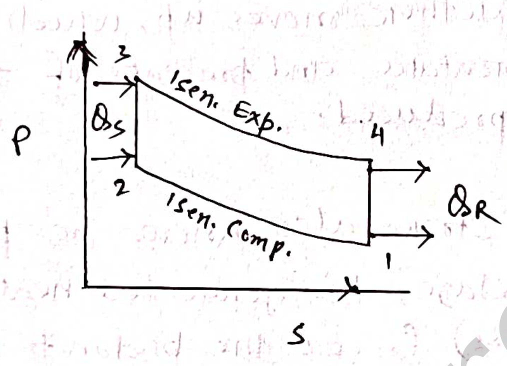
PETROL ENGINE

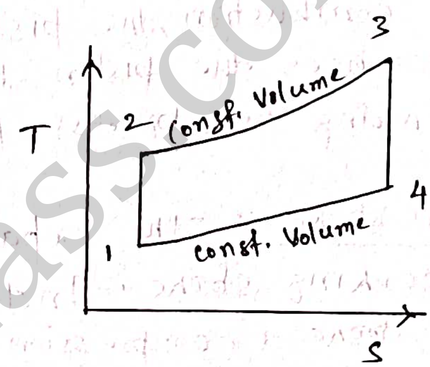
1) Working Principle : The petrol engine, also known as spark ignition (SI) engine working principle is smiliar to the compression ~~ratio~~ ignition (CI) engine, but there is little difference.

A petrol engine works according to the Otto cycle. A petrol engine works in the following ~~way~~ Process —

* Process 1-2 : Adiabatic (isentropic) compression
* Process 2-3 : Constant-volume heat addition
* Process 3-4 : Adiabatic (isentropic) expansion
* Process 4-1 : Constant-volume heat rejection



P-V Diagrame



T-S Diagrame

Petrol Engine engine works on below ways —

* Suction stroke
* Compression stroke
* Expansion or Working or Power Stroke
* Exhaust stroke

~~* Compression stroke~~
~~* Working stroke~~
~~*~~

⇒ Suction Stroke : For the suction stroke or Intake stroke, the ~~moves~~ piston moves downward. As it moves down, a vaccum creates inside the combustion chamber; due to that, the air-fuel mixture starts coming from the outside into the combustion chamber in correct proportion.

In this stroke, the suction valve opens, and the exhaust valve remains closed.

⇒ Compression Stroke : When the suction process of the air-fuel mixture completes according to the requirements, the piston travels upwards for the air-fuel mixture compression.

As the piston moves up, it pressurizes the mixture into the combustion chamber. During this stroke, the intake valve and exhaust valve are closed.

Due to the compression stroke or process, the temperature of the air-fuel mixture became very high.

At the end of the compression process, a spark plug fires a spark and ignites the air-fuel mixture.

Due to the provided spark, the combustion process of the air-fuel ~~f~~ mixture occurs inside the combustion chamber. Due to this combustion, the piston further moves up, which further increases the ~~piston~~ temperature and pressure of the mixture. During this process, heat produced.

⇒ Expansion Stroke :- The expansion stroke also known as power stroke or working stroke. In this stage, the generated heat in the previous stroke (compression process) forces the piston to move downward (TDC to BDC) and turns the crankshaft.

Due to piston's downward motion, the air-fuel mixture expands inside the chamber, and the pressure of the mixture decreases.

⇒ Exhaust stroke :- In this stroke, the piston moves upward, opens the exhaust valve, and releases useless gases from the combustion chamber.

After completing the exhaust stroke, the piston again moves down and all four strokes repeat.

Parts of Petrol Engine :- The main parts of Petrol engine are given below –

1. Spark plug
2. Cylinder or Combustion chamber
3. Carburetor
4. Piston
5. Intake or suction valve
6. Connecting rod
7. Exhaust Valve

DIESEL ENGINE

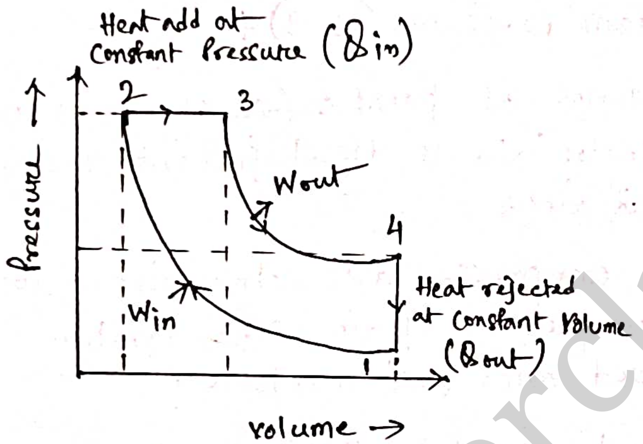
1 Working Principle of Diesel Engine —

A diesel engine works on the basic principle of the diesel cycle consists of four processes those are —

