Government Polytechnic Nanakpur

DEPARTMENT OF MECHANICAL ENGINEERING

E - NOTES

HYDRAULICS AND PNEUMATICS

HOD/O.I. (Mechanical) : **Sh.SHALANDER MOR**

Faculty Name: **Er.Amit Kumar**

Semester: 4^{th} Sem

LEARNING OUTCOMES

After undergoing this course, the students will be able to:

- Explain fluid properties, their units and conversion.
- Use and Maintain different types of pressure gauges.
- Calculate velocity and discharge of various liquids.
- Apply Bernoulli’s theorem for calculating pipe diameter and height of pipe from ground.
- Calculate pipe friction and losses in pipelines.
- Specify hydraulic machines for different applications.
- Select maintain and resolve troubles in pumps.
- Apply Pascal’s law in practical applications.
- Maintain hydraulic and pneumatic system

TURBINE AND PUMP

- A **turbine** is a rotary engine that extracts energy from a fluid flow and converts it into useful work

Eg: steam turbine, gas turbine, hydraulic turbine

- Hydraulic Turbines transfer the kinetic energy and potential energy of water into a rotation .

- We can generate electricity by coupling to electric generator
- Pump is work consuming device and it is just opposite to turbine.

Eg. Centrifugal pump

CLASSIFICATION OF HYDRAULIC TURBINES:

1. BASED ON FLOW PATH

- Axial Flow
- Radial Flow
- Tangential Flow
- Mixed Flow

2. Based on flow path

- **Axial Flow Hydraulic Turbines:** flow path of the liquid mainly parallel to the axis of rotation. Eg: Kaplan turbine

- **Radial Flow Hydraulic Turbines:** liquid flowing mainly in a plane perpendicular to the axis of rotation.

- **Tangential Flow Hydraulic Turbines:** liquid flowing mainly in a plane tangential to the turbine. Eg: Pelton turbine

- **Mixed Flow Hydraulic Turbines:** For most of the Hydraulic Turbines used there is a significant component of both axial and radial flows. They are called as Mixed Flow Turbines.

eg. Francis Turbine is an example of mixed flow type, in Francis Turbine water enters in radial direction and exits in axial direction.

3. BASED ON WORKING PRINCIPLE

- Impulse turbine
- Reaction turbine

Kinetic energy changes and pressure energy

Stator → runner

Kinetic energy changes but pressure energy remains constant

Fig Impulse machine

- Pressure change occur only in the nozzles of the machine. Eg : Pelton Turbine.

- The change in fluid velocity and reduction in its pressure causes a reaction on the turbine blades.

  Eg: Francis and Kaplan Turbines

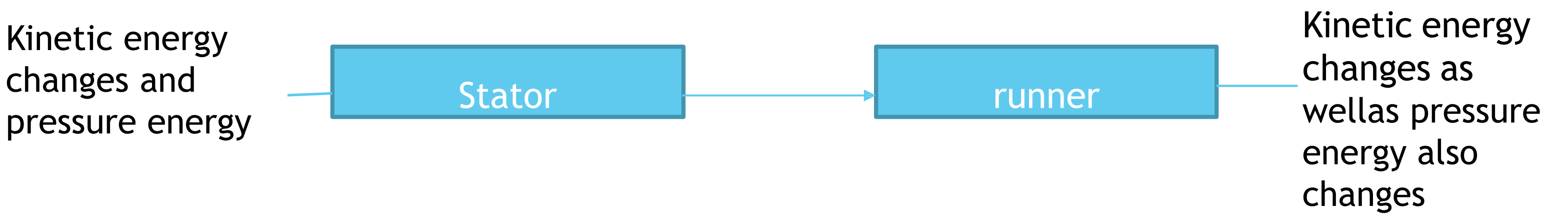
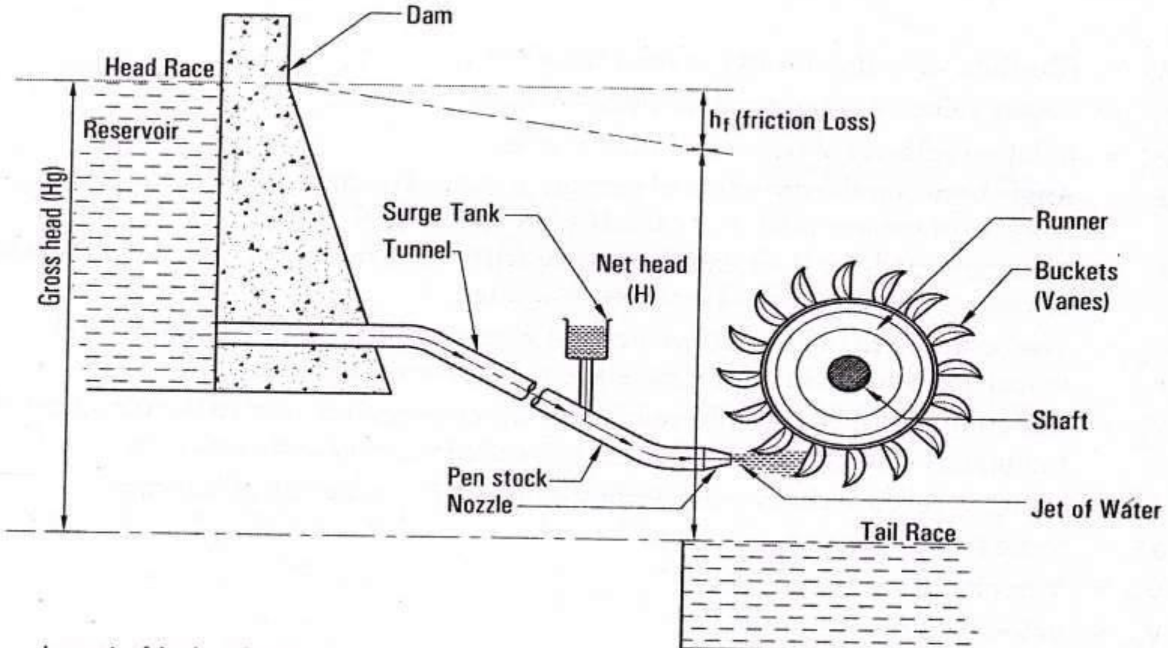


Fig Reaction machine

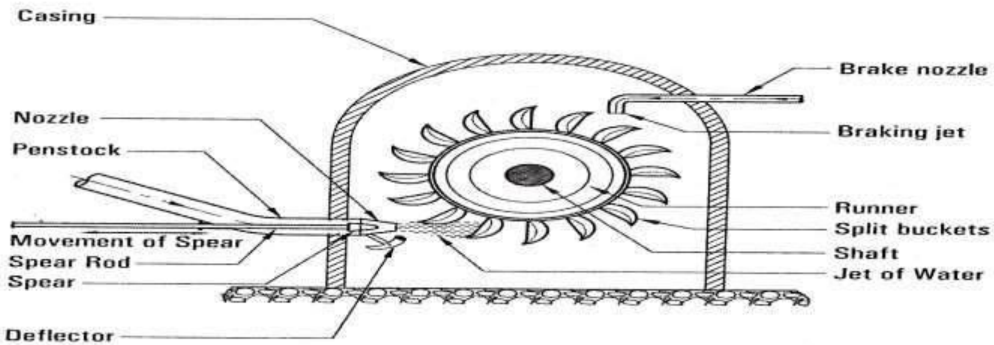
SL NO	IMPULSE TURBINE	REACTION TURBINE
1	Impulsive force is rotating the turbine	Reaction force is rotating turbine
2	Pressure of liquid is decreasing in nozzle before entering to turbine	Pressure decreases as it flows over the blades
3	Blades are of symmetrical profile	Blades having aerofoil profile
4	The size of turbine is small for the same power output	Size of reaction turbine is large for the same power output
5	Whole pressure energy of water is converted into kinetic energy before passed onto turbine wheel	Part of pressure energy only converted to kinetic energy
6	Water discharges directly from turbine wheel to tail race	Water discharges into a draft tube then it is finally discharged to tail race
7	Pressure of water will be atmospheric as it flows over moving blades	Pressure of water continuously decreases as it flows over the blades

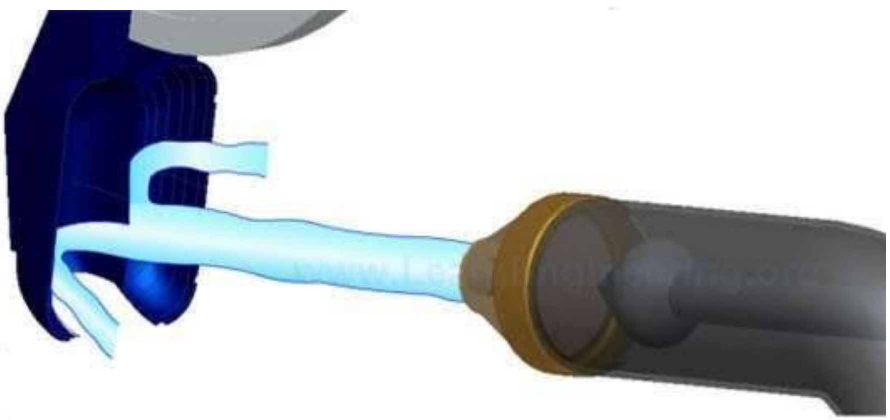
PELTON TURBINE POWER PLANT



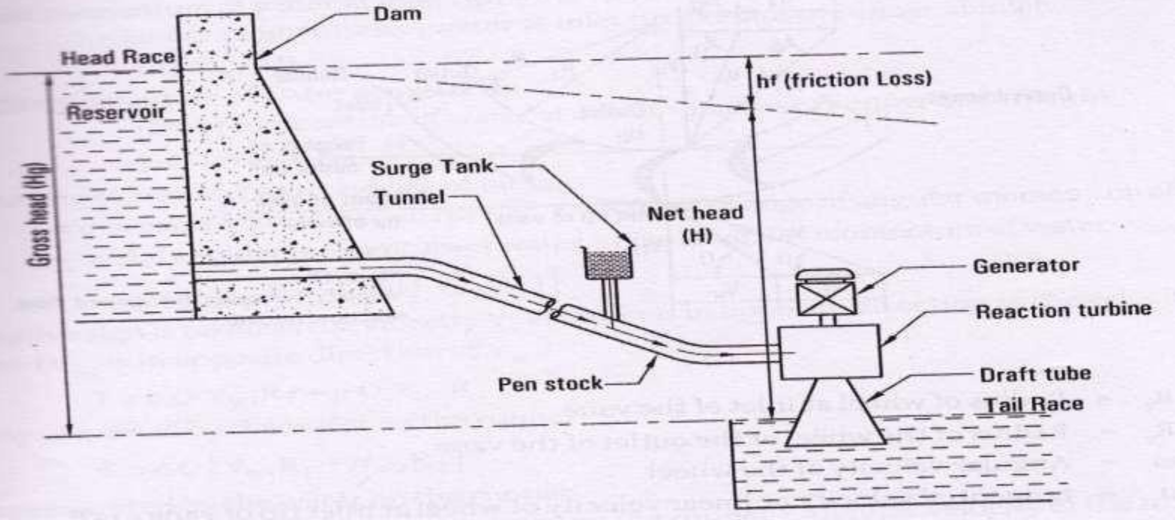
Layout of hydro-electric powerplant
with pelton wheel

PELTON TURBINE



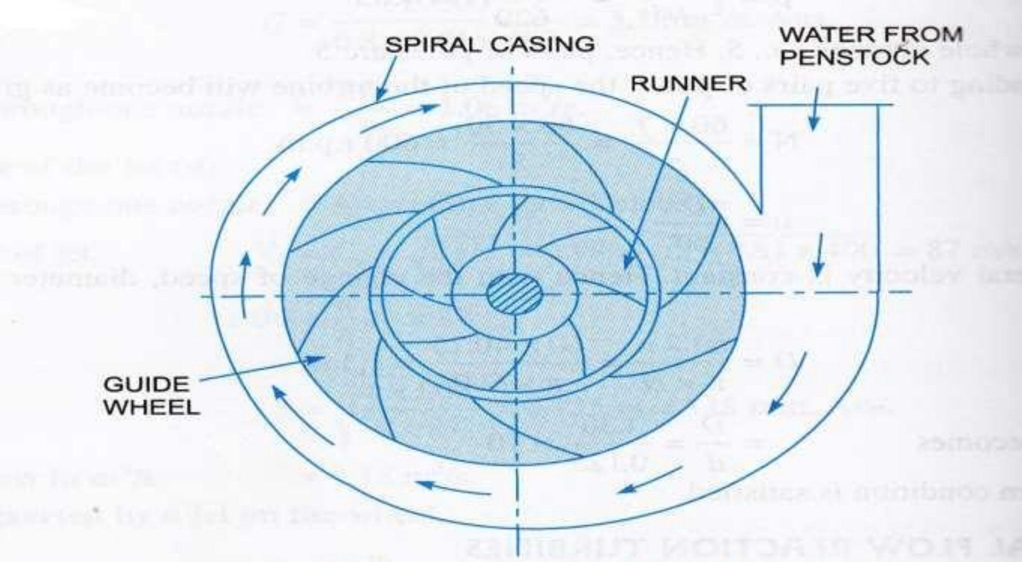


REACTION TURBINE



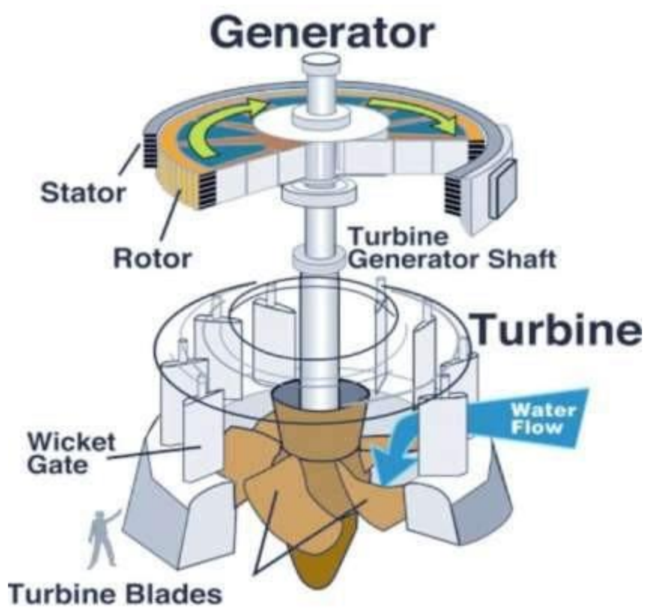
General layout of a Reaction turbine hydro-electric power plant

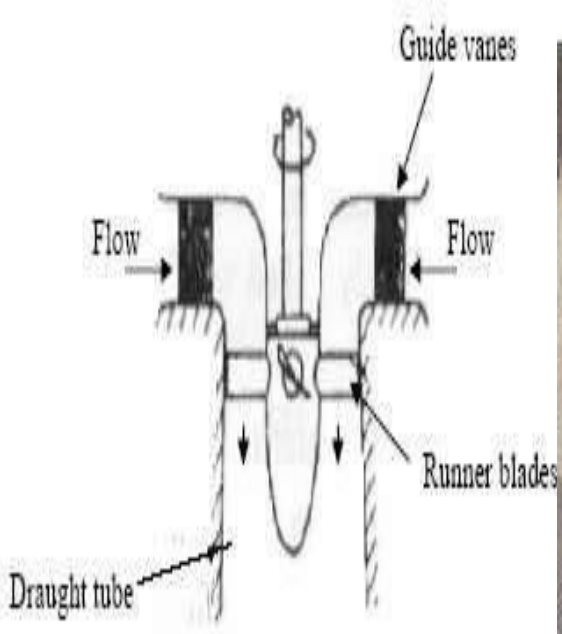
Francis Turbine



Main parts of a radial reaction turbines.

Kaplan Turbine:





CLASSIFICATION OF PUMPS

Pumps are broadly classified into

1. Positive- displacement pumps
2. Rotodynamic pumps

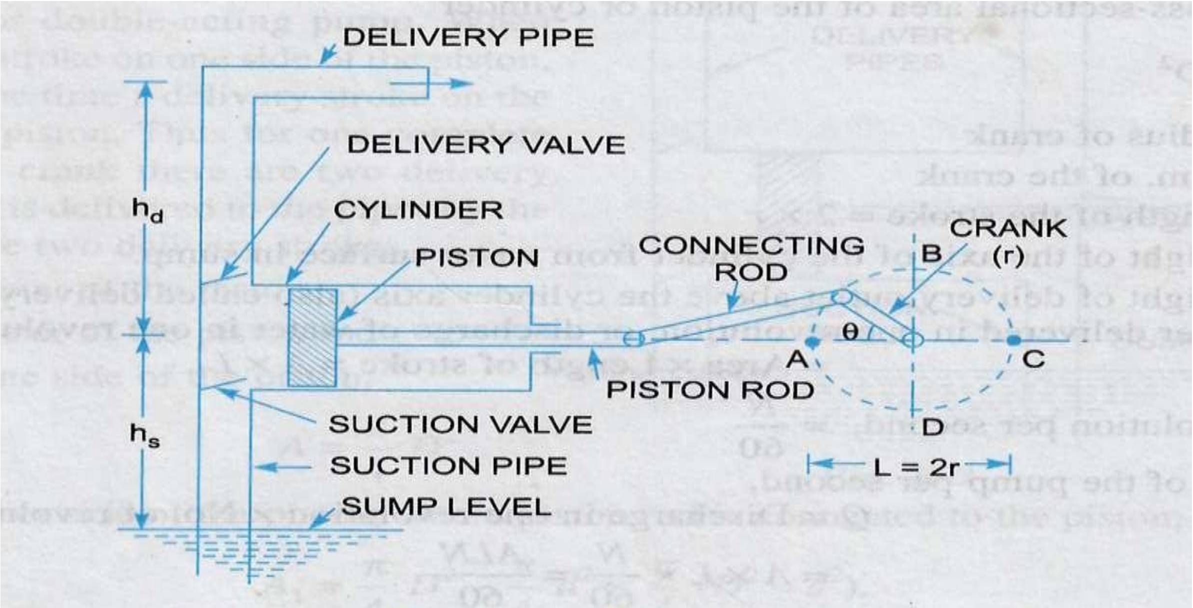
- Positive- displacement pumps: They make a fluid move by trapping a fixed amount and displacing the trapped volume into the discharge pipe. Discharge is directly proportional to speed.

Eg : Reciprocating pump, Vane pump, Gear pump

- Rotodynamic pumps: It is a machine in which energy is continuously imparted to the pumped fluid by means of a rotor and thus fluid is raised to higher elevation.

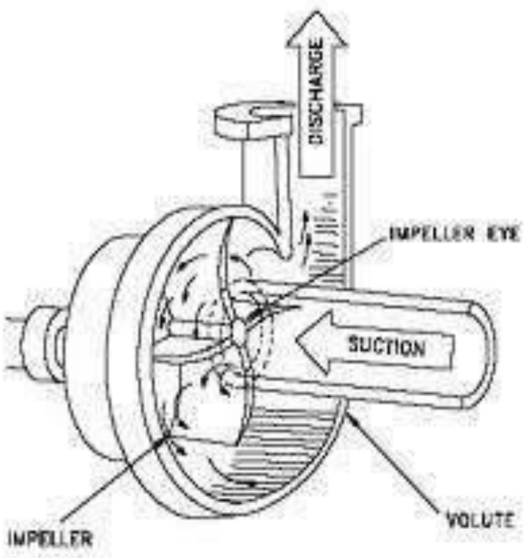
Eg: Centrifugal pump

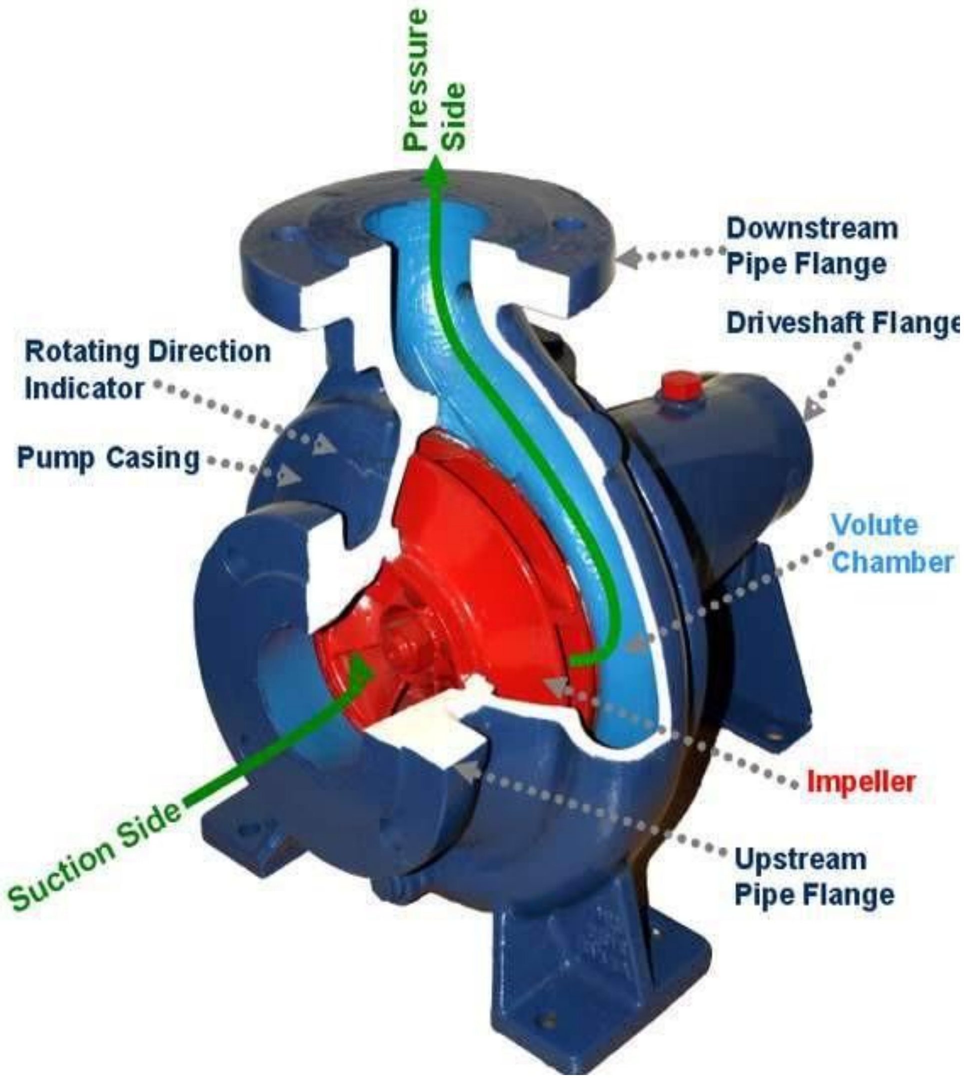
RECIPROCATING PUMP

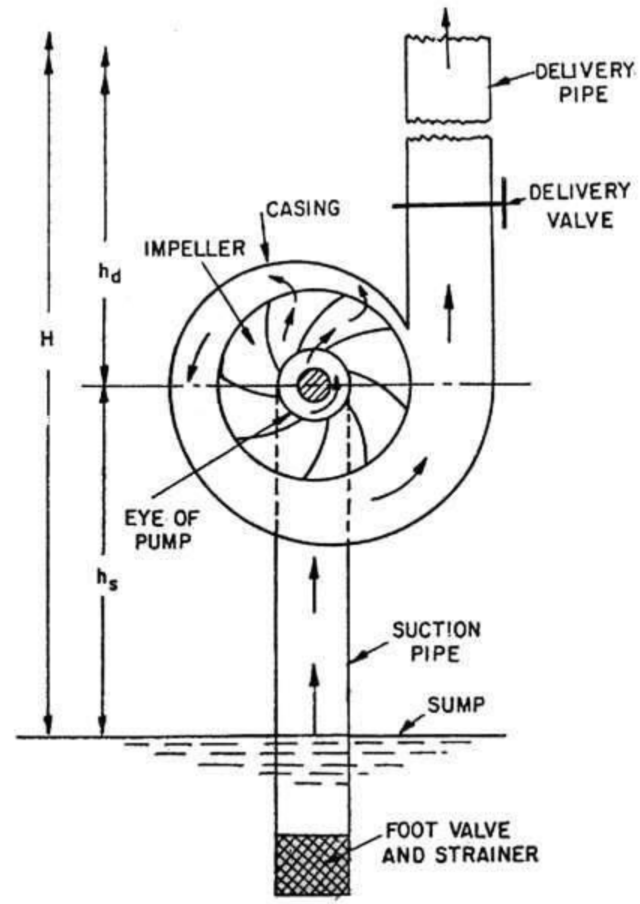


Main parts of a reciprocating pump.

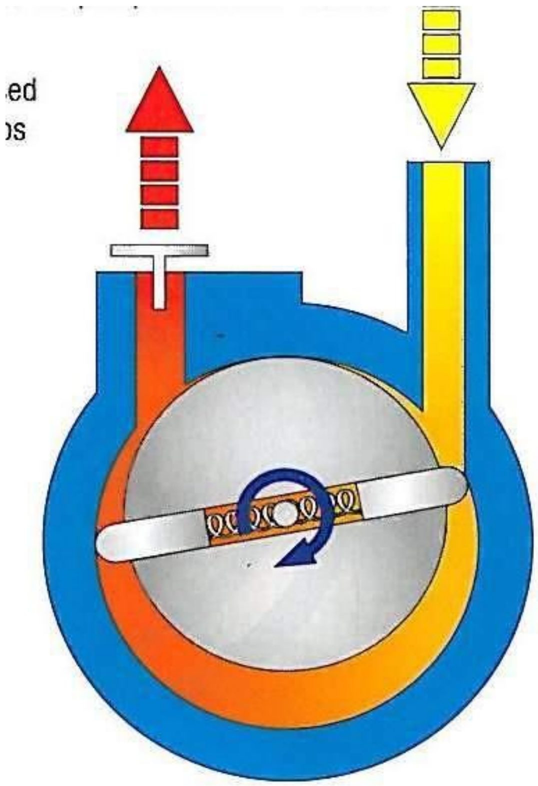
Centrifugal pumps



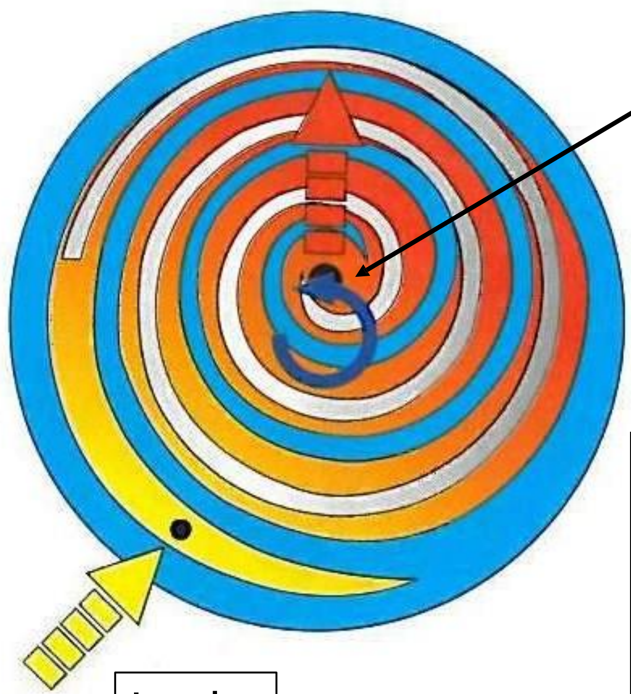

Pressure Side
Downstream Pipe Flange
Driveshaft Flange
Rotating Direction Indicator
Pump Casing
Volute Chamber
Impeller
Suction Side
Upstream Pipe Flange


DELIVERY PIPE
DELIVERY VALVE
CASING
IMPELLER
h_d
H
EYE OF PUMP
h_s
SUCTION PIPE
SUMP
FOOT VALVE AND STRAINER

Rotary vane pump



Scroll Pump

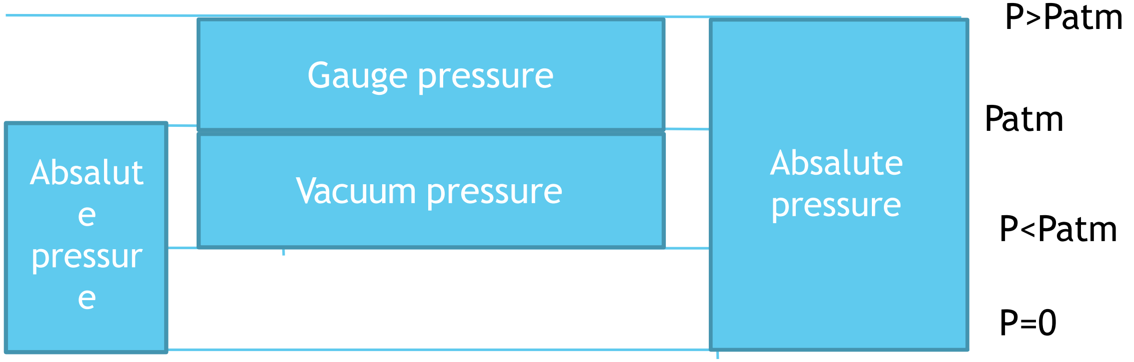

Exhaust port in center
Intake
Blue area rotates counterclockwise with silver area sprung against it. Volume between parts decreases.

Pressure

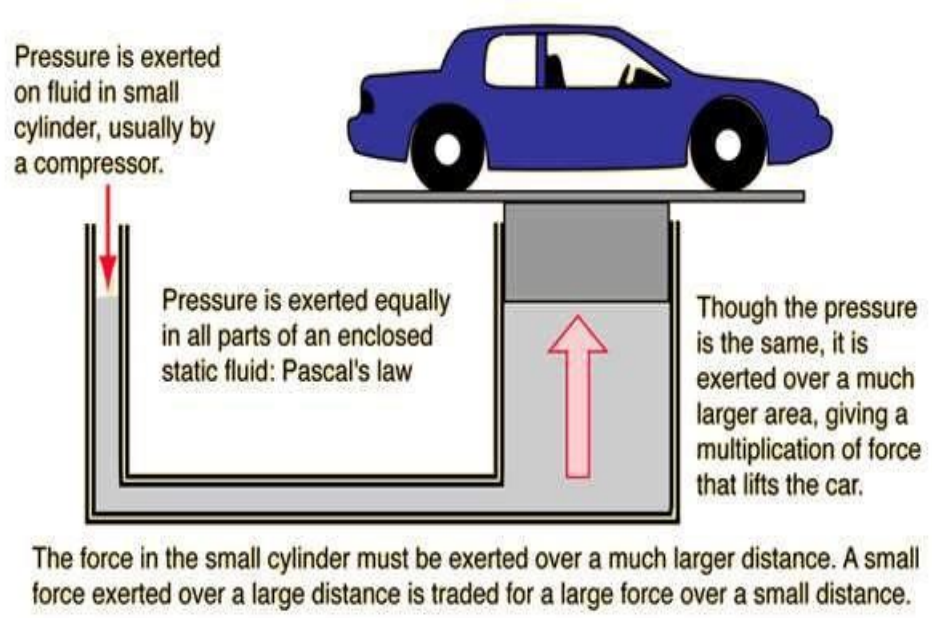
- Fluid pressure = $\frac{\text{Normal compressive force}}{\text{Area}}$
- It is compressive in nature
- S.I unit is Pascal
- 1 atm pressure=101325 pa
- 1 atm pressure=1.o1325 bar
- 1 atm pressure=101.325 Kpa
- 1 atm pressure=10.3 mtr of water
- 1 atm pressure=76cm of Hg
- Atm pressure is measured by barometer
- It is scalor quantity ⟶ Acq. To pascal law

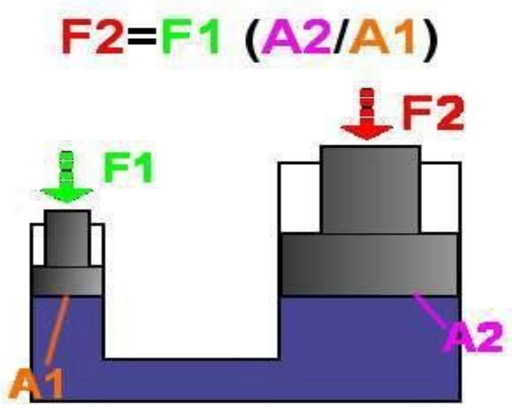
Pressure of fluid expressed in 3 forms

- **Absolute pressure**
- **Gauge pressure**
- Negative gauge



Pascal law:


Pressure is exerted on fluid in small cylinder, usually by a compressor.
Pressure is exerted equally in all parts of an enclosed static fluid: Pascal's law
Though the pressure is the same, it is exerted over a much larger area, giving a multiplication of force that lifts the car.
The force in the small cylinder must be exerted over a much larger distance. A small force exerted over a large distance is traded for a large force over a small distance.


F2=F1 (A2/A1)
F2
F1
A2
A1

Pressure Variation in a Fluid at Rest- Hydrostatic law

$$\frac{\partial p}{\partial x} = 0 \qquad \frac{\partial p}{\partial y} = 0 \qquad \frac{\partial p}{\partial z} = -\gamma$$

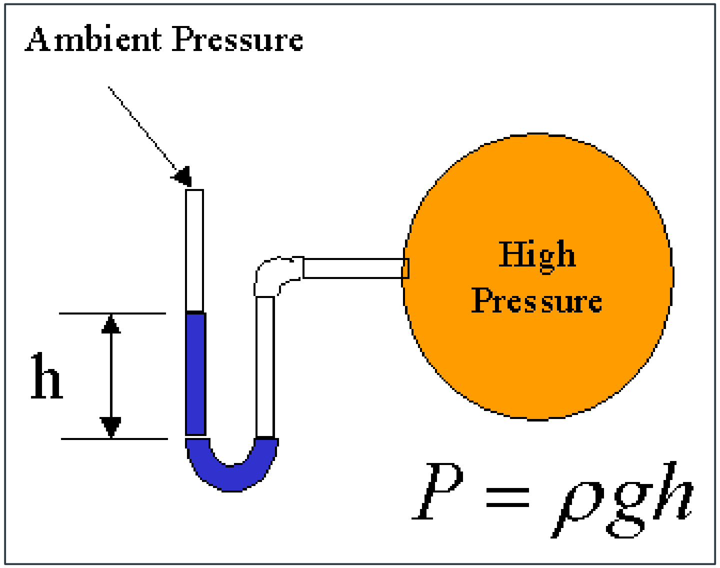
Pressure measuring instruments:

- **Simple manometers**
  - Peizometer
  - U-tube manometer
  - Single column manometer
- **Differential manometer**
  - 2piezometer d.f
  - Inverted u-tube manometer
  - U-tube differential manometer
- **Pressure gauges**
  - Bourdon tube pressure gauges
  - Diaphragam pressure gauges

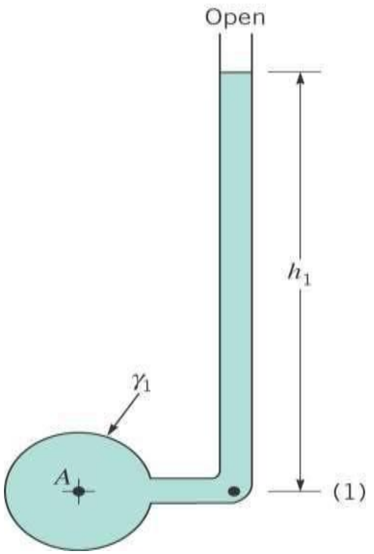
Manometers

Principle of operation: Manometers are devices in which columns of suitable liquid are used to measure the difference in pressure between two points, or between a certain point and the atmosphere (p_{atm}).

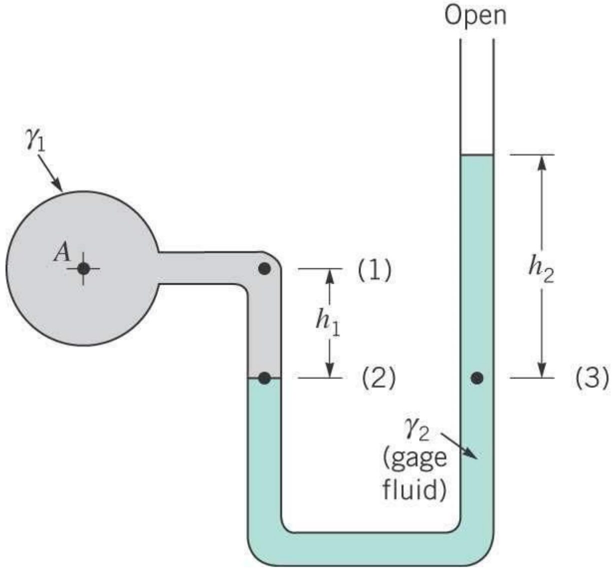
➢ Applying fundamental equations of hydrostatics the pressure difference, P, between the two liquid columns can be calculated.



PEIZOMETER



U-TUBE MANOMETER



Single column manometer

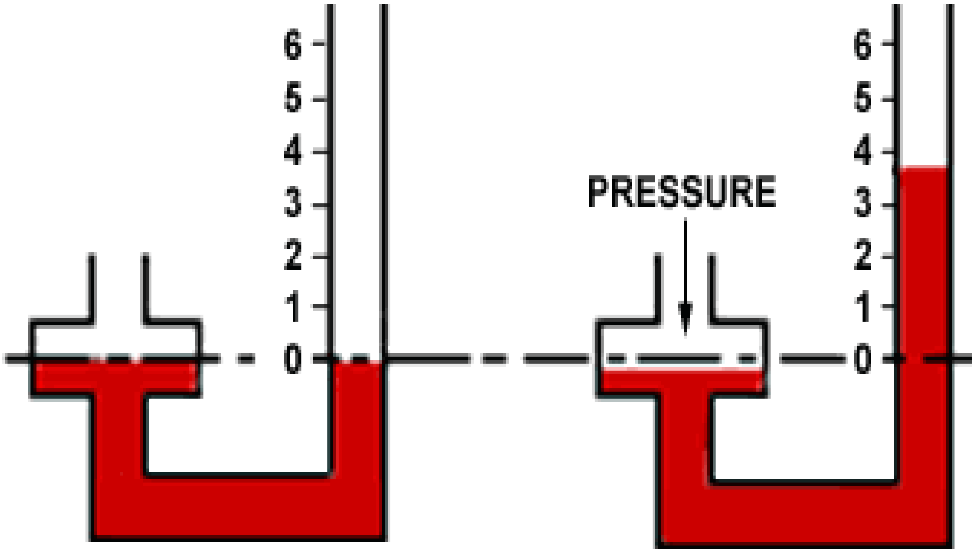
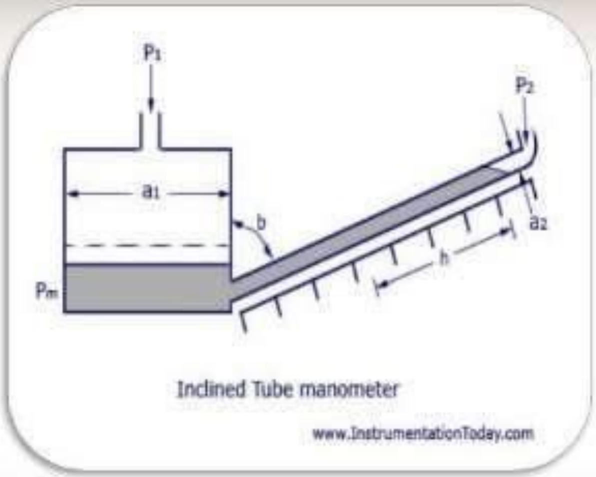


Fig. 2-4

Inclined tube manometer

- It is slant manometer.
- The angle of measuring leg is about 10º.
- Inclination is done to improve the sensitivity.
- This manometer is used to measure very small pressure difference.



