
UET LAHORE(Faisalabad Campus)

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**Electrical Engineering(2020)**

# Lab Manual

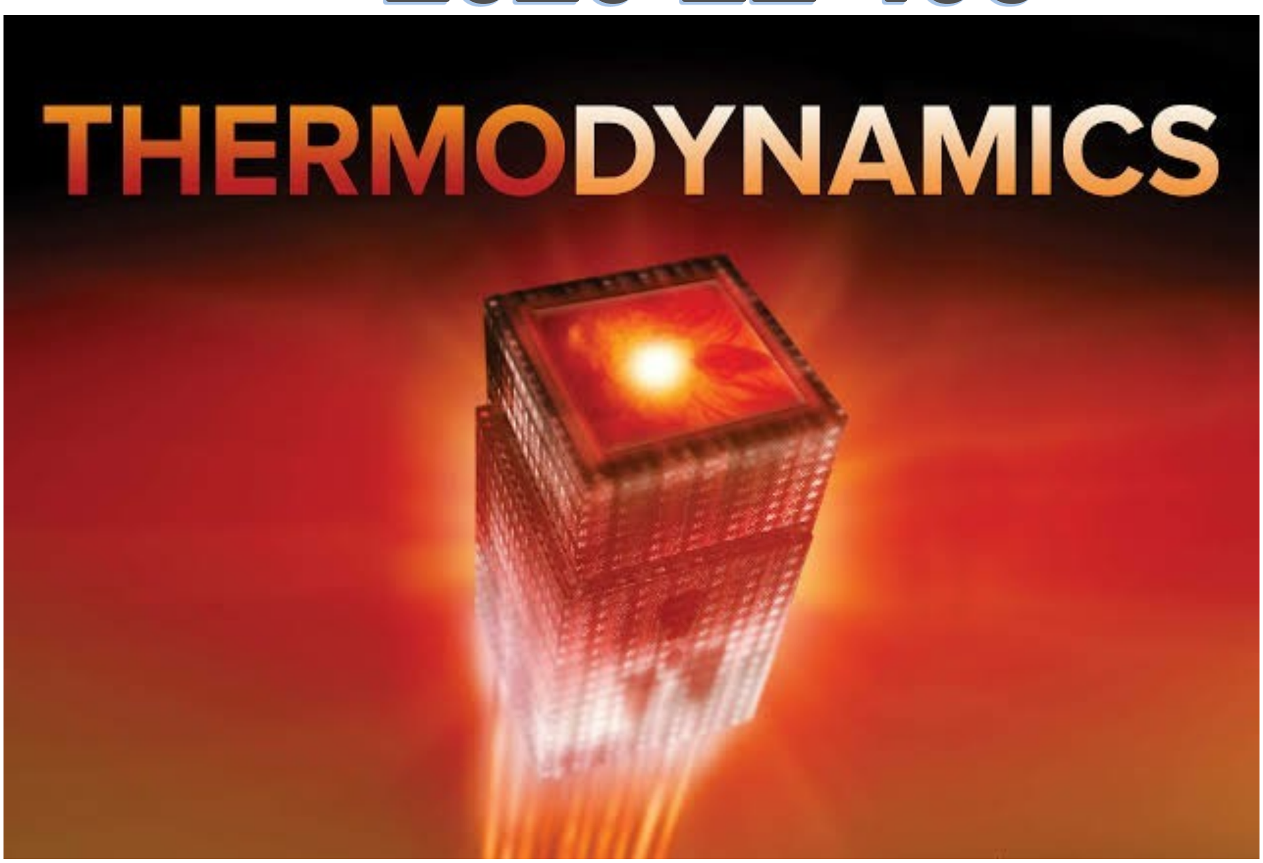
# Thermodynamics

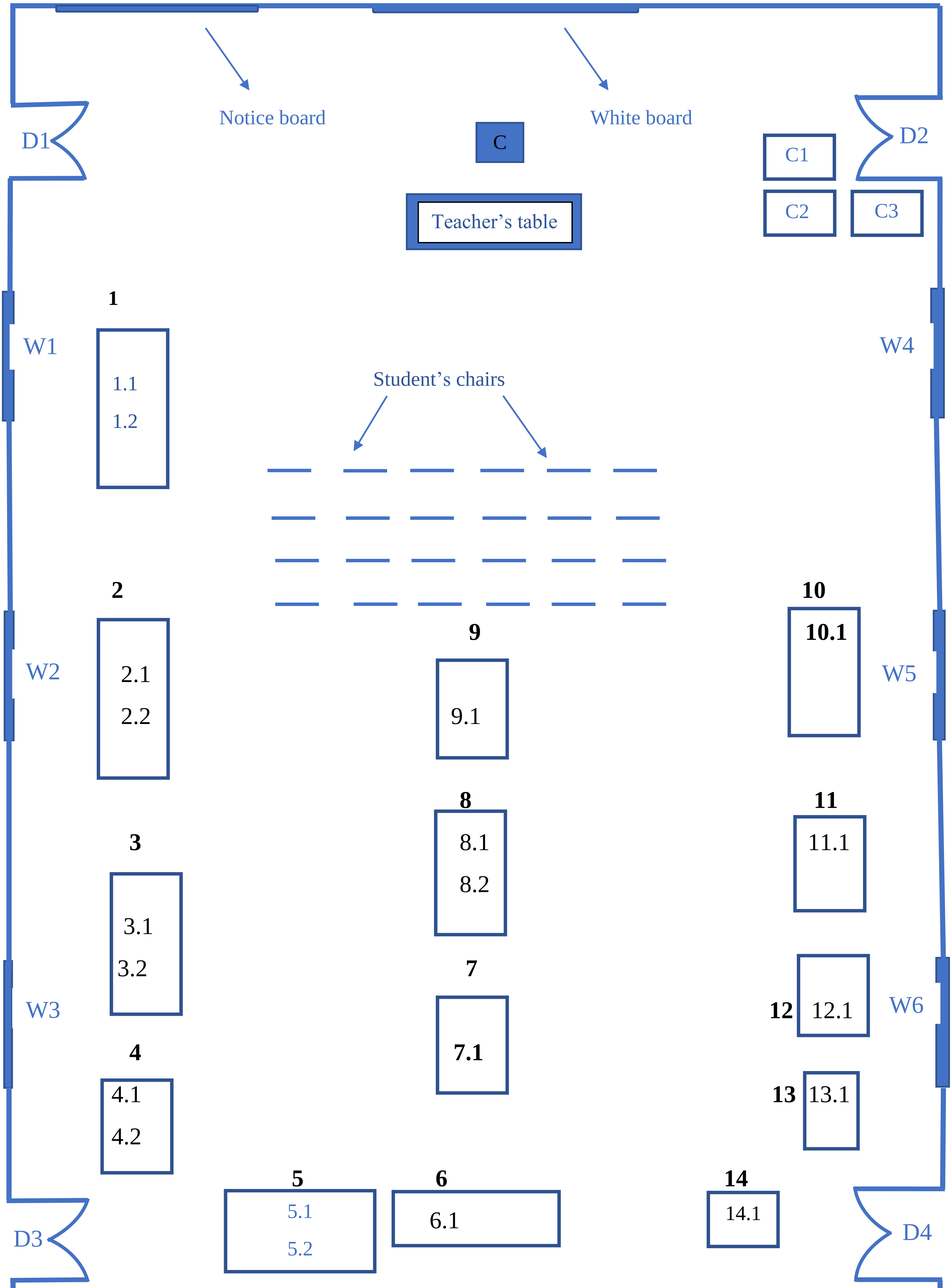
**Submitted To:**

**Sir Waqas Arshad**

**Registration No:**

**2020-EE-405**






**D1,D2,D3,D4=Door** **C1,C2,C3=Cupboard** **C=Teacher's Chair**
**W1,W2,W3,W4,W5,W6=Window**

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# Thermodynamics Lab 1

# Layout of Thermodynamics Lab

**What is layout?**

Layout is defined as a process to locate and marks a work piece in order to give guidance to the machinist or the visitor. **Or** The process of setting out material on an area.

**Purpose of layout:**

Layout act as a visual reference to the machinist. It provides **proper direction** for manufacturing operation. It guides machinist to his desired place or point.

| Thermodynamics Lab | | | |
|---|---|---|---|
| **Sr No.** | | **Apparatus Name** | **Model No.** |
| **1** | **1.1** | Rankin Cycle System Turbine  Hydrolic Bench | S220 |
| **2** | **2.1** | Nozzle Pressure Distribution | F 300B |
| | 2.2 | Nozzle Pro | F 300A |
| | | Compressionable Flow Range | F300 |
| **3** | **3.1** | Absorption Refrigeration | 816/01295 |
| | **3.2** | Heat Transfer Service Unit | H112 |
| | **3.3** | Boiling Heat Transfer Module | |
| 4 | 4.1 | Thermal Radiation Equipment | TE6C/EV |
| | 4.2 | Heat Transfer Service Unit | TE6/EV |
| | 5.1 | Heat Exchanger Service Module | TD360 |
| | **5.2** | Heat Transfer Equipment Base Unit | TD102 |
| 6 | **6.1** | Heat Pump Trainer | BPC/EV |
| **7** | **7.1** | Cross Flow Heat Exchanger | TE93 |
| 8 | **8.1** | Four Stroke Singal Cyclinder Diesal Engine Demonstration Unit | IPC-9200-DE |
| | **8.2** | Two Stroke Petrol Engine Demonstration Unit | ART-NR-4042 |

| | | | |
|---|---|---|---|
| 9 | **9.1** | Cooling Tower Trainer | RAD-CTS-3 |
| 10 | **10.1** | Labortary Air Conditioning Trainer | IPC-512-RAC |
| 11 | **11.1** | Mechanical Heat Pump Trainer | IPC-2002-RH |
| 12 | **12.1** | Commercial Refrigeration Trainer | IPC-2007-1 |
| 13 | **13.1** | Vortex Tube Refrigerator | R434/07043 |
| 14 | **14.1** | Thermo Electric Heat Pump Trainer | R534 |

**1.1: Rankine Cycle Steam Turbine:**

The **Rankine cycle** is a model used to predict the performance of steam turbine systems. It was also used to study the performance of reciprocating steam engines. The Rankine cycle is an idealized thermodynamics cycle of a heat engine that converts heat into mechanical work while undergoing phase change. It is an idealized cycle in which friction losses in each of the four components are neglected. The heat is supplied externally to a closed loop, which usually uses water as the working fluid.

Figure No. 1.1: Model of Rankine Cycle Steam Turbines.

**2.1: Nozzle Pressure Distribution:**

The Nozzle Pressure Distribution Unit, “TPT”, allows to investigate the pressure distribution and the mass flow rate in nozzles (convergent divergent and convergent nozzles). The unit includes three types of nozzles:  Convergent type (conical) nozzle, with 6 pressure tapings. Convergent-divergent nozzle, with 5 pressure tapings. Convergent-divergent nozzle, with 8 pressure tapings. The nozzles are made of brass and have been mechanized accurately. Several pressure tapping are available, being each one connected to its own manometer.


Figure no. 2.1 : Model of Nozzle Pressure Distribution.

**2.2(a): Nozzle Pro:**

Nozzle PRO is a unique and easy-to-use FEA tool for vessel and piping engineers. It is specifically designed to analyze individual nozzles (straight, hillside, pad-reinforced), saddles, lugs and pipe shoes. Reinforcing pads for lugs and wear plates for shoes and saddles can be integral and non-integral. You can include beam elements to pipe up to the nozzle in order to include the correct attached pipe stiffness and thus applying the correct loads in your analysis.

Figure no. 2.2 (a) : Model of Nozzle Pro.

## 2.2(b): Compressible Flow Range:

**Compressible flow** (or **gas dynamics**) is the branch of fluid mechanics that deals with flows having significant changes in fluid density. While all flows are compressible, flows are usually treated as being incompressible when the Mach number (the ratio of the speed of the flow to the speed of sound) is less than 0.3 (since the density change due to velocity is about 5% in that case). The study of compressible flow is relevant to high-speed aircraft, jet engines, rocket motors, high-speed entry into a planetary atmosphere, gas pipelines, commercial applications such as abrasive blasting, and many other fields.


Figure no. 2.1(b): Model of Compressible Flow Range.

**3.1: Absorption Refrigeration:**

An **absorption refrigerator** is a **refrigerator** that uses a heat source (e.g., solar energy, a fossil-fueled flame, waste heat from factories, or district heating **systems**) to provide the energy needed to drive the cooling process. The principle can also be used to air-condition buildings using the waste heat from a gas turbine or water heater.

Figure no. 3.1: Model of Adsorption Refrigeration.

**<u>3.2: Heat Transfer Service Unit:</u>**

Radiation heat transfer is the process in which the thermal energy is exchanged b/w two surfaces by obeying the laws of Electromagnetic.

Figure no. 3.2: Model of Heat Transfer Service Unit.

**<u>3.3(a): Boiling Heat Transfer Module:</u>**

A bench top accessory designed to allow students to experimentally investigate convective, nucleate and film boiling. The unit consists of a high strength clear glass cylinder with instrumented electric heater element immersed in a volatile solvent that boils at low pressure.

Figure no. 3.3(a): Model of Boiling Heat Transfer Module.

**3.3(b): Flow Boiling Demonstration Unit:**

The **Flow Boiling Demonstration Unit** is a floor-mounted unit designed to provide a visual demonstration of the flow boiling processes that can occur inside the vapor generating tubes of practical plant such as refrigeration, steam, chemical and food processing systems**.**

Figure no. 3.3(b): Flow Boiling Demonstration Unit.

**4.2: Heat Transfer Service Unit:**

Both conduction and convection require matter to transfer heat. Radiation is a method of heat transfer that does not rely upon any contact between the heat source and the heated object. For example, we feel heat from the sun even though we are not touching it. Heat can be transmitted though empty space by thermal radiation. Thermal radiation (often called infrared radiation) is a type electromagnetic radiation (or light). Radiation is a form of energy transport consisting of electromagnetic waves traveling at the speed of light. No mass is exchanged and no medium is required.


Figure no. 4.2: Model of Radiation Heat Transfer.

## 5.1: Heat Exchanger Service Module:

The concentric tube heat exchanger was designed in order to study the process of heat transfer between two fluids through a solid partition. It was designed for a counter-flow arrangement and the logarithmic mean temperature difference (LMTD) method of analysis was adopted. Water was used as fluid for the experiment.

