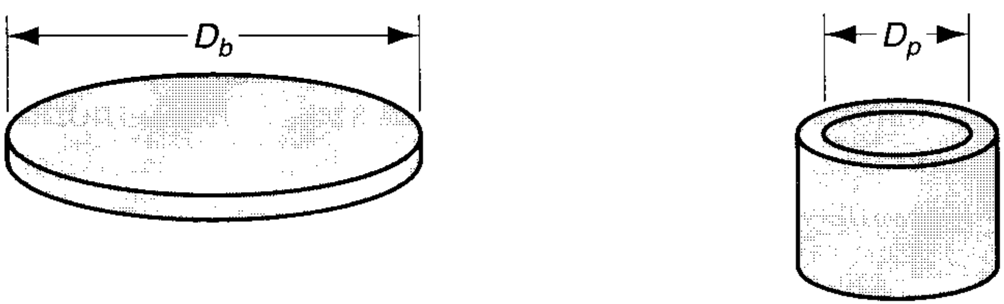


Deep drawing of a cup-shaped part: (*Left*) start of the operation before punch contacts blank, and (*Right*) end of stroke

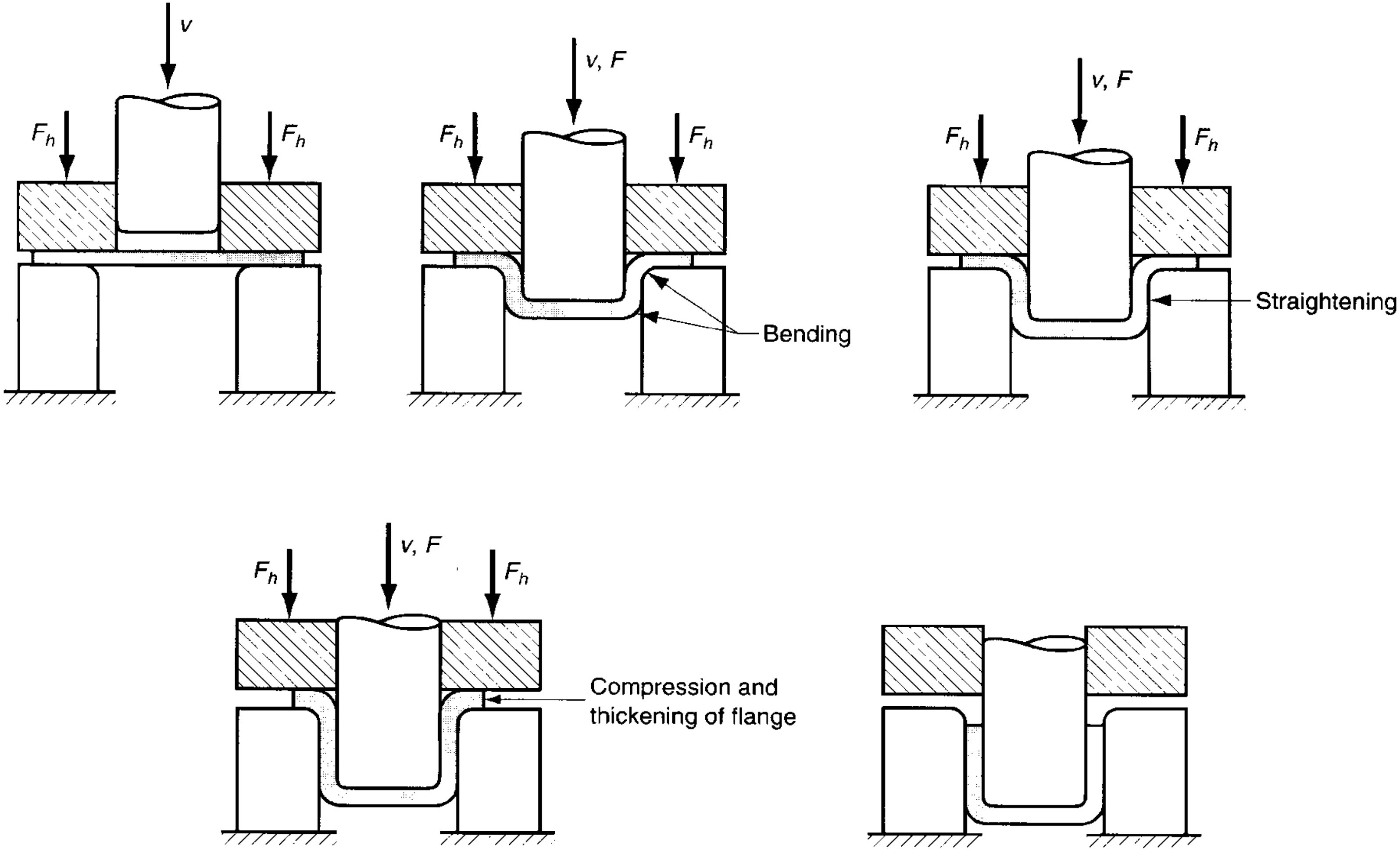
Drawing



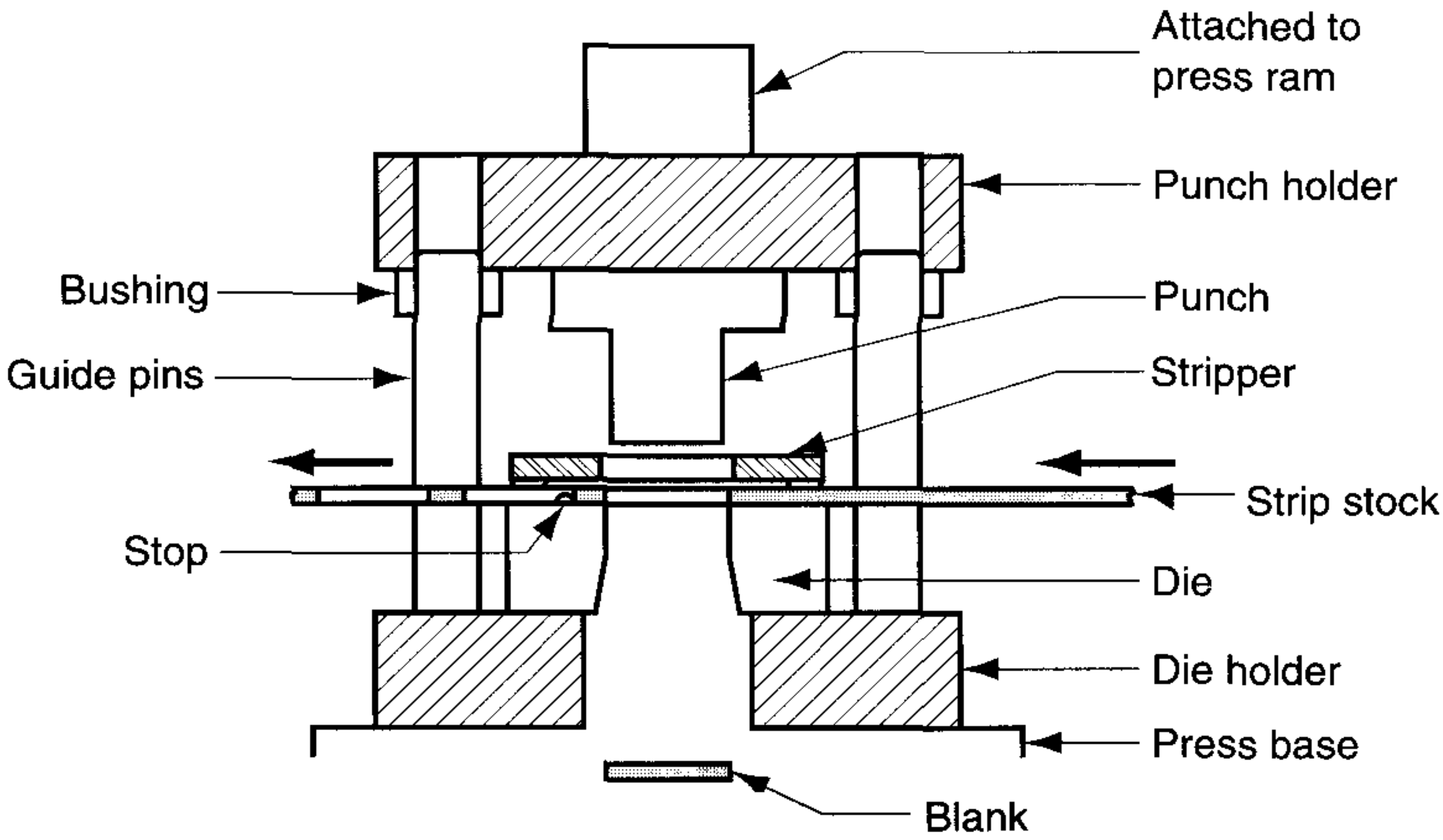
(a)



Deep Drawing



Dies


Attached to press ram
Punch holder
Bushing
Punch
Guide pins
Stripper
Strip stock
Stop
Die
Die holder
Press base
Blank

Sheet metal forming processes

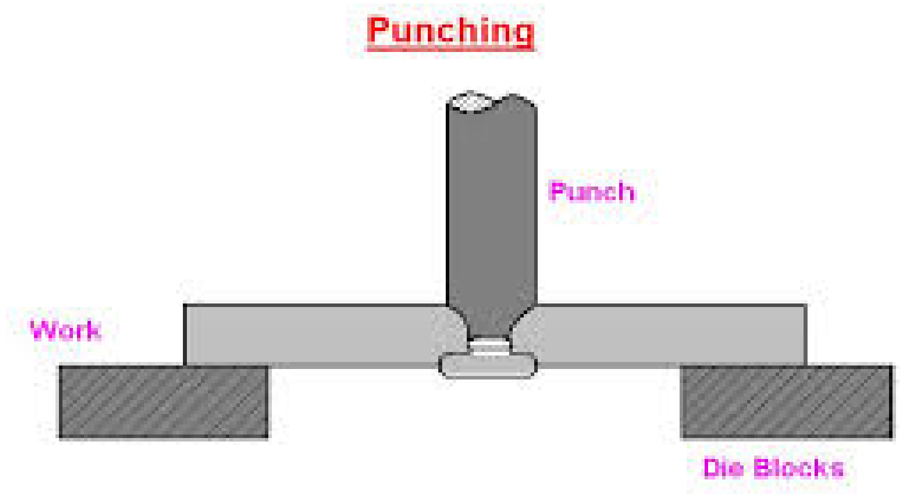
Sheet metal processes can be broken down into two major classifications and one minor classification

- Shearing processes

processes which apply shearing forces to cut, fracture, or separate the material.

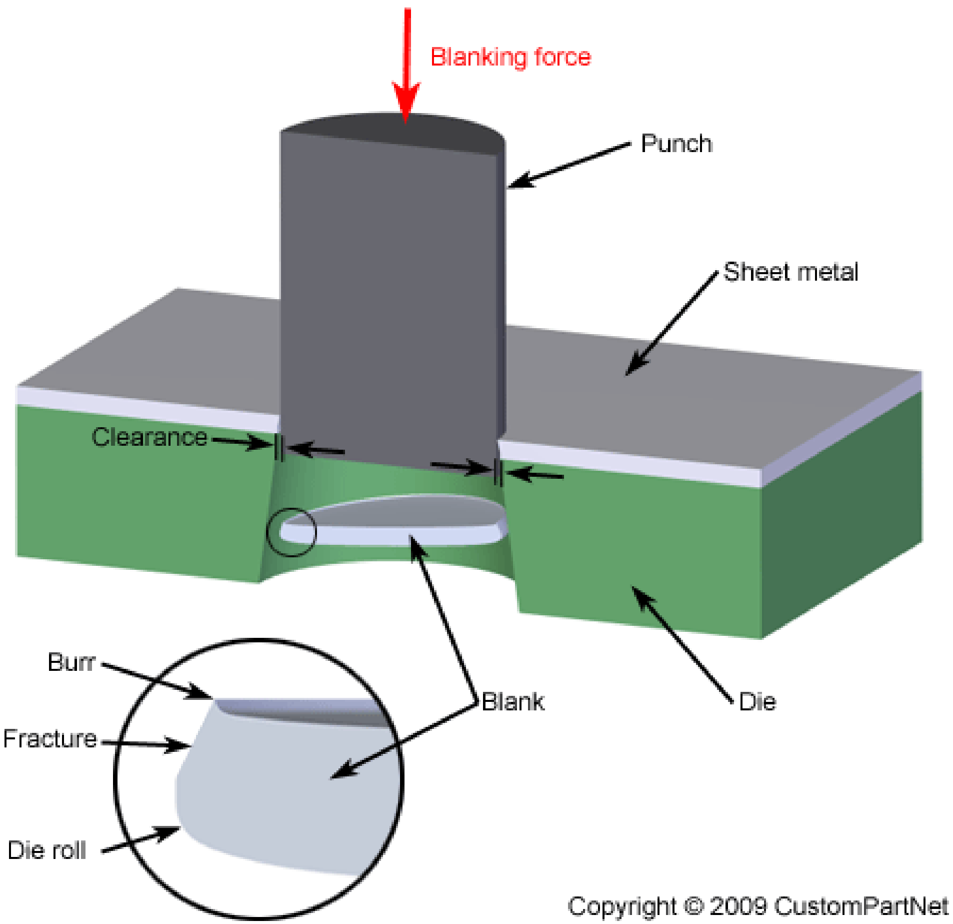
Shearing Process

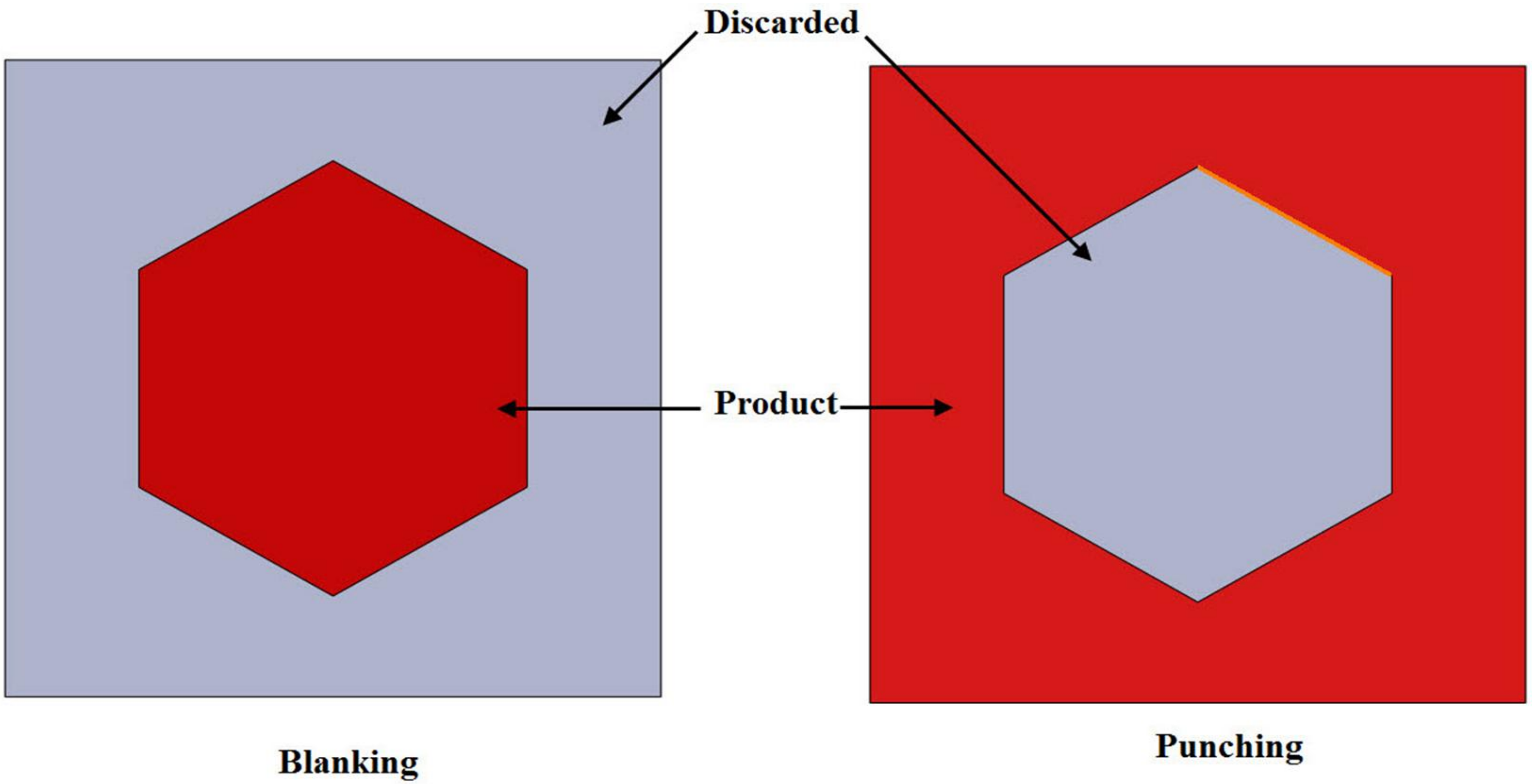
1. Punching: shearing process using a die and punch where the interior portion of



Blanking:

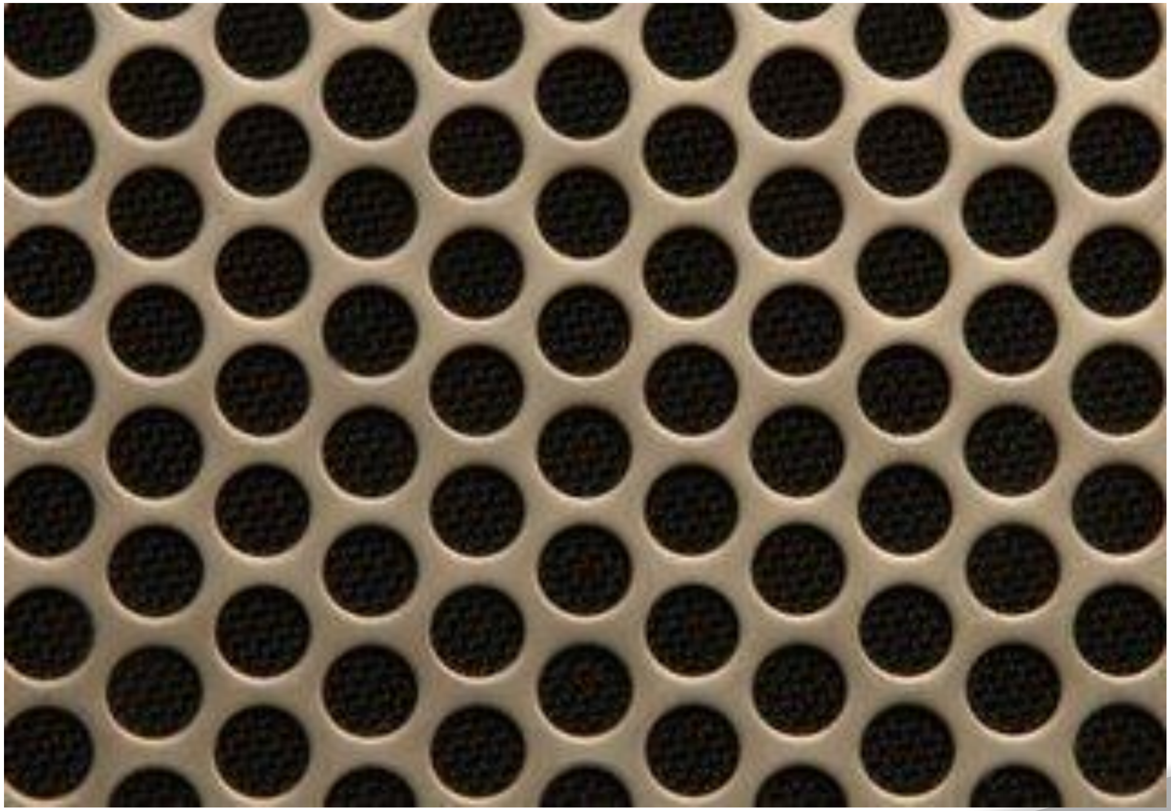
shearing process using a die and punch where the exterior portion of the shearing operation is to be discarded

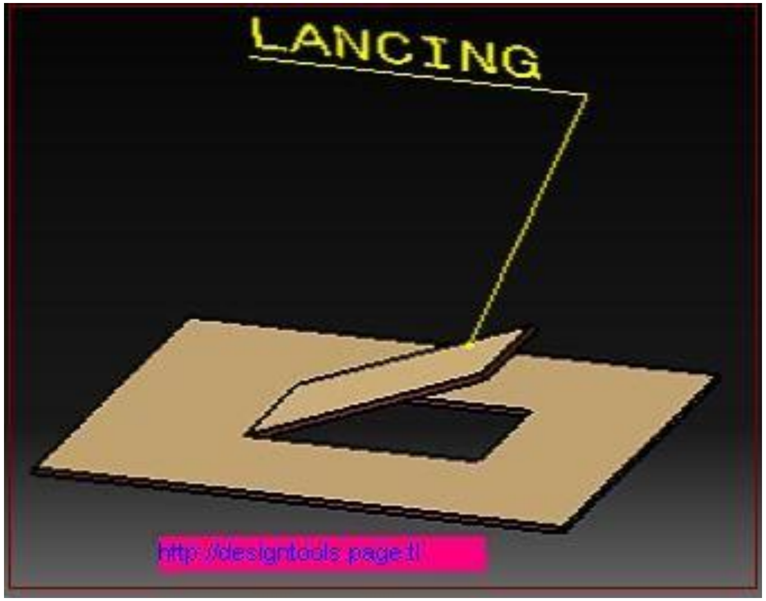

Blanking force
Punch
Sheet metal
Clearance
Burr
Fracture
Die roll
Blank
Die
Copyright © 2009 CustomPartNet

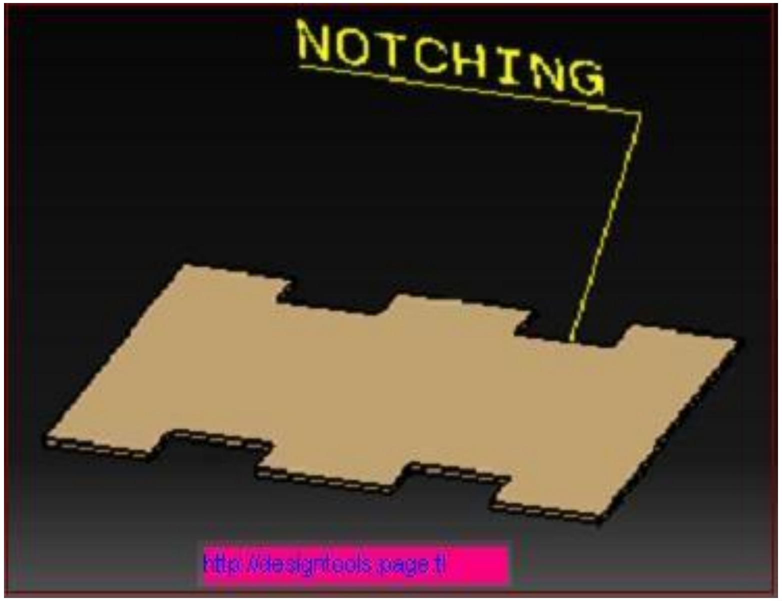

Discarded
Product
Blanking
Punching

Components made with blanking and punching

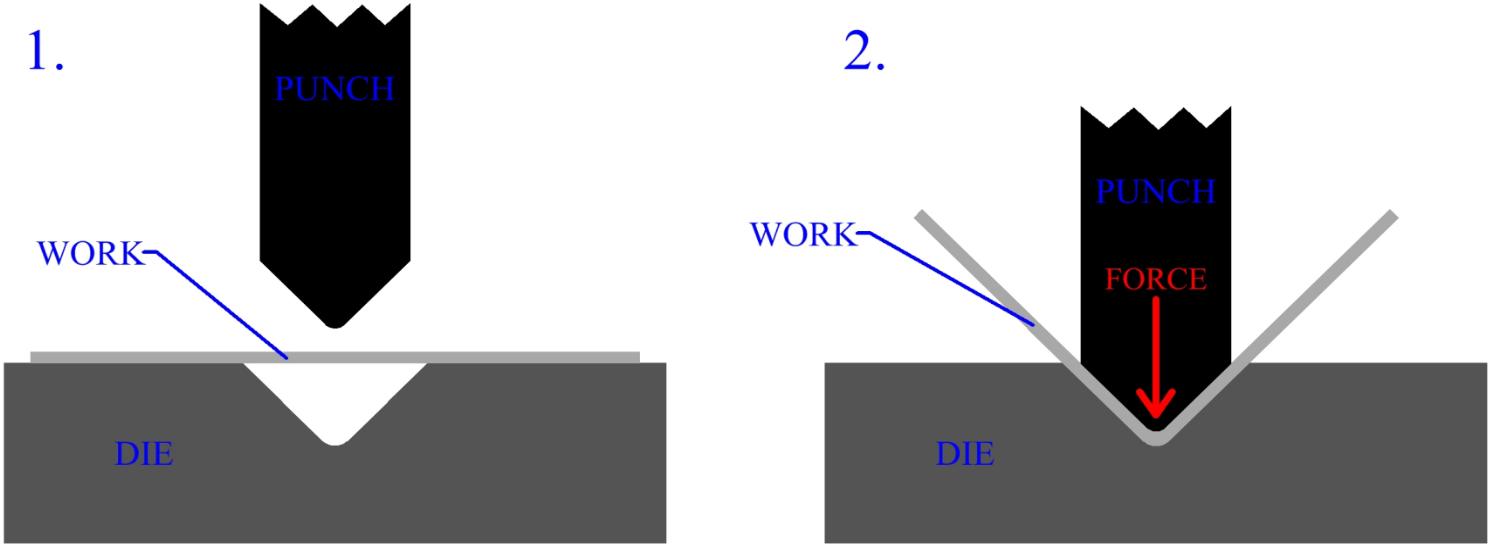
Perforating:

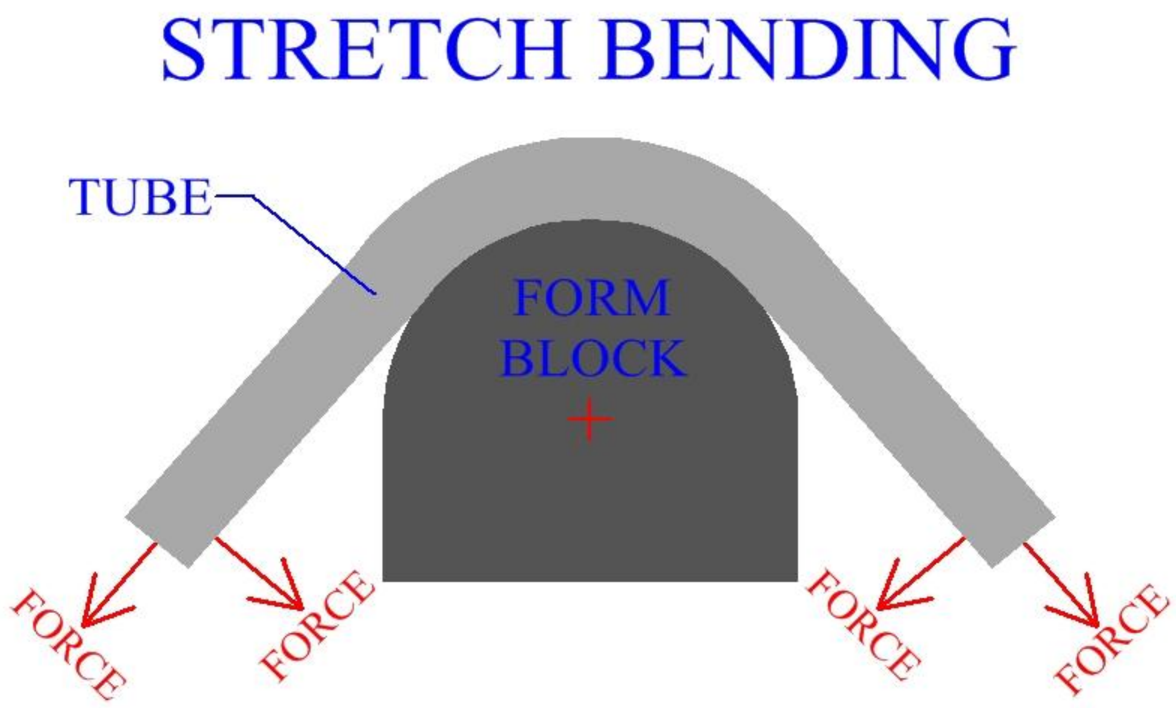


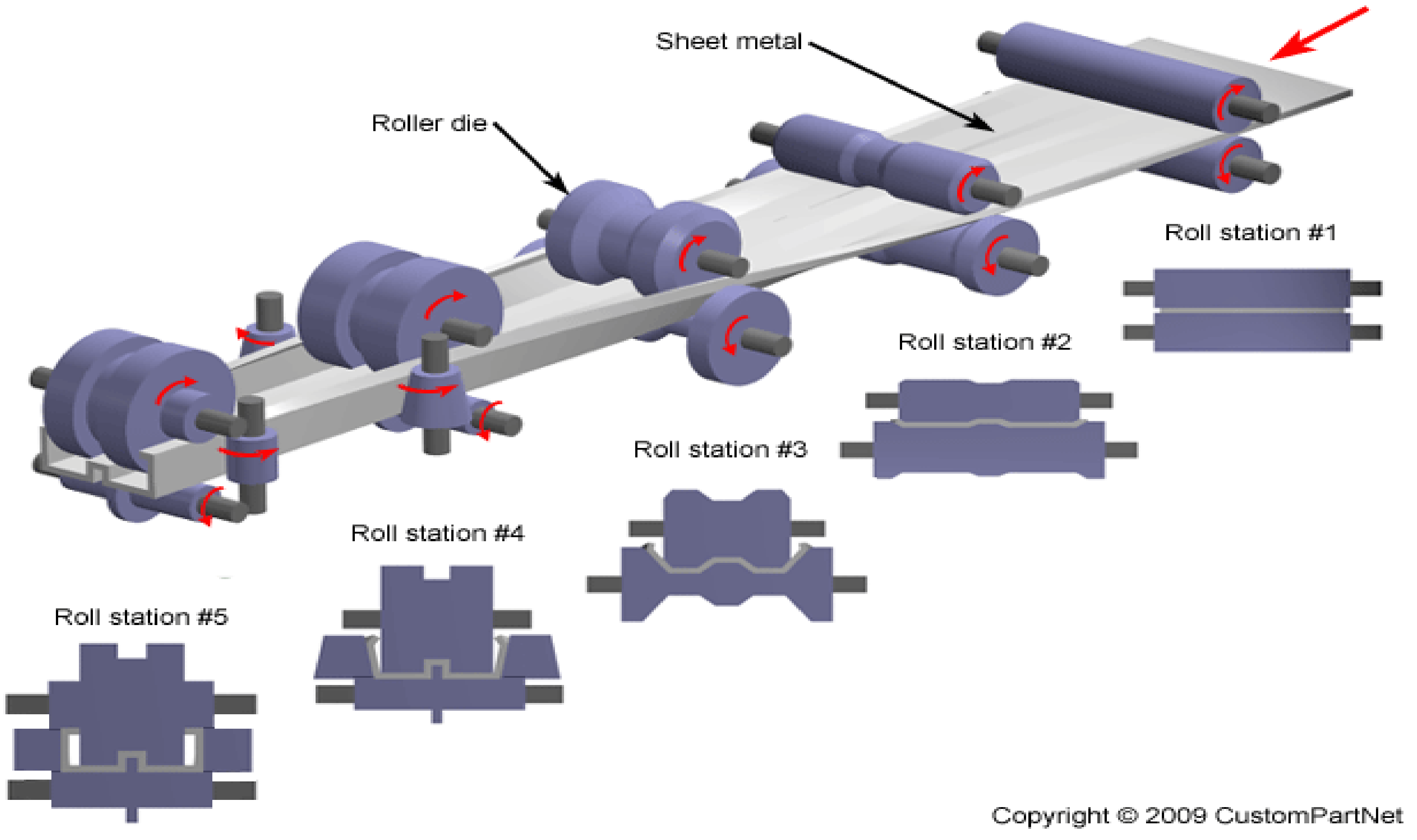

LANCING
http://designtools.page.tl

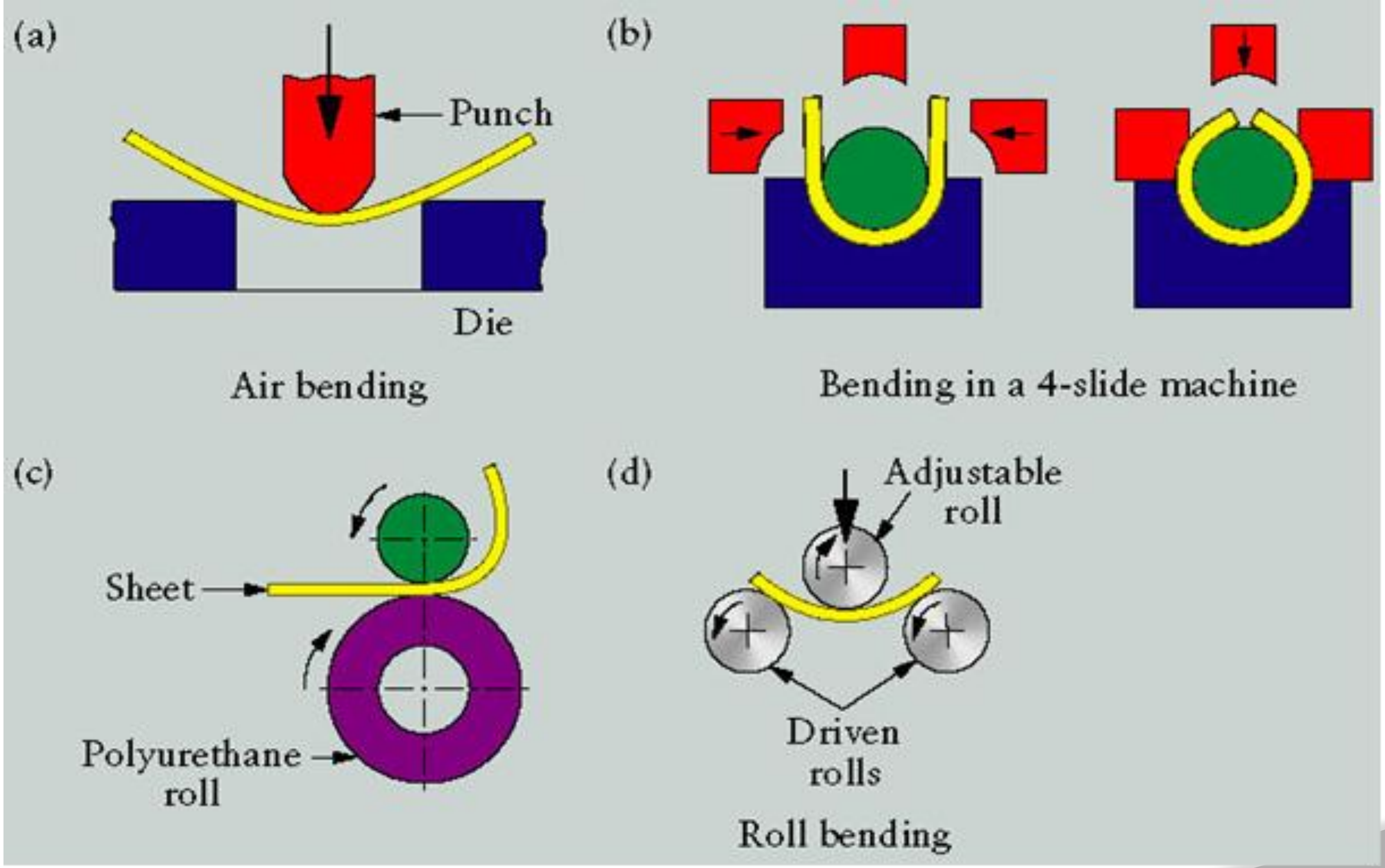

NOTCHING
http://designtools.page.tl

SHEET METAL BENDING WITH A V DIE

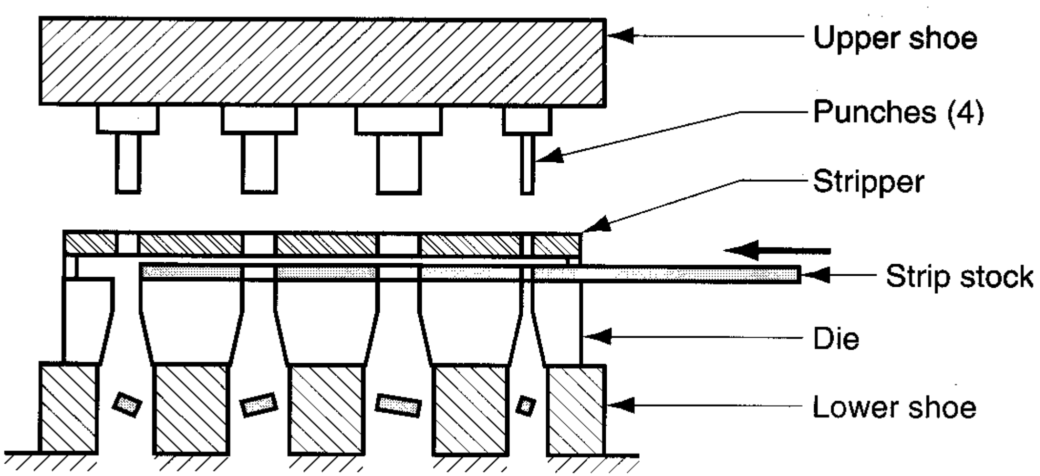



STRETCH BENDING
TUBE
FORM
BLOCK
FORCE
FORCE
FORCE
FORCE

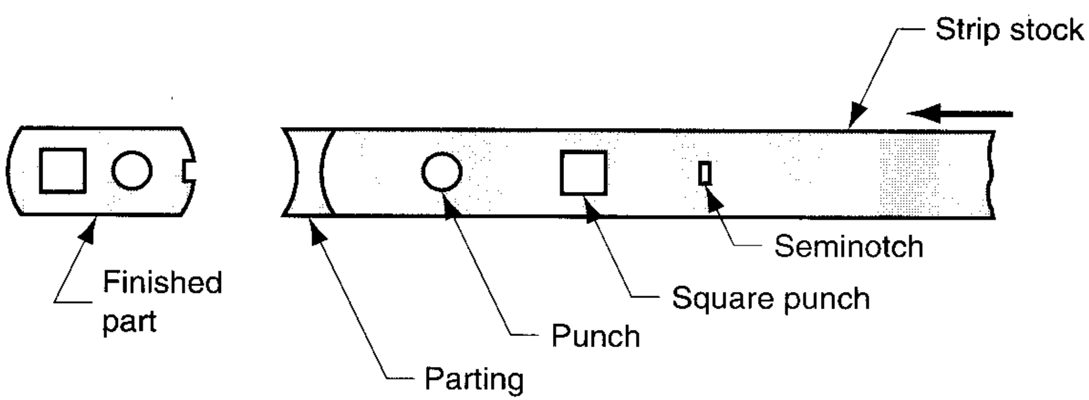

Sheet metal
Roller die
Roll station #1
Roll station #2
Roll station #3
Roll station #4
Roll station #5
Copyright © 2009 CustomPartNet


(a)
Punch
Die
Air bending
(b)
Bending in a 4-slide machine
(c)
Sheet
Polyurethane roll
(d)
Adjustable roll
Driven rolls
Roll bending

Dies

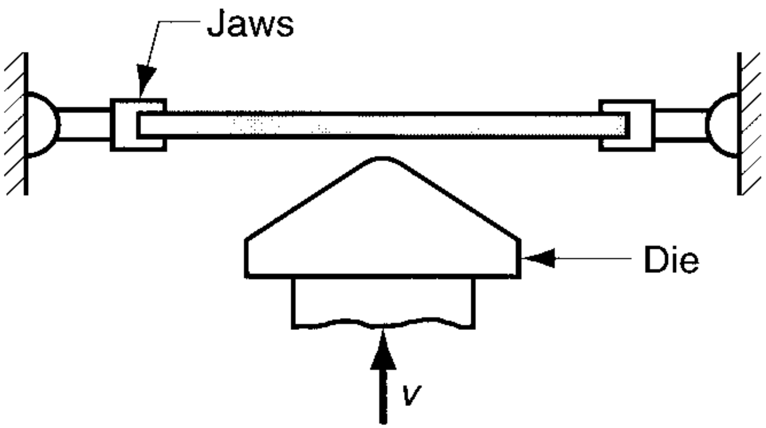

Upper shoe
Punches (4)
Stripper
Strip stock
Die
Lower shoe

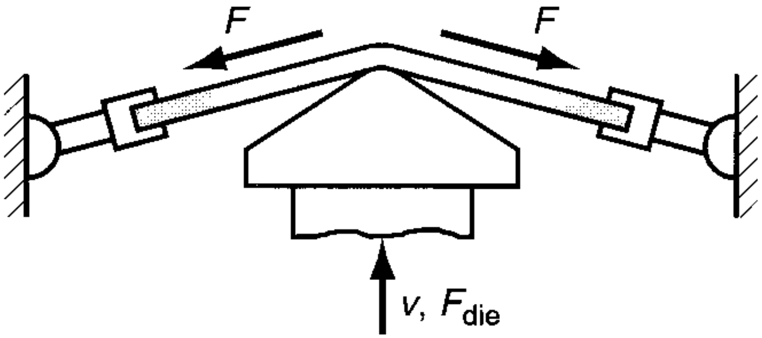
(a)


Strip stock
Finished part
Seminotch
Square punch
Punch
Parting

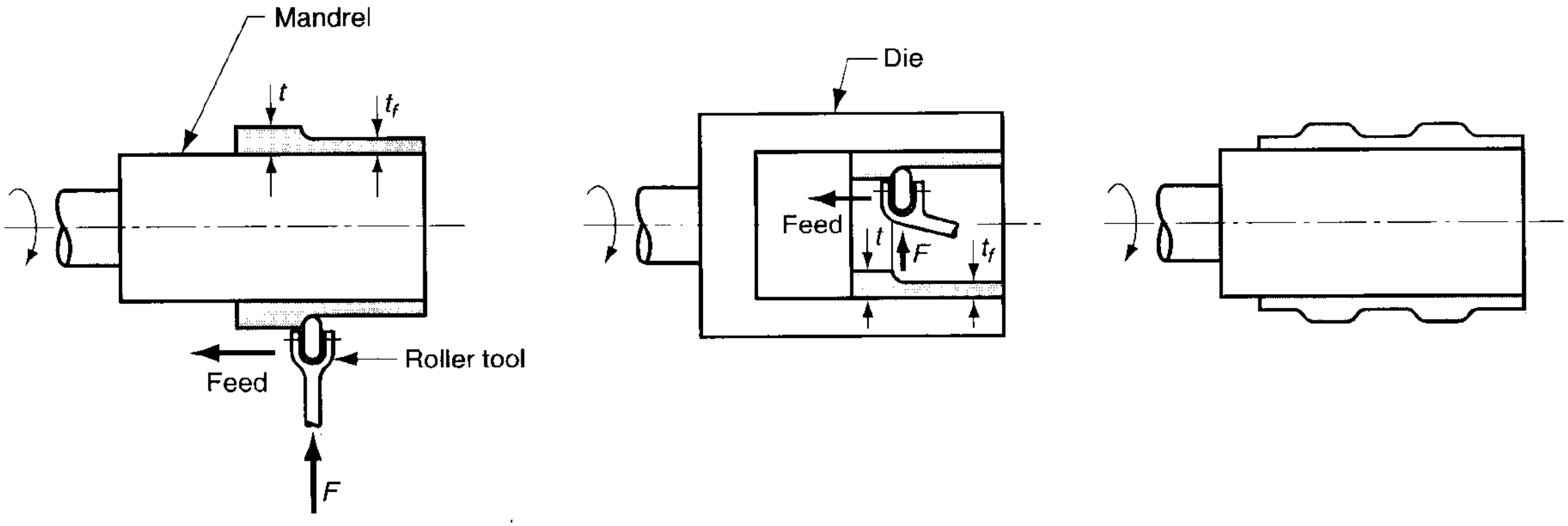
(b)

Stretch Forming

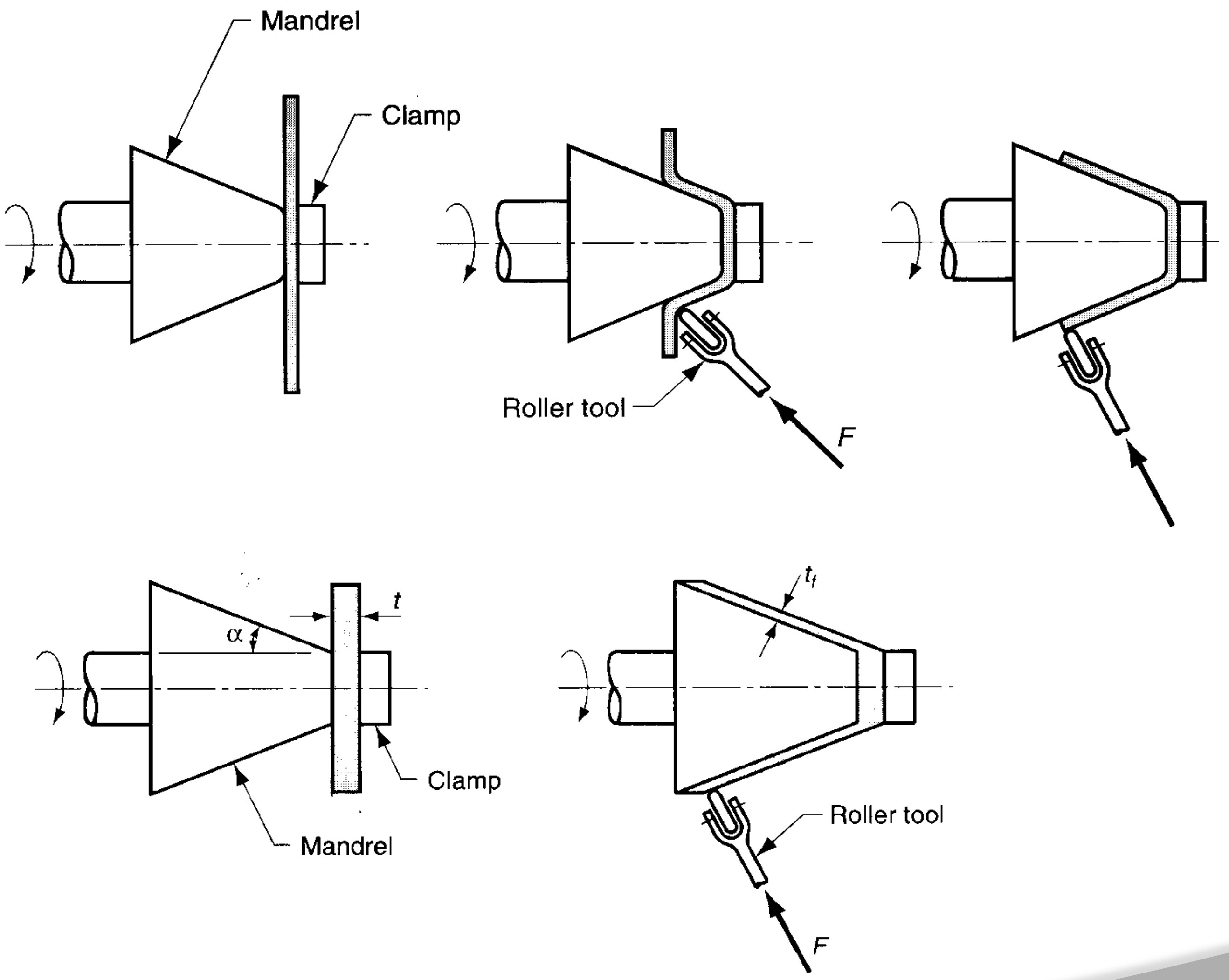




Spinning



Spinning



Mandrel
Clamp
Roller tool
F
α
t
Clamp
Mandrel
t_f
Roller tool
F

MODULE-IV

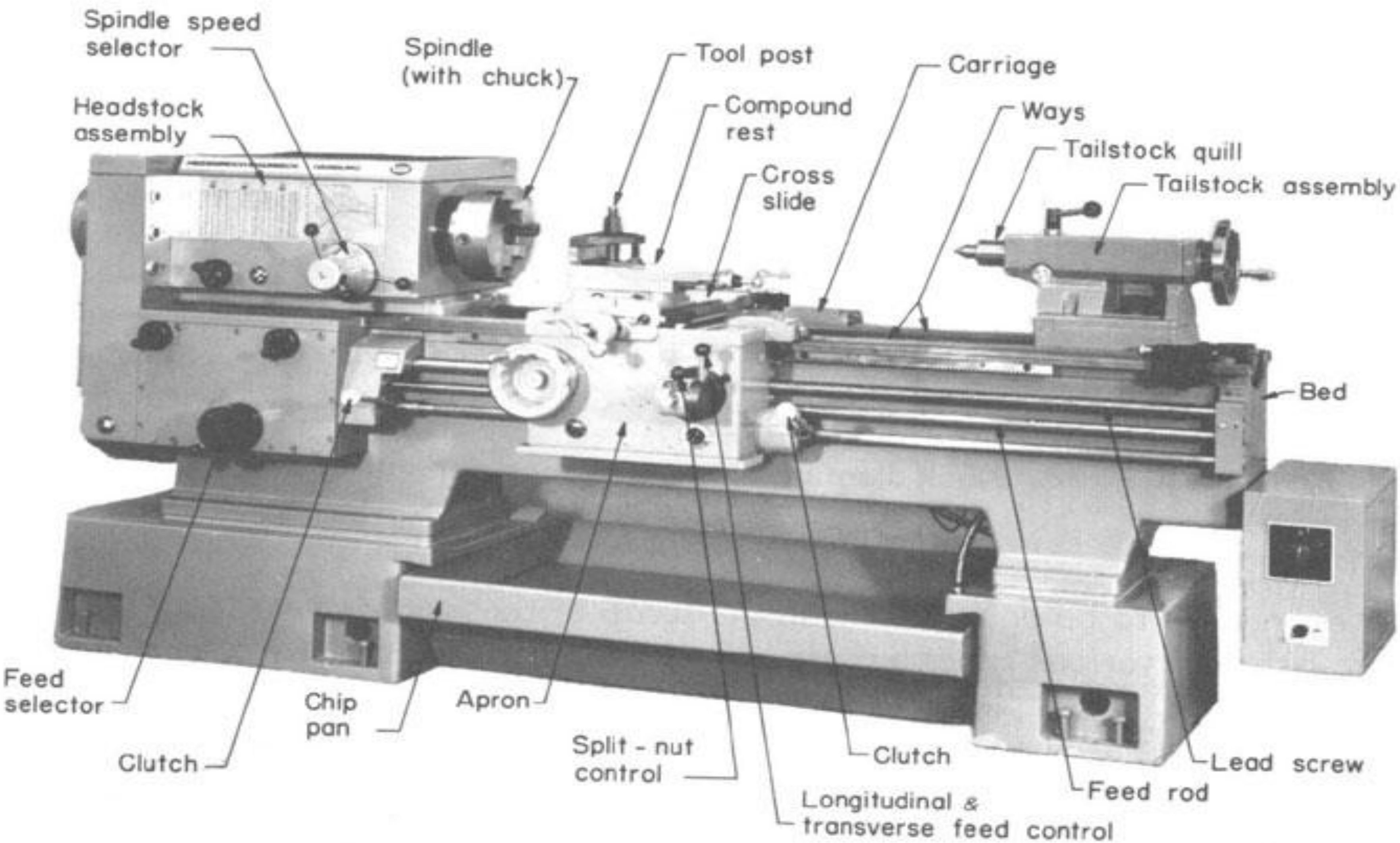
- **CONVENTIONAL AND UNCONVENTIONAL MACHINING PROCESSES**

MODULE-IV

CLOs	Course Learning Outcome
CLO10	Discuss the principle of advanced materials and what factors drive to develop the composite materials.
CLO11	Extend the outputs of earlier research and discover good ideas for new products or improving current products.
CLO12	Memorize procedure and steps to keep the products working effectively.

