Military Institute of Science & Technology (MIST)
Dhaka
Department of Computer Science and Engineering

ME 122
Fundamental of Mechanical Engineering Sessional
LEVEL-1, TERM-II

Contact Hr: 4 Credit: 2

Name of the Experiments:

1. Study of Thermal Power Plant
2. Study of Refrigeration system and Air-conditioning Unit
3. Study of Centrifugal Pump
4. Study of Turbine
5. Study of an Automotive IC Engine, Different Engine Subsystems and Engine Control Unit (ECU)
6. Study of Automotive Transmission System
7. Study of Engine Lathe and Milling Machine
8. Study of Welding
9. Tensile Test of Mild Steel (UTM)

General Guidelines:

- Student must remain present in lab/ workshop in time.
- Student must wear apron and put on shoes during experiment.
- Student should submit report before the class starts.
- Final quiz will be taken based on daily report submitted, lectures given during experiment and provided instruction sheet

Report must contain:

- Top sheet with necessary information (name of the experiment, no of expt, date of performance, date of submission, group number etc)
- Objectives
- Work material/ Machines / Tool/ Equipments used (with their specifications)
- Experimental condition (speed, feed, depth of cut, cutting fluid) and procedure
- Necessary figures
- Discussion
- Assignment

Experiment 01
Study of Thermal Power Plant

Objectives:

- Introduction of different components of steam power plant
- To study the functions of boiler mountings and accessories.
- To learn about other power plants.

Theory:

Electricity sector in Bangladesh

The largest energy consumers in Bangladesh are industries and the residential sector, followed by the commercial and agricultural sectors.

The utility electricity sector in Bangladesh has one national grid with an installed capacity of 21,419 MW as of September 2019. The total installed capacity is **20,000 MW** (combining solar power). Bangladesh's energy sector is booming. Recently Bangladesh started construction of the **2.4-gigawatt (GW) Rooppur Nuclear Power Plant** expected to go into operation in **2023**. According to the Bangladesh Power Development Board in July 2018, 90 percent of the population had access to electricity. However, per capita energy consumption in Bangladesh is considered low. Bangladesh will need an estimated **34,000 MW** of power by **2030** to sustain its economic growth of over 7 percent.

Power plant Introduction:

POWER PLANT is an assembly of equipment's that produces and deliver mechanical and electrical energy. The electric energy uses in home, industry, agriculture and transportation purpose. The electrical energy is convenient form of energy because it can be generated centrally in bulk and transmitted over long distance. Electrical energy is generated by different form of energy. Like water energy, wind energy, geothermal energy, chemical energy, nuclear energy. The common sources of energy in our country are coal, water, oil and gas.

Power plant is the place where electricity produced using some conventional or nonconventional energy sources.

Based on the source of energy power plants are classified into different types

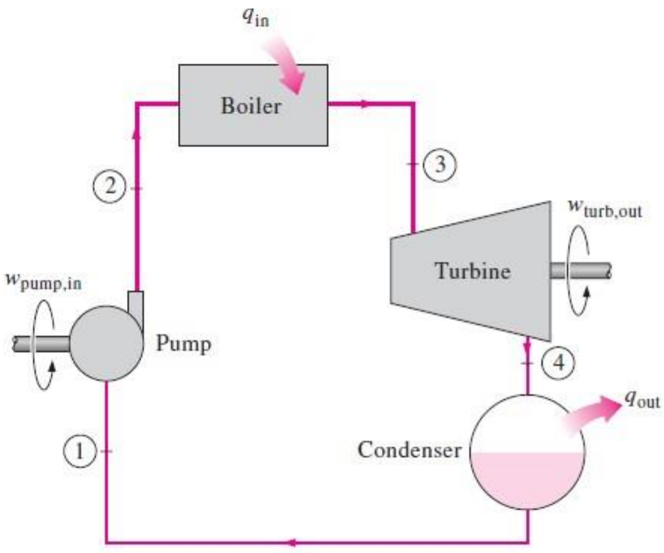
1. Thermal power plant
2. Hydro-electric power plant
3. Nuclear power plant
4. Gas turbine power plant
5. Diesel engine power plant

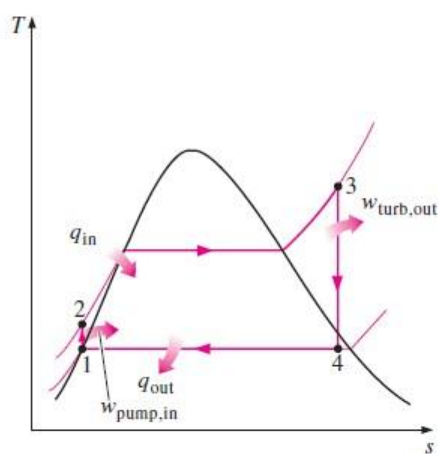
Steam power plant:

Generally, steam power plant is called as thermal power plant. The steam power plant can perform two purposes. To generate electricity only and to generate electricity along with production of steam for process heating. Steam power plant works on **RANKINE CYCLE.** Working fluid is **steam** and **water.**

➢ The main components of cycle are

1. **Boiler:** Boiler is used to produce steam. Heat energy produced by coal is used to produce steam. Water is allowed to heat until it becomes into vapor state. Vapor is sent into turbine.
2. **Turbine:** Turbine produces the work. Work produced is used to run the generator. The enthalpies at the enter and exit of the turbine are different. Then Vapor is sent into the condenser.
3. **Condenser:** The vapor is condensed to water in the condenser and sent into the pump.
4. **Feed pump:** Pump send the water again into the Boiler and the cycle repeats again.





1-2	Isentropic compression in a pump
2-3	Constant pressure heat addition in a boiler
3-4	Isentropic expansion in a turbine
4-1	Constant pressure heat rejection in a condenser

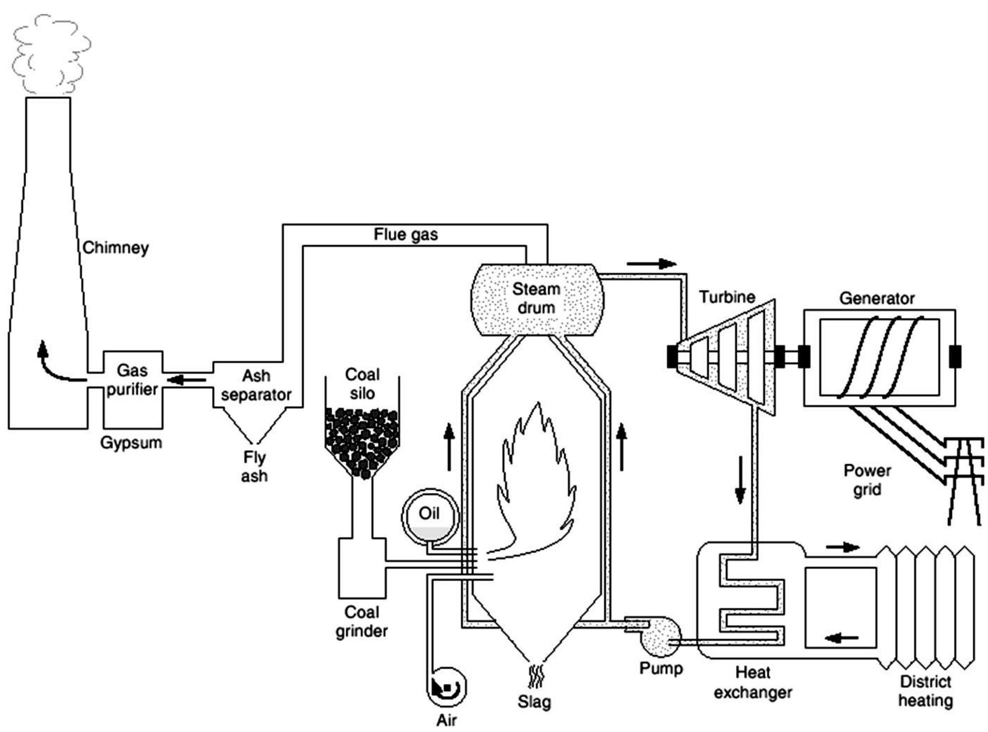


Figure: Layout of a steam power plant.

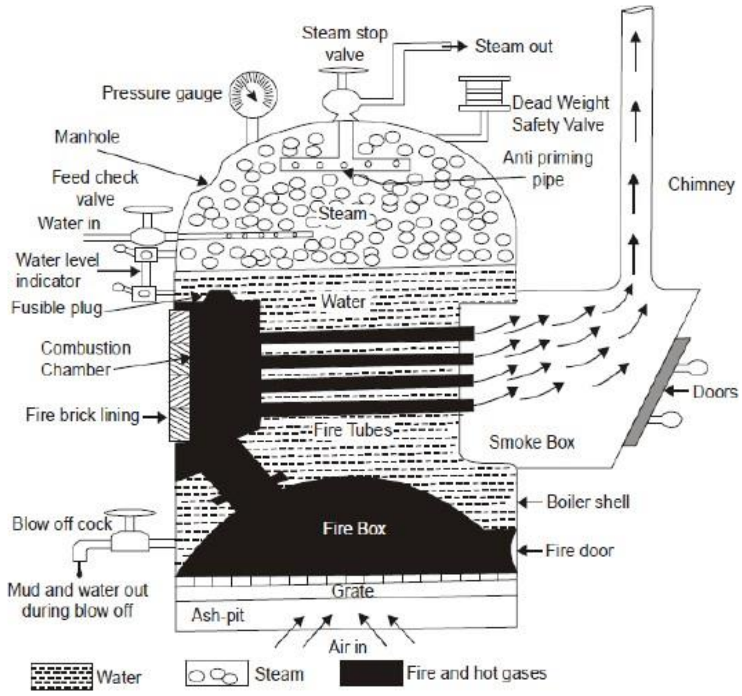


Figure: Cochran Boiler

Cochran Boiler:

It is a multi-tubular vertical fire tube boiler having a number of horizontal fire tubes. it is the modification of a simple vertical boiler where the heating surface has been increased by means of a number of fire tubes. Its consist of,

Shell: It is hemispherical on the top, where space is provided for steam.
Grate: It is placed at the bottom of the furnace where coal is burnt.
Fire box (furnace): It is also dome-shaped like the shell so that the gases can be deflected back till they are passed out through the flue pipe to the combustion chamber.
Flue pipe: It is a short passage connecting the fire box with the combustion chamber.
Fire tubes: A number of horizontal fire tubes are provided, thereby the heating surface is increased.
Combustion chamber: It is lined with fire bricks on the side of the shell to prevent overheating of the boiler. Hot gases enter the fire tubes from the flue pipe through the combustion chamber.
Chimney: It is provided for the exit of the flue gases to the atmosphere from the smoke box.
Manhole: It is provided for inspection and repair of the interior of the boiler shell.

Boiler Mountings:

Boiler mountings are the machine components that are mounted over the body of the boiler itself for the safety of the boiler and for complete control of the process of steam generation. Various boiler mountings are as under:

1) Pressure gauge
2) Water Level Indicator
3) Fusible plug
4) Safety Valve
5) Steam stop valve
6) Feed check valve
7) Blow-off cock
8) Man and Mud hole

Boiler Accessories:

Boiler accessories are those components which are installed either inside or outside the boiler to increase the efficiency of the plant and to help in the proper working of the plant. Various boiler accessories are:

1) Air Preheater
2) Economizer
3) Super-heater
4) Feed Pump

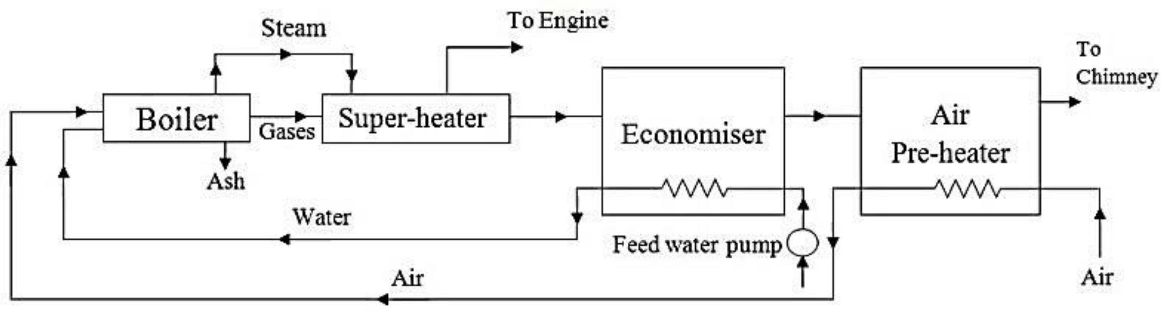
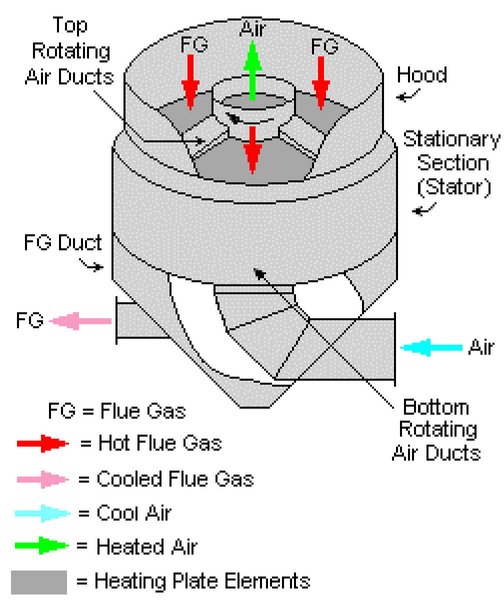


Fig- Schematic diagram of a boiler plant

Air Preheater:

Waste heat recovery device in which the air to on its way to the furnace is heated utilizing the heat of exhaust gases The function of air pre-heater is to increase the temperature of air before enters the furnace. It is generally placed after the economizer; so, the flue gases pass through the economizer and then to the air preheater. An air-preheater consists of plates or tubes with hot gases on one side and air on the other.



Typical Stationary Plate Air Preheater

Economizer:

It is a device in which the waste heat of the flue gases is utilized for heating the feed water. To recover some of the heat being carried over by exhaust gases. This heat is used to raise the temperature of feed water supplied to the boiler.

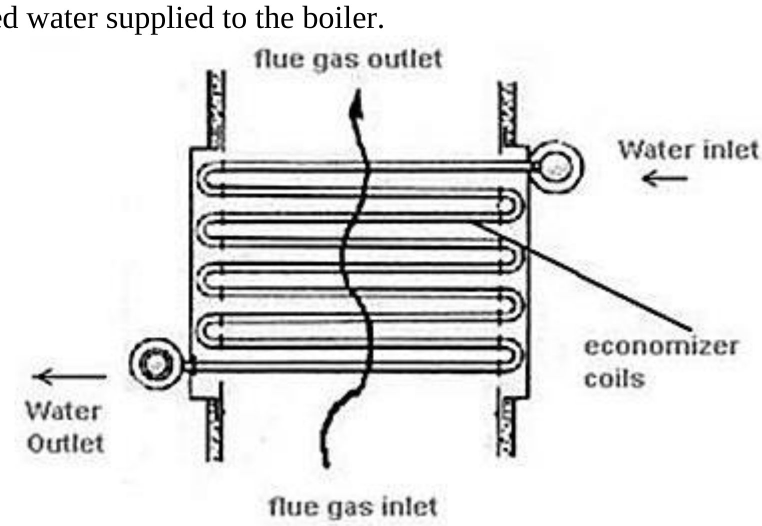


Fig: Economizer

Superheater:

The function of super heater is to increase the temperature of the steam above its saturation point. To superheat the steam generated by boiler. Super heaters are heat exchangers in which heat is transferred to the saturated steam to increase its temperature.

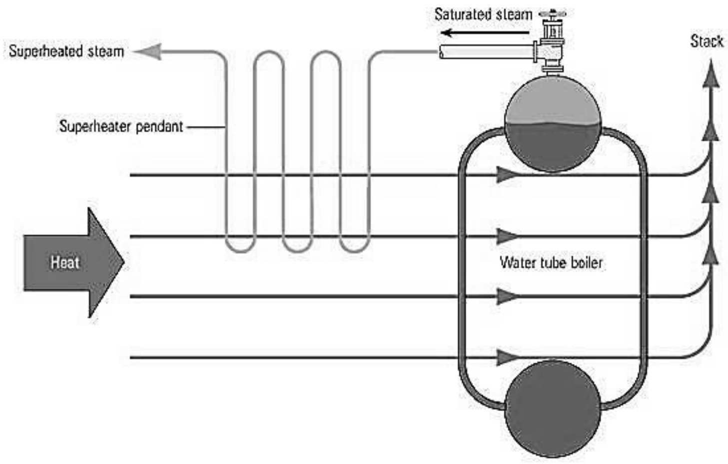
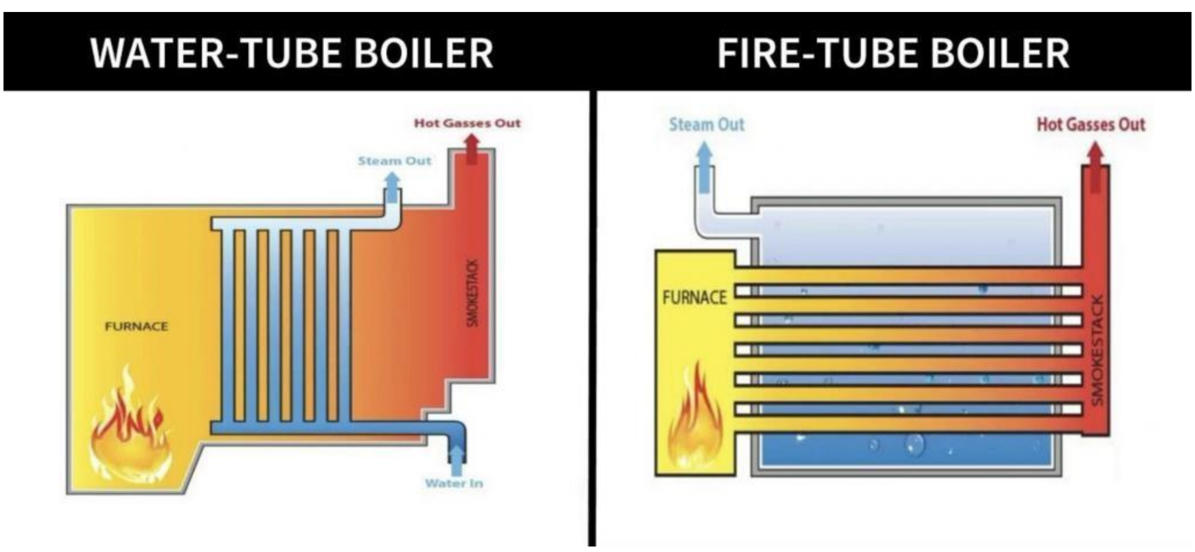


Fig: Superheater

<u>Classification of boilers</u>

According to contents in the Tube:
<u>a)</u> <u>Fire tube boiler</u>: In fire tube boilers, the flue gases pass through the tube and water surround them. Vertical tubular, Lancashire, Cochran, Cornish, Locomotive fire box, Scotch marine etc are some fire tube boilers.

<u>b)</u> <u>Water tube boiler</u>: In water tube boiler, water flows inside the tubes and the hot flue gases flow outside the tubes. Babcock and Wilcox boiler, Stirling boiler, La-mont boiler, Benson boiler, Loeffler boiler etc are some of water tube boilers.



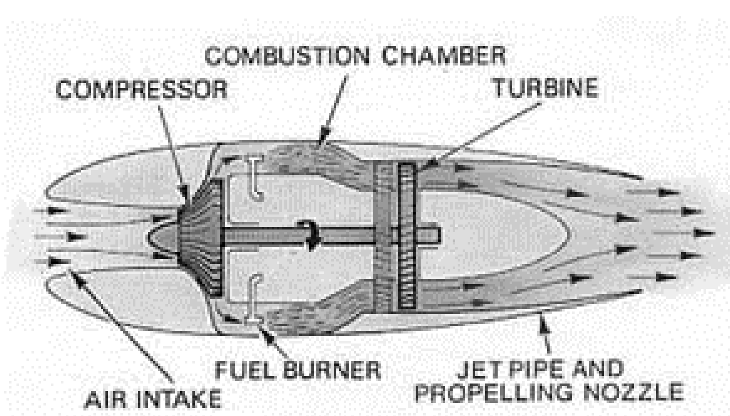


Figure: Diagram of a Gas Turbine

Gas Turbine Power Plant:

In the **gas turbine power plant** air is compressed in a compressor. This compressed air then passes through a combustion chamber where the temperature of the compressed air rises. That high temperature and high-pressure air is passed through a gas turbine. In turbine the compressed air is suddenly expanded; hence it gains kinetic energy, and because of this kinetic energy the air can do mechanical work for rotating the turbine.

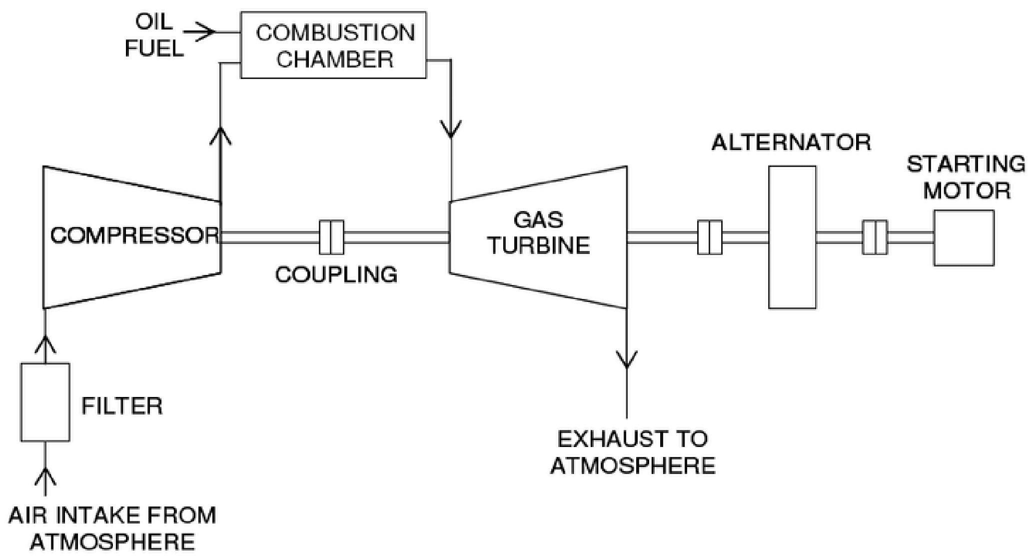


Figure: Gas Turbine Power Plant

Combined Gas–Vapor Power Cycles

The continued quest for higher thermal efficiencies has resulted in rather innovative modifications to conventional power plants. A popular modification involves a gas power cycle topping a vapor power cycle, which is called the **combined gas–vapor cycle**, or just the **combined cycle**. The combined cycle of greatest interest is the gas-turbine (Brayton) cycle topping a steam-turbine (Rankine) cycle, which has a higher thermal efficiency than either of the cycles executed individually.

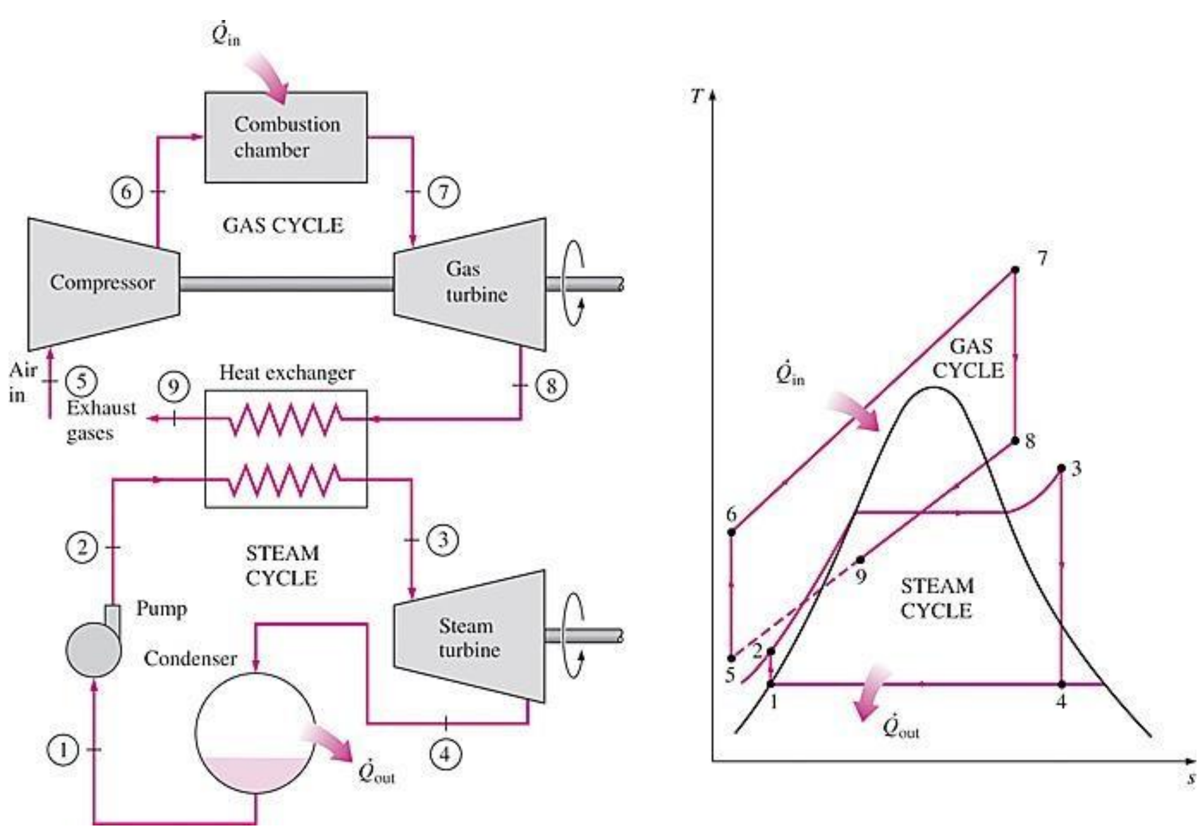


Figure: Combined Gas–Vapor Power Cycles

Experiment 02

Study of Refrigeration system and Air-conditioning Unit

Objectives:

- To learn the fundamental analysis methodology of air conditioning and refrigeration.
- To learn the functions of the different components Refrigeration and Air conditioning system
- To identify the components of the Refrigeration and Air conditioning system
- To learn the importance of Refrigerant

Theory:

Refrigeration: Refrigeration is a process of reducing and maintaining low temperature of a space or material below the temperature of the surroundings. “Refrigeration is the process of removing heat from an enclosed space, or from a substance, and rejecting it elsewhere for the purpose of lowering the temperature of the enclosed space or substance and then maintaining that lower temperature.”