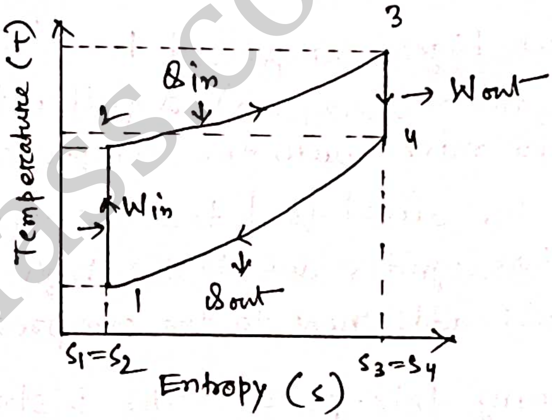
1. Suction Stroke
2. Compression stroke
3. Expansion stroke
4. Exhaust stroke

OR

1. Process – 1 (suction) (0 – 1)
2. Process – 2 [Isentropic Compression] (1 – 2)
3. Heat Addition at Constant Pressure Process – 2 (2 – 3)
4. Isentropic Expansion-Process – 4 (3 – 4)



P-V Diagram



T-S Diagram

⇒ Process -1 [Suction Stroke] – (0–1):

- For the suction of air, the engine piston moves from TDC to BDC (down ward stroke). As it moves downward, the fresh air starts entering the engine cylinder from the ~~at~~ atmosphere.
- During this process, the exhaust valve remains closed, and the suction valve opens.

⇒ Process 2 Isentropic Compression (1–2):

- After suction, the suction valve closes and the piston moves up (from BDC to TDC)
- During the compression process, the temperature of the air increases from T_1 to T_2 the volume redues from V_1 to V_2 and pressure rises from P_1 to P_2.

- However during this whole process, there is no change in ~~enth~~ enthalpy ($s_1 = s_2$).
- This process is Known as Isentropic because there is ~~chan~~ no change of enthalpy.
- In isentropic compression, the air is compressed up to such high ~~temperature~~ temperature and pressure that the air-fuel mixture ignites ~~itself~~ itself, and it doesn't need any extra external heat source or spark plug.

⇒ Process 3 Heat Addition at Constant Pressure (2-3) :-

- When highly compressed ~~I~~ air reaches at point 2 (as shown in the PV and TS diagram), a fuel injector injects diesel fuel into the cylinder, which mixes with the compressed air.
- As the diesel fuel touches the compressed air, the air-fuel mixture ignites due to the high compression of air. This ignition process adds heat to the compressed air-fuel mixture.
- During this process, the piston becomes constant, and pressure also remains constant ($P_2 = P_3$). However, enthalpy increases from S_2 to S_3, temperature increases from T_2 to T_3, and also volume increases from V_2 to V_3.

⇒ Process 4 Isentropic Expansion (3-4) :-

- In this process, the mixture expands into the cylinder.
- Due to the expansion, the heat of the ignited air-fuel mixture works on the piston and forces it to move down, which rotates the crankshaft. This rotation of the crankshaft further moves the car.
- During this whole process, the pressure of mixture falls from P_3 to P_4, Volume increases from V_3 to V_4, and temperature also reduces from T_3 to T_4, However, entropy doesn't change $S_3 = S_4$.

⇒ Process 5 Constant Volume Heat Rejection (4-1):-

- After the expansion process, the piston moves downward to remove the waste heat from the cylinder.

TRANSMISSION SYSTEM

The mechanism that transmits the power developed by the engine of automobile to the engine to the driving wheels is called the Transmission System (Power Train). It is composed of —

- Clutch
- The gear box
- Propeller shaft
- Universal joints
- Rear axle
- Wheel
- Tyres

⇒ Requirements of Transmission System —

- Provide means of connection and disconnection of engine with rest of power train train without shock and smoothly.
- Provide a varied leverage between the engine and the drive wheels.
- Provide means to transfer power in opposite direction.
- Enable power transmission at varied angles and varied lengths.
- Enable speed reduction between engine and the drive wheels in the ratio of 5:1.
- Enable diversion of power flow at right angles.
- Provide means to drive the driving wheels ~~and~~ at different speed when required.
- Bear the effect of torque reaction, driving trust and braking effort effectively.

⇒ Main Units of Transmission System —

- Clutch
- Gear Box
- Transfer Case
- Propeller Shaft and Universal Joints
- Final Drive
- Differential
- Torque Tube
- Road wheel

Type of Transmission System —

1. Manual Transmission
2. Intelligent Manual Transmission (IMT)
3. Automated Manual Transmission (AMT)
4. Automatic Transmission (AT)
5. Continously Variable Transmission (CVT)
6. Semi-automatic Transmission
7. Dual-clutch
8. Sequential
9. Torque Converter
10. Tip tonic

⇒ Manual Transmission —

A manual transmission is a system that requires the driver to manually select a gear by operating ~~by~~ a gear stick and clutch to change gears. This transmission system is consists of a set of gear (different sizes) along with a pair of shafts.

Advantages —

- It is considered better for off-road purposes.
- This type of transmission system provide high torque load.

Disadvantages —

- Not everyone can drive.
- Higher learner curve.
- These are require more work during driving.