U-tube differential manometer

Case 2 - U-tube upright differential manometer connected between two pipes at different levels and carrying different fluids

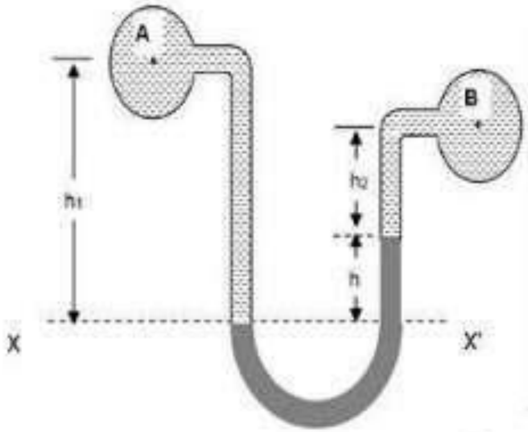
Left limb eq : $h_A + h_1 S_1$

Right limb eq : $h_B + h_2 S_2 + hS$

* Pressure is same at the datum line :

$$h_A + h_1 S_1 = h_B + h_2 S_2 + hS$$

$$h_A - h_B = h_2 S_2 - h_1 S_1 + hS$$

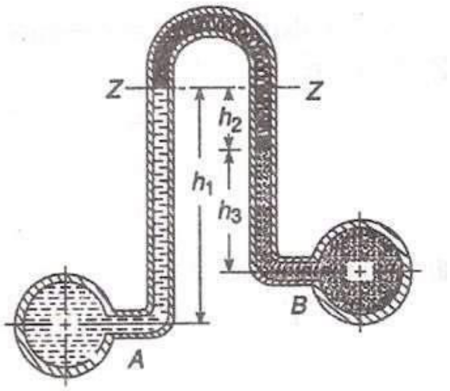


Inverted Differential Manometer:

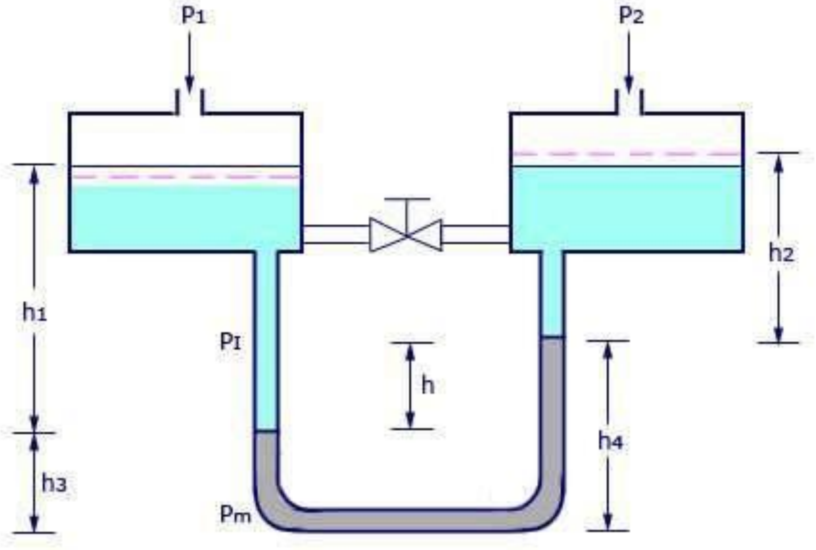
- Type of differential manometer in which an inverted U-tube is used.
- Used for measuring difference of low pressure.

1. Pressure head in the left limb above Z-Z = ha-s1h1
2. Pressure head in the right limb above Z-Z = hb-s2h2-s3h3
3. Equating we get, ha-s1h1 = hb-s2h2-s3h3

(Where; ha, hb are Pressure in pipes A and B expressed in terms of head of liquid, respectively)



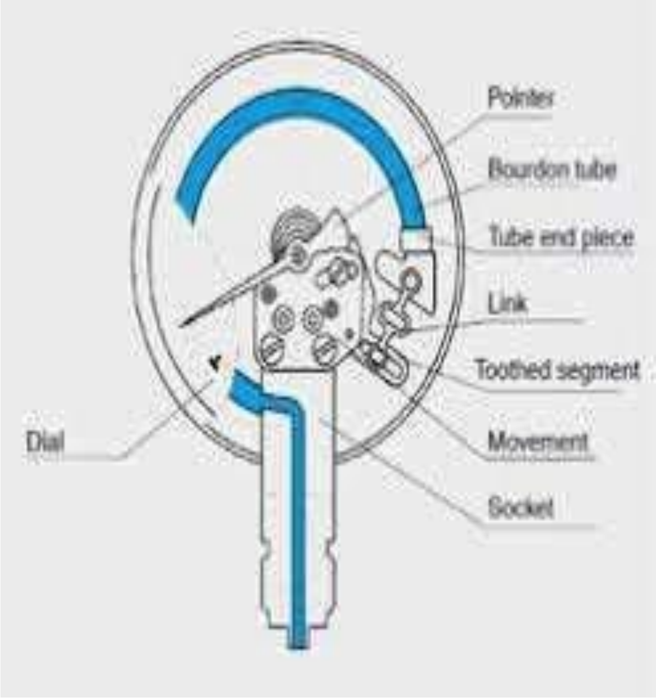
Micromanometer



Manometer With Large Seal Pots

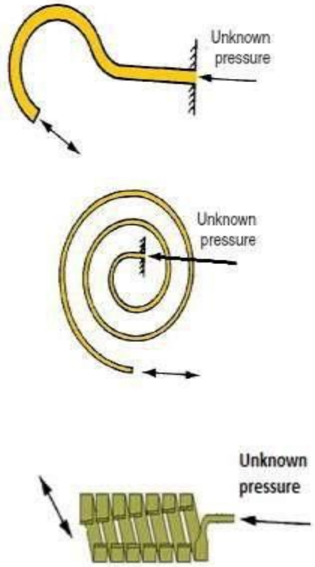
www.InstrumentationToday.com

Bourdon Gauge (Mechanical)



Bourdon tube

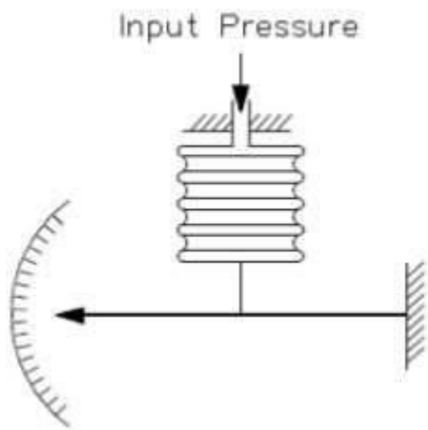
- The three common shapes of Bourdon tube are the C-type, the spiral type and the helical type.
- The maximum possible deflection of the free end of the tube is proportional to the angle subtended by the arc through which the tube is bent. For a C-type tube, the maximum value for this arc is somewhat less than 360°.
- Where greater measurement sensitivity and resolution are required, spiral and helical tubes are used.



Diaphragm pressure gauge

BELLOWS

- bellows sensor is an axially flexible, cylindrical enclosure with folded sides. When pressure is applied through an opening, the closed end extends axially.
- Bellows elements can measure absolute pressure, gauge pressure, vacuum, or differential pressure.



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Journal of Operational Research :Prof. Angappa Gunasekaran

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Hydraulics and Pneumatics 3rd Edition

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Thank You

Government Polytechnic Nanakpur

DEPARTMENT OF MECHANICAL ENGINEERING

E - NOTES

INDUSTRIAL ENGINEERING

HOD/O.I. (Mechanical) : **Sh.SHALANDER MOR**

Faculty Name: **Er. Sanjay Kumar**

Semester: 4th Sem

LEARNING OUTCOMES

After undergoing this course, the students will be able to:

- Use industrial engineering concepts to improve productivity
- Use resources optimally and economically.
- Apply work study techniques for improving production
- Explain various incentive plans
- Solve planning, scheduling and sequencing problems for shop floor
- Interpret different kinds of production systems
- Prepare break-even analysis and Gantt chart.
- Locate suitable plant location and draw plant layout for different production system.
- Maintain inventory optimally and classify different types of inventory

CHAPTER-1

PRODUCTIVITY

Production

Production is the process by which raw materials and other inputs are converted into finished products. Production is the backbone of a nation's economic progress.

Productivity

- Productivity is the efficiency of the production system,which is expressed by the ratio between output and input.

$$\textit{Productivity} = \frac{\text{Quantity of goods and service produced}}{\textit{Amount of resource used}}$$

Benefits from Productivity

1. For Management:

(i) More profit earning

(ii) Increase in market share.

(iii) better utilization of resources

2. For Worker:

(i) Better carrier prospects

(ii) Job security

(iii) Better working conditions

3.For Consumer:

(i) Better product quality at reduced prices.

(ii) Satisfaction

4.For Nation:

(i) Better utilization of resources.

(ii) Increase in per capita income.

(iii) More foreign exchange to the nation.

Factors affecting Productivity

1.Internal Factors:

(i)Product Factor

(ii)Plant and Equipment

(iii) Technology

(iv)Material and Energy

(v) Human Factors

(vi) Work methods

(vii) Management style

2.External Factors

(i)Natural resourses

(ii)Government and infrastructure

(iii) Diffrence between Productuin and Productivity

Causes of Low Productivity:

(i)Improper design of product

(ii)Incorrect quality standards

(iii) Improper machine used

(iv)Poor Planning

Methods to Improve Productivity:

1. Technology Based Improvement

(i) Robotics

(ii) Laser technology

(iii) Energy technologFlexible manufacturing system

2. Employee based Improvement

(i) Employee promotion

(ii) Personal develoment

3.Material Based Improvement:

(i) Material planning and control
(ii) Purchasing, logistics
(iii) Material storage and retrieval
(iv) Waste elimination

4. Process Based Improvement

(i) Work simplification
(ii) Job evaluation
(iii) Human factor engineering

Methods to improve Productivity:

1. Technology Based Improvement
2. Employee Based Improvement
3. Based Improvement
4. Process Based Improvements
5. Product Based Improvement

CHAPTER-2

WORK STUDY

Work Study:

Work study is primarily concerned with discovering the best way of doing jobs and establishing standards based on such methods.

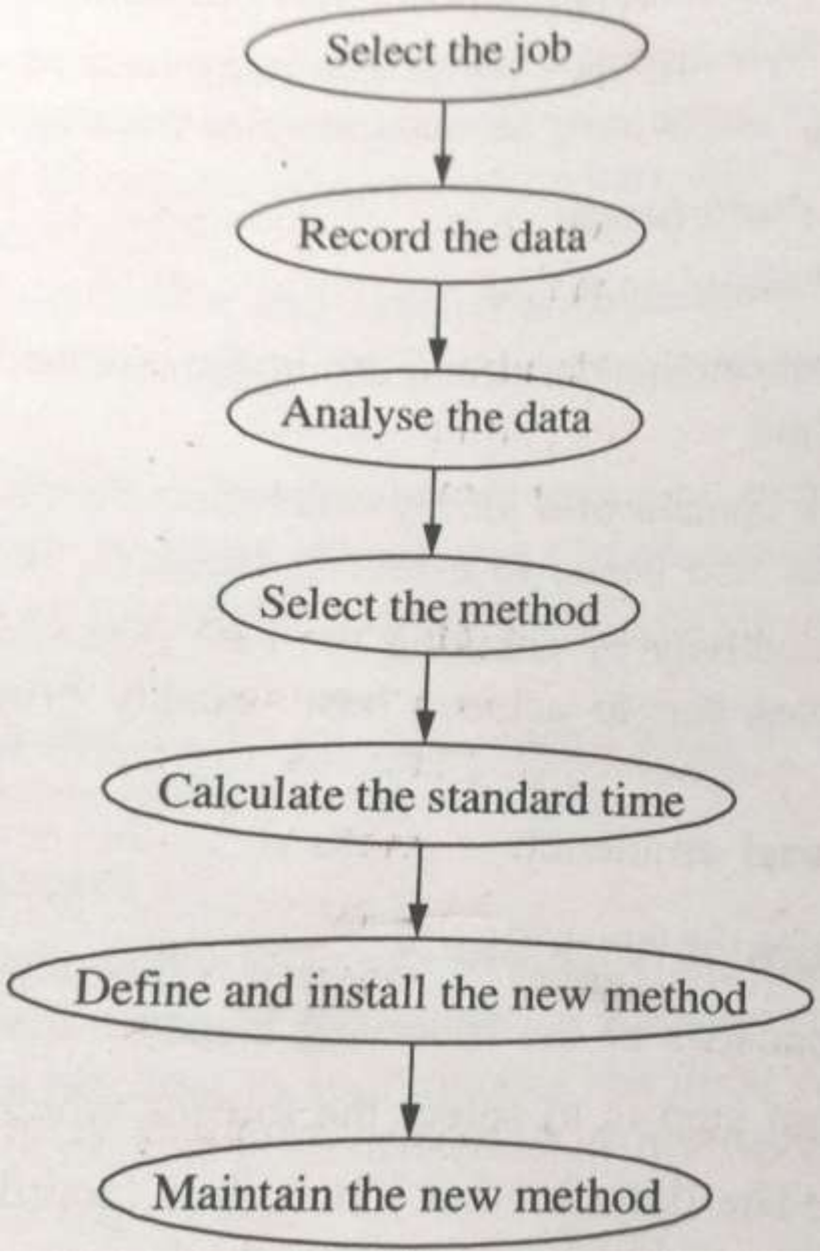
Work study is a general term associated with two techniques:

(i) Method study

(ii) Work measurement

Basic Procedure of work study:

(a) Select the job
(b) Record the data
(c) Analyse the data
(d) Select the method
(e) Calculate the standard time
(f) Define and install the new method
(g) Maintain the new method


Select the job
Record the data
Analyse the data
Select the method
Calculate the standard time
Define and install the new method
Maintain the new method

Components of work study:

The components of work study are

(i)Method study

(ii)Work measurement

Method Study:

Method study deals with the manner in which work is performed. The best possible method is adopted for work or improvements can be done in current methods.

Steps in Method Study:

(a) Select the job

(b) Recording the important facts about the job

(c) Examine the job

(d) Developing the most economical method

(e) Evaluate various alternative methods

(f) Defining the new methods

(g) Install the new method

(h)Maintain the new developed method

2.Work Measurement:

Work measurement means measuring the work by establishing a time for a worker to carry out specified job at a defined level of performance.

Steps in Work Measurement:

(a) Select the job

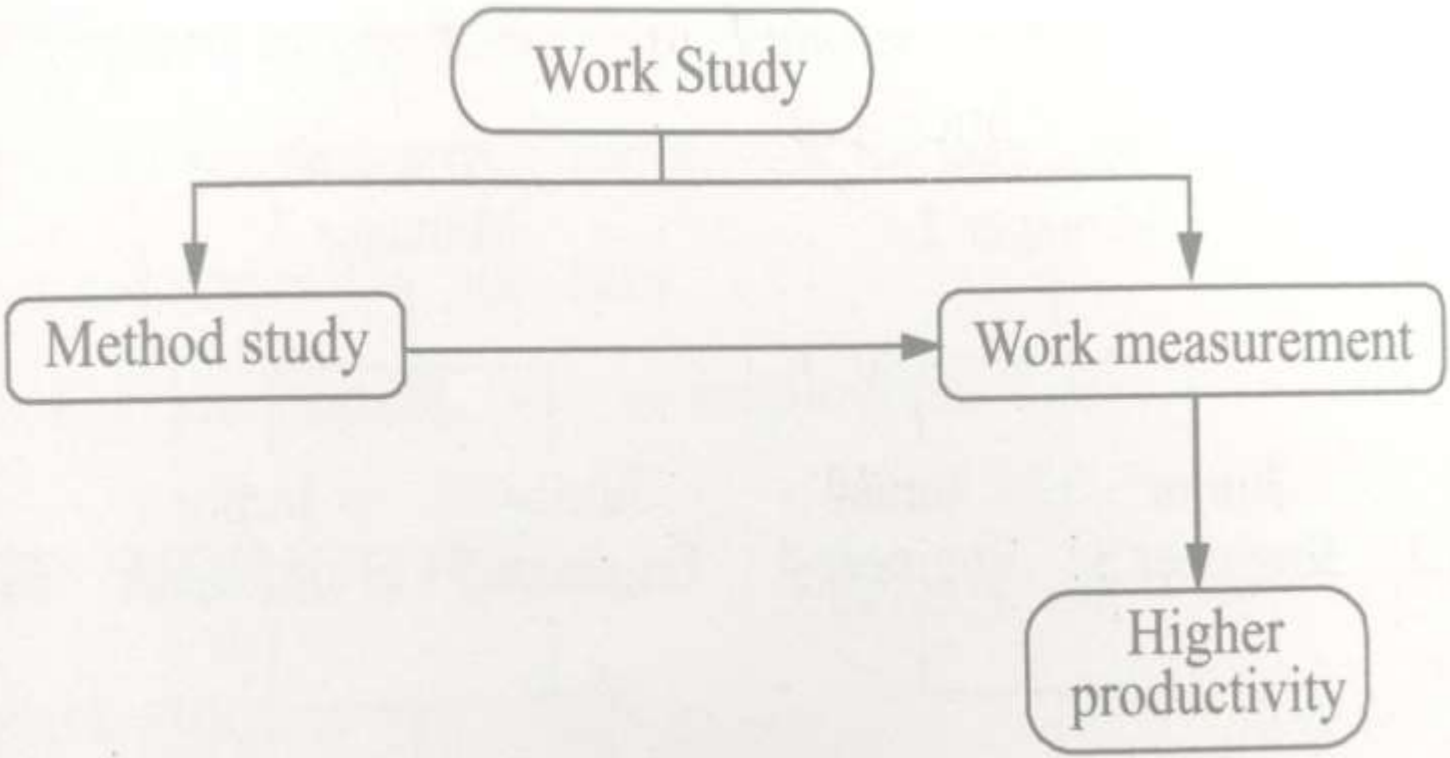
(b) Record the data

(c) Examine the relevant facts

(d) Calculate the basic time

(e) Calculate the standard time

(f) Install and maintain


Work Study
Method study
Work measurement
Higher productivity

Inter-Relation Between Method Study And Work Measurement:

Both method study and work measurement are associated with work study and are closely linked to each other. Method study reduces the content of job, whereas work measurement investigates and reduces ineffective time associate with job.

CHAPTER-3

Method Study

Method Study:

Method study is the systematic recording and critical examination of the present and proposed ways of doing work, as a means of developing and applying easier and more effective methods to reduce cost.

Method Study Procedure

Symbol used in Process Chart

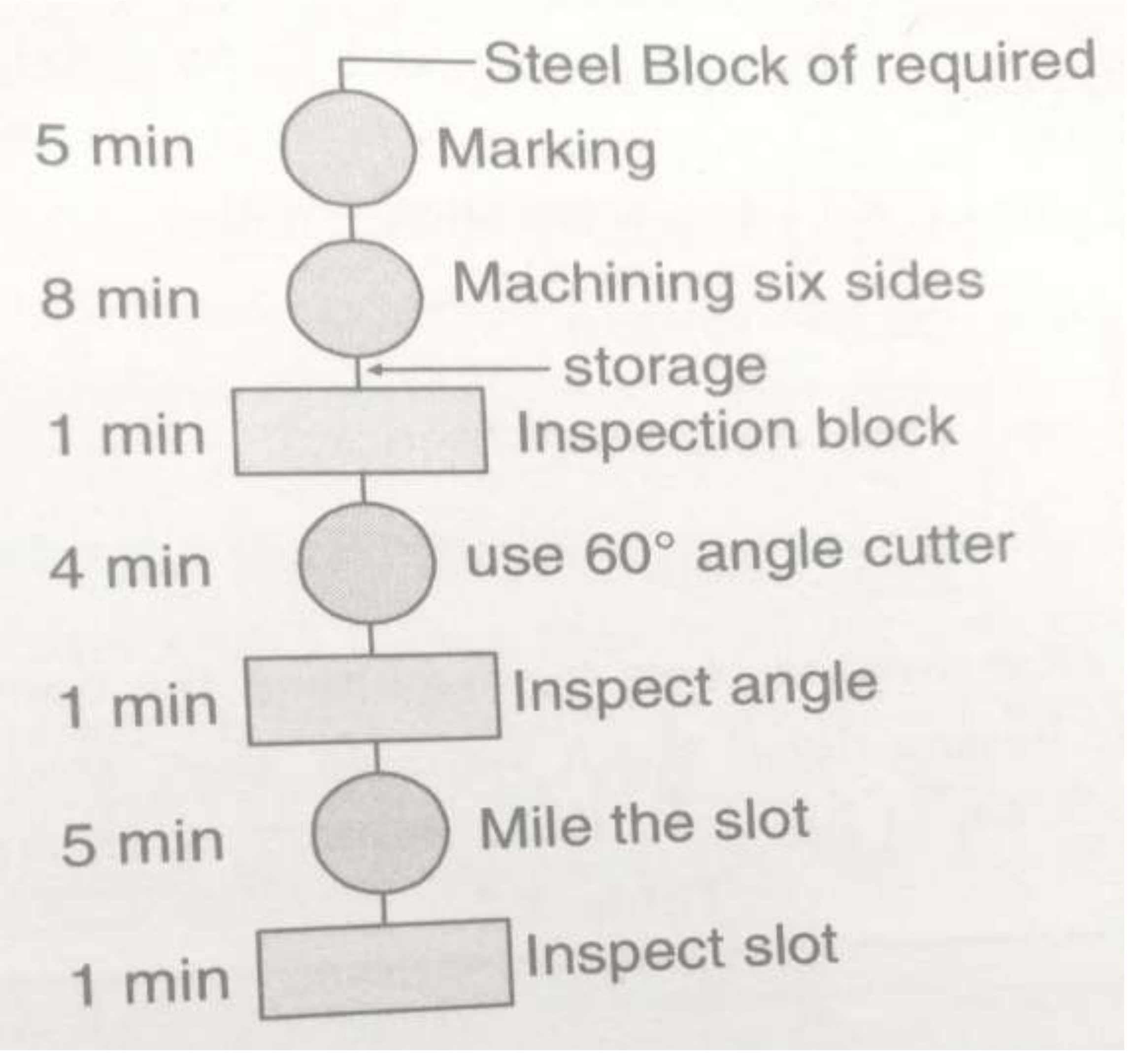
S.No.	Event	Symbol	Description
1.	Operation		It indicates the main steps in a process. Generally the part, material or product is modified or changed during operation.
2.	Inspection		It indicates any type of inspection checks, measurement, visual security for quality and quantity.
3.	Transportation		It indicates the movement of materials or equipments from one location to another.
4.	Delay		It occurs when something stops the process and the product waits for next event.
5.	Storage		It indicates a stage when a finished good or raw material awaits in action. Storage shows an authorized control over an item.
6.	Transportation and inspection		It indicates the combined activity of transportation and inspection.
7.	Operation and transportation		It indicates the combined activity of operation and transportation.
8.	Inspection and operation		It indicates the combined activity of inspection and operation.

Process Chart:

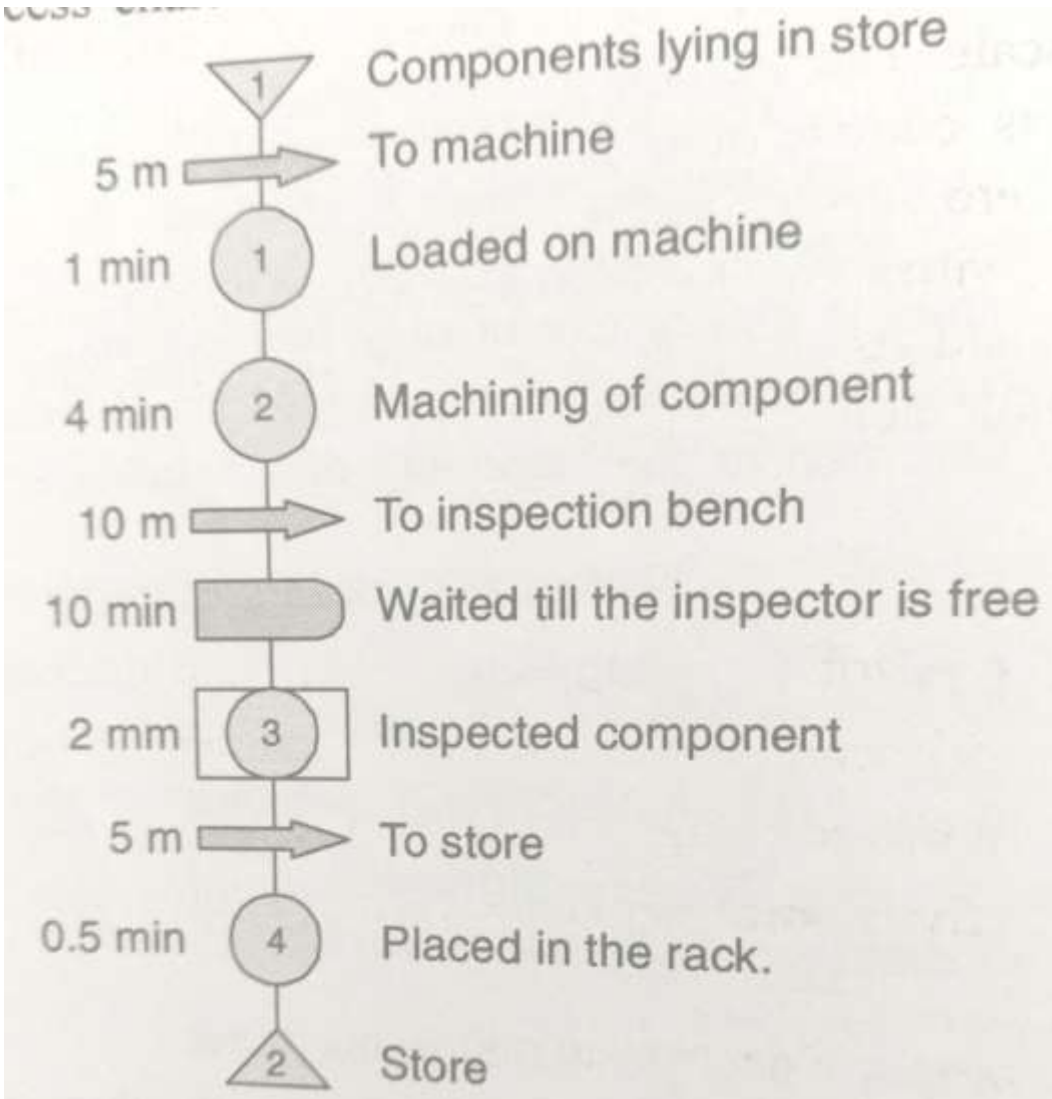
It is a diagram which gives an overall view of the process. It helps in visualizing various possible alternations or improvements. A process chart records graphically, the operations connected with a process.

1. Outline process chart
2. Flow process chart
3. Two handed process chart

Outline Process Chart



Flow Process chart



Two Handed Process Chart :

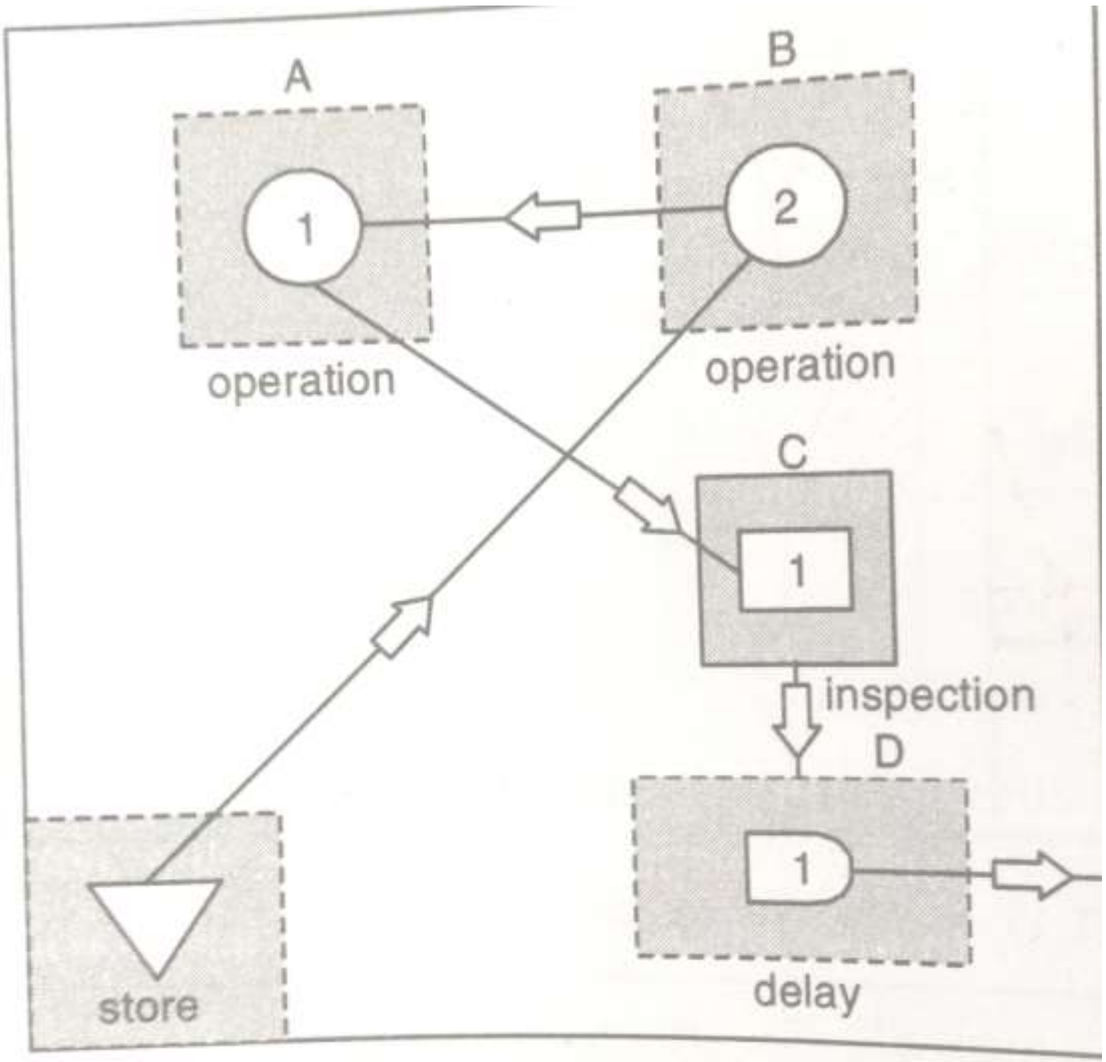
Table 3.5

Left hand		Right hand	
Description	Symbol	Symbol	Description
Pick up Bolt	○	D	Idle
Hold	▽	○	Pick up Nut
Hold	▽	⇨	To Left Hand
Hold	▽	○	Assemble (Screw up)

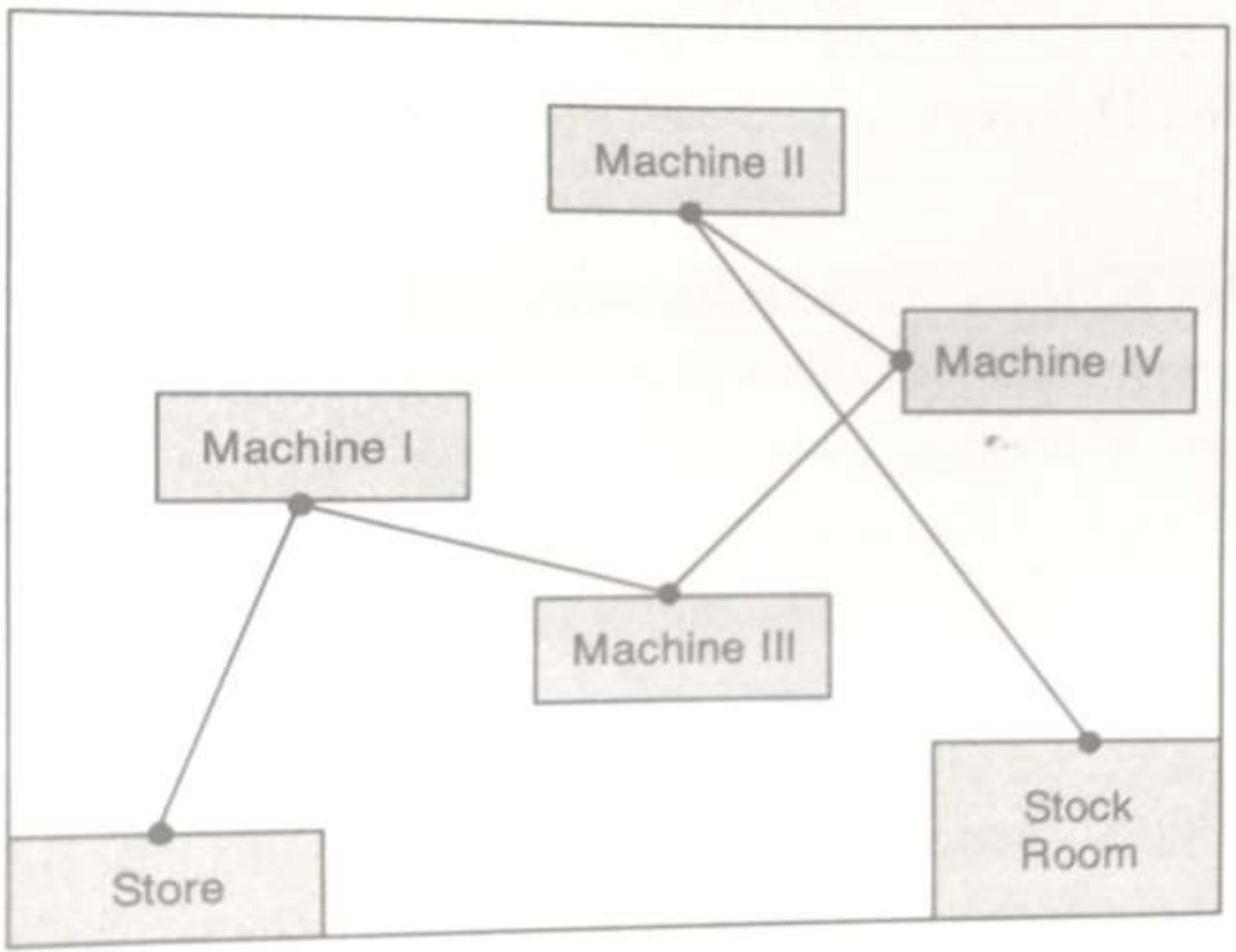
Summary of this chart is as shown in table 3.7.

S.No.	Symbol	○	⇨	◁	D
1.	Frequency (L.H.)	2	2	2	2
2.	Frequency (R.H.)	5	4	–	–

FLOW DIAGRAM:



String Diagram:



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DEPARTMENT OF MECHANICAL ENGINEERING

E - NOTES

MATERIALS AND METALLURGY

HOD/O.I. (Mechanical) : **Sh.SHALANDER MOR**

Faculty Name: Arvind

Semester: 4th Sem

LEARNING OUTCOMES

After undergoing this course, the students will be able to:

•Distinguish between metals and non metals and ferrous and non ferrous materials.

•Analyse microstructure and changes in microstructure due to heat treatment.

•Carryout various heat treatment processes such as annealing, normalizing. tempering hardening.

•Draw and interpret iron-carbon diagram.

•Classify various types of plastics and rubber.

•Explain properties and applications of composites, ceramics and smart materials.

•Select suitable material to be used for various engineering applications.

NEED TO STUDY MATERIALS

Materials used in building bridges that can hold up automobiles, pedestrians…

for
skyscraper
s in the
Windy
City

materials for
space
exploration

INTRODUCTION

Q1.What is material science?

¬Materials science or materials engineering is an interdisciplinary field involving the properties of matter and its applications to various areas of science and engineering.

¬This scientific field investigates the relationship between the structure of materials at atomic or molecular scales and their macroscopic properties.

¬Materials science also deals with *fundamental properties* and *characteristics* of materials.

Scope of Material Science

The field encompasses the complete knowledge spectrum for materials ranging from the basic end (materials science) to the applied end (materials engineering).

Historical Perspective

- Materials are so important in the development of civilization that we associate Ages with them.
- In the origin of human life on Earth, the Stone Age, people used only natural materials, like stone, clay, skins, and wood.
- When people found copper and how to make it harder by alloying, the Bronze Age started about 3000 BC.
- The use of iron and steel, a stronger material that gave advantage in wars started at about 1200 BC.
- The next big step was the discovery of a cheap process to make steel around 1850, which enabled the railroads and the building

Why Study Materials Science ?

- To be able to select a material for a given use based on considerations of cost and performance.
- To understand the limits of materials and the change of their properties with use.
- To be able to create a new material that will have some desirable properties.
- All engineering disciplines need to know about materials. Even the most "immaterial", like software or system engineering depend on the development of new materials, which in turn alter the economics, like software-hardware

Classification of Engineering Materials

Materials

- **Metals**
  - **Ferrous**: Cast iron, Steel, Stainless steel,
  - **Nonferrous**: Aluminum, Titanium, Copper, etc.
- **Ceramics**: Oxides, Nitrides, Carbides, Glasses, Graphite, Diamond, etc.
- **Polymers (Plastics)**
  - **Thermoplastic**: Acrylics, PE, PVC, etc.
  - **Thermoset**: Epoxies, Phenolics,
  - **Rubber (Elastomer)**: Poly-urethanes

Composites-reinforced plastics, metal or ceramic matrix, laminates, others.

Semiconductors-Silicon, Germanium, Gallium phosphor, other.

Biomaterials-biocompatible materials, Co-Cr-Mo, Co-Ni-Mo metal alloys (for hip)

METALS

- Metals account for about two thirds of all the elements and about 24% of the mass of the planet.
- Metals have useful properties including strength, ductility, high melting points, thermal and electrical conductivity, and toughness.

- The key feature that distinguishes metals from non-metals is their bonding.
- Metallic materials have free electrons that are free to move easily from one atom to the next.
- The existence of these free electrons has a number of profound consequences for the properties of metallic materials.
- For example, metallic materials tend to be good electrical conductors because the free electrons can move around within the metal so freely.


Aluminium
Brass
Cast Iron
Bronze
Steel
Metal Sludge
Copper

Ceramics

- A ceramic has traditionally been defined as “an inorganic, nonmetallic solid that is prepared from powdered materials, is fabricated into products through the application of heat, and displays such characteristic properties as hardness, strength, low electrical conductivity, and brittleness.“
- The word ceramic comes from the Greek word "keramikos", which means "pottery.“
- They are typically crystalline in nature and are
compounds formed between metallic and nonmetallic elements such as aluminum and oxygen (alumina-Al_2O_3), calcium and oxygen (calcia - CaO), and silicon and nitrogen (silicon nitride-Si_3N_4).

Depending on their method of formation, ceramics can be dense or lightweight.

Typically, they will demonstrate excellent strength and hardness properties; however, they are often brittle in nature.

Ceramics can also be formed to serve as electrically conductive materials or insulators.

Some ceramics, like superconductors, also display magnetic properties.

They are also more resistant to high temperatures and harsh environments than metals and polymers.

Due to ceramic materials wide range of properties, they are used for a multitude of applications.

Classification of Ceramics

Glasses
- optical
- containers / household

Clay products
- whiteware (dinnerware, floor and wall tile, electrical porcelain, etc.))
- bricks

Refractories
- (brick and monolithic products used in metal, glass, cements, ceramics, energy conversion, petroleum, and chemicals industries)

Abrasives
- sandpaper
- cutting
- polishing

Cements
- (for roads, bridges, buildings, dams, and etc.)
- composites : structural

Advanced ceramics
- Structural (cutting tools, and engine components)
- Electrical (capacitors, insulators, circuit packages, integrated piezoelectrics, magnets and superconductors)
- Coatings (engine components, cutting tools)
- Chemical and environmental (filters, membranes, catalysts, and catalyst supports)

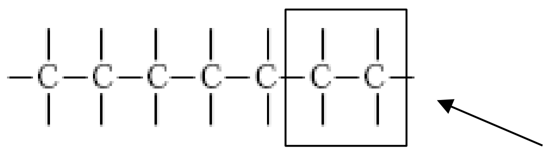
The atoms in ceramic materials are held together by a chemical bond which will be discussed a bit later.

Briefly though, the two most common chemical bonds for ceramic materials are covalent and ionic.

Covalent and ionic bonds are much stronger than in metallic bonds and, generally speaking, this is why ceramics are brittle and metals are ductile.

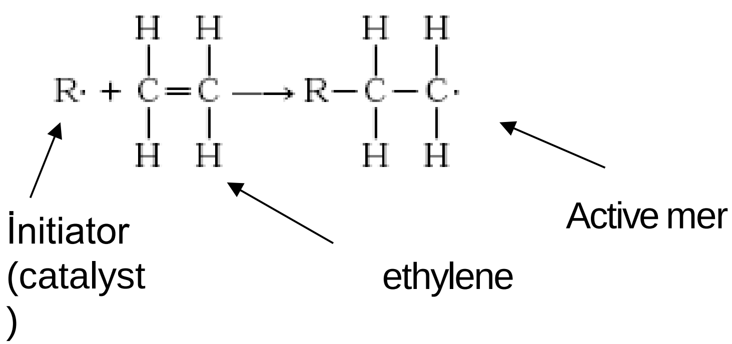
Polymers

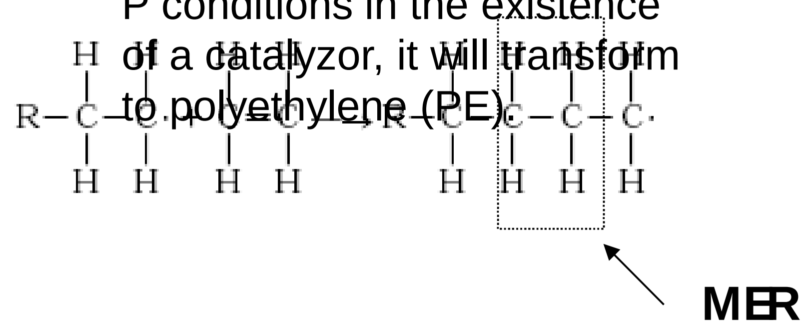
- A polymeric solid can be thought of as a material that contains many chemically bonded parts or units which themselves are bonded together to form a solid. The word polymer literally means "many parts."
- Two industrially important polymeric materials are plastics and elastomers.