Ton of Refrigeration (TR):

Ton of Refrigeration (abbreviated as TR) is an important historical unit of refrigeration capacity. Originally 1 TR was defined as the rate of heat transfer required to make 1 short ton (2000 lbs) of ice per day from water at 0^oC. American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) defines 1 TR as equivalent to a refrigeration capacity of 3516.85 W or 3023.95 kcal/h. Tons of Refrigeration or simply Tons is often used as a general term to indicate the capacity or size of the refrigeration plant. Thus 1 TR air conditioner has a refrigeration capacity of 3516.85 W at the prescribed temperatures.

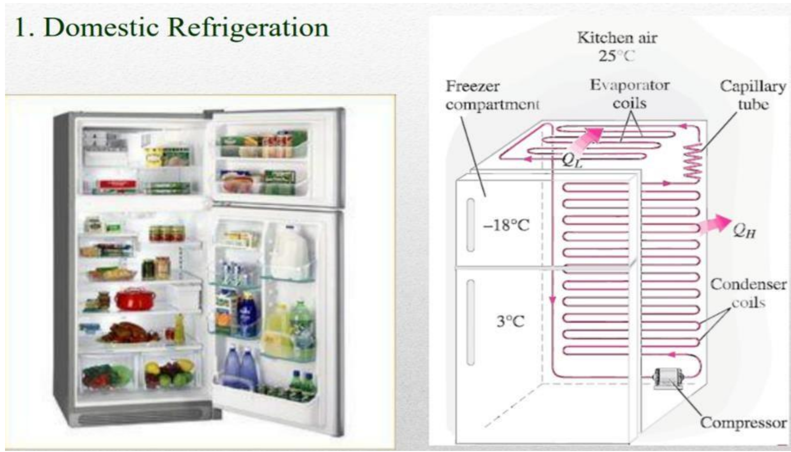
Classifications

Based on Applications

- Domestic Refrigeration
- Commercial Refrigeration
- Industrial Refrigeration
- Comfort Air Conditioning
- Industrial Air Conditioning

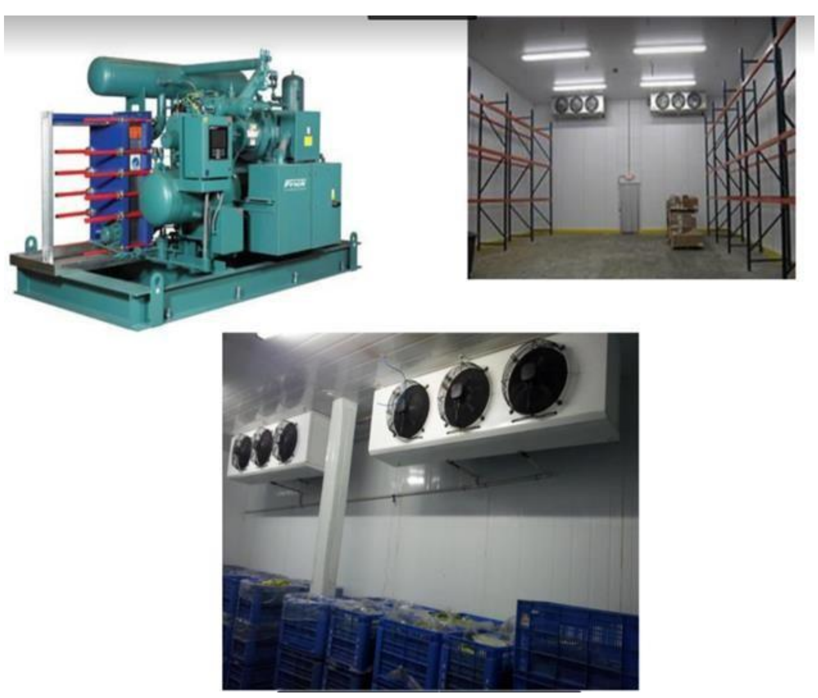
Applications:

1. Domestic Refrigeration



2. Commercial Refrigeration

3. Industrial Refrigeration



Based on Energy Input

- Vapor-Compression Refrigeration System
- Absorption Refrigeration System

Vapor Compression Refrigeration System

The Vapor Compression Refrigeration system uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere. All such systems have four components:

1. Compressor (Generally a Reciprocating Compressor)
2. Condenser (It condenses the high pressure gaseous refrigerant and acts as storage tank)
3. Expansion Device (Also called a throttle valve. May be a globe valve or simply a capillary tube)
4. Evaporator (Also termed as cooling coil. It is generally a copper coil with high surface area)

Vapor Compression Refrigeration System

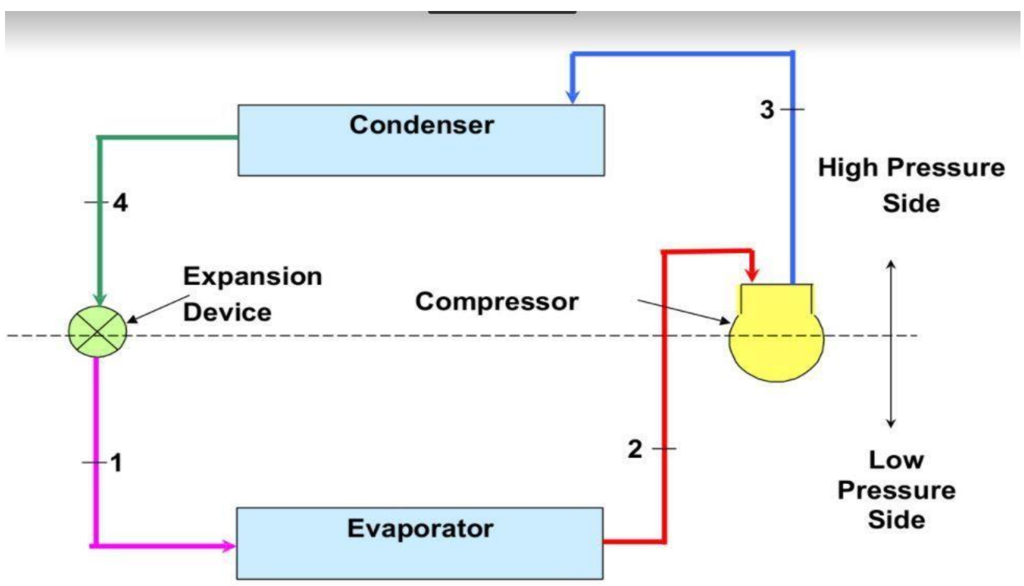


Figure: Schematic Diagram of VCRS

►The processes of this cycle are

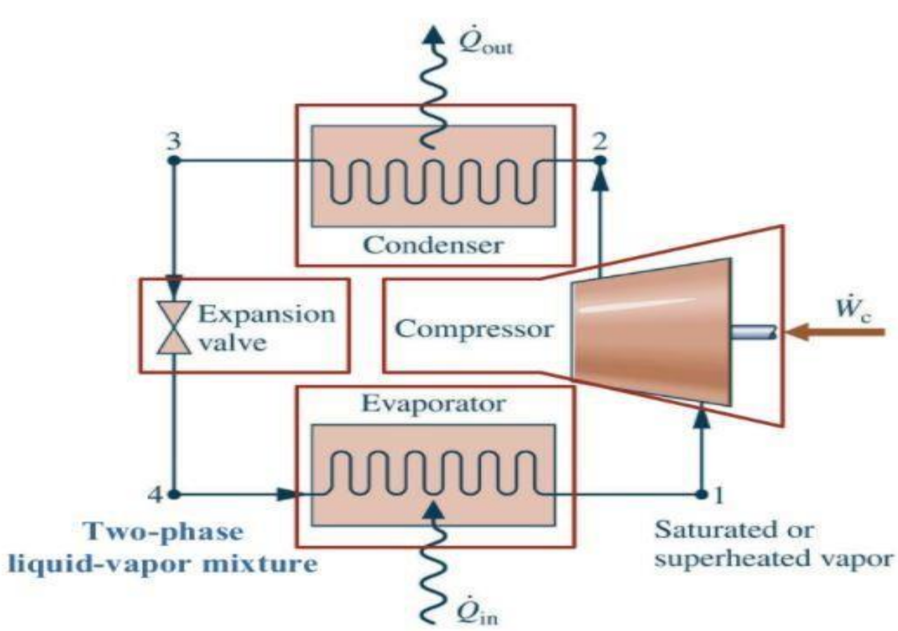


Figure: Schematic Diagram of VCRS

Process 4-1:

Two-phase liquid-vapor mixture of refrigerant is evaporated through heat transfer from the refrigerated space.

Process 1-2:

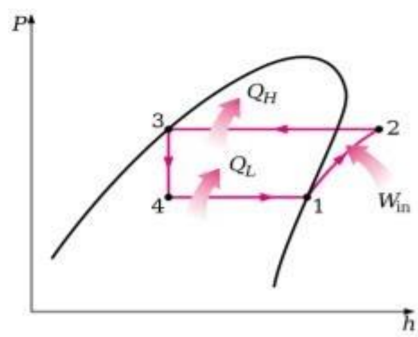
Vapor refrigerant is compressed to a relatively high temperature and pressure requiring work input.

Process 2-3:

Vapor refrigerant condenses to liquid through heat transfer to the cooler surroundings.

Process 3-4:

Liquid refrigerant expands to the evaporator pressure.



$$\begin{aligned} Q_L &= Q_{41} = m(h_1 - h_4) \\ Q_H &= Q_{23} = m(h_2 - h_3) \\ W_{in} &= W_{12} = m(h_2 - h_1) \\ COP &= Q_L / W_{in} \end{aligned}$$

$1 \to 2$: Isentropic compression, $P_{evap} \to P_{cond}$

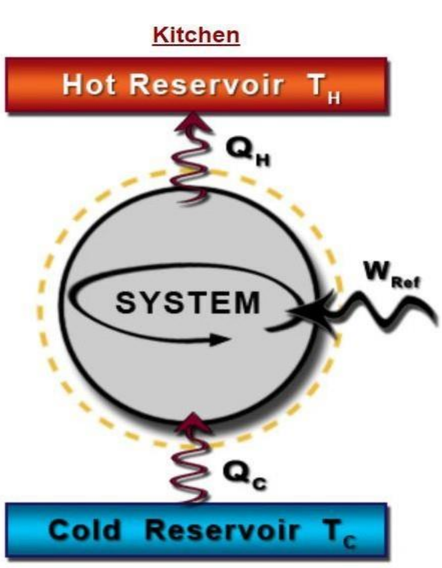
$2 \to 3$: Isobaric heat rejection, Q_H

$3 \to 4$: Isenthalpic expansion, $P_{cond} \to P_{evap}$

$4 \to 1$: Isobaric heat extraction, Q_L

Cop: Coefficient of Performance: COPR

A measure of the performance of a refrigeration cycle.



$$COP_R = \frac{\text{Desired Output}}{\text{Required Input}}$$

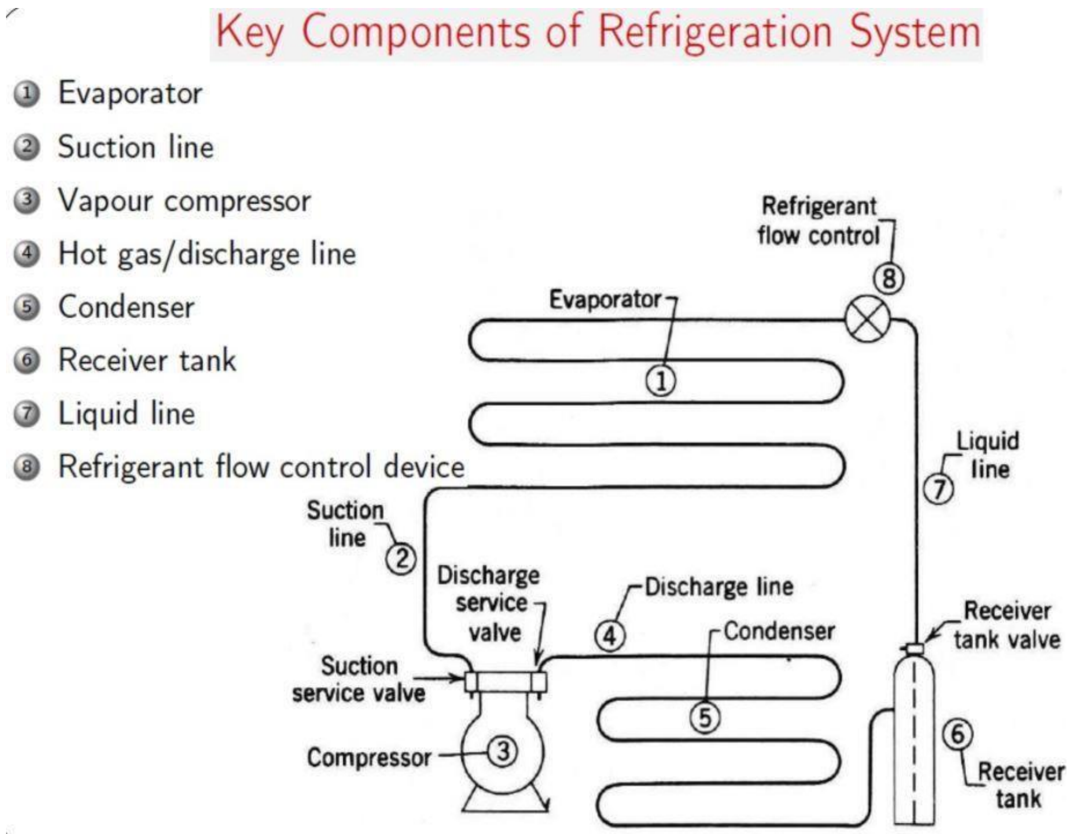
For refrigeration cycles:

$$COP_R = \frac{Q_C}{W_{ref}}$$

$$COP_R = \frac{Q_C}{Q_H - Q_C}$$

$$COP_R = \frac{1}{Q_H / Q_C - 1}$$

First Law: $W_{ref} = Q_H - Q_C$



There are four principal control volumes involving these components:

►Evaporator

►Compressor

►Condenser

►Expansion valve

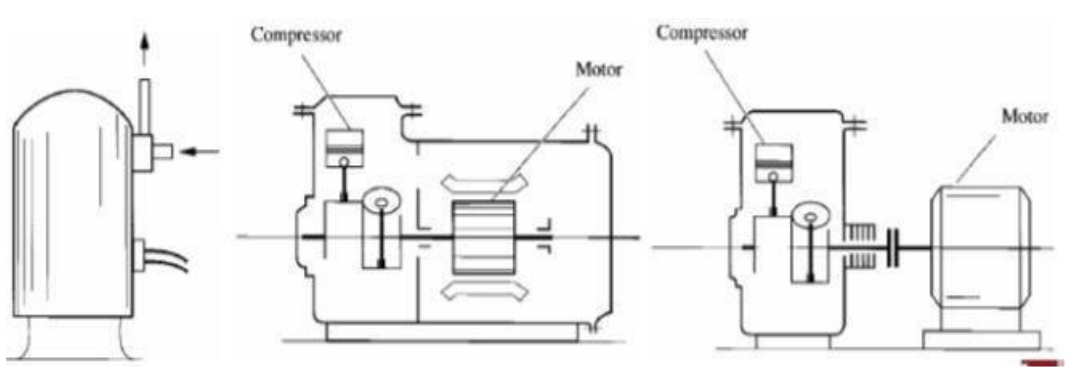
Compressors:

The purpose of the compressor in the vapour compression cycle is to compress the low-pressure dry gas from the evaporator and raise its pressure to that of the condense. Compressors can be:

1 Hermetic/sealed/welded

2 Semi-hermetic/accessible hermetic

3 Open



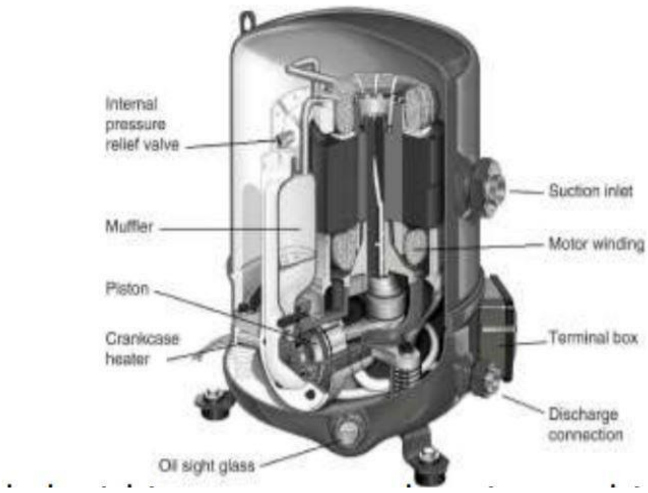
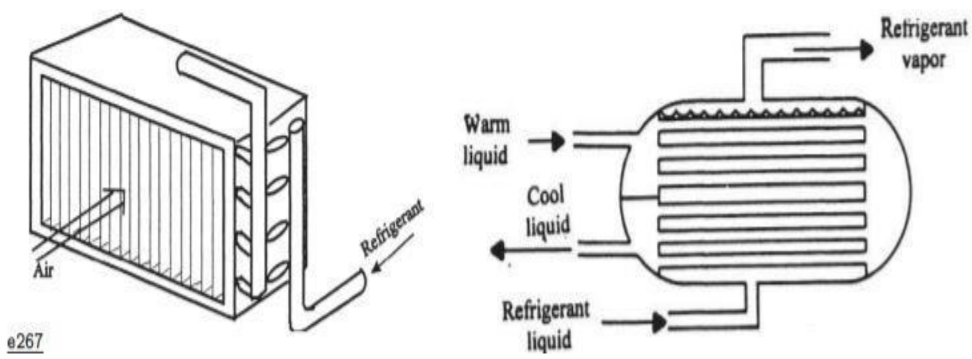


Figure: Hermetically sealed Compressor

Evaporator:

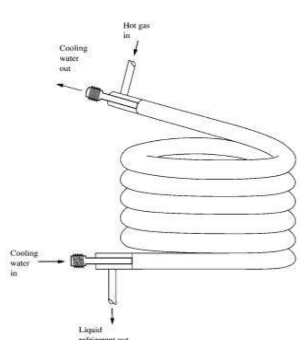


Condenser:

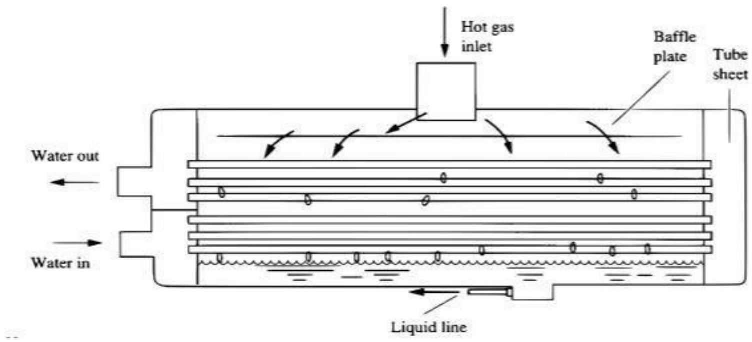
Based on the cooling medium used, condensers used in refrigeration systems can be classified into the following three categories:

- Water-cooled condensers
    a. Double-tube condenser b. Shell-and-tube condenser
- Air-cooled condensers
- Evaporative condenser.

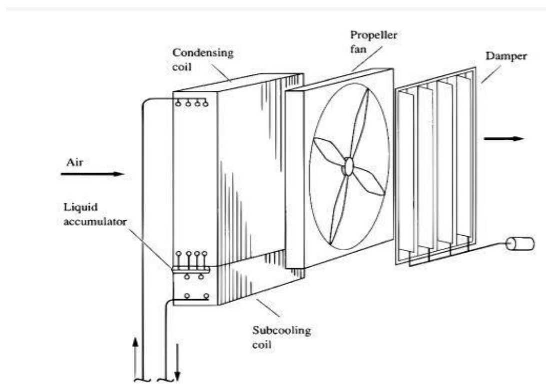
    - Double-tube Condenser:



- Shell-and-tube Condenser:



- Air-cooled Condenser:



- Evaporative condenser

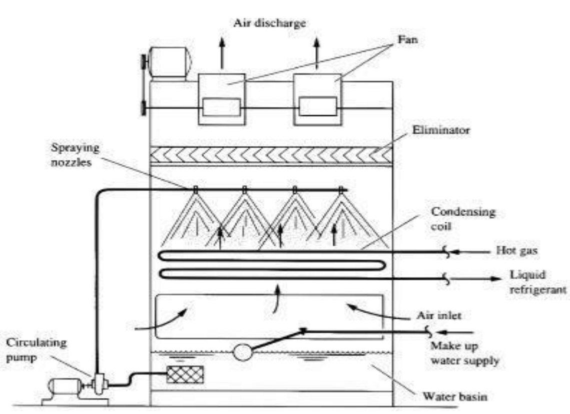


Figure: Evaporative Condenser

Expansion valve:

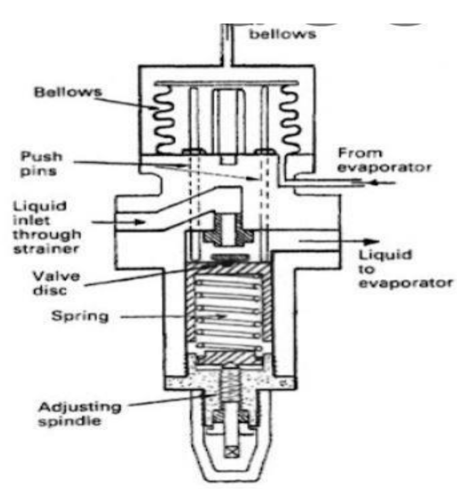


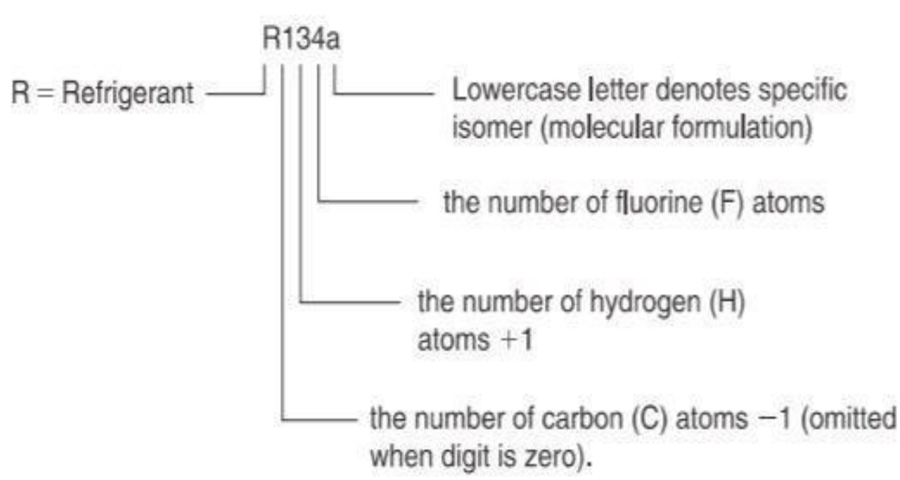
Figure: TXV (Thermostatic expansion valve)

Refrigerant

Refrigerants are well known as the fluids providing a cooling effect during the phase change from liquid to vapor. These are used in refrigeration, air conditioning, and heat pump systems, as well as process systems.

Some Desirable Properties of Refrigerants

- High latent heat of vaporization
- Less refrigerant flow required High suction gas density
- Small and compact equipment Low compression ratio
- Low power consumption and higher volumetric efficiency of compressors. Positive but not excessive pressures at evaporating and condensing conditions. Low condensing pressure
- Lighter compressors, piping etc. High thermal conductivity
- Good heat transfer, reduced size of heat transfer equipment. Chemically stable, compatible with construction materials and miscible with lubricants. Non-corrosive, non-toxic, non-flammable and environmentally friendly



Types of Refrigerants

Refrigerants are classified into different groups depending on their chemical composition. The most common refrigerant groups include:

- Chlorofluoro carbons (CFCs)
- Hydrofluoro carbons (HFCs)
- Hydro chloro fluoro carbons (HCFCs)
- Natural Refrigerants

Air Conditioning Systems

Air conditioning is the cooling and dehumidification of indoor air for thermal comfort. In a broader sense, the term can refer to any form of cooling, heating, ventilation, or disinfection that modifies the condition of air. An air conditioner (often referred to as AC) is an appliance, system, or mechanism designed tostabilize the air temperature and humidity within an area (used for cooling as well as heating depending on the air properties at a given time), typically using a refrigeration cycle but sometimes using evaporation, commonly for comfort
Cooling in buildings and motor vehicles.

Air Conditioning is the most important application of refrigeration. “Air Conditioning is the process of air treatment which controls the temperature, humidity, cleanliness and distribution of the air simultaneously to meet the requirements of a conditioned space.” An air conditioner serves the purpose of an air cooler, air heater and an air cleaner.