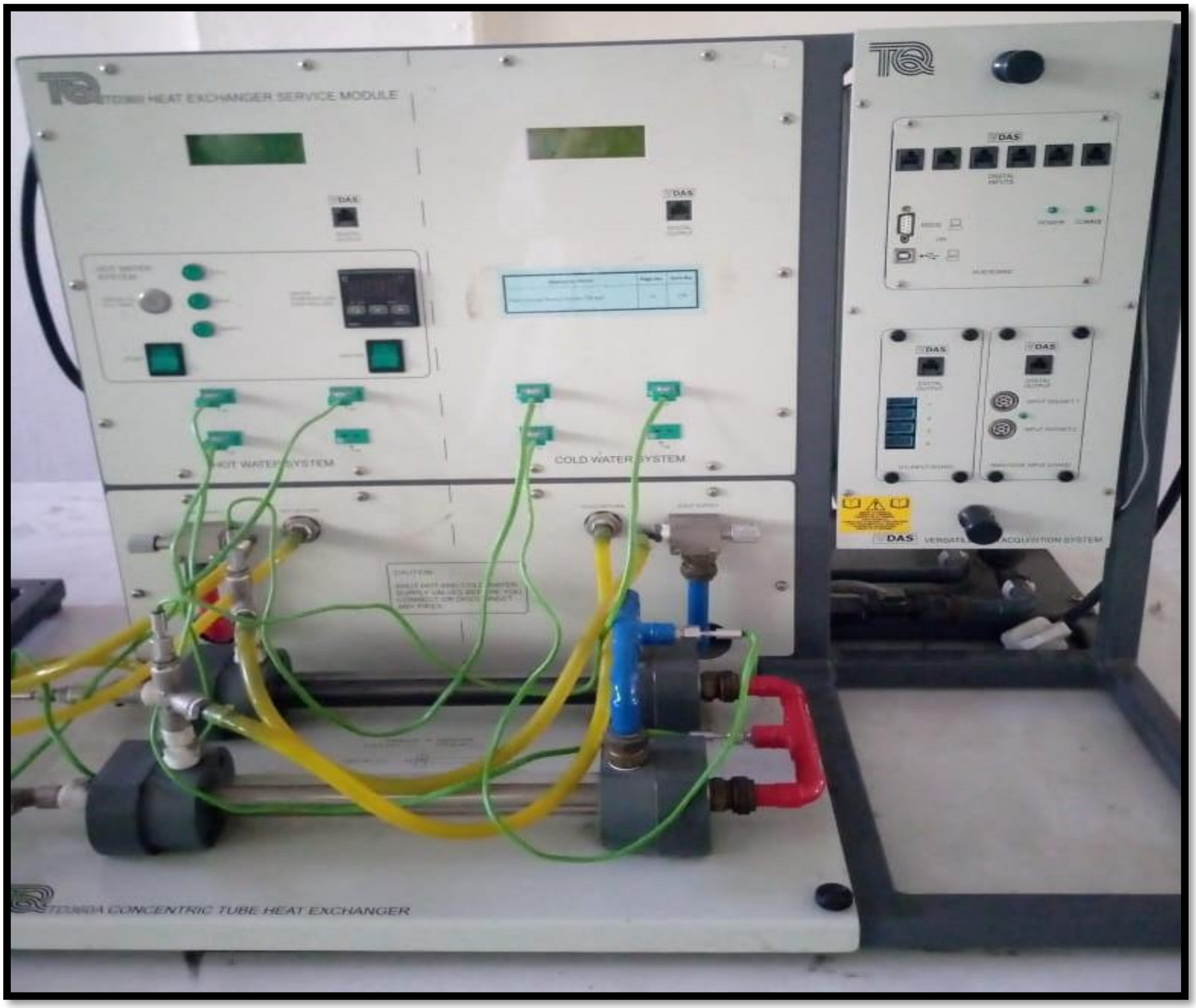


Figure no. 5.1: Model of Concentric Tube Heat Exchanger.

## 5.2: Heat Transfer Equipment Base Unit:

To Measure the Temperature Distribution For Steady State **Conduction** Of Energy Through A Uniform Plane Wall And Demonstrate The Effect Of A Change İn **Heat** Flow. This **experiment** aims to determine the temperature gradient during **linear heat transfer** by **conduction** along the wall.

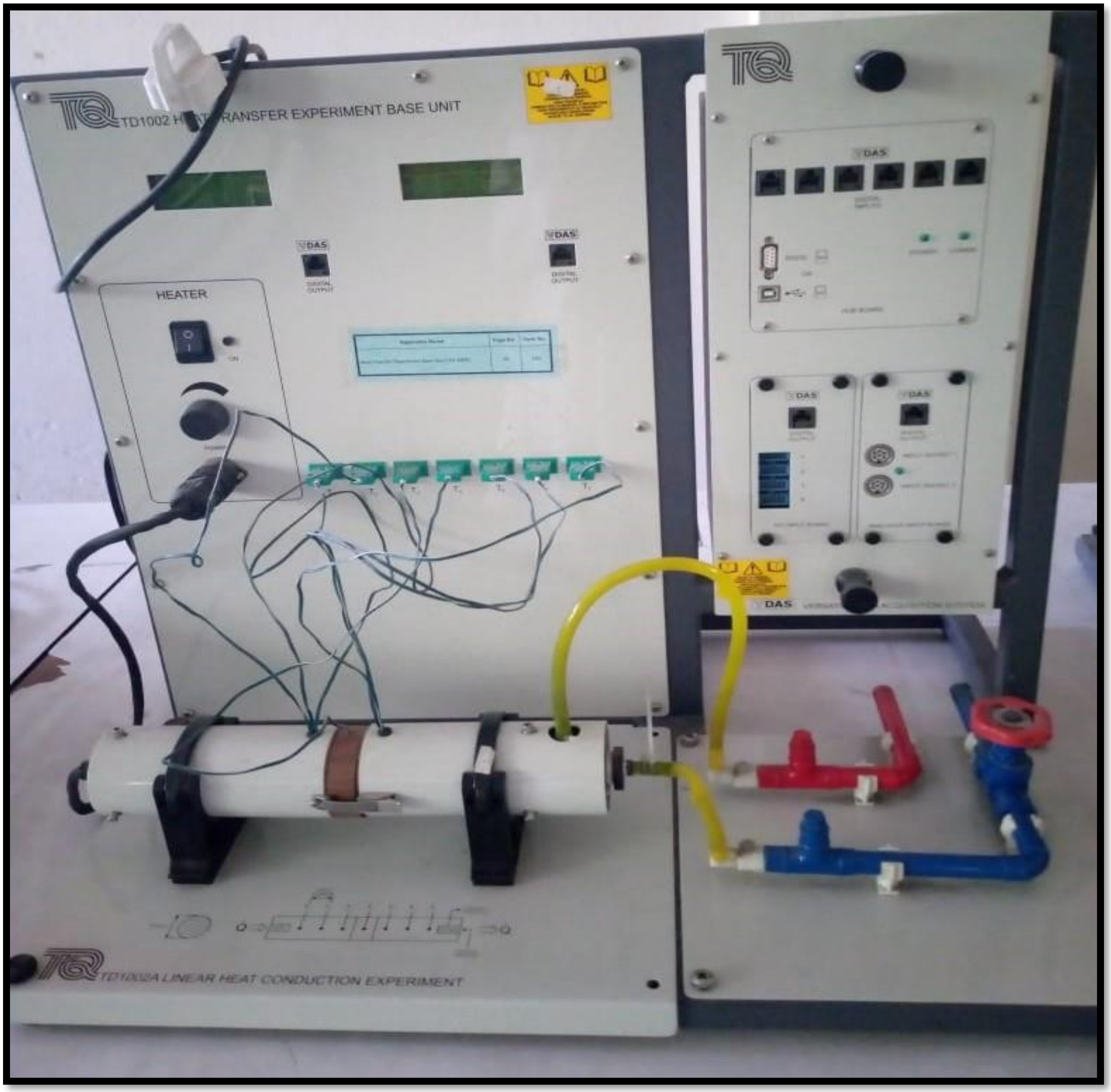


Figure no. 5.1: Heat Transfer Equipment Base Unit

**<u>6.1: Heat Pump Trainer:</u>**

When it's cold outside a **heat pump** extracts this outside **heat** and transfers it inside. When it's warm outside, it reverses directions and acts like an air conditioner, removing **heat** from your home. One advantage of a **heat pump** is that it moves **heat** instead of generating **heat**, giving you more energy efficiency.


Figure no. 6.1: Model of Heat Pump.

## 7.1: CROSS FLOW HEAT EXCHANGER

For comprehensive studies into the principles and performance of **heat exchangers**. The equipment allows students to quickly assess **heat** transfer rates by forced convection. They monitor the rate of cooling of a body of known **thermal** capacity in an air **flow**.

Figure no. 7.1: cross flow heat exchanger

## . <u>8.1: Four Stroke Single Cylinder Diesel Engine:</u>

A **four-stroke engine** (also known as **four-cycle**) is an internal combustion **engine** in which the piston completes **four** separate **strokes** which constitute a single thermodynamic **cycle**. A **stroke** refers to the full travel of the piston along the cylinder, in either direction.

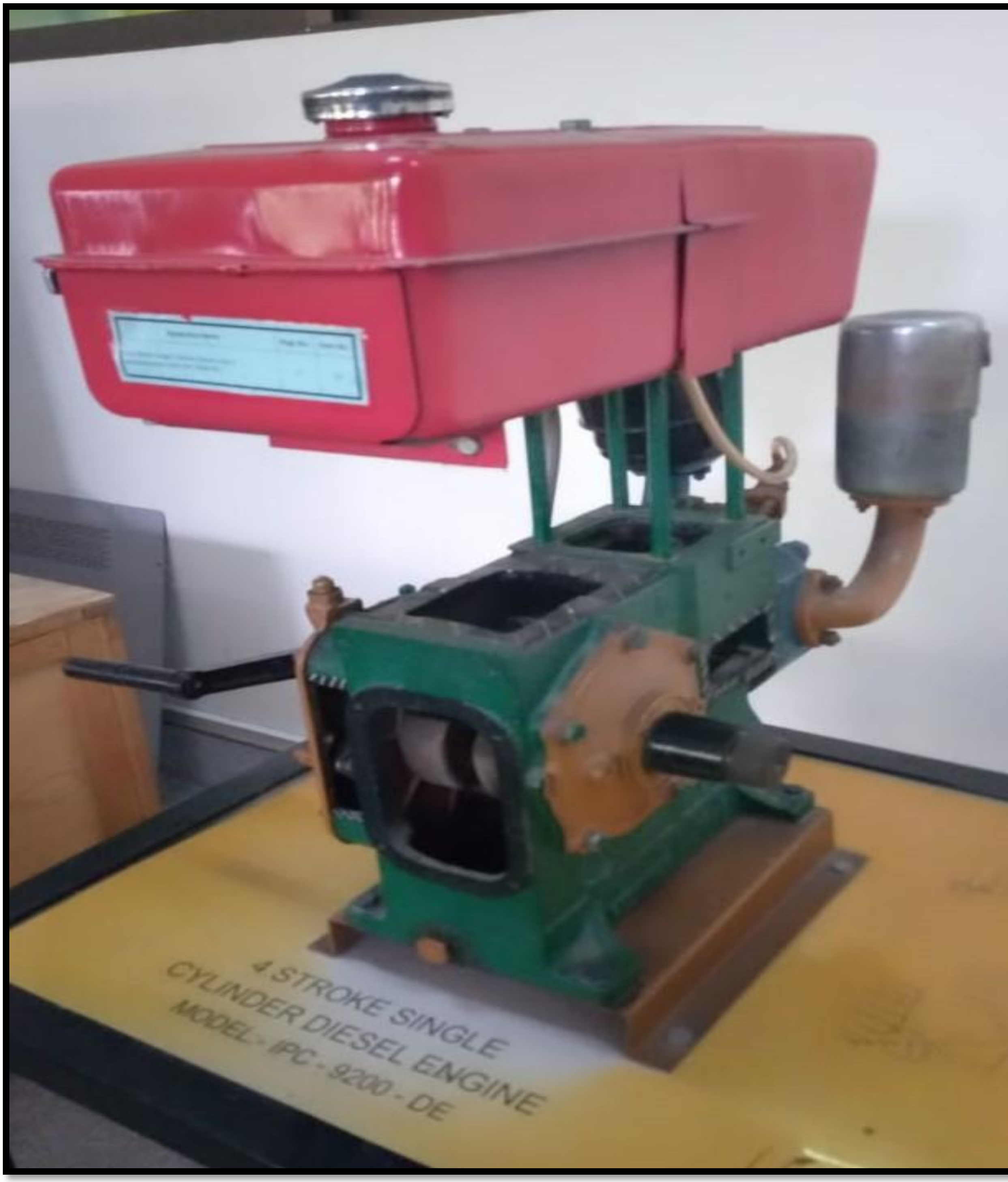


Figure No. 8.1 : Model of Four Stroke Single Cylinder Diesel Engine.

## 8.2: Two Stroke Petrol Engine:

A **two-stroke** (or **two-cycle**) **engine** is a type of internal combustion engine which completes a power cycle with two strokes (up and down movements) of the piston during only one crankshaft revolution. In a two-stroke engine, the end of the combustion stroke and the beginning of the compression stroke happen simultaneously, with the intake and exhaust functions occurring at the same time.


Figure no. 8.2: Model of Two Stroke Petrol Engine.

**<u>9.1: Cooling Tower Trainer</u>**

This trainer will familiarize students with the operation of forced draft counter-flow cooling tower systems. It can operate independently or be connected to other Labtech Refrigeration and Air Conditioning trainers. Water to be cooled is recirculated through a tower which sprays the water through a baffle system with forced airflow to maximize the cooling effect. A transparent Plexiglas panel allows the water flow to be seen inside.

Figure no. 9.1: Model Cooling Tower Trainer

**10.1: Laboratory Air Conditioning Trainer:**

Air conditioning systems are vital in ensuring the comfort of people at home and in the workplace, and refrigeration systems are essential to the storage and preservation of our food resources. We are especially finding a massive acceptance of these systems in developing nations where they have not been widely used before. This increases the importance of having qualified technicians who can install, service and repair this equipment.

Figure no. 10.1: Model of Laboratory Air Conditioner

**11.1: Mechanical Heat Pump Trainer:**

The mechanical heat pump is the most prevailing heat pump to be applied commercially. Its principle of operation: Inside a mechanical heat pump the pressure of a refrigerant is increased with the use of a compressor. Due to this increase in pressure, the condensation temperature rises. Most installations have an electric motor to drive the compressor. Two types of mechanical heat pumps are available: a system that with direct expansion of the refrigerant at the inlet of the evaporator (dx system) and a so called 'pump system' heat pump where liquid refrigerant is pumped to the evaporators. Both types are described in more detail below.

Figure no. 11.1: Model of Mechanical Heat Pump Trainer

**12.1: Commercial Refrigeration Trainer:**

This commercial refrigeration trainer is an advanced unit used to train students in commercial refrigeration and air conditioning systems.


Figure no. 12.1: Model of Commercial Refrigerator.

## 13.1: Vortex Tube Refrigerator:

The **vortex tube**, also known as the **Ranque-Hilsch vortex tube**, is a mechanical device that separates a compressed gas into hot and cold streams. The gas emerging from the "hot" end can reach temperatures of 200 °C (392 °F), and the gas emerging from the "cold end" can reach −50 °C (−58 °F). It has no moving parts.


Figure no. 13.1: Model of Vortex Tube Refrigerator.

## 14.1 Thermo Electric Heat Pump Trainer:

A **heat pump** is a device that transfers heat energy from a source of heat to what is called a thermal reservoir. Heat pumps move thermal energy in the opposite direction of spontaneous heat transfer, by absorbing heat from a cold space and releasing it to a warmer one. A heat pump uses external power to accomplish the work of transferring energy from the heat source to the heat sink. The most common design of a heat pump involves four main components – a condenser an expansion valve, an evaporator and a compressor. The heat transfer medium circulated through these components is called refrigerant.


Figure no. 14.1: Model of Thermo Electric Heat Pump.

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# Lab 2

## Experiment no. 1

## Observe the working principle of Two Stroke Petrol/Spark Ignition Engine

## 1: Introduction:

A two-stroke (or two-cycle) engine is a type of internal combustion engine which completes a power cycle with two strokes (up and down movements) of the piston during only one crankshaft revolution.