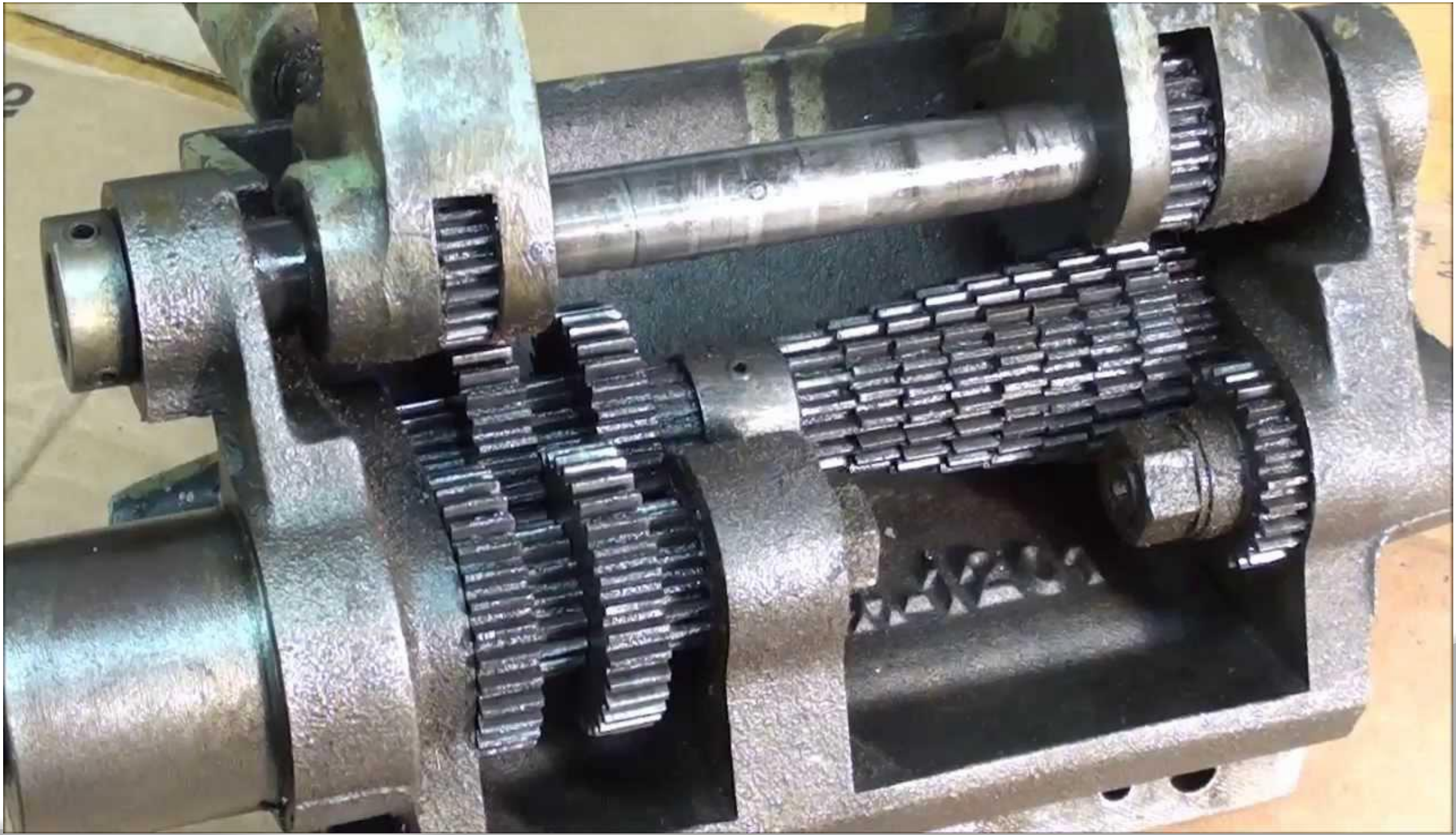
- **LATHE MACHINE**

- **• Bed: Usually made of cast iron. Provides a heavy rigid frame on which all the main components are mounted.**

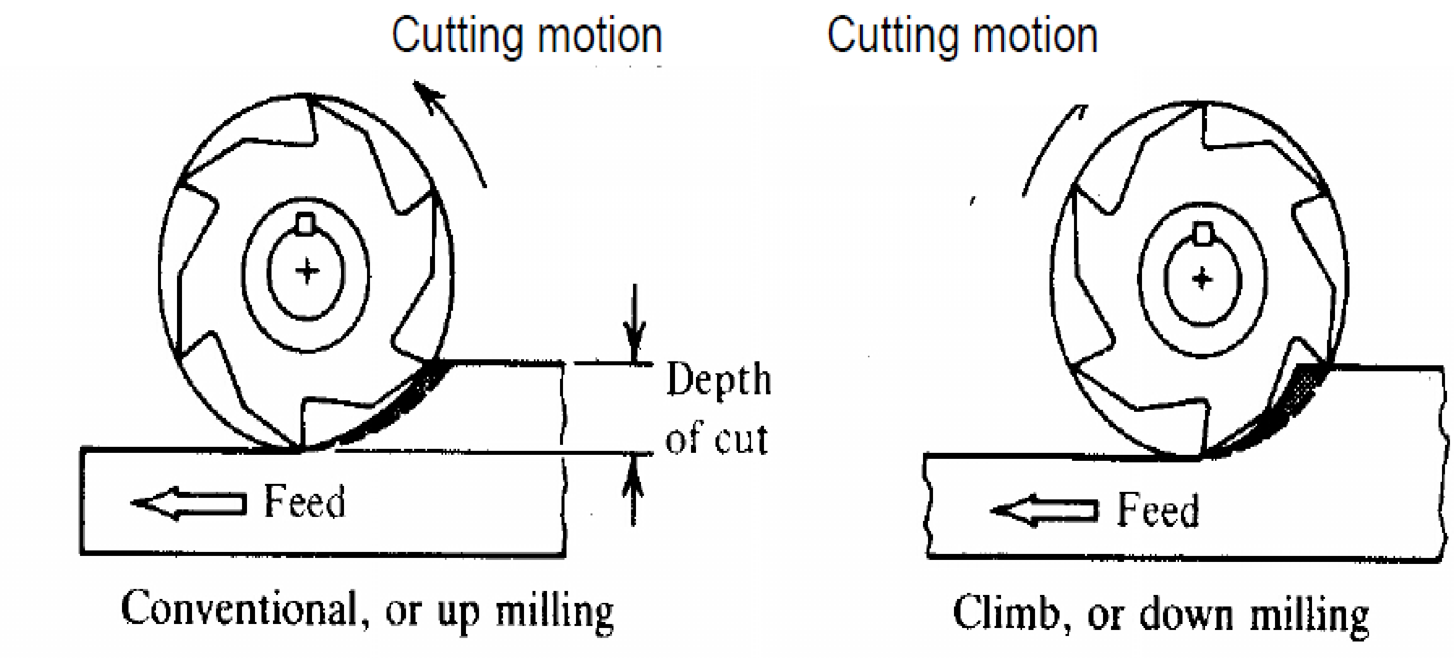

Spindle speed selector
Spindle (with chuck)
Tool post
Carriage
Headstock assembly
Compound rest
Ways
Tailstock quill
Cross slide
Tailstock assembly
Bed
Feed selector
Chip pan
Apron
Clutch
Split - nut control
Clutch
Lead screw
Feed rod
Longitudinal & transverse feed control

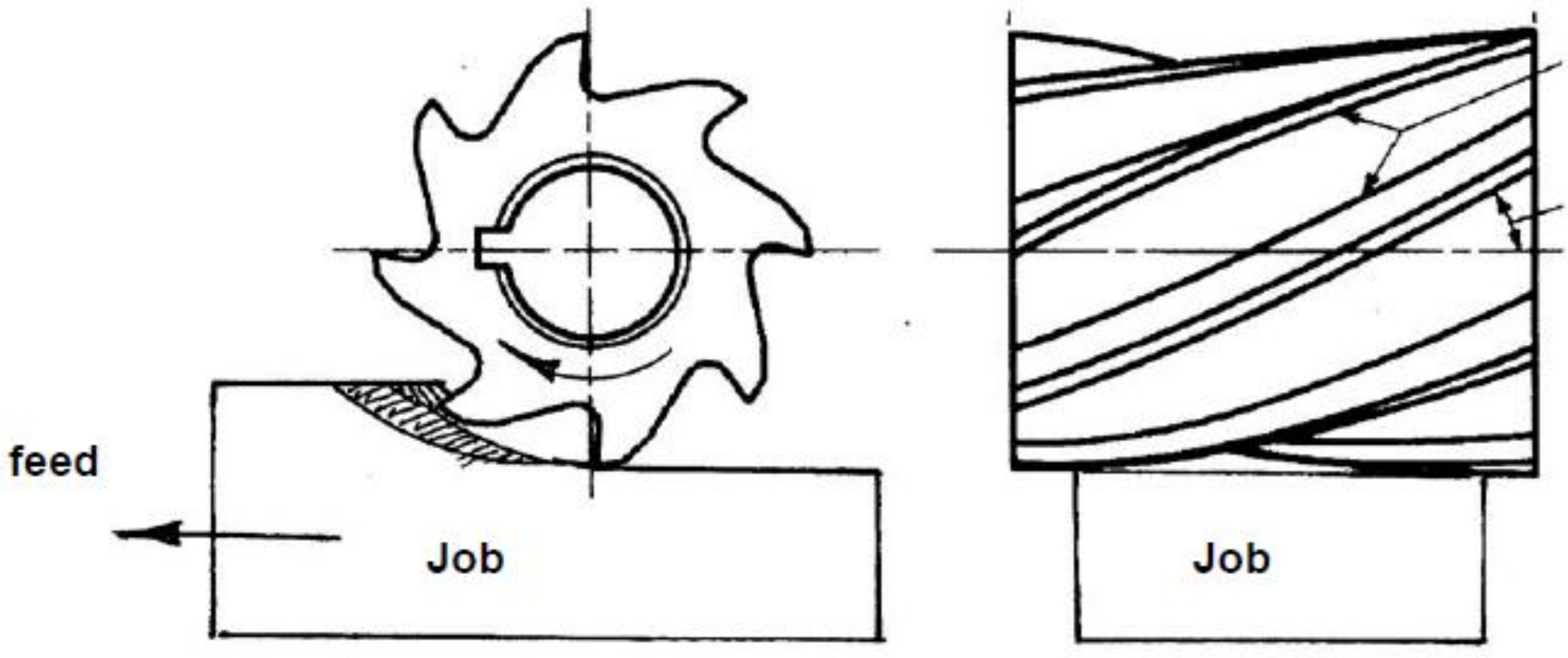
- Headstock: mounted in a fixed position on the inner ways, usually at the left end. Using a chuck, it rotates the work.
- Spindle: Hole through the headstock to which bar stock can be fed, which allows shafts that are up to 2 times the length between lathe centers to be worked on one end at a time.
- Chuck: 3-jaw (self centering) or 4-jaw (independent) to clamp part being machined.
- Tailstock: Fits on the inner ways of the bed and can slide towards any position the headstock to fit the length of the work piece. An optional taper turning attachment would be mounted to it.

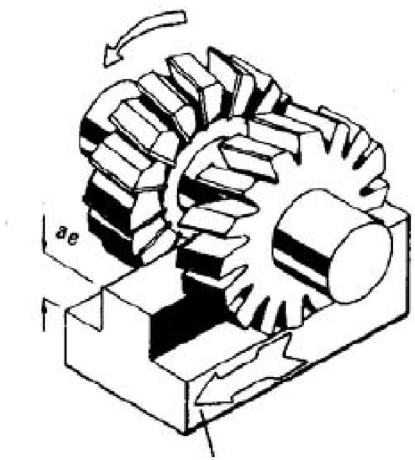
- Compound Rest: Mounted to the cross slide, it pivots around the tool post.
- Apron: Attached to the front of the carriage, it has the mechanism and controls for moving the carriage and cross slide.
- Feed Rod: Has a keyway, with two reversing pinion gears, either of which can be meshed with the mating bevel gear to forward or reverse the carriage using a clutch.
- Lead Screw: For cutting threads.
- deflection.



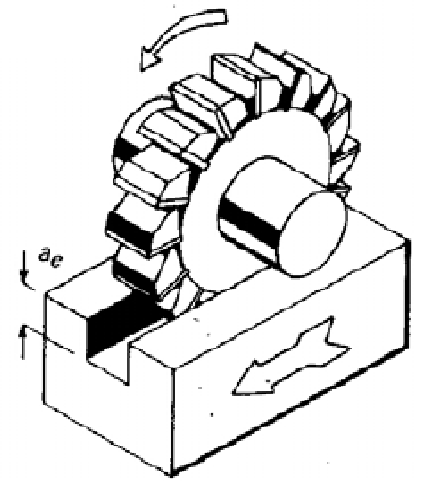
The basic function of milling machines is to produce flat surfaces in any orientation as well as surfaces of revolution,


Cutting motion
Cutting motion
Depth
of cut
Feed
Feed
Conventional, or up milling
Climb, or down milling

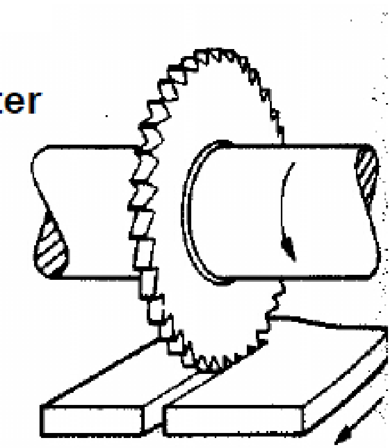

feed
Job
Job



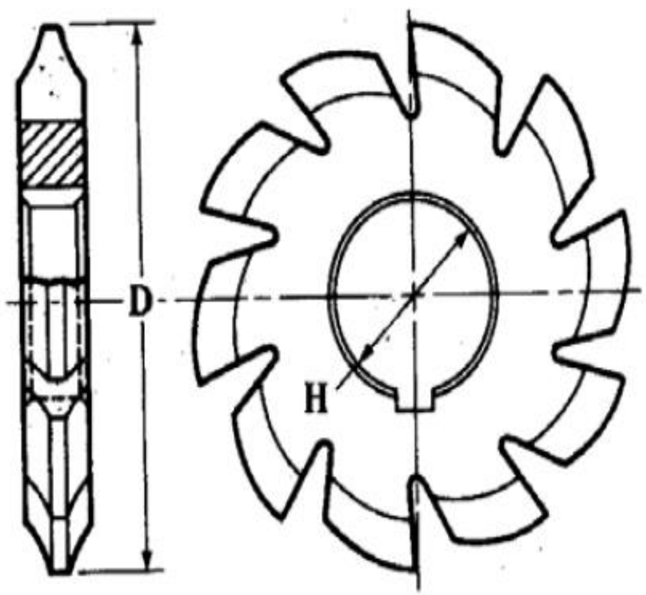
(a) parallel facing by
two side (single) cutter

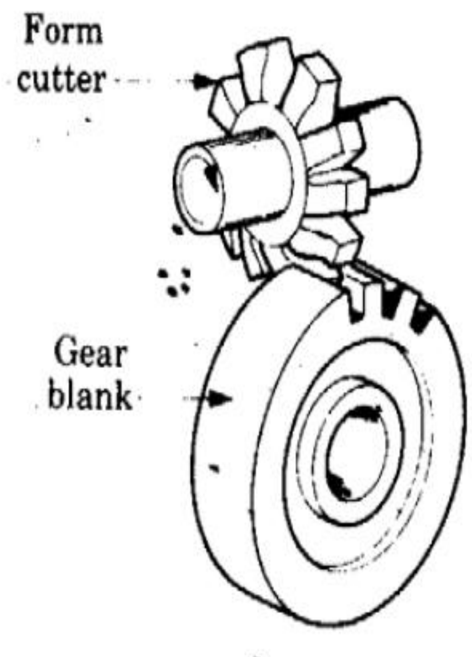


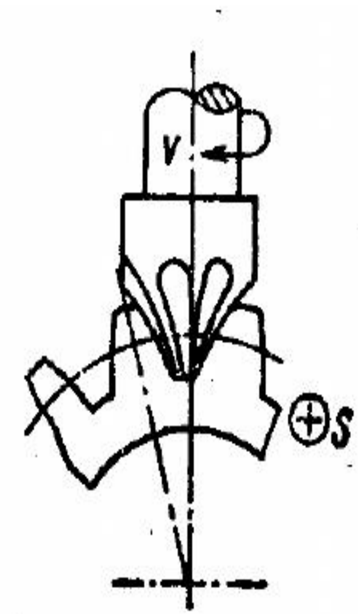
(b) slotting by side (double sided)
milling cutter