MER unit

If, for example, ethylene is subjected to appropriate T an P conditions in the existence of a catalyzor, it will transform to polyethylene (PE).





Polymers have many properties that make them attractive to use in certain conditions. Many polymers:

-are less dense than metals or ceramics,

-resist atmospheric and other forms of corrosion, offer good compatibility with human tissue,

or

-exhibit excellent resistance to the conduction of electrical current.

The polymer plastics can be divided into two classes,
-thermoplastics and thermosetting plastics, depending on how they are structurally and chemically bonded.

The term ‘thermoplastic’ indicates that these materials melt on heating and may be processed by a variety of molding and extrusion techniques.

Alternately, ‘thermosetting’ polymers can not be melted or remelted.

Rubber is a natural occurring polymer.

However, most polymers are created by engineering the combination of hydrogen and carbon atoms and the arrangement of the chains they form.

The polymer molecule is a long chain of covalent-bonded atoms and secondary bonds then hold groups of polymer chains together to form the polymeric material.

Composites

A composite is commonly defined as a combination of two or more distinct materials, each of which retains its own distinctive properties, to create a new material with properties that cannot be achieved by any of the components acting alone.
For example, Fiberglass sheet is a composite since it is made of glass fibers imbedded in a polymer.

Composite materials are said to have two phases. The reinforcing phase is the fibers, sheets, or particles that are embedded in the matrix phase.

The reinforcing material and the matrix material can be metal, ceramic, or polymer.

Typically, reinforcing materials are strong with low densities while the matrix is usually a ductile, or tough, material.

Some of the common classifications of composites are:

- Reinforced plastics
- Metal-matrix composites
- Ceramic-matrix composites
- Sandwich structures
- Concrete

- If the composite is designed and fabricated correctly, it combines the strength of the reinforcement with the toughness of the matrix to

achieve a combination of desirable properties not available in any single conventional material.

-

Questions…

1. What is Material Science and Metallurgy?
2. Differentiate between material science and material engineering?
3. Classify the engineering materials.
4. What are metals and composites? Give 2 properties of each.
5. Differentiate between thermosetting and thermoplastic polymer.

Thank You

Government Polytechnic Nanakpur

DEPARTMENT OF MECHANICAL ENGINEERING

E - NOTES

THERMODYNAMICS-II

HOD/O.I. (Mechanical) : **Sh.SHALANDER MOR**

Faculty Name: Er. Amit Kumar

Semester: 4th Sem

LEARNING OUTCOMES

After undergoing this course, the students will be able to:

- Explain the working of IC engine.
- Diagnose and rectify simple problems in fuel supply and ignition system.
- Explain the functioning of different components of fuel supply of diesel engine.
- Explain the working of lubrication and cooling system in IC engine.
- Assist in testing an IC engine.
- Explain the functioning of steam turbine, gas turbine and jet propulsion.

References:

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Engineering Fundamentals of the Internal Combustion Engine
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An Introduction to Combustion : Concepts and Applications w/IBM3.5' D
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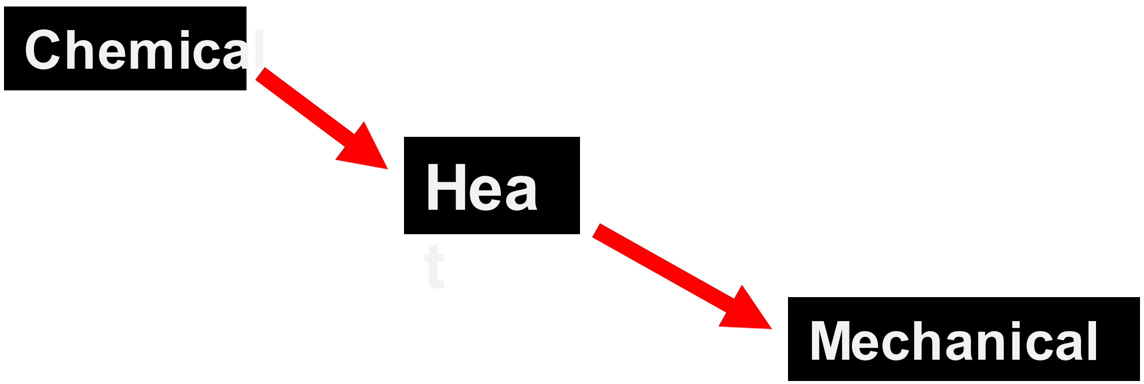
INTRODUCTION

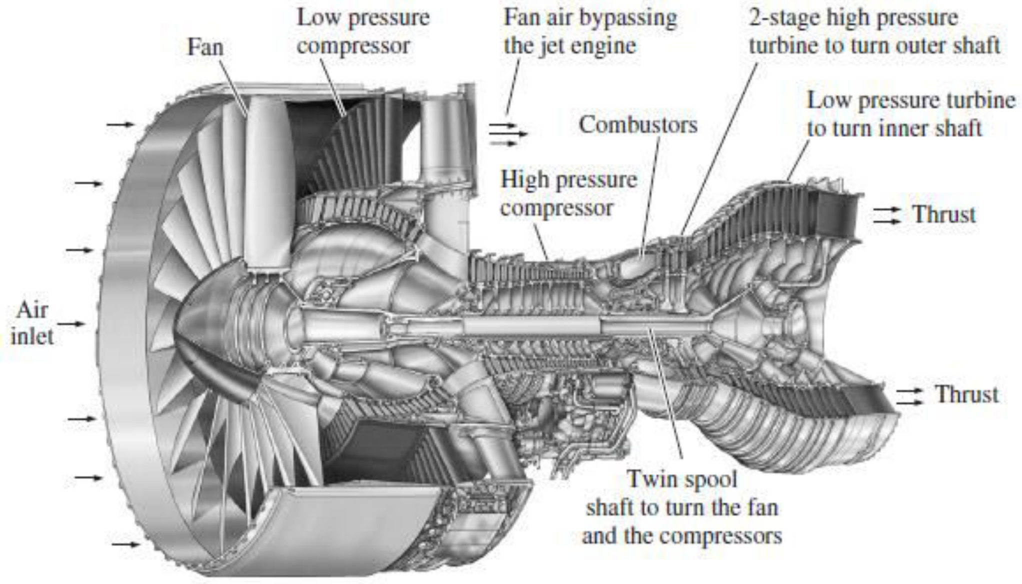
The internal combustion engine is a heat engine that converts chemical energy in a fuel into mechanical energy



This thermal energy raises the temperature and pressure of the gases within the engine, and the high-pressure gas then expands against the mechanical mechanisms of the engine. This expansion is converted by the mechanical linkages of the engine to a rotating crankshaft, which is the output of the engine.

Internal combustion engines are **reciprocating engines** having pistons that reciprocate back and forth in cylinders internally within the engine.

Engine types not covered by this course include steam engines and gas turbine engines, which are better classified as **external combustion engines (i.e., combustion takes place outside the** mechanical engine



ENGINE CLASSIFICATIONS

Internal combustion engines can be classified in a number of different ways:

1. Types of Ignition

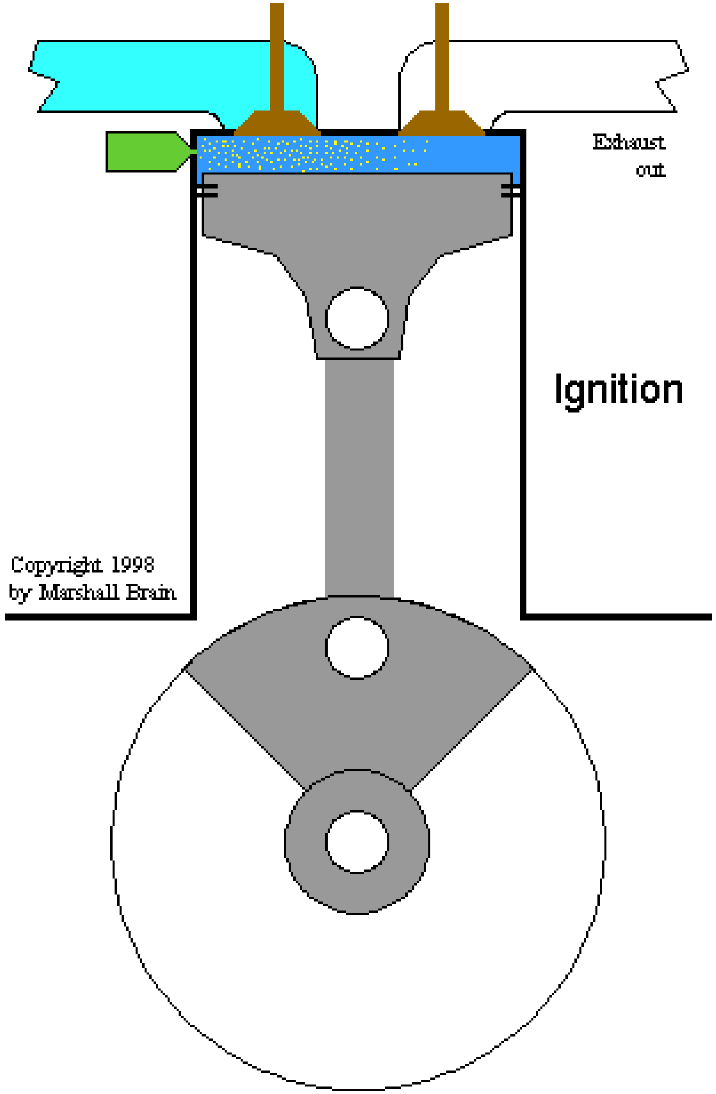
(a) Spark Ignition (SI). An SI engine starts the combustion process in each cycle by use of a spark plug. The spark plug gives a high-voltage electrical discharge between two electrodes which ignites the air-fuel mixture in the combustion chamber surrounding the plug.

(b) Compression Ignition (CI). The combustion process in a CI engine starts when the air-fuel mixture self-ignites due to high temperature in the combustion chamber caused by high compression.

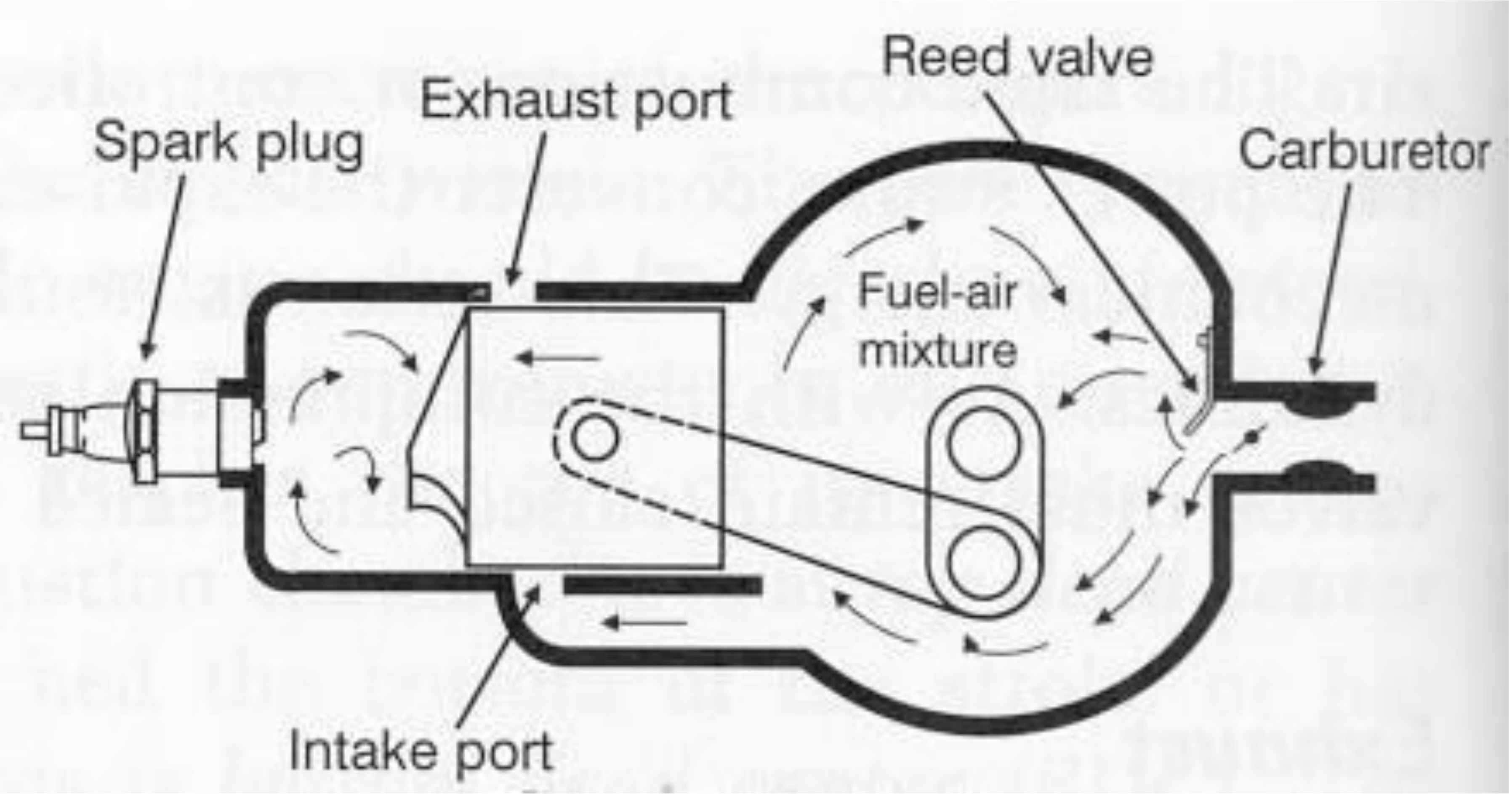
2. Engine Cycle

(a) Four-Stroke Cycle. A four-stroke cycle experiences four piston movements over two engine revolutions for each cycle.
(b) Two-Stroke Cycle. A two-stroke cycle has two piston movements over one revolution for each cycle.

Four-Stroke Cycle C.I. Engine



Two-Stroke Cycle Engines

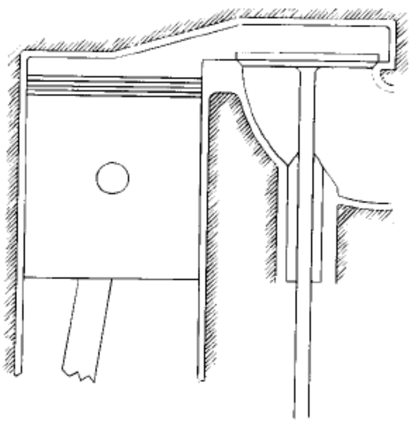


Comparison of Two-Stroke vs. Four-Stroke Cycle Engines

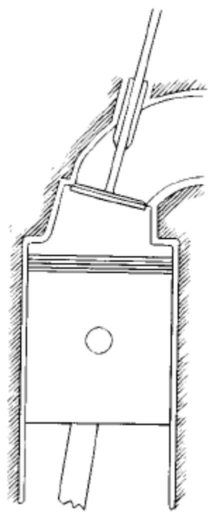
Two-Stroke Cycle Engines	Four-Stroke Cycle Engines
Lighter weight	Heavier weight
Operates in many positions	Operates in limited positions
Higher power to weight ratio	Lower power to weight ratio
Engine oil usually mixed with fuel	Engine oil in a reservoir
Louder operation	Quieter operation
Higher engine speeds	Slower engine speeds
More vibration	Smoother operation
Rough idling operation	Smoother Idling operation

3. Valve Location

(a) Valves in head (overhead valve), also called I Head engine.
(b) Valves in block (flat head), also called L Head engine. Some historic engines with valves in block had the intake valve on one side of the cylinder and the exhaust valve on the other side. These were called **T Head engines.**



(a)



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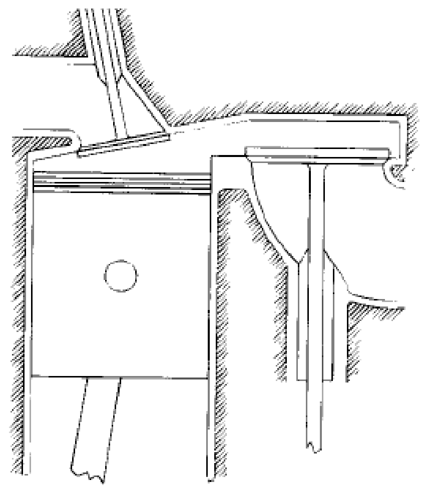

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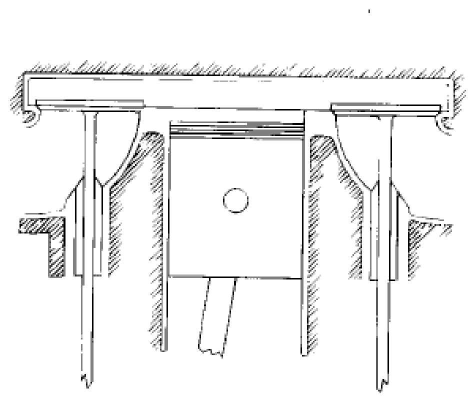


(d)

L Head engine **I Head engine** **F Head engine** **T Head engine**

4. Basic Design

(a) Reciprocating. Engine has one or more cylinders in which pistons reciprocate back and forth. The combustion chamber is located in the closed end of each cylinder. Power is delivered to a rotating output crankshaft by mechanical linkage with the pistons.

(b) Rotary. Engine is made of a block (stator) built around a large non-concentric rotor and crankshaft. The combustion chambers are built into the non-rotating block.

5. Position and Number of Cylinders

(a) Single Cylinder.

(b) In-Line.

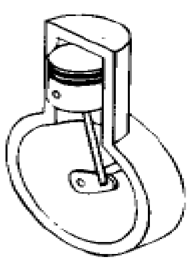
(c) V Engine.

(d) Opposed Cylinder Engine.

(e) W Engine.

(f) Opposed Piston Engine.

(g) Radial Engine.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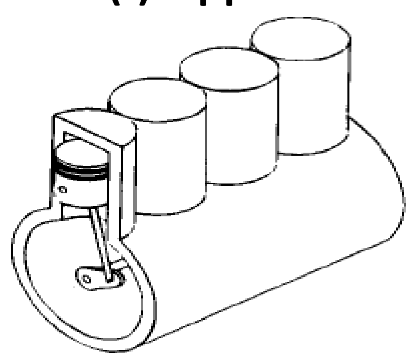
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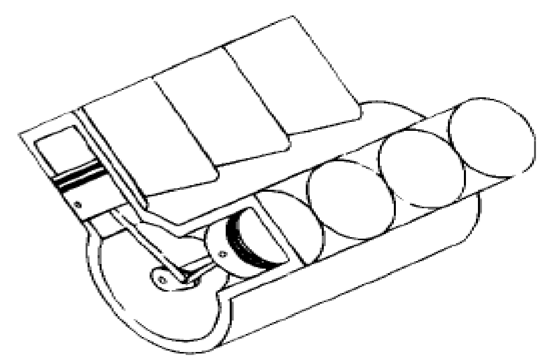
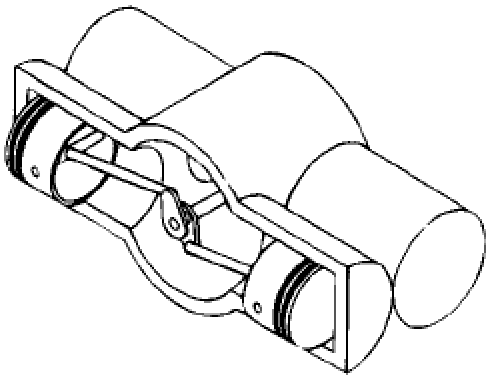

(c)

Internal Combustion Engine



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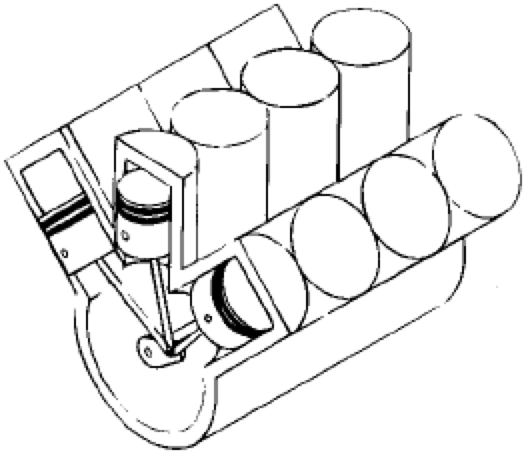

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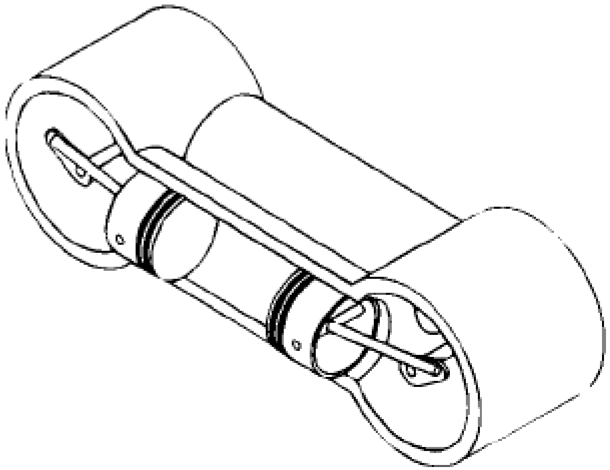
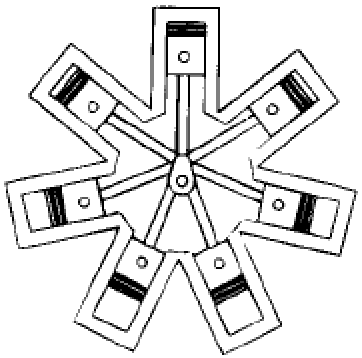


(f)



(g)

6. Air Intake Process

(a) **Naturally Aspirated**. No intake air pressure boost system.
(b) **Supercharged**. Intake air pressure increased with the compressor driven off of the engine crankshaft (Fig. 1-8).
(c) **Turbocharged**. Intake air pressure increased with the turbine-compressor driven by the engine exhaust gases (Fig. 1-9).
(d) **Crankcase Compressed**. Two-stroke cycle engine which uses the crankcase as the intake air compressor. Limited development work has also been done on design and construction of four-stroke cycle engines with crankcase compression.

7. Method of Fuel Input for SI Engines

(a) Carbureted.
(b) Multipoint Port Fuel Injection. One or more injectors at each cylinder intake.
(c) Throttle Body Fuel Injection. Injectors upstream in intake manifold.

8. Fuel Used

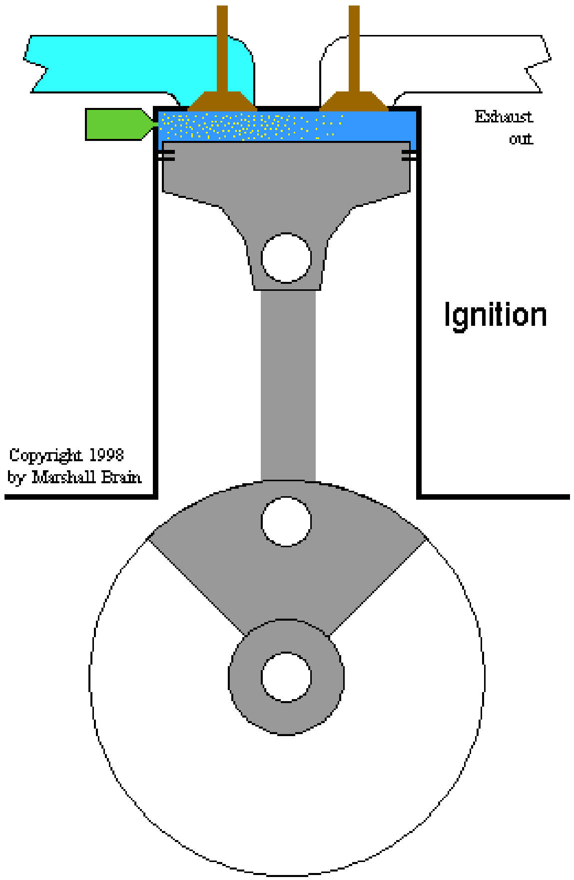
(a) Gasoline.
(b) Diesel Oil or Fuel Oil.
(c) Gas, Natural Gas, Methane.
(d) LPG.
(e) Alcohol-Ethyl, Methyl.
(f) Dual Fuel. There are a number of engines that use a combination of two or more fuels. Some, usually large, CI engines use a combination of methane and diesel fuel. These are attractive in developing third-world countries because of the high cost of diesel fuel. Combined gasoline-alcohol fuels are becoming more common as an alternative to straight gasoline automobile engine fuel.
(g) Gasohol. Common fuel consisting of 90% gasoline and 10% alcohol.

9. Application

(a) Automobile, Truck, Bus.
(b) Locomotive.
(c) Stationary.
(d) Marine.
(e) Aircraft.
(f) Small Portable, Chain Saw, Model Airplane.

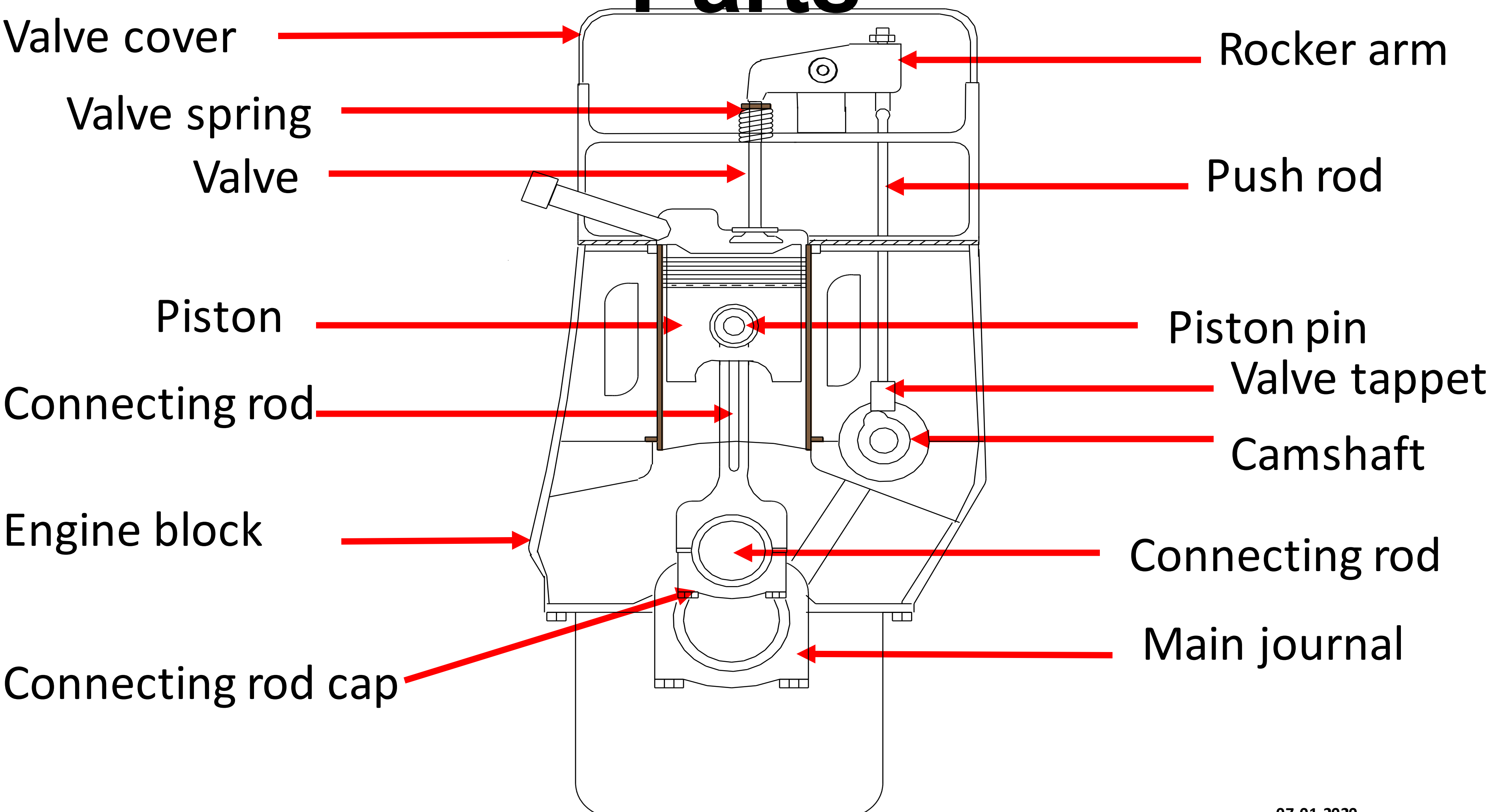
1O. Type of Cooling

(a) Air Cooled.
(b) Liquid Cooled, Water Cooled.



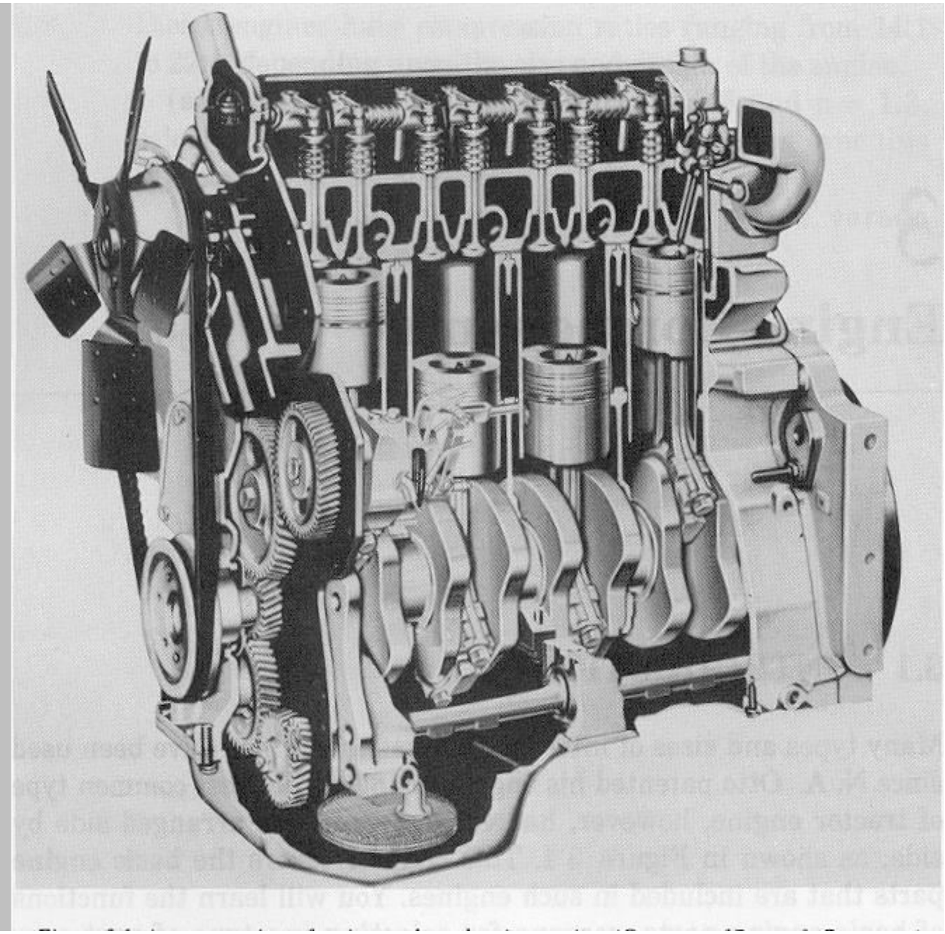
ENGINE COMPONENTS

Name of Engine Parts



ENGINE COMPONENTS

Cylinder Block



"Backbone" of the engine.

- Supports / aligns most other components.
- Part of basic tractor frame.

Contains:

- Cylinders
- Coolant passages
- Oil passages
- Bearings

One-piece, gray cast iron

Cylinders

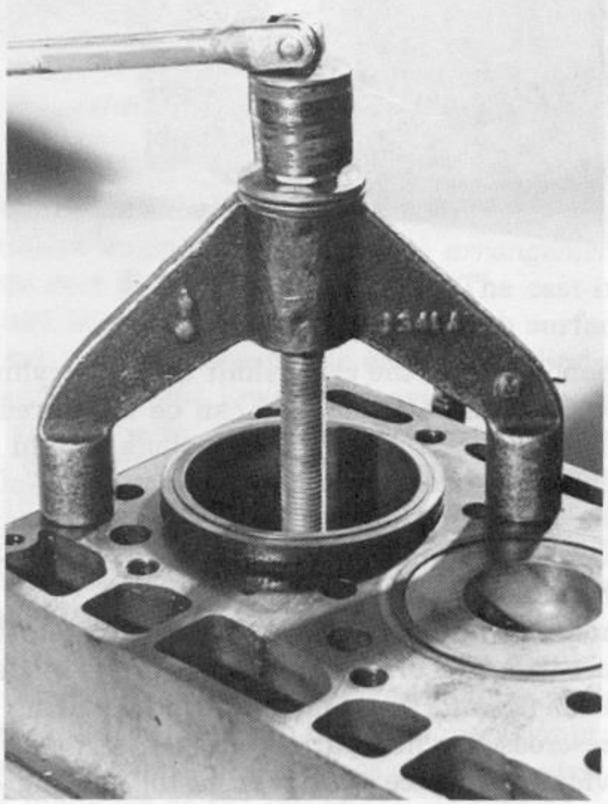
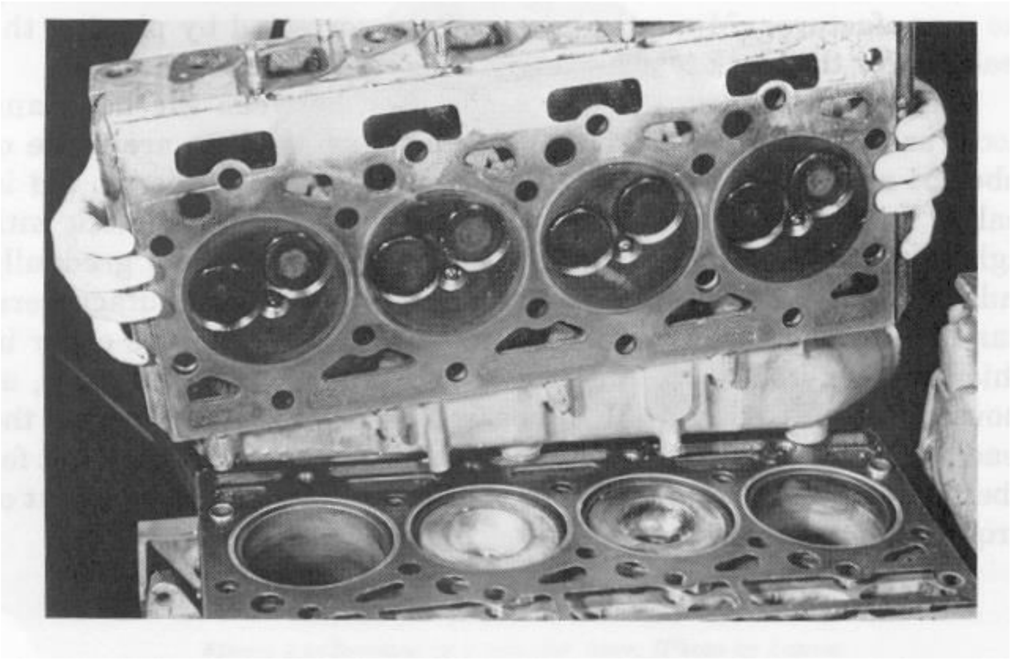


Figure 3.4–Removal of a cylinder liner. (Photo by Laurie Goering.)

- **Cylindrical holes in which the pistons reciprocate.**
- **May be:**
  - **Enblock**
  - **Liners**
    - **Wet liners**
    - **Dry liners**
- **Cylinder bore – diameter of cylinder**

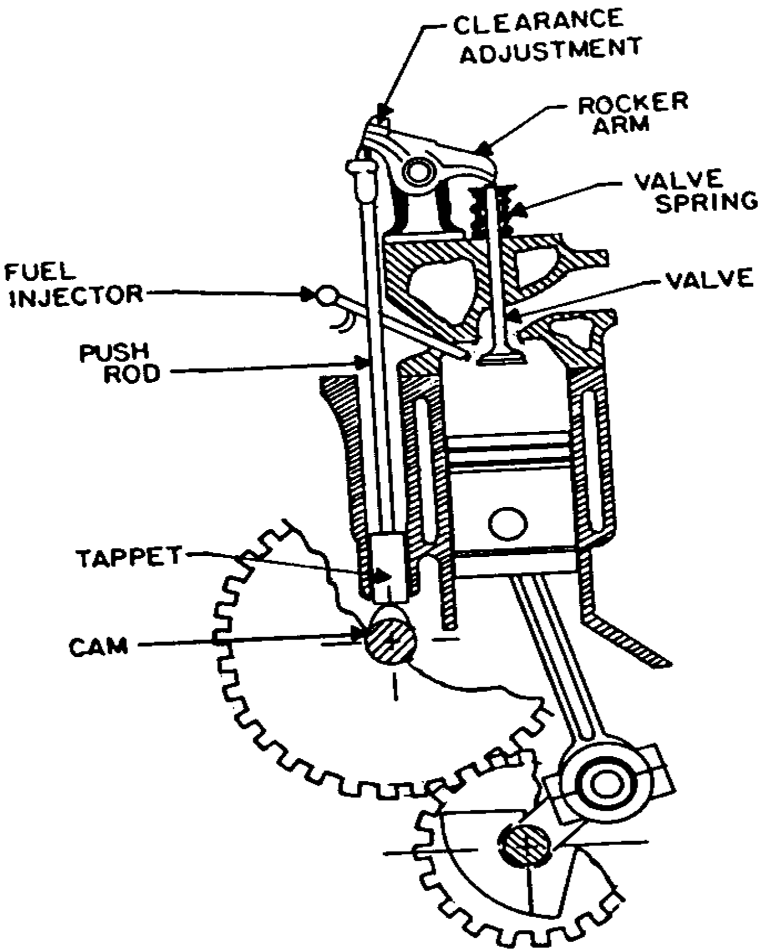
Cylinder Head



Seals the "top-end" of the combustion chamber.
Contains the valves and the intake and exhaust "ports".
Head bolts and head gasket ensure air-tight seal of the combustion chamber.
Contains oil and coolant passages.

One-piece castings of iron alloy.

Valve Train



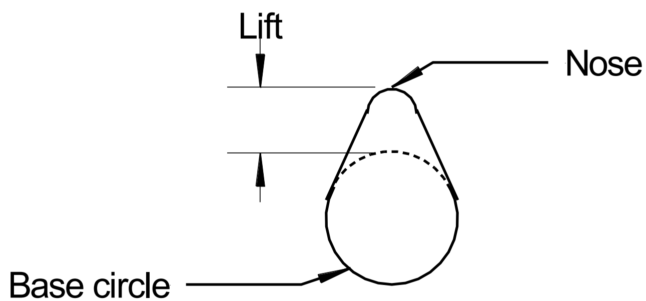
- Controls flow into and out of the combustion chamber.
  - **Time and Duration**
- Tractor engines use “Overhead Valve (OHV)” configuration.
- Components
  - **Camshaft**
  - **Valve tappets**
  - **Push rods**
  - **Rocker arm**
  - **Valves**
  - **Valve springs**
  - **Valve rotators**
  - **Valve seats**

Camshaft

Open the intake and exhaust valves at correct time and for correct duration.

Driven by gear (or chain) from the crankshaft.

2:1 crankshaft to camshaft gear ratio.