- **Actually stroke means movement of piston between top position of piston and bottom position of piston**

In a two-stroke engine, the end of the combustion stroke and the beginning of the compression stroke happen simultaneously, with the intake and exhaust (or scavenging) functions occurring at the same time. A 2-stroke engine is an engine in which there are 2 phases in a cycle of operation of the engine. Stroke basically, means the sudden movement of piston which is converted into a rotary motion at crankshaft. This rotation is coupled to gear system and differential, which turns the wheel. Reciprocating motion used in reciprocating engines and other mechanisms is back and forth motion. Each cycle of reciprocation consists of two opposite motions, there is a motion in one direction and then a motion back in the opposite direction. Each of this motion is called **stroke**. There are basically 4 processes in a petrol/spark engine- **Intake** (of fuel), **Compression**, **Ignition** and **Exhaust**. Intake of fuel and Compression happens in the first stroke and the next 2 processes in the second stroke.


*Figure 1: Model of Two Stroke Petrol Engine.*

# Parts List and Details:

i. Inlet port
ii. Carburetor
iii. Transfer port
iv. Piston
v. Exit hole
vi. Cylinder
vii. Spark plug/glow plug
viii. Connecting rod
ix. Crankshaft
x. Crank case
xi. Gudgeon pin
xii. Integral fins/cooling fins

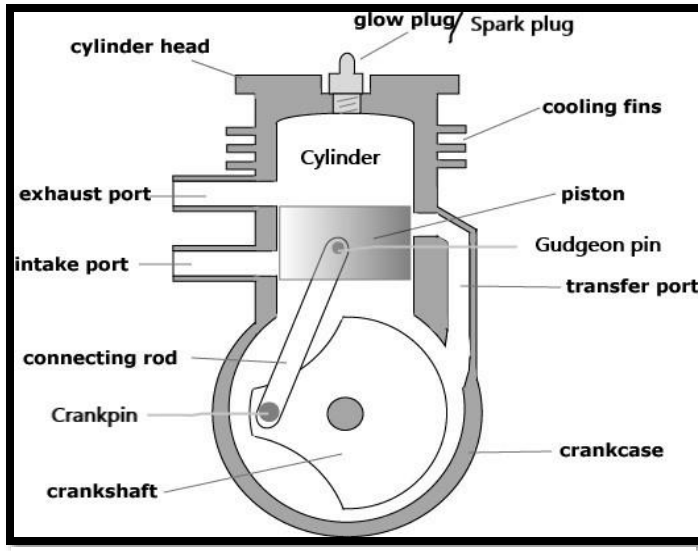
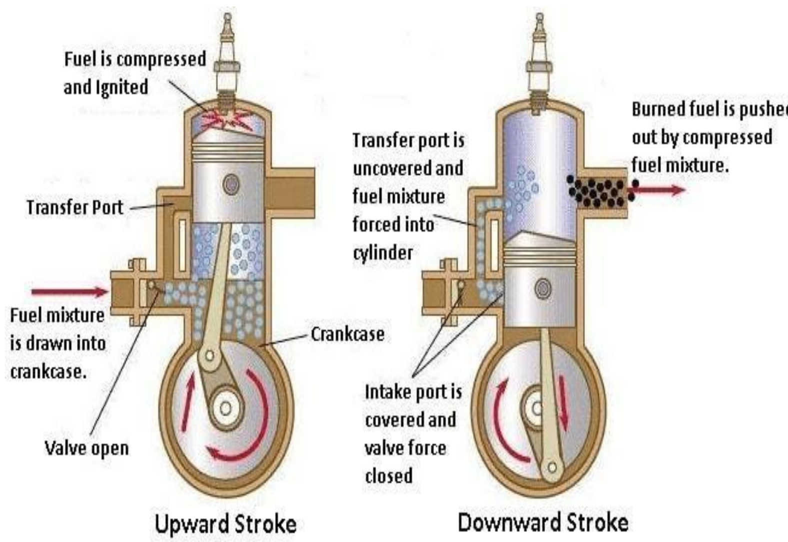



*Figure2:Labelled Diagram of Two Stroke Petrol Engine.*

## Inlet port:

➢ The inlet ports connect to a transfer passage leading to the fully enclosed crankcase. Air trapped in the crankcase is compressed by the decent of the piston on its power stroke as shown




## Use:

➢ Intake ports are needed for the air fuel mixture to be properly directed into the combustion chamber for proper combustion.

## Carburetor:

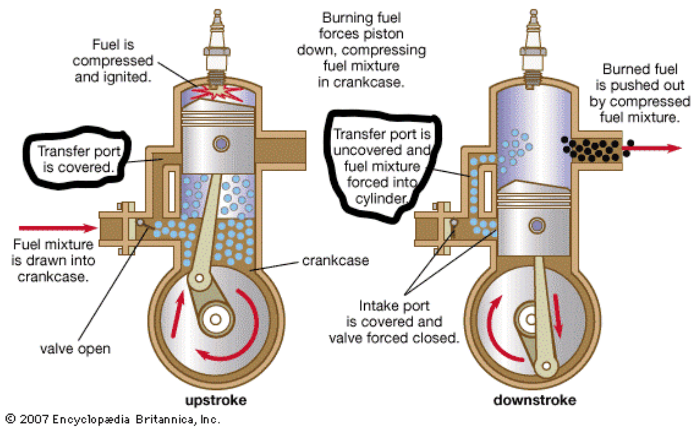
- A carburetor is a device that mixes air and fuel for internal combustions in the proper air fuel ratio for combustion.

## Use:

- It is used to control the speed of vehicles. It converts petrol into fine droplets and mixes it with air in such a way that it burns smoothly in engine.

## Transfer port:

- It is the passage b/w the cylinder and crankcase. This passage transport fresh air/fuel mixture supplied by the intake from the crankcase to the area of the cylinder currently above the cylinder as shown in figure.




## Use:

- It cools the cylinder. It is also uses in scavenging of the exhaust gases to the outlet.

## Piston:

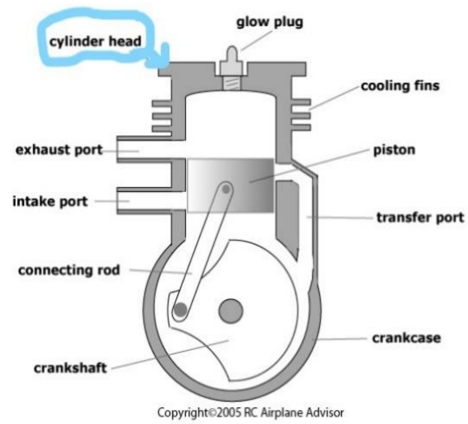
- Piston is another vital engine component. It is a partly hollow cylindrical part closed at one end, fitted to each of the engine's cylinders and attached to the crankshaft by a connecting rod. Each piston moves up and down in its cylinder, transmitting power created by the exploding fuel to the crankshaft via a connecting rod.

## Outlet Port:

- The outlet port is higher and thus is exposed first during the power stroke to allow the exhaust gases to begin flowing out of the cylinder.
- The point in the cylinder through which the burnt gases are exhausted out.

## Cylinder:

- In two stroke engines, on the other hand, the crankcase is serving as a pressurization chamber to force fuel air into the chamber
- So, it can't hold thick oil. Instead you mix oil in with gas to lubricate the crankshaft, connecting rod and cylinder walls as shown in figure.

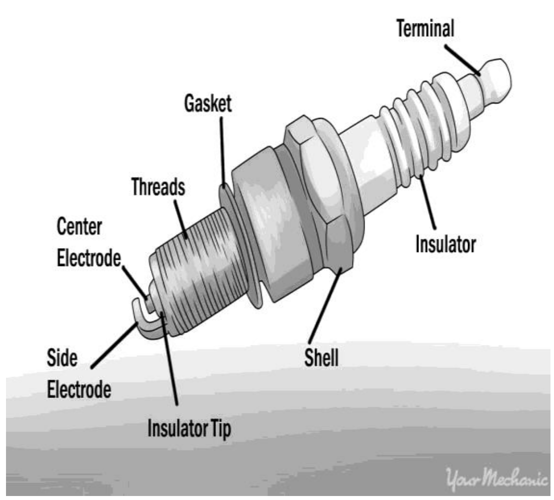



## Use:

- It not also prevents the air/fuel from travelling into the exhaust port, but also creates a stirring turbulence that enhances combustion efficiency, power and economy

## Spark plug:

- It is a device for delivering electric current from an
  Ignition chamber to of a spark ignition to ignite the mixture of air/fuel by an electric spark, while containing the combustion pressure within the engine
  As shown in Figure

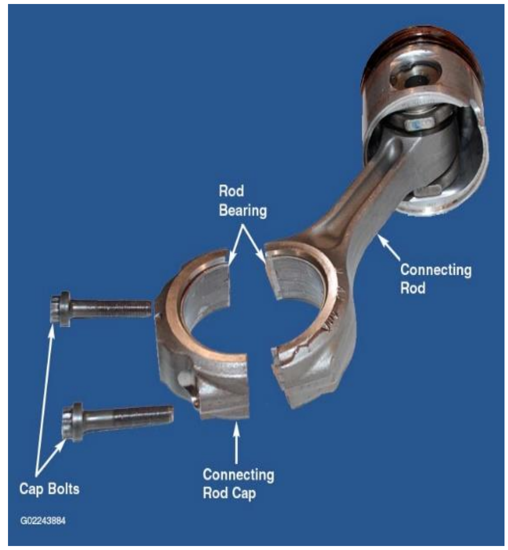



## Use:

- The combustion and reduces the specific combustion automatically will help to increase the efficiency.

## Connecting rod:

- A connecting rod is also known as con rod is a part Of the piston engine which connects the piston to crankshaft. Together with the crank the connecting rods converts the reciprocating motion of the piston into the rotation of the crankshaft as shown in Figure:




## Use:

- It is required to transmit the compressive and tensile forces from the piston and rotate at both ends. It is mostly used in internal combustion engines and steam engines.

## Crankshaft:

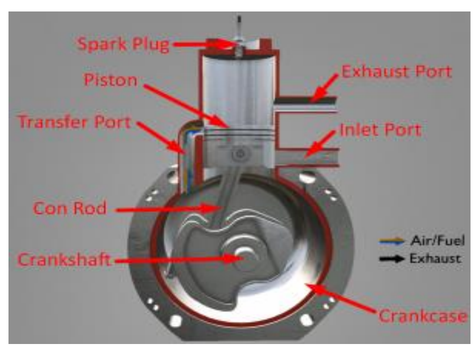
- A crankshaft is a rotating shaft (In conjunction with the connecting rods) converts the reciprocating motion of the pistons as shown in figure

## Use:

- Crankshaft is commonly used in internal combustion engines and consists of series of crank and crank pins to which the connecting rods are attached.

## Crank Case:

- In a two stroke engines crankcase is serving as a pressurization chamber to force air/fuel into the cylinder so it can hold a two-stroke engine typically use crankcase compression design, resulting in the fuel/air mixture passing through the crankcase before entering the cylinder as shown in figure.




## Gudgeon pin:

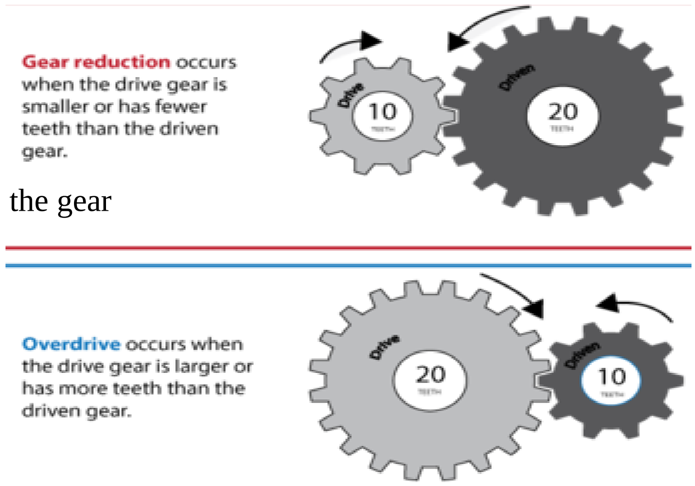
The gudgeon pin/wrist pin connects the piston to the connecting rod, and provides a bearing for the connecting rod to pivot upon as the piston moves.

## Integral fins:

The lining outside the engine is integral fins that externally cools the cylinder.

# Driver and Driven Gear

Gears are used to transfer kinetic energy in a rotary motion using levers. Each tooth on a gear can be simplified as a lever which can be used to produce a mechanical advantage in a system. In a geared system there is a 'Driver', the gear which is powered, and a 'Driven', the gear that is moved. When the two engage the rotary motion is reversed. The rate of rotation is given in RPM (revolutions per minute) and calculated




**input speed/gear ratio**

## There are 3 reasons for implementing gears into a system:

**Change Speed:** This is achieved by making the number of teeth on each gear different. The larger 'Driver' gear has a greater number of teeth than the smaller 'Driven' gear, increasing the number of rotations it makes. The difference between each gear is given as a ratio.

Driven gear teeth/Driver gear teeth = Ratio

**Change Force:** If the 'Driver' gear is smaller than the 'Driven' gear the speed of rotation is decreased, however, the force applied is increased. The increase in torque occurs much in the same way a lever is given a mechanical advantage by using differing lengths. A gear is simply multiple levers arranged in a circle

**Change Direction of Force:** When two gears engage the direction of force is reversed as one pushes the other away. Motion can be changed in a linear direction as shown or at an angle by altering the shape of the tooth profiles

# Explanation

## PROCESSES:

**There are following processes in Two Stroke Engine:**

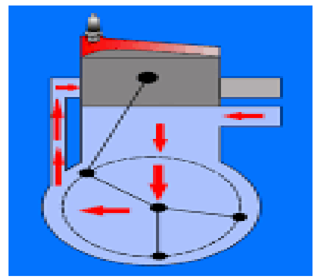
## Intake:

- During the intake stroke, the fuel air mixture from the carburetor is taken in from the intake valve and the exhaust from the previous cycle is expelled from the exhaust shaft. Actually, exchange of fuel-air mixture with exhaust gases is not perfect. The piston creates an area of flow pressure when it is at the beginning of intake stroke and sucks in air from both intake and exhaust shaft. Hence, exhaust gases are sucked back into the engine for combustion and the fuel-air mixture from the intake shaft are expelled.

## Compression:

- During the compression stroke, the fuel-air mixture (along with some exhaust gases) is compressed. This is the first half of cycle until the piston reaches its highest point in the cylinder .The next half of the cycle occurs when a spark plug ignites the fuel-air mixture when the piston is at its peak, thereby causing the violent expansion of gases and pushing the piston back down to power the crankshaft and ultimately your vehicle.(This is sometime known as ("Power Stroke")

## Ignition:



During upward stroke of a 2-stroke spark ignition cycle, the piston moves upward i.e. from the bottom dead center to the top dead center. While moving up, it compresses the air-fuel mixture in the combustion chamber. The spark plug ignites the compressed charge in the combustion chamber and produces the power stroke.

## Power:

- At the top of the stroke, the spark plug ignites the fuel mixture. The burning fuel expands, driving the piston downward, to complete the cycle. (At the same time, another crankcase compression stroke is happening beneath the piston.)

## Exhaust:

Toward the end of the stroke, the piston exposes the intake port, allowing the compressed fuel/air mixture in the crankcase to escape around the piston into the main cylinder. This expels the exhaust gasses out the exhaust port, usually located on theopposite side of the cylinder. Unfortunately, some of the fresh fuel mixture is usually expelled as well.

## WORKING OF THE CYCLE

- In a two-stroke engine, the end of the combustion stroke and the beginning of the compression stroke happen simultaneously, with the intake and exhaust functions occurring at the same time. Fuel enters from the carburetor and reaches to cylinder for accumulation. There is a transfer port, from which fuel reaches to the top level of the engine and then there pressure exists, which causes to burn the fuel. Likely, transfer port and inlet port there is a exist port, from which fuel come out.