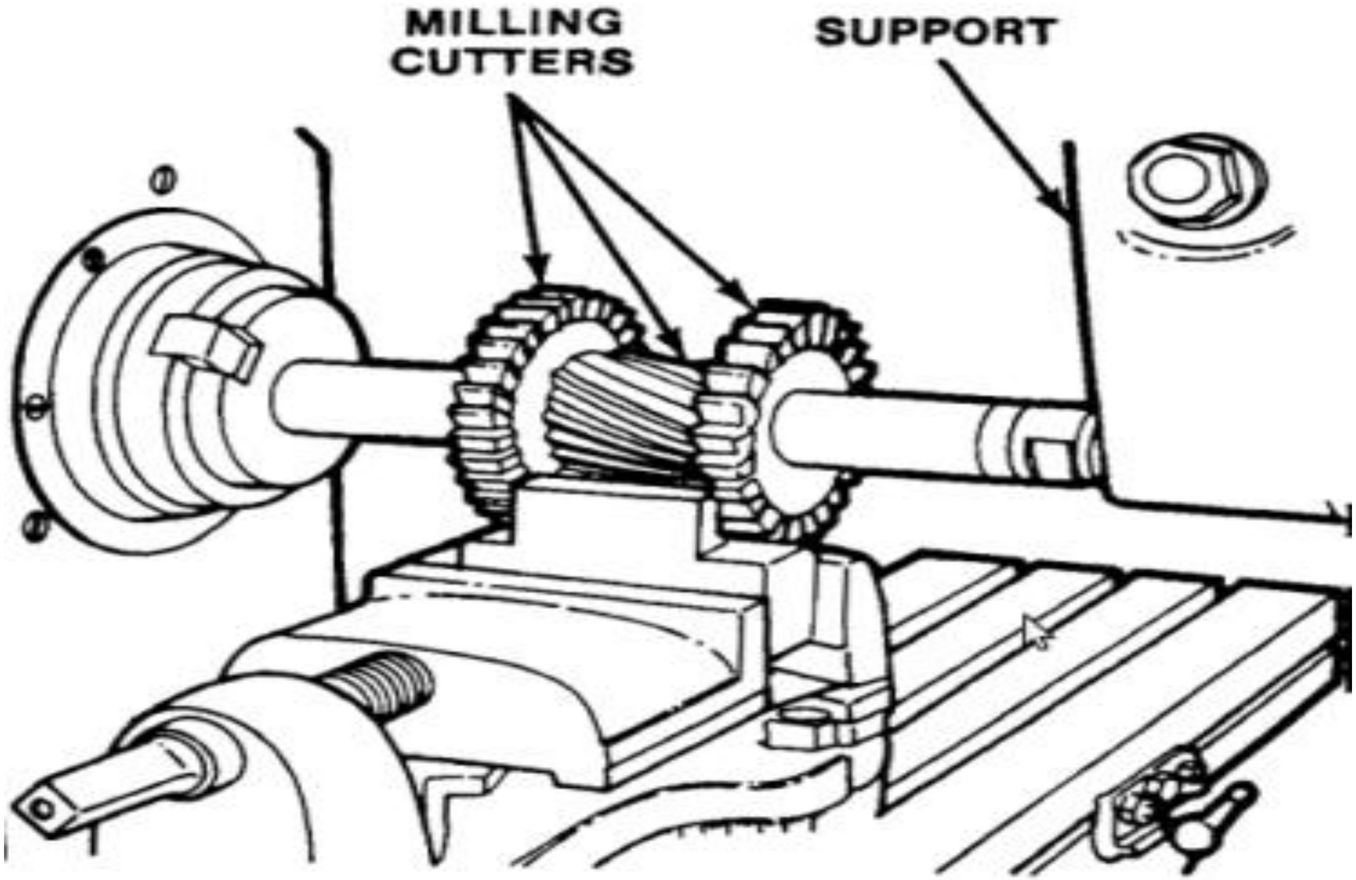


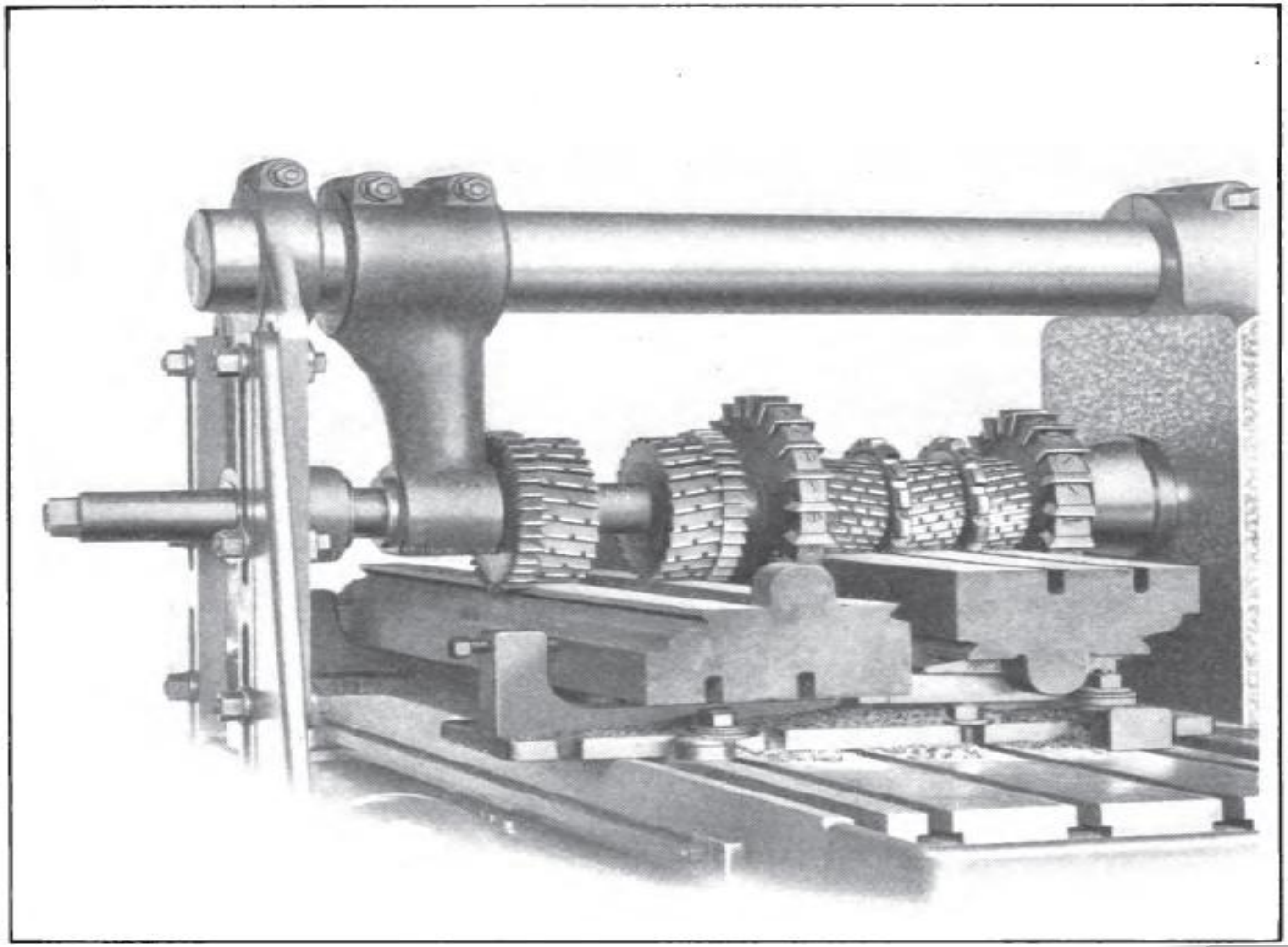
(c) Parting by slitting saw

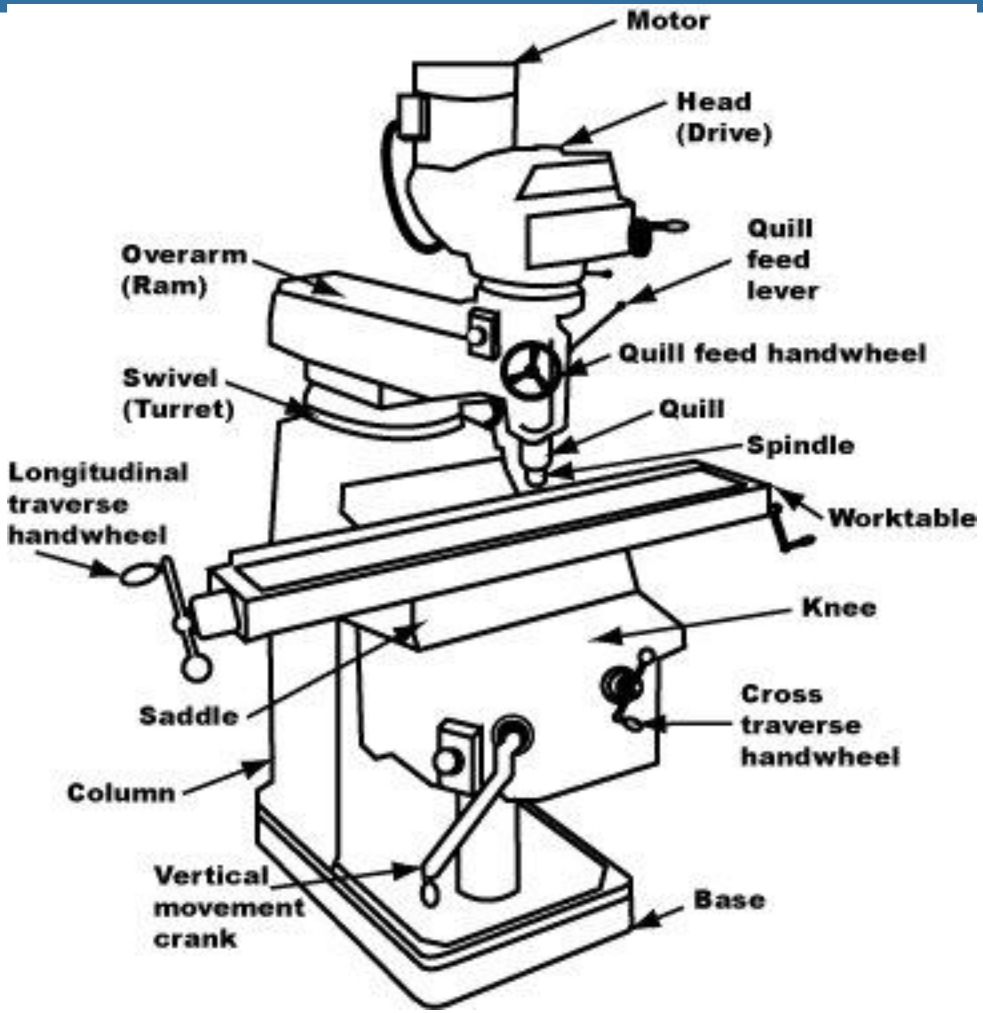

D
H


Form cutter
Gear blank


V
S


MILLING CUTTERS
SUPPORT




Motor
Head (Drive)
Quill feed lever
Overarm (Ram)
Quill feed handwheel
Swivel (Turret)
Quill
Spindle
Longitudinal traverse handwheel
Worktable
Knee
Cross traverse handwheel
Saddle
Column
Vertical movement crank
Base

Conventional Machining VS NonConventional Machining

- The cutting tool and workpiece are always in physical contact, with a relative motion against each other, which results in friction and a significant tool wear.

- In non-traditional processes, there is no physical contact between the tool and workpiece. Although in some non-traditional processes tool wear exists, it rarely is a significant problem.

- Material removal rate of the traditional processes is limited by the mechanical properties of the work material. Non-traditional processes easily deal with such difficult-to-cut materials like ceramics and ceramic based tool materials, fiber reinforced materials, carbides, titanium-based alloys.

- In traditional processes, the relative motion between the tool and work piece is typically rotary or reciprocating. Thus, the shape of the work surfaces is limited to circular or flat shapes. In spite of widely used CNC systems, machining of three-dimensional surfaces is still a difficult task. Most non-traditional processes were develop just to solve this problem.

- Machining of small cavities, slits, blind or through holes is difficult with traditional processes, whereas it is a simple work for some non-traditional processes.

- Traditional processes are well established, use relatively simple and inexpensive machinery and readily available cutting tools. Non-traditional processes require expensive equipment and tooling as well as skilled labor, which increases significantly the production cost.

Classification OF Processes

- Mechanical Metal removal Processes
- It is characterized by the fact that the material removal is due to the application of mechanical energy in the form of high frequency vibrations or kinetic energy of an abrasive jet.

- 1. Ultra sonic Machining (USM).

2. Abrasive Jet Machining (AJM).

3. Water Jet Machining (WJM).

- Electro-Chemical
- It is based on electro-chemical dissolution of materials by an electrolyte under the influence of an externally applied electrical potential.

  1. Electro-Chemical Machining (ECM).
  2. ECG
  3 ECD

- Thermal Method

The material is removed due to controlled, localized heating of the work piece. It result into material removal by melting and evaporation.

The source of heat generation in such cases can be widely different.

1.Electric Discharge Machining (EDM).

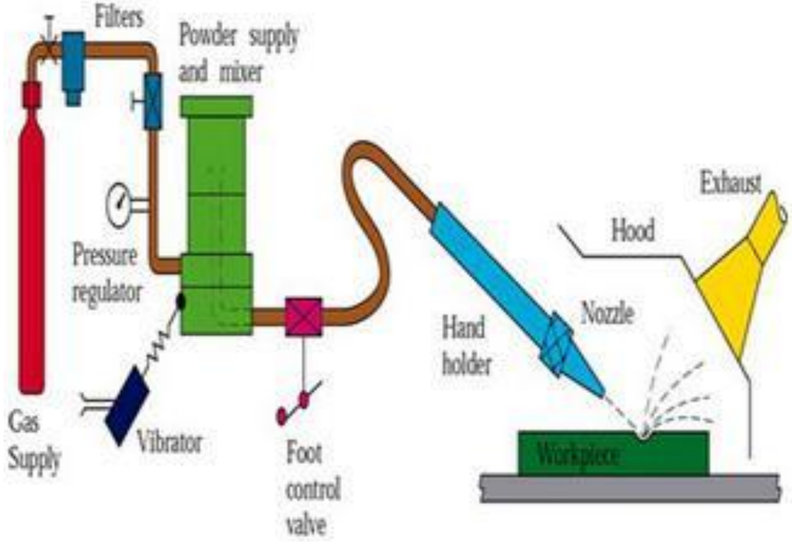
2. Plasma Arc Machining (PAM).

3. EBM 4. LBM

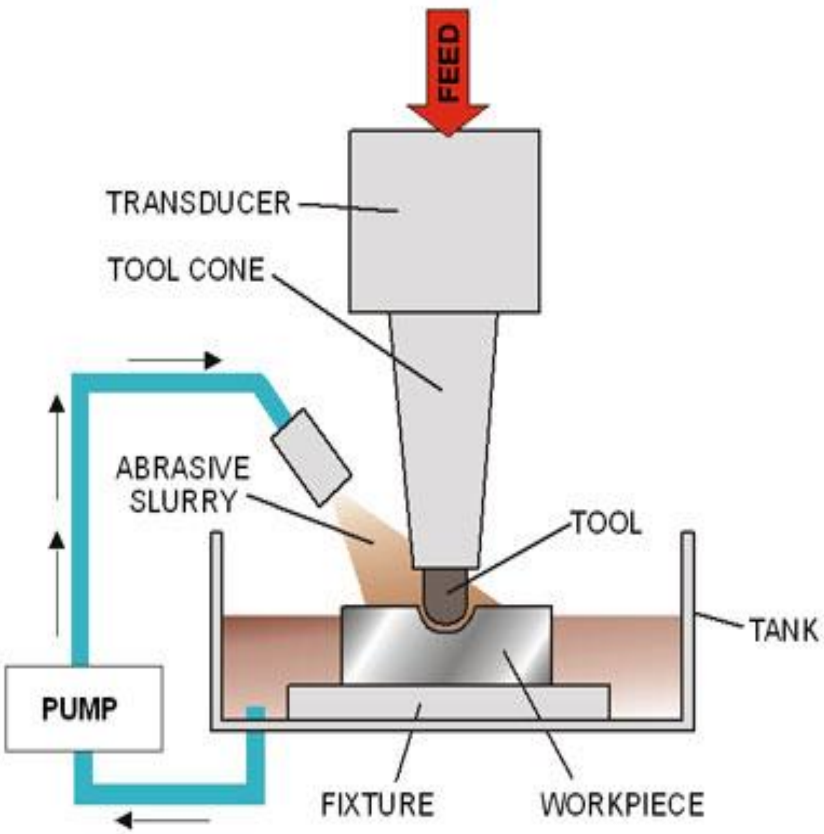
Abrasive Water-Jet Cutting

- A stream of fine grain abrasives mixed with air or suitable carrier gas, at high pressure, is directed by means of a nozzle on the work surface to be machined.
- The material removal is due to erosive action of a high pressure jet.
- AJM differ from the conventional sand blasting process in the way that the abrasive is much finer and effective control over the process parameters and cutting. Used mainly to cut hard and brittle materials, which are thin and sensitive to heat.