Basic Air conditioning system:

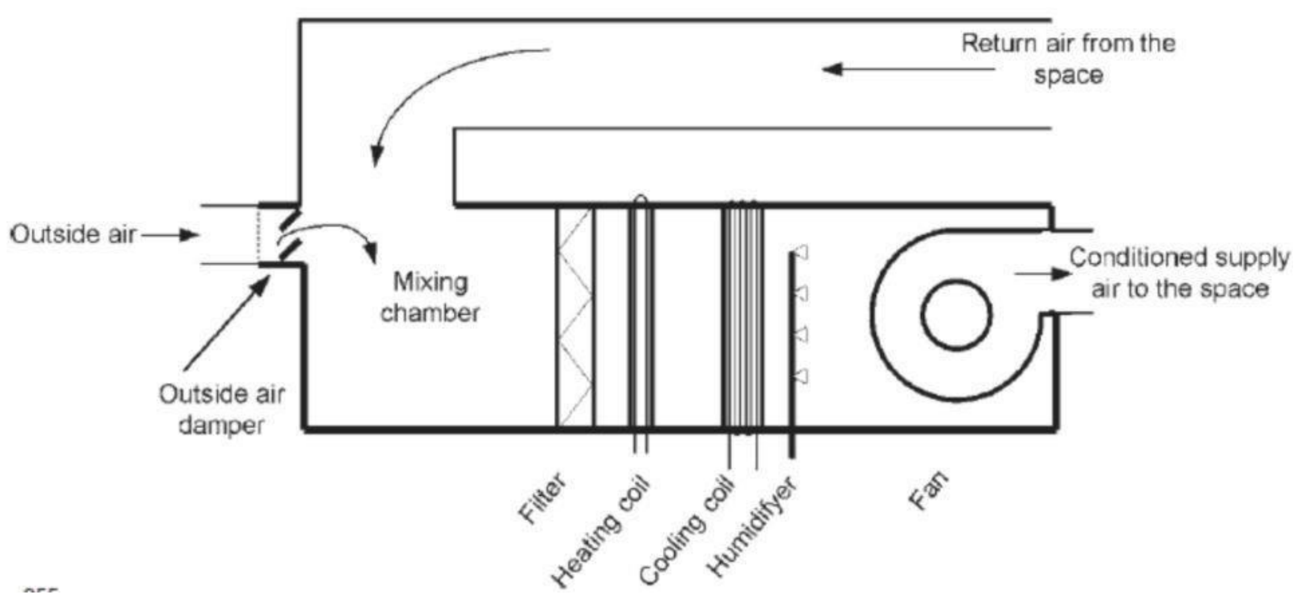


Figure: Basic Air conditioning system

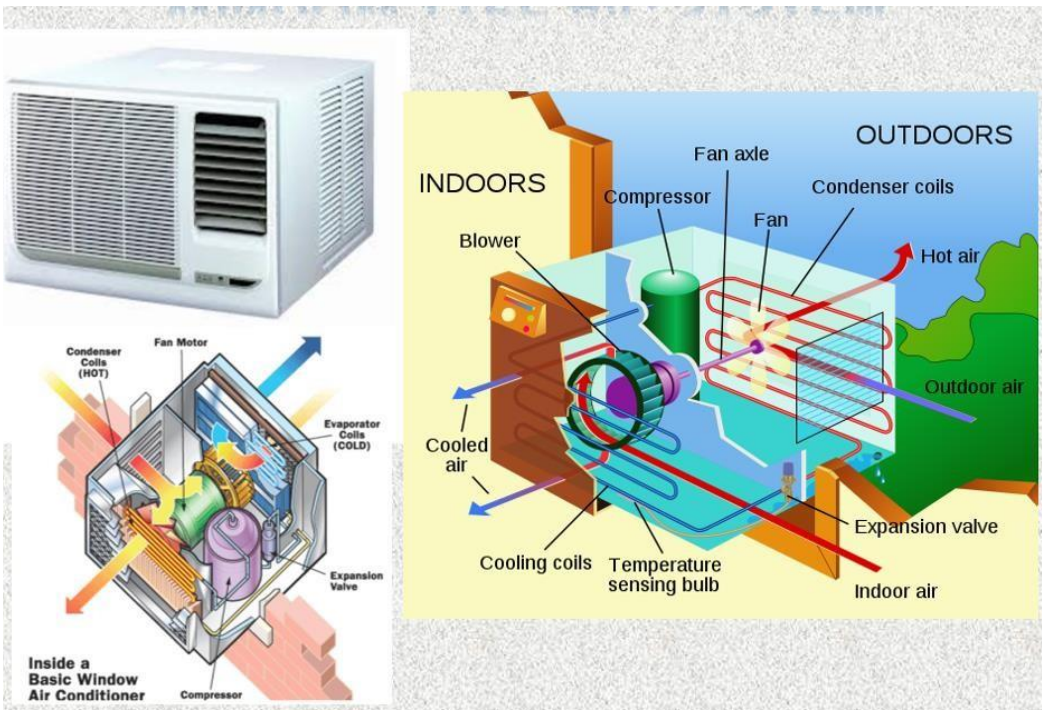
- In many buldings there is a variety of spaces with different users and varrying thermal loads. When a system is designed to provide independent control in different spaces , each space is called a zone.
- Zoning lead 4 broad categories of A/C system:
  1. Unitary , refigeration-based system
  2. All-air systems.
  3. Air and water systems.
  4. All water systems.

1. Unitary, Refrigeration-based systems

- Single Package Units
- Split Package Units

Single Package Units

Window Air Conditioner



Split Package UnitsSplit

System

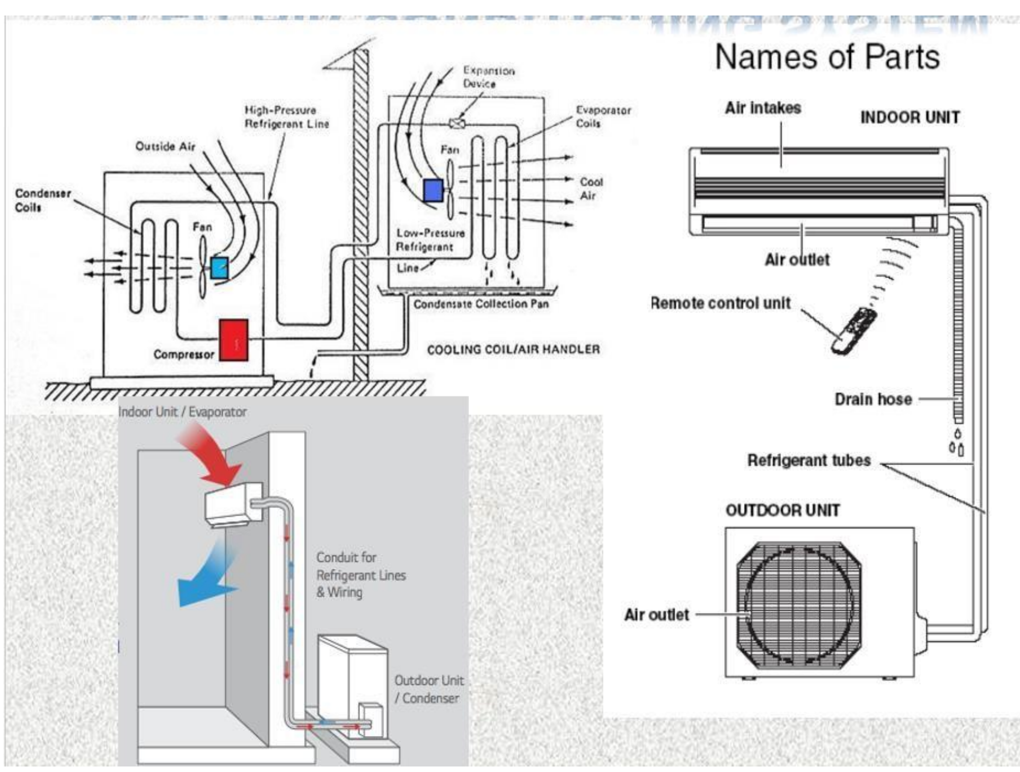


Figure: Split Package Units ,Split System

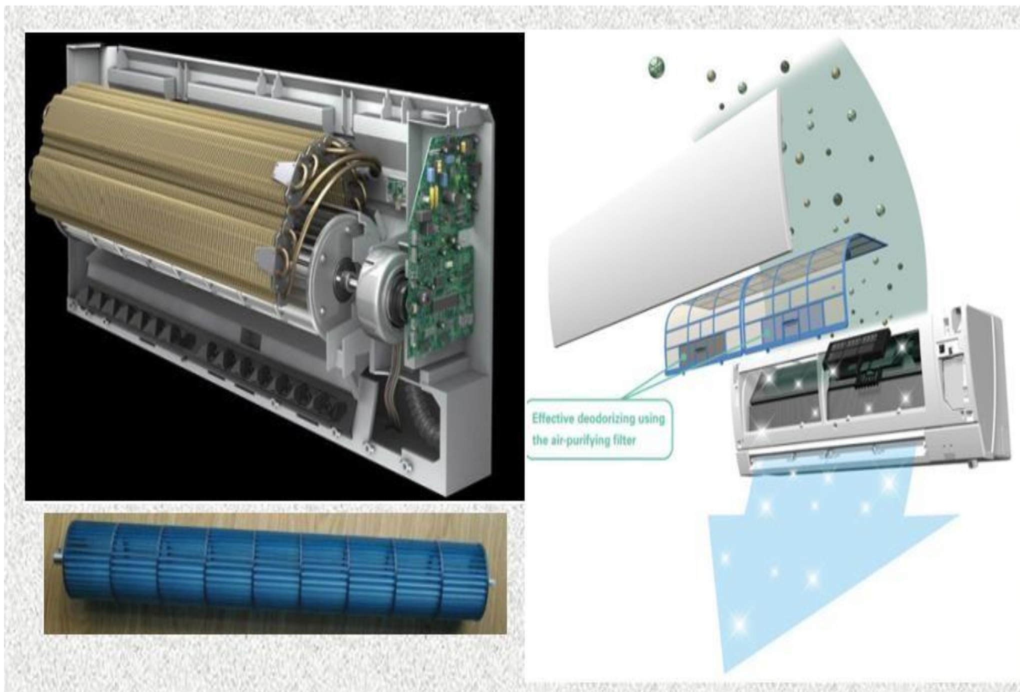


Figure: Split Package Units ,Split System

Split Package Units Ducted
Split Type A/C

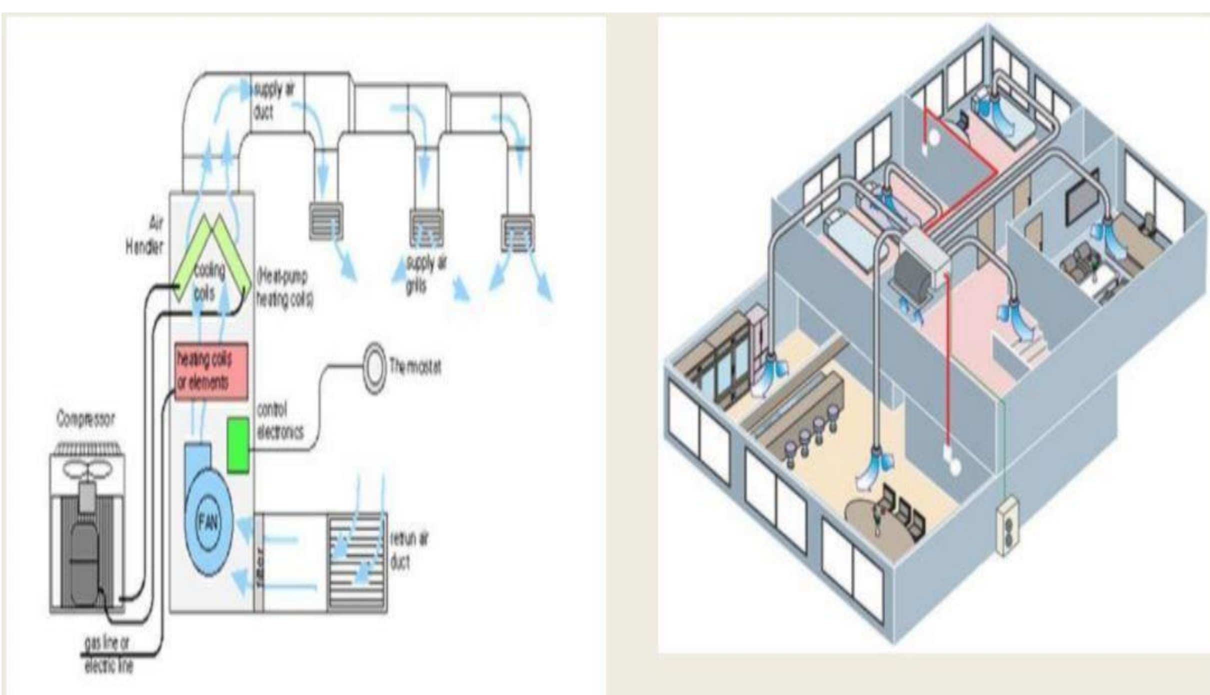


Figure: Ducted Split Type A/C

Split Package Units Chiller Type or Central A/C

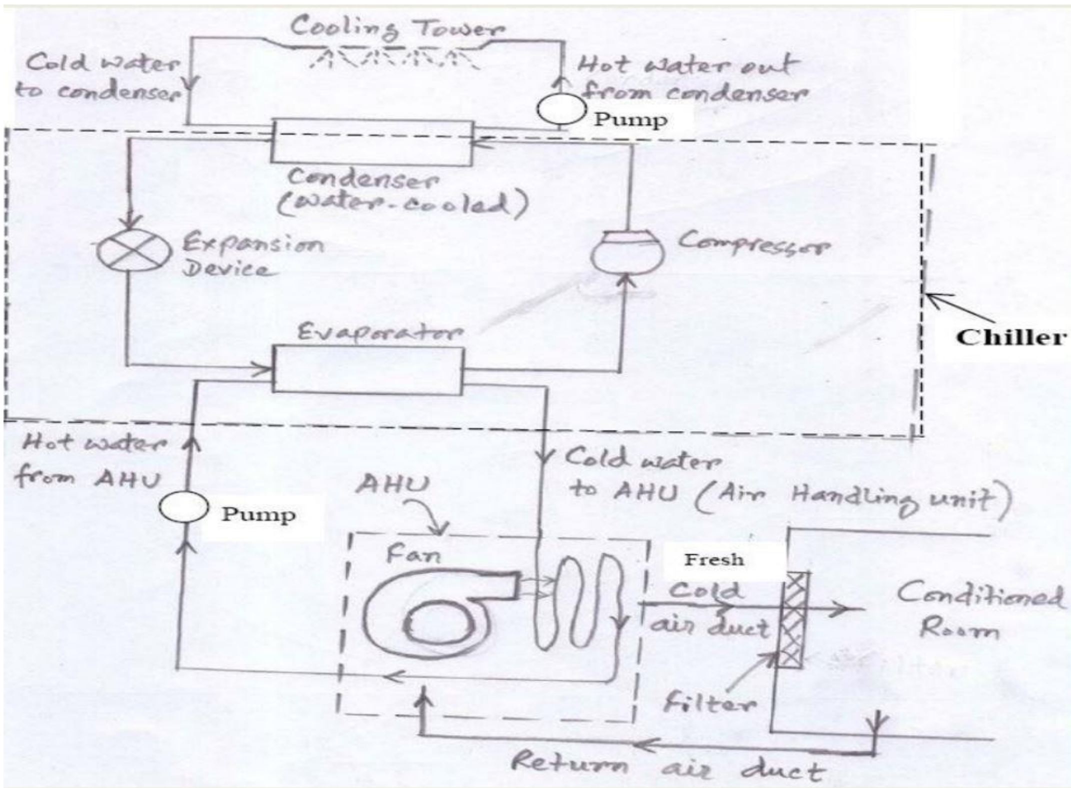


Figure: Schematic diagram of Chiller Type or Central AC

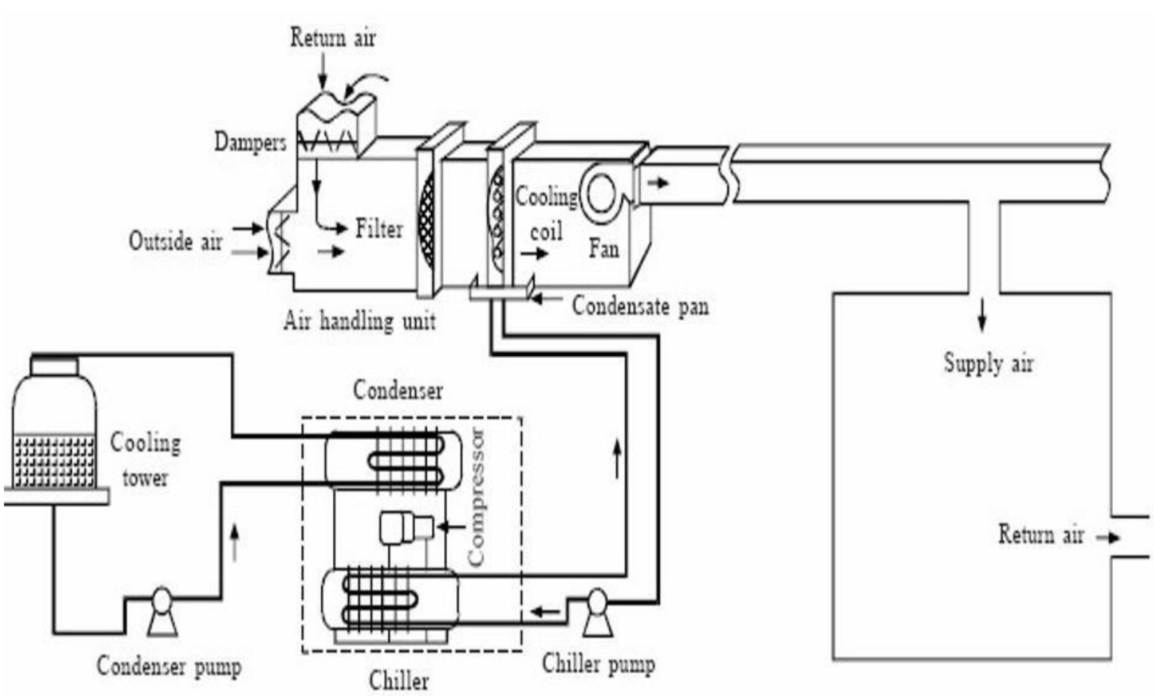


Figure: Chiller Type or Central AC

Experiment 03

Study of Centrifugal Pump

Objective:

- To get the basic knowledge related to pump
- To know the working principle of a centrifugal pump

Introduction:

What is Pump?

A pump is a device that is used for lifting the liquid from ground sources to the upper top surface or fromone place to another place. Pumps are operated by the mechanism that is rotary, reciprocating and it consumes energy while performing mechanical work which is moving fluid from one place to another.

What is a Centrifugal Pump?

A centrifugal pump uses a centrifugal force to pump the fluids. Therefore, it is known as a centrifugalpump.

Centrifugal Force:

Centrifugal force affects an object or material moving in a circular pattern by causing it to pull away fromthe central axis or center point of the path along which it travels.

A Centrifugal pump is a mechanical machine that pumps the fluids by converting the **mechanical power** (rotational energy) into the **pressure energy** of the fluid flow. This mechanical power generally suppliesby the electric motor or engine.

It is a simplest type of hydraulic equipment that uses in a wide variety of industries and in many everydayappliances to move fluids from low to high-pressure areas. It uses **an impeller** to pump the fluid or waterfrom one location to other.

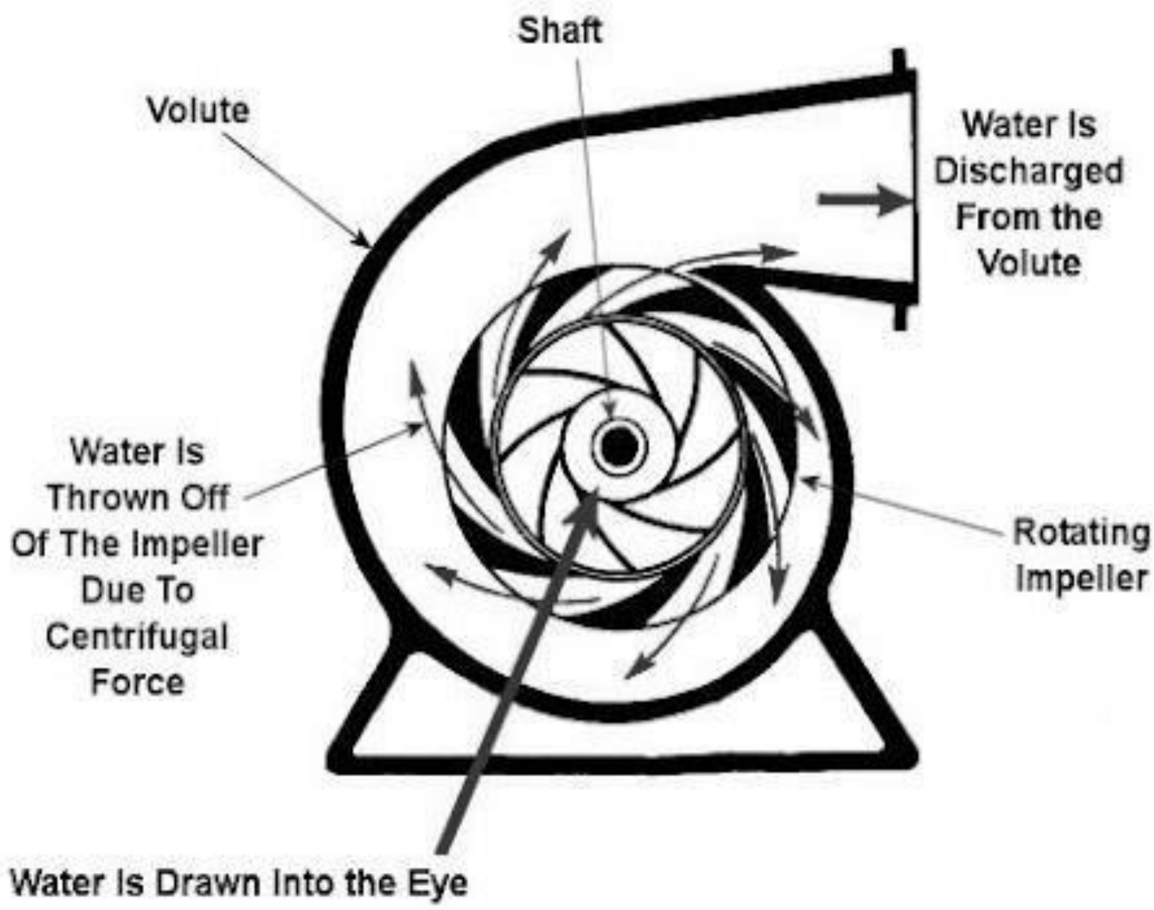


Figure: Schematic Diagram of a Centrifugal Pump

The **impeller** is the key component of a centrifugal pump. It consists of a series of **curved vanes**. Theseare normally sandwiched between two discs (an enclosed impeller). **The rotational motion of the impeller accelerates the fluid out through the impeller vanes into the pump casing**.

Figure: Impeller Types (Open, Semi-Open/ Semi- enclosed, Enclosed)

The main reason for their popularity is that these pumps have no power loss due to friction. This dynamicpump has a simple design and very easy to control. They don't have leakage and heat transfer problems. This is the reason they get preference over the positive displacement pump.

Working Principle of a centrifugal pump:

A centrifugal pump works in the following way:

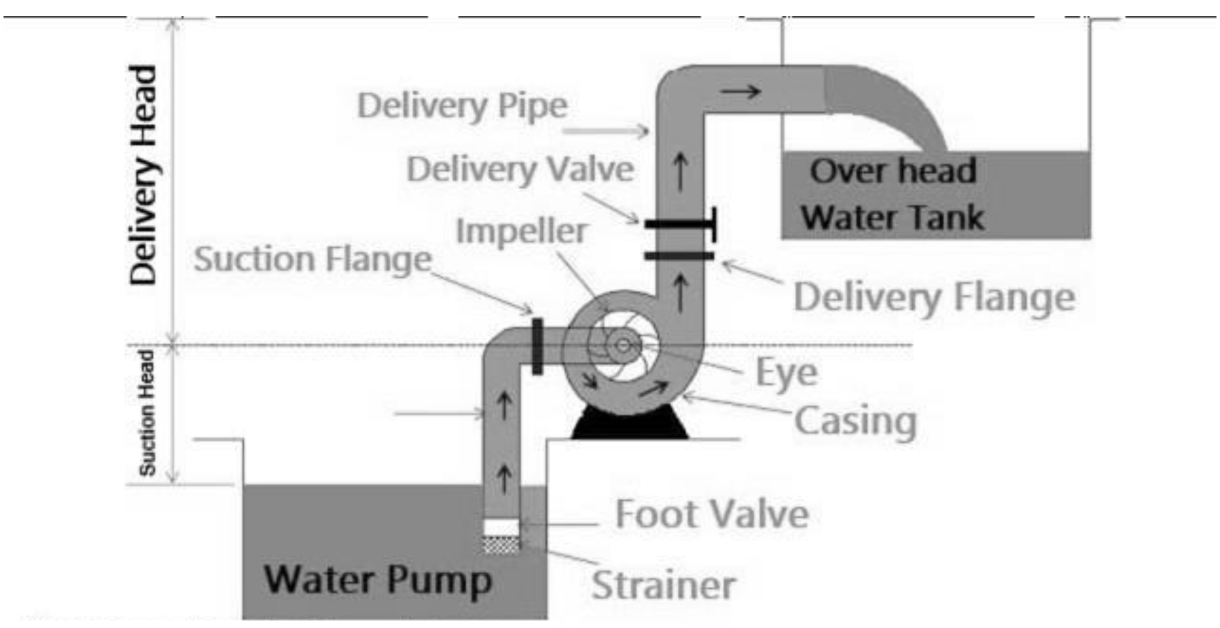


Figure: Working Principle of a centrifugal pump

First of all, mechanical power is provided to the pump impeller by an electric motor or engine. The impeller directly connects with the electric motor through a shaft and reciprocates with the motion of themotor shaft.

When the impeller starts rotating, a vacuum starts generating inside the impeller's eye. Due to thisvacuum, the water starts to enter inside the eye in the axial direction.