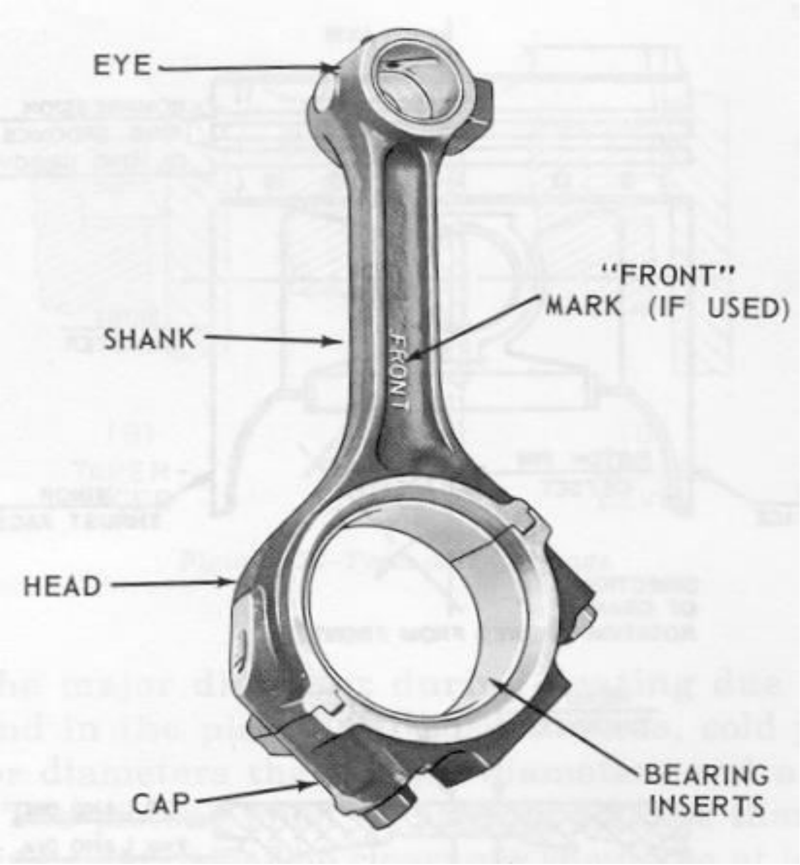


Cam Profile

Piston and Rings

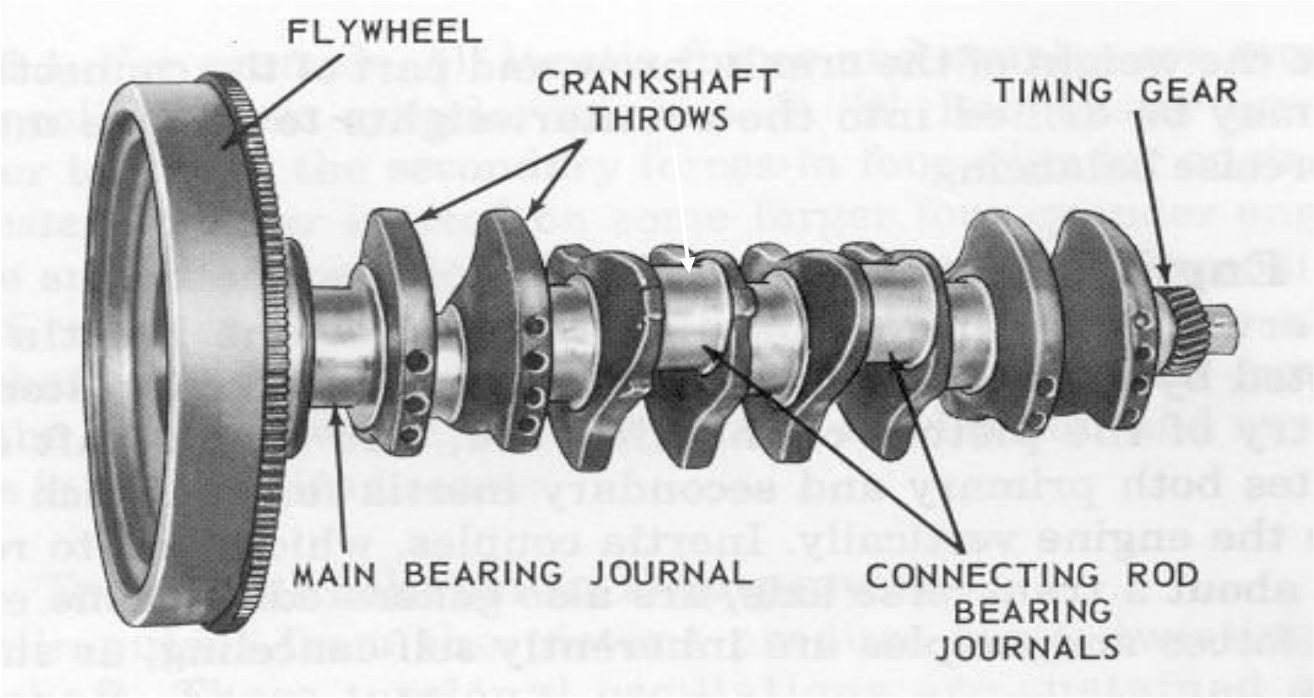
- Piston
  - Forms the "moveable bottom' of the combustion chamber.
    - Iron alloy or aluminum
- Rings
  - Compression
  - Oil-control
    - Cast iron
- Piston pin

Connecting rod



- Connects the piston to the crankshaft
- Converts reciprocating piston motion to rotary motion at the crankshaft.
- Nomenclature
- Drop-forged steel

Crankshaft



Works with connecting rod to change reciprocating to rotary motion.

Transmits mechanical energy from the engine.

Made of heat-treated steel alloys.

TERMINOLOGY AND ABBREVIATIONS

The following terms and abbreviations are commonly used in engine technology

- **Internal Combustion (IC)**
- **Spark Ignition (SI)** An engine in which the combustion process in each cycle is started by use of a spark plug.
- **Compression Ignition (CI)** An engine in which the combustion process starts when the air-fuel mixture self-ignites due to high temperature in the combustion chamber caused by high compression.
- **Top-Dead-Center (TDC)** Position of the piston when it stops at the furthest point away from the crankshaft.
- **Bottom-Dead-Center (BDC)** Position of the piston when it stops at the point closest to the crankshaft.
- **Direct Injection (DI)** Fuel injection into the main combustion chamber of an engine.
- **Indirect Injection (IDI)** Fuel injection into the secondary chamber of an engine with a divided combustion chamber.
- **Bore** Diameter of the cylinder or diameter of the piston face, which is the same minus a very small clearance.

Internal Combustion Engine

- **Stroke** Movement distance of the piston from one extreme position to the other: TDC to BDC or BDC to TDC.
- **Clearance Volume** Minimum volume in the combustion chamber with piston at TDC.
- **Displacement or Displacement Volume** Volume displaced by the piston as it travels through one stroke.
- **Smart Engine** Engine with computer controls that regulate operating characteristics such as air-fuel ratio, ignition timing, valve timing, exhaust control, intake tuning, etc.
- **Air-Fuel Ratio (AF)** Ratio of mass of air to mass of fuel input into engine.
- **Fuel-Air Ratio (FA)** Ratio of mass of fuel to mass of air input into engine.
- **Ignition Delay (ID)** Time interval between ignition initiation and the actual start of Combustion

BASIC ENGINE CYCLES

Most internal combustion engines, both spark ignition and compression ignition, operate on either a four-stroke cycle or a two-stroke cycle.

A- Four-Stroke SI Engine Cycle

1. First Stroke: Intake Stroke or Induction *The piston travels from TDC to* BDC with the intake valve open and exhaust valve closed. This creates an increasing volume in the combustion chamber, which in turn creates a vacuum.

2. Second Stroke: Compression Stroke *When the piston reaches BDC, the* intake valve closes and the piston travels back to TDC with all valves closed. This compresses the air-fuel mixture, raising both the pressure and temperature in the cylinder.

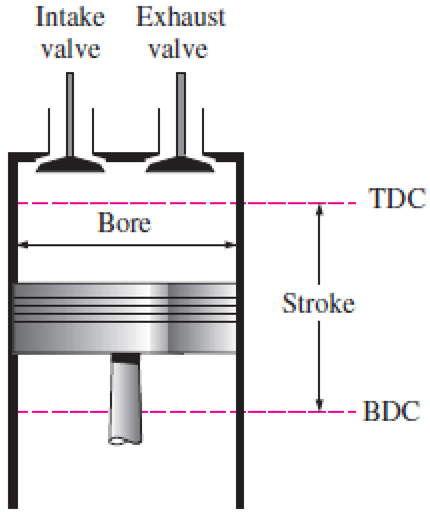
3. Combustion: *Combustion of the air-fuel mixture occurs in a very short but* finite length of time with the piston near TDC (i.e., nearly constant-volume combustion).

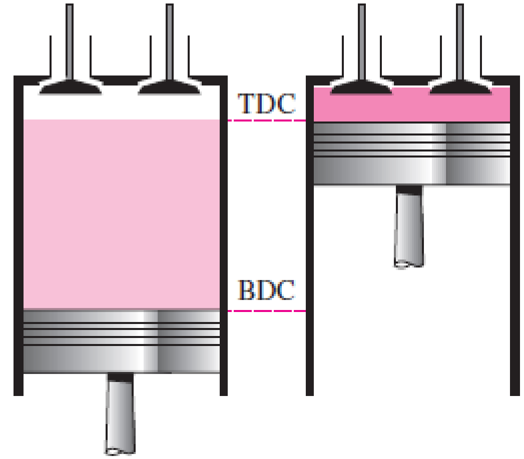
4. Third Stroke: Expansion Stroke or Power Stroke *With all valves closed,* the high pressure created by the combustion process pushes the piston away from TDC. This is the stroke which produces the work output of the engine cycle.

5. Exhaust Blowdown *Late in the power stroke, the exhaust valve is opened* and exhaust blow down occurs.

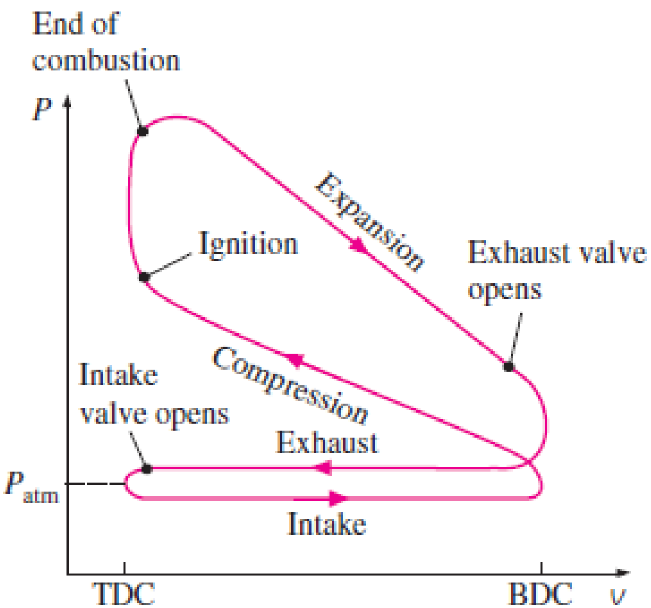
6. Fourth Stroke: Exhaust Stroke *By the time the piston reaches BDC,* exhaust blowdown is complete, but the cylinder is still full of exhaust gases at approximately atmospheric pressure.

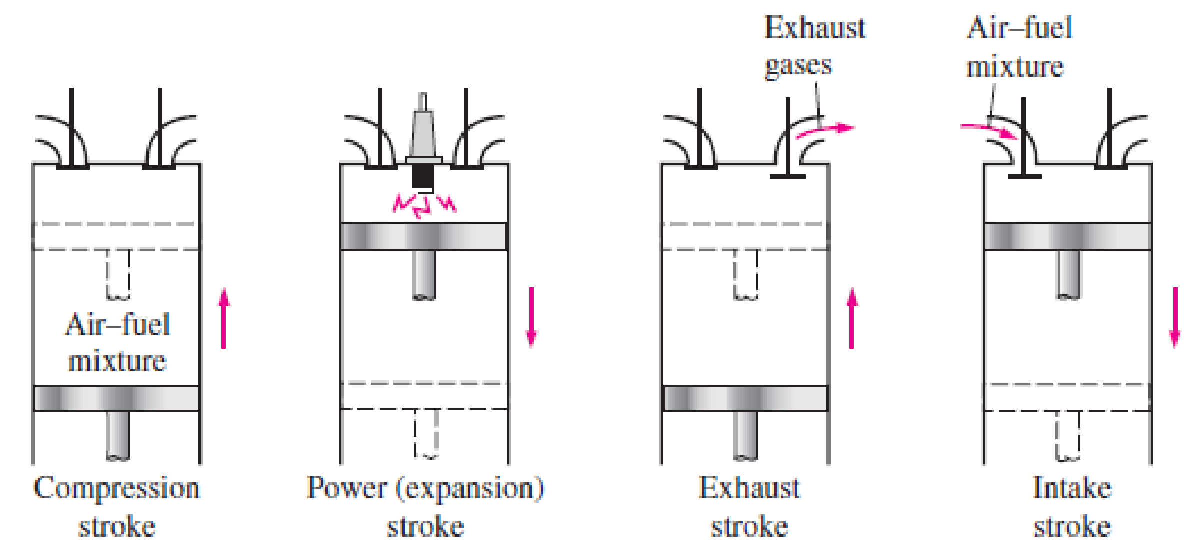
Internal Combustion Engine





(*a*) Displacement volume (*b*) Clearance volume





(*a*) Actual four-stroke spark-ignition engine

B- Four-Stroke CI Engine Cycle

1. First Stroke: Intake Stroke *The same as the intake stroke in an SI engine* with one major difference: no fuel is added to the incoming air.

2. Second Stroke: Compression Stroke *The same as in an SI engine except* that only air is compressed and compression is to higher pressures and temperature.

3. Combustion *Combustion is fully developed by TDC and continues at* about constant pressure until fuel injection is complete and the piston has started towards BDC.

4. Third Stroke: Power Stroke *The power stroke continues as combustion* ends and the piston travels towards BDC.

5. Exhaust Blowdown *Same as with an SI engine.*

6. Fourth Stroke: Exhaust Stroke *Same as with an SI engine.*

Internal Combustion Engine

C- Two-Stroke SI Engine Cycle

1. **Combustion** *With the piston at TDC combustion occurs very quickly, raising* the temperature and pressure to peak values, almost at constant volume.

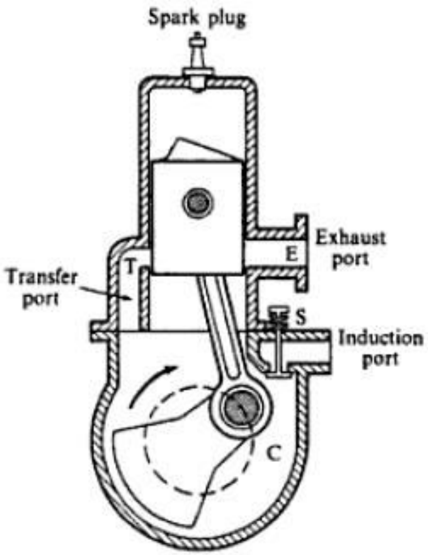
2. *First Stroke: Expansion Stroke or Power Stroke* *Very high pressure created* by the combustion process forces the piston down in the power stroke. The expanding volume of the combustion chamber causes pressure and temperature to decrease as the piston travels towards BDC.

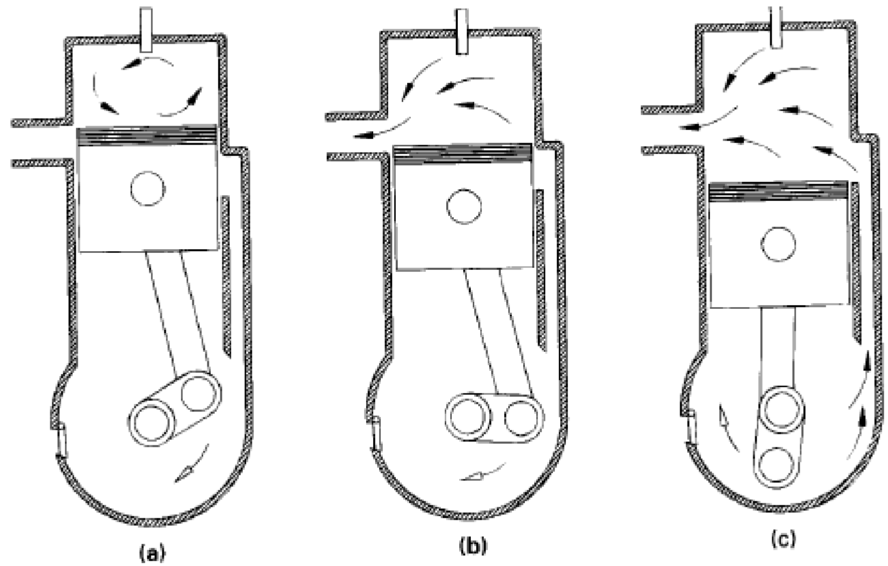
3. Exhaust Blowdown *At about 75° bBDC, the exhaust valve opens and* blowdown occurs. The exhaust valve may be a poppet valve in the cylinder head, or it may be a slot in the side of the cylinder which is uncovered as the piston approaches BDC. After blowdown the cylinder remains filled with exhaust gas at
lower pressure.

4. Intake and Scavenging *When blowdown is nearly complete, at about 50°* bBDC, the intake slot on the side of the cylinder is uncovered and intake air-fuel enters under pressure.

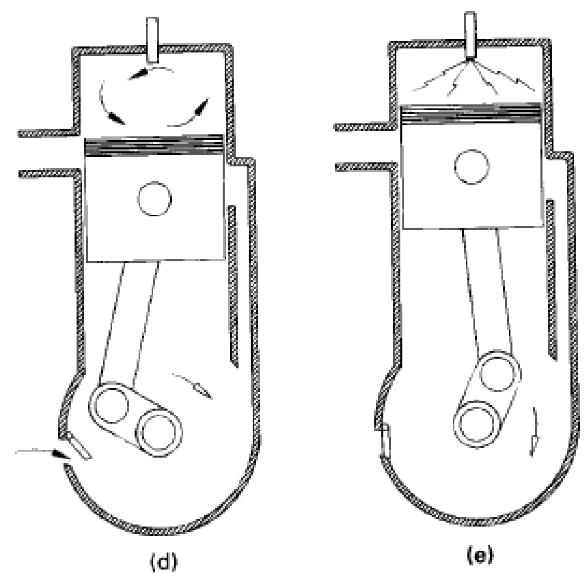
5. Second Stroke: Compression Stroke *With all valves (or ports) closed, the* piston travels towards TDC and compresses the air-fuel mixture to a higher pressure and temperature. Near the end of the compression stroke, the spark plug is fired; by the time the piston gets to IDC, combustion occurs and the next engine cycle begins.

Internal Combustion Engine





Two-stroke SI engine operating cycle with crankcase compression. **(a)** Power or expansion stroke. High cylinder pressure pushes piston from TDC towards BDC with all ports closed. Air in crankcase is compressed by downward motion of piston. **(b)** Exhaust blowdown when exhaust port opens near end of power stroke. **(c)** Cylinder scavenging when intake port opens and airfuel is forced into cylinder under pressure. Intake mixture pushes some of the remaining exhaust out the open exhaust port. Scavenging lasts until piston passes BDC and closes intake and exhaust ports. **(d)** Compression stroke. Piston moves from BDC to TDC with all ports closed. Intake air fills crankcase. Spark ignition occurs near end of compression stroke. **(e)** Combustion at almost constant volume near TDC.

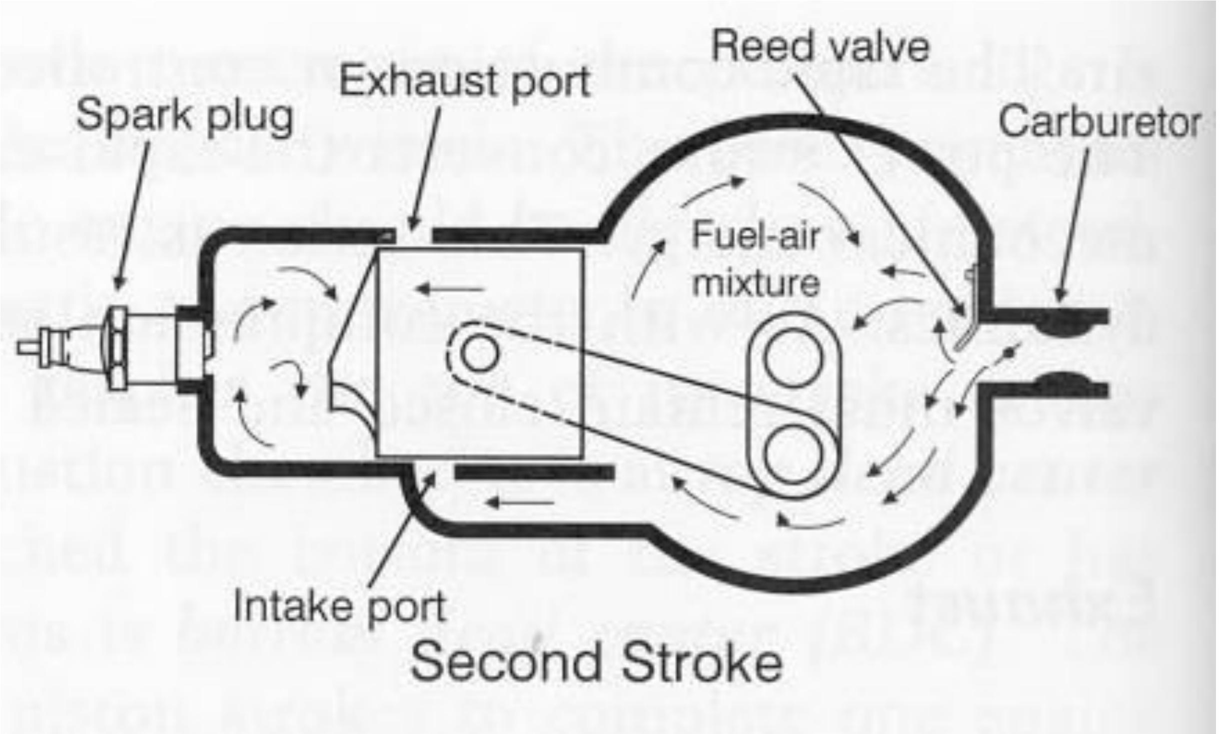


D- Two-Stroke CI Engine Cycle

The two-stroke cycle for a CI engine is similar to that of the SI engine, except for two changes.

1- No fuel is added to the incoming air, so that compression is done on air only.

2- Instead of a spark plug, a fuel injector is located in the cylinder. Near the end of the compression stroke, fuel is injected into the hot compressed air and combustion is initiated by self-ignition.



ENGINE EMISSIONS AND AIR POLLUTION

The exhaust of automobiles is one of the major contributors to the world's air pollution problem. Recent research and development has made major reductions in engine emissions, but a growing population and a greater number of automobiles means that the problem will exist for many years to

Four major emissions produced by internal combustion engines are hydrocarbons (He), carbon monoxide (CO), oxides of nitrogen (NOx), and solid particulates.

1- Hydrocarbons are fuel molecules which did not get burned and smaller non-equilibrium particles of partially burned fuel.

2- Carbon monoxide occurs when not enough oxygen is present to fully react all carbon to CO_2 or when incomplete air-fuel mixing occurs due to the very short engine cycle time.

3- Oxides of nitrogen are created in an engine when high combustion temperatures cause some normally stable N_2 to dissociate into monatomic nitrogen N, which then combines with reacting oxygen.

4- Solid particulates are formed in compression ignition engines and are seen as black smoke in the exhaust of these engines. Other emissions found in the exhaust of engines include aldehydes, sulfur, lead, and phosphorus.

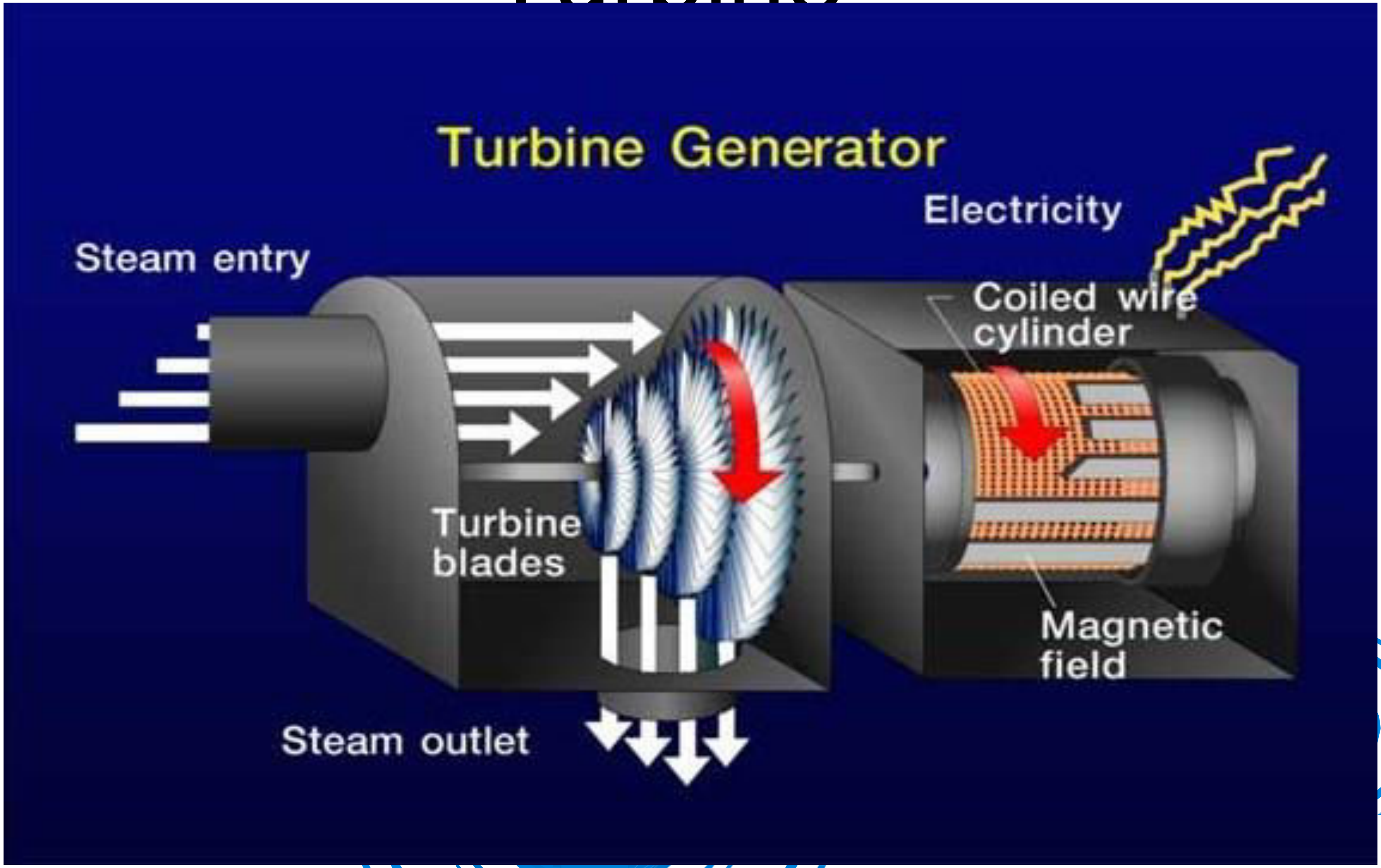
STEAM TURBINE

What is the Turbine?

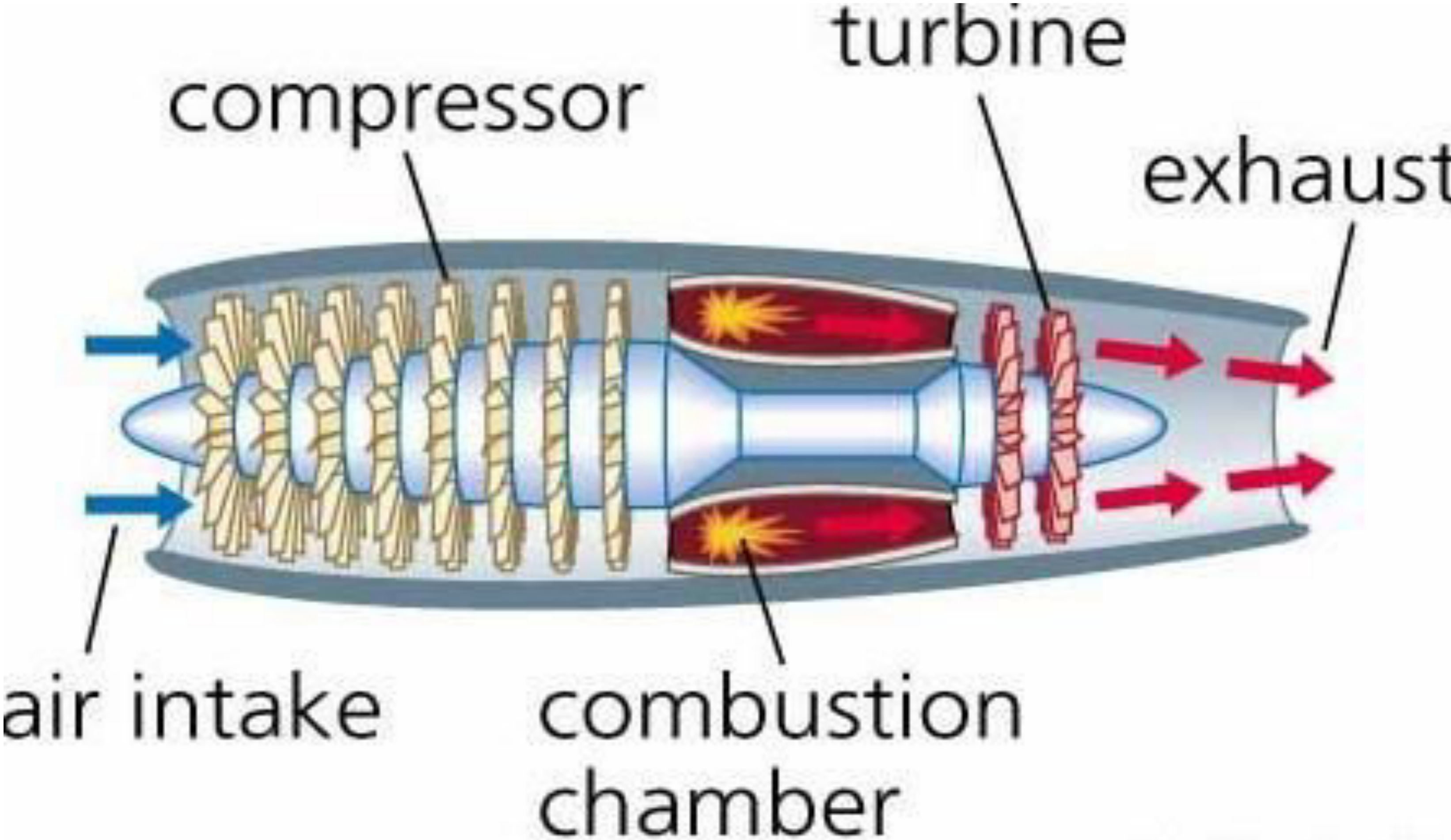
TURBINE is a power machine to drive working machine such as compressor, pump, electrical generator.

- Steam Turbine
- Gas Turbine

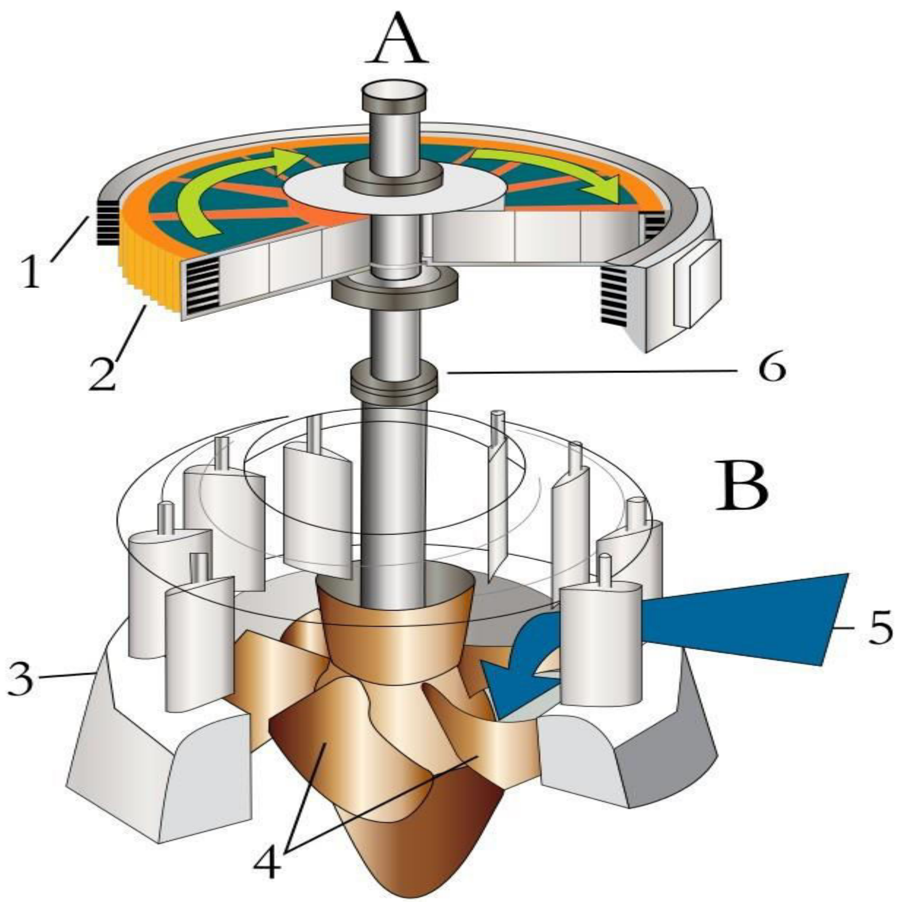
Steam Turbine

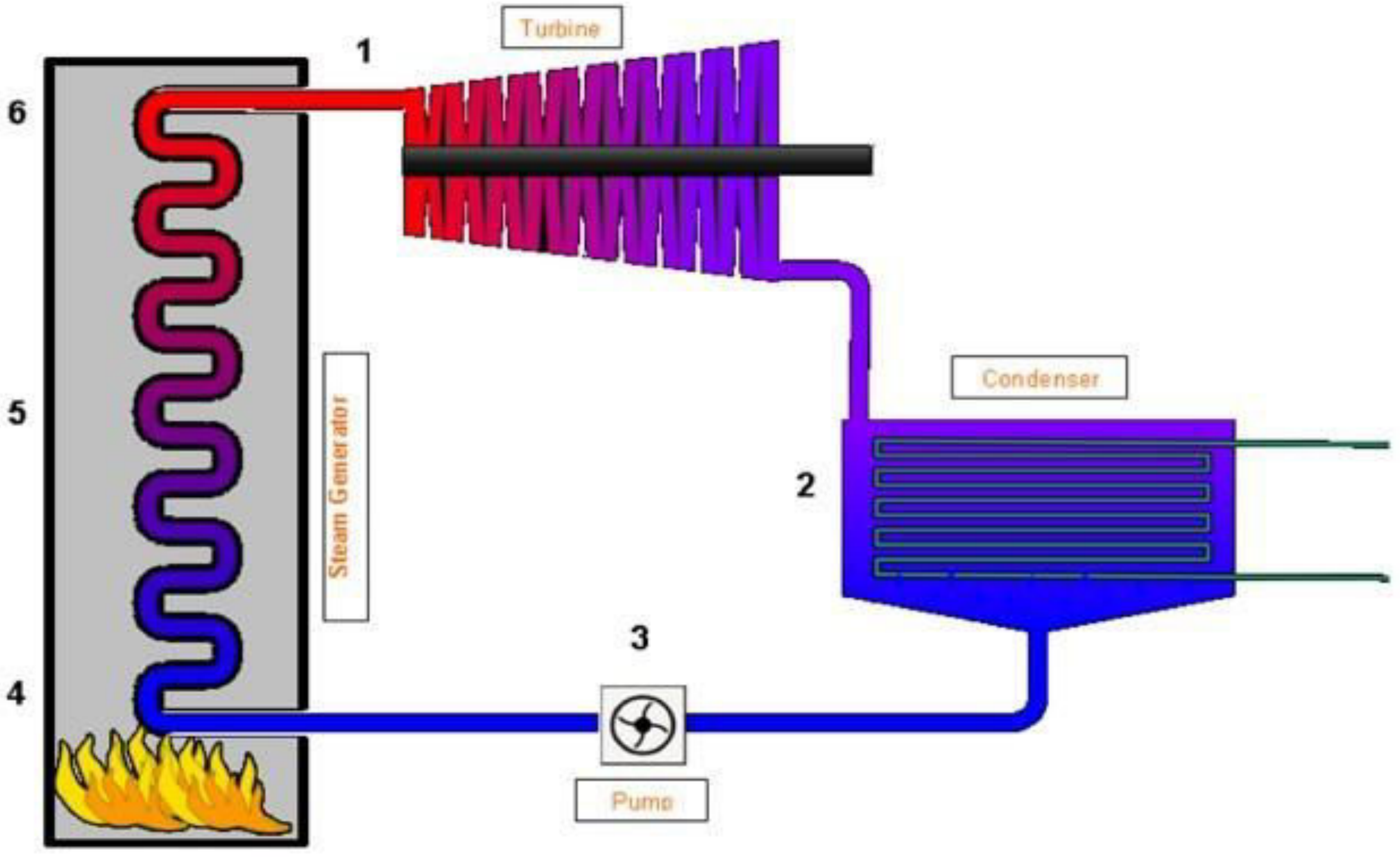


Gas Turbine


turbine
compressor
exhaust
air intake
combustion
chamber

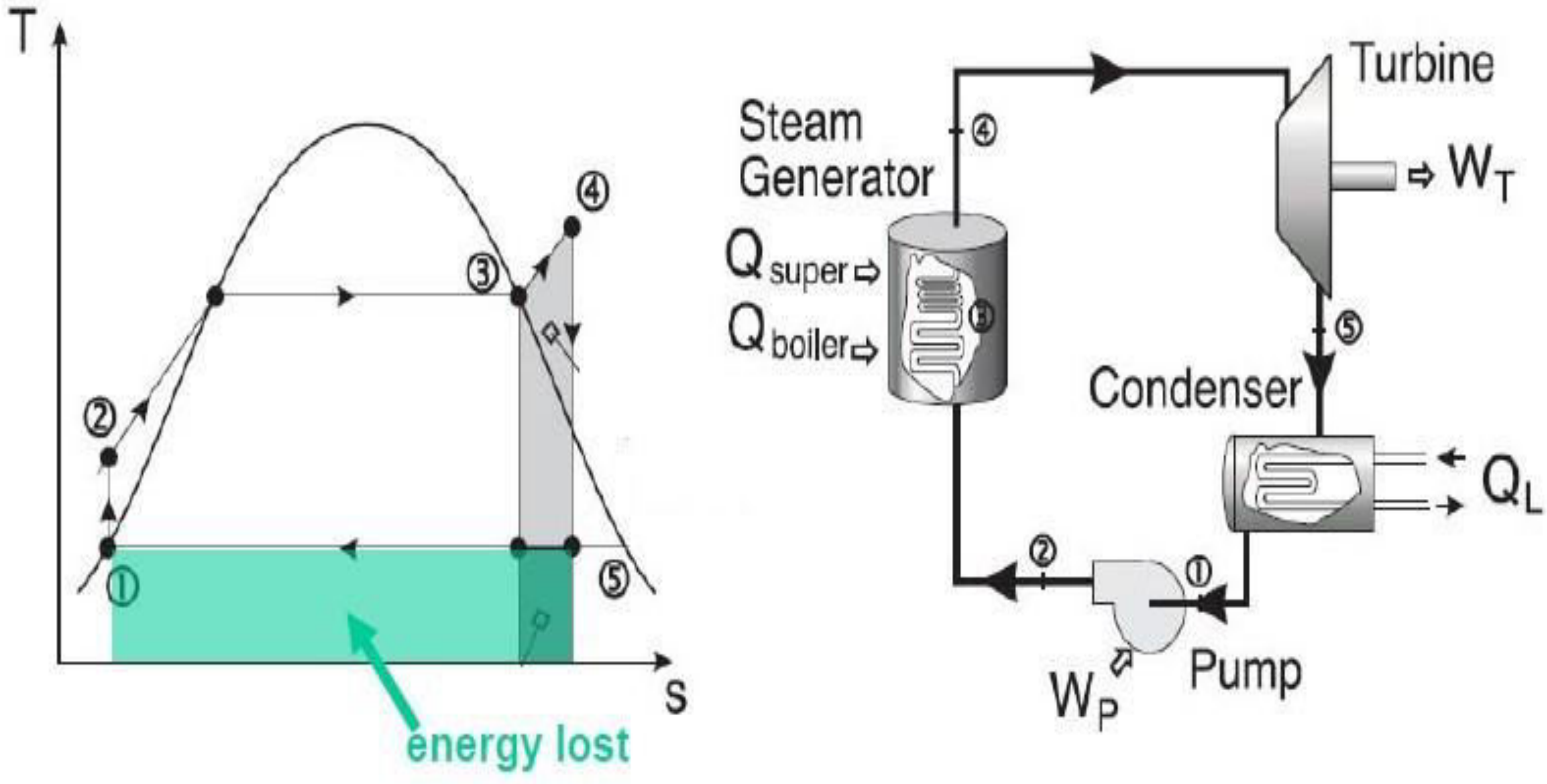
Water Turbine



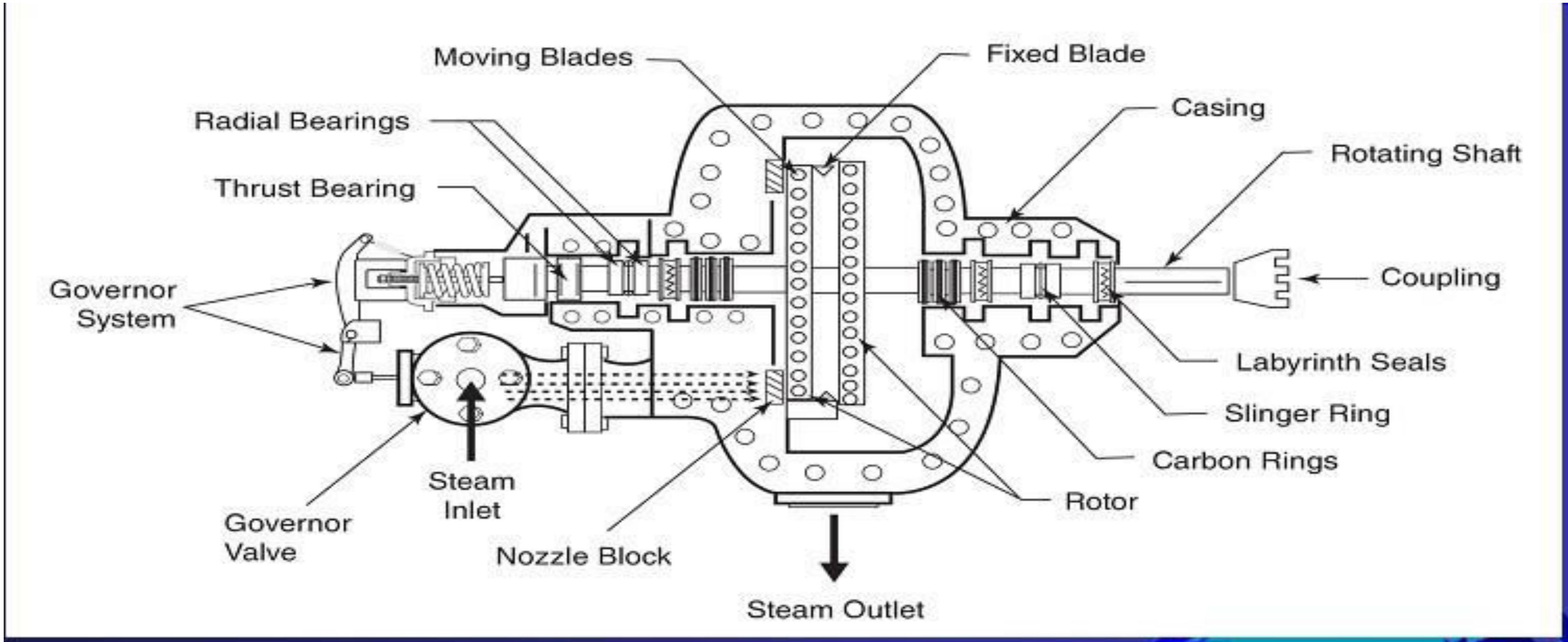


Turbine
1
6
5
4
Steam Generator
Condenser
2
3
Pump

Rankine Cycle



Parts and equipment



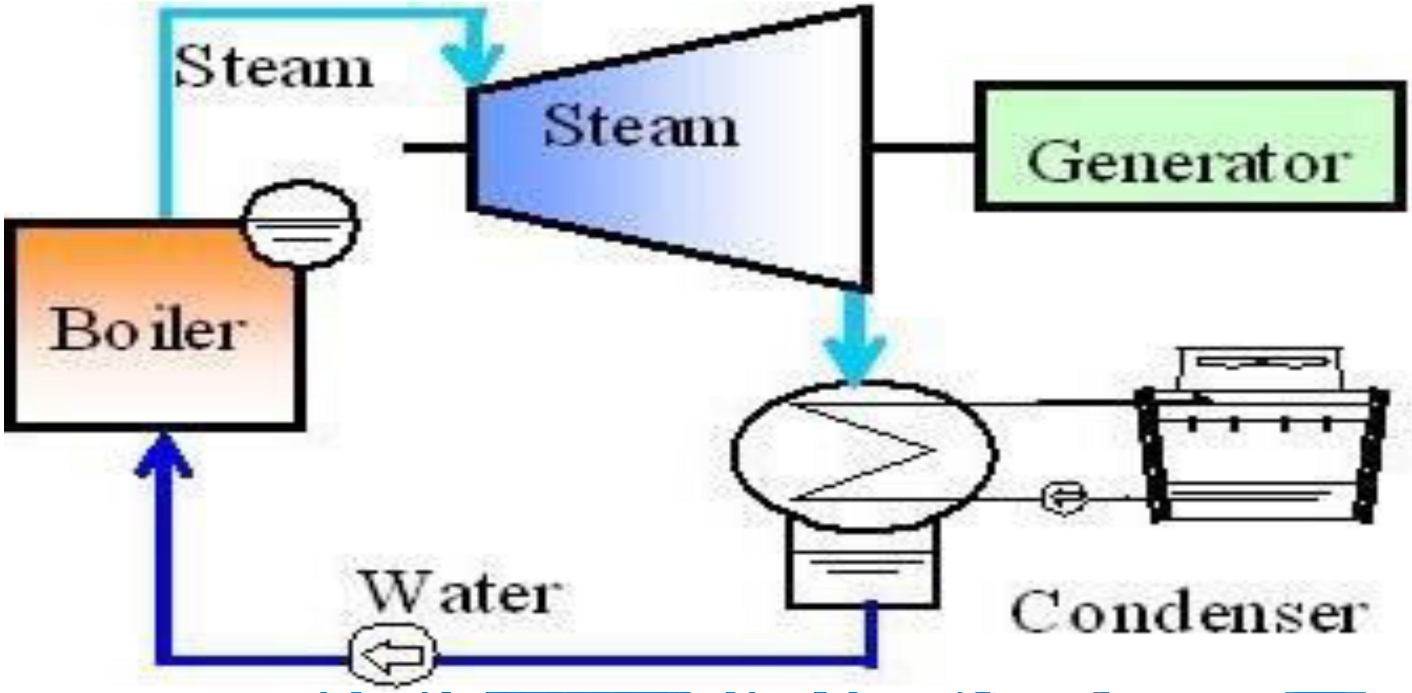
- Rotor
- Fixed Parts
- Fixed Blades
- Casing
- Steam Chest
- Nozzle
- Bearings
- Seals
- Governing Mechanism
- Lubrication System
- Other parts