⇒ Intelligent Manual Transmission —

Simply and quite accurately put the Intelligent Manual Transmission is a clutchless manual transmission. It is similar to the manual gearbox, it has gears and gear lever. The drivers almost feel like an automatic car as the IMT doesn't have a clutch padel, but just a brake and an accelerator pedal.

Advantages —

- By using IMT car, you can have complete control over what gear your car is in and you would'not have to rely on software.
- The cost of an IMT is also closer to that of a regular manual transmission.

◊ Hand Forging ◊

A file is a high-carbon steel or alloy steel tool with a series of teeth designed to remove material from a workpiece by abrasion. Files are indispensable in hand forging for refining shapes and preparing surfaces for assembly or further processing.

Key Features of Files:

- *Material*: Made of high-carbon steel or alloy steel for durability.
- *Hardness*: Teeth are hardened to ensure long-lasting performance.
- *Versatility*: Suitable for various materials, including metals, wood, and plastics.

Applications:

- Smoothing rough surfaces after forging or machining.
- Creating precise dimensions and finishes.
- Sharpening cutting tools, saws, and blades.

Parts of a File:

- *Tang*: The narrow, pointed end that fits into the handle.
- *Heel*: The flat section at the base of the file's body.
- *Face*: The working surface with teeth.
- *Edge*: The sides of the file, which may be toothed or smooth.

Types of Files

Files are categorized based on their shape, cut pattern, and specific applications.

Types Based on Shape

Flat File:

Rectangular cross-section with one or both edges tapered and teeth on all faces.
Uses: General-purpose filing for flat surfaces, squaring edges, and large areas.

Round File:

Circular cross-section with uniform tapering.
Uses: Filing concave surfaces, enlarging holes, and shaping internal contours.

Half-Round File:

One flat side and one curved side.
Uses: Versatile for flat and curved surfaces, ideal for general and detailed work.

Triangular File:

Triangular cross-section with sharp edges.
Uses: Filing corners, grooves, and V-shaped notches.

- *Light Pressure*: Prevents surface deformation.
- *Single-Directional Filing*: Ensures smooth and precise results.
- *Use of Lubricants*: Apply light oil or kerosene to reduce friction and clogging.

Common Defects in Filing

- *Clogged Teeth*: Reduces efficiency; use a file card for cleaning.
- *Rounded Edges*: Caused by uneven filing pressure.
- *Chipped Teeth*: Results from excessive force or improper use.

@ *Soldering in Hand Forging*

Soldering is a vital process in metalworking, including hand forging, where it is used to join metal pieces together using a filler material (solder). This section explains the meaning of solder, the role of fluxes, and their effects on different metals.

Definition

- Soldering is a process of joining two or more metal pieces by melting a filler material (solder) that has a lower melting point than the workpieces.
- The process occurs below **450°C**, distinguishing it from brazing and welding.

Characteristics of Solder

- *Composition*: Commonly made of tin (Sn) and lead (Pb) in various proportions. Lead-free solders are also widely used, especially in electrical and plumbing applications.
- *Melting Point*: Ranges from **180°C to 250°C** depending on the solder composition.
- *Forms*: Available as wires, bars, or preformed pellets.

Applications

- *Electrical Work*: Joining wires and components in circuits.
- *Sheet Metal Work*: Sealing joints in roofing or ductwork.
- *Plumbing*: Creating leak-proof connections in pipes.

Fluxes in Soldering

Flux is a chemical cleaning agent applied to the metal surfaces before soldering to remove oxides and contaminants. It ensures a strong, clean bond between the solder and the workpiece.

Types of Flux

- *Rosin Flux*:
  - Derived from pine resin.
  - Used primarily in electronics for non-corrosive applications.
- *Acid Flux*:

@ ***Rivet Joint***

Rivet Joint: A rivet joint is a permanent mechanical fastener joint that consists of a cylindrical shaft with a head on one end. The tail end of the rivet is deformed using a hammer or rivet gun to create a second head, securing the materials together.

Applications of Rivets

- *Construction*: Joining steel plates in bridges, towers, and buildings.
- *Automotive*: Fixing body panels and components.
- *Aerospace*: Riveting aircraft skins for structural integrity.
- *Shipbuilding*: Assembling hulls and structural parts.

Types of Rivets

Solid Rivets

- *Description*: Made from a single piece of metal, requiring a hammer or rivet gun for installation.
- *Materials*: Steel, aluminum, copper.
- *Uses*: Heavy-duty applications like bridges and aircraft.

Blind Rivets (Pop Rivets)

- *Description*: Can be installed from one side of the material.
- *Structure*: Includes a mandrel that snaps after installation.
- *Uses*: Automotive and construction work where access to the back of the joint is restricted.

Tubular Rivets

- *Description*: Hollow rivets with a partial or full hole through the shank.
- *Uses*: Leatherworking, lightweight materials, and decorative applications.

Split Rivets

- *Description*: The shank splits into two parts when driven, forming a secure connection.
- *Uses*: Woodworking and light materials.

Flush Rivets (Countersunk Rivets)

- *Description*: Have a flat head that sits flush with the surface after installation.
- *Uses*: Aircraft and aerodynamic surfaces where smoothness is essential.