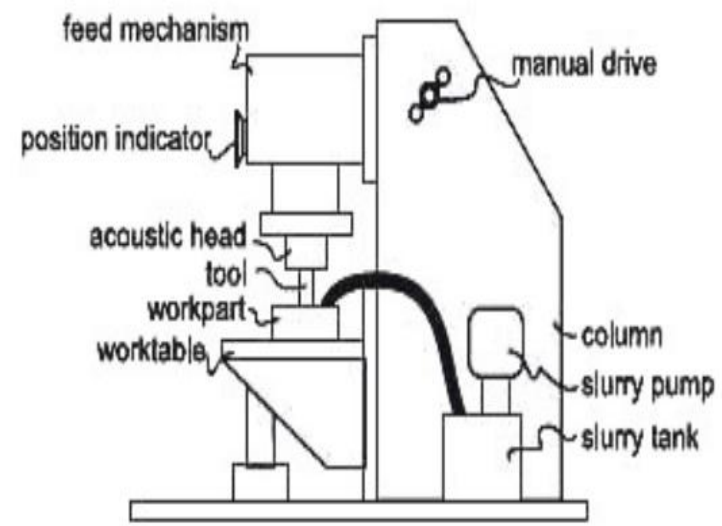
Abrasive Jet Machining Setup



Ultrasonic Machining (USM)



Ultrasonic Machine Parts



Principal components of an ultrasonic machine.

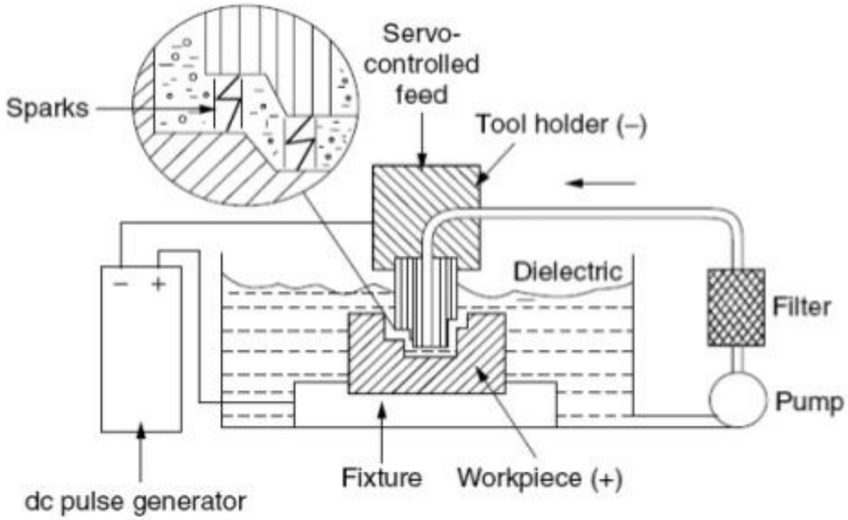
Ultrasonic Machining (USM)

- Ultrasonic machining (USM) is the removal of hard and brittle materials using an axially oscillating tool at ultrasonic frequencies [18–20 kHz]
- During that oscillation, the abrasive slurry of B_4C or SiC is continuously fe into the machining zone between a soft tool (brass or steel) and the workpiece.
- The abrasive particles are, therefore, hammered into the workpiece surfac and cause chipping of fine particles from it.
- The oscillating tool, at amplitudes ranging from 10 to 40 μm, imposes a static pressure on the abrasive grains and feeds down as the material is removed to form the required tool shape.
- USM is characterized by the absence of any deleterious effect on the metallic structure of the workpiece material.

ELECTRICAL DISCHARGE MACHINING

- Electrical Discharge Machining (EDM) is a controlled metal-removal process that is used to remove metal by means of electric spark erosion.
- In this process an electric spark is used as the cutting tool to cut (erode) the work piece to produce the finished part to the desired shape.
- In the EDM process an electric spark is used to cut the workpiece, which takes the shape opposite to that of the cutting tool or electrode.
- Generally the workpiece is made positive and the tool negative. Hence, the electrons strike the job leading to crater formation due to high temperature and melting and material removal.

ELECTRICAL DISCHARGE MACHINING



Electro discharge machining (EDM) Diagram

ELECTRICAL DISCHARGE MACHINING

Electric Discharge Machining (EDM)

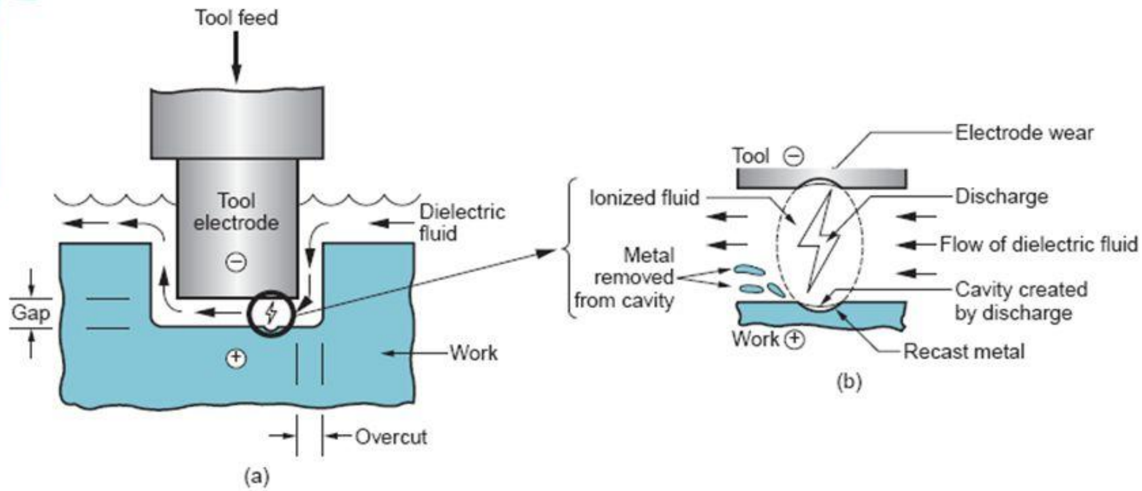
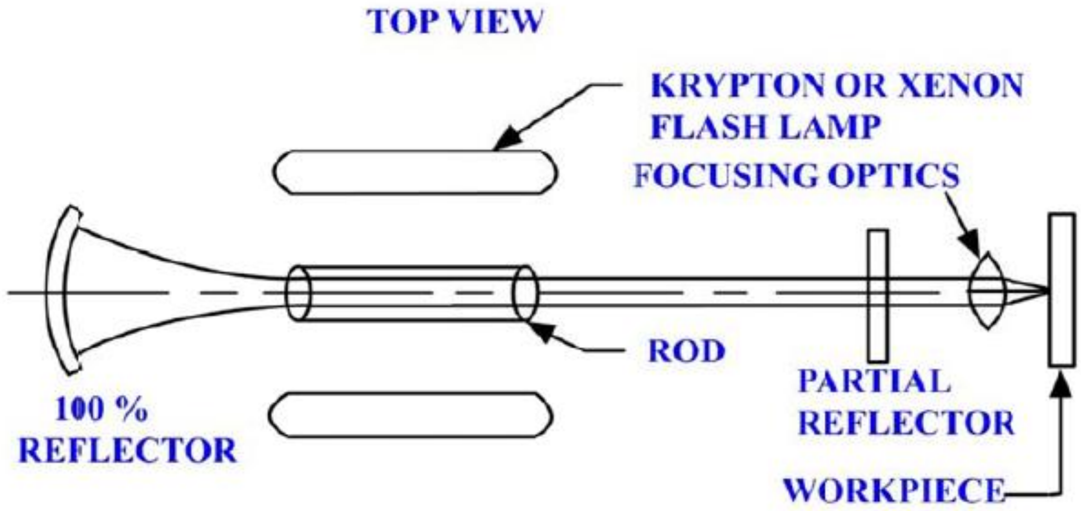


FIGURE 26.7
Electric discharge machining (EDM): (a) overall setup, and (b) close-up view of gap, showing discharge and metal removal.

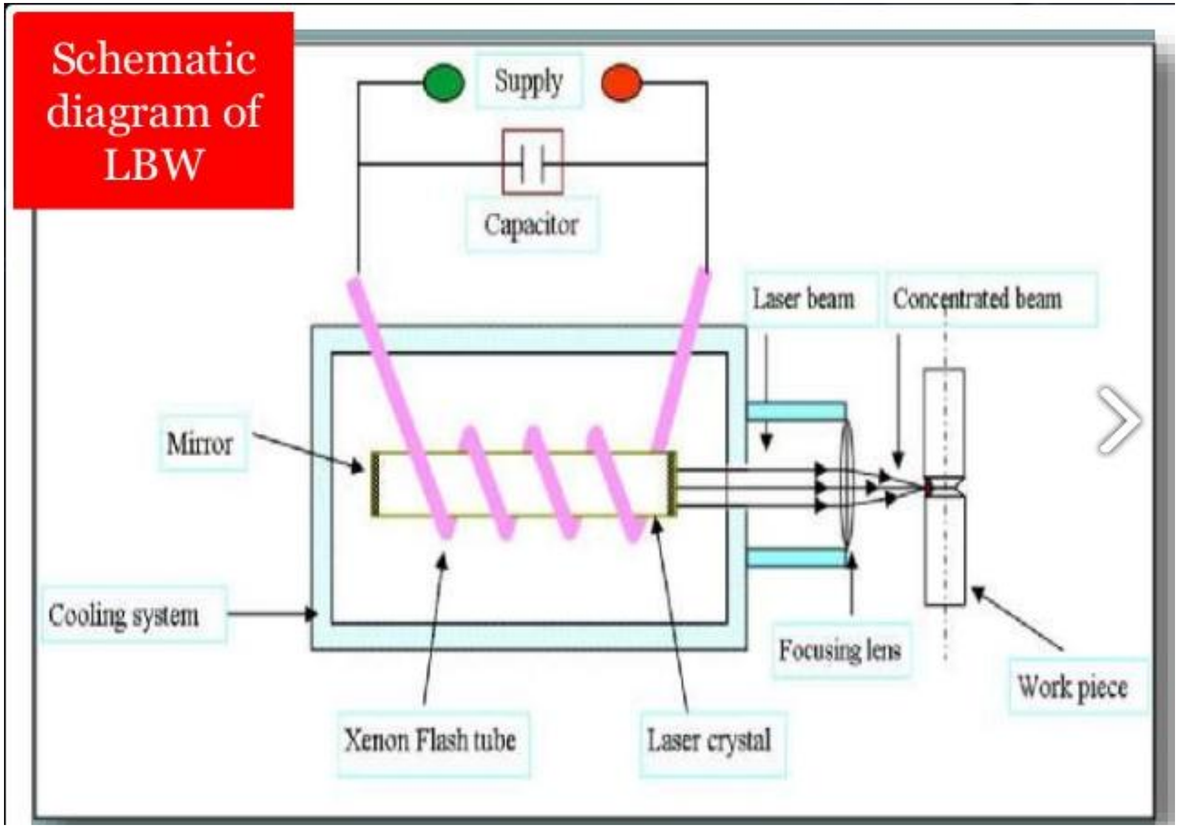
Laser Beam Maching

- “light amplification by stimulated emission of radiation.”
- Electrons are atomic particles that exist at specific energy levels. These energy levels are unique and are different for every atom or molecule.
- Electrons in outer rings are at higher energy levels than those in the inner rings. A flash of light can bump electrons to higher energy levels by the injection of energy. When an electron drops from an outer ring to an inner ring or level, the excess of energy is given off as light.
- The wavelength or the color emitted is related to the amount of energy released.

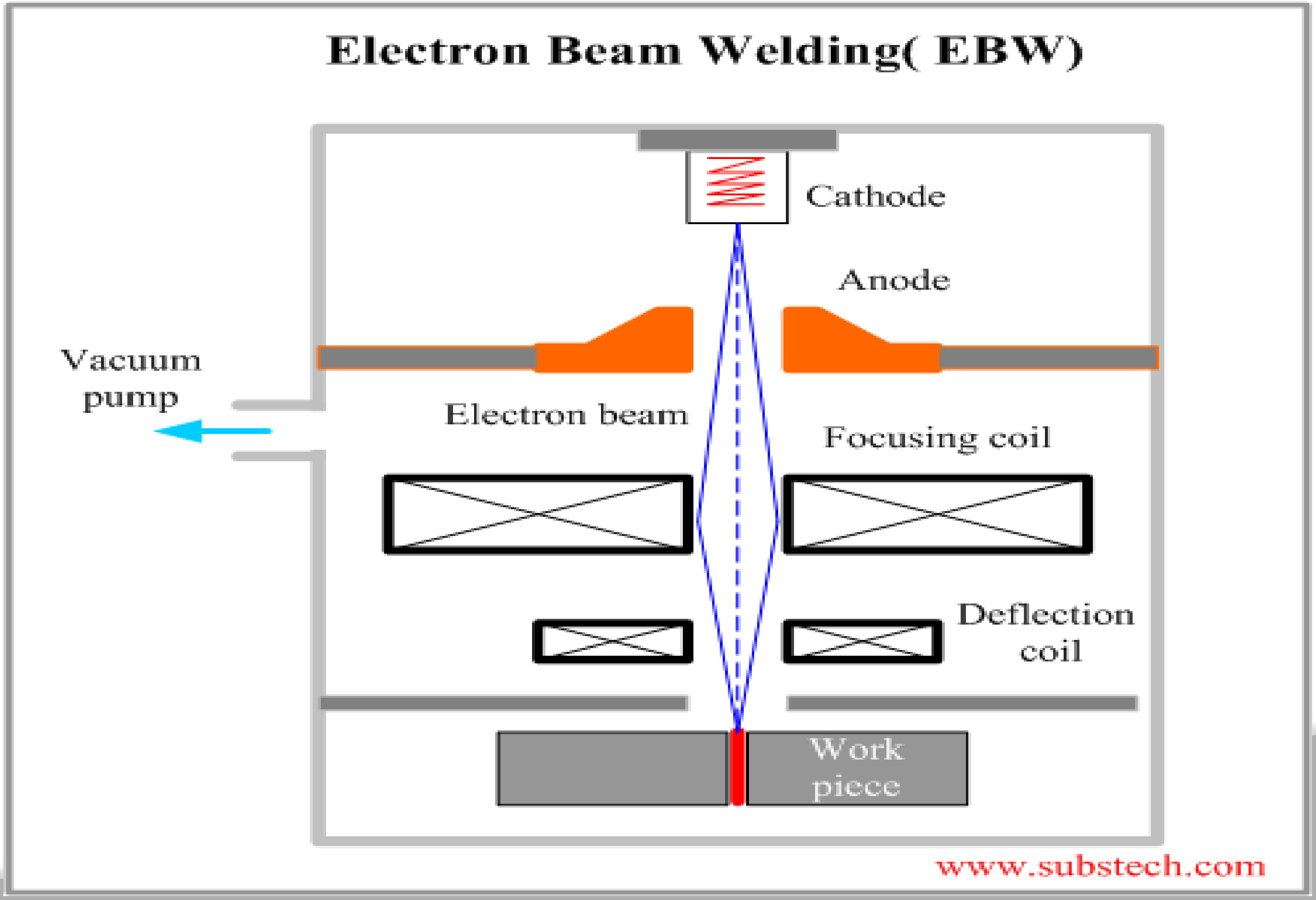
Laser Beam Maching



Laser Beam Maching



Electron Beam



MODULE - V

- **AIRCRAFT COMPOSITES**

MODULE - V

CLOs	Course Learning Outcome
CLO13	Gain knowledge about what materials used to manufacture for each component in an aircraft.
CLO14	Ability to summarize the efficiency of the product development in achieving the mission goal.
CLO15	Ability to summarize the efficiency of the safety of flight

Composite Material

- In the 1940s, the aircraft industry began to develop synthetic fibers to enhance aircraft design.
- Since that time, composite materials have been used more and more.
- A “composite” material is defined as a mixture of different materials or things.
- This definition is so general that it could refer to metal alloys made from several different metals to enhance the strength, ductility, conductivity or whatever characteristics are desired.

- Wrought aluminum alloys
- Cast aluminum alloys

Aluminum and Its Alloys

- Aluminum is the most abundant metal in the Earth's crust, and the third most abundant element therein, after oxygen and silicon.
- It is a silvery-white metal.
- It is light-weight, non-toxic, and can be easily machined or cast.
- Pure aluminum is soft and ductile, but can be strengthened by alloying with small amounts of copper, magnesium, and silicon.

Aluminum

- Aluminum is strong, corrosion resistant,
- It also conducts electricity and heat

well, and is readily weldable by MIG or TIG processes.

- In terms of ease of construction, aluminum is excellent.
- Aluminum provides the option to make use of much greater plate thickness within a given weight budget, so that strength can be greater than with steel.

Wrought aluminum

- Those aluminum products that have been subjected to plastic deformation by hot- and cold working mill processes (such as
rolling, extruding, and drawing, either singly or in combination), so as to transform cast aluminum ingot into the desired product form.
- One significant change being implemented by designers of automobiles and military vehicles today is converting driveshafts, radiators, cylinder heads, suspension members, and other structural components to aluminum.

Casting Aluminum

- Aluminum can be cast by all common casting processes. Aluminum casting alloys are identified with a unified, four-digit (xxx.x) system.
- Commercial casting alloys include heat- treatable and non-heat-treatable compositions. Alloys that are heat treated carry the temper designations 0, T4, T5, T6, and T7. Die castings are not usually solution heat treated because the temperature can cause blistering.