Steam turbine can be classified as the following:

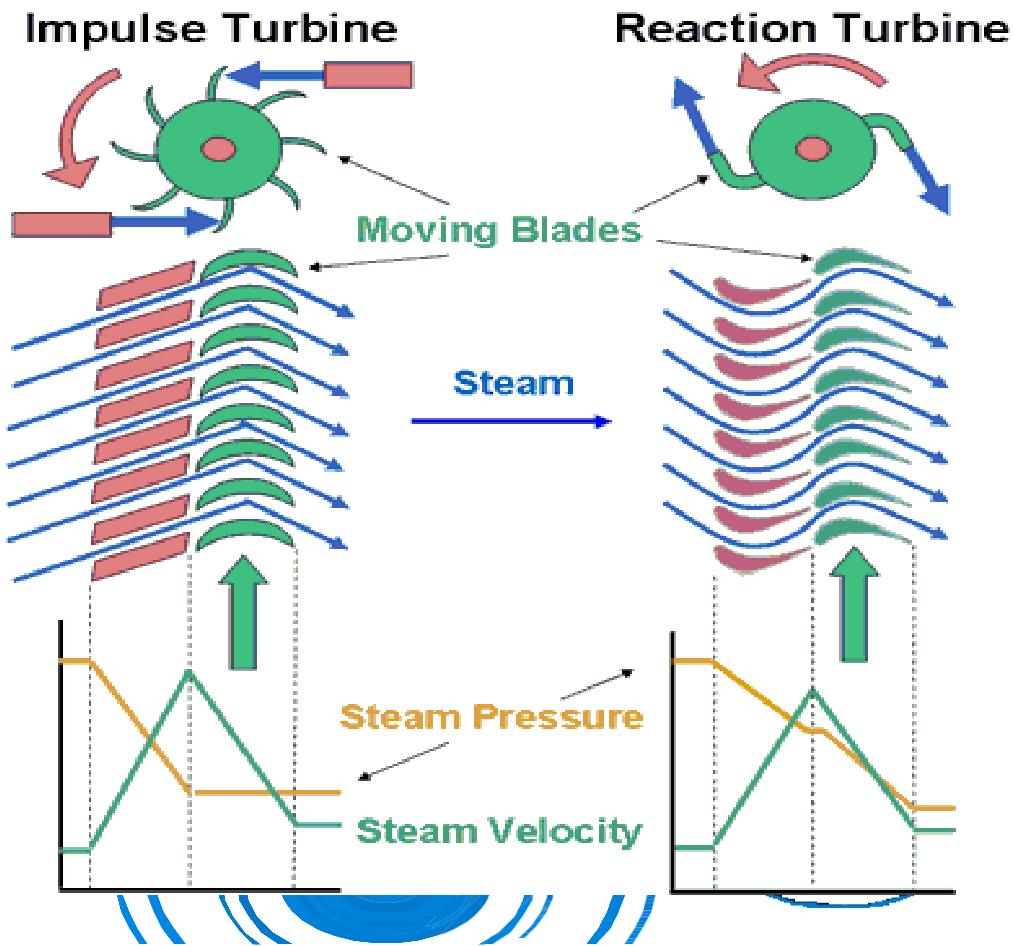
- ***By steam supply and exhaust conditions:***
  - Back pressure Turbine or none condensing turbine.
  - Condensing Turbine.
  - Extraction Steam Turbine.
  - Induction Steam Turbine
  - Reheat Steam Turbine
- ***By Blades and Stages design:***
  - Impulse Turbine
  - Reaction Turbine.

Condensing Steam Turbine

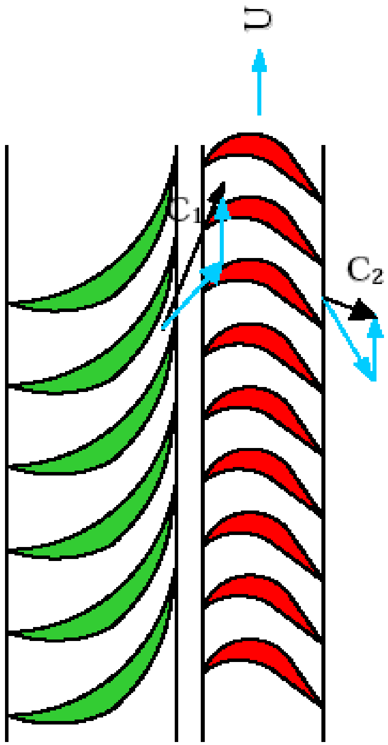
- Condensing turbines are most commonly found in electrical power plants. These turbines exhaust steam from a boiler in a partially condensed state, typically of a quality near 90%, at a pre

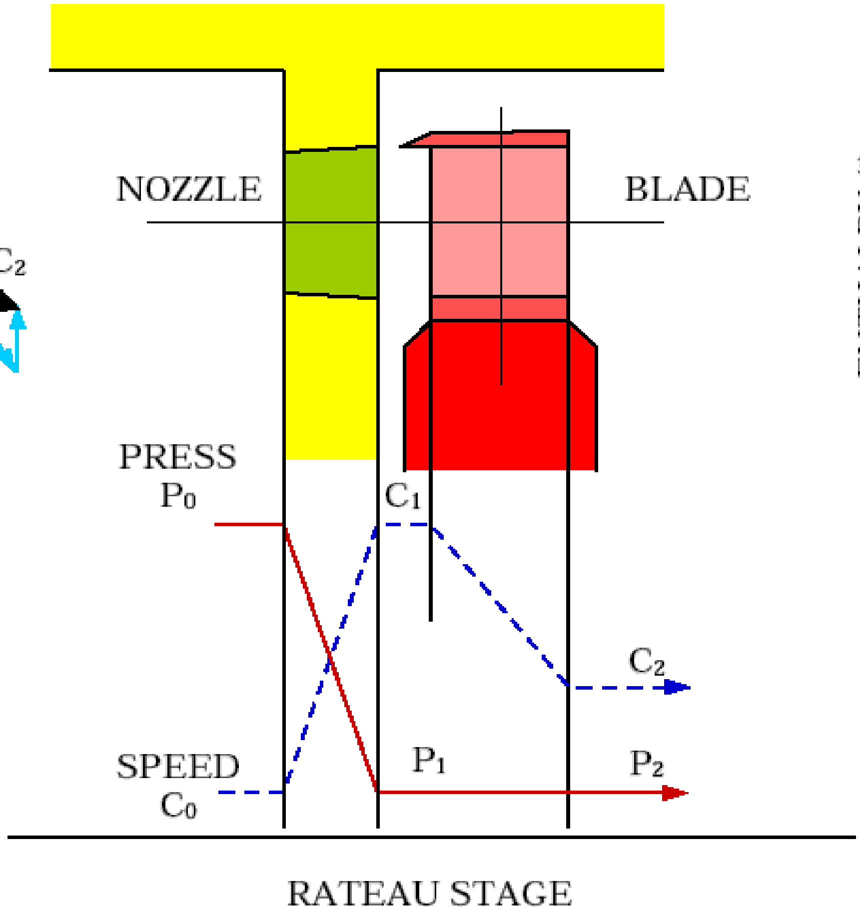


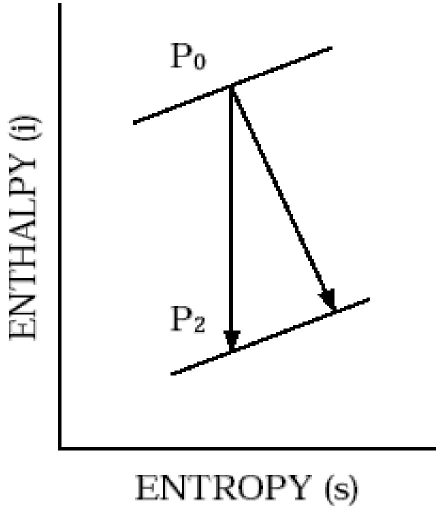
Impulse & Reaction Turbines



Impulse Turbines







Impulse Steam Turbine

- On Impulse Turbine a thermal expansion take place only in the nozzles and static energy is converted to the kinetic energy
- There is no pressure different at inlet and outlet of blades on the rotor, because the thermal expansion only in

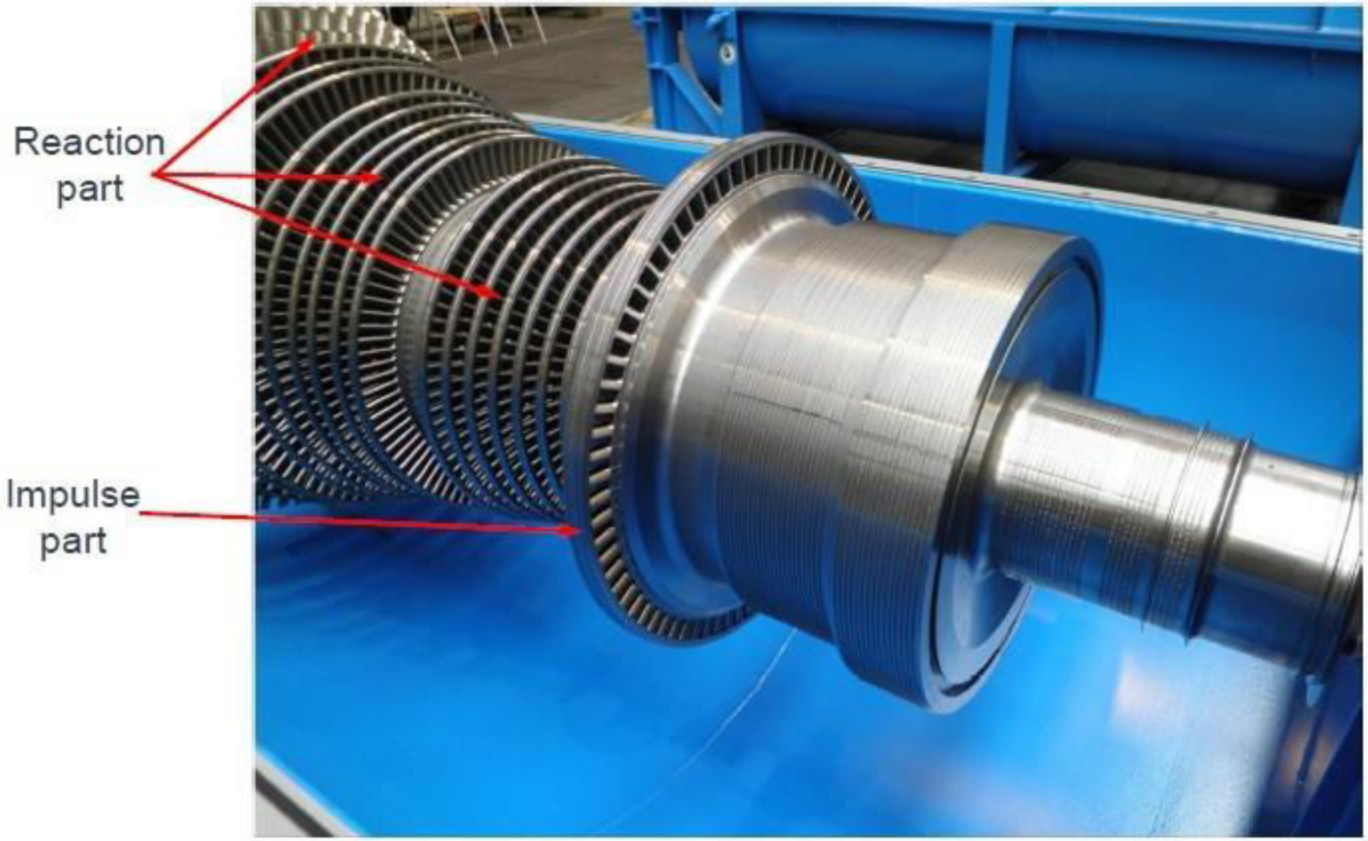
Reaction Steam Turbine

Thermal expansion occurs both in the nozzles and blades. The impulse force comes from the kinetic energy which is converted in the nozzles, and reaction force created in the blades comes due to decreasing steam pressure. These two forces produce the rotation torque of the blades on the rotor. On

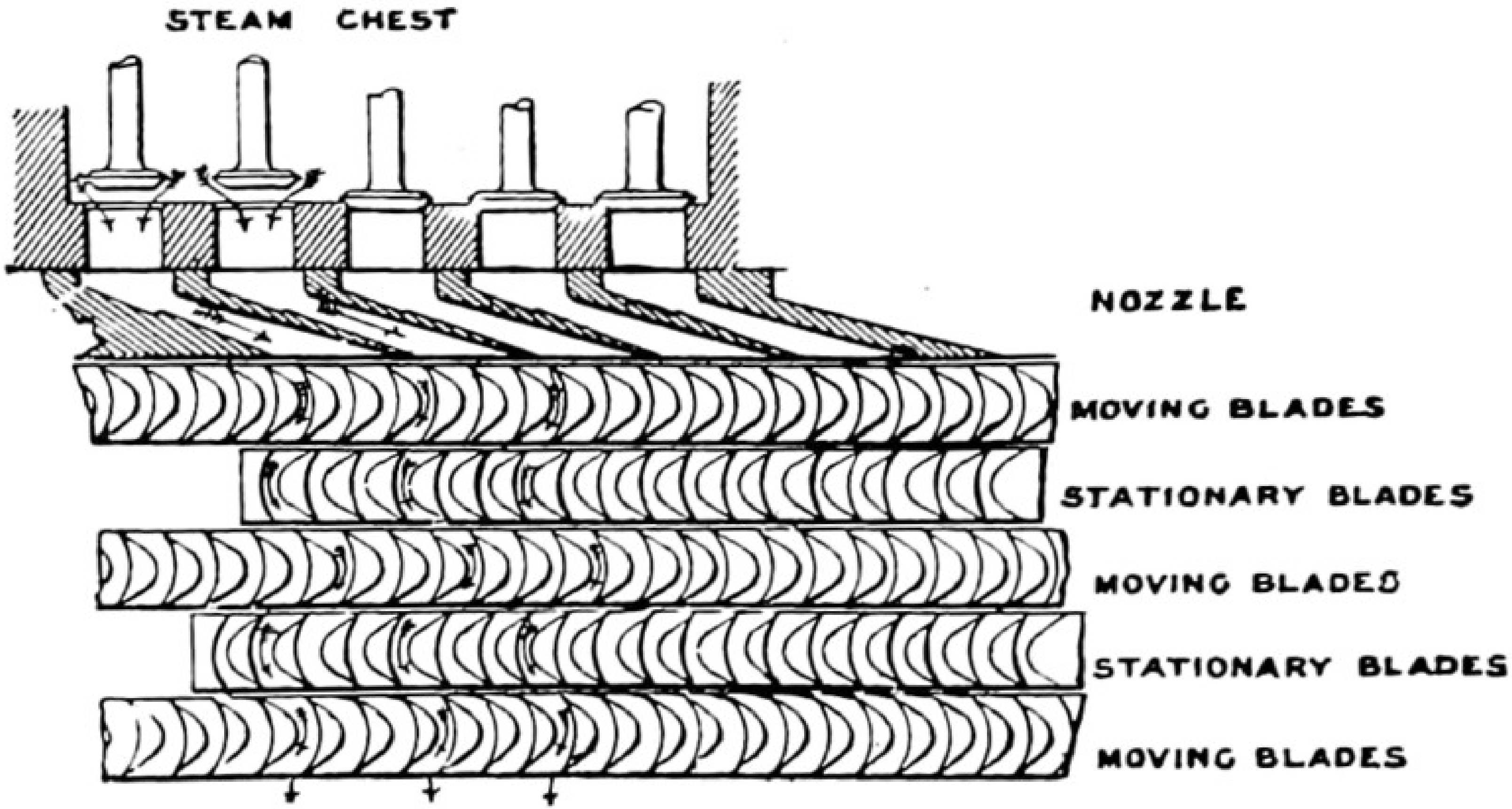
Impulse and Reaction Turbine

Impulse blading	Reaction blading
Advantages:	
+ Quick start up	+ Indiffererent to unbalance
+ Faster load changes	+ High efficiency in base load opeartion
+ Lesser axial forces	
Disadvantages:	
- High losses at blades & vanes	- Strong axial forces
- Sensitive to unbalance & vibration	- Slow start up & load changes

Actually, Steam turbine using in the refineries are combined impulse and reaction to get more advantages and less disadvantages



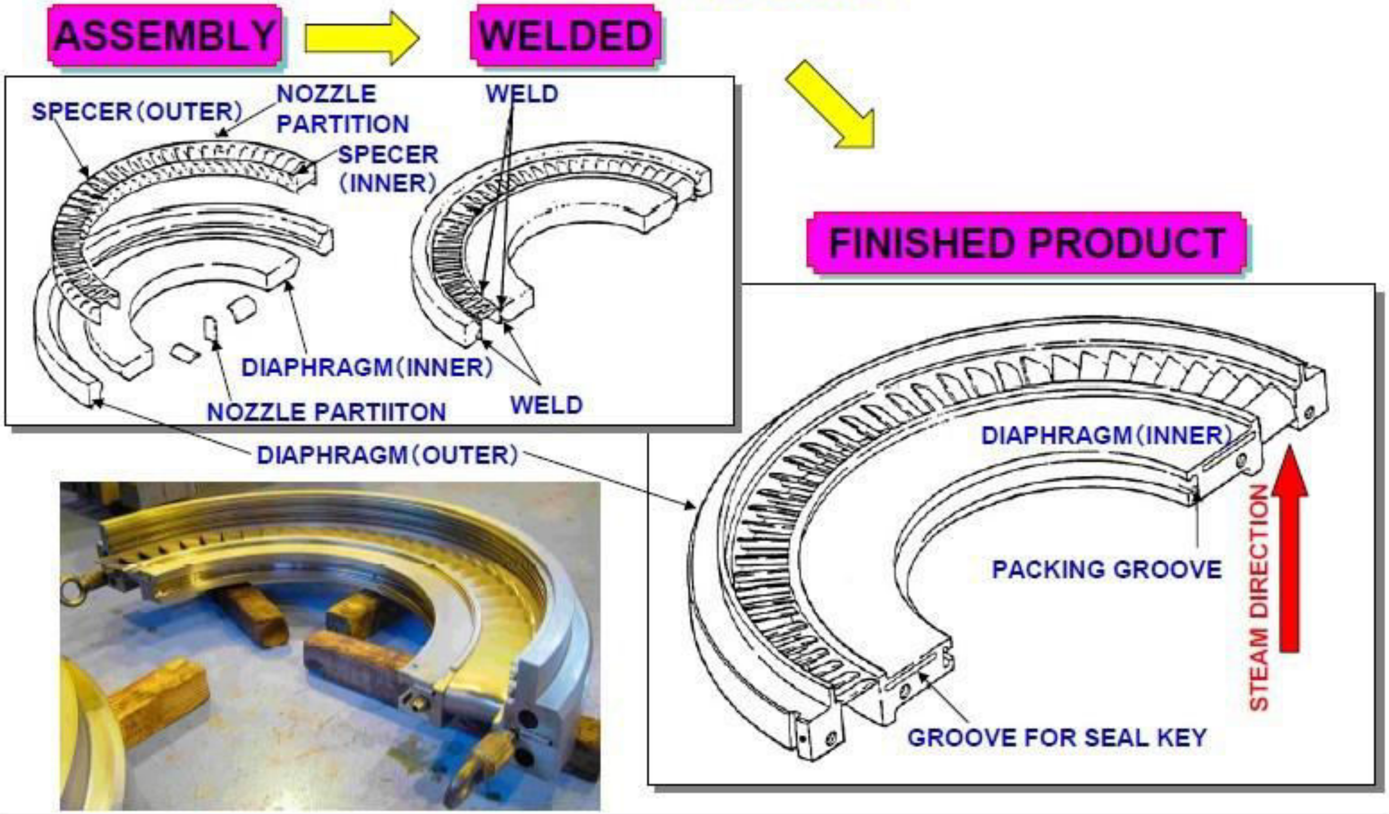
Nozzle



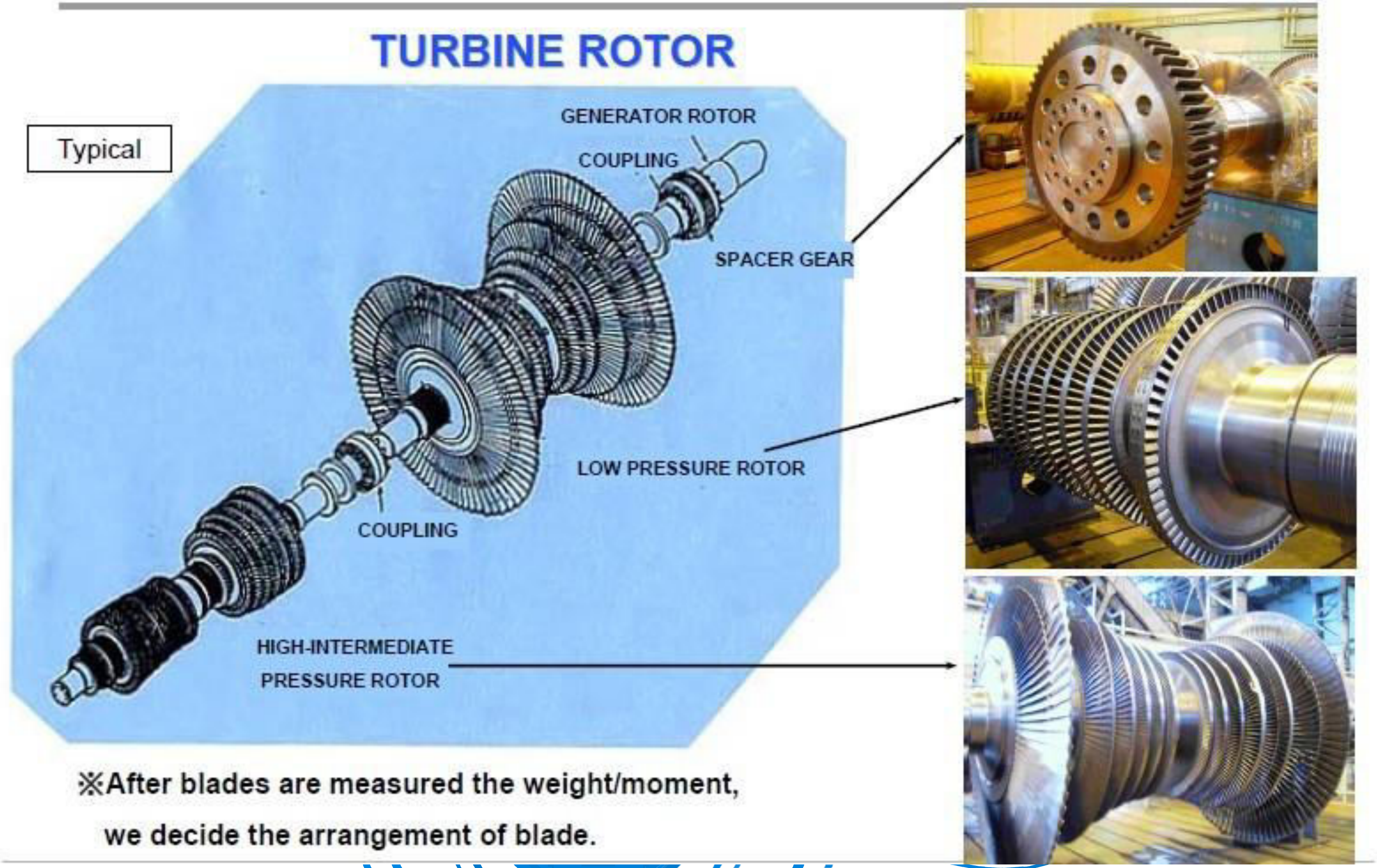
STEAM CHEST
NOZZLE
MOVING BLADES
STATIONARY BLADES
MOVING BLADED
STATIONARY BLADES
MOVING BLADES

MAJOR PARTS / Nozzle

STAGE NOZZLES



MAJOR PARTS / Rotor

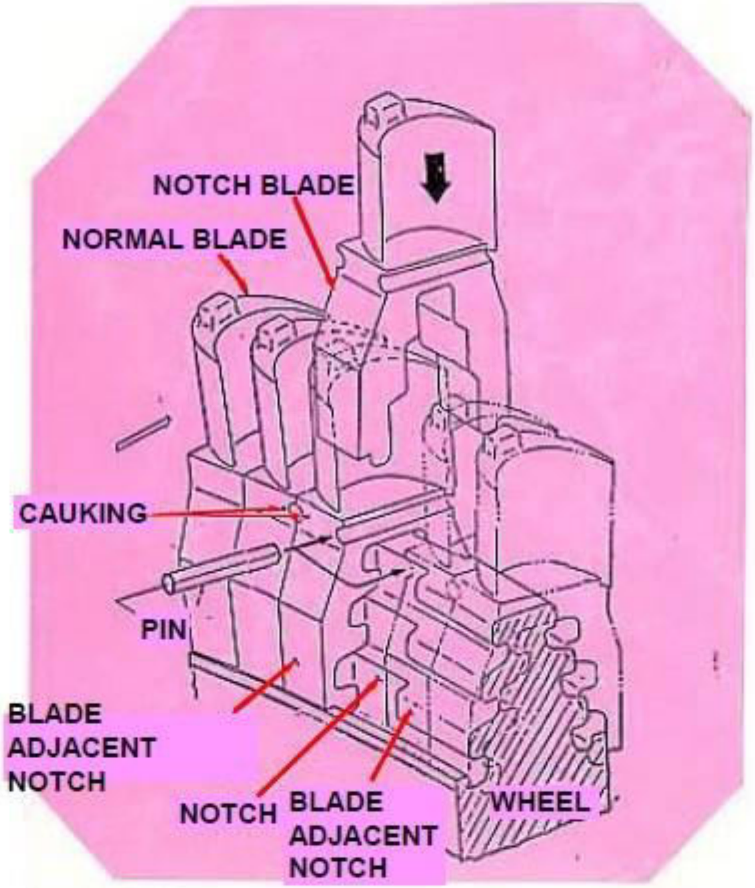


※After blades are measured the weight/moment,

we decide the arrangement of blade.

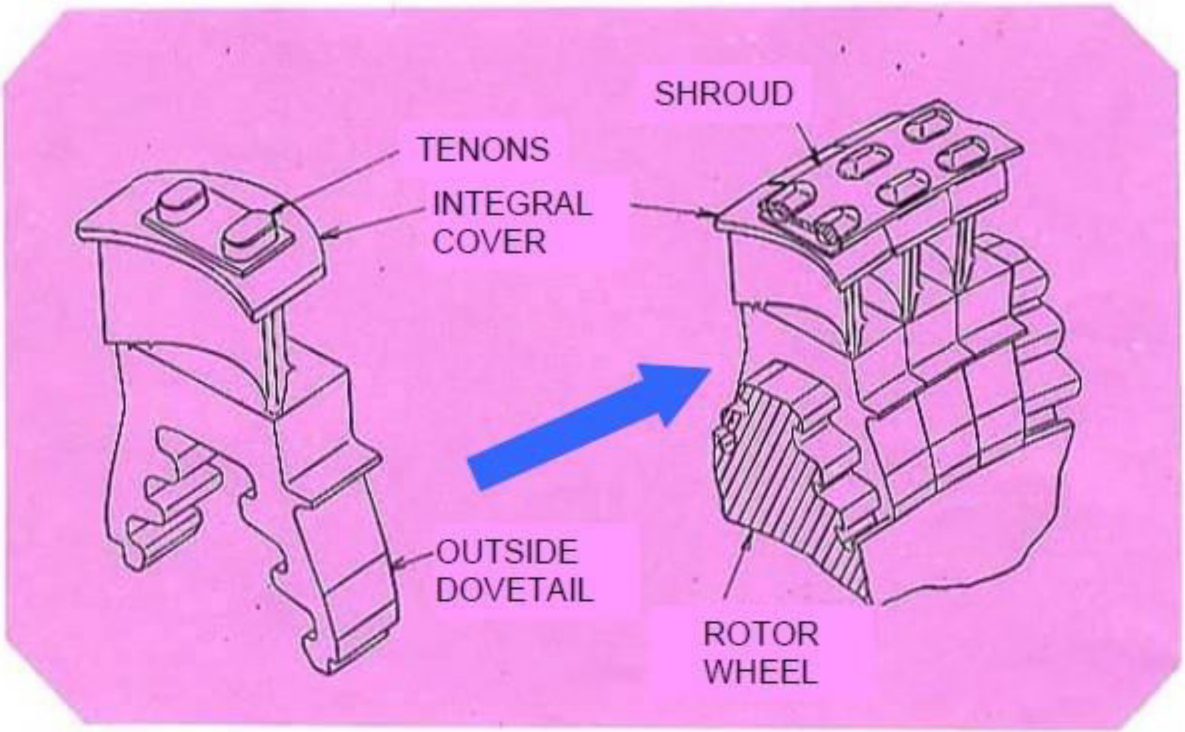
MAJOR PARTS / Blade

STAGE BLADES



Typical

MAJOR PARTS / Blade

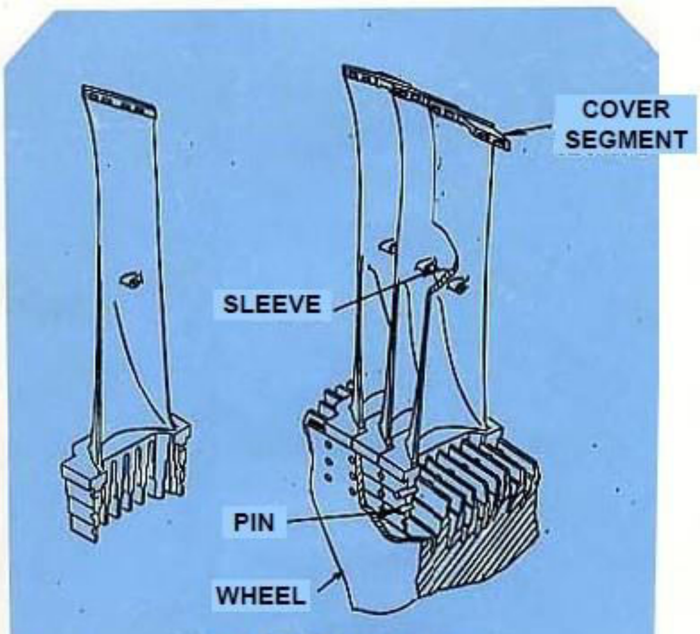


FIRST STAGE BLADE

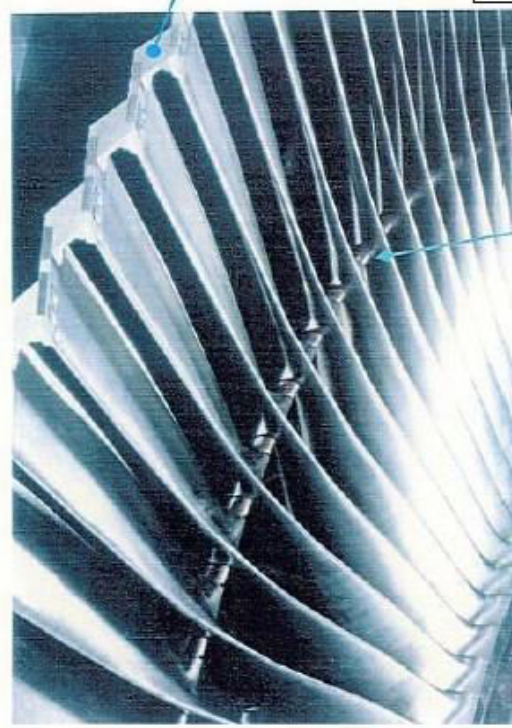
Typical

MAJOR PARTS / Blade

LONGER BLADES IN THE LOW PRESSURE SECTION

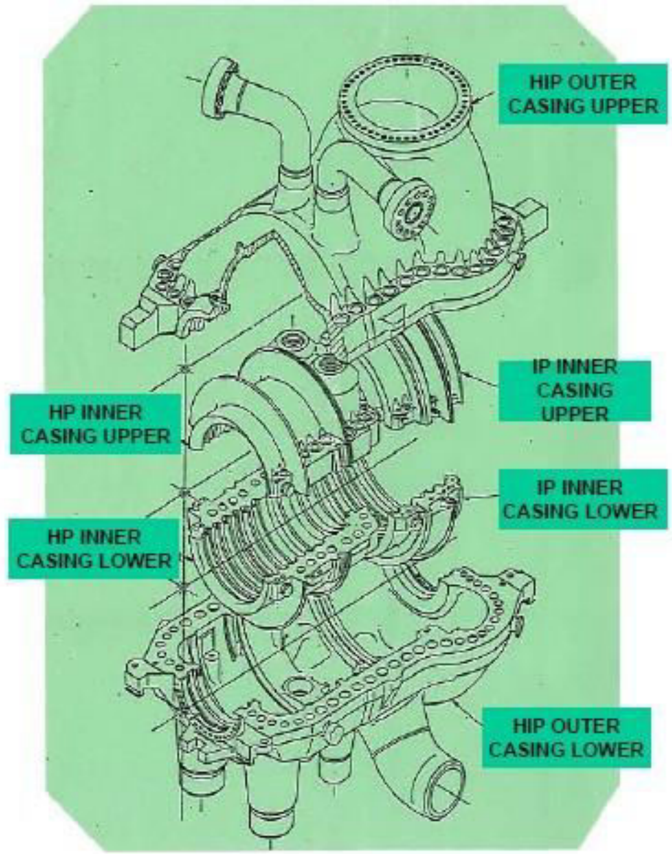


Last Stage Blade(L-0)



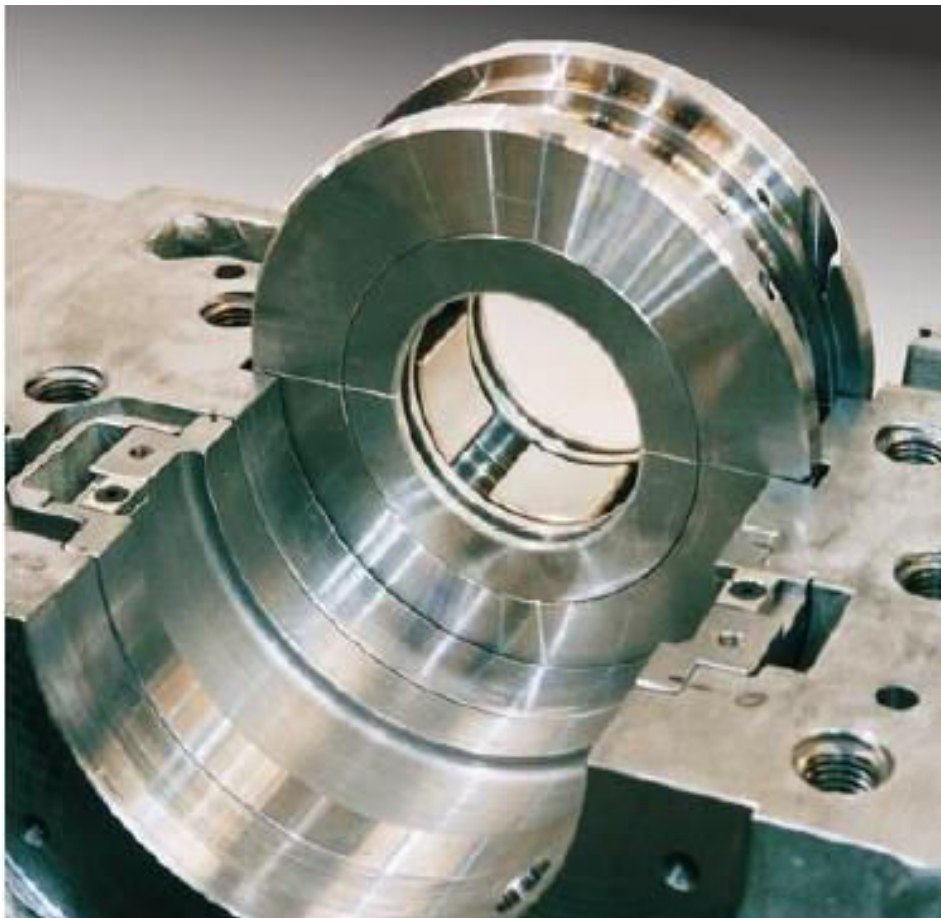
MAJOR PARTS / Casing

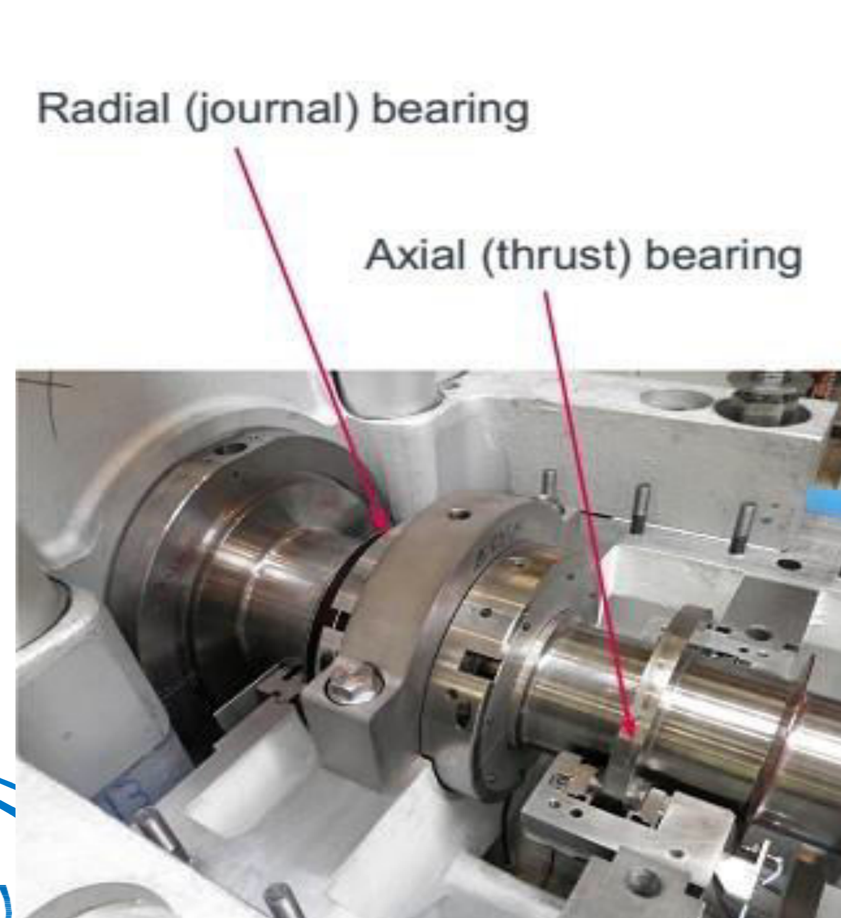
HIP CASING



Typical

Thrust & Radial bearings





Journal Bearing

BENEFITS

GE Oil & Gas tilting-pad journal bearings have many advantages including:

- improved dynamic performance of the rotor-bearing system and drastic reduction of instability caused by the lubricating oil;

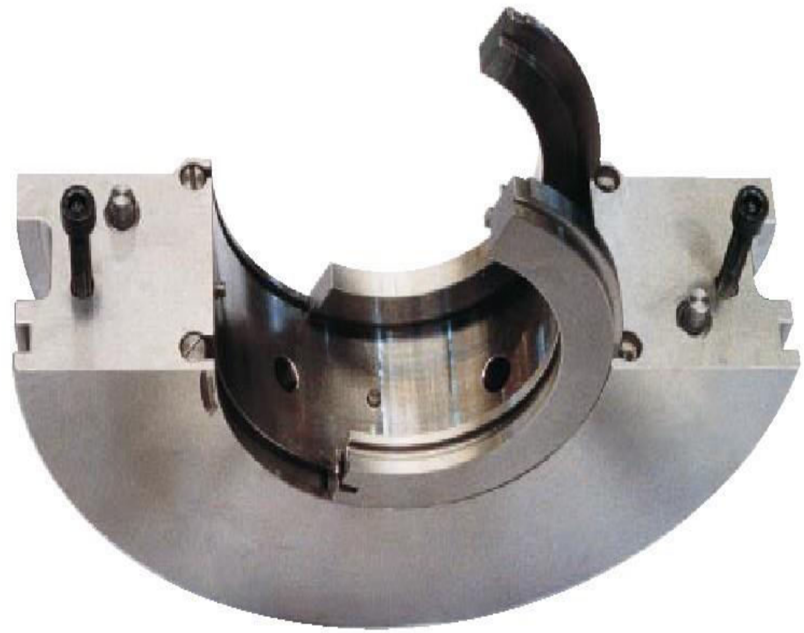


Figure3

References:

Internal Combustion Engine Fundamentals
By John B. Heywood
McGraw-Hill Higher Education 1988

Engineering Fundamentals of the Internal Combustion Engine
by Willard W.Pulkrabek
Prentice Hall, 1st edition,1997.