As the water enters in the eye, the water strikes the blades of the impeller. The impeller rotates the waterradially and axially outward with the help of centrifugal force. This impeller continues this movement ofwater until it passes through all its components.

The impeller blades convert the kinetic energy of the water into its speed and increase the water speed.

After passing through the impeller, the water enters into the diffuser area. This diffuser slows down the water by reducing its speed. It converts the speed of the water into pressure energy. After increasing thedesired pressure, the water discharges through the pump outlet and transfer it into the desire position.

In this way, a centrifugal pump increases the pressure and pumps the different fluids. In simple words, in a centrifugal pump, fluid or water rises to a certain height due to the centrifugal force acting on these fluids or water. Therefore, this pump knows as a centrifugal pump. And this a complete working principleof the centrifugal pump.

<u>NPSH (Net Positive Suction Head):</u>

NPSH or Net Positive Suction Head is a very important part of a pumping system. The systems NPSHA must be higher than the pump's NPSHR in order for proper pump performance and to eliminate the risk ofdamaging a pump in short order and shut down operations that depend on that pump.

NPSH Available ($NPSH_A$): The absolute pressure at the suction port of the pump.

NPSH Required ($NPSH_R$): The minimum pressure required at the suction port of the pump to keep thepump from damaging.

Cavitation:

Cavitation occurs in centrifugal pumps when the Net Positive Suction Head Available ($NPSH_A$) is lower than the Net Positive Suction Head Required (NPSHR) causing the formation and accumulation of bubbles around the impeller eye that then collapse resulting in a series of mini implosions and significantdamage to both the impeller and the casing.

Priming of a Centrifugal Pump:

Priming simply means preparing or getting something ready for operation. For a centrifugal pump to work properly, you need to fill it up with water. Priming of a centrifugal pump is the process of filling theliquid at the suction pipe and the impeller. Priming is done to put pump into working order by filling or charging with water.

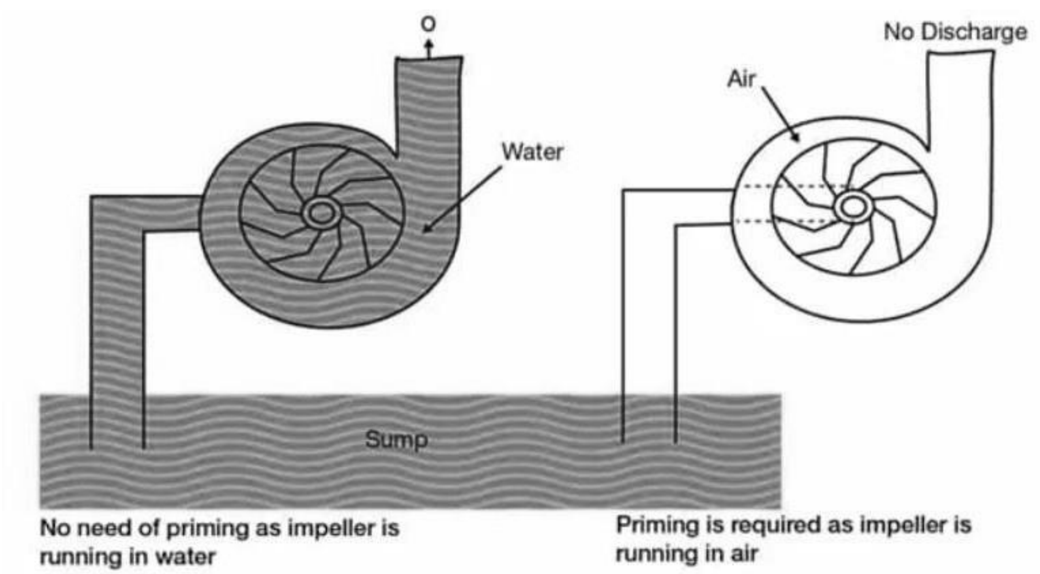


Figure: Requirement of Pump Priming

Why Priming is required?

Pressure developed by the impeller of centrifugal pump, is proportional to the density of the fluid in the impeller. If the impeller is running in air, it will produce only a negligible pressure. This pressure will notsuck water from its source through the suction pipe. To avoid this, pump is first filled up with water.

Method

By taking readings from a centrifugal pump and associated sensors across a range of flow rates through the pump.

Equipment Required

- Centrifugal Pump Demonstration Unit
- Interface device (IFD)
- PC, with required software

Theory

The operating characteristics of a centrifugal pump may be described or illustrated by using graphs of pump performance. The three most commonly used graphical representations of pump performance are:

1. Change in total head produced by the pump, H_t
2. Power input to the pump, P_m
3. Pump efficiency, E

Total Head

The change in total head produced as a result of the work done by pump can be calculated as:

H_t = Change in static head + change in velocity head + change in elevation

$= H_s + H_v + H_e$

where

H_s = Change in static head

$$= \frac{(P_{out} - P_{in})}{\rho g}$$

where P_{in} is the fluid pressure at inlet in Pa and P_{out} is the fluid pressure at outlet in Pa.

H_v = Change in velocity head

$$= \frac{(V_{out} - V_{in})^2}{2g}$$

where V_{in} is the fluid velocity at inlet in m/s and V_{out} is the fluid velocity at outlet in m/s.

H_e = Change in elevation

Power Input

The mechanical power input to the pump may be calculated as:P_m =

rotational force x angular distance

$= 2.\pi.n.t/60$

Where, ‘n’ is the rotational speed of pump in revolutions per minute and ‘t’ is the shafttorque in Nm.

Pump efficiency

The efficiency of the pump may be calculated as

$$E \quad = 100 \times \frac{P_h}{P_m}$$

Where P_h is the hydraulic power imparted to fluid:

$$P_h \quad = H_t . Q . \rho . g$$

Where Q is the volume flow rate in m³/s, and P_m is the mechanical power absorbed by pump:

$$P_m = 2.\pi.n.t$$

Each of these parameters is measured at constant pump speed, and is plotted against the volume flow rate, Q, through the pump. An example of this type of graphical representation of pump performance is given in Figure A1.

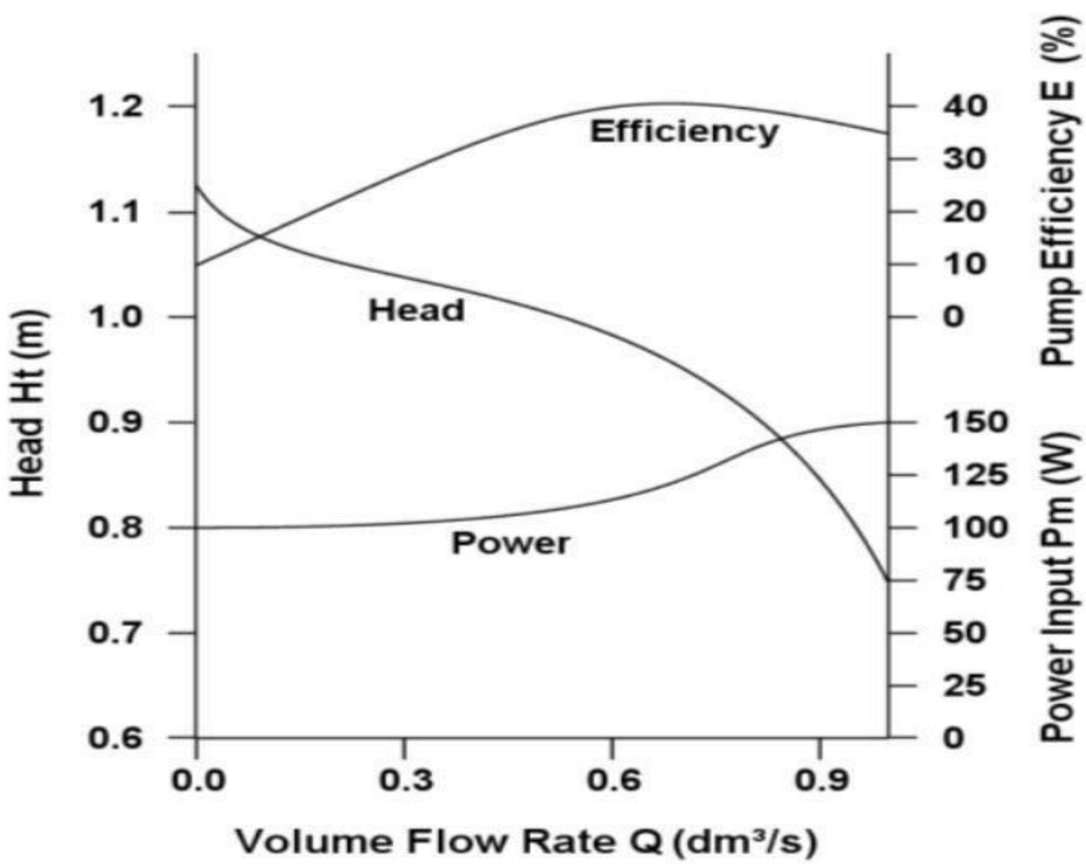


Figure A1

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The H_t-Q curve shows the relationship between head and flow rate. The head decreases as flow rate increases. This type of curve is referred to as a rising characteristic curve.

The P_m-Q curve shows the relationship between the power input to the pump and thechange in flow rate through the pump. Outside the optimum operating range of the pump this curve flattens, so that a large change in pump power produces only a smallchange in flow velocity.

The E-Q curve shows the pump capacity at which the pump operates most efficiently. Inthe example here, the optimum operating capacity is 0.7 dm^3/s, which would give a head of 1.2m.

Equipment Setup

Ensure the drain valve is fully closed.

If necessary, fill the reservoir to within 20cm of the top rim. Ensure

the inlet valve and outlet gate valve are both fully open.

Ensure the equipment is connected to the IFD and the IFD is connected to a suitablePC. The red and green indicator lights on the IFD should both be illuminated.

Ensure the IFD is connected to an appropriate mains supply, and switch on the supply.

Run the software. Check that ‘IFD: OK’ is displayed in the bottom right corner of the screen and that there are values displayed in all the sensor display boxes on the mimicdiagram.

Procedure

Switch on the IFD.

Switch on the pump within the software using the Power On/Standby button.

Using the software, set the speed to 80%. The interface will increase the pump speed until it reaches the required setting. Allow water to circulate until all air has been flushedfrom the system. Slightly closing and opening the inlet valve and gate valve a few timeswill help in priming the system and eliminating any bubbles caught within the valve mechanism. Leave the inlet valve fully open.

Close the gate valve to give a flow rate Q of 0. (Note that the pump will not run well withthe gate valve closed or nearly closed, as the back pressure produced is outside normaloperating parameters. The pump should begin to run more smoothly as the experiment progresses).

Select the "GO" icon to record the sensor readings and pump settings on the resultstable of the software.

Open a little to give a very low flow. Allow sufficient time for the sensor readings to stabilize then select the "GO" icon to record the next set of data.

Increase the flow in small increments, allowing the sensor readings to stabilize then recording the sensor and pump data each time.

Using the arrow buttons on the software display, reduce the pump speed to 0%. Select 'Save' or 'Save As…' from the 'File' menu and save the results with a suitable file name.

Switch off the system within the software using the Power On/Standby button.

Data Sheet

Motor Torque =. .... Nm

Motor Speed = ...rpm

Diameter of inlet pipe, d_{in} = 0.0235 m

Diameter of outlet pipe, d_{out} = 0.0175 m

Vertical distance between inlet and outlet H_e = 0.075m

No of Observation	**Temperature T (◦C)**	**Flow Rate Q (L/s)**	**Inlet Pressure P_{in} (kPa)**	**Outlet Pressure P_{out} (kPa)**	**Total Head, H_t (m)**	**Power Input P_m (W)**	**Efficiency E (%)**
1.							
2.							
3.							

Results

Plot a graph of Head against Flow Rate. On the secondary axis plot a graph of Mechanical Power or/and of Efficiency against Flow Rate.

Conclusion

Examine and describe the shapes of the graphs obtained, relating this to the changing performance of the pump as the flow rate changes. Locate the point of maximum efficiency and determine the maximum efficiency and the flow rate at which it occurs.

Compare the shapes of the curves obtained to the example presented in Figure A1. Discuss any similarities and differences in pump performance between the example presented and the pump on the system

Experiment 04

Study of Turbine

Objectives:

- To know basic working principle of pelton wheel.
- Find out the performance characteristics of a pelton wheel in various condition.

Introduction:

Hydropower/ Water Turbine:

The water turbine changes the **kinetic energy of the falling water** into **mechanical energy** at the turbine shaft.

Falling water spins the water turbine. The turbine converts mechanical energy into electrical energy.

Reaction Turbine:

The working of the reaction turbine can be well understand by taking a rotor having moving nozzles and water of high pressure is coming out of the nozzle. As the water leaves the nozzle, a reaction force is experienced by the nozzle. This reaction force rotates the rotor at very high speed. **Francis, Kaplan** Turbines are reaction turbines.

In the same way in reaction turbine, a reaction force is generated by the fluid moving on the runner blades. The reaction force produced on the runner blades makes the runner to rotate. Fluid after moving over the runner blades enters into draft tube and finally to the trail race.

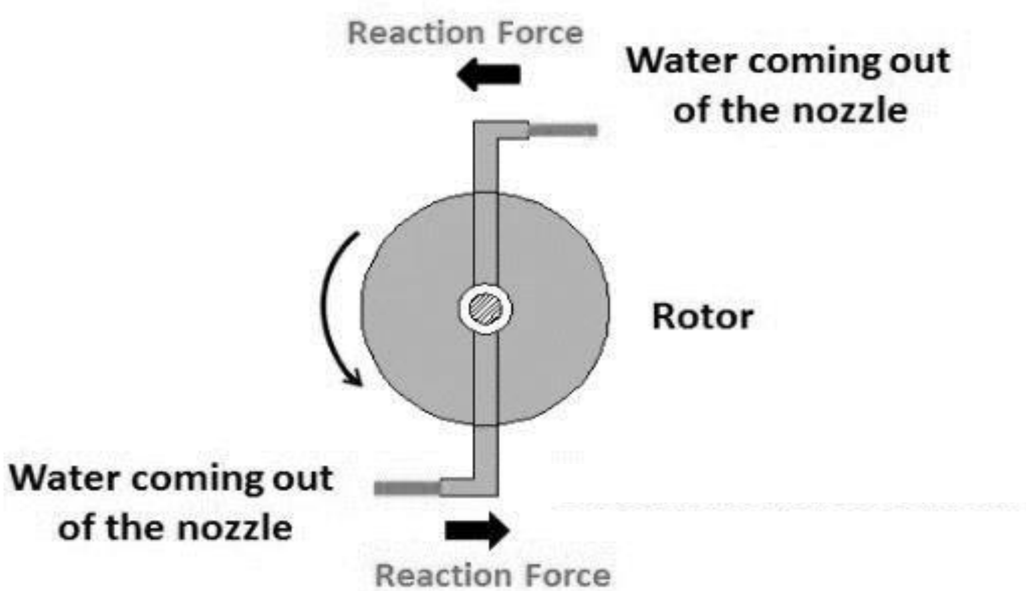


Figure: Reaction Turbine

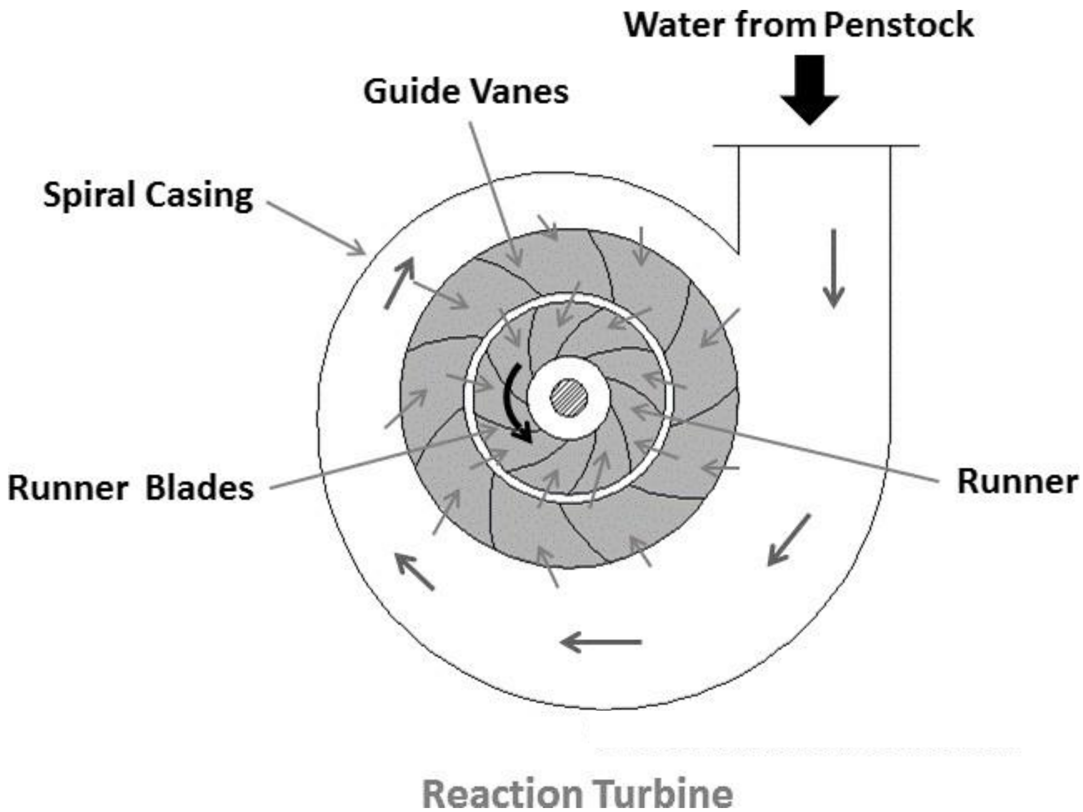


Figure: Reaction Turbine

Low head and high velocity water enters the spiral casing. And as it enters the casing it starts flowing through guide vanes into the runner blades. Guide vanes guides the flow of water to strike the runner blades at proper angle, to produce maximum power output. The water flowing through spiral casing is able to keep its pressure energy consistent throughout the circumference of spiral casing due to its uniformly decreasing cross-section area.

These guide vanes can change their angle to increase or decrease the flow rate of water into turbine. And the runner blades are also made adjustable, as when the flow of water is fast and energy demand is less than they would pitch themselves to incline at a smaller angle with the axis of turbine. And when the load on the turbine is more and flow of water is less, they would adjust themselves at a greater angle with the axis of turbine. Two factors which determines the efficiency of a reaction turbine are the angle of attack of water when it strike runner blades, and the profile of runner blade over which water glides. Due to the adjustability of both the guide vanes and runner blades, we are now able to use this turbine over a wide range of water potential and load demands.

Impulse Turbine:

Impulse turbines are defined as turbines in which high-velocity jets of water or steam collide with the blades of the turbine to rotate the turbine and produce electricity using this winding. The impulse turbine is so named because it acts on the impulse force created for the striking blade of the water jet.

In impulse turbines, water hits the blade tangentially; hence it is also known as a tangent flow turbine. Impulse turbines are suited for high head and low discharge of water. This means that it is used when the amount of water flow is small, and there is high pressure due to the high location of the water head.

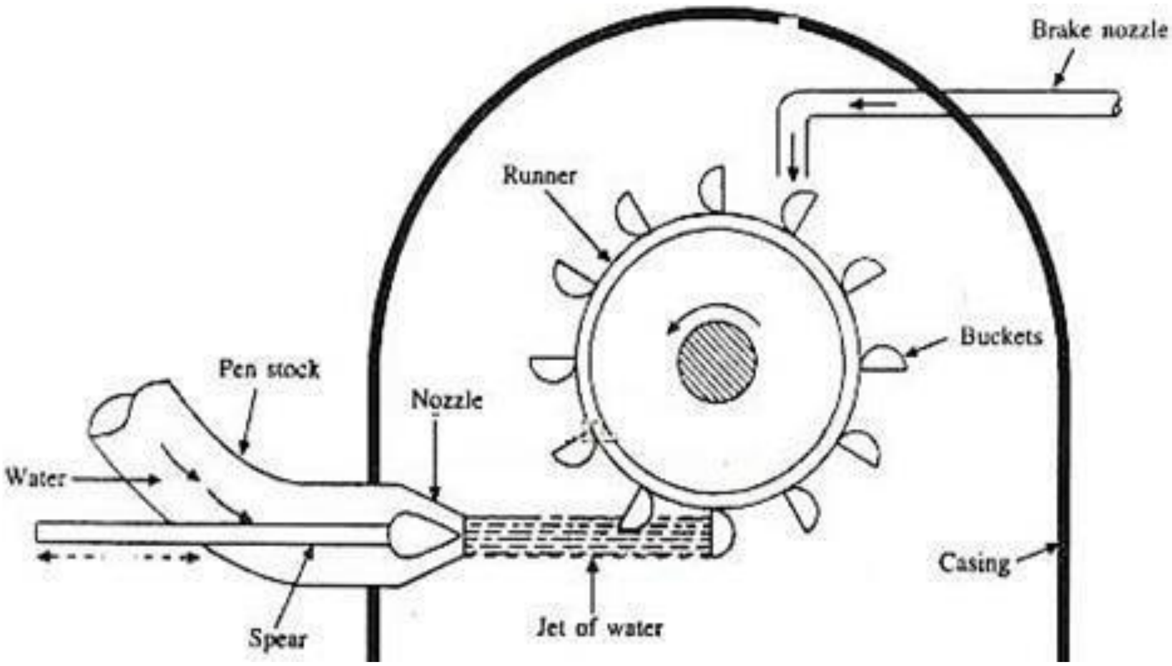


Figure: Impulse Turbine (Pelton-Wheel)

Difference between Impulse and Reaction Turbine:

The main differences between Impulse and Reaction turbines are, all hydraulic energy is converted into kinetic energy by a nozzle in the Impulse turbine and whereas In Reaction turbine Only some amount of the available energy is converted into kinetic energy.

Impulse Turbine has lower efficiency than reaction turbines but requires less space than reaction turbine.

Apparatus: Pelton turbine demonstrator HM289

Technical Data

Pelton turbine
- power output: approx. 70W at 2.700min^{-1}
- rotor diameter: 70mm

Measuring ranges
- torque: 0..0,5Nm
- speed: 0. 9.000min^{-1}

Theory:

The Pelton wheel extracts energy from the impulse of moving water, as opposed to its weight like traditional overshot water wheel. Although many variations of impulse turbines existed prior to Pelton's design, they were less efficient than Pelton's design; the water leaving these wheels typically still had high speed, and carried away much of the energy. Pelton's paddle geometry was designed so that when the rim runs at ½ the speed of the water jet, the water leaves the wheel with very little speed, extracting almost all of its energy, and allowing for a very efficient turbine

Function:

The water flows along the tangent to the path of the runner. Nozzles direct forceful streams of water against a series of spoon-shaped buckets mounted around the edge of a wheel. As water flows into the bucket, the direction of the water velocity changes to follow the contour of the bucket. When the water-jet contacts the bucket, the water exerts pressure on the bucket and the water is decelerated as it does a "u-turn" and flows out the other side of the bucket at low velocity. In the process, the water's momentum is transferred to the turbine. This "impulse" does work on the turbine. For maximum power and efficiency, the turbine system is designed such that the water-jet velocity is twice the velocity of the bucket. A very small percentage of the water's original kinetic energy will still remain in the water; however, this allows the bucket to be emptied at the same rate it is filled, (see conservation of mass), thus allowing the water flow to continue uninterrupted. Often two buckets are mounted side-by-side, thus splitting the water jet in half (.This balances the side-load forces on the wheel, and helps to ensure smooth, efficient momentum transfer of the fluid jet to the turbine wheel.

Because water and most liquids are nearly incompressible, almost all of the available energy is extracted in the first stage of the hydraulic turbine. Therefore, Pelton wheels have only one turbine stage, unlike gas turbines that operate with compressible fluid.

Procedure:

1) Fill the water tank with around 15 litres of clean water.

2) Switch on interference module.

3) Loosen the tension bolt on the breaking device until the belt is no longer under any tension.

4) Switch on pump open valve on service unit check connection for leaks and run up the turbine.

5) Check whether plausible measured values are displayed. (otherwise check sensor connection)

6) Using tension bolt tension the belt and retard the turbine. The torque display on pc should now start to increase.

7) Using the ball cock adjust the flow rate and pressure to the require levels.

8) Loosen the adjusting screw for the turbine brake and record the first measuring point without any load applied. The turbine is running at maximum speed.

9) Increase the load gradually using the adjusting screw and record the subsequent measuring points. When doing this wait for the measured value to archive a steady state.

10) Finally increase the load until the turbine locks up.

Data table:

Obs no	Flow rate Q L/min	Pressure (pa)	Mechanical Power-w	Hydraulic power-w	Efficiency η	Torque T- (N-m)	Speed N-(rpm)

Calculation & result:

The mechanical useful output power for the turbine is calculated from the torque and speed

$$P_{mech} = \frac{2*\pi}{60*100} * M * n \quad W$$

The hydraulic output power for the turbine is calculated from the pump head (in bar) and the pumping flow rate(in/min)

$$P_{hyd} = \frac{100}{60} * p * v \quad W$$

The efficiency level is yielded from the ratio of mechanical useful output to the hydraulic input power

Type equation here.

$$\eta = \frac{P_{mech}}{P_{hyd}} * 100\% \text{ in } \%$$

EXPERIMENT NO – 05

Study of an Automotive IC Engine, Different EngineSubsystems and Engine Control Unit (ECU)

Objectives:

i. Identification and study of functions of different engine components.
ii. Study the different operational system of an IC engine.
iii. Study the relation between Multipoint Fuel injection (MPFI) System and ECU

The **internal combustion engine** (IC Engine) is a heat engine that converts heat energy (chemical energy of a fuel) into mechanical energy (usually made available on a rotating output shaft).