Aluminum Castings

- Good fluidity for filling thin sections
- Low melting point relative to those required for many other metals
- Rapid heat transfer from the molten aluminum to the mold, providing shorter casting cycles
- Hydrogen is the only gas with appreciable solubility in aluminum and its alloys, and hydrogen solubility in aluminum can be readily controlled by processing methods
- Many aluminum alloys are relatively free from hot-short

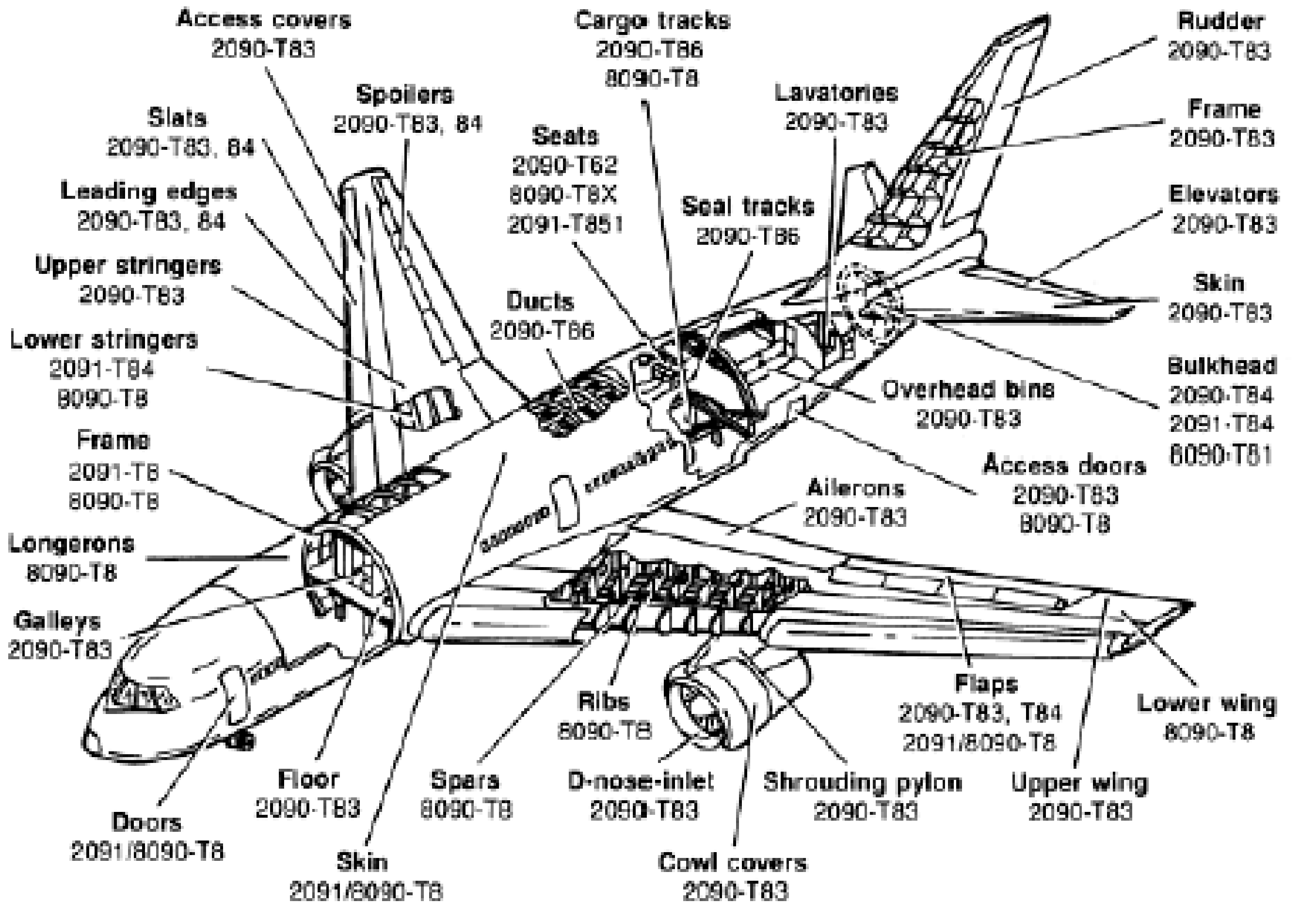
Selection of Casting Alloys

- Casting process considerations: fluidity, resistance to hot tearing, solidification range
- Casting design considerations: solidification range, resistance to hot tearing, fluidity, die soldering (die casting)
- Mechanical-property requirements: strength and ductility, heat treatability, hardness
- Service requirements: pressure tightness characteristic, corrosion resistance, surface treatments, dimensional stability, thermal stability
- Economics: machinability, weldability, ingot and melting costs, heat treatment

Aluminum Castings

- Castings are usually moderately good enough to be used for welding & machining purposes. They can offer better corrosion resistance than wrought products.
- Aluminum automotive pistons generally are permanent mold castings. This design usually is superior in economy and design flexibility.
- The alloy most commonly used for passenger car pistons has a good combination of
- foundry, mechanical, and physical characteristics, including low thermal expansion.
- Heat treatment improves hardness for improved machinability.

Use of aluminum-lithium alloys in commercial aircraft



Alloys of Al–Cu system

- Composition 4 – 6 % Cu

- Copper substantially improves strength and hardness in the as-cast and heat- treated conditions

- Copper generally reduces corrosion resistance and, in specific compositions stress corrosion susceptibility

- Copper also reduces hot tear resistance and decreases castability

Nonmetallic Aircraft Materials

- Plastics
- Rubber
- Glass
- Carbon Composites
- Fibers
- Resins

Plastics

- Plastics are used in many applications throughout modern aircraft.
- These applications range from structural components of thermosetting plastics reinforced with fiberglass to decorative trim of

thermoplastic materials to windows.

Rubber

- Rubber is used to prevent the entrance of dirt, water, orair, and to prevent the loss of fluids, gases, or air.
- It is also used to absorb vibration, reduce noise and cushion impact loads.
- It is used to include not only natural rubber,

but all synthetic and silicone rubbers.

Glass Composite

- Glass fiber is a material consisting of numerous extremely fine fibers of glass.
- Glass fiber has roughly comparable mechanical properties to other fibers such as polymers and carbon fiber.
- Although not as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites.

Carbon Composites

- A composite is basically a material that contains both a reinforcing material to provide strength and stiffness and a matrix material to surround and hold the reinforcement together.
- Carbon-Carbon (C/C) Composites may be manufactured with different orientation of the reinforcing phase (carbon fibers)
- Unidirectional structure, bi-directional structure (cloth made of multiple carbon fiber yarns), multi-directional structure (3D, 4D, 5D, etc.).

C/C composites are lightweight, high-strength composite materials capable of withstanding temperatures over 3000°C.

Carbon/Carbon Nozzle Throat Inserts

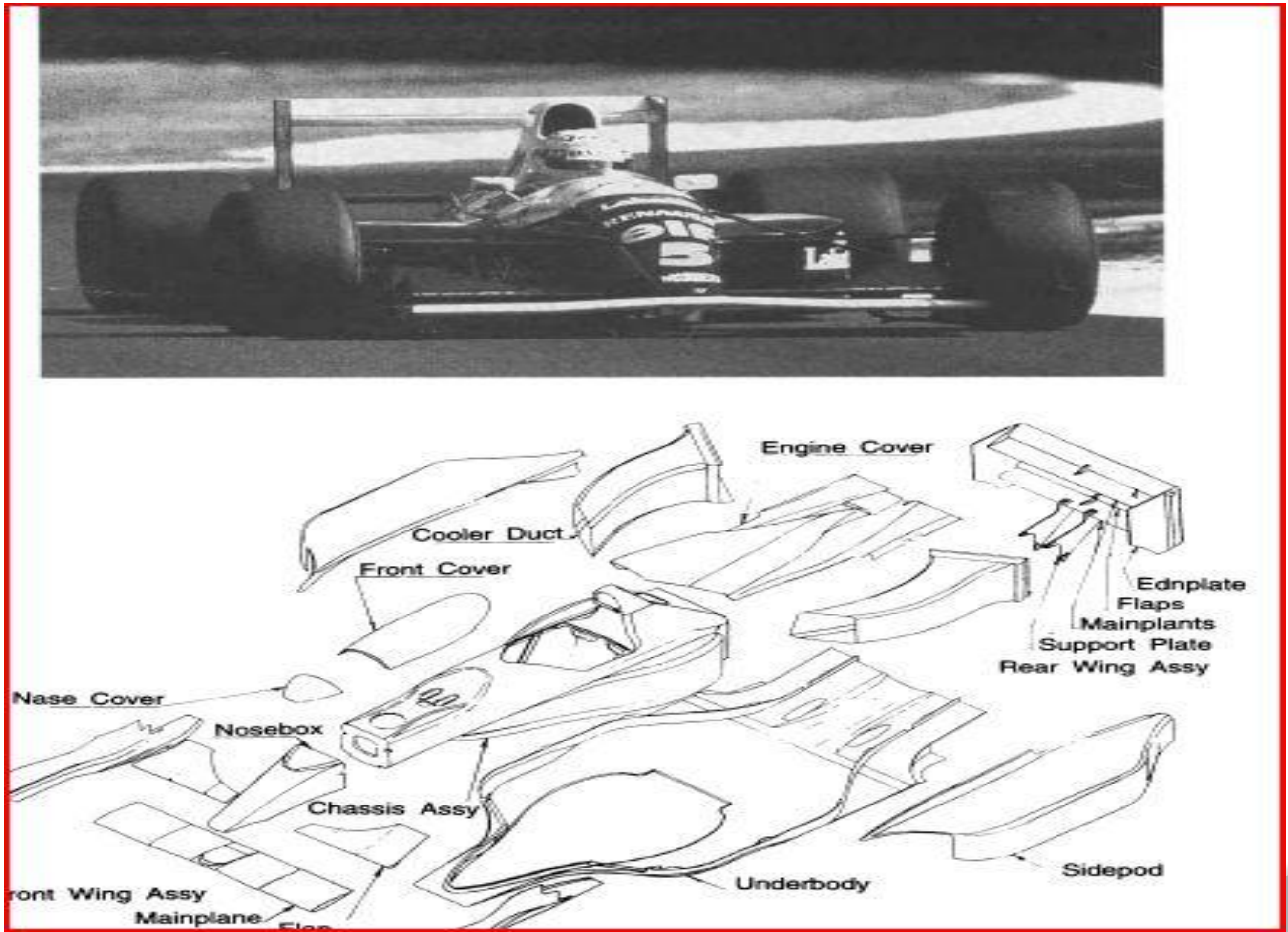
C/C composites use the strength and modulus of carbon fibers to reinforce a carbon matrix to resist the rigors of extreme environments.

Properties of Carbon-Carbon Composites

- Excellent thermal shock resistance;
- High Thermal Conductivity
- Low density
- High strength

Applications of Carbon-Carbon Composites

- High performance braking systems (eg. brake discs for high speed aircrafts)
- Refractory material (eg. protection tubes and grids)
- Hot-pressed dies
- Heating elements
- Turbojet engine components (eg. rocket nozzles).


Engine Cover
Cooler Duct
Front Cover
Ednplate
Flaps
Mainplants
Support Plate
Rear Wing Assy
Nase Cover
Nosebox
Chassis Assy
ront Wing Assy
Mainplane
Underbody
Sidepod

Fibers

- Fibers are a class of materials that are continuous filaments or discrete elongated pieces.
- They are crystalline, present in both plants & animals.
- They are used for making textiles, ropes, utilities, strings etc.
- These are of two types
- (1) Natural Fibers
- (2) Synthetic fibers

Resins

ROLE OF RESINS IN FRP COMPOSITES

Composite:

- A heterogeneous combination of two or more materials
  - reinforcing elements such as fibers, fillers
  - binders such as resins or polymers
- These materials differ in form or composition on a macroscale.
- There exists interface between these materials - compatibility

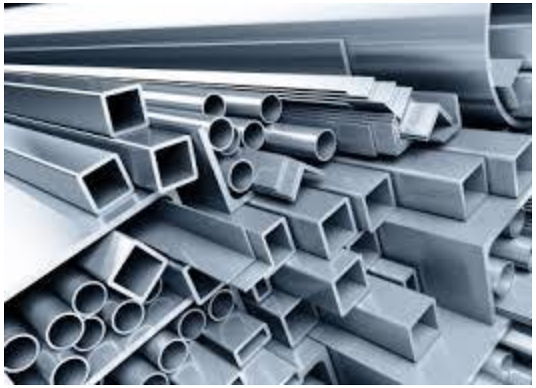
Fiber:

- Load-bearing component.

Resin:

- Dissipate loads to the fiber network
- Maintain fiber orientation
- Protect the fiber network from damaging environmental conditions such as humidity and high temperature
- Dictates the process and processing conditions

Production of semi Fabricated Forms



Purpose of Alloying

- To retain physical properties at high temperature
- To improve corrosion and wear resistance
- To obtain fine grain size

Advantages of Alloy

- Harder and tougher
- High hardenability
- High corrosion and oxidation resistance
- Stronger

Super Alloys

- Nickel Alloys
- Titanium Alloys

NICKEL

Properties of Nickel

- Good resistance to action of both acids and alkalis
- Hard, malleable and magnetic
- More corrosion resistance to salt water and atmosphere
- High tensile strength

Thermocouples

Nickel coated components

Advantages of titanium

- Good strength
- Low density
- Excellent corrosion resistance to many aggressive media
- Non-magnetism
- Resistance to erosion and erosion-corrosion
- Most of its alloys have high mechanical properties in a wide temperature range

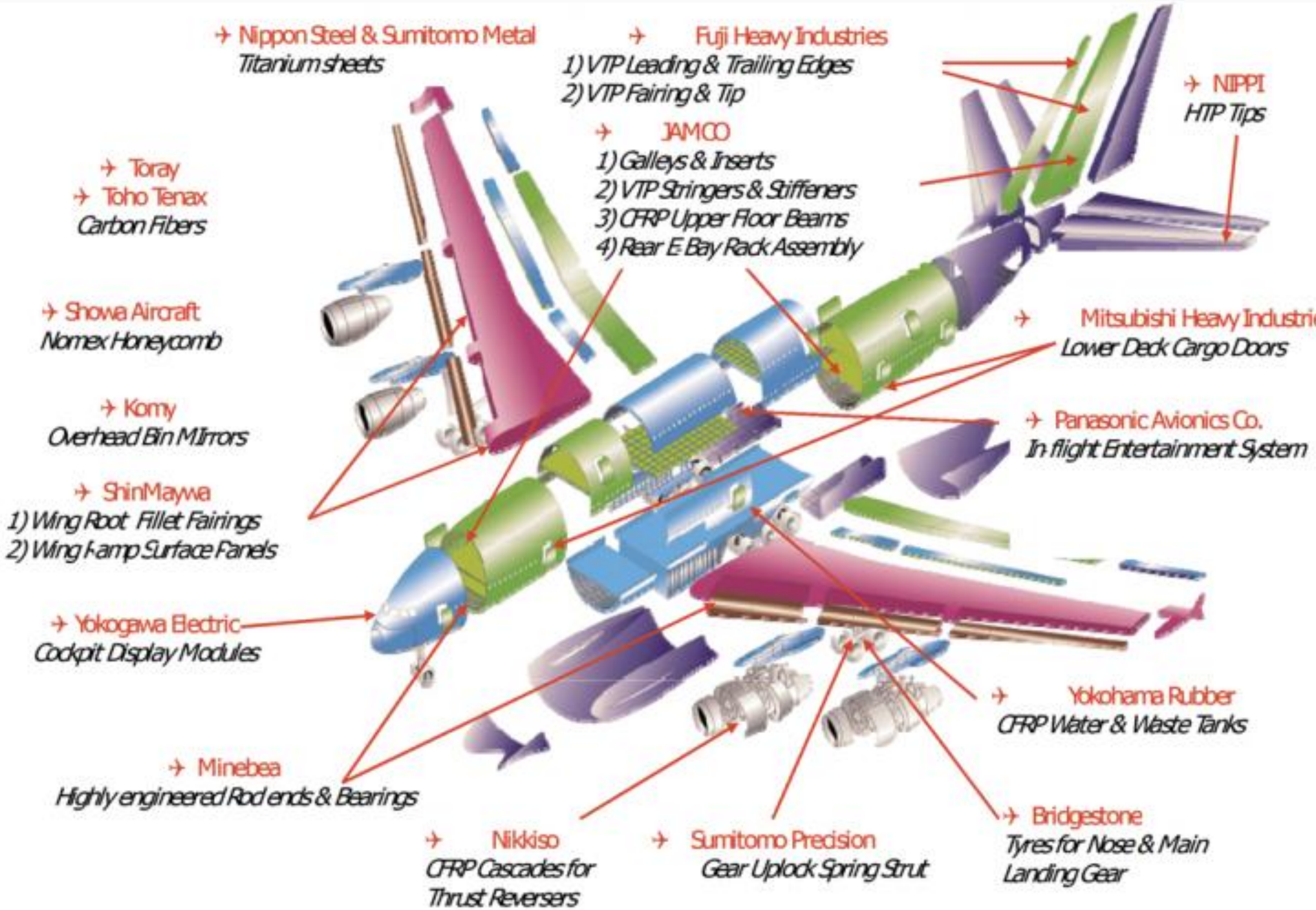


Fig. 3 Japanese suppliers for A380 ((C)AIRBUS)

Titanium Appilications

- In the petroleum and chemical industries
- Car suspension springs

- Heat Exchanger materials
- Die-cast parts for automobiles, luggage, and electronic devices
- biomedical implants such as hip prostheses

Titanium Alloys

The alloys of titanium can be classified into three main groups as follows

- Alpha and Near Alpha alloys(α- alloys and Near α- alloys)
- Alpha-beta alloys(α+β alloys)
- Beta alloys(β alloy)

α- alloys and Near α- alloys

- They Contain 5% of Aluminum and 2.5 % of Tin.
- Which improves mechanical properties like creep resistance.
- Reasonably good ductility and have excellent properties at cryogenic temperatures.