An Introduction to Combustion : Concepts and Applications w/IBM 3.5' Disk
by Stephen R. Turns
McGraw-Hill Higher Education , Bk & Disk edition,1995

Government Polytechnic Nanakpur

DEPARTMENT OF MECHANICAL ENGINEERING

E - NOTES

WORKSHOP TECHNOLOGY-II

HOD/O.I. (Mechanical) : **Sh.SHALANDER MOR**

Faculty Name: **Sh.SHALANDER MOR**

Semester: 4th Sem

LEARNING OUTCOMES

After undergoing this course, the students will be able to:

- Perform turning, step turning, taper turning, threading and knurling operation on lathe machine.
- Resharpen/grind single point tool.
- Select material and tool geometry for cutting tools on lathe.
- Perform drilling, reaming, counter boring, counter sinking and tapping operations on drilling machine.
- Explain the nomenclature of a drill
- Perform filing, cutting, fitting and die tapping operations
- Perform keyway cutting and angular/step surface shaping on shaper.
- Explain geometry of single point tools, various types of lathe tools and tool materials.
- Explain uses of lathe accessories and different types of lathes.
- Explain boring operation, features of boring machine and boring tool.
- Explain the uses and features of jigs, fixtures, locating devices and clamping devices.
- Select cutting fluid for different materials and operations.
- Describe the features of various types of broaching machines.

UNIT – I

CUTTING TOOLS AND CUTTING MATERIALS

- A cutting tool is subjected to static and dynamic forces, high temperature, wear and abrasion. To get reasonable tool life, the tool material should meet following requirements:
- 1. Hot hardness 2. Wear and abrasion resistance. 3.Impact toughness.

CUTTING TOOL AND ITS TYPE

- The tools which are used for the purpose of cutting the metals in the desired shape and size are called cutting tool.
- 1. Single Point Cutting Tool
- 2. Multi Point Cutting Tool

- The cutting tools may also be classified according to the motion as follow:
- 1. Linear motion tools
- 2. Rotary motion tools
- 3. Linear and Rotary motion tools

VARIOUS TYPES OF SINGLE POINT CUTTING TOOLS AND THEIR USES

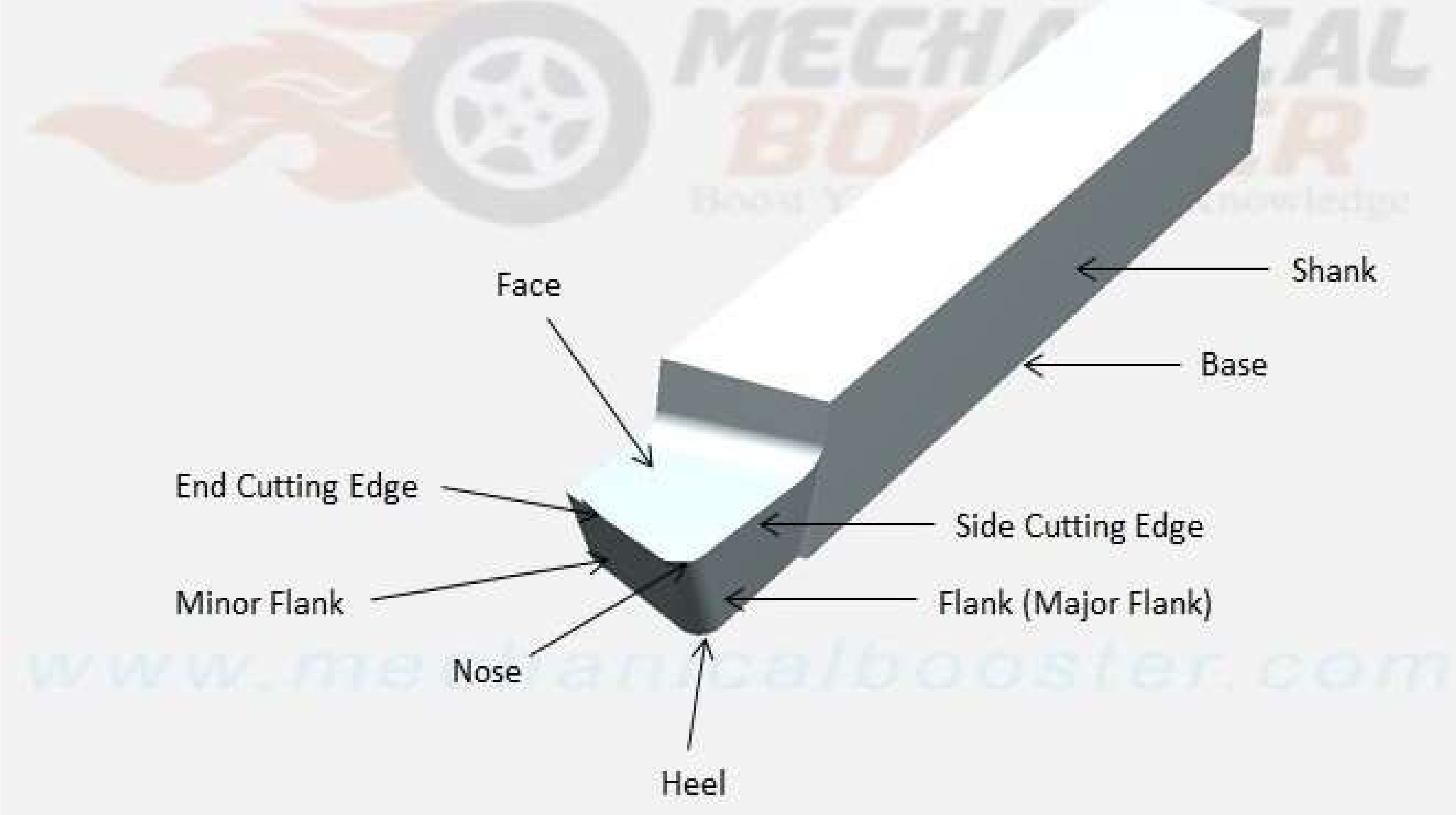
- **Tools for Lathe machines:**
- 1. Turning tool
- 2. Facing tool
- 3. Chamfering tool
- 4. External threading tool
- 5. Internal threading tool
- 6. Boring tool
- **Tools for Planers:**
- 1. Straight and Bent Roughing Tools
- 2. Straight Beck, Round Nose and Goose Neck Tools

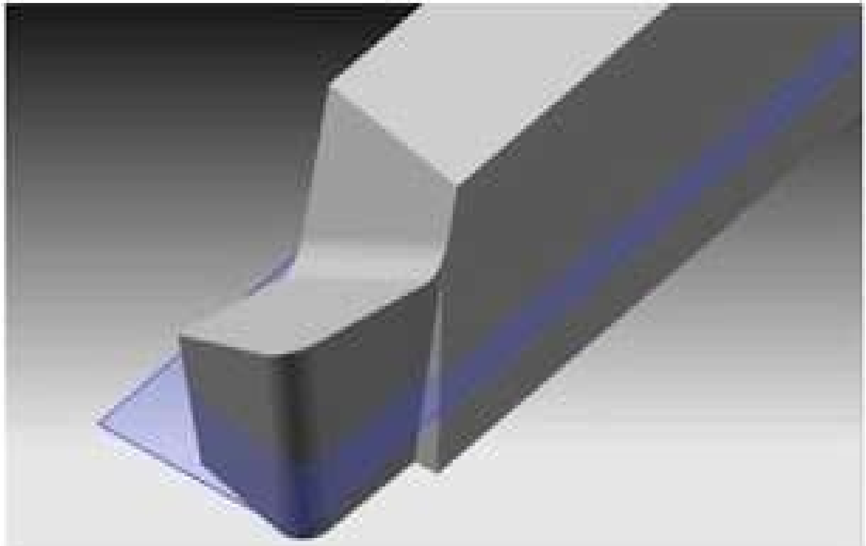
Tools for shapers

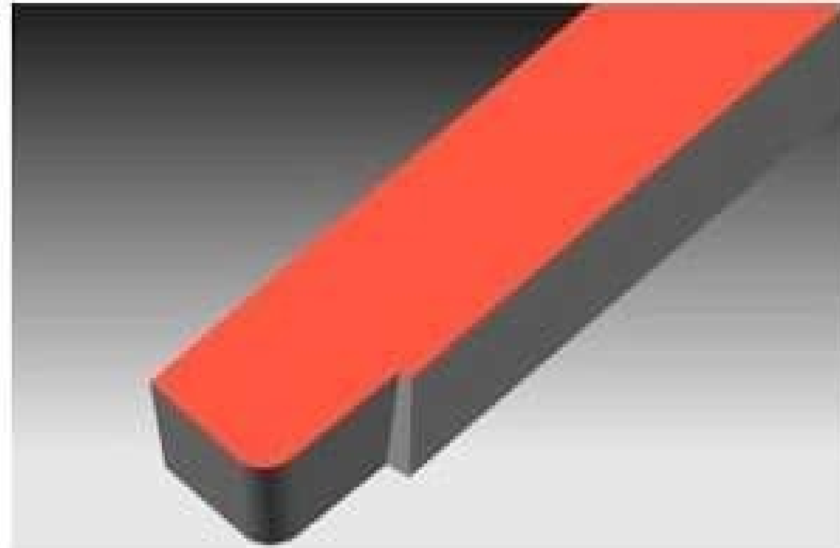
- 1. Round nose roughing tool
- 2.Down cutting tool
- 3. Square nose finishing tool
- 4. Side recessing tool
- 5. Parting off tool
- 6. Goose neck tool

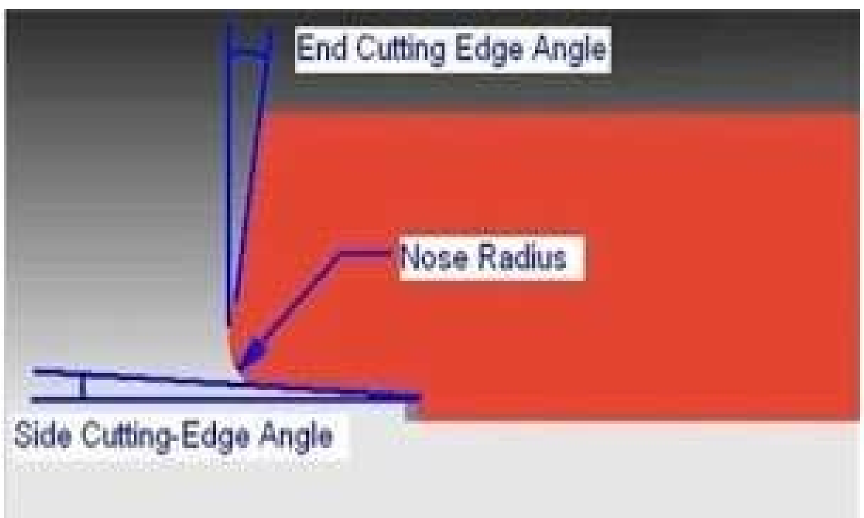
IMPORTANT TERM RELATING TO SINGLE POINT CUTTING TOOL

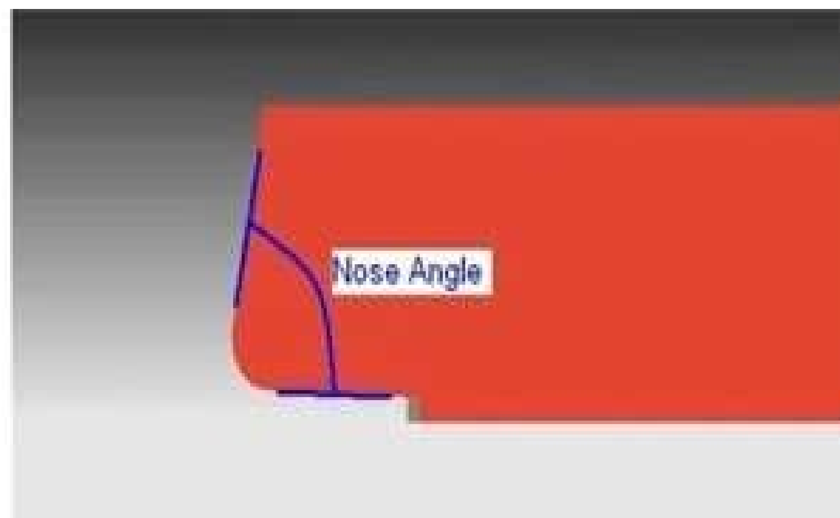
- **Single point cutting tool**

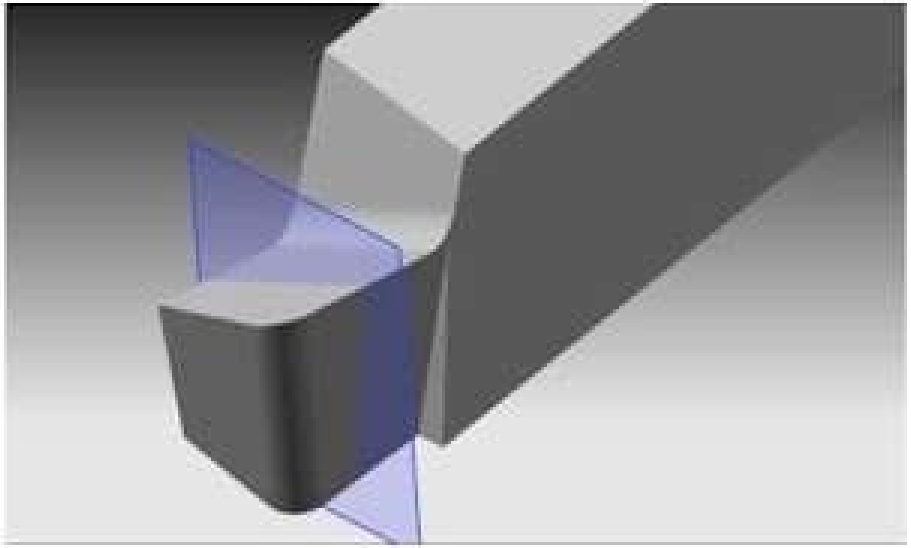


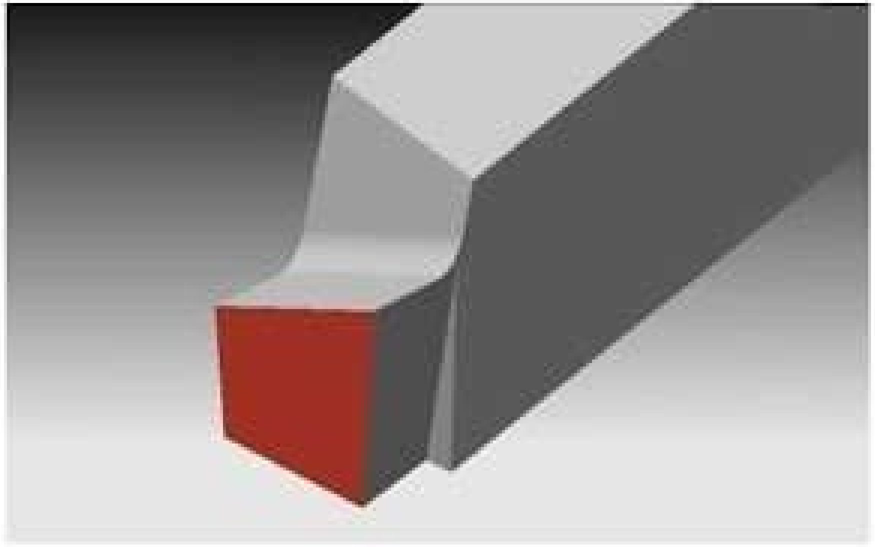


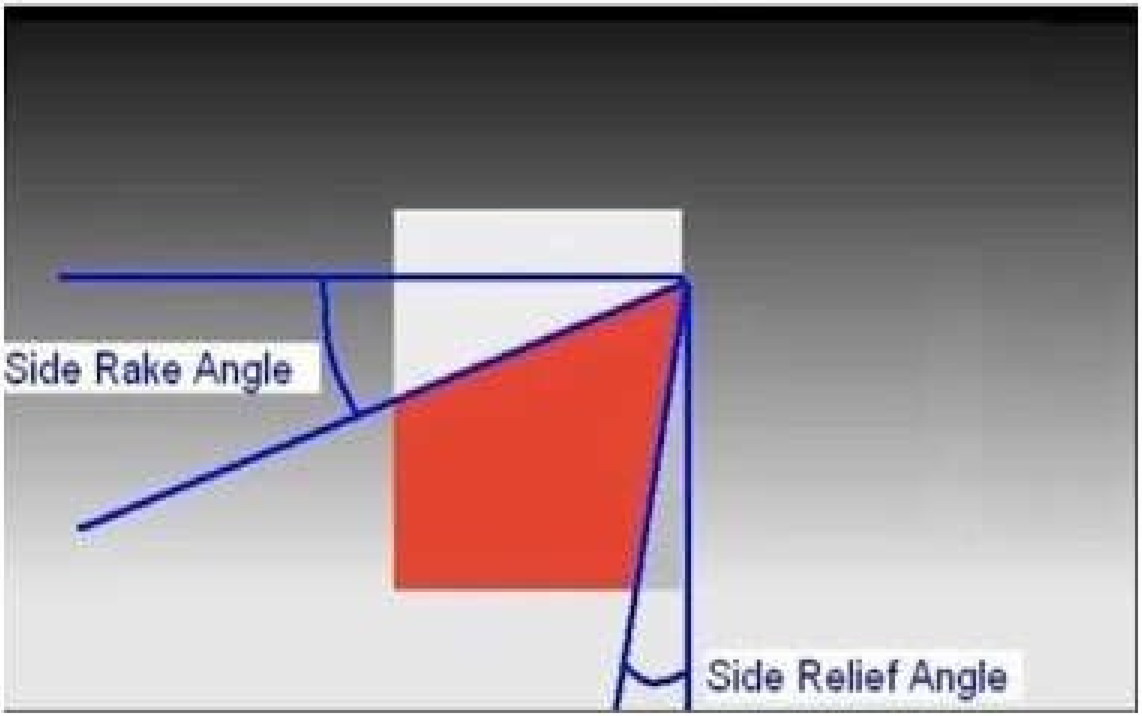



End Cutting Edge Angle
Nose Radius
Side Cutting-Edge Angle


Nose Angle






Side Rake Angle
Side Relief Angle

1. Shank
2. Flank
3. Face
4. Heel
5. Nose
6. Neck
7. Cutting edge

Angles

The various angles of the single point cutting tool have great importance. Each angle has its own function and speciality.

TOOL SIGNATURE

The shape of a tool is specified in a special sequence and this special sequence is called tool signature. The tool signature is given below

1. Back rake angle
2. Side rake angle
3. End relief / Clearance angle
4. Side relief / Clearance angle
5. End cutting edge angle
6. Side cutting edge angle
7. Nose radius

EFFECT OF HEAT PRODUCED DURING METAL CUTTING

- It reduced the tool life
- It reduced the surface finish
- It causes the welding of chips with the face of tool
- Repeated replacement of tools occurs which increases the cost

CUTTING SPEED

Cutting speed of a cutting tool may be defined as the speed at which the cutting edge passes over the material.

FEED

- Feed of a cutting tool may be defined as the distance through which the tool advances in to or along work piece each time the tool passes a certain position in its travel over the surface.

DEPTH OF CUT

- Depth of cut may be defined as the perpendicular distances measured from the machined surface to the un cut surface of the work piece.

PROPERTIES OF THE CUTTING TOOL MATERIALS

- It should be harder then the cutting material of work piece
- It should be tough
- It should be cheap
- It should be high resistant to wear to ensure longer tool life
- It should be able to be fabricated and shaped easily.

CUTTING TOOL MATERIAL

- HIGH SPEED STEEL
- HIGH CARBON STEEL
- TUNGSTEN CARBIDE
- CEMENTEDCARBIDS
- STELLITE
- CERAMIC CUTTING MATERIALS
- DIAMOND

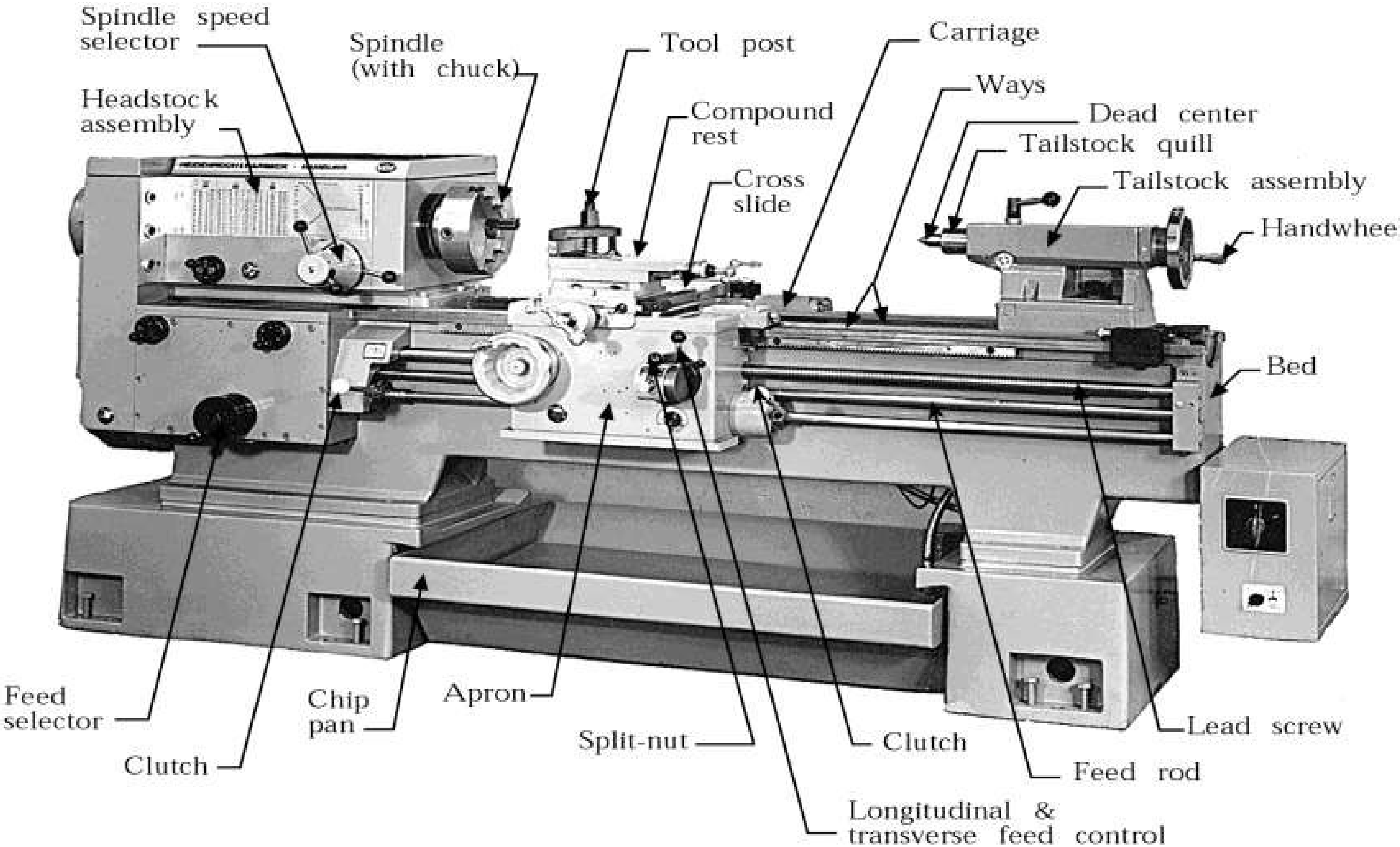
UNIT-II

LATHE

- Lathe is a machine, which removes the metal from a piece of work to the required shape and size.
- Lathe is one of the most important machine tools in the metal working industry. A lathe operates on the principle of a rotating workpiece and a fixed cutting tool.

FUNCTION OF LATHE

- Lathe is to remove excess material in the form of chips by rotating the work piece against a stationary cutting tool


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

MAIN PART OF LATHE

Lathe Machine is also known as "**Centre Lathe**", because it has two centres between which the job can be held and rotated.

The main parts of centre lathe are:

1.Bed

2. Head stock

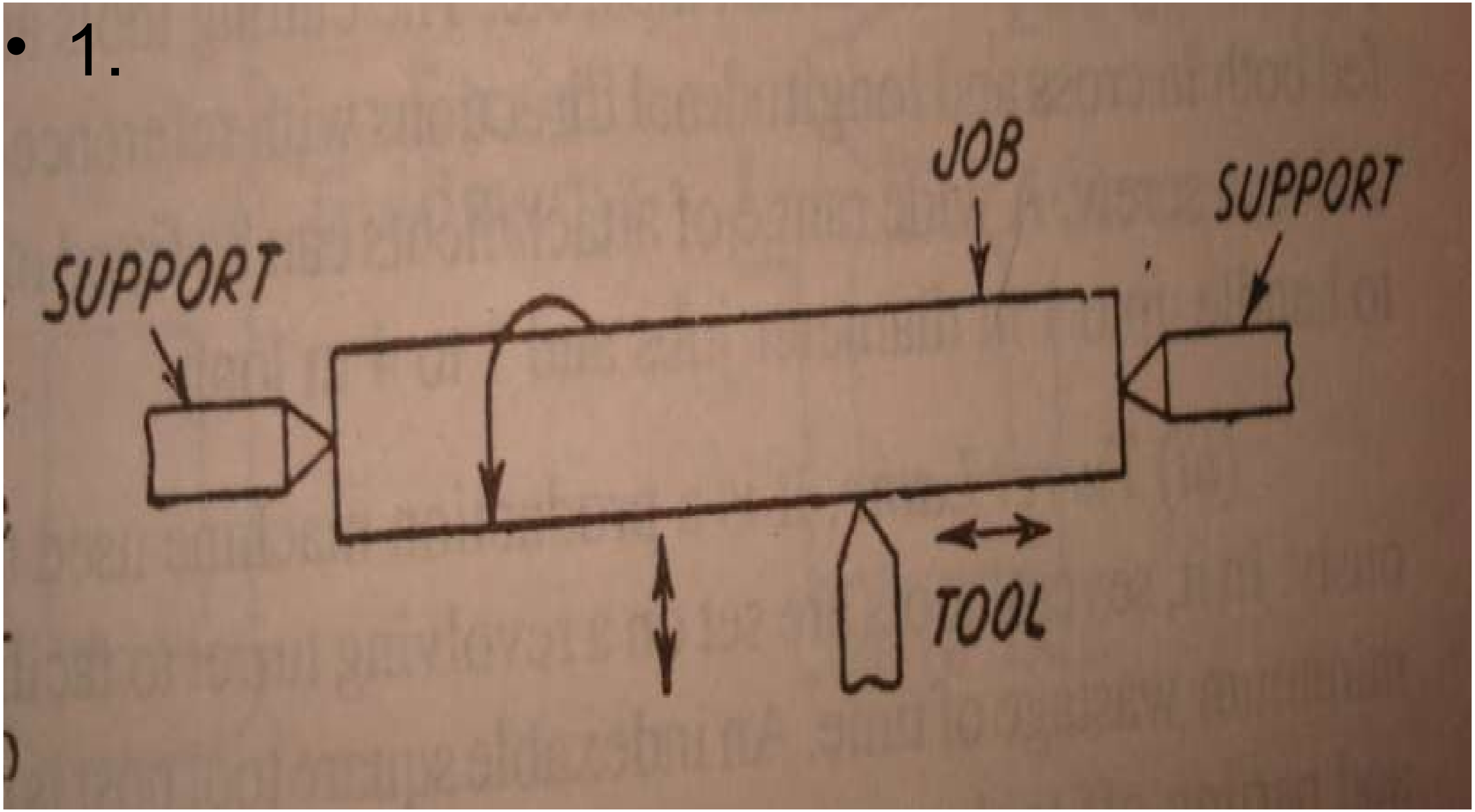
3. Tailstock

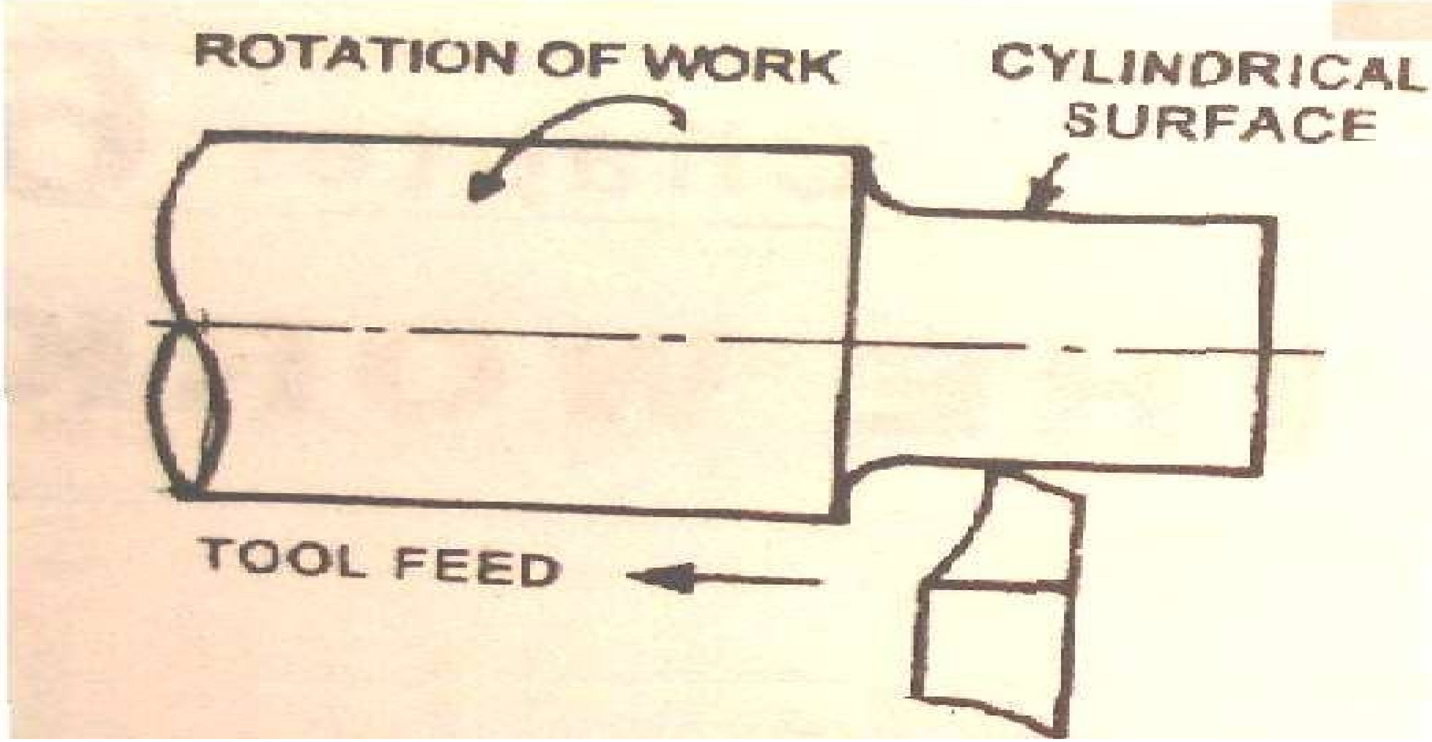
4. Carriage

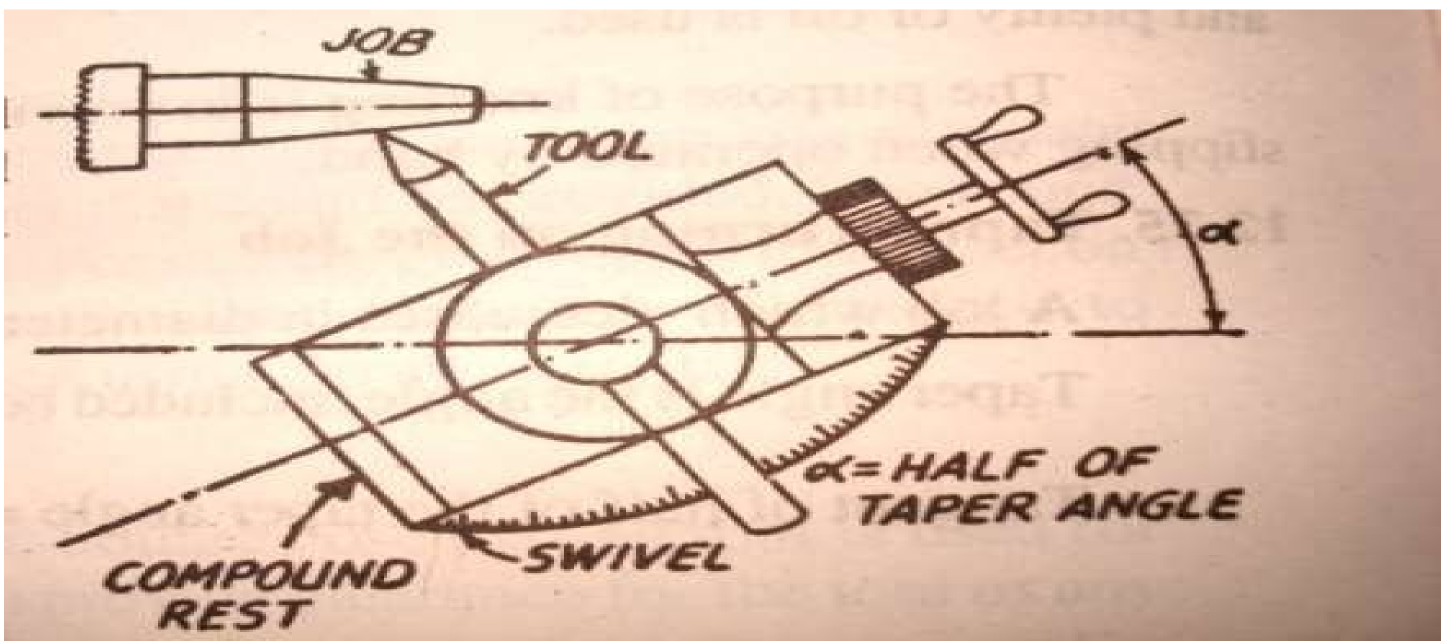
5. Feed mechanisms

Working Principle of Lathe

- 1.




ROTATION OF WORK
CYLINDRICAL SURFACE
TOOL FEED


JOB
TOOL
α
α= HALF OF TAPER ANGLE
COMPOUND REST
SWIVEL

WORKING PRINCIPLES OF LATHE

- It holds the work between two supports called centres.
- Chuck or Face plate is also used for holding the work.
- Chuck or face plate is mounted on machine spindle
- Cutting tool is held and supported on a tool post.
- Movement of the job is rotation about spindle axis
- Tool is fed against the revolving work
- Movement of the tool is either parallel to or at any inclination to the work axis

TYPES OF LATHE MACHINE

1. Speed lathe
2. Engine or centre lathe
3. Bench lathe
4. Tool room lathe
5. Capstan and turret lathe
6. Automatic lathe
7. Special purpose lathe

LATHE OPERATIONS

LATHE ACCESSORIES

1. Centres
2. Lathe dog or carrier
3. Chucks
4. Collets
5. Face plates
6. Driving plate
7. Angle plate
8. Mandrels
9. Rests
10. Milling attachment
11. Taper turning attachment.