Classifications of IC Engines:

IC engines can be classified according to:
1. Number of cylinders – 1, 2, 3, 4, 5, 6-to-16-cylinder engines.
2. Arrangement of cylinders – Inline, V-type, Flat type, etc.
3. Arrangement of valves and valve trains – In-block camshaft, OHC, DOHC, etc.
4. Type of cooling – Air-cooled, Water-cooled, etc.
5. Number of strokes per cycle – 2-stroke, 4-stroke engines.
6. Type of fuel burned – Petrol, diesel, CNG, etc.
7. Method of ignition – Spark Ignition (SI), Compression Ignition (CI).

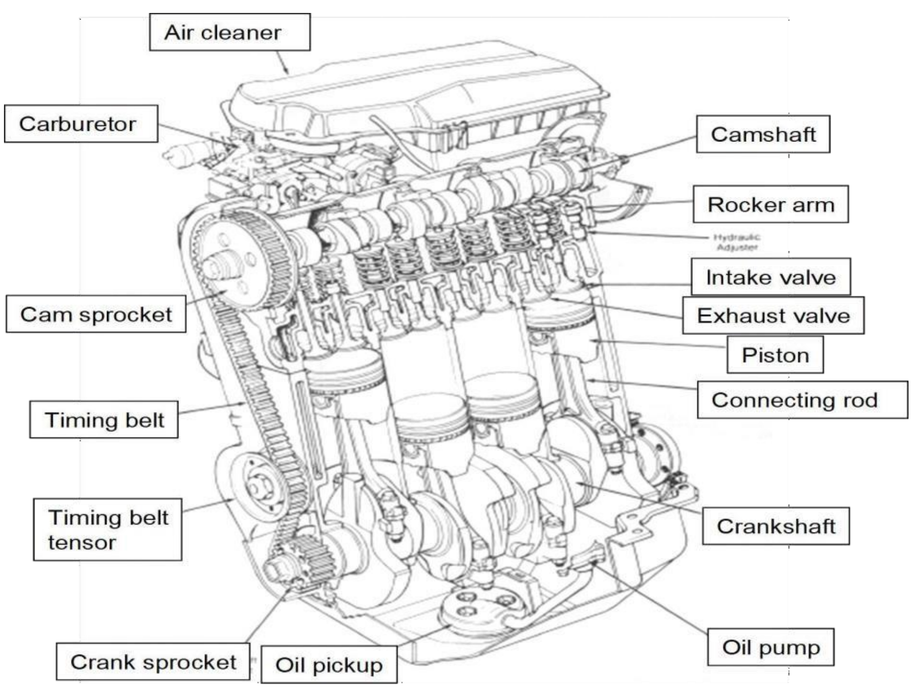


Figure: Different engine components

Constructional details of I.C. Engines

A cross-section of an air-cooled I.C. engine with principal parts is shown in Fig. (Air-cooled I.C. engine).

A. Parts common to both Petrol and Diesel engine:

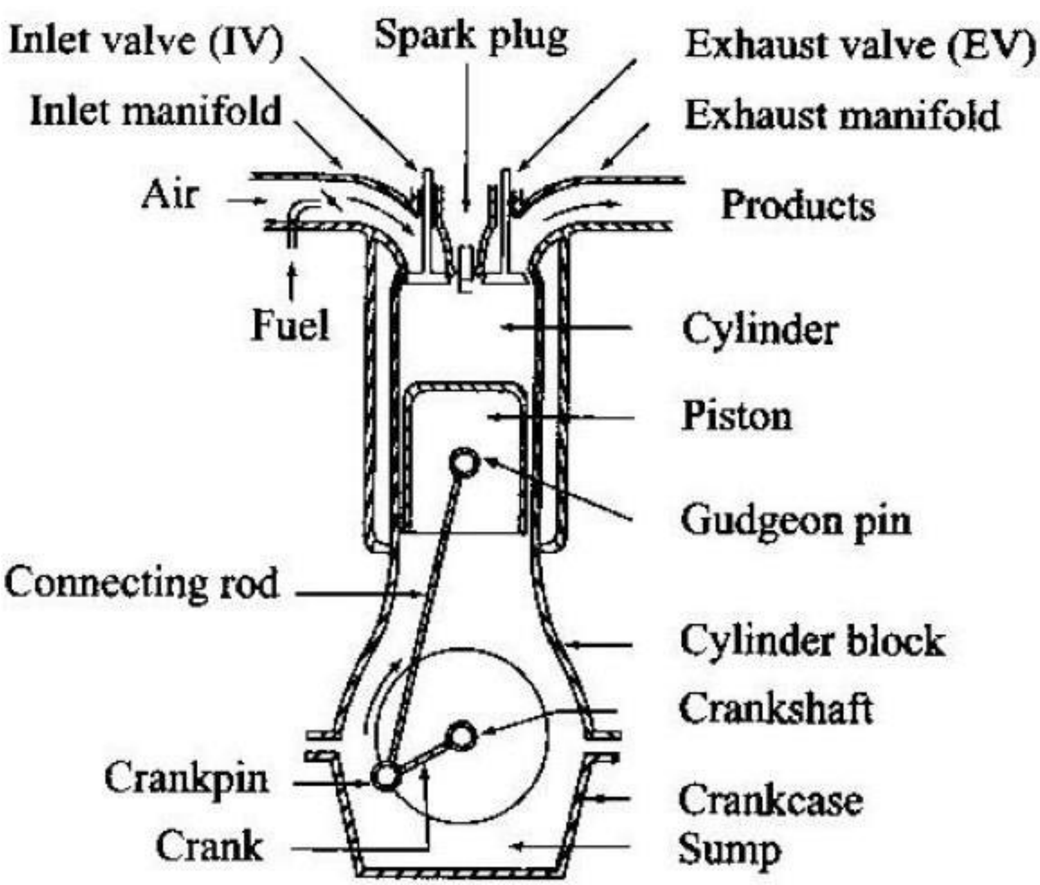
1. Cylinder, 2. Cylinder head, 3. Piston,
4. Piston rings, 5. Gudgeon pin, 6. Connecting rod,
7. Crankshaft, 8. Crank, 9. Engine bearing,
10. Crank case. 11. Flywheel, 12. Governor,
13. Valves and valve operating mechanism.

B. Parts for Petrol engines only:

1. Spark plug, 2. Carburettor, 3. Fuel pump.

C. Parts for Diesel engine only :

1. Fuel pump, 2. Injector.



Different engine components:

1. **Cylinder block:** The cylinder block is the foundation of the engine. Usually made of cast iron; Contains coolant passages.

2. **Cylinder Head:** A detachable unit of an engine bolted to the top of the cylinder block

3. **Crankcase:** Holds the cylinder and crankshaft of an IC engine. Made of cast iron. Also serves as a sump for the lubricating oil.

4. **Connecting Rod:** Connecting rod is used to transmit the motion from the piston to the crankshaft. Made of forged-steel or cast iron.

5. **Crankshaft:** It is considered as the backbone of an engine. Its function is to Convert reciprocating motion of the piston into rotary motion with the help of connecting rod. Made of forged steel.

6. **Piston:** The piston is a cylindrical plug that moves up and down in the engine cylinder. Made of aluminum, cast steel or cast iron. It contains piston rings (oil & compression).

7. **Flywheel:** Mounted on the crankshaft. To maintain its speed const. Storing excess energy during the power stroke, which is returned during another stroke.

8. **Intake and Exhaust Valve:** Intake valve usually made of a chromium-nickel alloy and slightly larger than exhaust valve for higher volumetric efficiency and also combustion. Exhaust valve made of a silicon-chrome alloy since it operates at higher temps.

Four Stroke Spark Ignition (SI) Engine:

Stroke 1:	Fuel-air mixture introduced into cylinder through intake valve
Stroke 2:	Fuel-air mixture compressed
Stroke 3:	Combustion occurs and product gases expand doing work
Stroke 4:	Product gases pushed out of the cylinder through the exhaust valve

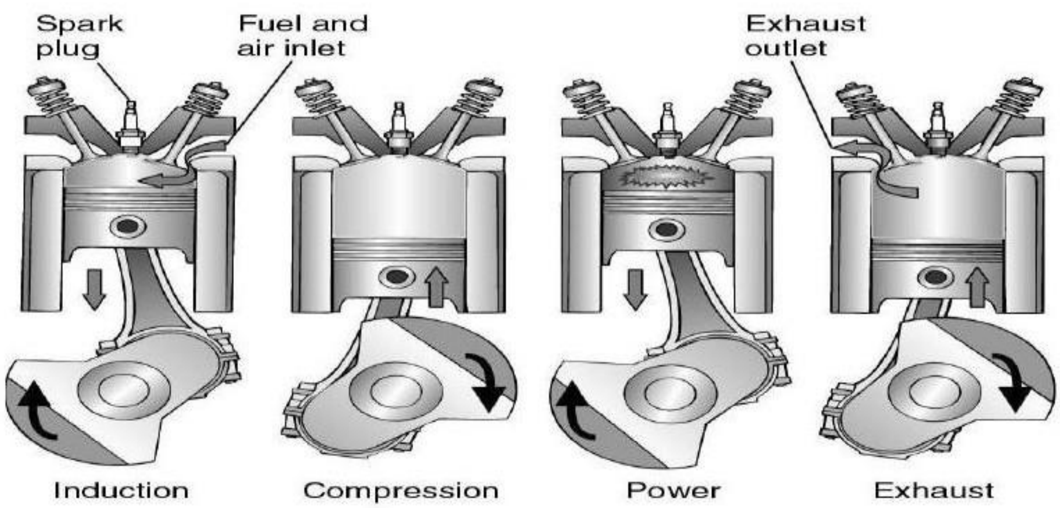


Figure: Different strokes of the SI Engine

Orientation with the following systems:

1. Fuel supply system
2. Lubricating oil system
3. Cooling water system
4. Air intake and exhaust system

Comparison of Petrol and Diesel Engines

SL No	**Petrol (SI) Engine**	**Diesel (CI) Engine**
1	A petrol engine draws a mixture of petrol and air during suction stroke.	A diesel engine draws only air during suction stroke.
2	The carburetor is employed to mix air and petrol in the required proportion and to supply it to the engine during suction stroke.	The injector or atomizer is employed to inject the fuel at the end of compression stroke.
3	Pressure at the end of compression is low.	Pressure at the end of compression is high.
4	The charge is ignited with the help of sparking plug.	The fuel is injected in the form of fine spray. The temperature of the compressed air is sufficiently high to ignite the fuel.

Engine Sub-systems

4. Air intake and exhaust system:

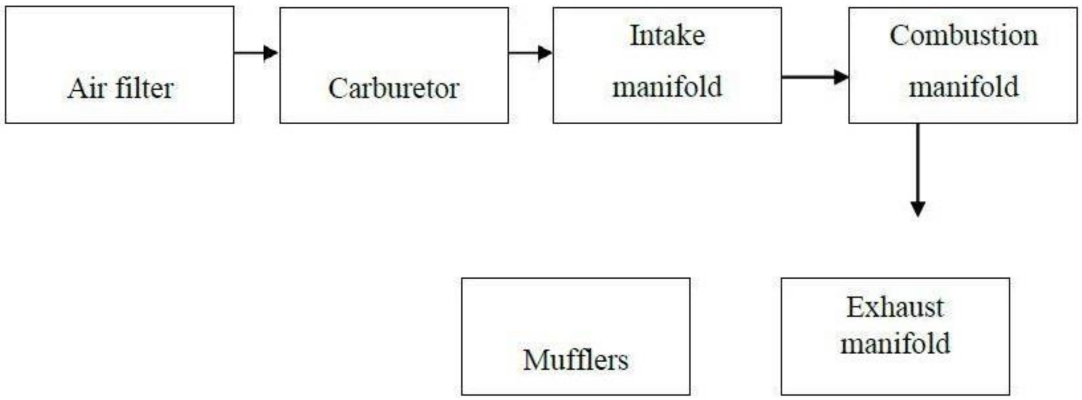
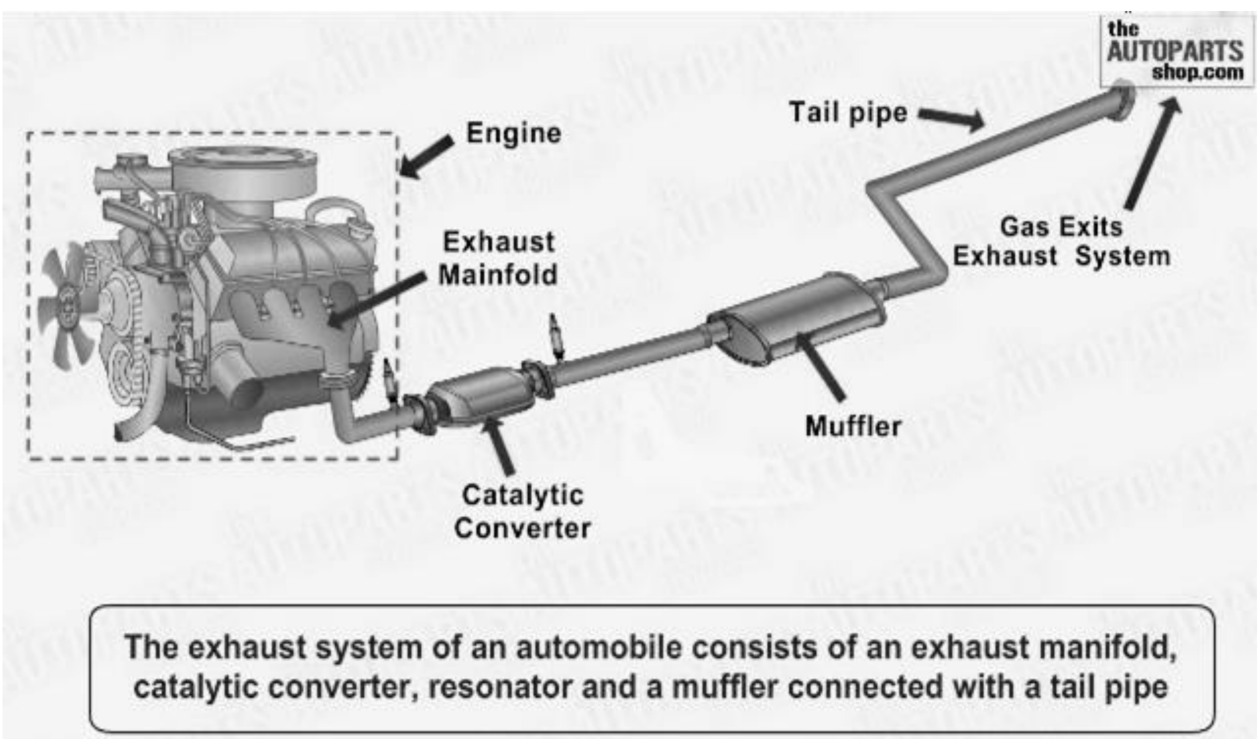


Figure: Flow diagram of air intake and exhaust system

Exhaust system consists of -

- Exhaust Manifold
- Catalytic Converter
- Exhaust Pipe
- Muffler/ Silencer



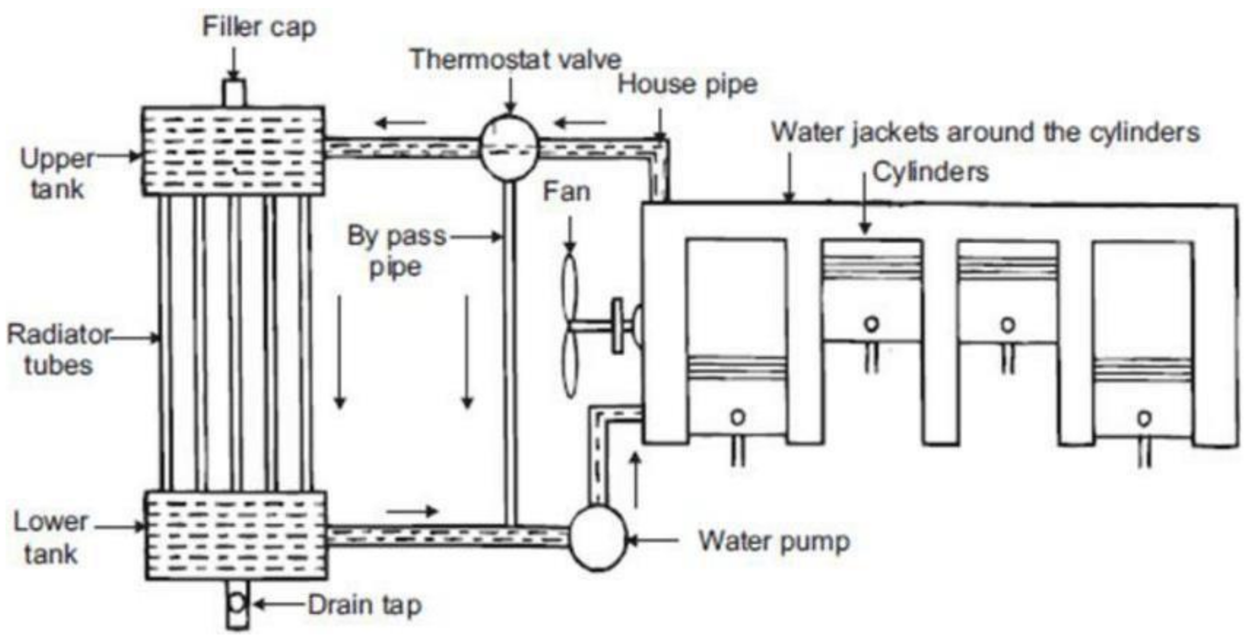
Engine Cooling System

Purpose of cooling

a. To keep the engine at its most efficient temp at all speeds and operating conditions.
b. To take away extra heat before it damages engine parts.
c. It also helps bring the engine up to normal operating temp as quickly as possible

Components

• Radiator – Water-Air Heat Exchanger, Large surface area, Cross flow from fan
• Pressure Cap – Maintains pressure, two-way valves
• Expansion Tank – Keeps radiator filled with water (hot and cold) controlling volume
• Hoses – Fabric reinforced Rubber
• Thermostatic Valve – Maintains water temperature in the water-jacket in certain desired level by controlling flow
• Water Jacket – Water filled space around cylinders
• Fan – Electrical/Mechanical Drive – Motor/Fan belt - advantage/ disadvantages
• Pump – Centrifugal type – low head
• Coolant Temperature Sensor



Cooling system working principle

- The fluid circulates through pipes and passageways in the engine.
- As the liquid passes through the hot engine, it absorbs heat, cooling the engine.
- After the fluid leaves the engine, it passes through a heat exchanger, or radiator, which transfers the heat from the fluid to the air blowing through the exchanger.
- The liquid-cooling system for automobiles offers the most efficient cooling and it maintains an optimum engine temp.
- The pump sends the fluid into the engine block, where it makes its way through passages in the engine around the cylinders.
- Then it returns through the cylinder head of the engine.
- The thermostat is located where the fluid leaves the engine.
- The thermostat sends the fluid back to the pump directly if the thermostat is closed.
- If it is open, the fluid goes through the radiator first and then back to the pump.
- There is also a separate circuit for the heating system.
- This circuit takes fluid from the cylinder head and passes it through a heater core and then back to the pump.

Lubrication System

Purpose of lubrication

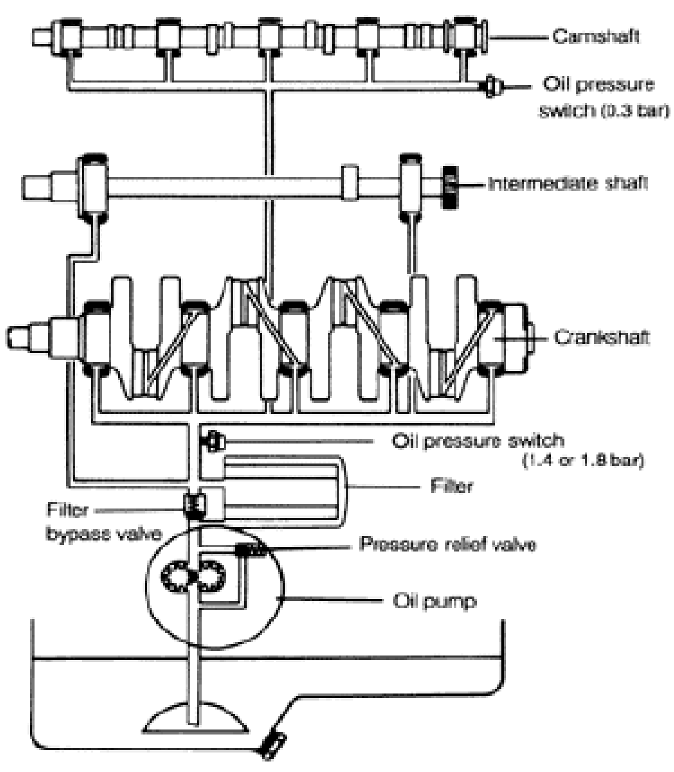
• Reduce friction between moving parts
• Reduce wear of the moving parts as far as possible
• Provide cooling effect

LUBRICANTS

• Lubricants are required to protect undue wear wherever one rotates in another parts
• Different moving parts like the steering system, axle’s differential, transmission, brakes etc use special type of lubricants

LUBRICATION SYSTEM

Lub Oil Sump
(Chamber)
↓
Strainer
↓
Pump
(Cam operated gear/vane fitted with relief valve)
↓
Filter
(Replaceable cartridge)
↓
Main Oil Gallery
↓
Holes/Passages/Channels
(to valves, cam, crank-piston)
↓
Return to sump
(gravity feed)



Designation of Lub Oil

SAE 30, SAE 40 (higher number more viscous)

SAE 10W-30, SAE 5W-20 (Multiple viscosity)

Electronic Fuel Injection (EFI) System and ECU

What is EFI?

EFI is a way of delivering fuel to the engine by electronically controlling injection directly into the intake manifold near the intake valve

Electronic Control System

This system consists of-

- Various engine SENSORS,
- Electronic Control Unit (ECU),
- Fuel injector assemblies, and related wiring

ECU

- The ECU determines precisely how much fuel needs to be delivered by the injector based on the engine SENSORS output.
- Injector is turned on for the precise amount of time to deliver proper air/fuel ratio to the engine.
- Small computer connected directly to engine
- Monitors engine parameters through the use of sensors
- Manages throttle control, ignition, fuel injection, and power

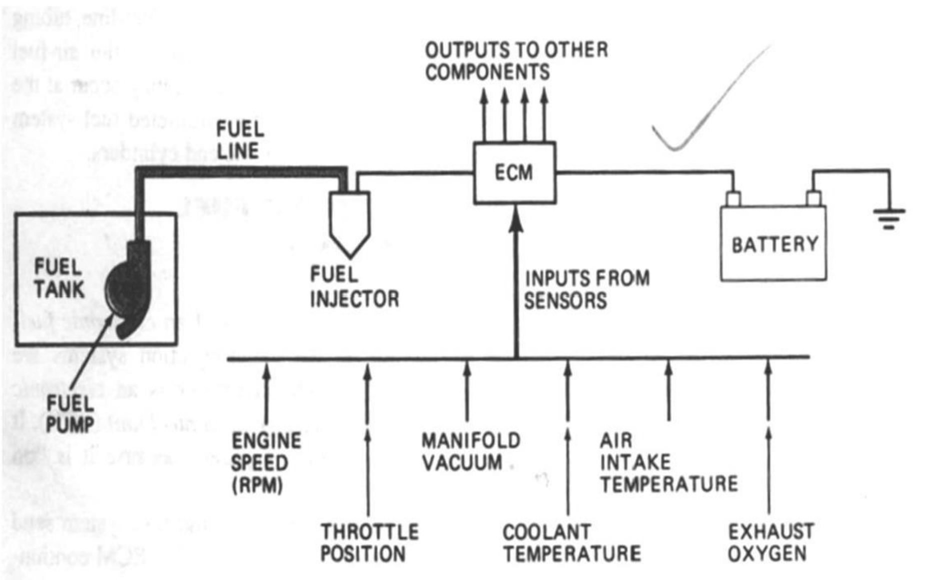
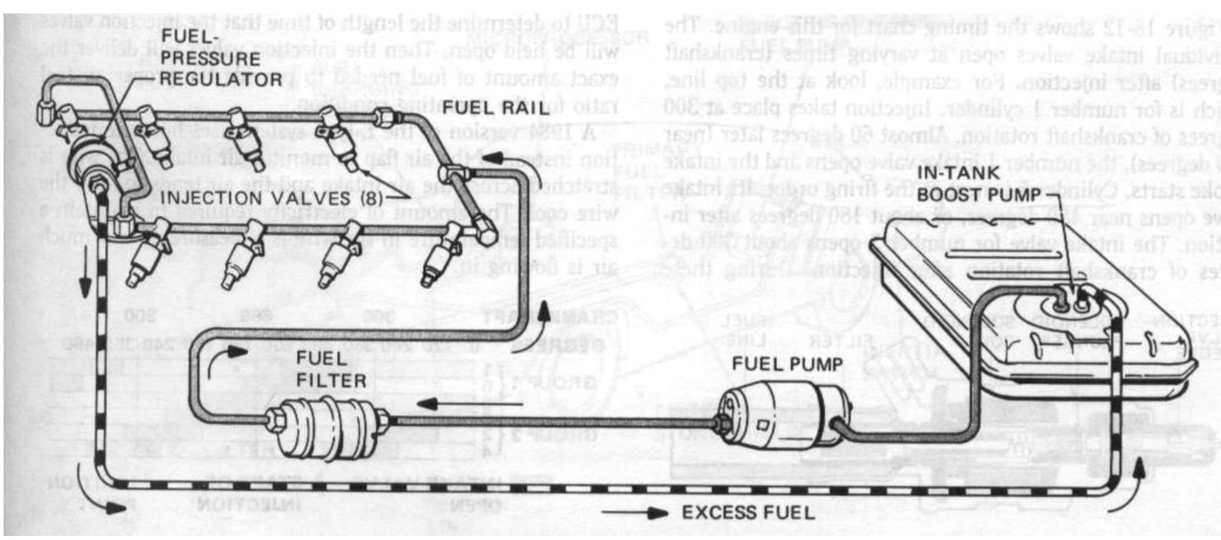


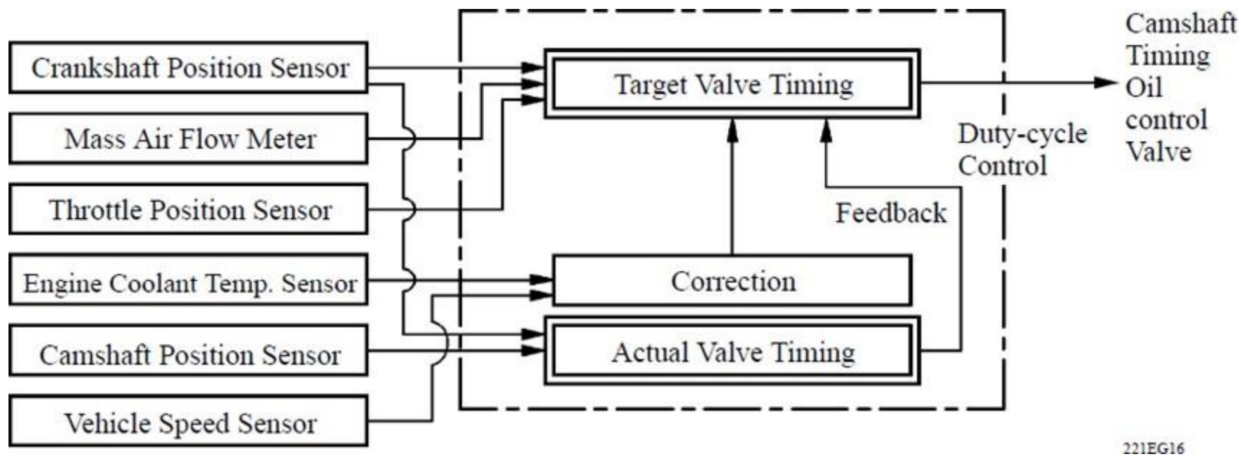
Fig. 19-5 Simplified electronic fuel-injection system. Sensors (bottom) provide information or input to the ECM. The ECM then determines the amount of fuel needed and opens the injectors to produce the desired air-fuel ratio.