- The whole process is represented by **P-V diagram** and **T-S diagram:**

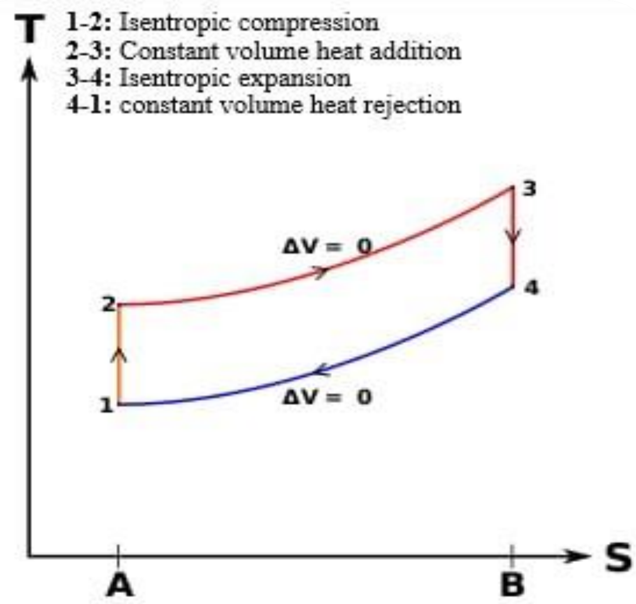



*Figure 1:T-S diagram of Working of Two Stroke Petrol Engine.*

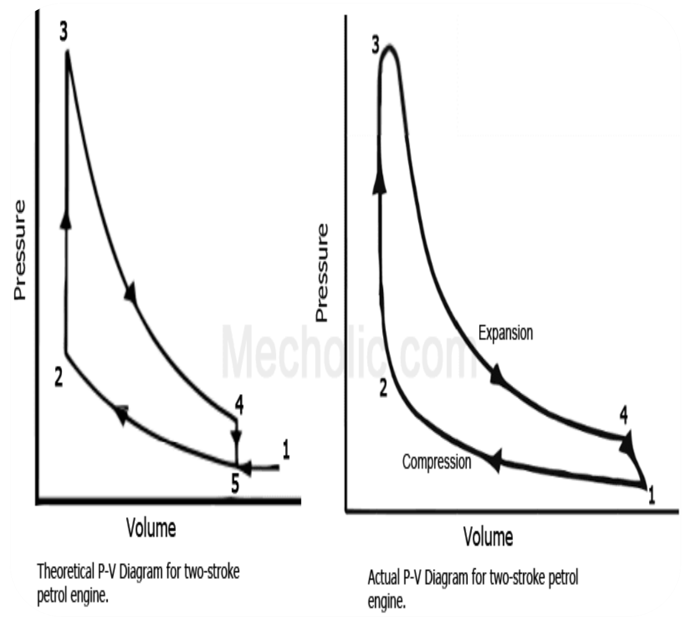



*Figure 2: P-V diagram of Working of Two Stroke Petrol Engine.*

| **Advantages:** | **Disadvantages**: |
|---|---|
| The power developed will be nearly twice that of four stroke engine of same dimension and operating at the same speed. The work required to overcome the friction of the exhaust and suction strokes is saved. Low weight. Construction is simple. Low thermal efficiency. Can run at higher speeds (5000 rpm). Low maintenance cost<br><br>**1RPM=4 Process=2 Strokes** | As cycle is repeating itself again and again, a part of the fresh mixture is lost through exhaust port. Part of the piston stroke is lost. Heavy consumption of lubricating oil. Two-stroke engines are not fuel efficient, so we would get fewer miles per gallon. |

## Application:

- Two stroke engine are preferred when mechanically simplicity, light weight, and high power to weight ratios are traditionally technique of mixing oil into fuel, they also have the advantage of working in any orientation as there is no oil reservoir dependent on gravity; this is an essential proper power tools such as chainsaws. Therefore, it has been used in large diesel engines, mostly large industrial and marine engines, as well as some trucks and heavy machinery.

**Two stroke Petrol Engine is used in following machines;**

- Dirt Bike
- Lawn mowers
- Outboard engines
- Chain saws
- Line Trimmers
- Jet Skis
- Snowmobiles
- Model Air Planes
- Light Motorcycles
- Go Karts, Ultra-lights, Scooters Go-Karts etc.

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# Lab 2

## Experiment no. 3

## Observe the Working Principle of Four Stroke Diesel Engine/Compression Ignition

Diesel engine may be designed as either two stroke or four stroke cycles.

- **A Four Stroke Diesel Engine** is an internal combustion engine in which the piston completes four separate strokes while turning a crankshaft. A stroke refers to the full travel of the piston along the cylinder, in either direction.

### Introduction:

In the 1890s, a German inventor, Rudolf Diesel has patented his invention of an efficient, slow burning, compression ignition, internal combustion engine. The original cycle proposed by Rudolf Diesel was a constant temperature cycle. In later years Diesel realized his original cycle would not work and he adopted the constant pressure cycle, which is known as the Diesel cycle. Diesel engines may be designed as either two stroke or four stroke cycles. The four stroke Diesel engine is an internal combustion (IC) engine in which the piston completes four separate strokes while turning a crankshaft. A stroke refers to the full travel of the piston along the cylinder, in either direction. Therefore, each stroke does not correspond to single thermodynamic process given in chapter Diesel Cycle – Processes. Diesel engine, any internal-combustion engine in which air is compressed to a sufficiently high temperature to ignite diesel fuel injected into the cylinder, where combustion and expansion actuate a piston. It converts the chemical energy stored in the fuel into mechanical energy, which can be used to power freight trucks, large tractors, locomotives, and marine vessels. A limited number of automobiles also are diesel-powered, as are some electric-power generator sets.

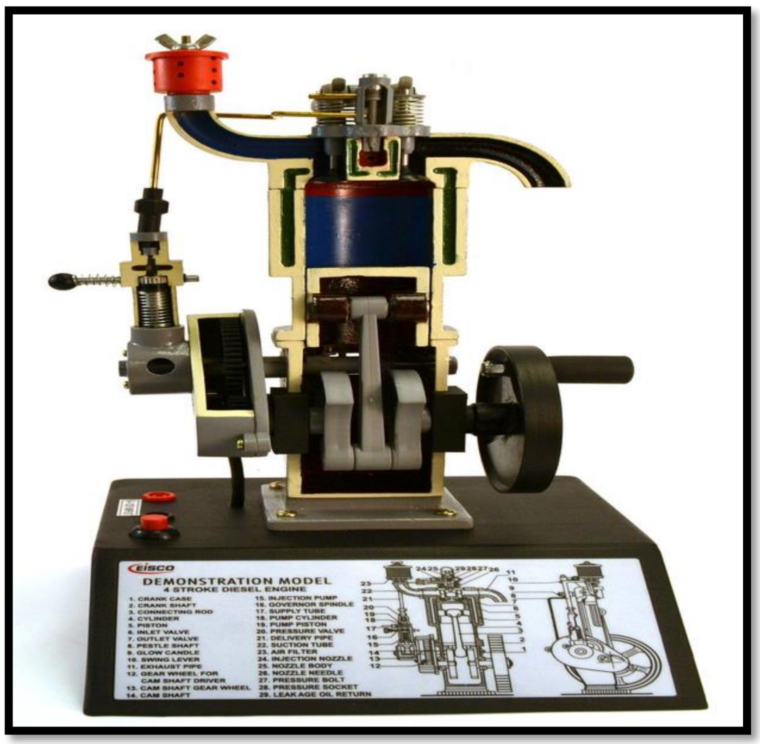



*Figure 1:: Model of four stroke Diesel engine*

The diesel engine uses a four-stroke combustion cycle just like a gasoline engine. The four strokes are **intake stroke, compression stroke, combustion/expansion stroke** and **exhaust stroke.**

## Parts list and details

Most parts of four stroke diesel engine is similar to four stroke petrol engine except there is **no spark plug** to ignite the air-fuel mixture. It intakes air and compresses it and then injects the fuel directly into the combustion chamber (direct injection). It is the heat of the compressed air that lights the fuel in a diesel engine.

**Fuel Injector:**

One is fitted in the cylinder head for each cylinder and is like a spring-loaded valve. It allows fuel to be sprayed into the cylinder at the precise moment in an atomized form.

**Fuel Injection Pump:**

Can be a multi element type driven by a chain or gears from the crankshaft or camshaft. Each element is connected to a fuel injector. In some engines there is a pump for each cylinder and it is driven off the camshaft. The fuel pump accurately meters the fuel and delivers it under high pressure at a precise moment to the spray nozzle of the fuel injector.

**Heat Plug/Glow Plug:**

Sometimes called glow plugs. One is fitted to each cylinder on pre-combustion chamber engines. They are fitted to assist in the ignition of fuel to start the engine when the engine is cold. Some diesel engines contain a glow plug. When a diesel engine is cold, the compression process may not raise the air to a high enough temperature to ignite the fuel. The glow plug is an electrically heated wire (think of the hot wires you see in a toaster) that heats the combustion chambers and raises the air temperature when the engine is cold so that the engine can start.

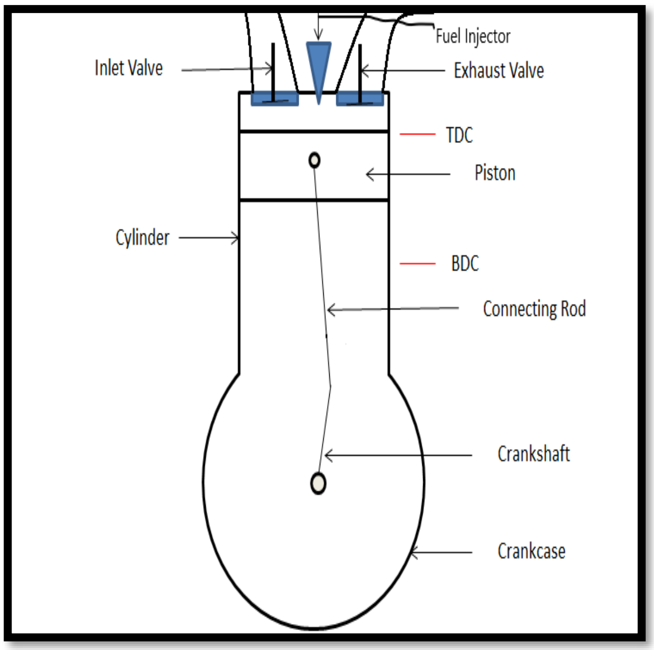


*Figure 2:Labelled diagram of four stroke diesel engine*

**Explanation:**

## Processes:

The four processes of four stroke diesel engine are given below in following:

- Suction stroke
- Compression stroke

- Power stroke / Expansion stroke
- Exhaust stroke

## Suction Stroke:

- With the movement of the piston from T.D.C. to B.D.C. during this stroke, the inlet valve opens and the air at atmospheric pressure is drawn inside the engine cylinder; the exhaust valve however remains closed.

## Compression Stroke:

- The air drawn at atmospheric pressure during the suction stroke is compressed to high pressure and temperature as the piston moves from B.D.C. to T.D.C. Both the inlet and exhaust valves do not open during any part of this stroke.

## Power stroke / Expansion Stroke:

- As the piston starts moving from T.D.C to B.D.C, the quantity of fuel is injected into the hot compressed air in fine sprays by the fuel injector and it (fuel) starts burning at constant pressure. The fuel is injected at the end of compression stroke but in actual practice the ignition of the fuel starts before the end of the compression stroke. The hot gases of the cylinder expand adiabatically .Thus doing work on the piston.

## Exhaust Stroke:

- The piston moves from the B.D.C. to T.D.C. and the exhaust gases escape to the atmosphere through the exhaust valve. When the piston reaches the T.D.C. the exhaust valve closes and the cycle is completed.

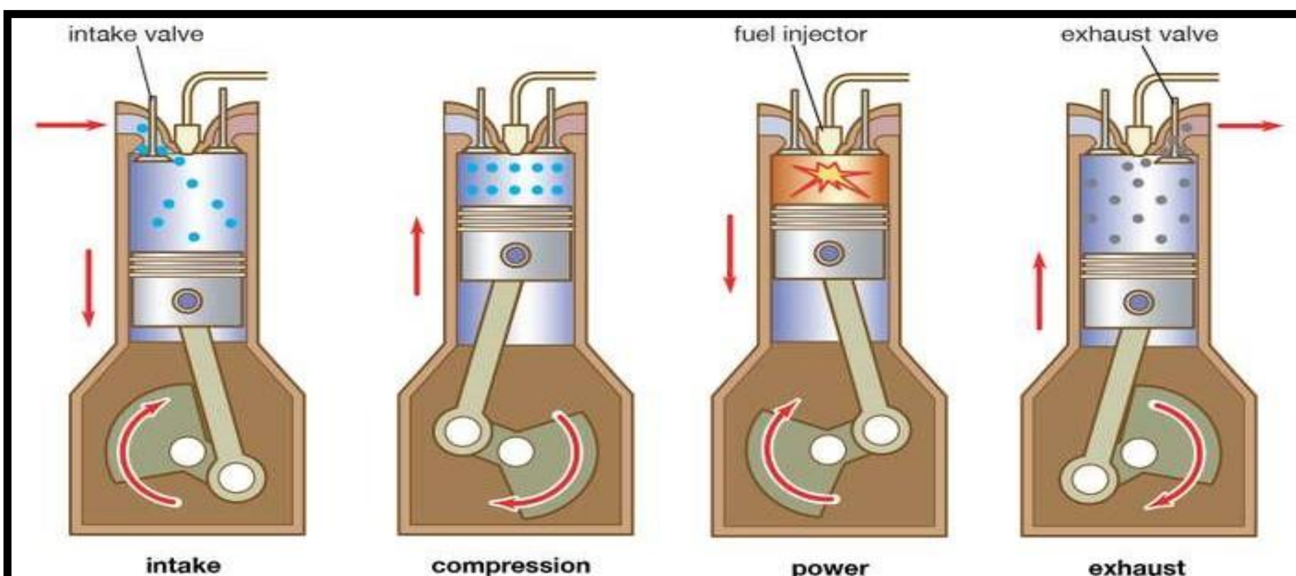



*Figure 3:: Working principle of four stroke diesel engine*

## Graphical Representation:

- Process 1 to 2 is isentropic compression
- Process 2 to 3 is reversible constant pressure heating
- Process 3 to 4 is isentropic expansion
- Process 4 to 1 is reversible constant volume cooling

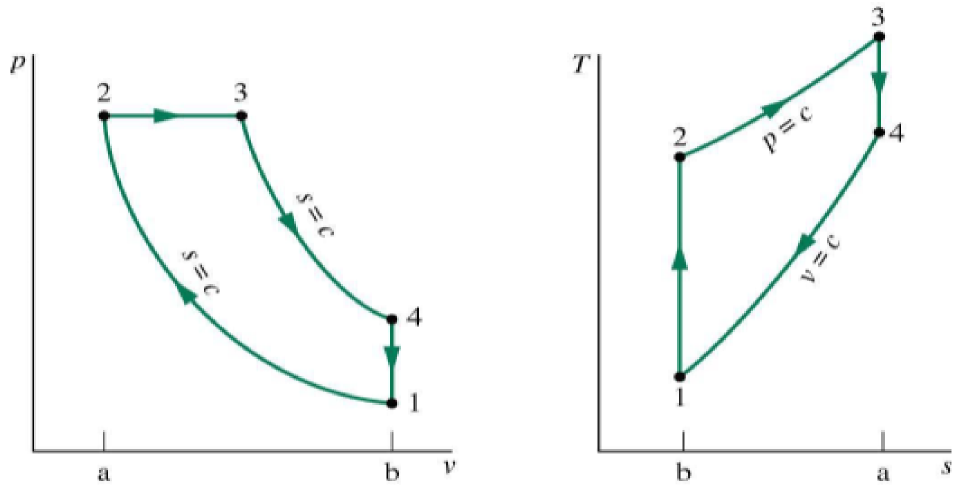



Figure 6- $p - v$ and $T - s$ diagrams for ideal Diesel cycle.