Self-Piercing Rivets

- *Description*: Can pierce the material during installation without pre-drilling holes.
- *Uses*: Automotive and thin sheet metal applications.

◊ Basic Fitting ◊

@ ***Linear Measurements and Its Units***

Linear measurement determines the length, width, or height of an object. It is crucial for precise fitting and assembly in mechanical work.

Tools Used for Linear Measurement-

- **Steel Rule**: Measures small lengths, typically accurate up to ±0.5 mm.
- **Measuring Tape**: Used for longer distances, commonly 3 m, 5 m, or 10 m in length.
- **Vernier Caliper**: Measures internal, external, and depth dimensions with a least count of 0.02 mm or 0.01 mm.
- **Micrometer**: A precision tool for measuring small dimensions, with a least count of 0.01 mm or 0.001 mm.

Units of Measurement-

Metric System:

- Millimeter (mm): 1 mm = 0.001 m
- Centimeter (cm): 1 cm = 0.01 m
- Kilometer (km): 1 km = 1000 m

Imperial System:

- Inch (in): 1 inch = 25.4 mm
- Foot (ft): 1 foot = 12 inches

Conversions-

- To convert meters to inches: Multiply by 39.37.
- To convert inches to millimeters: Multiply by 25.4.

Example:
Convert 5.25 inches to millimeters:
5.25 × 25.4 = 133.35 mm

Applications

- Used in quality control to verify dimensions.
- Essential for fitting operations and machining processes.

Advanced Tools

- **Digital Vernier Calipers**: Provide electronic readings with high accuracy.
- **Laser Measuring Tools**: Used for long distances with high precision.

3. **Grooving and Slotting**:
    - Cross-cut and cape chisels are used for creating grooves, keyways, and slots.
4. **Shaping and Finishing**:
    - Round-nose and diamond-point chisels are used for detailed shaping and finishing tasks.

@ *Files – Types, Grade, Cut, Section, Length, Care, and Uses of Common Files*

Files are hand tools used for shaping, smoothing, and finishing metal, wood, or plastic surfaces. They consist of a hardened steel blade with cutting teeth and a handle for grip. In fitting tasks, files are indispensable for achieving precision and finishing work.

Construction

A file is made of high-carbon steel or alloy steel, hardened and tempered to retain its cutting teeth. The file consists of the following parts:

- **Blade**: The working surface with cutting teeth.
- **Tang**: The pointed end inserted into the handle.
- **Handle**: Made of wood or plastic, it provides a firm grip.

Types of Files

Files are classified based on their shape, cut, and usage:

1. **Flat File**:
    - Rectangular cross-section with tapering edges.
    - Used for general-purpose filing, such as flattening or smoothing surfaces.
2. **Half-Round File**:
    - One flat side and one rounded side.
    - Used for filing flat and curved surfaces.
3. **Round File**:
    - Circular cross-section.
    - Used for enlarging holes or filing curves.
4. **Square File**:
    - Square cross-section.
    - Used for filing square holes or grooves.
5. **Triangular File**:
    - Triangular cross-section.
    - Used for filing corners or angles.
6. **Needle File**:
    - Small files for intricate or detailed work.

Grades of Files

Files are graded based on the coarseness of their teeth:

- **Rough**: Large, widely spaced teeth for heavy material removal.
- **Bastard**: Medium teeth for general-purpose work.
- **Second Cut**: Finer teeth for semi-finishing tasks.
- **Smooth**: Very fine teeth for finishing and polishing.

Cuts of Files

The arrangement and angle of teeth determine the cut of a file:

@ *Drills and Drilling Machines*

Drills and drilling machines are fundamental tools in the fitting workshop, used for creating precise cylindrical holes in various materials. Understanding the components, types, and proper usage of drills and drilling machines ensures accuracy, efficiency, and safety in operations.

Drills and Their Terms

Types of Drills (Based on Shank, Flute, and Systems of Size)

1. **Shank Types**:
    - **Straight Shank**: Used in handheld or small drilling machines; fits directly into the chuck.
    - **Taper Shank**: Fits into the tapered hole of a machine spindle, ensuring self-locking.
2. **Flute Types**:
    - **Straight Flutes**: Used for soft materials like plastic or wood.
    - **Helical Flutes**: Common in twist drills, designed for efficient chip removal.
3. **System of Sizes**:
    - **Metric System**: Sizes in millimeters, e.g., 5 mm, 10 mm.
    - **Imperial System**: Sizes in inches, e.g., 1/4 inch, 1/2 inch.
    - **Numbered or Lettered System**: For very small drill sizes, common in specific industries.

Drill Angle and Their Importance

Common Drill Angles

- **Point Angle**:
    - Standard: 118° for general-purpose drilling.
    - 135° for harder materials like stainless steel to reduce wear.
- **Helix Angle**:
    - Standard: 30° for twist drills.
    - Low helix (10–20°): For hard materials to prevent jamming.
    - High helix (40°): For soft materials like aluminum.
- **Clearance Angle**:
    - Ensures the cutting edge clears the workpiece material, reducing friction.