ADVANTAGES OF LATHE MACHINE

- Greater production over a given period.
- More economy in floor space.
- Improvement in accuracy.
- Floor space maintenance and inventory requirements are reduced.
- More consistently accurate work than turrets.
- More constant flow of production.
- Scrap loss is reduced by reducing operator error.
- During machine operation operator is free to operate another machine/ can inspect completed parts.

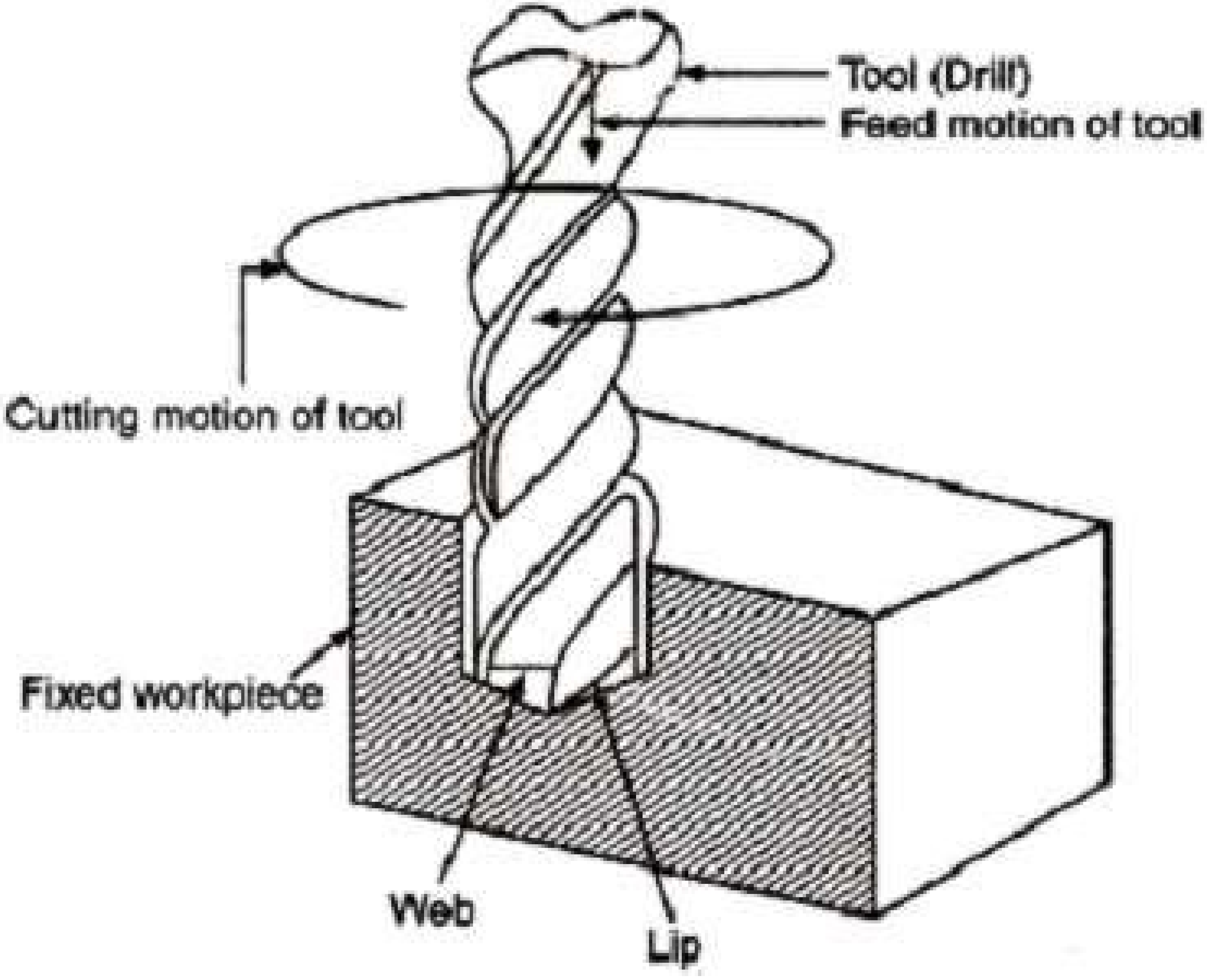
UNIT – III

DRILLING

- The drilling machine or drill press is one of the most common and useful machine employed in industry for producing forming and finishing holes in a work piece.

- **WORKING PRINCIPLE OF DRILLING**

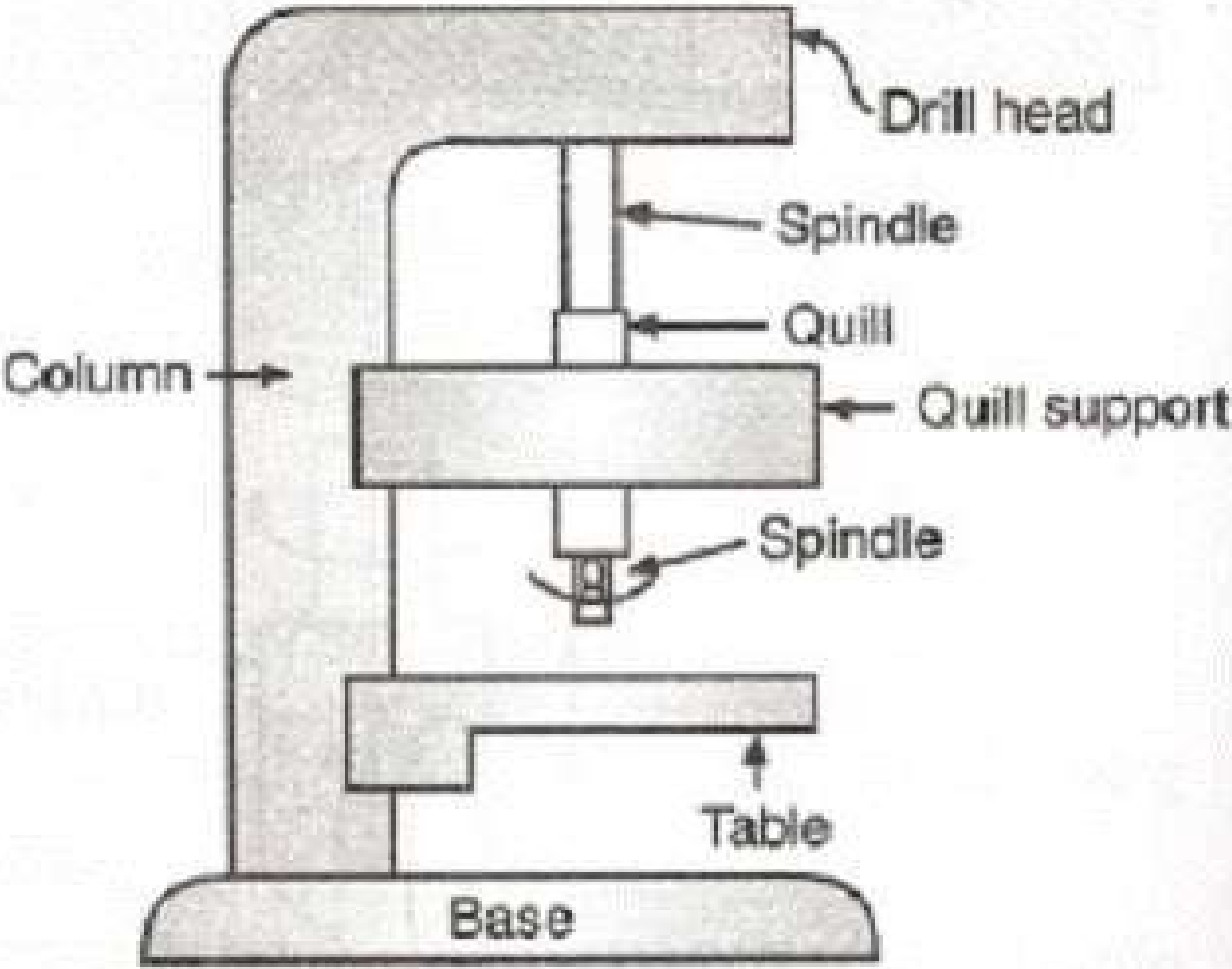
The rotating edge of the drill exerts a large force on the work piece and the hole is generated. The removal of metal in a drilling operation is by shearing and extrusion.


Tool (Drill)
Feed motion of tool
Cutting motion of tool
Fixed workpiece
Web
Lip

MAIN PARTS OF DRILLING MACHINE

The machine has only a hand feed mechanism for feeding the tool into the work piece. This enables the operator to feel how the drill is cutting and accordingly he can control the down feed pressure. Sensitive drill presses are manufactured in bench or floor models.

1. Base
2. Column
3. Adjustable table
4. Spindle
5. Head
6. Drill chuck


Drill head
Spindle
Quill
Column
Quill support
Spindle
Table
Base

TYPES OF DRILLING MACHINE

- Portable Drilling Machine
- Sensitive or Bench Drill
- Upright Drilling Machine(Single Spindle)
- Upright Drilling Machine(Turret Type)
- Radial Drilling Machine
- Multiple Spindle Drilling Machine
- Deep Hole Drilling Machine
- Gang Drilling Machine
- Horizontal Drilling Machine
- Automatic Drilling Machine

OPERATION OF DRILLING MACHINE

- Drilling
- Reaming
- Boring
- Counter Boring
- Counter Sinking
- Spot Facing
- Tapping
- Core drilling
- Buffing
- Step drilling
- Grinding
- Counter sinking

UNIT – IV

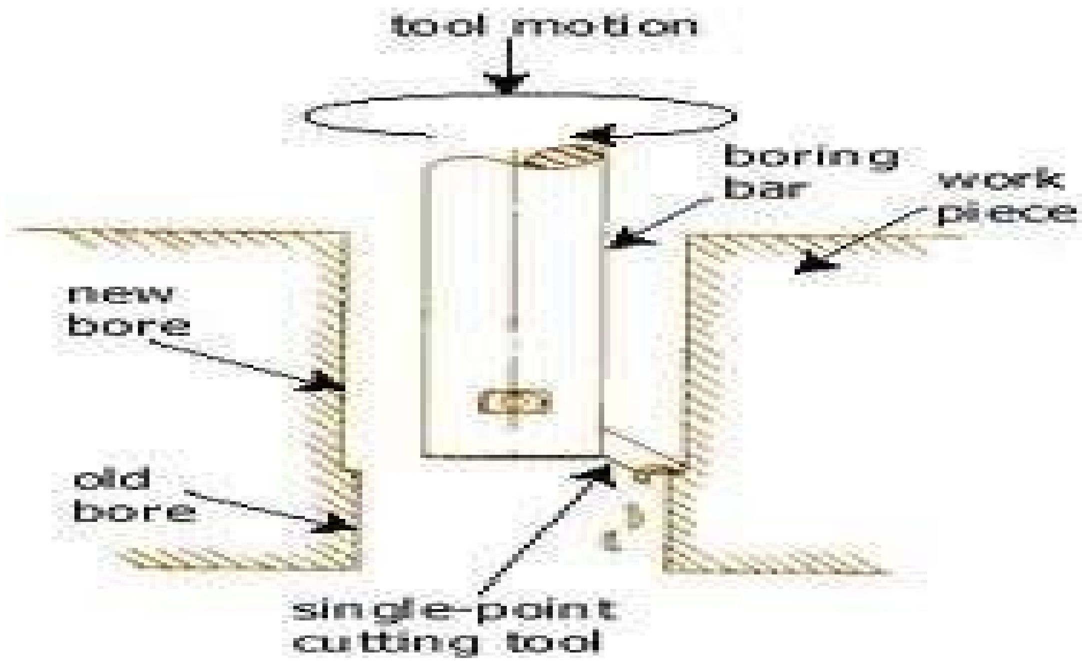
BORING

Boring is a process of producing circular internal profiles on a hole made by drilling or another process. It uses single point cutting tool called a boring bar. In boring, the boring bar can be rotated, or the work part can be rotated. Machine tools which rotate the boring bar against a stationary work piece are called boring machines (also boring mills).

Boring can be accomplished on a turning machine with a stationary boring bar positioned in the tool post and rotating work piece held in the lathe chuck as illustrated in the figure. In this section, we will consider only boring on boring machine.

PRINCIPLE OF BORING

In horizontal boring machine, the work piece is held on the machine table and kept stationary, while boring tool revolves. At the same time, the tool may be moved forward or backward in a direction parallel to its axis of rotation and can also be offset in a direction perpendicular to its axis of rotation.



CLASSIFICATION OF BORING MACHINES

1. Horizontal boring machine
2. Vertical boring machine
3. Jigs boring machine
4. Special purpose boring machine

HORIZONTAL BORING MACHINE

▪

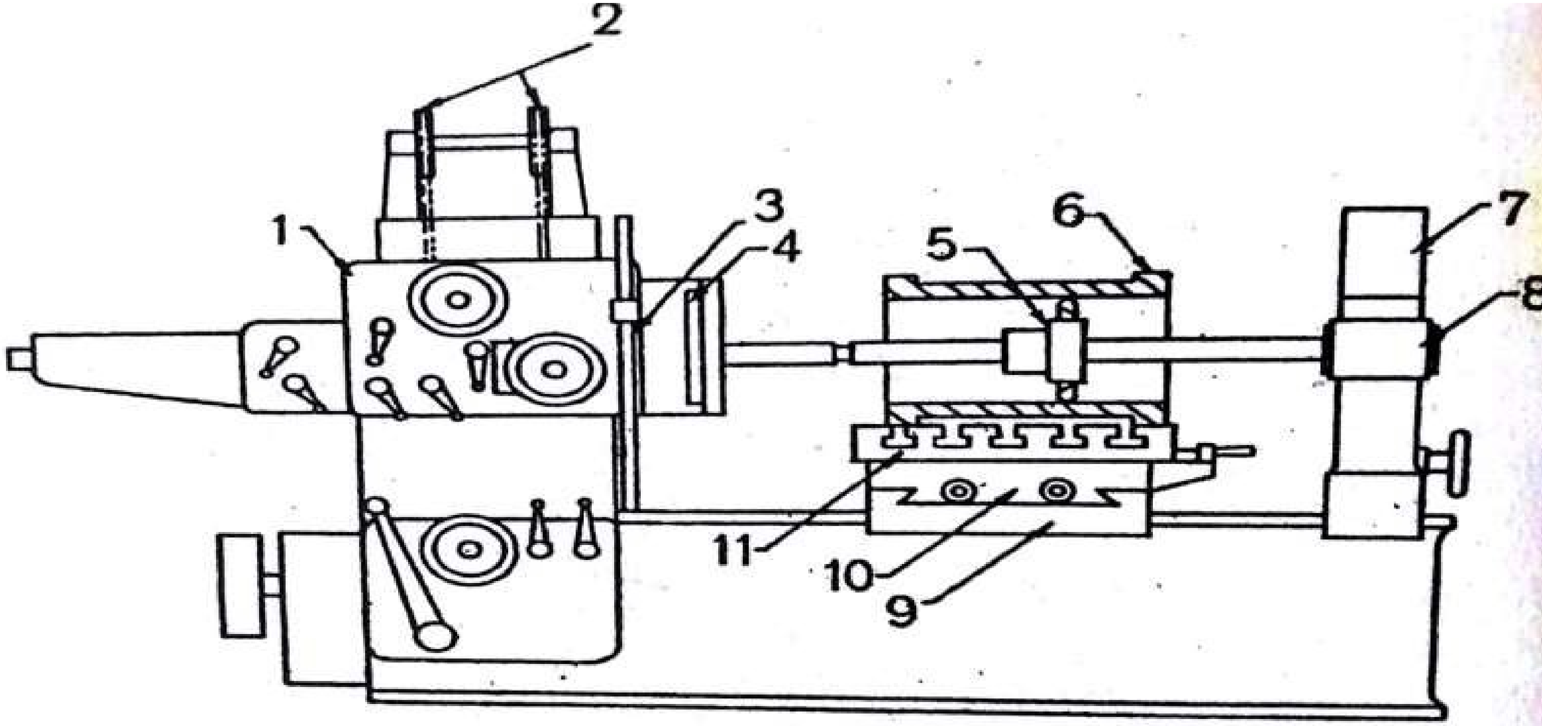


Figure 6.1 Horizontal boring machine

1. Headstock, 2. Pulley for counter balancing weight of headstock, 3. Headstock elevating screw, 4. Boring head, 5. Boring cutter on boring bar, 6. Work, 7. End supporting column, 8. Bearing block, 9. Saddle, 10 Cross-slide, 11. Table.

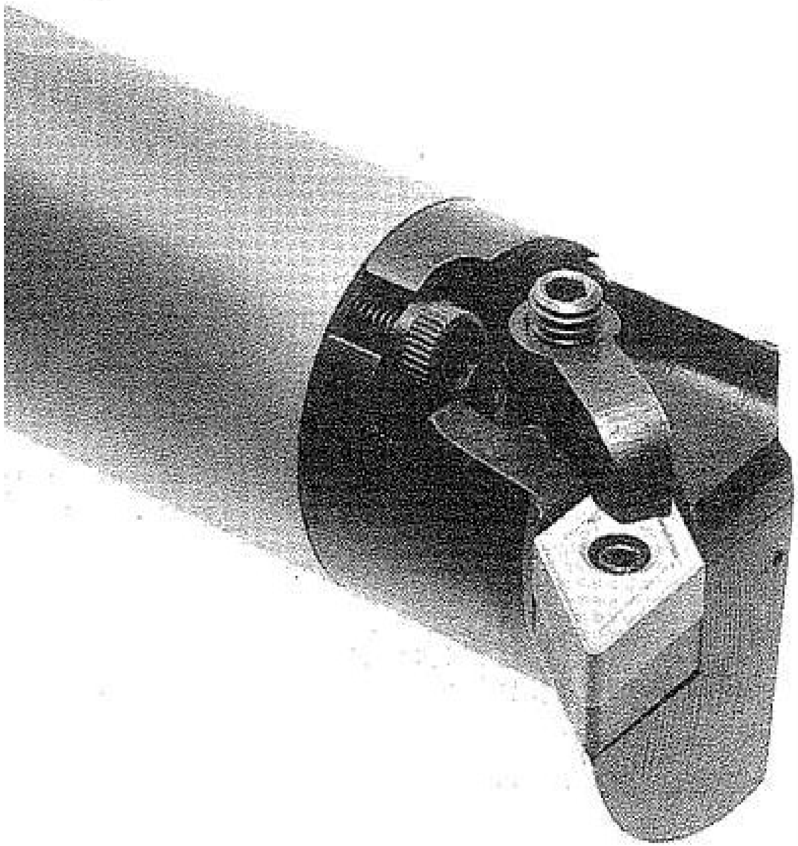
1. Bed
2. Saddle
3. Table
4. Base
5. Column
6. Headstock
7. End support column

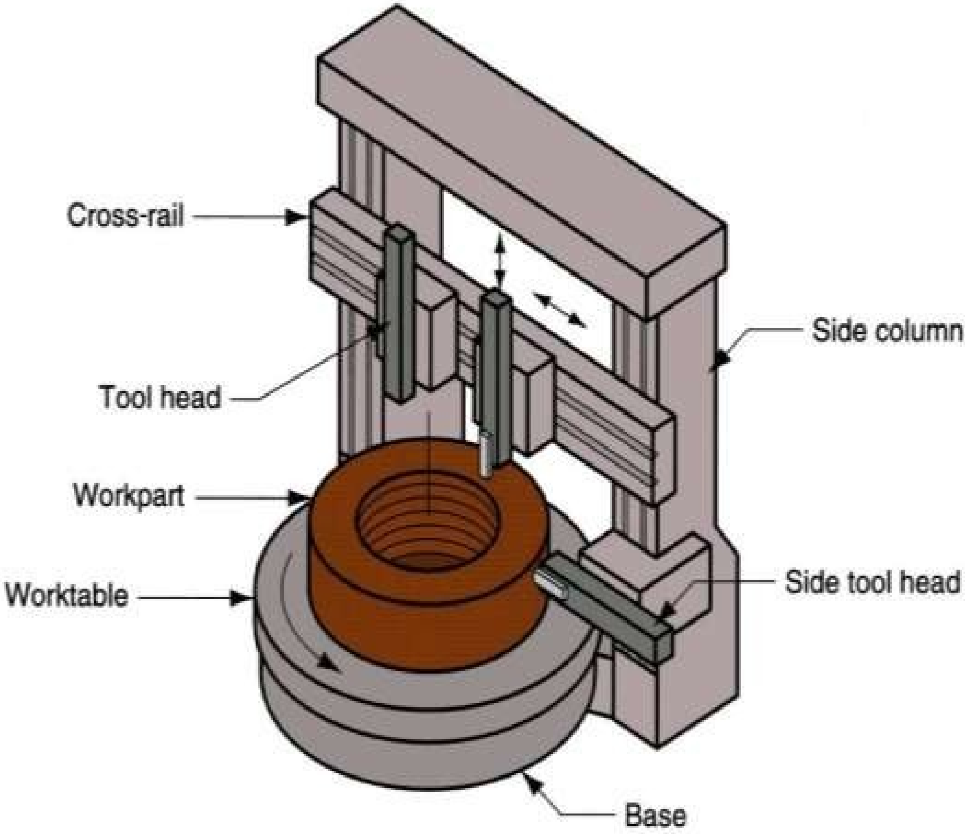
VERTICAL BORING MACHINE

A vertical boring mill is used for large, heavy work parts with diameters up to 12 m. The typical boring mill can position and feed several cutting tools simultaneously. The work part may be mounted on a rotating worktable.

VERTICAL BORING MACHINE

- Boring bar made by cemented carbide





CUTTING TOOLS FOR BORING

The typical boring bar is shown in the figure. When boring with a rotating tool, size is controlled by changing the radial position of the tool slide, which hold the boring bar, with respect to the spindle axis of rotation. For finishing machining, the boring bar is additionally mounted in an adjustable boring head for more precise control of the bar radial position.

1. Forged tool
2. Inserted teeth boring tool
3. Boring tool bit in boring bar

Boring bar with indexable carbide insert (*Left*), and adjustable boring head with accessories (*Right*).

BORING OPERATIONS

- Internal taper boring
- External taper boring
- Necking or cutting off
- Boring a large diameter
- Boring a small diameter
- Spot facing
- Reaming
- Counter boring
- Threading
- Facing
- Trepanning
- Milling

UNIT – V
SHAPING, PLANNING AND SLOTTING

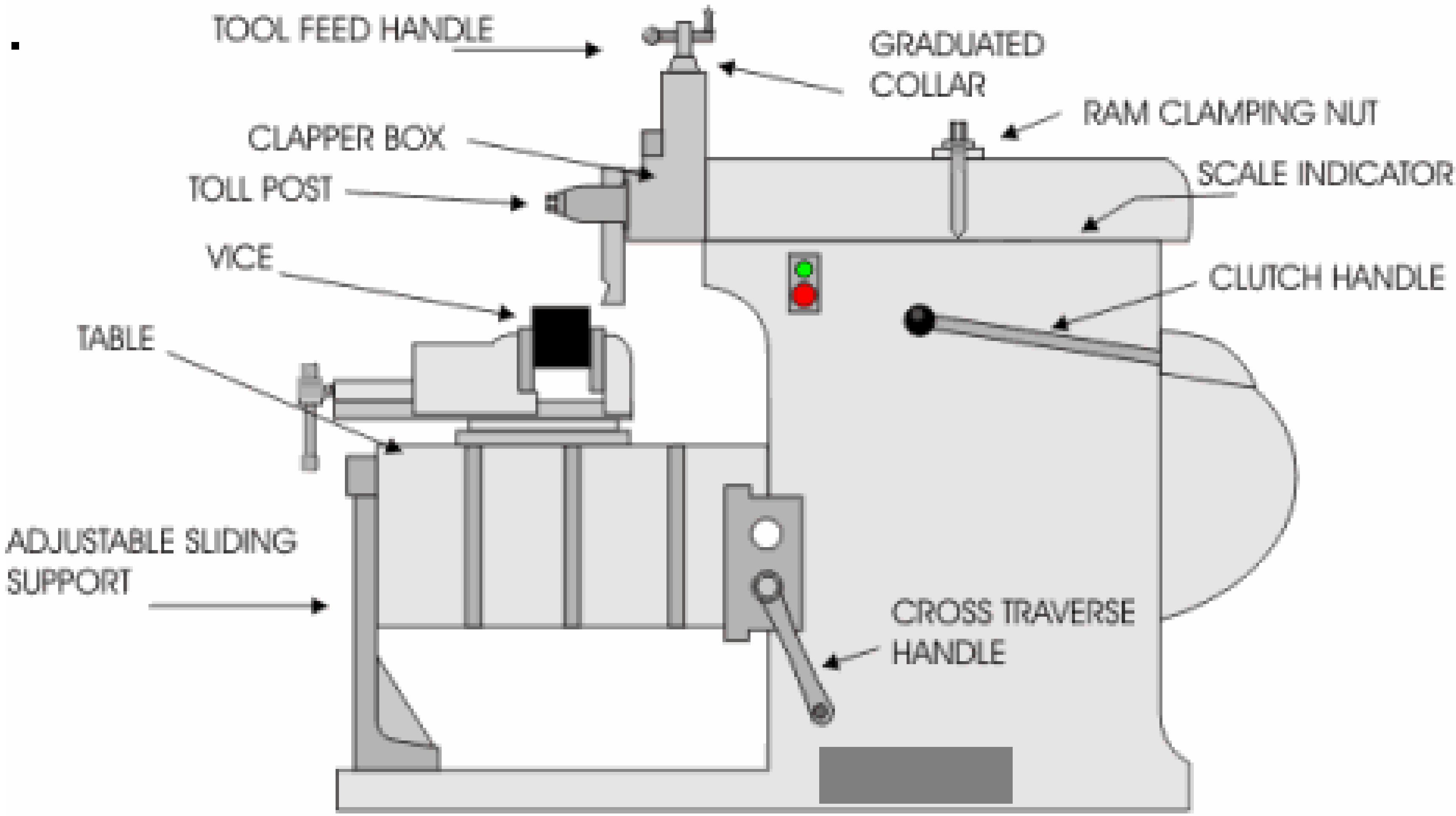
SHAPING

Shaping or shaper machine is a reciprocating type of machine tool used for producing small flat surfaces with the help of a point cutting tool which reciprocates over the stationary work piece.

A shaping machine is used to machine surfaces. It can cut curves, angles and many other shapes. It is a popular machine in a factory workshop because its movement is very simple although it can produce a variety of work. They are less common in school workshops, perhaps because of their moving parts which present a high risk.

DESCRIPTION OF SHAPER MACHINE

▪



MAIN PARTS OF SHAPER MACHINE

- Base
- Column
- Cross rail
- Saddle
- Table
- Ram
- Tool head
- Shaper head

CLASSIFICATION OF SHAPER MACHINE

- Crank shaper
- Geared shaper
- Hydraulic
- Horizontal shaper
- Vertical shaper
- Travelling head shaper
- Plain shaper
- Universal shaper
- Push cut type shaper
- Draw type shaper

WORKS ON SHAPER MACHINE

- Shaping a vertical grooves
- Shaping horizontal flat surfaces
- Shaping a dovetail slide
- Shaping flat inclined surfaces
- Shaping v-block
- Shaping a jib and guide jib
- Shaping a curved surface

PLANER

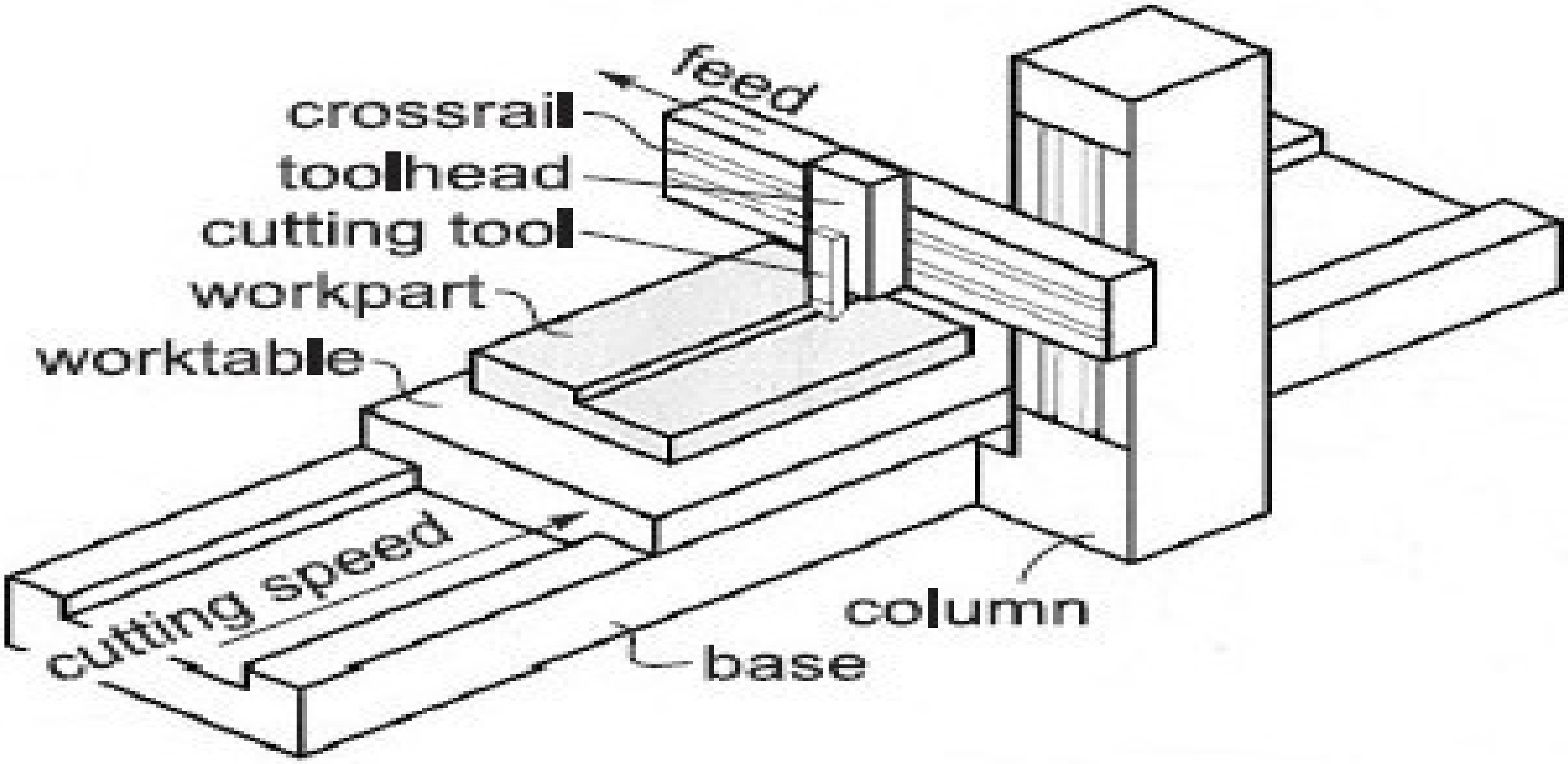
The machine tool for planning is a *planer*. Cutting speed is achieved by a reciprocating worktable that moves the part past the single-point cutting tool. Construction and motion capability of a planer permit much larger parts to be machined than on a shaper.

CLASSIFICATION OF PLANING MACHINE

1. Standard or double housing planer
2. Open side planer
3. Pit type planer
4. Edge or plate planer
5. Divided table planer
6. Universal planer

DESCRIPTION OF PLANER MACHINE

▪



Components of an open-side planer.

MAIN PARTS OF PLANER MACHINE

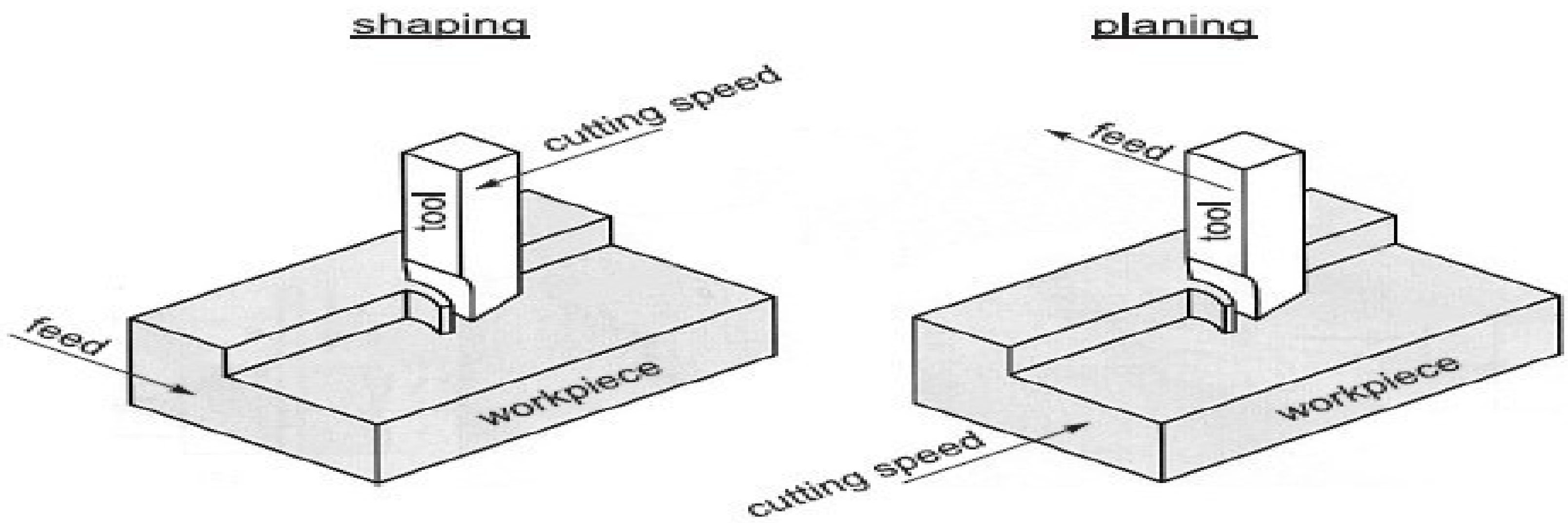
- Bed
- Table
- Housing
- Cross rail
- Saddle
- Tool head

WORKS ON PLANER MACHINE

- Bed and slides of all kind of machine
- Large structures and frames of different engine
- Locomotive frames
- Forging hammer die block
- Dies , jigs and fixtures
- Helical grooves on large valves
- Deep slot on large motors
- Roll mill bearing
- Lathe carriage and way
- Pressure plate
- Parts of large hydraulic presses

DIFFERENCE SHAPER AND PLANER

Planning and *shaping* are similar operations, which differ in the kinematics of the process. Planning is a machining operation in which the primary cutting motion is performed by the work piece and feed motion is imparted to the cutting tool. In shaping, the primary motion is performed by the tool, and feed by the work piece.



Kinematics of shaping and planing.

SALTTING MACHINE

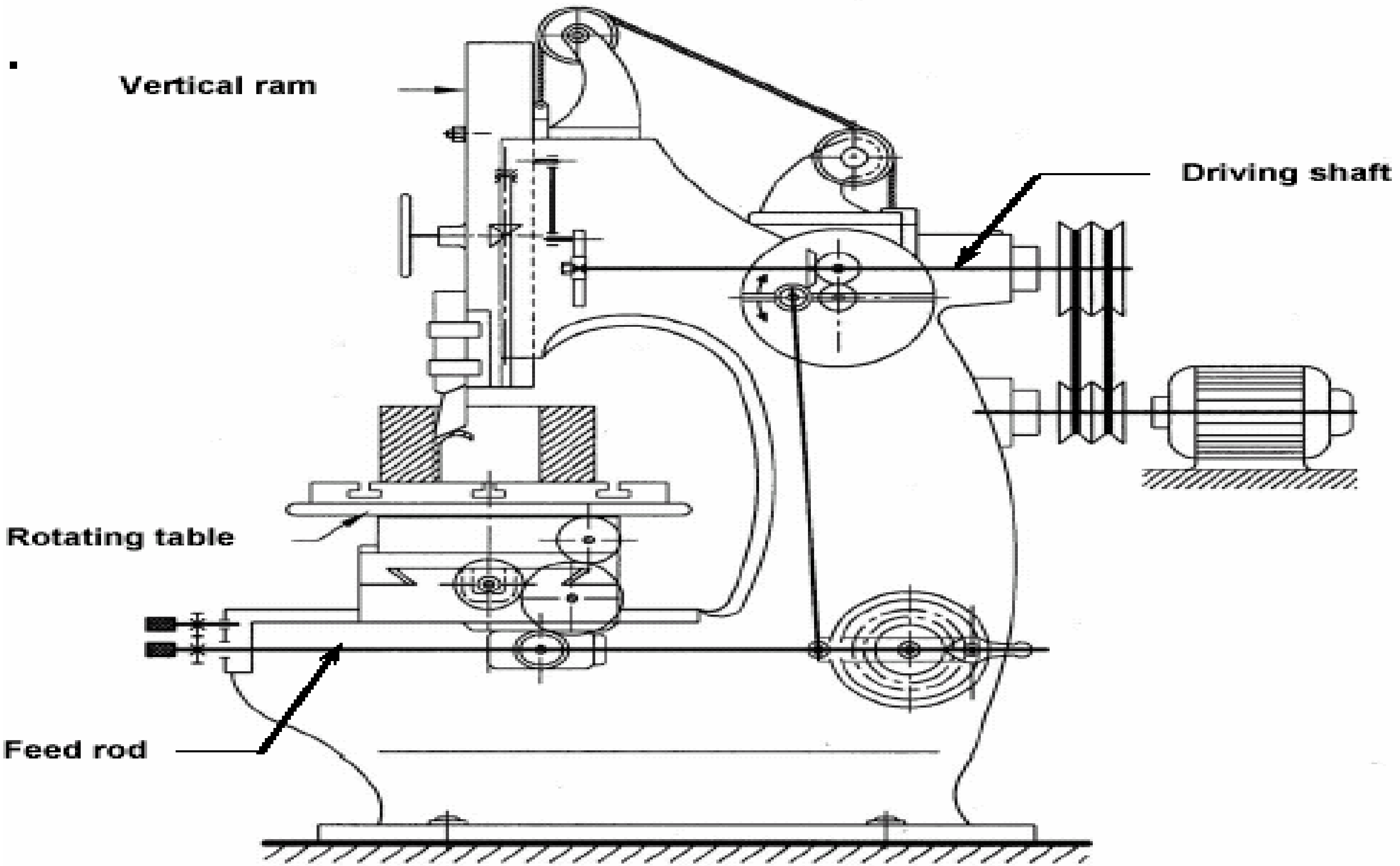
Slotting machines can simply be considered as vertical shaping machine. Unlike shaping and planning machines, slotting machines are generally used to machine internal surfaces (flat, formed grooves and cylindrical.

CLASSIFICATION OF SLOTTING MACHINE

1.Punch type slotter machine

2.Precision slotter machine

DESCRIPTION OF SLOTTING MACHINE



MAIN PARTS OF SLOTTING MACHINE

- Base
- Column
- Saddle
- Cross slide
- Rotary table
- Ram and tool head assembly

WORKS ON SLOTTING MACHINE

1. Cutting keyway or spline
2. Cutting serrations
3. Finishing die opening
4. Finishing a punch profile
5. Matching tall or bulky pieces
6. Finishing regular or irregular section
7. Cutting cam profile

DIFFERENCE BETWEEN SLOTTER AND PLANER

SALOTTING MACHINE

- Tool reciprocates
- Only one tool operates at a time
- Work is stationary with table feed motion
- Light duty machine
- Material removal rate is less as compared to planer
- Slotter ram of tool can be tilted with respect to table surface

PLANING MACHINE

- Tool is stationary with intermittent feed motion.
- Multiple tools can operate at a time
- Work reciprocates on the table
- Heavy duty machine
- Material removal rate is more
- No tilting of tool heads

UNIT – VI

BROACHING

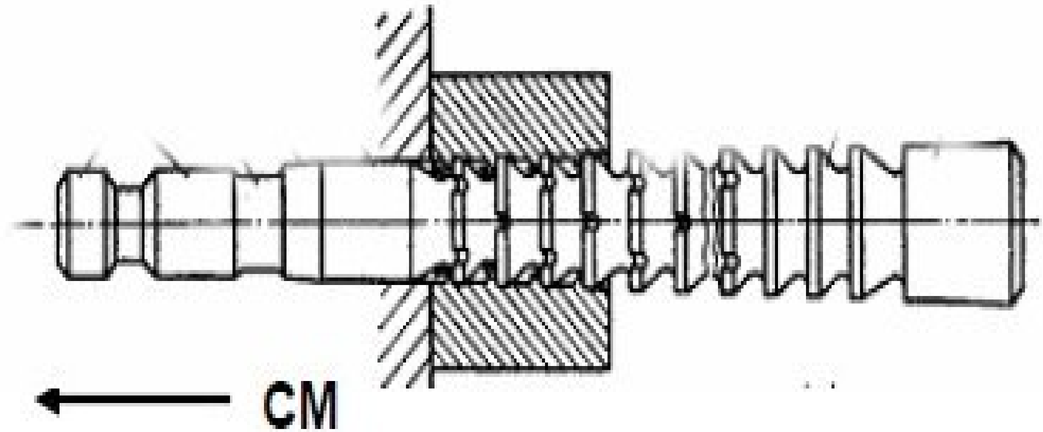
Broaching is a machining operation in which a tool used is called as **broach** having series of cutting teeth.