*Figure 4:: Ideal PV and TS diagram for four stroke diesel Engine*

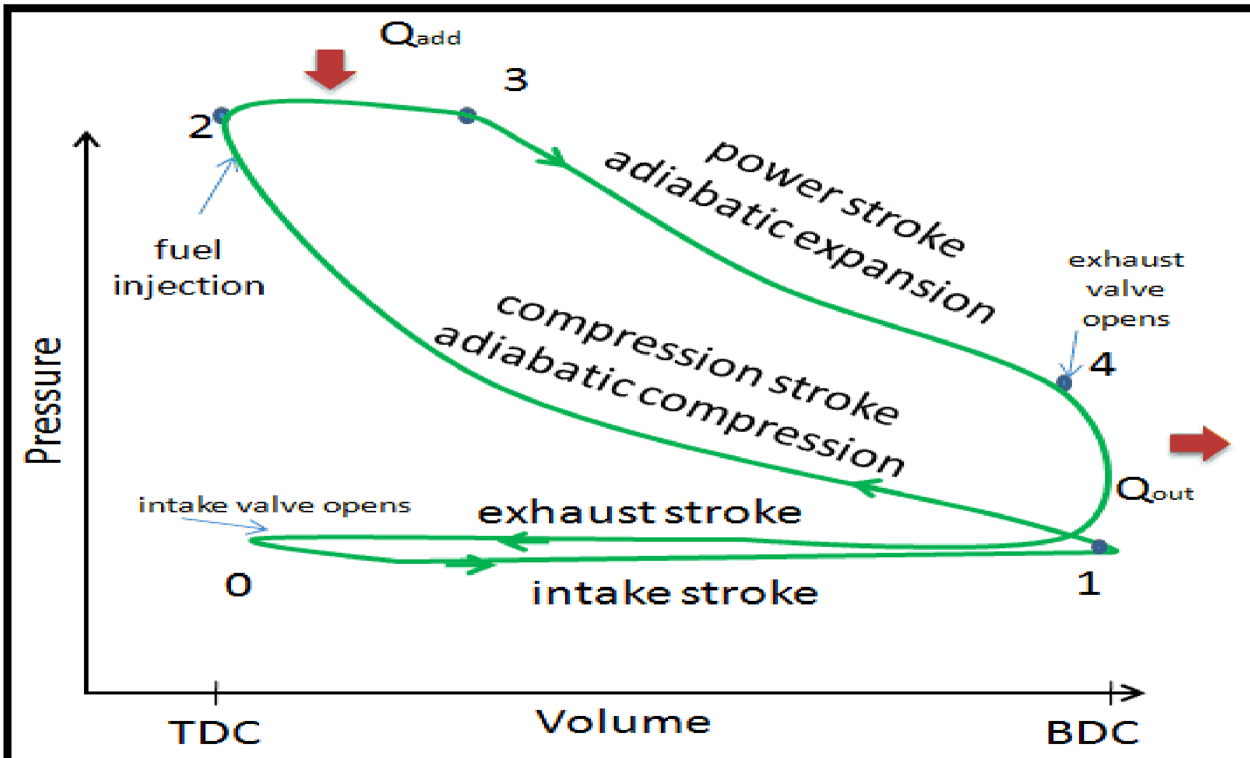



*Figure 5:Actual PV diagram of four stroke diesel engine*

## Lean Mixture and Rich Mixture

- The key difference between lean and rich mixture is that we use lean mixture for maximum efficiency and we use rich mixture for maximum power in an engine.
- Lean mixture has more air than the required quantity of air for complete combustion of fuel. It has 24-25 petrol/diesal and 75-76 air.
- On the other hand, rich mixture has less air than the required quantity of air for complete combustion of fuel in engine.

| Advantages of diesel engine | Disadvantages of diesel engine |
|---|---|
| The most important advantage of the diesel engine is that it gets great mileage. It delivers 25 to 30 percent better fuel economy compared to that of similarly performing gasoline engines. The efficiency of the diesel engine is highest and is energy dense fuel. Better fuel economy is delivered by diesel engine than gasoline because it contains more usable energy. The diesel engine has advantage of higher torque compared to petrol powered engine of the same volume. Due to high torque, diesel engine poses an advantage because high torque helps in the city traffic allowing the movement minimal engine turnover in traffic jams. | The cost of diesel engine is almost same or more than that of gasoline. Therefore, it is not cost effective. Due to high cost factor, diesel engine is posing to be as a disadvantage.<br><br>Diesel fuel is largely used at homes, for commercial trucks and heating oil. Hence the demand for the diesel engine is growing resulting in increases price of diesel fuel which is more likely continue to rise because of competition from those other users |

## Applications:

The four-stroke diesel engine has been used in the majority of heavy-duty applications for many decades. It uses a heavy fuel containing more energy and requiring less refinement to produce. The most efficient Otto-cycle engines run near 30% thermal efficiency. They were originally used as a more efficient replacement for stationary steam engines. Since the 1910s they have been used in submarines and ships. Use in locomotives, trucks, heavy equipment and electricity generation plants followed later. Diesel engines in trucks, trains, boats, and barges help transport nearly all products people consume. Diesel fuel is commonly used in public buses and school buses. Diesel fuel powers most of the farm and construction equipment in the United States.

There are several applications of diesel engines and some of them are.

- Diesel generators
- Locomotives
- Farming equipment
- In construction equipment
- In cargo and cruise ships
- In buses and trucks

## Difference

| Four Stroke Petrol Engine | Four Stroke Diesel Engine |
|---|---|
| • Petrol engine uses spark plug to ignite the fuel-air mixture.<br>• It intakes fuel-air mixture from carburetor during Intake stroke.<br>• It uses petrol as fuel.<br>• The clearance volume during compression is greater.<br>• Efficiency of petrol engine is 25% to 30%.<br>• Petrol engine is less heavy.<br>• Ignition occurs at constant volume.<br>• Petrol engine provides low torque and high speed.<br>• The compression ratio in a gasoline-powered engine will usually not be much higher than 10:1 due to potential engine knocking (autoignition) and not lower than 6:1.<br>• Combustion temperature is nearly 2500 $^0$C and pressure inside cylinder is 100bar during combustion. | • There is no spark plug needed to ignite the fuel.<br>• It intakes only air during intake stroke and then through fuel injector injects diesel in form of spray during compression.<br>• It uses diesel as fuel.<br>• The clearance volume is very less as compared to petrol engine.<br>• Efficiency of diesel engine is 35% to 40%.<br>• Diesel engine is heavier than petrol engine.<br>• Ignition occurs at constant pressure.<br>• Diesel engine provide high torque and low speed.<br>• The Diesel engines have the compression ratio that normally exceed 14:1 and ratios over 22:1 are also common.<br>• Combustion temperature is nearly 500-600C and pressure inside cylinder is 32-50 bar during combustion. |

# Lab 3

## Experiment no. 2

## Observe the Working Principle of Four Stroke Petrol/Spark Ignition Engine

- A Four Stroke Engine is an engine which works with four basic steps to a successful rotation of the crankshaft, the intake, compression, power and exhaust stroke.

## Introduction:

A petrol engine is an internal combustion engine with spark-ignition, designed to run on petrol (gasoline) and similar volatile fuels. A four-stroke engine (also known as four-cycle) is an internal combustion engine in which the piston completes four separate strokes which comprise a single thermodynamic cycle. A stroke refers to the full travel of the piston along the cylinder, in either direction. Four stroke cycle engine s is working at completed four stroke of the piston or two revolution of the crank shaft it is called as four stroke engine. There is two types of valves present 1. Inlet valve 2. Exhaust valve. Four stroke petrol Engine working at the four types of stroke **Suction/intake stroke, Compression stroke, Power stroke or expansion stroke** and **Exhaust stroke.** A single cycle requires two revolutions of the crankshaft to complete.

*Figure 1: Model of Four Stroke Petrol Engine.*

## Parts list and Details:

The parts of Four Stroke Petrol Engine are much similar to Two Stroke Petrol Engine including

| | | | | | |
|---|---|---|---|---|---|
| **carburetor** | **spark plug** | **crankshaft** | **connecting rod** | **piston** | **cylinder** |

with same working process except Inlet and Transfer port which are replace by **Intake Valve** and **Exhaust Valve.** In addition to crankshaft for each cylinder there is another shaft known as **CAM Shaft** for each intake and exhaust valve.

**CAM Shaft:**

In four-stroke cycle engines and some two-stroke cycle engines, the valve timing is controlled by the camshaft. It can be varied by modifying the camshaft, or it can be varied during engine operation by variable valve timing. The camshaft is a mechanical component of an internal combustion engine. It opens and closes the inlet and exhaust valves of the engine at the right time, with the exact stroke and in a precisely defined sequence. The camshaft is driven by the crankshaft by way of gearwheels, a toothed belt or a timing chain.

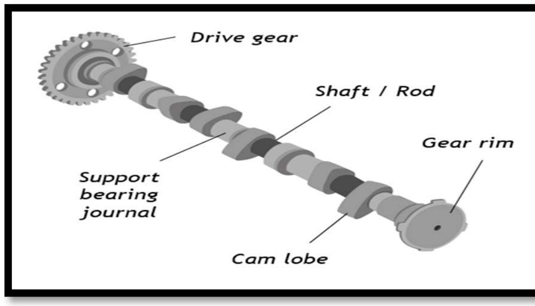
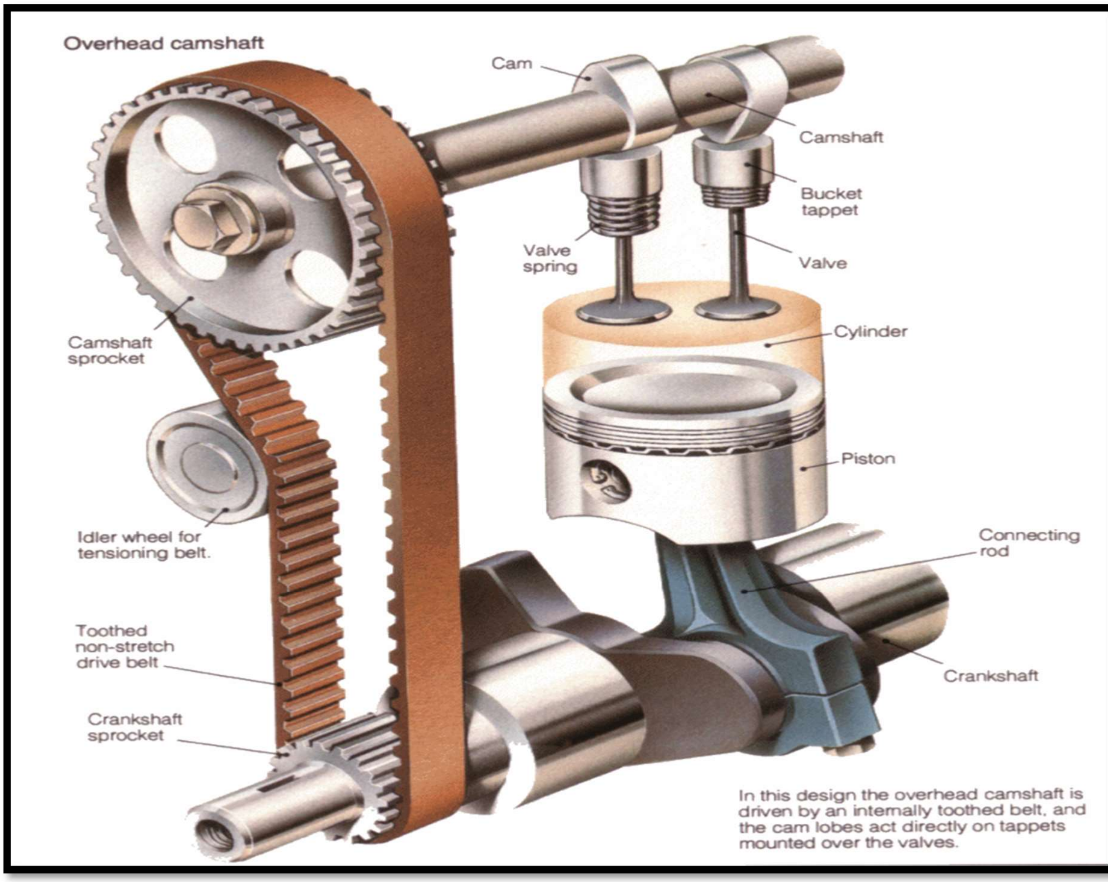



Figure 2:CAM Shaft Model.




**Intake Valve:**

Intake valve let the air-petrol mixture in during Intake stroke. The edge of camshaft pushes the intake valve down and air-petrol mixture enter the cylinder.

**Exhaust Valve**

Exhaust valve is opened when combustion ends. The edge of camshaft pushes the exhaust valve down and burnt gases leave the cylinder.

The intake valves are larger because the air and fuel volume taken in by the engine is greater than the exhaust volume.

## Explanation:

### Processes:

There are following processes in Four Stroke Petrol Engine:

- Intake Stroke
- Compression Stroke
- Combustion/Power Stroke
- Exhaust Stroke

## Intake Stroke:

- It is where the intake valves are open and the air is drawn into the cylinder. The fuel injector sprays the fuel into the cylinder to achieve the perfect air-fuel ratio. The downward movement of the piston causes the air and fuel to be sucked into the cylinder.

## Compression Stroke:

- In this stroke, both the intake and exhaust valves are closed. The upward movement of the piston causes the air-fuel mixture to be compressed upwards towards the spark plug. The compression makes the air and fuel to be sucked into the cylinder.

## Combustion/Power Stroke:

- During this stroke, both the intake and exhaust valves are still closed. The spark plug produces a spark to ignite the compressed air-fuel mixture. The resulting energy of the combustion forcefully pushes the piston downward.

## Exhaust Stroke:

- It is the last stroke, when the exhaust valves are open and the exhaust gases are forced up by the resulting piston.