Importance

- Correct angles improve cutting efficiency and tool life.
- Reduces heat generation, minimizing material deformation.
- Ensures smooth chip removal and prevents drill breakage.

Coolant Use for Drilling

Purpose of Coolants

- Reduces heat generated at the cutting edge.
- Improves tool life by minimizing wear.
- Ensures smooth chip removal and prevents material sticking.

Types of Coolants

1. **Oil-Based Coolants**: Suitable for metals requiring lubrication.

◊ Welding ◊

Welding is a fabrication process that joins materials, typically metals or thermoplastics, by applying heat, pressure, or both. The materials melt and fuse together, forming a strong **permanent joint** upon cooling.

Types of Welding

Welding is divided by two groups – 1. Forge or Pressure Welding 2. Fusion or Non-pressure Welding.

Forge or Pressure Welding
This welding is done by pressure without additional filler metal. According to heat created by it is divided into three types-

1. Blacksmith's fire (Blacksmiths forge welding)
2. Electric current (Resistance welding)
3. Friction (Friction welding)

Further Resistance welding is divided into 6 types-

1. Spot welding
2. Seam welding
3. Projection welding
4. Upset butt welding
5. Flash but welding
6. Percussion welding

Brief Comparison of Resistance Welding Types

Aspect	Spot Welding	Seam Welding	Projection Welding	Upset Butt Welding	Flash Butt Welding	Percussion Welding
Description	Localized welding at discrete points using electrodes.	Continuous welding by rolling electrodes along the joint.	Welding at multiple points using projections on the workpiece.	Joining two parts by applying pressure and heat along the entire cross-section.	Joining two parts by flashing (arcing) and applying pressure.	Welding by applying high-intensity current for a very short duration.
Thickness	0.5–3 mm (up to 6 mm combined).	0.2–3 mm (thin sheets).	0.5–5 mm (depends on projection size).	1–25 mm (thicker materials).	3–50 mm (very thick materials).	Thin sheets and small components.
Joint	Lap joints.	Overlapping seams.	Lap joints with projections.	Butt joints.	Butt joints.	Lap or butt joints.
Applications	Automotive body panels, electronics, appliances.	Liquid-tight joints in tanks, pipes, and radiators.	Nuts, bolts, and studs onto plates or sheets.	Joining rails, rods, and wires.	Heavy-duty applications like axles, pipes, and frames.	Precision components in electronics and aerospace.

Advantages	High speed, low cost, localized heat.	Continuous welds, liquid-tight joints.	Multiple welds in a single operation.	Strong joints, high efficiency for thick materials.	Strong joints for heavy-duty applications.	Extremely fast process with precise energy input.
Example	Car body panels, battery tabs.	Radiators, fuel tanks, pipelines.	Fastening nuts or studs to metal sheets.	Joining railway tracks, rods, wires.	Axles, heavy-duty frames.	Electronic components, surgical instruments.

Fusion or Non-pressure Welding

This welding is done by fusion with additional filler metal. According to heat created by it is divided into three types-

1. Electric arc
2. Gas
3. Chemical reaction

Further Electric arc is divided into 6 types-

1. Carbon arc welding
2. Metal arc welding
3. Submerged arc welding
4. Inert gas welding (Tungsten Inert Gas Welding - TIG, Metallic Inert Gas Welding - MIG)
5. Stud arc welding
6. Atomic hydrogen welding

Brief Comparison of Electric arc welding Processes

Aspect	Carbon Arc Welding (CAW)	Metal Arc Welding (SMAW)	Submerged Arc Welding (SAW)	Inert Gas Welding (TIG & MIG)	Stud Arc Welding	Atomic Hydrogen Welding (AHW)
Heat Source	Electric arc between a carbon electrode and workpiece.	Electric arc between a metal electrode and workpiece.	Electric arc beneath a flux blanket.	Electric arc with inert gas shielding.	Electric arc between the stud and workpiece.	Electric arc between two tungsten electrodes in hydrogen atmosphere.
Electrode	Non-consumable carbon electrode.	Consumable metal electrode (coated or flux-cored).	Consumable metal electrode (wire).	- TIG: Non-consumable tungsten.	Stud itself acts as an electrode.	Non-consumable tungsten electrodes.
Shielding	Limited; no flux or gas shielding.	Flux coating or gas shielding (optional).	Granular flux provides shielding.	Inert gas (argon, helium, or CO_2).	None; relies on rapid molten metal solidification.	Hydrogen gas prevents oxidation.
Thickness	Thin to medium	Wide range of materials (1–30 mm).	Thick materials (6–50 mm).	TIG: Thin materials;	Suitable for thick plates with studs.	Thin to medium