α+β alloys

- They Contain 6% of Aluminum and 4% of Vanadium which improves the good formability.
- Alpha-beta alloys have higher strength and respond to heat treatment
- Fusion weld efficiencies up to 100% are attainable.
- This class of titanium alloys account for more than 70% of all commercially available titanium alloys.

β alloys

- They Contain 3% of Aluminum, 10% of Vanadium which improves the good forging capabities.
- Beta alloys are readily heat treatable to improve.
- Generally weldable and offer high strength up to intermediate temperature levels.
- Cold formability is generally excellent.

Emerging trends in aerospace

Individual Effects of Following Elements

- Tungsten
- Chromium
- Molybdenum
- Vanadium
- Nickel
- Sulphur

Individual Effects of Following Elements

- Manganese
- Silicon
- Copper
- Cobalt
- Aluminium
- Lead

MAGNESIUM

Properties of Magnesium

- Lightest of all metals (weighing two third of aluminium).
- It burns when heated in air with a dazzling bluish white light extremely rich in ultra-violet rays
- May be sand cast, gravity cast or die cast
- Ductile and malleable

Properties of Magnesium

- Carries away heat easily
- Its thermal coefficient of expansion is high
- Not responsive to heat treatment and mechanical working
- Soft, sliver white metal
- Good machinability
- Possess strength to weight ratio

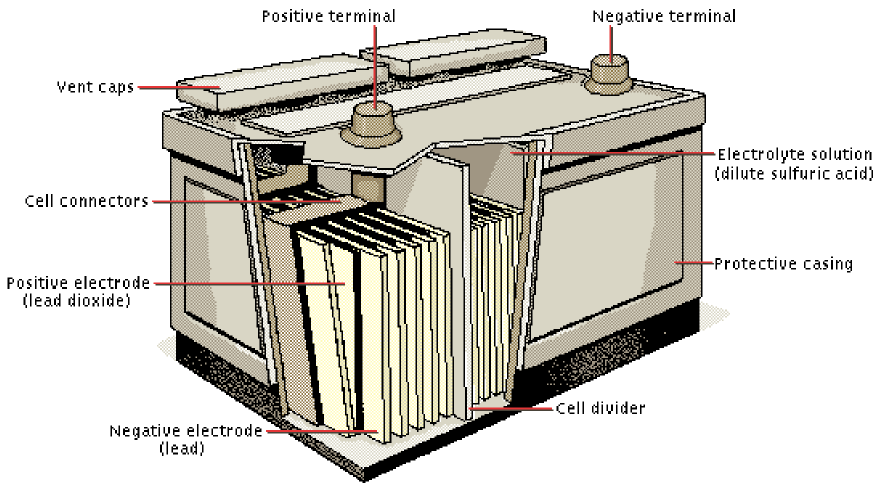
Magnesia bricks

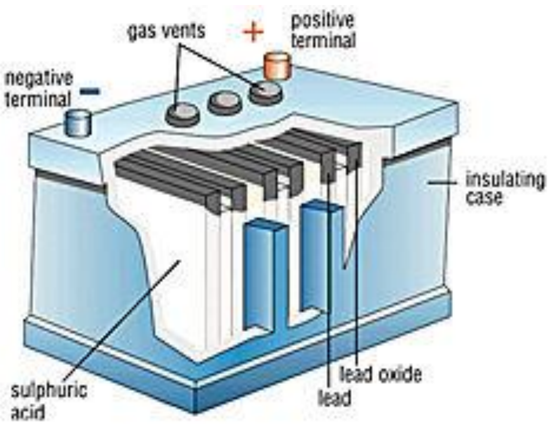
LEAD

Properties of Lead

- High density
- Malleability
- Resistance to chemical action
- Low melting point
- Low electrical conductivity
- High absorbing power for radiation such as X-rays, γ- rays

Storage batteries





Lead coated components

CHROMIUM

Properties of Chromium

- Silvery white malleable metal
- Strong and hard
- Resistant to action of air, water and CO_2 at ordinary room temperature
- Alloys with iron and nickel

Uses of Chromium

- In electroplating iron articles to resist corrosion and improve appearance
- Important constituent of many alloy steels
- In massive form as a target in x-ray tubes

Chromium coated components

Materials used for aircraft components

Characteristics and applications,

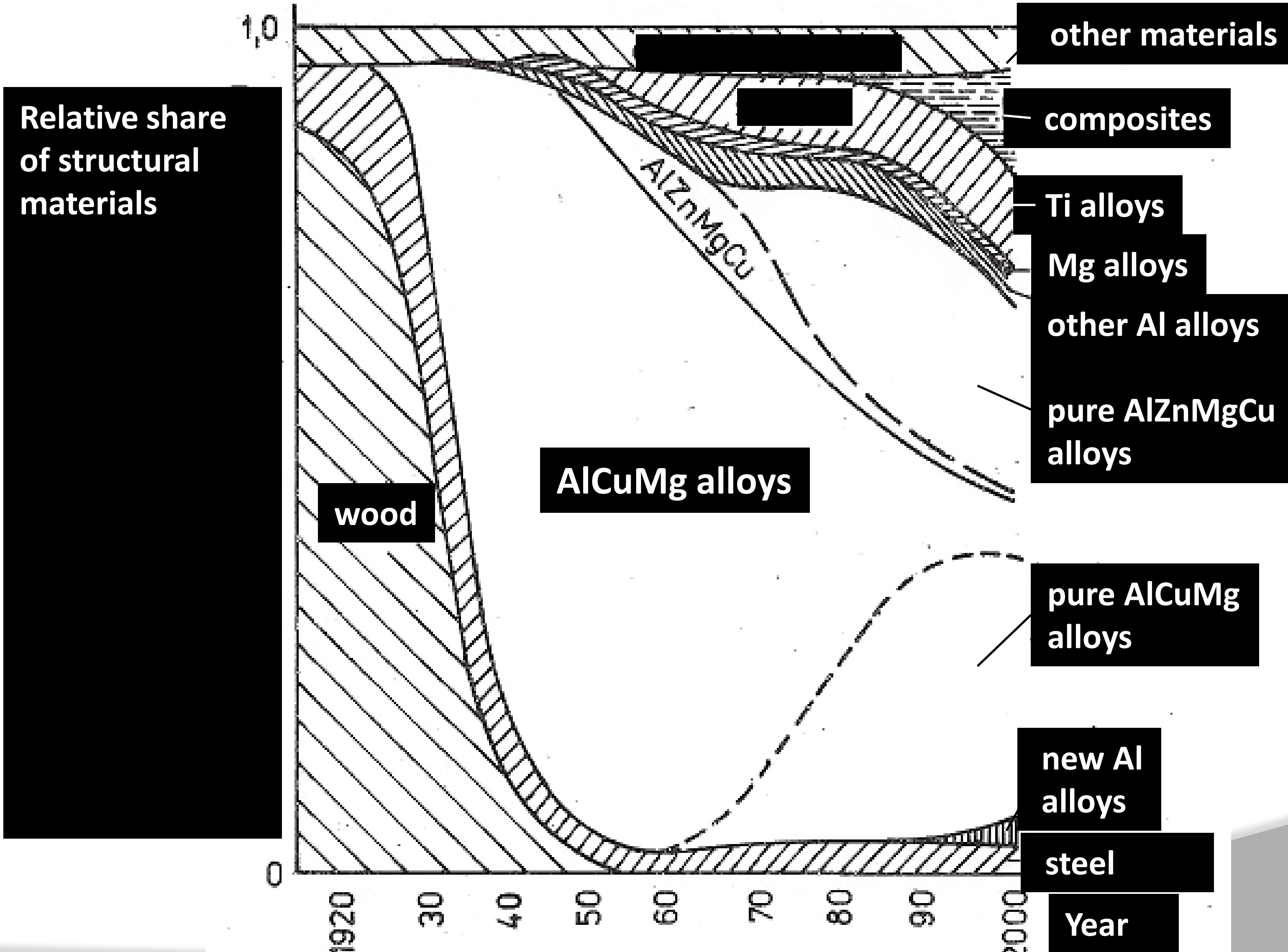
Classification of aircraft materials;

Materials used for aircraft components,

AIRCRAFT MATERIALS

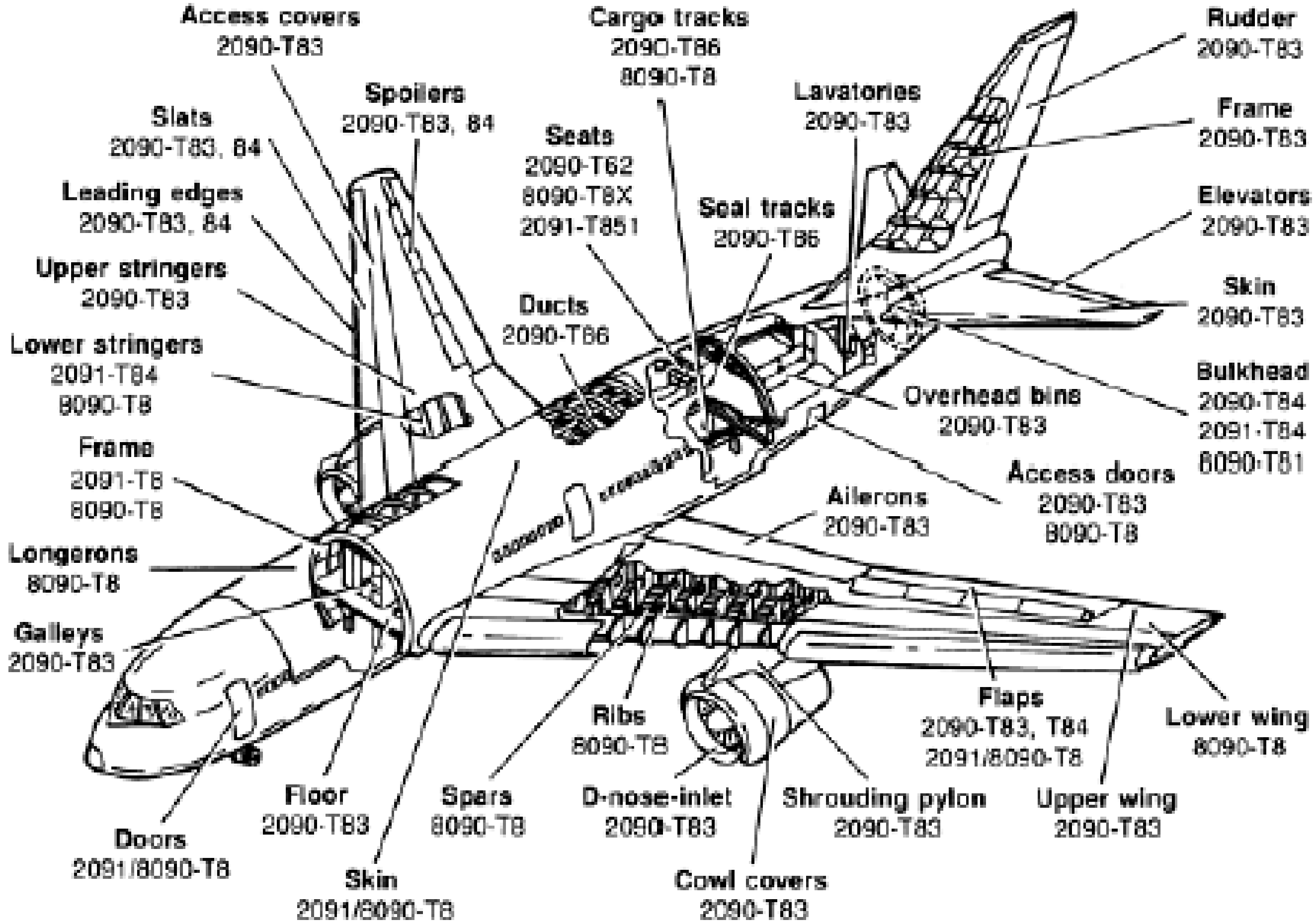
- Basic requirements
- High strength and stiffness
- Low density
- => high specific properties e.g. strength/density, yield strength/density, E/density
- High corrossion resistance
- Fatigue resistance and damage tolerance
- Good technology properties (formability, machinability, weldability)
- Special aerospace standards and specifications

Development of aircraft materials for airframe structures



Application of composite materials

Use of aluminum-lithium alloys in commercial aircraft



Typical castings in aircraft structures

0,4 kg
180 x 150 x 100 mm

Magnesium Alloys

- Basic wrought Mg alloys

- Mg-Al-Zn (AZ)alloys
- The most common alloys in aircraft industry, applicable up to 150 °C
- Composition – 3 to 9 % Al, 0.2 to 1.5 % Zn, 0.15 to 0.5 % Mn
- Increasing Al content → strength improvement , but growth of susceptibility to stress corrosion
- Zn → ductility improvement
- (Cd + Ag) as Zn replacement → high strength up to 430 Mpa

					7
				275	7
AZ31B-H24	3.0Al-1.0Zn	sheet, plates	290	220	15

- Mg-Zn-Zr alloys (ZK)

- Zn → strength improvement
- Zr → fine grain → improvement of strength, formability and corrosion resistance
- Better plasticity after heat treatment
- Alloying with RE a Cd → tensile strength up to 390 MPa
- Application up to 150 °C

Titanium Alloys

Characteristics of titanium and titanium alloys

- Pure titanium - 2 modifications

- αTi – to 882 °C, hexagonal lattice
- βTi – 882 to 1668°C, cubic body centered lattice
- With alloying elements, titanium forms substitution solid solutions α and β

- Commercially pure titanium can be used as structural material in many applications, but Ti alloys have better performance.

Composite Materials

- Most composites consist of a bulk material (the ‘matrix’), and a reinforcement, added primarily to increase the strength and stiffness of the matrix. This reinforcement is usually in fibre form.
-
- Today, the most common man-made composites can be divided into three main groups:
- Polymer Matrix Composites (PMC’s) – These are the most common and will be discussed here. Also known as FRP - Fibre Reinforced Polymers (or Plastics) – these materials use a polymer-based resin as the matrix, and a variety of fibres such as glass, carbon and aramid as the reinforcement.

perature
einforce it with short
e and boron nitride (BN).

Polymer fibre reinforced composites

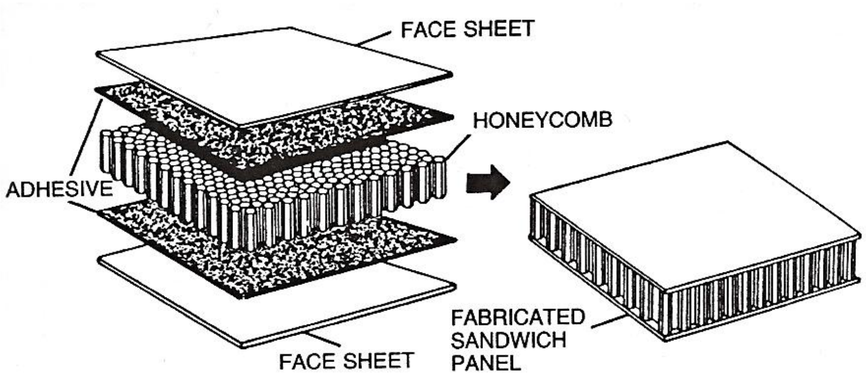
- Common fiber reinforced composites are composed of
- fibers and a matrix.

- Fibers are the reinforcement and the main source of strength
- while the matrix 'glues' all the fibres together in shape
- and transfers stresses between the reinforcing fibres.

- Sometimes, fillers or modifiers might be added
- to smooth manufacturing process, impart special properties, and/or reduce product cost.

Sandwich materials

- Structure – consists of a lightweight core material covered by face sheets on both sides. Although these structures have a low weight, they have high flexural stiffness and high strength.
- Skin (face sheet)
- Metal (aluminium alloy)
- Composite material
- Core



Carbon Fibre Reinforced Plastic(CFRP)

- A new structural material having the most influence is carbon fibre reinforced plastic (CFRP).
- The Airbus A380 uses some all-CFRP components and has a large proportion of the fuselage manufactured using a unique aluminium/reinforced-plastic sandwich

- CFRP offers durability and is relatively light.
- The designers have to exploit the potential weight saving with care.
- The fuel efficiency at the maximum payload–range point was shown to be 33% improved on the 777-200LR.

Resin

- In polymer chemistry and materials science
- Resin is a solid or highly viscous substance of plant or synthetic origin that is typically convertible into polymers.
- Resins are usually mixtures of organic compounds.

- Plants secrete resins for their protective benefits in response to injury.
- The resin protects the plant from insects and pathogens

Thank You