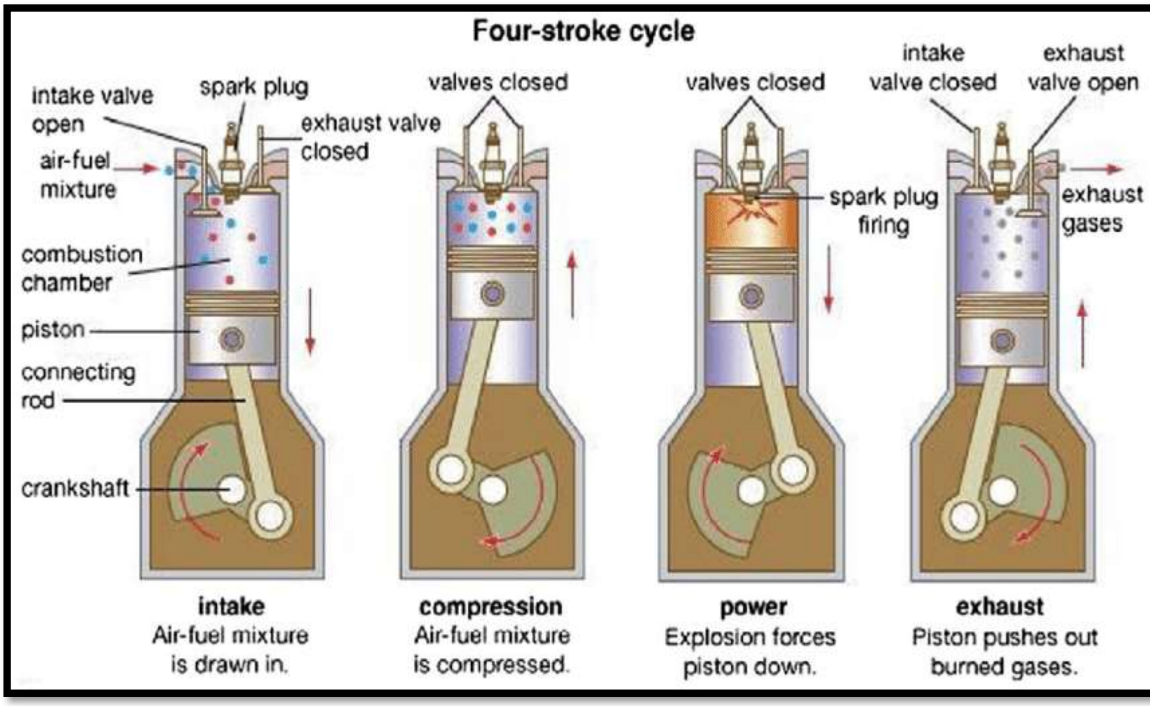



*Figure 3:Four Strokes of Petrol Engine*

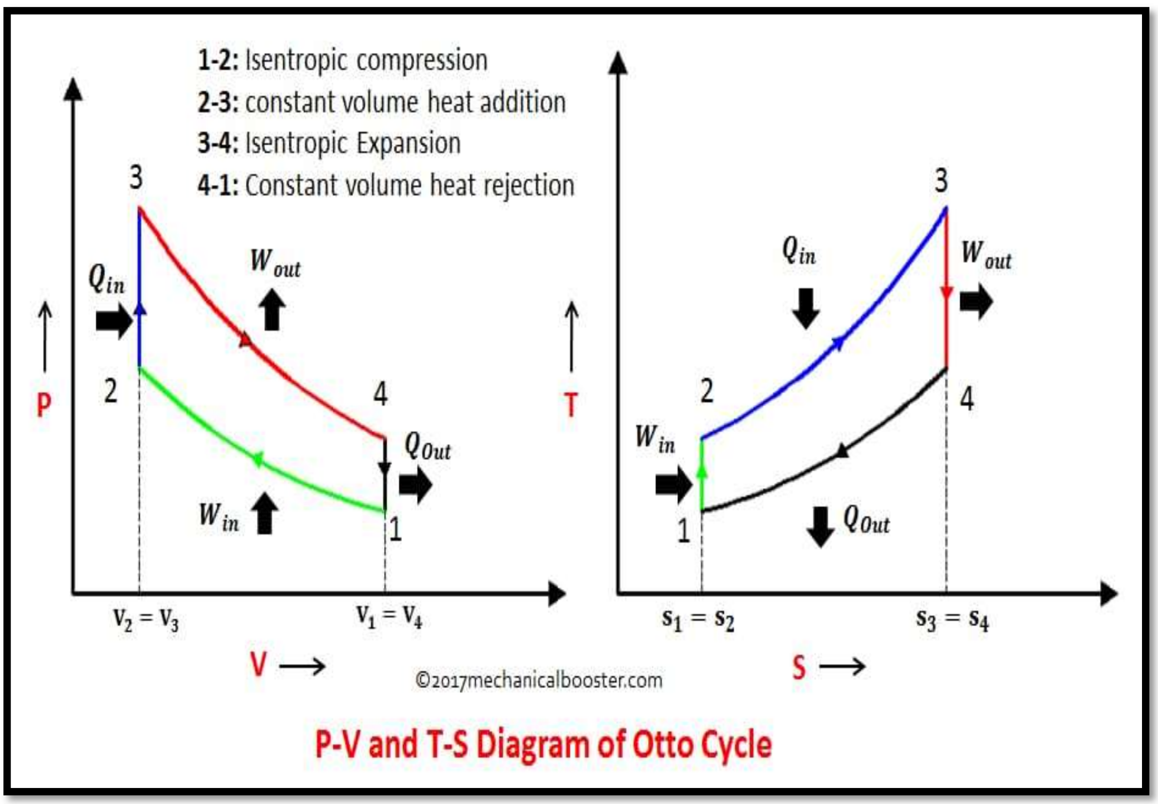



*Figure 4:P-V Diagram and T-S diagram of four stroke Petrol Engine*

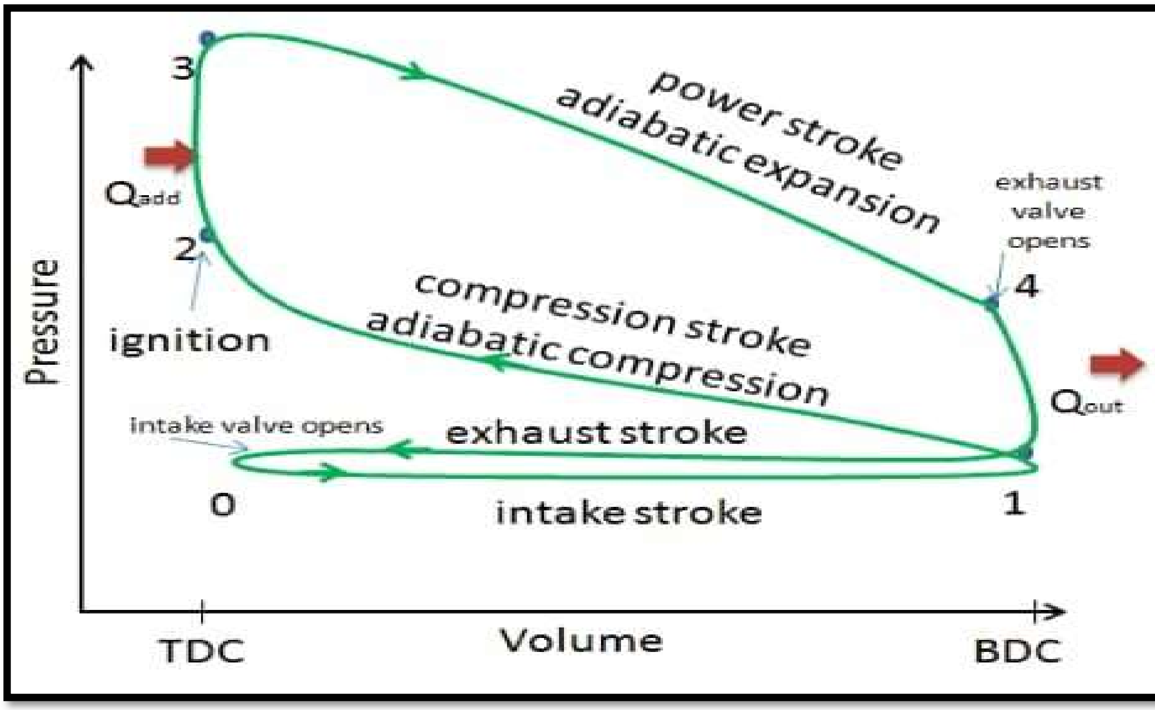



*Figure 5:Actual /Real P-V diagram*

| Advantages | Disadvantages |
|---|---|
| • Less fuel consumption.<br>• Thermal efficiency is more.<br>• More volumetric efficiency.<br>• Less wear and tear. | • More components.<br>• Separate valve mechanism is required.<br>• More cost.<br>• More complicated design. |

## Application:

The four-stroke version is generally used for larger applications and is the most common type of engine used in automobiles today. This type of engine is an ingenious and practical design that has powered millions of vehicles. It produces a large amount of power in an efficient and effective manner. It also generally produces less pollution and lasts longer than a two-stroke engine. The engine was created by **Nikolas Otto** in the mid-1800s, and in his honor, it's sometimes known as the Otto Engine. The four main strokes or steps that make up the cycle are intake, compression, combustion, and exhaust, which is sometimes called the **Otto** cycle.

- Automobiles
- Motorcycles
- Aircraft
- Motorboats
- Small engines, such as lawn mowers, chainsaws and portable engine generators.

## Difference between Two Stroke Engine and Four Stroke Engine:

| Two Stroke Engine | Four Stroke Engine |
|---|---|
| In a 2-stroke engine, the entire combustion cycle is completed with just one piston stroke: a compression stroke followed by the explosion of the compressed fuel. During the return stroke, the exhaust is let out and a fresh fuel mixture enters the cylinder. | being followed by a return stroke. In a 4-stroke engine, the piston completes 2-strokes during each revolution: one compression stroke and one exhaust stroke, |
| It is more powerful. | It is less powerful. |
| The spark plugs fire once every single revolution, and power is produced once every 2-strokes of the piston. | The spark plugs fire only once every other revolution, and power is produced every 4-strokes of the piston. |
| In two stroke engine, one power stroke is there for every two strokes. | In four stroke engine, one power stroke is there for every four strokes. |
| It is less complicated. | It is more complicated. |
| It is less expensive. | It is more expensive. |
| It has ports for pulling in fuel and air. | It has intake and exhaust valves rather than ports for pulling in fuel and air. |
| It produces loud with a high-pitched buzz. | It produces more of a soft humming noise. |
| Here only motion of piston controls the opening and closing of ports. | There is camshafts which control the opening and closing of intake and exhaust valves. |
| Two stroke engine has less parts | Four stroke engine has more parts and heavier. |
| In two stroke engine, there is ports for fuel intake | In four stroke engine, there is valves for intake and exhaust. |
| Two stroke has less efficiency. | Four stroke engine has more efficiency because it consumes less fuel. |
| Two-stroke engines also require the oil to be pre-mixed in with the fuel. | These engines also do not require pre-mixing of fuel and oil, as they have a separate compartment for the oil. |

| | |
|---|---|
| **Name** | Muhammad Arslan Raza |
| **Section** | A |
| **Roll no.** | 2020-EE-403 |

# Lab 6

## Experiment no. 5

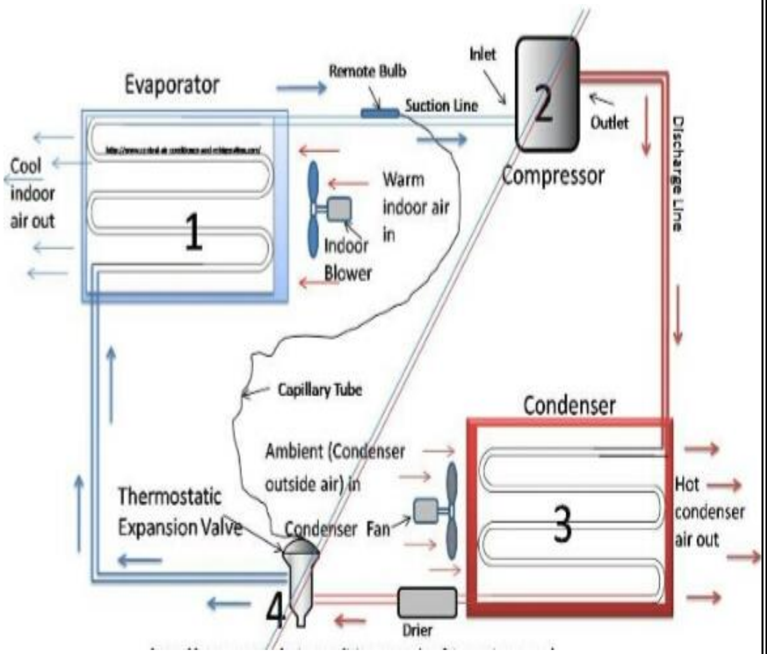
## DEMONSTRATION OF THE WORKING OF AIR CONDITIONER CYCLE

## Introduction:

"Air conditioning is the process of removing heat and moisture from the interior of an occupied space to improve the comfort of occupants."

This warming and cooling of the air is usually referred to as winter and summer air conditioning. An air conditioner collects hot air from a given space, processes it within itself with the help of a refrigerant and a bunch of coils and then releases cool air into the same space where the hot air had originally been collected. This is essentially how all air conditioners work. Air conditioners are basically refrigerators whose refrigerated space is a room or a building instead of the food compartment. A window air conditioning unit cools a room by absorbing heat from the room air and discharging it to the outside. The same air-conditioning unit can be used as a heat pump in winter by installing it backwards. In this mode, the unit absorbs heat from the cold outside and delivers it to the room. Air-conditioning systems that are equipped with proper controls and a reversing valve operate as air conditioners in summer and as heat pumps in winter. There are four components of air conditioning cycle. These four majors' components are divided into two difference pressure: high pressure and low pressure. The high-pressure side is the condenser units (outdoor) and the low-pressure side is the air conditioning evaporator (indoor). The divided point between high and low pressure cut through the compressor and the expansion valve.


*Figure 1:model of air conditioner*




## Parts Lists:

An air conditioning system consists of five mechanical components:

- Compressor
- Expansion valve
- Condenser Coil (Hot)
- Evaporator Coil (Cool)
- Refrigerant(dichlorofluoromethane)

## Working of Parts:

## Explanation:

The inside unit is normally inside the house somewhere, in the attic, basement, closet or crawl space. The outside unit is normally located on the side or back of the building. When air flows over the cold coils, heat from the air gets transferred to the refrigerant inside the coils. After the air flows over the coils, it gets cold.

- This process follows the **2nd law of thermodynamics**, which says that heat naturally (spontaneously) flows from a warmer body to a cooler body.