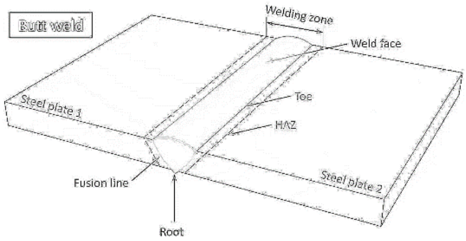
	materials (up to 10 mm).			MIG: Wide range.		materials (up to 12 mm).
Applications	Light sheet metal, repair work.	Structural fabrication, general-purpose welding.	Heavy fabrication (pipes, tanks, vessels).	TIG: Aerospace, electronics; MIG: Automotive, fabrication.	Stud welding in automotive and construction.	Aerospace, tool manufacturing, stainless steel.
Advantages	Simple and inexpensive.	Versatile, widely used, cost-effective.	High deposition rate, minimal spatter.	High-quality welds, versatile.	Quick and strong joint formation.	Clean welds, strong joints.
Example	Repairing thin metal sheets.	Welding steel frames, bridges, and pipes.	Welding large pipelines and pressure vessels.	TIG: Welding aluminum; MIG: Car body panels.	Attaching studs to automotive parts.	Welding stainless steel in aerospace.

Types of Welding Joints

Welding joints are configurations where two or more metal pieces are joined together using welding processes. Each joint type is designed for specific applications based on structural requirements, material thickness, and load conditions.

1. Butt Joint

- Two metal pieces are placed in the same plane, edge to edge.
- Most common and versatile joint type.



Applications

- Used in structural work, pipelines, and pressure vessels.
- Suitable for thick and thin materials.

Features

- Simple design and easy to prepare.
- Requires precise alignment for strong joints.

Subtypes

- **Square Butt Joint**: Straight edges; used for thin materials.
- **Single Bevel Butt Joint**: One edge is beveled for thicker materials.
- **Double Bevel Butt Joint**: Both edges are beveled for very thick materials.

◊ Measurement ◊

@ *Units of Measurement*

CGS System (Centimeter-Gram-Second)

- *Base Units*:
  - Length: Centimeter (cm)
  - Mass: Gram (g)
  - Time: Second (s)
- *Derived Units*:
  - Area: cm^2
  - Volume: cm^3
  - Force: Dyne (1 dyne = 10^{-5} N)
  - Energy: Erg (1 erg = 10^{-7} J)
- *Applications*: Used in scientific research for small-scale measurements.

FPS System (Foot-Pound-Second)

- *Base Units*:
  - Length: Foot (ft)
  - Mass: Pound (lb)
  - Time: Second (s)
- *Derived Units*:
  - Area: ft^2
  - Volume: ft^3
  - Force: Pound-force (lbf)
  - Energy: Foot-pound (1 ft-lbf = 1.3558 J)
- *Applications*: Commonly used in construction and engineering in the U.S.

MKS System (Meter-Kilogram-Second)

- *Base Units*:
  - Length: Meter (m)
  - Mass: Kilogram (kg)
  - Time: Second (s)
- *Derived Units*:
  - Area: m^2
  - Volume: m^3
  - Force: Newton (1 N = 1 $kg \cdot m/s^2$)
  - Energy: Joule (1 J = 1 N·m)
- *Applications*: Global standard for engineering and science.

Steel Rule Graduations in Metric

Description

- Material: Hardened stainless steel for durability.
- Graduations: Marked in millimetres (mm) and centimetres (cm).

    - Subdivided into fractions like 1/16 inch or decimals like 0.1 inch.
- *Vernier Scale*: Contains divisions corresponding to 0.001 inch increments.

Numerical Example: Metric Vernier Scale

Problem: Calculate the total reading for a Vernier caliper with a metric scale.

- *Given*:
    - Main Scale Reading = 12 mm
    - Vernier Scale Reading = 18 divisions
    - Least Count = 0.02 mm

Formula: Total Reading = Main Scale Reading + (Vernier Scale Reading × Least Count)

Calculation: Total Reading = 12 + (18 × 0.02) = 12 + 0.36 = 12.36 mm

Answer: The total reading is 12.36 mm.

Numerical Example: Inch Vernier Scale

Problem: Calculate the total reading for a Vernier caliper with an inch scale.

- *Given*:
    - Main Scale Reading = 2.5 inches
    - Vernier Scale Reading = 5 divisions
    - Least Count = 0.001 inch

Formula: Total Reading = Main Scale Reading + (Vernier Scale Reading × Least Count)

Calculation: Total Reading = 2.5 + (5 × 0.001) = 2.5 + 0.005 = 2.505 inches

Answer: The total reading is 2.505 inches.

Applications of Vernier Scales

- *Engineering and Machining*:
    - Precise measurement of machine components.
    - Ensures adherence to design specifications.
- *Quality Control*: Verification of tolerances and dimensions in manufacturing.
- *Educational Use*: Training in precision measurement techniques for students and apprentices.
- *Medical Equipment*: Used in the production of surgical instruments and implants.

Common Errors and Solutions

- *Zero Error*:
  - Occurs when the zero on the Vernier scale does not align with the zero on the main scale.
  - *Solution*: Adjust using the calibration mechanism.
- *Parallax Error*:
  - Caused by improper eye alignment.
  - *Solution*: Align the eye perpendicular to the scale.
- *Improper Handling*:
  - Leads to wear and tear, affecting accuracy.
  - *Solution*: Use tools carefully and perform regular maintenance.