Basic Operation of ECU System

- Air enters the engine and then measured by the AIR FLOW METER,
- As the air flows into cylinder, fuel is mixed into the air by injector,
- ECU pulses the injector On and OFF. When it is ON just enough spraying of fuel occurs, to ensure ideal air/ fuel ratio 14.7:1
- The ECU Control delivers precise amount of fuel to the engine.

Using the engine speed signal, vehicle speed signal, and the signals from mass air flow meter, throttle Position sensor and water temperature sensor, the engine ECU can calculate optimal valve timing for each driving condition and controls the camshaft timing oil control valve. In addition, the engine ECU uses signals from the camshaft position sensor and crankshaft position sensor to detect the actual valve timing, thus providing feedback control to achieve the target valve timing.



Experiment No 06

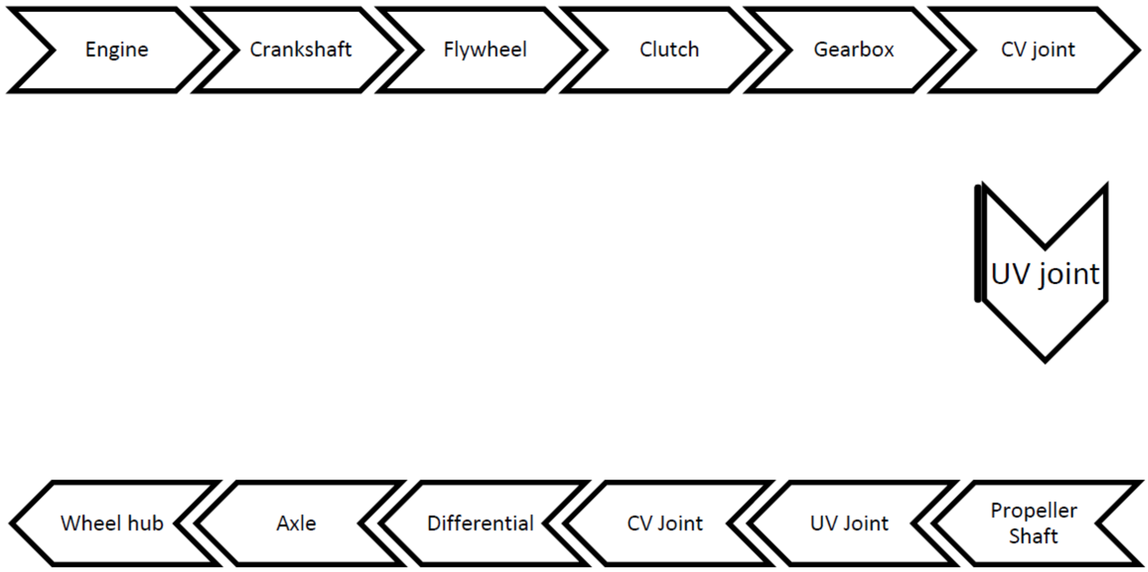
Study of Automotive Transmission System

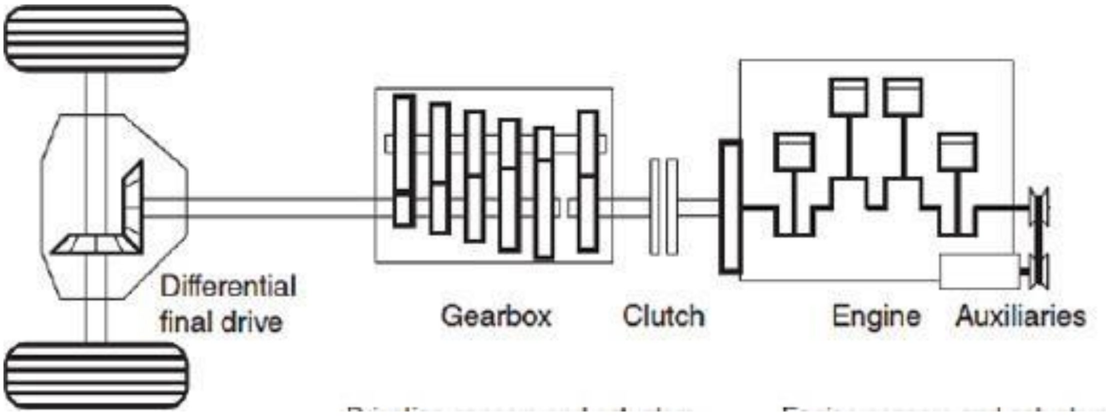
OBJECTIVE

To observe and study the constructional details, working principles and operation of the Automotive Transmission systems.

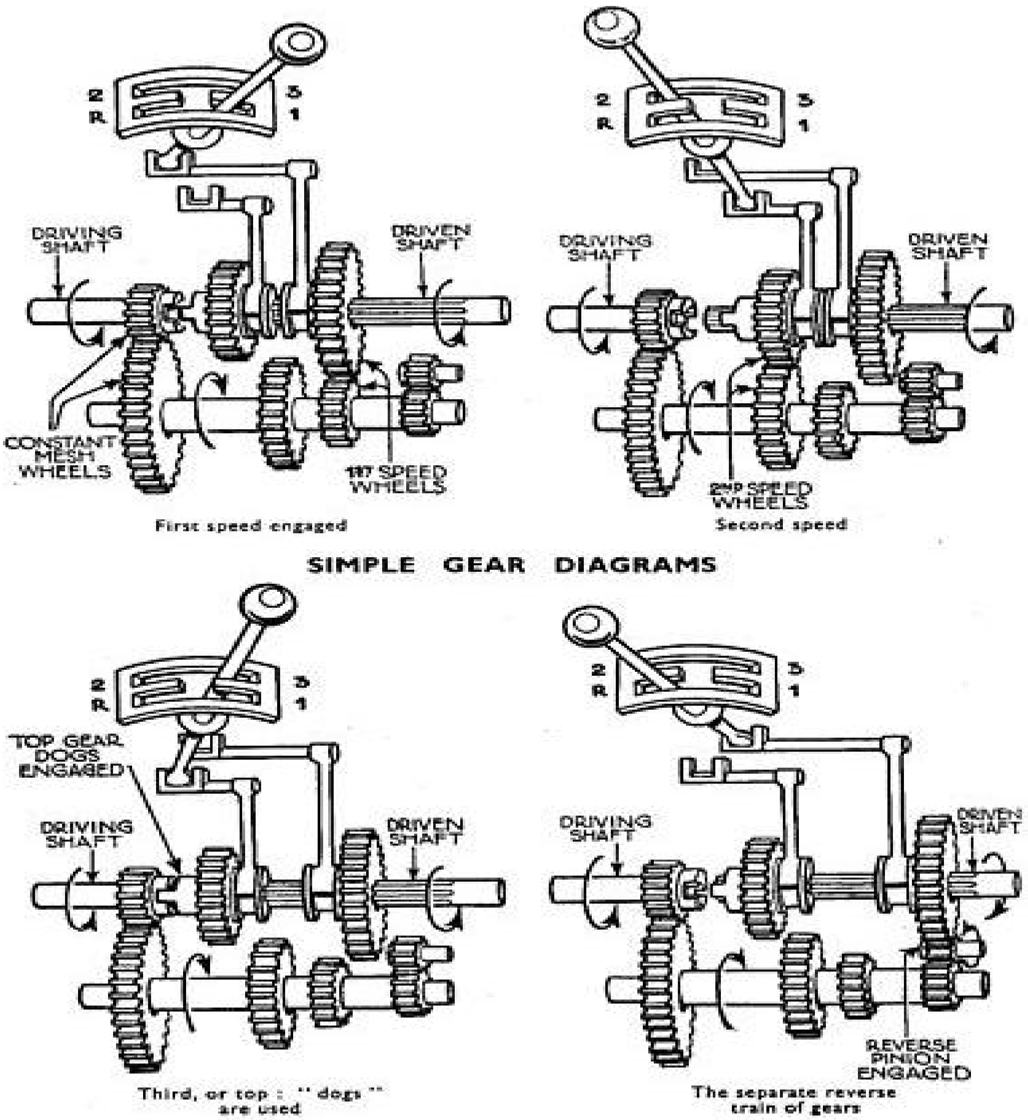
THEORY

The combustion of fuel in the cylinder produces mechanical energy and rotates the crankshaft of an engine. The rotation of engine is low at start and slowly becomes constant over time to a higher value. This rotation needs to be transferred to the wheels. But engine rotates at constant speed while wheel require different speed to propel the car through different terrain and environment. To get different speed values in the wheels, a mechanical system is incorporated in the vehicle which allows the driver to change the wheel speed without changing the engine speed. So, the engine can run at optimum speed to consume least fuel. This mechanism is gearbox. The output of the gearbox still possesses some difficulties in reaching the wheel so some more components are added to make the transmission system. This system consists of clutch, gearbox, UV joints, CV joints, propeller shaft, differential, axles and bearings. The order of the power transmission can be expressed as following:

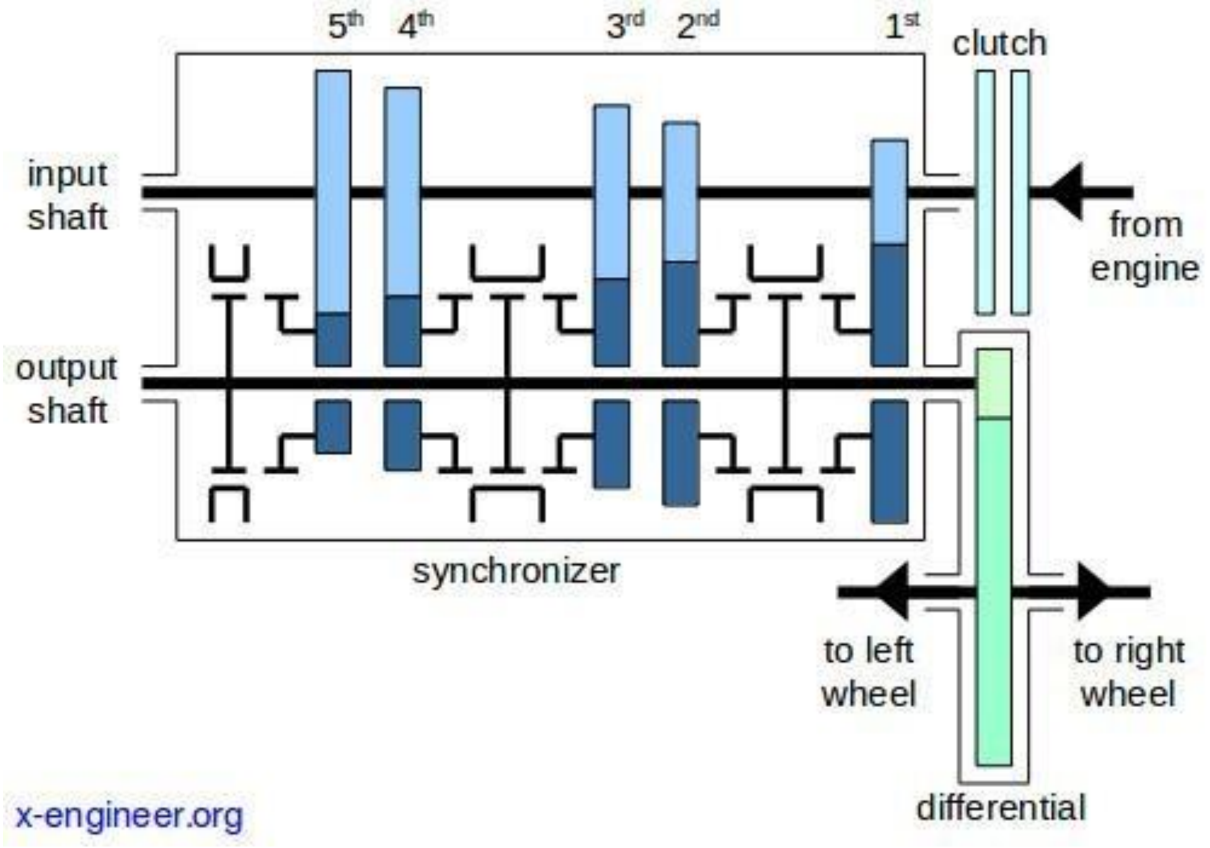




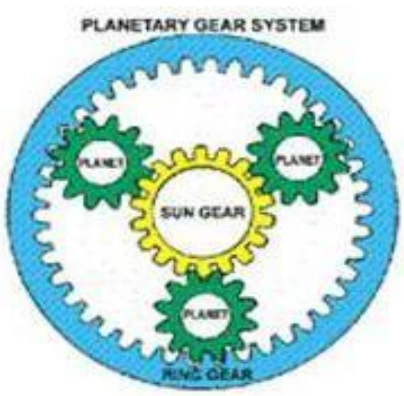
The most common transmission systems that have been used for the automotive industry are manual transmission, automatic transmission (transaxle), semiautomatic transmission, and continuously variable transmission (CVT).

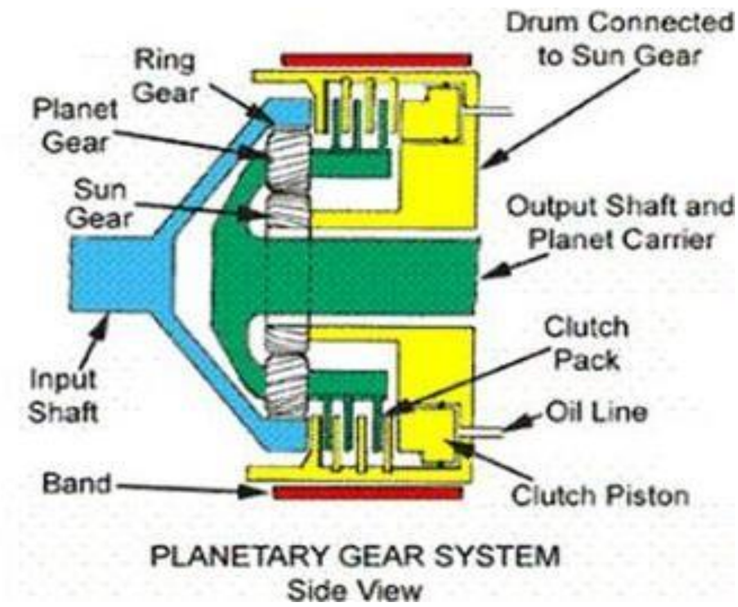


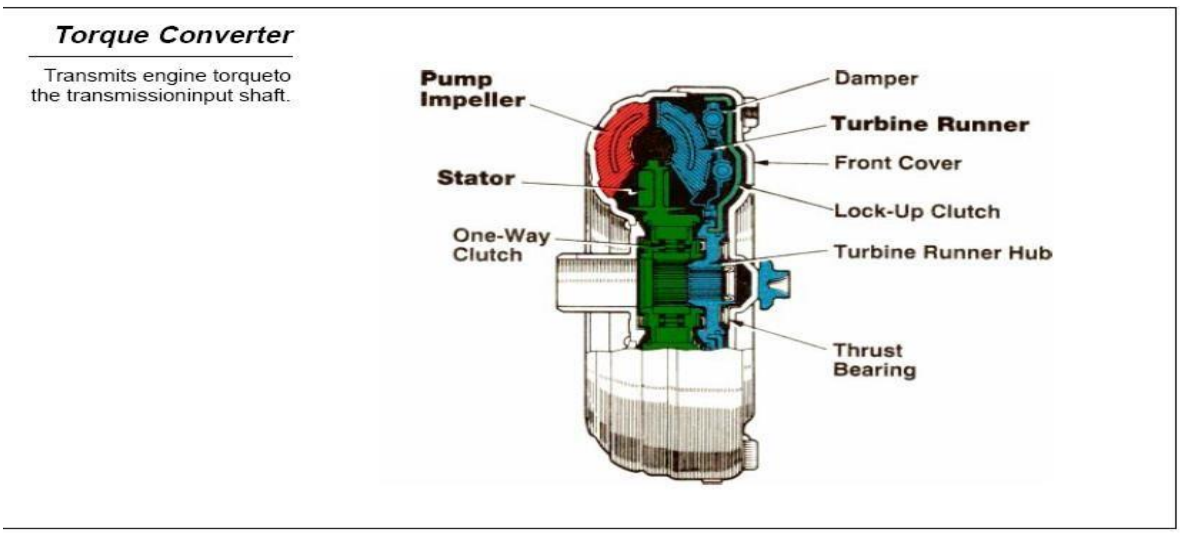
Manual transmission: The first transmission invented was the manual transmission system. The driver needs to disengage the clutch to disconnect the power from the engine first, select the target gear, and engage the clutch again to perform the gear change. There are two/three shafts which engage/disengage the gear sets. Output shaft with greater diameter gear gives low speed but high torque, required at accelerating the vehicle and smaller diameter gear gives high speed and low torque for faster cruise.



<u>Automatic transmission</u> (transaxle): Torque converter replaces the spring driven clutch which works by fluid power. Flywheel is coupled to pump and gearbox is coupled to a turbine and a stator stands in between them to form the torque converter. Power is transmitted by fluid medium in between them so, there is no friction and so, this can withstand high force. The traditional gearbox is replaced by planetary gear mechanism where one input into the gear can provide two different output, either from the ring gear or from the carrier and provide different output speed. The no of gears in a vehicle is decided by the no of planetary gears connected in the system. Gear change takes place automatically and so, there is incorporation of intelligence. Sensors take data of engine RPM, temp, wheel speed, throttle position etc and change the gear by actuating valve train. So, the driver don't need to constantly change gear which can be tedious.



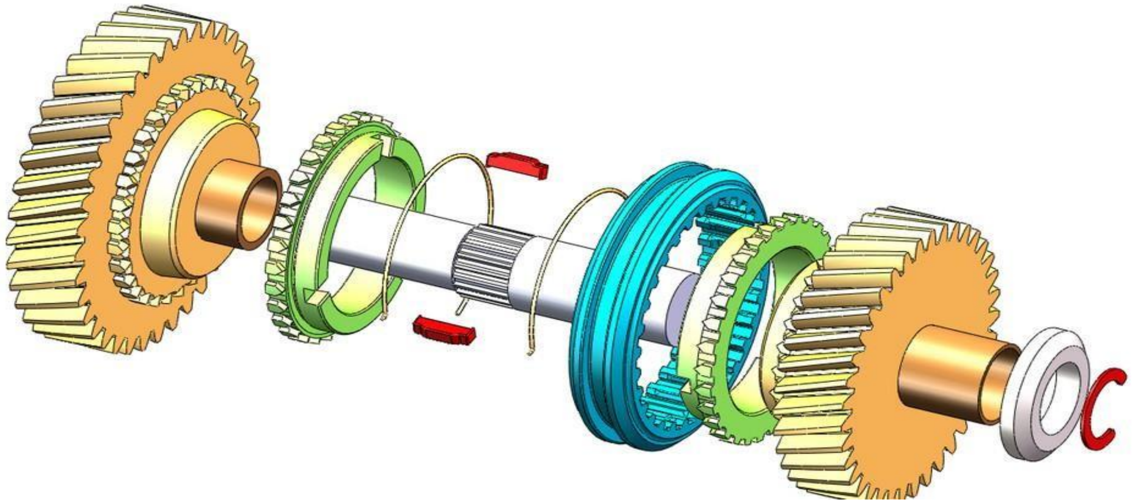




Synchronizers

Synchronizers are used to prevent gear clash during gear shifting. In Manual transmissions in modern passenger cars **synchronizers** are used to eliminate the need for double-clutch. Unlike the lathe machine where gears physically mesh, in automotive gearbox the synchronizer moves and meshes with a gear to engage it.

- To allow the collar and the gear to make frictional contact before the dog teeth make contact. This lets the collar and the gear to synchronize their speeds before the teeth need to engage.
- They ensure that the gears and sliding sleeves about to mesh rotate at the same speed.



Differential gear:

In automobiles and other wheeled vehicles, the differential allows the outer drive wheel to rotate faster than the inner drive wheel during a turn. This is necessary when the vehicle turns, making the wheel that is traveling around the outside of the turning curve roll farther and faster than the other. The average of the rotational speed of the two driving wheels equals the input rotational speed of the drive shaft. An increase in the speed of one wheel is balanced by a decrease in the speed of the other.

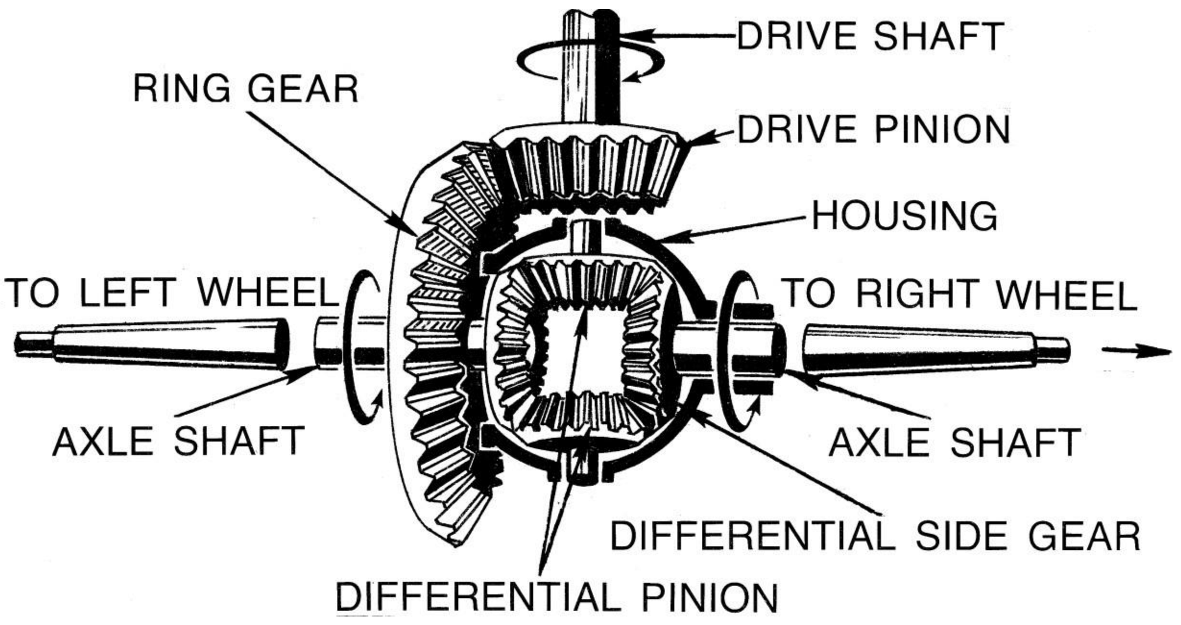


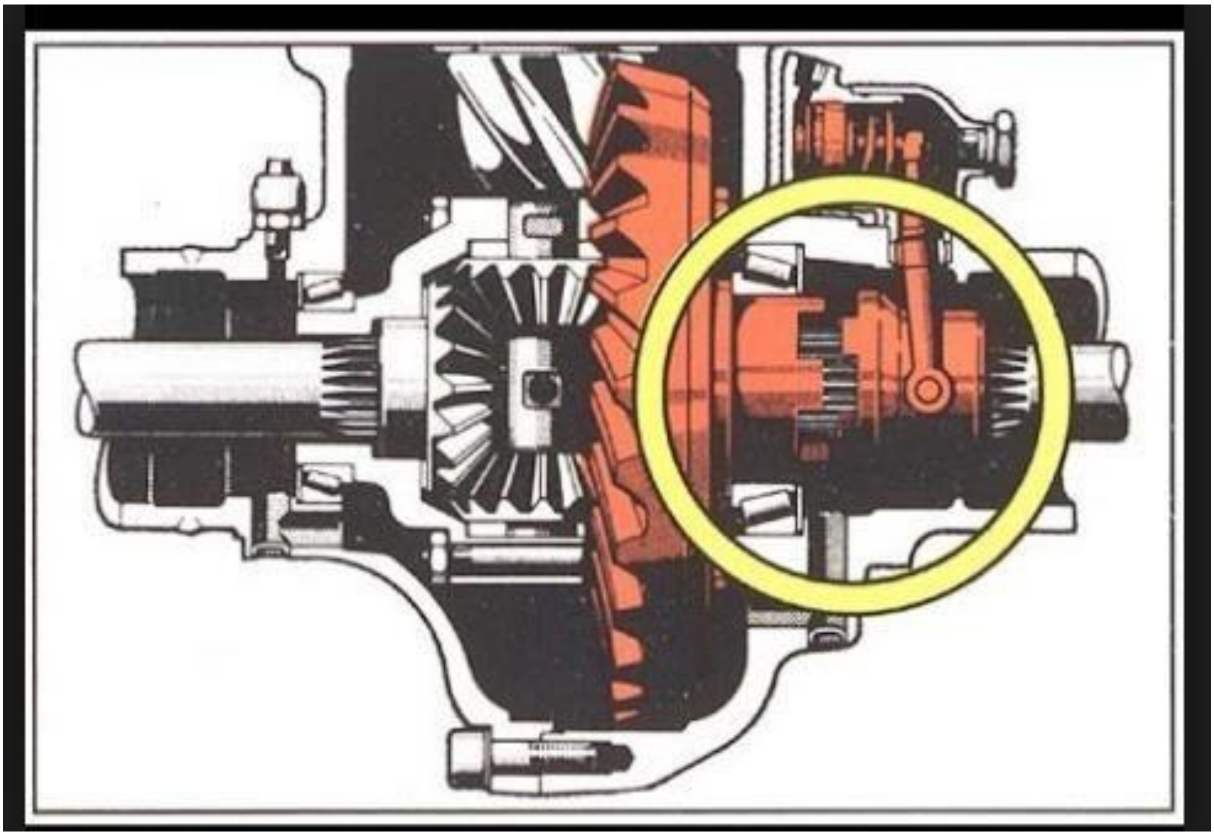
Fig- Differential gear system

When used in this way, a differential couples the input shaft (or prop shaft) to the pinion, which in turn runs on the ring gear of the differential. This also works as reduction gearing. On rear wheel drive vehicles the differential may connect to half-shafts inside an axle housing, or drive shafts that connect to the rear driving wheels. Front wheel drive vehicles tend to have the pinion on the end of the main-shaft of the gearbox and the differential is enclosed in the same housing as the gearbox. There are individual drive-shafts to each wheel.