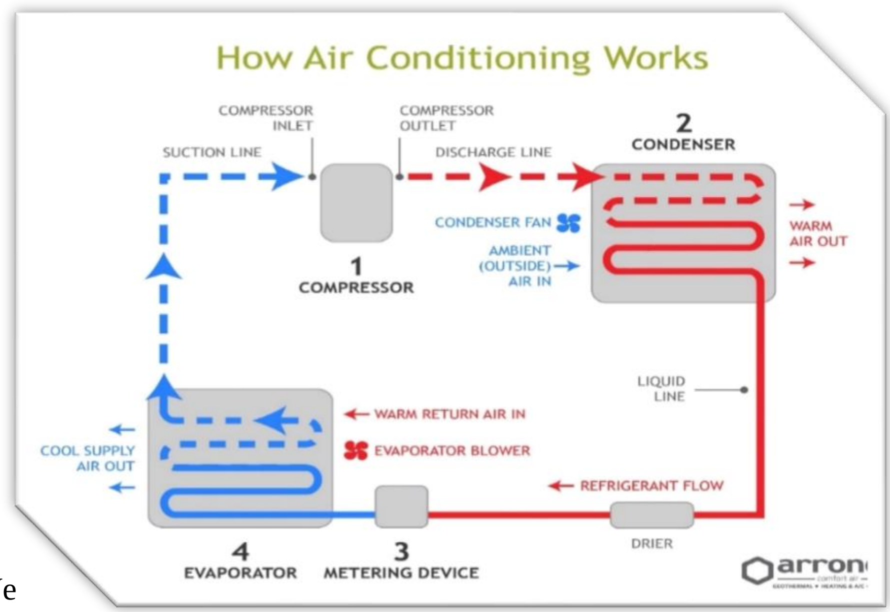
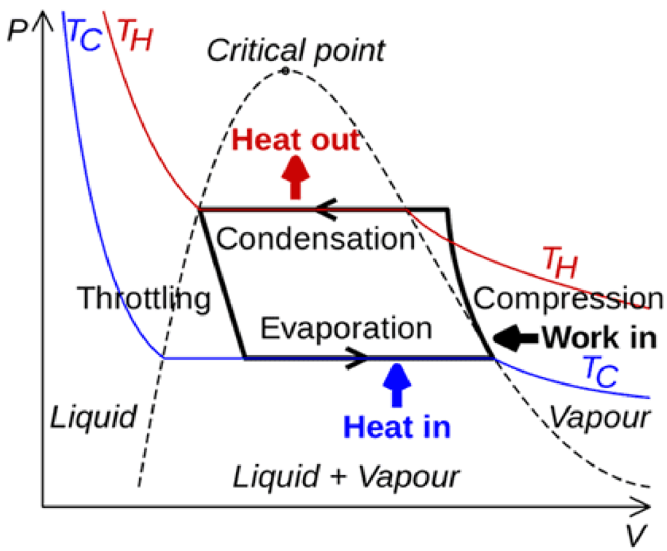


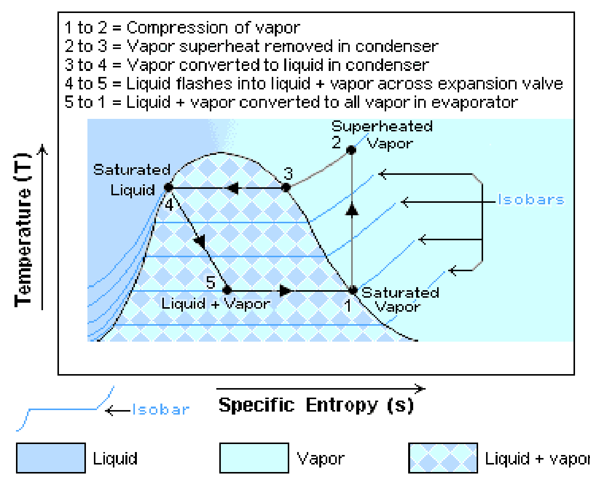

Figure 2:Working of air conditioning cycle

After the refrigerant absorbs the heat, its state changes from a liquid to a vapor. This warmer refrigerant gas then gets transferred to the compressor. Even though the refrigerant has absorbed heat from the indoor air, it is still fairly cool. The still cool, but warmer vaporized gas enters the compressor (located in the outside unit) to increase its pressure and temperature. We increase the temperature of the refrigerant because it needs to be warmer than the outdoor air. Since the refrigerant has been compressed (pressurized), it is now hotter than the outdoor air. A condenser fan blows hot outdoor air, heat is removed from the refrigerant and released into the outdoor air. Again, this is due to the 2nd law of thermodynamics. After the refrigerant loses thermal energy to the outdoor air, it condenses back into a liquid and gets pumped back inside. When the refrigerant leaves your outdoor condenser unit, its temperature is still pretty high. The refrigerant's temperature will need to drop significantly before it can absorb more heat from the indoor air.The metering device, usually a thermostatic expansion valve, is a special device that depressurizes the refrigerant, causing a drop in temperature. It does this by expanding the refrigerant into a larger volume. The refrigerant needs to be colder than the indoor air in order to absorb heat. Once the refrigerant gets cooled down, it flows back into the evaporator coils where it begins the cycle again.

## Working Diagrams:




**P-V Diagram**




**T-S Diagram**

*Figure 3:P-V and T-S Diagrams*

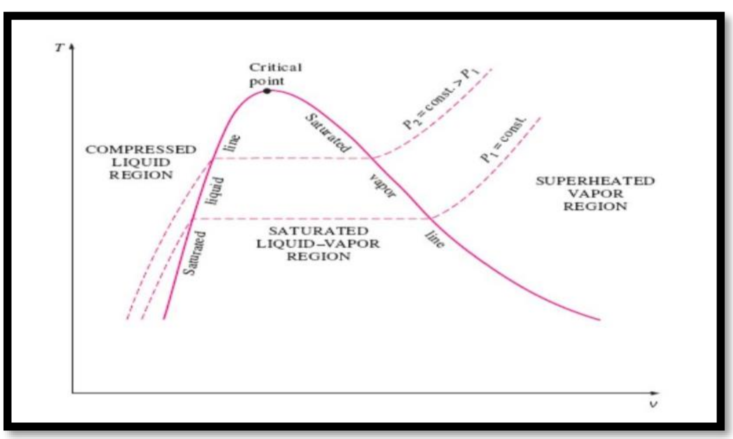



*Figure 4:T-V diagram of air conditioning cycle*

## ***1Ton AC*:**

**12 thousand BTU=1 ton**

1000 Kg of ice at room temperature for 24 hours, cooling obtained will be known as 1 ton.

## **Comparison Between AC and DC Inverter:**

There are two main types of inverter system:

- AC inverter
- DC inverter

➢ Basically, only the difference is the motor is driven by the inverter, not

the inverter device itself.

The inverter that drives an AC motor is called "**AC inverter**", and the

one which drives DC motor is called "**DC inverter**"

## **Application:**

- Air conditioning (often referred to as AC, A/C, or air con) is the process of removing heat and moisture from the interior of an occupied space to improve the comfort of occupants.

- Air conditioning can be used in both domestic and commercial environments. This process is most commonly used to achieve a more comfortable interior environment, typically for humans and other animals; however, air conditioning is also used to cool and dehumidify rooms filled with heat-producing electronic devices, such as computer servers, power amplifiers, and to display and store some delicate products, such as art work.

- Air conditioners often use as a fan to distribute the conditioned air to an occupied space such as a building or a car to improve thermal comfort and indoor air quality. Electric refrigerant-based AC units range from small units that can cool a small bedroom, which can be carried by a single adult, to massive units installed on the roof of office towers that can cool an entire building. The cooling is typically achieved through a refrigeration cycle, but sometimes evaporation or free cooling is used.

- Air conditioning systems can also be made based on desiccants (chemicals which remove moisture from the air).

- Some AC systems reject or store heat in subterranean pipes. In addition to buildings, air conditioning can be used for many types of transportation, including automobiles, buses and other land vehicles, trains, ships, aircraft, and spacecraft.

- Commercial buildings, which are built for commerce, including offices, malls, shopping centers, restaurants etc.
- High-rise residential buildings, such as tall dormitories and apartment blocks.
- Industrial spaces where thermal comfort of workers is desired.
- Cars, aircraft, boats, which transport passenger or fresh goods.
- Institutional buildings, which includes government buildings, hospitals, schools etc.
- Low-rise residential buildings, including single-family houses, duplexes, and small apartment buildings.

**EXPERIMENT No.6**

**DEMONSTRATION OF THE WORKING OF**

**REFRIGERATION CYCLE**

# Introduction:

- **• Definition:**
  The term **refrigeration** means cooling a space, substance or system to lower and/or maintain its temperature below the ambient one (while the removed heat is rejected at a higher temperature). In other words, **refrigeration** is artificial (human-made)
  cooling. A reverse thermodynamic cycle whereby heat is transferred from a body with a lower temperature to a body with a higher temperature owing to the expenditure of work. Refrigeration cycles are used in refrigerating machines and in gas refrigerators.

- "It is a well-known fact that heat flows in the direction of decreasing temperature as from a high temperature region to a low temperature region."
- But the reverse process (heat transfer from low to high temperature) cannot occur by itself (Clausius Definition of Second Law).
- This process requires a special device called **Refrigerator.**

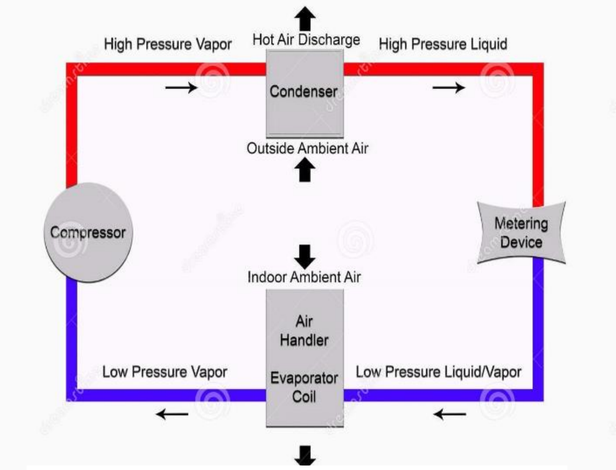


*Figure 1:Diagram of Refrigeration cycle*

# Part Lists:

The refrigeration cycle contains four major components:

- **Compressor**
- **Condenser**
- **Expansion device**
- **Evaporator**
- Refrigerant (Dichlorofluoromethane) remains piped between these four parts and is contained in the refrigerant loop. The refrigerant begins as a cool vapor and heads to the Compressor.

## Types Of Compressor:

The four most common types of air compressors are:
- Rotary Screw Compressor.
- Reciprocating Air Compressor.
- Axial Compressor.
- Centrifugal Compressor.

# Explanation:

**Refrigeration Cycle Consists of following process**

- Compression
- Condensation
- Expansion
- Evaporation

## Working Explanation:

### Compression:

- In this stage, the refrigerant enters the compressor as a gas under low pressure and having a low temperature. Then, the refrigerant is compressed adiabatically. So, the fluid leaves the compressor under high pressure and with a high temperature.

### Condensation:

- The high pressure, high temperature gas released heat energy and condenses inside the **condenser** portion of the system. The condenser is in contact with the hot reservoir of the refrigeration system.
- The gas releases heat into the hot reservoir because of the external work added to the gas. The refrigerant leaves as a high-pressure liquid.

### Expansion:

- The liquid refrigerant is pushed through a expansion valve, which causes it to expand. As a result, the refrigerant now has low pressure and lower temperature, while still in the liquid phase.
- The throttling valve can be either a thin slit or some sort of plug with holes in it. When the refrigerant is forced through the throttle, its pressure is reduced, causing the liquid to expand.

### Evaporation:

- The low pressure, low temperature refrigerant enters the evaporator, which is in contact with the cold reservoir. Because a low pressure is maintained, the refrigerant is able to boil at a low temperature. So, the liquid absorbs heat from the cold reservoir and evaporates. The refrigerant leaves the evaporator as a low temperature, low pressure gas and is taken into the compressor again.

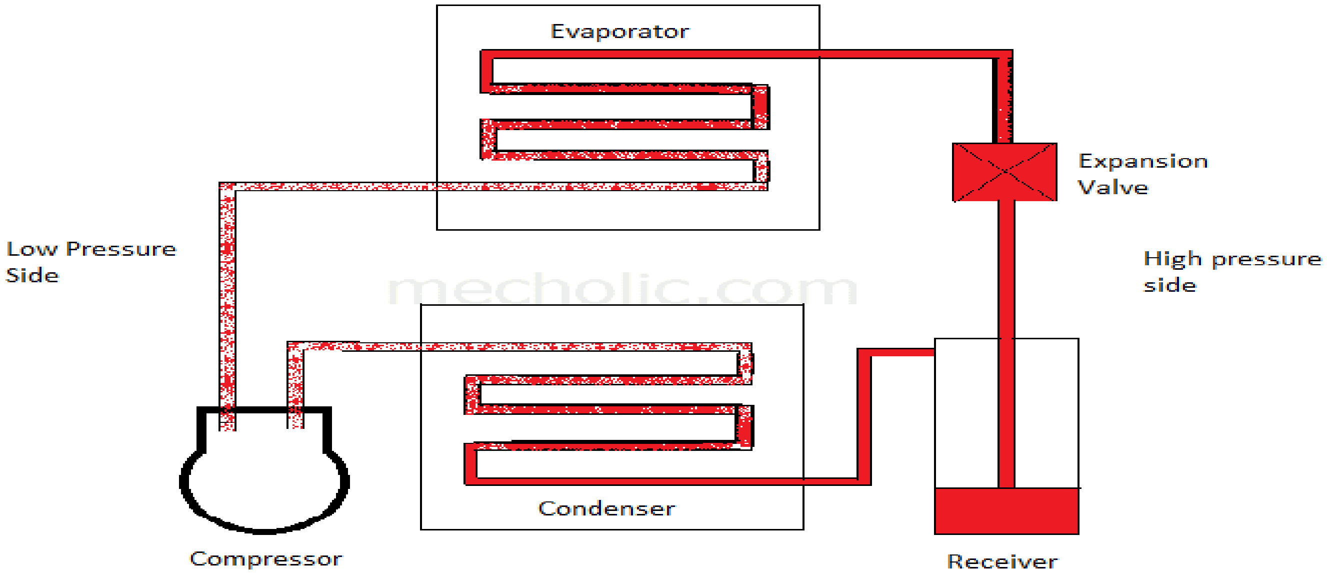
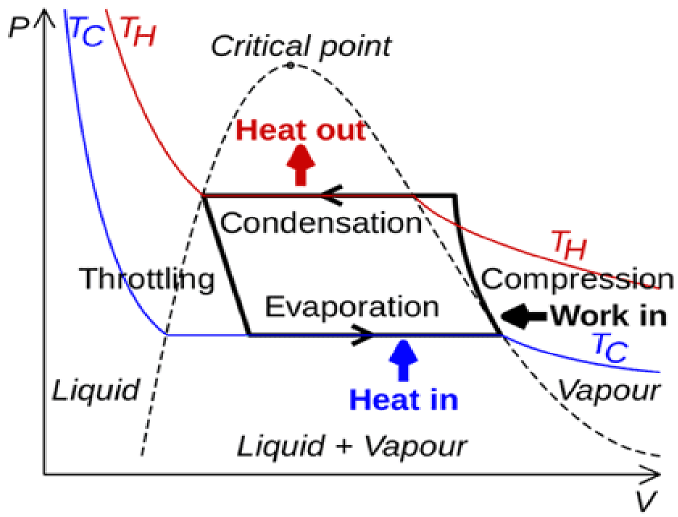
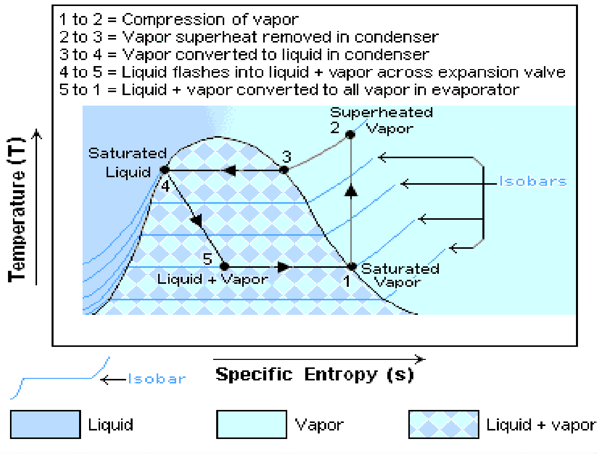



*Figure 2:Working Diagram of Refrigeration Cycle*

**Working Diagram:**




**P-V Diagram**




**T-S Diagram**

*Figure 3:Working Diagram P-V and T-S of Refrigeration Cycle*

## General Theory:

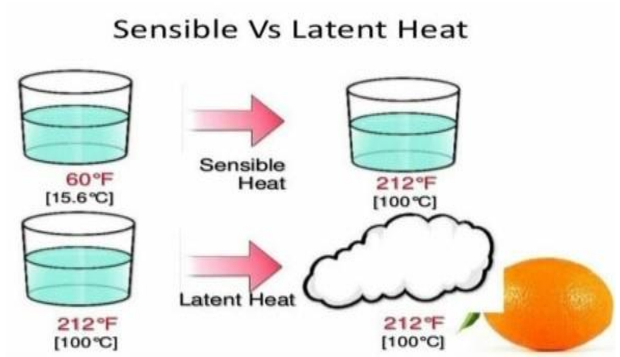
- High temperature takes place at Condenser.
- Low temperature takes place at Evaporator.
- Electricity is provided to Compressor, which is the main part of Refrigerator. Inside the compressor, electrical energy is converted into mechanical energy.
- Expansion valve is used to decrease the pressure and temperature of incoming liquid at least atmospheric temperature. If Expansion valve is not used, the heat will transfer from evaporator to room.
- Cooling takes place around evaporator.
- Heating takes place around condenser.
- Refrigerant delivers only cooling.
- A.C supplies both cooling and heating.
- Temperature is same at inlet and outlet of condenser.