Summary Table

Feature	**Metric Graduations**	**Inch Graduations**
Main Scale Division	1mm	0.1inch
Vernier Scale Division	0.02mm	0.001inch
Typical Use	Global engineering standards	US-specific applications

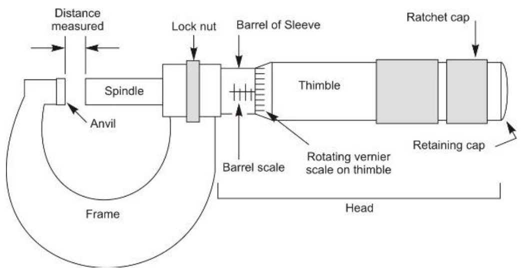
@ *Vernier Micrometre: Construction, Graduation, and Applications*

The Vernier micrometre combines the precision of a micrometre with the accuracy of a Vernier scale, making it an essential tool for high-precision measurements in engineering, machining, and quality control.

Construction of a Vernier Micrometre

Components

- *Frame*:
  - The U-shaped structure made of forged steel or cast iron.
  - Provides rigidity and holds the anvil and spindle.
- *Anvil*: The stationary measuring surface, made of hardened steel.
- *Spindle*:
  - The movable part controlled by a precision screw mechanism.
  - Moves towards or away from the anvil for measurement.
- *Sleeve (Barrel)*: Fixed component displaying the main scale in millimeters or inches.
- *Thimble*: A rotating component that carries the finer scale.
- *Vernier Scale*: Attached to the thimble or sleeve, allowing readings beyond the main scale precision (e.g., ±0.001 mm).
- *Ratchet Stop*: Ensures consistent measuring pressure to avoid errors.
- *Lock Screw*: Holds the spindle in position to secure the measurement.



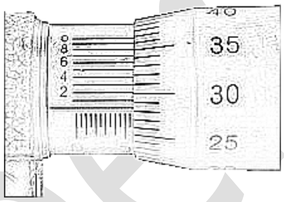
Graduation of a Vernier Micrometre

Main Scale

- Graduated in millimeters or inches on the sleeve.
- Each division represents 1 mm or 0.1 inch.

Thimble Scale

- Divided into 50 or 100 equal parts, each representing a fraction of the main scale division:
    - For metric: 1 division = 0.01 mm.
    - For inch: 1 division=0.001 inch.



Vernier Scale

- The Vernier scale allows readings with even greater precision by subdividing the smallest thimble division.

Least Count Formula:

Least Count = Smallest Division on Main Scale / Number of Divisions on Vernier Scale

Example:

- Main scale division: 1 mm.
- Vernier scale divisions: 10.
- Least count: Least Count=1/10=0.1 mm

Applications of Vernier Micrometres

- *Precision Measurement:* Measures external dimensions such as the diameter of rods, thickness of sheets, and width of parts.

- *Industrial Use:* Widely used in manufacturing and machining for quality control.
- *Research and Development:* Used in laboratories for high-accuracy experiments and component testing.
- *Calibration:* Helps calibrate other measuring instruments by providing a reference standard.

Advantages of Vernier Micrometres

- ***High Accuracy:*** Provides measurements up to ±0.001 mm or ±0.0001 inch.
- ***Versatility:*** Suitable for various materials and applications, including metal, plastic, and composite components.
- ***Consistency:*** Ensures repeatable results due to the ratchet stop mechanism.
- ***Ease of Use:*** Combines the readability of a micrometre with the precision of a Vernier scale.

Errors in Vernier Micrometres and Their Rectification

Zero Error

- *Cause*: Misalignment of zero marks on the main scale and thimble.
- *Rectification*: Adjust the micrometre using the zero-adjustment knob.

Parallax Error

- *Cause*: Viewing the scale from an angle.
- *Rectification*: Align the eye perpendicular to the scale for accurate readings.

Temperature Error

- *Cause*: Thermal expansion or contraction of the micrometre or workpiece.
- *Rectification*: Perform measurements in a controlled environment.

Wear and Tear

- *Cause*: Prolonged use leading to spindle or anvil deformation.
- *Rectification*: Regular calibration and replacement of worn parts.

Numerical Example

Problem: Measure the diameter of a rod using a Vernier micrometre.

- *Given*:
  - Main Scale Reading = 12 mm
  - Thimble Reading = 35 divisions
  - Vernier Scale Reading = 5 divisions
  - Least Count = 0.001 mm

◊ Sheet Metal ◊

Sheet metal is a versatile material widely used in manufacturing and construction due to its durability, lightweight nature, and ease of fabrication. It is typically less than 6 mm in thickness and is available in a variety of materials.

@ ***Metals and Non-Metals***

Sheet metal work involves the use of a wide variety of materials, including **metals** and **non-metals**, depending on the requirements of the application. Each material has distinct properties that make it suitable for specific operations like cutting, bending, forming, and joining.

Metals in Sheet Metal Work

Metals are elements or alloys that are typically solid at room temperature, malleable, ductile, and conductive. They are commonly used in sheet metal work due to their structural strength and versatility.