Differential lock:

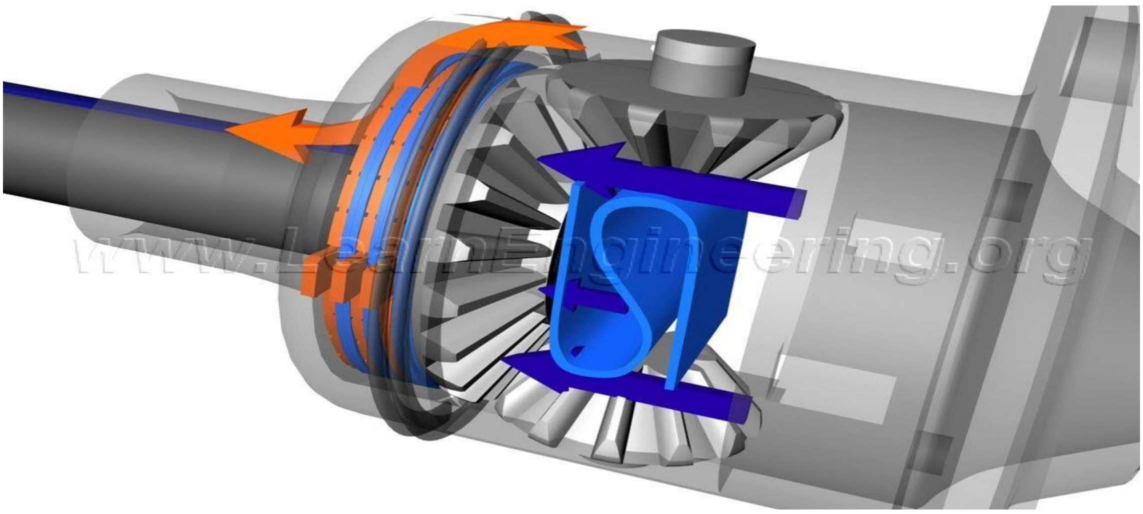
- In conventional differential if one of the wheels slips - all the power is transferred to that wheel (since grip is less). Ultimately the vehicle becomes stationary.
- This is overcome with differential lock which prevents slipping of gears on the wheel sides facing more traction or grip on the road.
- When the lock is activated, it allows power from drivetrain to equally transfer to both wheels and so, both wheels possess some rotary motion. This can help the slipping wheel take less power and allow the other wheel to propel the vehicle.

- When differential lock is activated, it is difficult to turn the vehicle since both the wheels are rotating at the same velocity.



Limited Slip Differential:

It has similar application as that of differential lock but the difference is that, it allows the wheels to rotate at different speed while none of the wheel speed reaching zero. So, it also helps a vehicle move when a wheel is slipping.



Clutch:

A simplified sketch of a single plate clutch is given in fig 1 Friction plate is held between the flywheel and the pressure plate. There are springs (the number may vary, depending upon design) arranged circumferentially, which provide axial force to keep the clutch in engaged position. The friction plate is mounted on a hub which is splined from inside and is thus free to slide over the gear box shaft. Friction facing is attached to the friction plate both sides to provide two annular friction surfaces for the transmission of power. A pedal is provided to pull the pressure plate against the spring force whenever it is required to be disengaged. Ordinarily it remains in engaged position as is shown in fig.

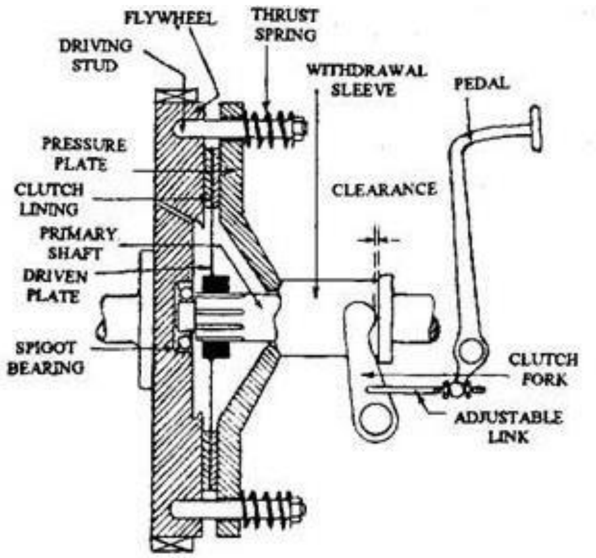


Fig- Single plate clutch

When the clutch pedal is pressed, the pressure plate is moved to the right against the force of the springs. This is achieving by means of a suitable linkage and a thrust bearing. With this movement of the pressure plate, the friction plate is released and the clutch is disengaged.

In actual practice the construction of the clutch differs. The pressure plate, the springs, the release levers and the cover form a sub assembly, called the cover assembly which can be mounted directly to the engine block, of course, placing the clutch plate in between the flywheel and the pressure plate with the clutch shaft inserted in this arrangement.

Advantages

1. With the single plate clutch, gear changing is easier than with the cone clutch, because the pedal movement is less in this case

2. It does not suffer from disadvantages of cone clutch i.e. bindings of cones etc. and henceit is more reliable

Disadvantages

1. As compared to cone clutch, the springs have to be more stiff and this means greater force require to be applied by the driver while disengaging.
2. In the assembled position releases lever rest against the center opening of the cover pressing there is an eyebolt nut which causes the strut to pull the pressure plate againstthe springs, thus holding together the assembly.
3. When the cover is bolted onto the flywheel, the pressure plate is further pushed back against the springs, causing them to be compressed further, which relaxes the release levers. Anti-rattle springs serve to prevent the undesirable noise due to release levers when the clutch is in the engaged position.

ASSIGNMENTS

1. Why gear box is used in a vehicle?

2. Explain clearly the necessity of a transmission in a vehicle.

3. What is the functioning of a clutch?

4. What is the principle of automotive brake?

5. What advantages are there in case of front wheel drive?

6. Explain the functioning of differential?

7. Explain the function of a universal joint.

8. Explain the function of a slip joint.

9. Explain the function of a CV joint.

10. What is the function of synchronizer?

Experiment No: 07
Study of Engine Lathe and Practice

Objectives:

- To introduce with lathe machine and lathe accessories
- To operate lathe to produce an assigned job

Theory:

In a lathe machine, material is removed from a work piece by rotating it when a cutting tool is moved longitudinally with a depth of cut. Lathe machines are widely used to work on cylindrical work pieces. Various lathe operations are turning (straight & taper), facing, threading, chamfering, parting, boring, drilling, knurling etc.

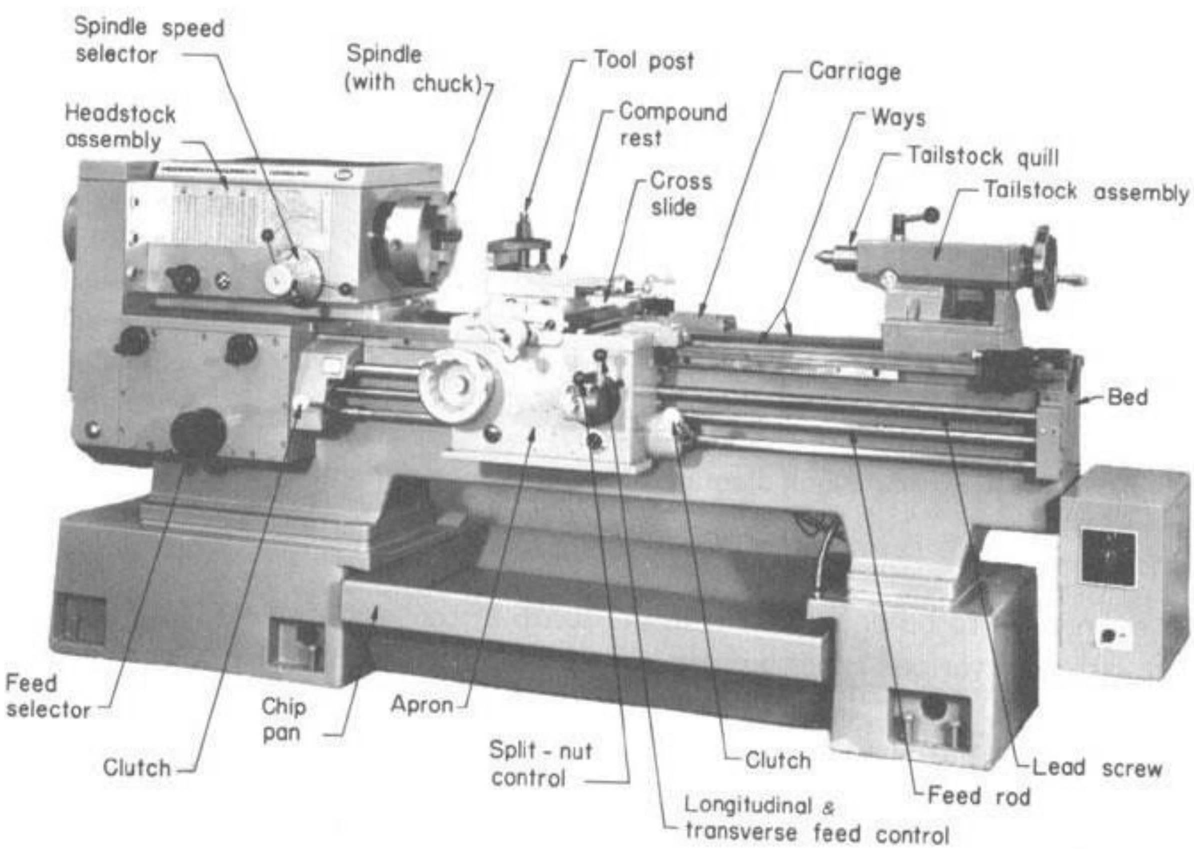


Figure Engine lathe with principle parts named

The principle movement of lathe is the rotation of spindle. The feed is given by the longitudinal travel of carriage and cross traverse of cross slide. The auxiliary movement is the rapid traverse of carriage & cross slide.

Principle units:

All engine lathes have practically the same arrangement of the principle units. In a typical engine lathe the principle units are:

1.Bed	2.Motor Drive	3.Feed Gear Box
4.Headstock	5. Tailstock	6.Spindle
7.Slide Ways	8.Lead Screw	9.Feed Rod
10.Saddle	11.Carriage	12.Cross Slide
13.Swivel Plate	14.Compound Rest	15.Top Slide
16.Tool Post	17.Half Nut	

Lathe accessories:

1.Lathe Centers	2.Lathe Dogs	3.Chuck
4.Steady Rest	5. Follower Rest	6.Faceplate
7.Mandrels	8.Tool Holders	9.Taper Attachments

Dimensions:

The size of a lathe is designated by two dimensions. The first is known as swing. This is the maximum diameter of work that can be rotated on a lathe. The second size dimension is the maximum distance between centers. This indicates the maximum length of the work piece that can be mounted between centers.

Applications:

Lathe is a very popular machine tool used for higher accuracy, improved control system, wider range of speed & feed and wider diversity of attachments. It is used for various purposes, such as

- Turning external cylindrical, taper & contour surfaces
- Boring cylindrical & taper holes
- Cutting external & internal threads
- Machining face surfaces
- Drilling, counter boring, counter sinking, reaming
- Cutting off, spot-facing etc.

Study of Different Operations in Engine Lathe and Manufacturing a Part

Objectives:

- To introduce with lathe machine and lathe operations
- To operate lathe using various operations to produce an assigned job

Theory:

Various operations can be done using lathe. Among them turning, facing, boring, parting, drilling, reaming, knurling etc are notable. Turning is the process of machining external cylinder and conical surfaces. It is usually performed on lathe. Relatively simple work and tool movements are involved in turning a cylindrical surface. The work piece is rotated longitudinally fed, single point cutting tool.

If the tool is fed at angle to the axis of rotation, an external conical surface is resulted, which is called “taper turning”. If the tool is fed at 90^0 to the axis of rotation, using a tool that is wider than the width of the cut, the operation is called “facing”.

Boring is internal turning. Boring can use single point cutting tools to produce internal cylinder or conical surfaces. It does not create the hole but rather machines or opens the hole up to a specific size.

Parting is the operation by which one section of a work piece is severed from the remainder by means of a cutoff tool. Because parting tools are quite thin and must have considerable overhang, this process is more difficult to perform accurately.

Assignments:

1. What operations are used to manufacture the assigned part in this experiment? Write down the name of operations with schematic figures sequentially.
2. What are the principal parts of Engine lathe machine?
3. What is the main different of a lathe & milling machine?
4. Why lathe machine is called mother of all machines?
5. Explain the purpose of a face plate, study rest & flower rest

Study of Milling Machine

Objective:

- To introduce with different types of milling machine & milling cutter
- To study & operate milling machine

Theory:

Milling machine is a machine tool that removes material from a work piece by rotating a cutter and moving it into the material. Milling machines are a very versatile machine tool. Milling machines are capable of machining one or two pieces as well as large volume production runs. The milling machines can produce a variety of surfaces by using a circular cutter with multiple teeth that progressively produce chips as the cutter rotates.

Types of milling machines:

There are two major types of milling machines, the vertical milling machine and the horizontal milling machine. As their names imply, a vertical milling machine spindle is vertical and the horizontal milling machine spindle axis is horizontal

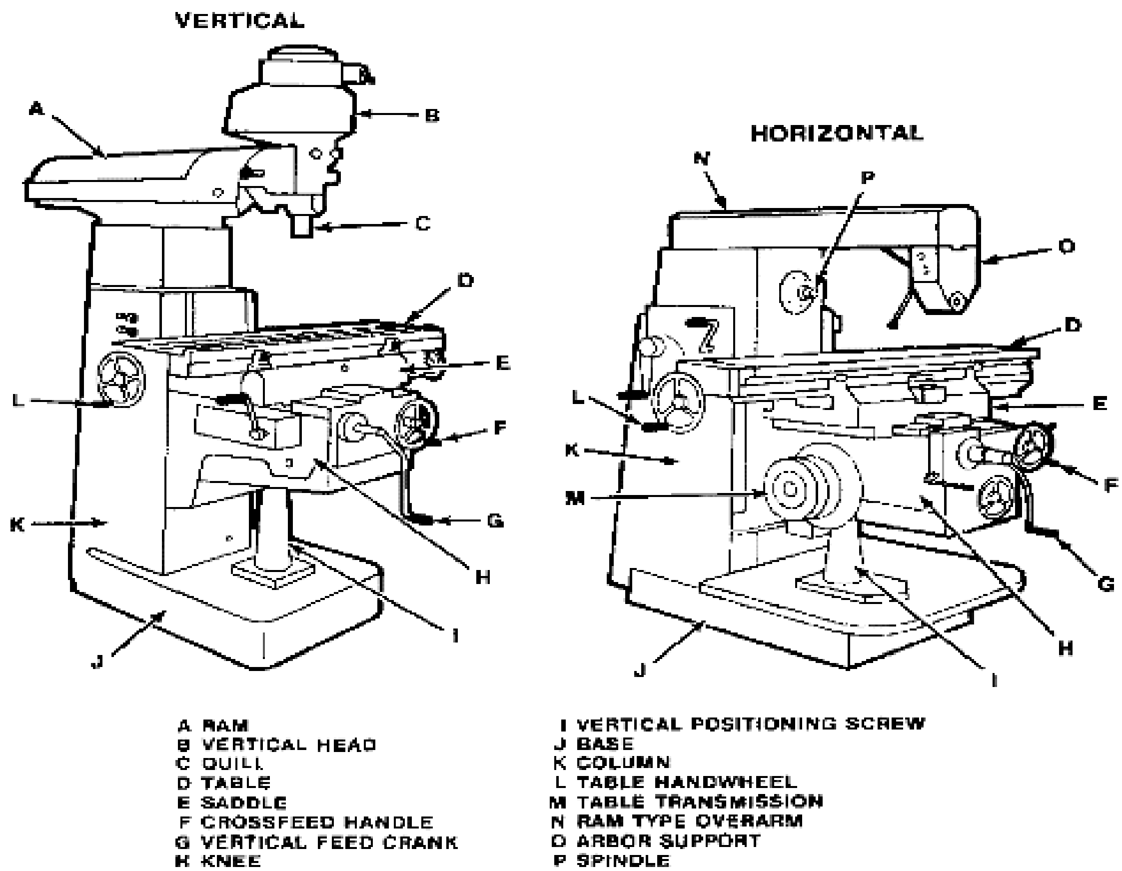
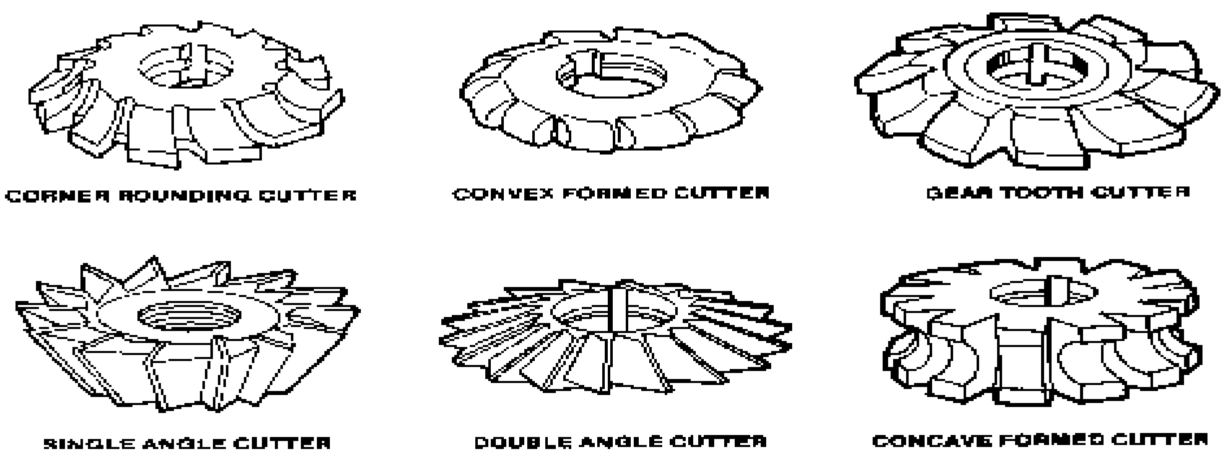


Figure: Vertical & Horizontal Milling Machine

In a knee & column type milling machine, five types of movement can be found. The longitudinal traverse hand wheel moves the worktable to the left & right, the cross traverse hand wheel moves the work table in & out. The vertical crank moves the knee, saddle & worktable up & down. The swivel plate gives the angular movement and spindle gives the rotary movement.

Types of milling cutter:

A milling cutter is a multiple point cutting tool that is used on a milling machine. They are available in many types, forms, diameters and widths.



Milling operations:

There are different types of milling operations such as, slab milling, face milling, end milling etc.

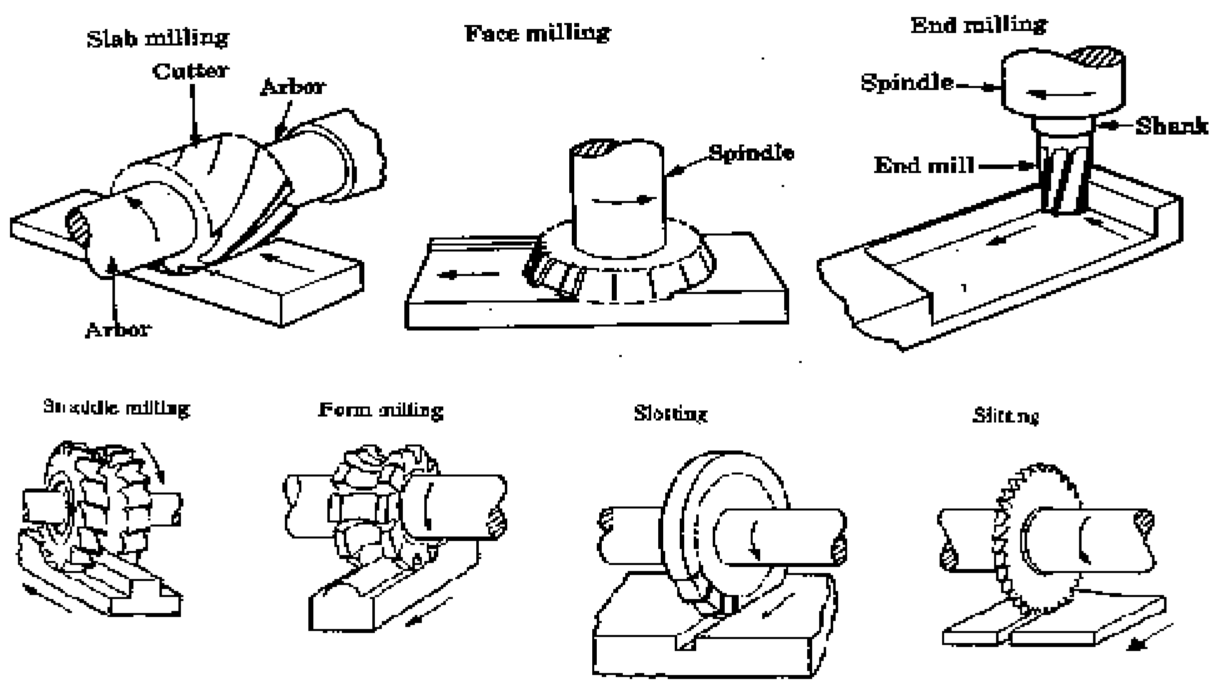


Figure : Various types of milling operation

Experiment No: 08

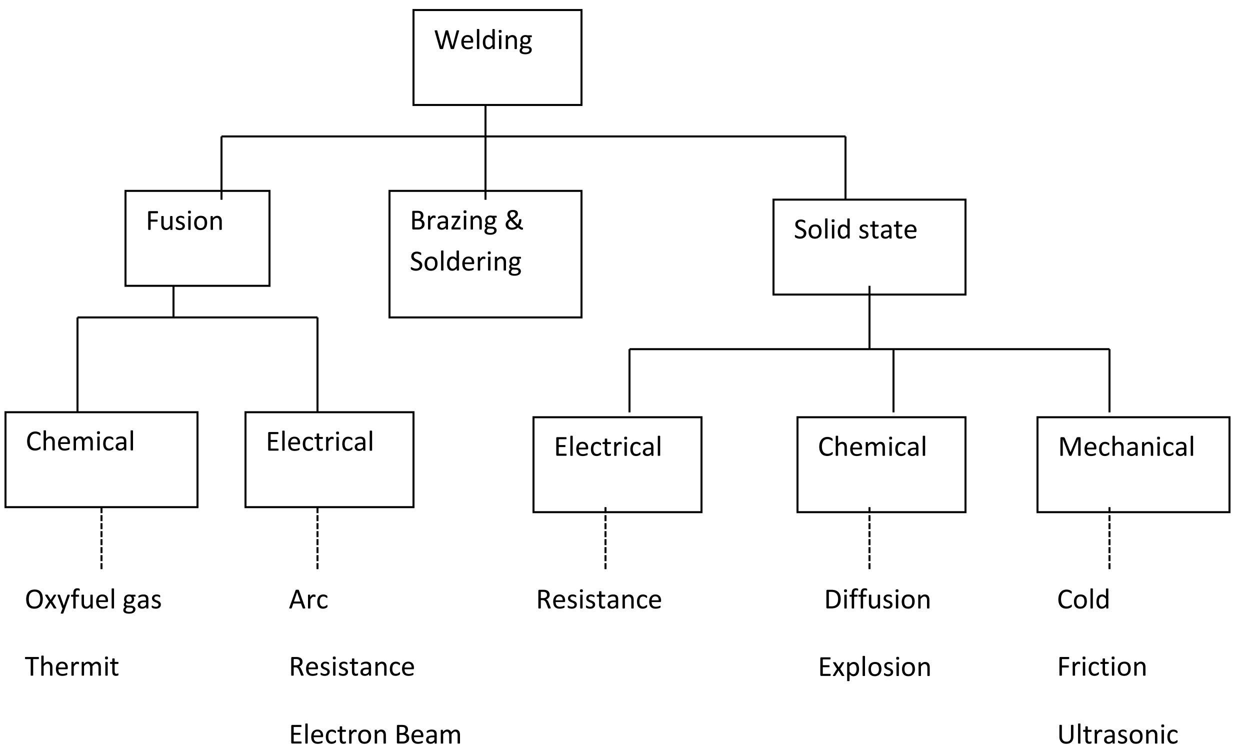
Study of welding

ARC WELDING

Definition of welding

Pieces of metals are joined together by fusing and coalescing them with the application of heat and filler metal.