In this operation broach is either **Pulled** or **Pushed** with the help of broaching machine on the work piece surface.

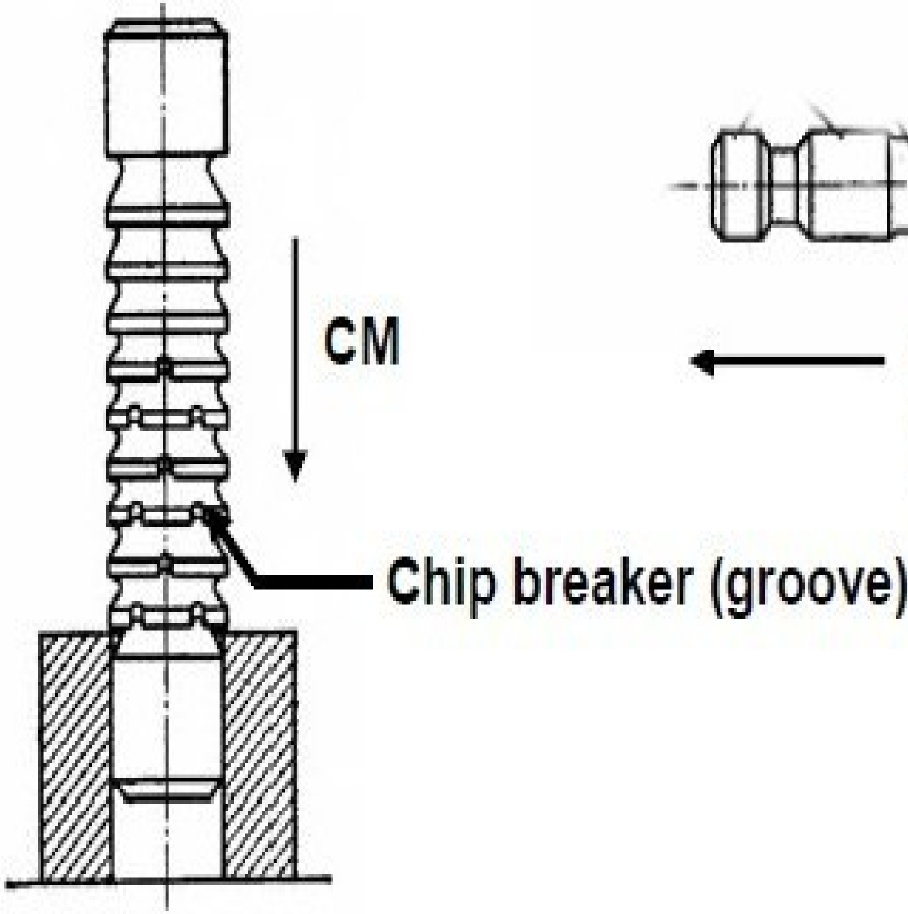
Parts that is produced by the broaching have **good surface finish** and **dimensional accuracy**.

PRINCIPLE OF BROACHING MACHINE

Broaching is a machining process for removal of a layer of material of desired width and depth usually in one stroke by a slender rod or bar type cutter having a series of cutting edges with gradually increased protrusion as indicated in Fig.a. In shaping, attaining full depth requires a number of strokes to remove the material in thin layers step – by – step by gradually in-feeding the single point tool (Fig.b).. Whereas, broaching enables remove the whole material in one stroke only by the gradually rising teeth of the cutter called broach. The amount of tooth rise between the successive teeth of the broach is equivalent to the in feed given in shaping.



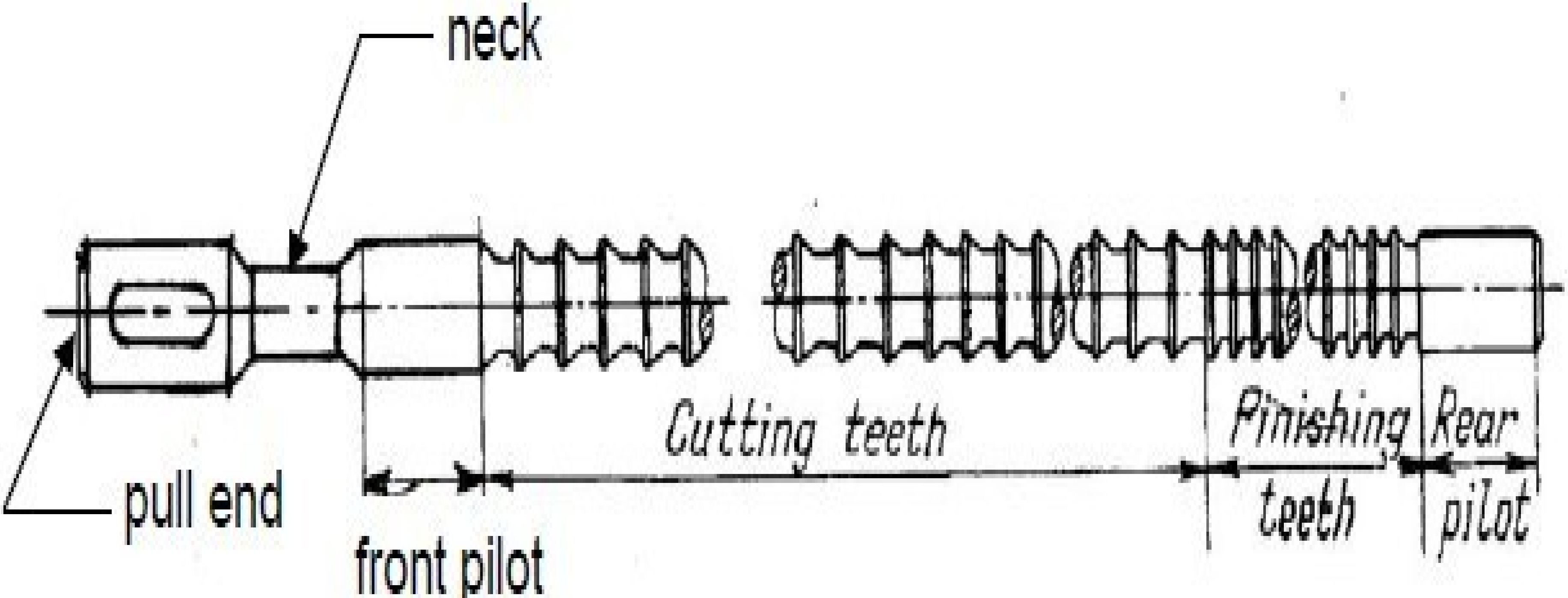
(a) horizontal pull type

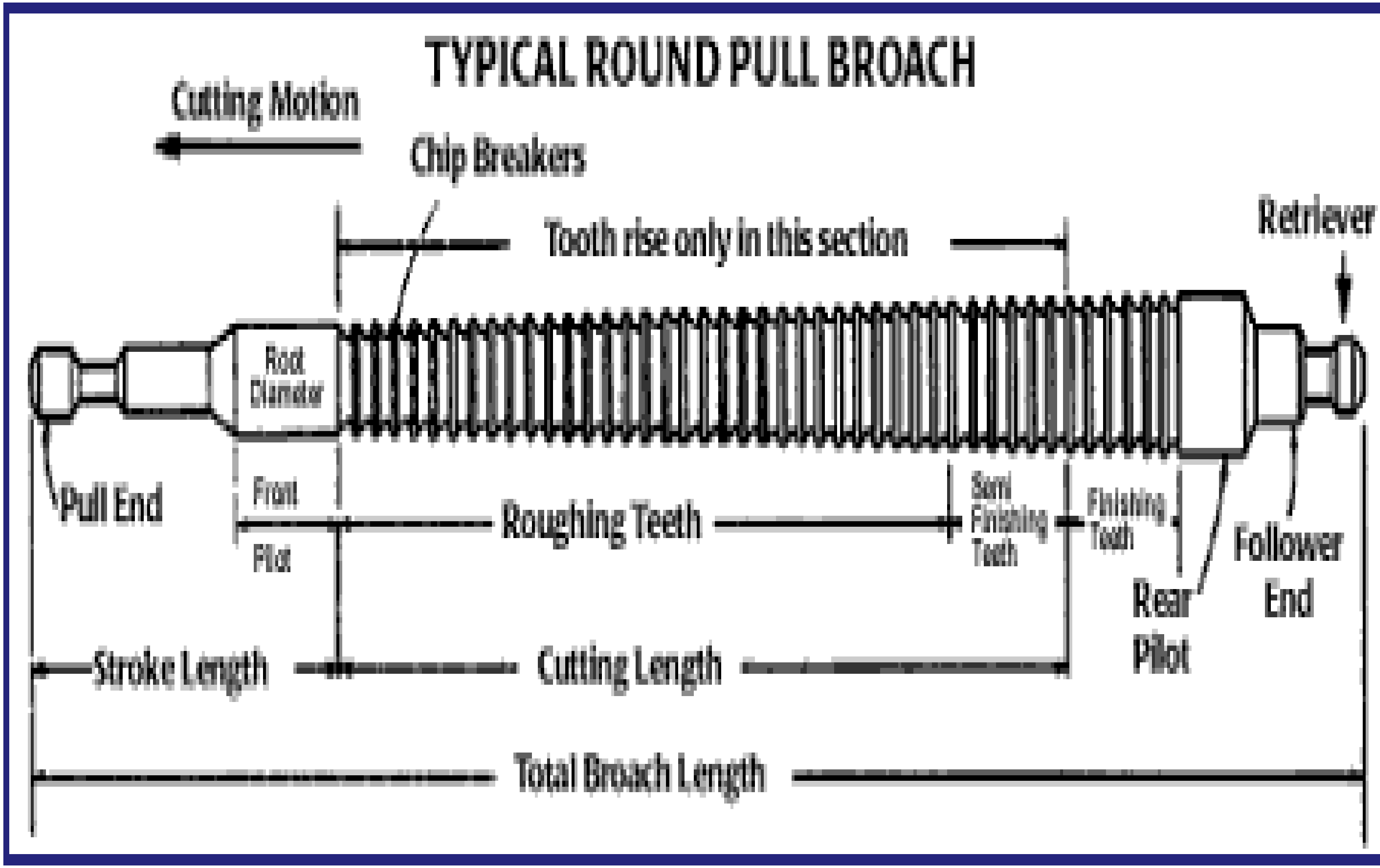


(b) vertical push type

NOMENCLATURE OF BROCHING TOOL

- Both pull and push type broaches are made in the form of slender rods or bars of varying section having along its length one or more rows of cutting teeth with increasing height (and width occasionally). Push type broaches are subjected to compressive load and hence are made shorter in length to avoid buckling.
- The general configuration of pull type broaches, which are widely used for enlarging and finishing preformed holes, is schematically shown in Fig.


neck
pull end
front pilot
Cutting teeth
Finishing teeth
Rear pilot


TYPICAL ROUND PULL BROACH
Cutting Motion
Chip Breakers
Tooth rise only in this section
Retriever
Root Diameter
Pull End
Front Pilot
Roughing Teeth
Semi Finishing Teeth
Finishing Tooth
Follower End
Rear Pilot
Stroke Length
Cutting Length
Total Broach Length

NOMENCLATURE OF BROCHING TOOL

- Pull end for engaging the broach in the machine.
- Neck of shorter diameter and length, where the broach is allowed to fail, if at all, under overloading.
- Front pilot for initial locating the broach in the hole.
- Roughing and finishing teeth for metal removal
- Finishing and burnishing teeth for fine finishing
- Rear pilot and follower rest or retriever

TYPES OF BROACHES MACHINE

- According to method of operation

  Push , pull or stationary broaches.
- According to type of operation

  Internal or external broaches.

- According to shape

  Solid , inserted tooth, built up or replaceable.
- According to function

  Roughing , finishing , keyways , burnishing, sizing and serrating.

Internal and external broaches

CLASSIFICATION OF BROACHING MACHINE

- Horizontal broaching machine.
- Vertical broaching machine.
- Duplex head broaching machine.
- Surface broaching machine.
- Continuous broaching machine.

BROACHING TECHNIQUES

1. Internal broaching 2. External broching

UNIT – VII

JIGS AND FIXTURES

Jigs and fixtures are special devices used for large scale production. The production of components with the help of jigs and fixtures is based on the concept of interchangeability where components are produced with in established tolerances. Jigs and fixture provide the means of clamping the components rapidly without any additional set up.

JIG : *A device that holds the work and locates the path of the tool.*

FIXTURE: *A device fixed to the worktable of a machine and locates the work in an exact position relative to the cutting tool.*

ELEMENT OF JIG AND FIXTURE

- Locating elements
- Clamping elements
- A rigid body in to which work piece are loaded
- Tool guiding element or tool setting element.
- Element for positioning or fastening the jig or fixture on the machine on which it is used.

USES OF JIGS AND FIXTURES

1) To reduce production cost
2) To increase production rate
3) To ensure high accuracy in part manufacture
4) To enable heavy and complicated complex shaped parts to be machined by being held rigidly to a machine
5) To provide interchange ability
6) Reduce quality control expenses
7) Less skilled labour & save labour costs
8) Improve work safety

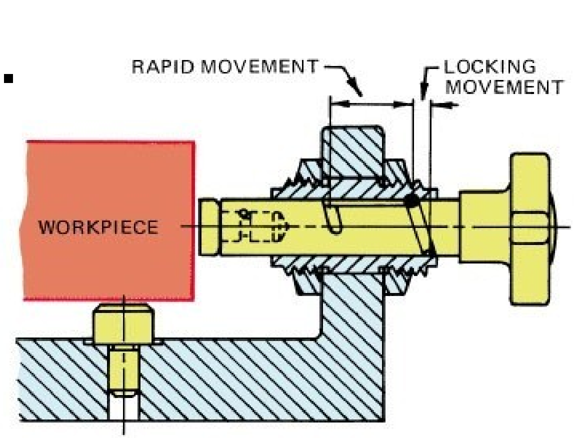
MATERIALS FOR JIGS AND FIXTURES

- Timber
- Cast iron
- Light metals
- Brasses and bronzes
- Steels

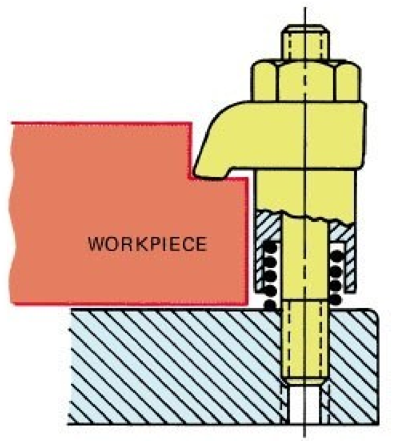
PRINCIPLES OF JIG AND FITURE DESIGN

- Reduction of ideal time
- Study of component
- Study of machine
- Production requirement
- Rigidity
- Location
- Loading
- Ejection of component
- Design for safety
- Coolant passage
- Swarf clearance
- Clamping
- Bushes
- Burr grooves
- Trunnions
- Jig base
- Spring location
- Wear

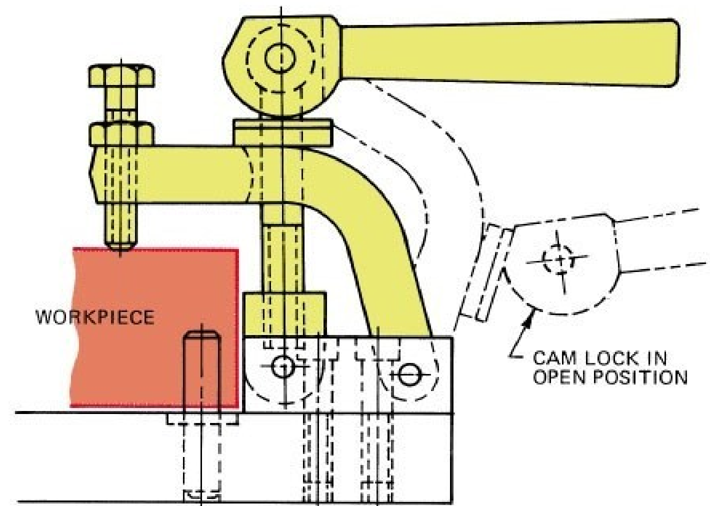
CLAMPING DEVICES



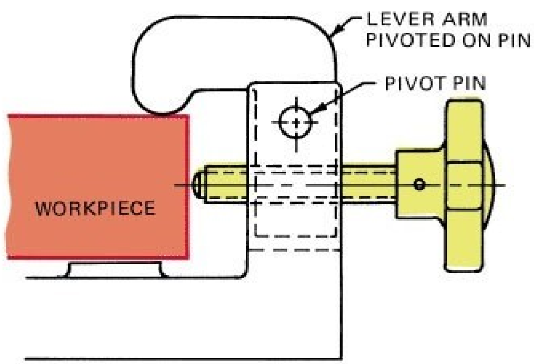
(A) LONG-TRAVEL CAM-LOCK CLAMP



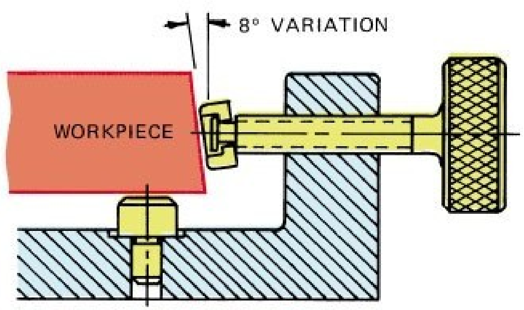
(B) SPRING-LOADED HOOK CLAMP



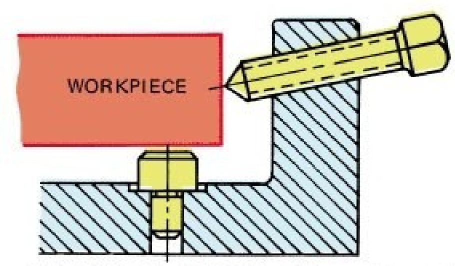
(C) HINGED CAM-ASSEMBLY CLAMP



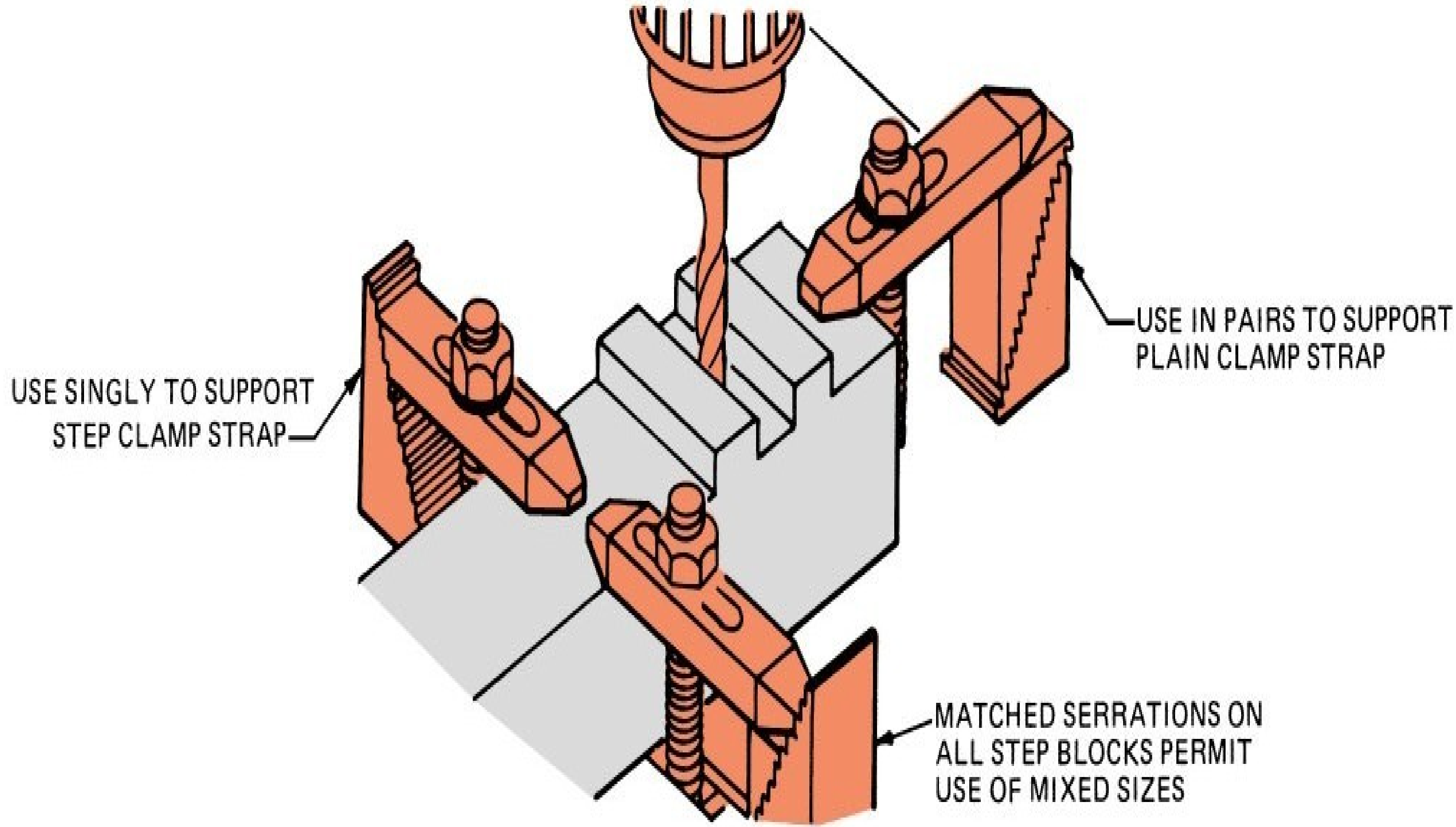
(D) TWO-DIRECTION CLAMP



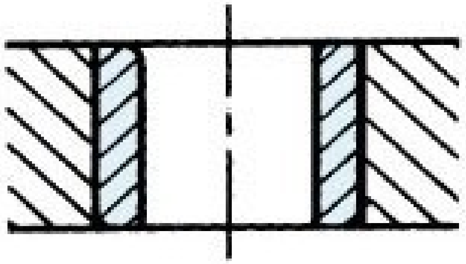
(E) TOGGLE-SCREW CLAMP



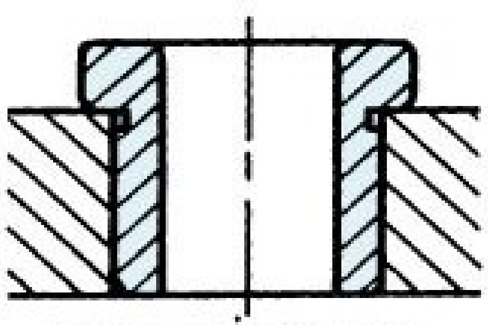
(F) CONICAL-POINT SETSCREW CLAMP


USE IN PAIRS TO SUPPORT
PLAIN CLAMP STRAP
USE SINGLY TO SUPPORT
STEP CLAMP STRAP
MATCHED SERRATIONS ON
ALL STEP BLOCKS PERMIT
USE OF MIXED SIZES

JIG BUSHES



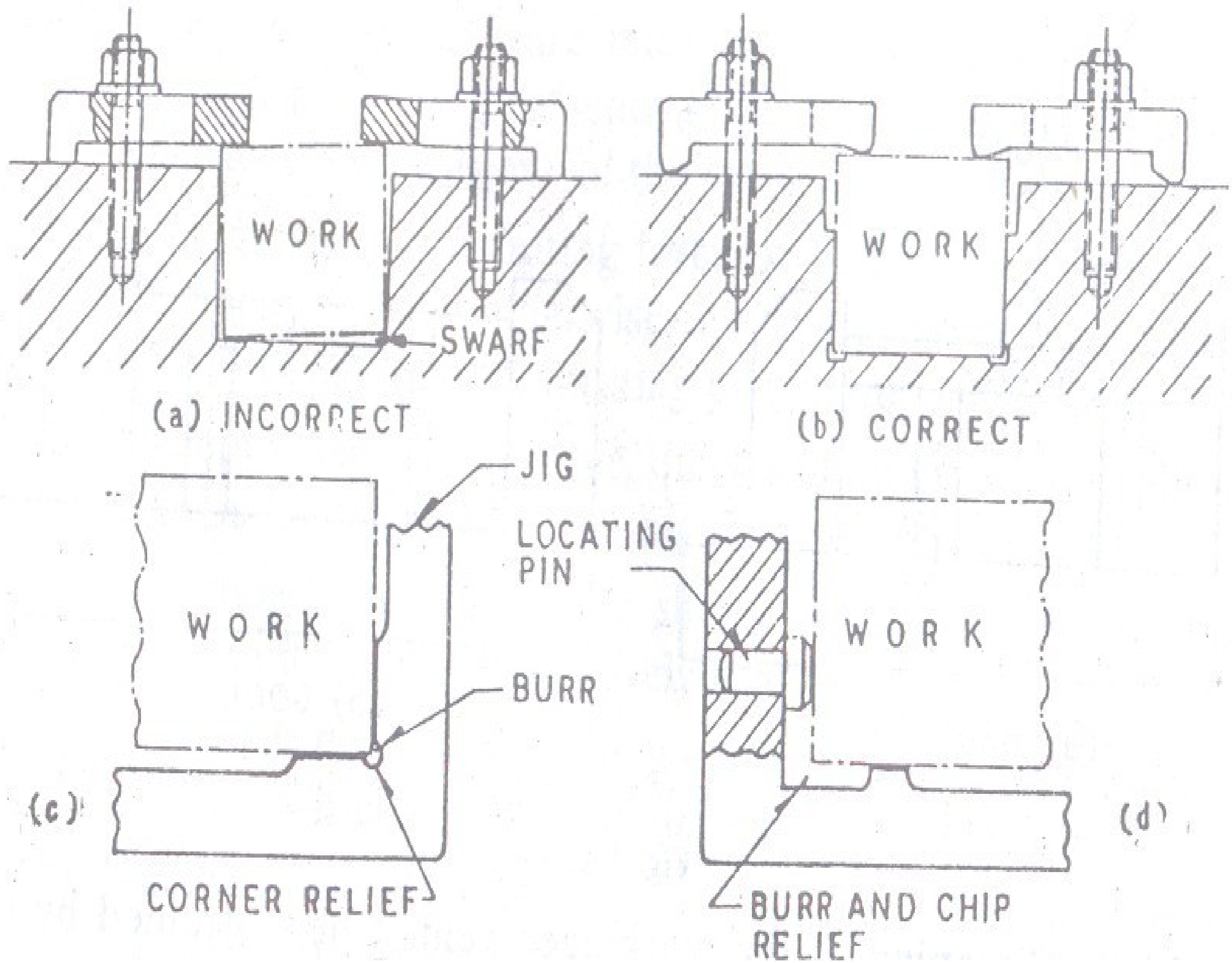
(A) HEADLESS



(B) HEAD TYPE

PRINCIPLE OF LOCATION

1) The principle of minimum locating points
2) The principle of mutually perpendicular planes
3) The principle of extreme position of pins
4) Relief should be provided where burr or swarf will get collected
5) Locating surface should be raised above the surrounding surfaces of J/F so that chips can be swept off readily.
6) Sharp corners in the locating surfaces must be avoided
7) Adjustable type locators to be used for rough surfaces

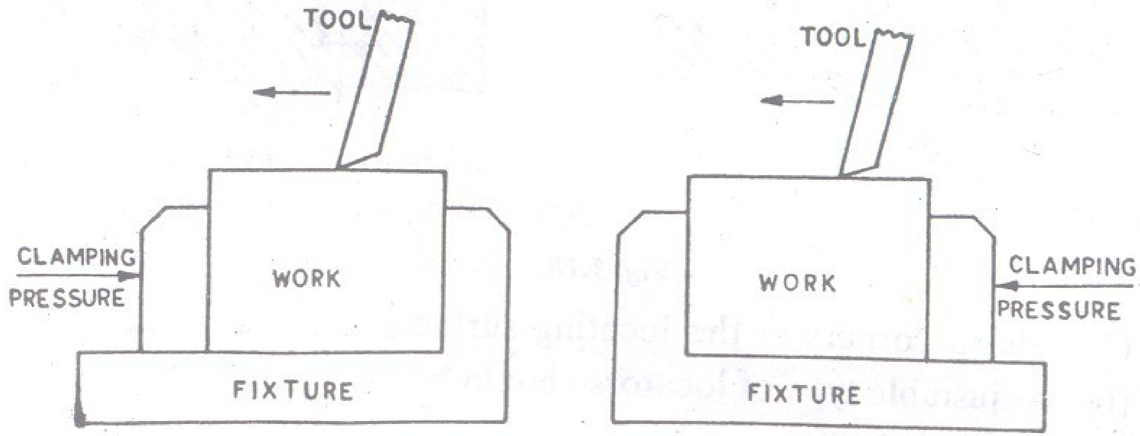

WORK
SWARF
(a) INCORRECT
WORK
(b) CORRECT
JIG
WORK
BURR
(c)
CORNER RELIEF
LOCATING PIN
WORK
(d)
BURR AND CHIP RELIEF

LOCATING DEVICES

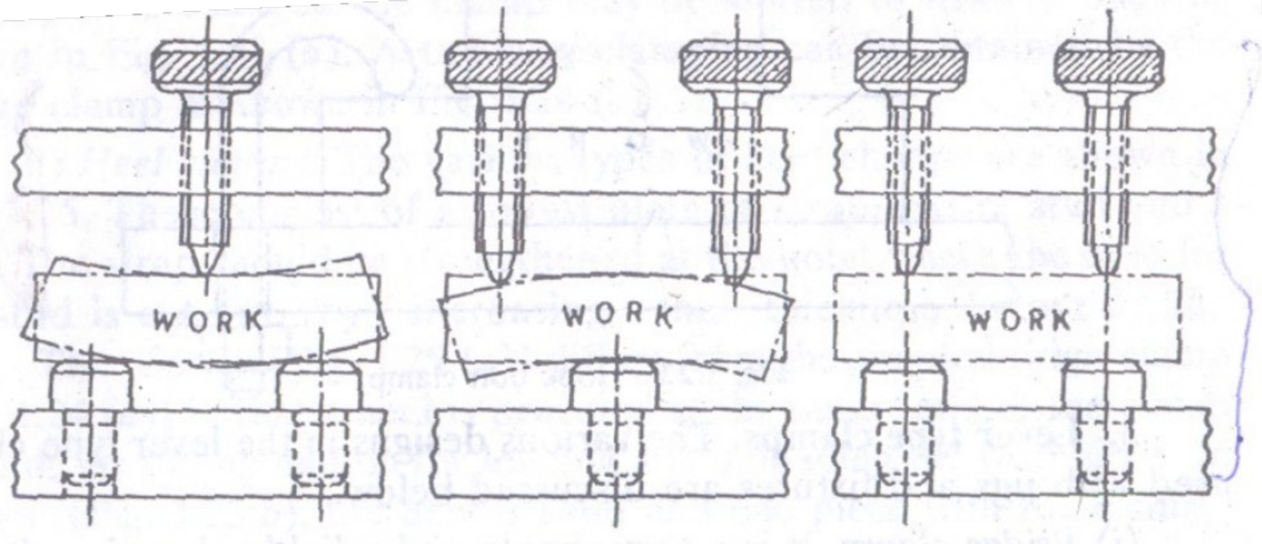
- Flat locators
- Cylindrical locators
- Conical locators
- Jack pin locators
- Vee locators
- Adjustable locators
- Flattened locators

PRINCIPLES OF CLAMPING

1) The clamping pressure applied against the work piece must counteract the tool forces
2) The clamping pressure should not be directed towards the cutting operation. Wherever possible it should be directed parallel to it.
3) The clamping pressure must not damage/deform the work surface.
4) Clamps should be arranged directly above the points supporting the work, otherwise distortion of work may occur.
5) Clamping pressure should be directed towards the points of support, else the work will tend to rise from support
6) Clamping should be simple, effective and fool proof.
7) Fibre pads should be riveted to clamp faces to avoid damage to fragile work pieces



(a) BAD (b) GOOD



(a) (b) (c)

TYPES OF CLAMPING

- Screw clamp
- Pivoted clamp
- Equalizing clamp
- Retractable clamp
- Two way clamp
- Edge clamp
- Special strap clamp
- Button clamp
- Plate strap clamp
- Hook bolt clamp
- Eccentric or cam clamp
- Swing leaf or latch type clamp
- Toggle clamp
- C- clamp

TYPES OF DRILLING JIGS

1. Template jig
2. plate type jig
3. Open type jig
4. Channel jig
5. Leaf Jig
6. Box type jig
7. Post jig
8. Pot jig
9. Indexing jig
10. Vice type jig

Template Jig

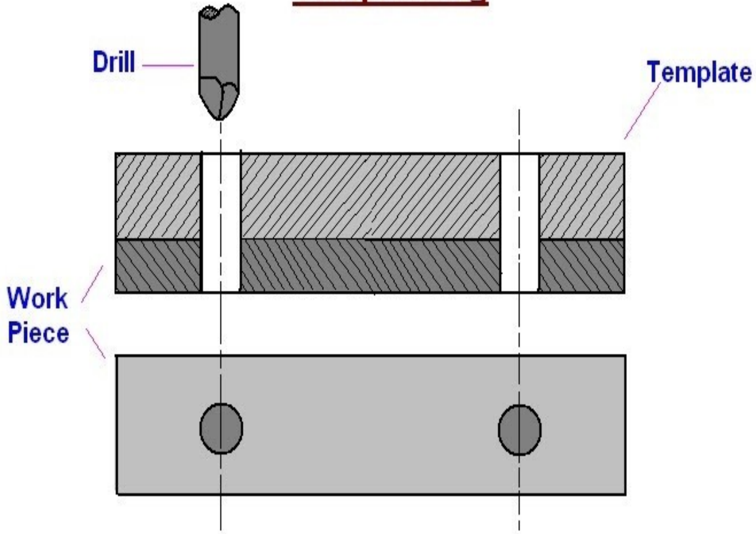
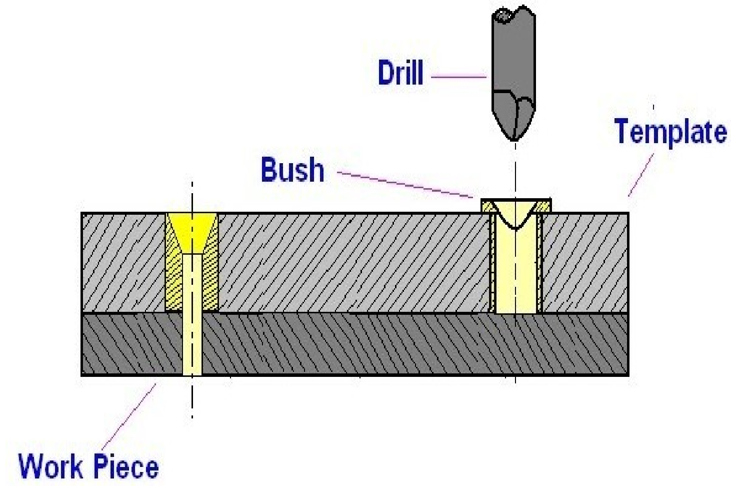
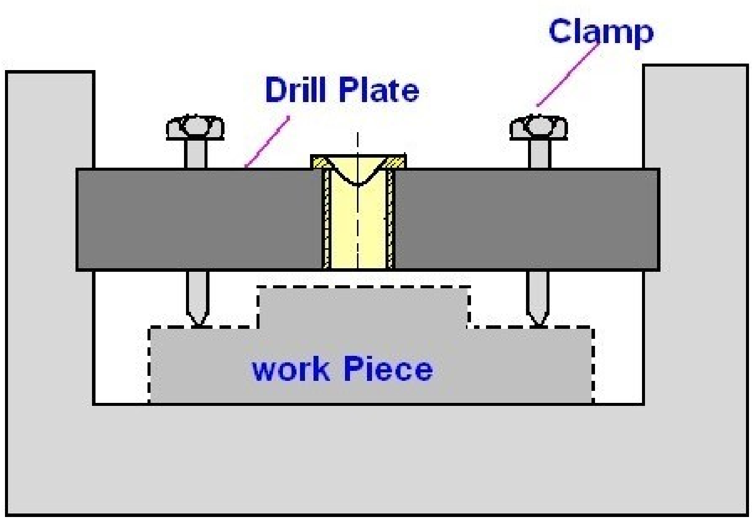


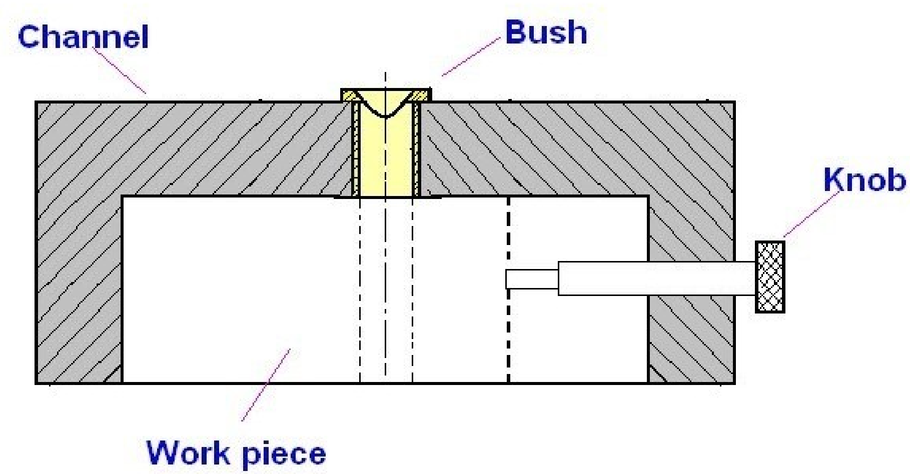
Plate Type Jig



Open Type Jig



Channel Jig



JIG BUSHES

- Fixed bushes
- Linear bushes
- Slip bushes
- Renewable bushes
- Special bushes
- Extended drill bush
- Screwed drill bush

DIFFERENCE BETWEEN JIGS AND FIXTURE

JIG	FIXTURE
Locates and Holds the work and guides the cutting tool in true position of the work	Only Holds & Positions the work, but doesn’t guide the work
Work Locating elements, Tool Guiding elements & Work Clamping elements	Work Locating elements, Tool setting elements & Work Clamping elements
Light	Heavy
Drilling, reaming , Tapping, Counterboring, Countersinking	Milling, Turning, Grinding, Broaching etc
Drill bushes used for tool guiding	Feeler gauges, setting blocks to adjust position of tool in relation to work

UNIT – VIII

CUTTING FLUIDS AND LUBRICANTS

- **CUTTING FLUID**
- Essential in metal-cutting operations to reduce heat and friction Centuries ago, water used on grindstones
- 100 years ago, tallow used (did not cool) Lard oils came later but turned rancid Early 20th century saw soap added to water Soluble oils came in 1936
- Chemical cutting fluids introduced in 1944

FUNCTIONS OF CUTTING FLUID

- To reduce cutting forces.
- To decrease wear and tear of the tool and increase tool life.
- To provide lubrication effect to the tool , work piece and chip.
- To improve surface finish and machinability.
- To protect the finished surface from oxidation and corrosion.
- To wash away the chip, scale and dust from and in between the working surfaces.
- To minimize friction at the matting surfaces thus prevent rapid rate increase of temperature.

PROPERTIES OF CUTTING FLUID

- It should be chemically stable.
- It should be non corrosive.
- It should be high flash point.
- It should cause no skin irritation.
- It should prevent the electrochemical effect of corrosion.
- It should not deteriorate on storage.
- It should be low cost.
- It should be readily available in qualities required for use.

TYPES OF CUTTING FLUIDS

- Neat cutting oils.
- Soluble oils.
- Synthetic fluids.
- Semi synthetic fluids.
- Mineral cutting oils.
- Chemical additive oils.
- Sulphurised mineral oils.
- Chemical compounds.

APPLICATION OF CUTTING FLUIDS

- By hand or brush
- Flood method
- Jet method
- Mist method

LUBRICANT

The function of a lubricant is simple. It The function of a lubricant is simple. It reduces friction between moving metal surfaces. A lubricant coats surfaces and resists being displaced by the pressure, keeping the metal parts separated. Lubricants also prevent corrosion, block contaminants and can serve as a coolant. A good lubricant flows easily under pressure and remains in contact with moving surfaces. It does not leak out from gravitational or centrifugal forces nor does it stiffen in cold temperatures.

TYPES OF LUBRICATION

- Solid lubrication

  Graphite , Zinc oxide , Molybdenum

- Semi – solid lubrication

  Greases

- Liquid lubrication

  Oils

COMMON METHODS OF LUBRICATION OF MACHINE TOOLS

- Grease cup
- Gravity feed
- Oil can
- Force feed
- Splash lubrication
- Hand oiling

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