Common Metals Used

- *Ferrous Metals (Contain Iron):*
  - *Mild Steel:*
    - Low carbon content (0.05%–0.25%), highly ductile, easy to weld.
    - Applications: Automotive panels, construction frameworks, HVAC ducts.
    - Tensile Strength: ~400 MPa.
  - *Stainless Steel:*
    - Contains chromium (~10% or more) for corrosion resistance.
    - Applications: Kitchen equipment, medical tools, chemical tanks.
- *Non-Ferrous Metals (Do Not Contain Iron):*
  - *Aluminum*:
    - Lightweight, corrosion-resistant, and easy to shape.
    - Applications: Aerospace components, automotive parts, roofing sheets.
    - Density: 2.7 g/cm³.
  - *Copper:*
    - Excellent electrical and thermal conductivity.
    - Applications: Electrical wiring, plumbing, roofing.
  - *Brass:*
    - Alloy of copper and zinc, corrosion-resistant.
    - Applications: Decorative items, musical instruments.
  - *Titanium:*
    - High strength-to-weight ratio, corrosion-resistant.
    - Applications: Aerospace, medical implants, marine hardware.

Properties of Metals

- *Ductility*: Ability to stretch into wires.
- *Malleability*: Ability to form thin sheets under compressive forces.
- *Conductivity*: Good conductors of heat and electricity.
- *Strength*: Can withstand high stress and loads.

Non-Metals in Sheet Metal Work

Non-metals are materials that lack metallic properties such as ductility, malleability, and conductivity. However, some non-metals are used in sheet metal work for lightweight and corrosion-resistant applications.

Common Non-Metals Used

- *Plastics:*
  - PVC (Polyvinyl Chloride): Lightweight, corrosion-resistant.
  - Applications: Roofing, decorative panels, protective coatings.
- *Composites:*
  - Fiberglass: A combination of glass fibers and resin.
  - Applications: Aircraft panels, automotive components, and industrial tanks.
- *Ceramics:*
  - Highly heat-resistant, used as insulation or coatings.
  - Applications: High-temperature furnaces, aerospace insulation.
- *Rubber:*
  - Provides sealing and vibration damping in sheet metal assemblies.
  - Applications: Gaskets, vibration mounts.

Properties of Non-Metals

- *Corrosion Resistance*: Excellent resistance to rust and chemical attacks.
- *Lightweight*: Ideal for applications requiring weight reduction.
- *Insulating*: Poor conductors of heat and electricity.

Comparison of Metals and Non-Metals in Sheet Metal Work

Aspect	Metals	Non-Metals
Malleability	High, can be shaped into sheets.	Low, generally brittle (except plastics).
Conductivity	Good conductors of heat and electricity.	Poor conductors (good insulators).
Corrosion Resistance	Requires coatings (e.g., mild steel).	Naturally resistant (e.g., plastics).
Strength	High tensile and compressive strength.	Lower strength but adequate for specific uses.
Density	Heavier than non-metals.	Lightweight.

@ ***Mild Steel and Non-Ferrous Metals***

Sheet metal fabrication often uses a variety of materials, including **mild steel** and **non-ferrous metals**, due to their unique properties, versatility, and applications. Below is a comprehensive explanation of these materials, their characteristics, and their uses in the sheet metal industry.

Mild Steel in Sheet Metal Work

Mild steel is a type of carbon steel with low carbon content, typically **0.05%–0.25%**, making it ductile and easy to work with.

- *Characteristics*:
  - High malleability and ductility.
  - Moderate tensile strength (~400 MPa).
  - Easily welded and machined.
  - Prone to rust unless protected with coatings (e.g., paint, galvanization).

Strength	Moderate tensile strength (~400 MPa).	Varies: Aluminum (~300 MPa), Titanium (~900 MPa).
Cost	Affordable and widely available.	More expensive than mild steel.
Applications	Construction, automotive, HVAC.	Aerospace, electrical, decorative.

@ ***Marking and Layout Tools***

Divider

A divider is a precision tool with two sharps, pointed legs used for marking arcs, circles, and transferring measurements onto sheet metal surfaces. The tool may have adjustable legs with a locking screw for maintaining the desired dimension.

Applications

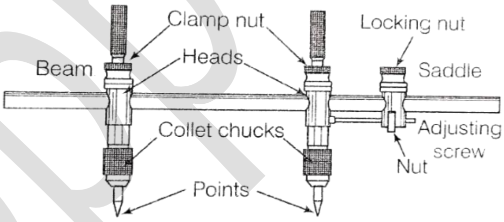
- Marking circles and arcs.
- Transferring dimensions from templates or scales.
- Dividing distances into equal parts.

Features

- Available in various sizes (e.g., 150 mm, 200 mm, or larger).
- Made of hardened steel for durability.

Trammels

Trammels consist of two adjustable heads attached to a beam or rod, allowing the marking of large circles and arcs.



Applications

- Used for drawing circles larger than what can be marked with a compass or divider.
- Common in ductwork and large cylindrical fabrications.

Features

- Adjustable heads for varying diameters.
- Can accommodate rods of different lengths for flexibility.

Scriber

A scriber is a hand tool with a hardened steel tip used to scratch fine lines onto sheet metal surfaces.