Classification of welding



Arc welding (SMAW)

Metallic arc welding uses a metallic electrode of soft grade of iron, low carbon steel or other kind of filler rod or wire according to kind of work which is required to be done. The size of the wire used varies from 1/16 in to 3/16 in dia.

The heat of the arc is not only sufficient to melt the end of the electrode, but also fuse the surface of the work being welded over a small area. The two metal being fused and at the same time coming into close contact cause complete intermixing. As supply of heat to the arc is constant, the deposition of metal from the electrode remains continuous and uniform.

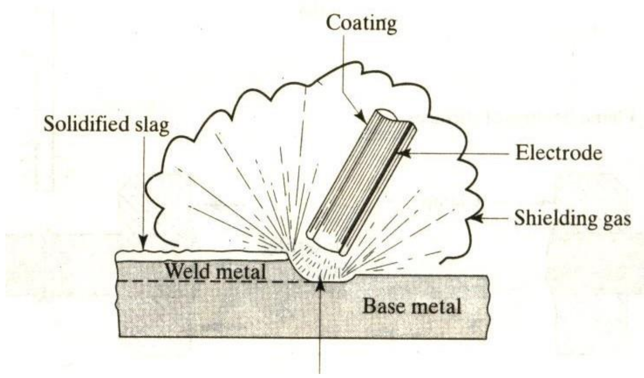


Figure: Schematic illustration of the shielded metal arc welding process.

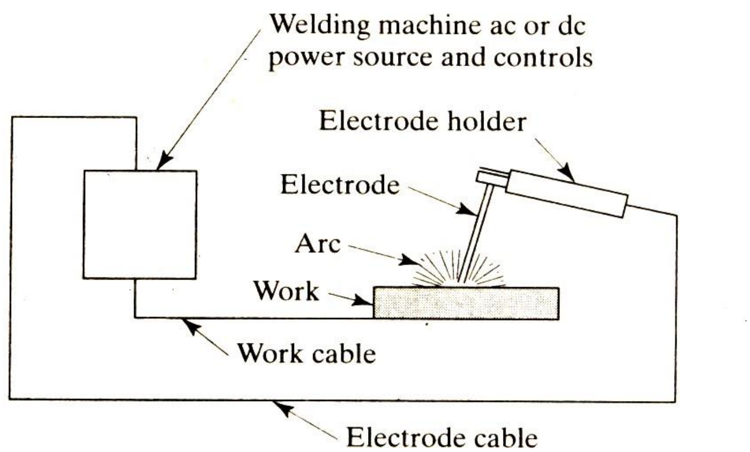


Figure-21: Schematic illustration of the shielded metal-arc welding operation (also known as stick welding, because the electrode is in the shape of a stick)

Characteristics of arc welding

Metal arc welding consists essentially of localized progressive melting and flowing together of adjacent edge of base metal parts by means of temperatures approximately 10000ºF of a sustained electric arc between a metal electrode and the base metal.

Polarity:

Polarity means the relative connection of electrode and work piece with power source.

There are two system of polarity. Namely:-

(a) Straight polarity: The arrangement of arc welding leads where work is connected with the positive pole and the electrode is connected with the negative pole of the circuit.

(b) Reverse polarity: Reverse polarity is just opposite of Straight polarity.

Application of arc welding

The principal advantages derived from the source of arc welding are (1) High quality welds, (2) great flexibility, (3) Rapid deposition rates, and (4) favorable unit welding costs. Some of the structures built by using arc welding are Tank, Bridge, Boilers etc.

Electrode

In electric arc welding, the weld metal is supplied through the action of the electric current as it passes through a metal rod called electrode.

Physical feature of electrode

Electrode consists of core wire and flux, Core wire is made of soft grade of Iron, Low carbon steel, or other kind of filler rod.

Metal electrode

Metal electrodes are generally used in hand welding. They are commercially manufactured in diameter size ranging from 1/16 in to 3/8 in and usually in length of 14 to 18 inches. The proper size of electrode to be used depends upon the requirements of the weld and the materials to be welded. The type of work and the composition of material to be welded determine the composition of the electrode. Among the several type of electrodes now in common use are bare electrode, dust and light coated electrode or semi coated and heavy coated or cover electrode.

The electric arc as a heat source

A source of AC or DC power is the ultimate source of heat in the electric arc. The arc itself is struck between the electrode and the work thus closing the electrical circuit. In DC welding, there is about 60 volts potential drop between the electrode and the work when no current is flowing. In AC welding, since the arc goes out 120 times a second, we require a slightly higher voltage e.g. 80 volts. The source of e.m.f. with either current is a rather specialized piece of equipment designed to have a high starting voltage in comparison to its working voltage but while the arc is burning the voltage drop across the arc is around 20-30 volts. The AC source is generally a transformer; the DC source is rotating generator.

Function of flux

It is a substance used in weld helps to reduce the melting point of the metal piece to be welded, prevent or remove oxidation. The brown colored coating on the electrode is called flux. This also serves the purpose of gradually cooling the depositing metal which is welded.

Gas metal arc welding

In Gas metal-arc welding (GMAW), formerly called metal inert gas welding, the weld area is shielded by an effectively inert atmosphere of argon, helium, carbon dioxide, or various other gas mixtures. The consumable bare wire is fed automatically through a nozzle into the weld arc.

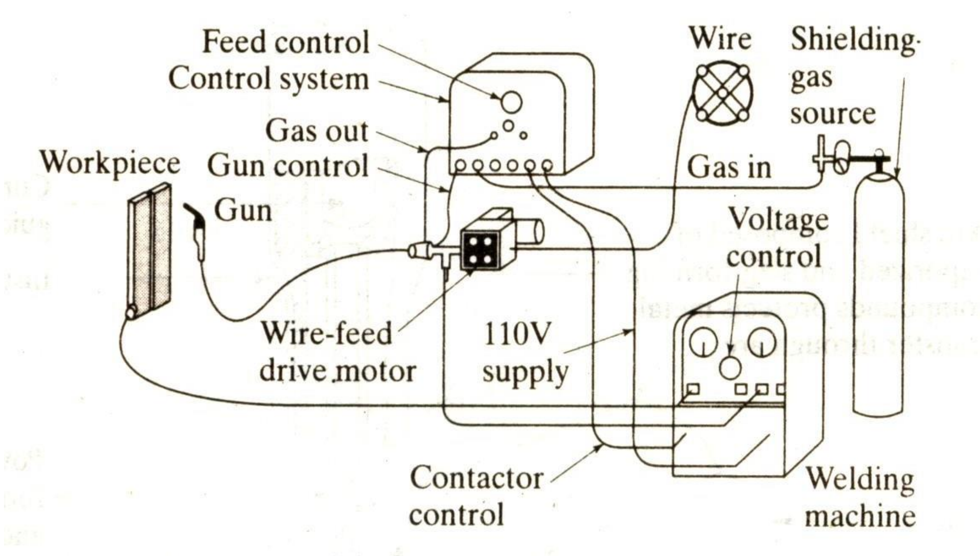


Figure: Basic Equipments Used In Gas Metal Arc Welding Operations

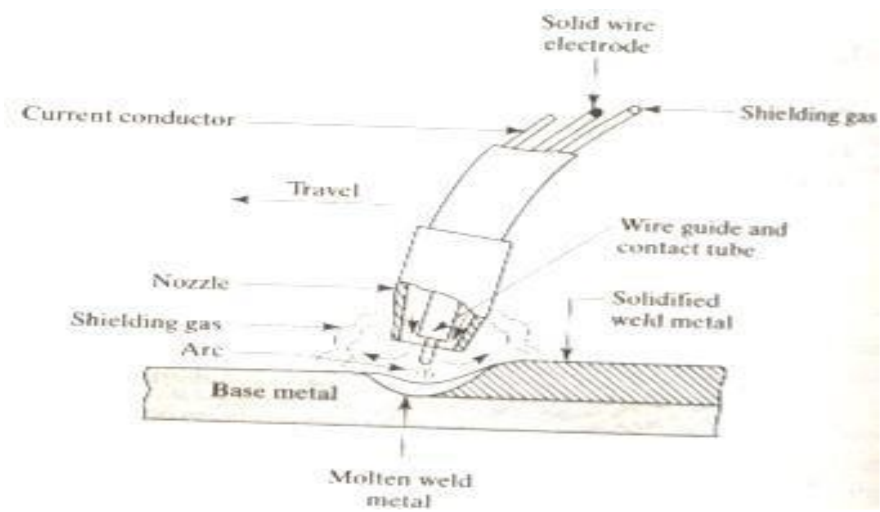


Figure: Schematic illustration of the gas metal arc welding process

Gas welding

Introduction of gas welding

Satisfactory Oxygas welding requires that a fuel gas be employed which will produce high temperature concentrated flame when burned at the presence of commercial oxygen. Gas welding consists of the use of a fuel gas flames as a source of heat to raise the temperature of a metal work piece to its fusion. The liquid bodies flow together and solidify subsequently to make the bond.

Definition of gas welding

Oxy acetylene fed to blow pipe where they are burned to form sources of intense heat. This is used to heat and fused the edge of the joint and to melt a filter rod, which is thus deposited in the molten state at the joint.

Application of oxy-acetylene welding

Most commercial metal are welded satisfactorily with the oxy-acetyling process. This probably accounts for its wide acceptance in dodder industry

Characteristics of oxy acetylene flame

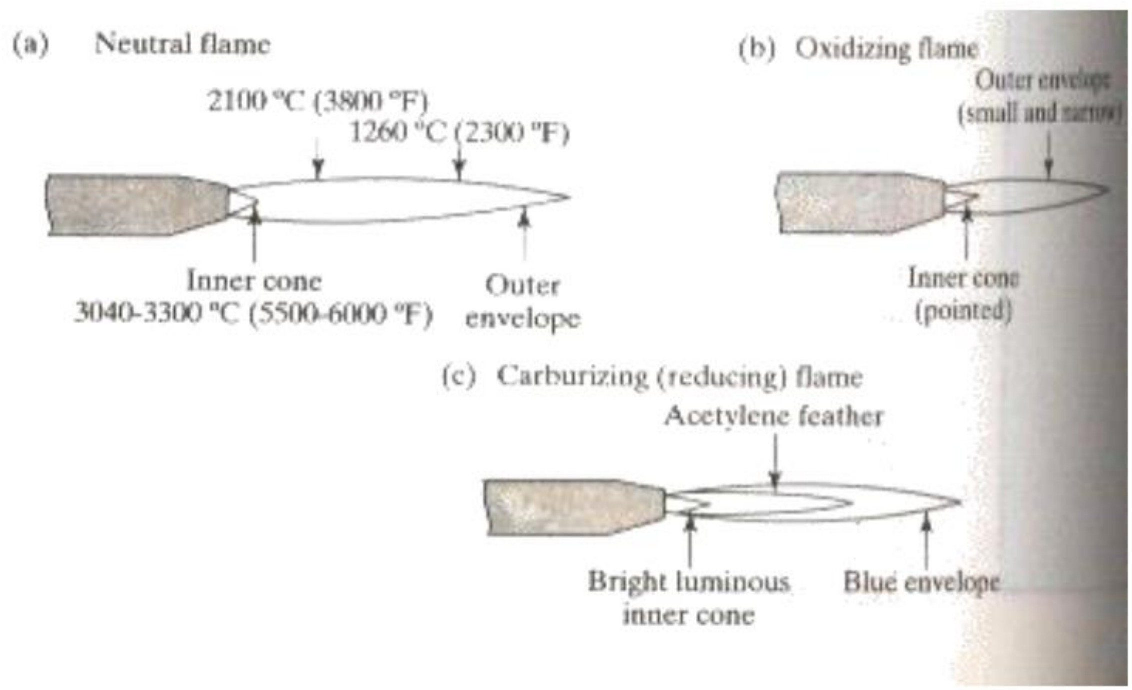


Figure: Different Oxy-Acetylene Flames

(1) **Neutral flame:** Equal proportion of oxy-acetylene Temperature 5850°F

(2) **Oxidizing flame:** Excess of oxygen. Temperatures 6300 °F

(3) **Reducing / Carburizing flame:** Excess of acetylene temperature 5550°F

Different types of flame used for welding different materials

Cast Iron: A neutral flame should be used along with cast iron filler rod of proper size. Flux is required for proper welding. It contains a mixture of iron oxide carbonate of soda

Aluminum: Neutral flame should be used when welding large aluminum casting The casting should be preheated about 600°F. Flux should be required for proper welding steel, stainless steel and

Counter: Flame should be used when welding large casting copper precept should be required Flux should be required for proper welding.

Brass: Oxidizing flame should be used including with flux.

Pressure in oxygen and acetylene cylinder

Cylinder is charged with oxygen at a pressure of 2200 lbs to 3000 lbs per square inch at 70°F. Since all gases expand when heated and contract when cooled, the pressure of the oxygen in the close cylinder will of course increase and decrease with the temperature changes as the cylinders volumes remain constant. if for an example a full cylinders of oxygen is allowed to stand outdoor for several hours when the temperature is say 30°F or just below freezing point the pressure of the cylinder with register approximately 2000 P.S.I; when temperature goes above 70°F the pressure in a full cylinder will raise above 2200 P.S.I and also acetylene cylinder changed with dissolve acetone with a pressure of 225 P.S.I at 60 to 70°F.

Technique of welding:

Butt joint:

The execution of butt joint is a frequent part of welding practice of brass with joint thickness being 1/32’’ and more. In dealing with such work there is a choice between two methods of workings.

a. Leftward (forward)
b. Rightward (or backward) method.

The leftward weld is made working from right to left. Whilst the receive direction is followed for right word working in each case the filler rod being held in the left carried to the left of the blow pipe. The left word method is fond most advantages on the sheet plate 1″/4 and non ferrous metals whilst sheet work over 1″/4 the right word method is used angle for the rod and two blow pipe are

a. Filler rod at angle of 30°-40° and blow pipe 60°-70°F
b. Filler rod at an angle of 30°-40°F and blow pipe 40°-50° right hand method.

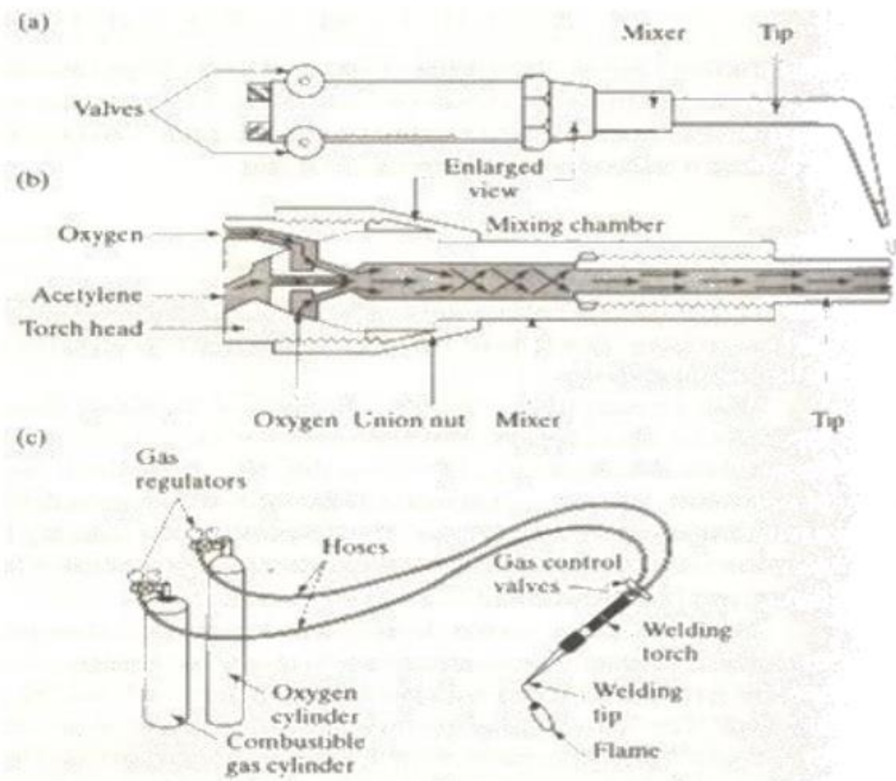


Figure: Gas Welding Equipments And Mixing Mechanism

The place of oxygen cutting in industry:

<u>Definition and classification</u>: the process of oxygen cutting consists of burning the materials along with pre determined path and removing the resultant oxide from the cut by jet of oxygen.

The Tip To Metal Distance

The time necessary to take the work piece to melting temperature greatly depends on the distance from the tip to the metal surface. The flame is hottest within 1.5 to 2 mm of its inner cone. Therefore in preheating the torch should be positioned so as to maintain this distance making the inner cone touches the surface. Otherwise cut surfaces may be cut and bruised. The piece separation between the tip and the work is of special importance in the case of height gauge. The metal is best pre heated when the hottest parts of the flame is concentrated on the surface of the work piece. Practically this distance is 1-5 to2-5 mm.

Starting Of Flame Cut

The pre heating flame is made to play on the edge piece until a small area around the start of cut raised to kindling temperature. In practice the start of a cut is usually heated until the surface layer of the metal is melted.

In cutting heavy section, the cutting tip is initially at an angle of 5 to 10 deg, to the surface of the piece to facilitate pre heating cross the entire thickness of the metal. In the case of height gauge (up to 50 mm) the tip should be hold vertically.

Brazing

Braze welding (for Bronge welding as it is sometimes refereed to) is similar to brazing in that it uses non ferrous filter metal which melts at temperature above 800 °F but below melting point of the base metal. It differs in that the filler metal is not distributed throughout the joint by capillary attraction. Brazing and braze welding are highly suitable method for joining dissimilar metals, repairing gray cast-iron casting and joining pipes thin gauge metals and small assemblies. They are extensively used in such industries and occupations as refrigeration, heating, air conditioning, electronics and auto automotive etc.

Soldering

Soldering is similar to brazing in that also filler metal is used to join the two metal surfaces without melting base metal. It is different from brazing in that the filler metal melts at temperature below 800 °F.

Joining of metal pieces by welding

There are five types of important joints in welding

1. Butt joint
2. Lap joint
3. Tee or fillet joint
4. Corner joint
5. Edge joint

Sub division of the above types of joint

Butt joints are classified as

1. open square butt joint
2. single VEE butt joint
3. double VEE butt joint
4. single W butt joint
5. Single U butt joint

Lap joint

1. Single fillet lap joint
2. Double fillet lap joint

TEE fillet joint

1. Single TEE joint
2. Single bevel TEE joint
3. Single J TEE joint
4. Double J TEE joint
5. Double bevel TEE joint

Corner joints are as follows

1. flash corner joint
2. Half open corner joint
3. Full open corner joint

Edge joint

1. Single edge joint
2. Double edge joint

Properties of

weldPenetration:

Penetration is an important property of any fusion weld. An appreciable depth of fusion assures through inter mingling of the filler and parent metal homogeneously in the fusion zone and elimination of void that would otherwise appear in the weld.

Distortion

When a metal is heated it expands and when it is cooled it Contracts. The contraction of weld metal as it cools after deposition causes distortion.

Reduce distortion

Distortion may be reduced by the use of a cooling jig that is a jig made of a material such as copper which serve the double function of holding the job in position and also conducting away the heat of welding.

Under Cut

A groove melted in to the base metal adjacent to the weld and left unfilled.

Defects of weld

1. blow holes/ porosity
2. Under cut
3. Distortion
4. Over lapping

Weld test

- **Non-destructive Tests**

1) Visual Inspection
2) Magnetic Particles
3) Penetrant method
4) Radio graphic method
5) Ultrasonic
6) Eddy current

- ## Destructive test

2) The bend test.
3) The impact test.
4) The tensile test.
5) The nick break test.
6) The hardness test.
7) The etch test.

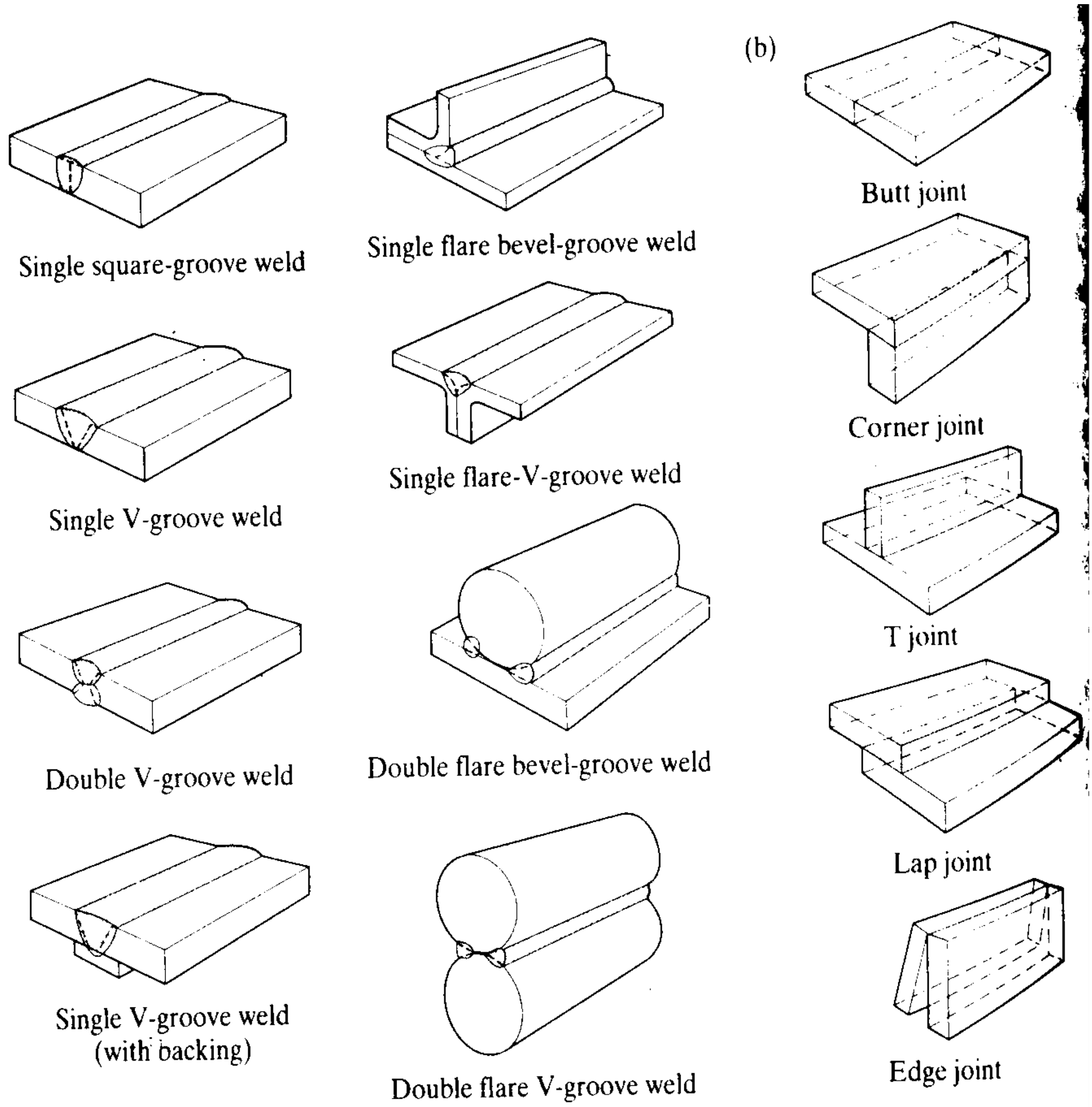


Figure: Example of Joints

EXPERIMENT NO – 9

"Tension Test of Mild Steel Specimen"

Objectives:

a. Observe the behavior of the mild steel specimen under the application of tensile load.

b. Draw the stress-strain diagram.

c. Observe the type and nature of fracture.

d. Determine the following from the stress-strain diagram:

(1). Proportional Limit.

(2). Yield Point.

(3). Ultimate Strength.

(4). Breaking Point.

(5). Percentage reduction in area.

(6). Percentage Elongation.

(7). Ductility.

(8). Modulus of Elasticity.

(9). Modulus of Resilience.

(10). Modulus of Toughness.

Specimen: Mild Steel

Machine: Universal Testing Machine (Model 5590-HVL series)

Procedure:

e. Measure the average cross-sectional dimensions of the specimen with the help of a slide calliper.

f. Measure the gauge length and mark lightly the gauge length of the specimen.

g. Firmly insert the upper end of the specimen in the fixed head of the universal testing machine (up to 75% of the jaw face length).

h. Adjust the adjustable crosshead to fix the gauge length and then grip the lower part of the specimen.

i. Open Merlin icon from computer, select test type, insert different relevant data in thecomputer.

j. Start pump (hydraulics on) and move actuator front to it's rest position.

k. Enter specimen dimension and press start in the computer to start the test.

l. Apply the load slowly and take the simultaneously observations of load and elongation of the specimen without stopping the machine.

j. Continue the loading until the yield point at which the rate of elongation shows a sudden increase.

k. Continuously apply the load, observe the necking of the specimen and record the readings of load until the specimen ruptures. Record the maximum and the breaking loads from the computer.

l. Take a print out of the stress-strain diagram and applied loads on the specimen.

m. Remove the broken specimen from the machine. Measure the dimensions at the smallest section. Fit the broken parts together and measure the length between the two punch marks again.

n. Observe the location and nature of the fracture.

2. Result:

a. Gauge length, L = mm.

b. Diameter of the Specimen = mm.

c. Original cross-sectional area = mm^2.

Table-1: (Experimental data and calculated result)

No of Obs	Load (F) in kN (kg)	Elongation Δ mm	Stress σ MPa	Strain, $\varepsilon = \Delta / L$ mm / mm	Results
1.					