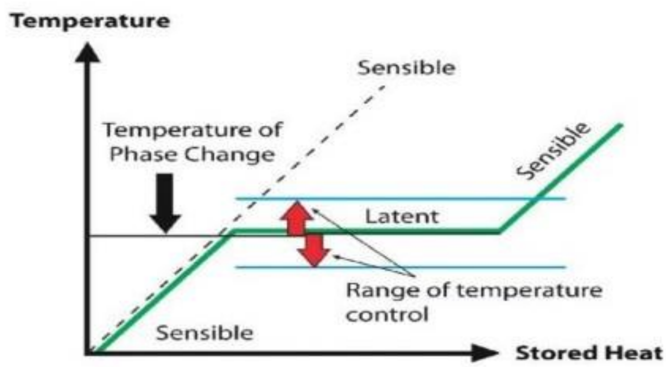
## Latent Heat:

- The amount of energy absorbed or released during a phase-change process is called the **Latent heat** and is greater than 100`C for a liquid like water.

## Sensible Heat:

- The amount of heat that is before the boiling point of a liquid and raised the temperature before reaching the boiling point is known as **Sensible heat.**



## APPLICATIONS:

The applications are given below in following:

- Domestic Refrigerator
- Water Cooler
- Air Conditioner
- Ice plant
- Cold Storage
- For chilling the oil to remove wax in oil refineries
- For preservation of tablets and medicines in Pharmaceutical industry
- For the preservation of blood tissues.

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# Lab 7

# Experiment no. 6

## Observe the working principle of Heat Pump

## Introduction:

A heat pump is a mechanical system that allows for the transference of heat from one location (the "source") at a lower temperature to another location (the "sink" or "heat sink") at a higher temperature. Thus a heat pump may be thought of as a "heater" if the objective is to warm the heat sink (as when warming the inside of a home on a cold day), or a "refrigerator" if the objective is to cool the heat source (as in the normal operation of a freezer). In either case, the operating principles are identical. Heat is moved from a cold place to a warm place. The objective of a heat pump, however, is to maintain a heated space at a high temperature. This is accomplished by absorbing heat from a low-temperature source, such as well water or cold outside air in winter, and supplying this heat to the high-temperature medium such as a house.

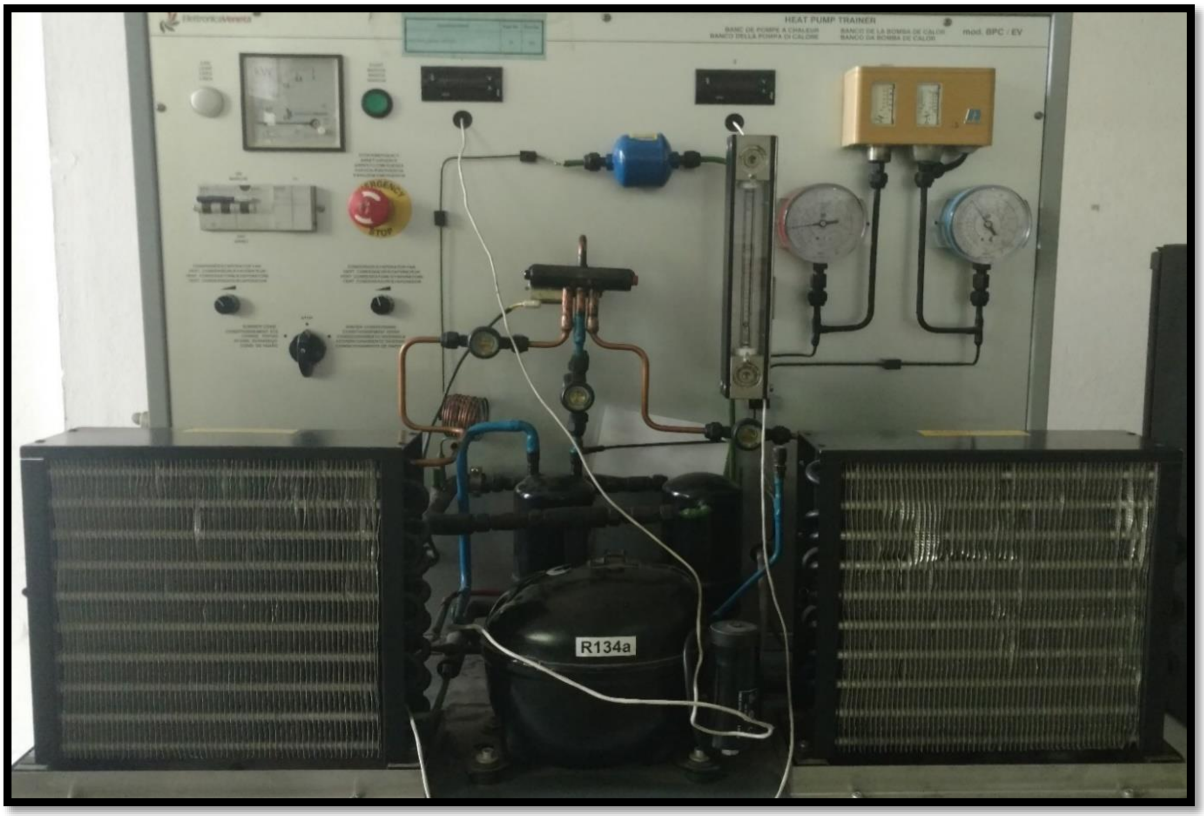


Figure no. 7.1: Model of Heat Pump

## Parts list and details:

Parts of heat pump is same as refrigerator or an air conditioner.

- Compressor
- Condenser
- Expansion valve/capillary tube
- Evaporator
- Control board
- Accumulator
- Heat strips
- Thermostat

**Control board:**
Controls whether the heat pump system should be in cooling, heating or defrost mode. **Coils:**

**The accumulator:**
A reservoir that adjusts the refrigerant charge depending on seasonal needs.

**Heat strips:**
An electric heat element is used for auxiliary heat. This added component is used to add additional heat on cold days or to recover from lower set back temperatures rapidly.

**Thermostat or control temperature:**
Sets your desired temperature.

## Explanation:

An air-source heat pump uses advanced technology and the refrigeration cycle to heat and cool your home. This allows a heat pump to provide year-round indoor comfort – no matter what the season is.

**Heat Pump in Air Conditioning Mode:**
When properly installed and functioning, a heat pump can help maintain cool, comfortable temperatures while reducing humidity levels inside your home.

1. Warm air from the inside of your house is pulled into ductwork by a motorized fan.
2. A compressor circulates refrigerant between the indoor evaporator and outdoor condensing units.
3. The warm air indoor air then travels to the air handler while refrigerant is pumped from the exterior condenser coil to the interior evaporator coil. The refrigerant absorbs the heat as it passes over the indoor air.
4. This cooled and dehumidified air is then pushed through connecting indoor ducts to air vents throughout the home, lowering the interior temperature.
5. The refrigeration cycle continues again, providing a consistent method to keep you cool.

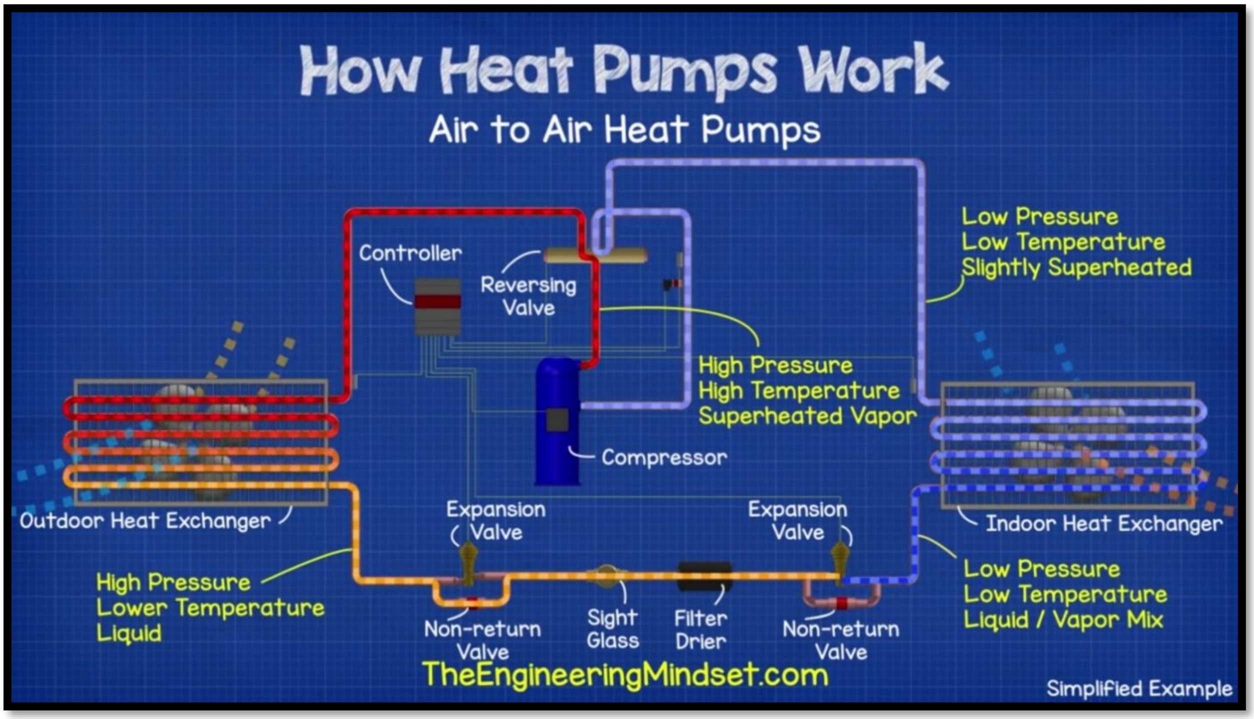


Figure no. 7.2: Heat Pump in Cooling mode

**Heat Pump in Heat Mode:**
Heat pumps have been used for many years in locations that typically experience milder winters. However, air-source heat pump technology has advanced, enabling these systems to be used in areas with extended periods of subfreezing temperatures.

1. A heat pump can switch from air condition mode to heat mode by reversing the refrigeration cycle, making the outside coil function as the evaporator and the indoor coil as the condenser.
2. The refrigerant flows through a closed system of refrigeration lines between the outdoor and the indoor unit.
3. Although outdoor temperatures are cold, enough heat energy is absorbed from the outside air by the condenser coil and release inside by the evaporator coil.
4. Air from the inside of your house is pulled into ductwork by a motorized fan.
5. The refrigerant is pumped from the interior coil to the exterior coil, where it absorbs the heat from the air.
6. This warmed air is then pushed through connecting ducts to air vents throughout the home, increasing the interior temperature.
7. The refrigeration cycle continues again, providing a consistent method to keep you warm.

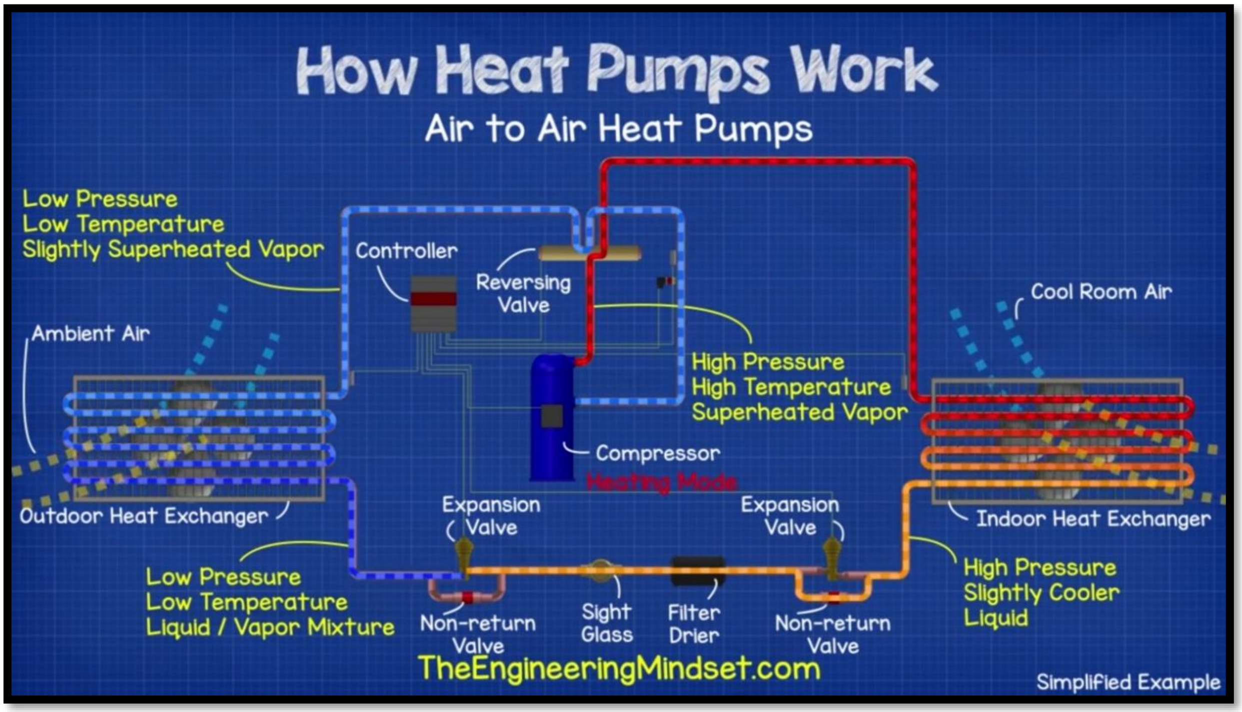


Figure no. 7.3: Heat Pump in heating mode

## Coefficient of performance:

The measure of performance of a heat pump is also expressed in terms of the coefficient of performance $COP_{HP}$, defined as

$COP_{HP}$= desired output/Required input

$COP_{HP}=Q_H/W_{net.in}$

**$COP_{HP}=1/(1-Q_L/Q_H)$**

It can also be expressed as:
**$COP_{HP} = COP_R + 1$** (for fixed values of $Q_L$ and $Q_H$)

This relation implies that the coefficient of performance of a heat pump is always greater than unity since $COP_R$ is a positive quantity.

## Readings:

**Temperature readings for winter cycle:**

| Compressor inlet | Compressor outlet | Condenser inlet | Condenser outlet | Liquid receiver | Expansion valve | Evaporator inlet | Evaporator outlet |
|---|---|---|---|---|---|---|---|
| 20.7 | 37.8 | 23.6 | 22.1 | 19.4 | -7.2 | -10.2 | 17 |

**Temperature readings for summer cycle:**

| Compressor inlet | Compressor outlet | Condenser inlet | Condenser outlet | Liquid receiver | Expansion valve | Evaporator inlet | Evaporator outlet |
|---|---|---|---|---|---|---|---|
| 17.8 | 41.5 | 25 | 21.6 | 18.5 | 4.5 | -8 | 14.1 |

## Pv , Tv and Ts diagrams:

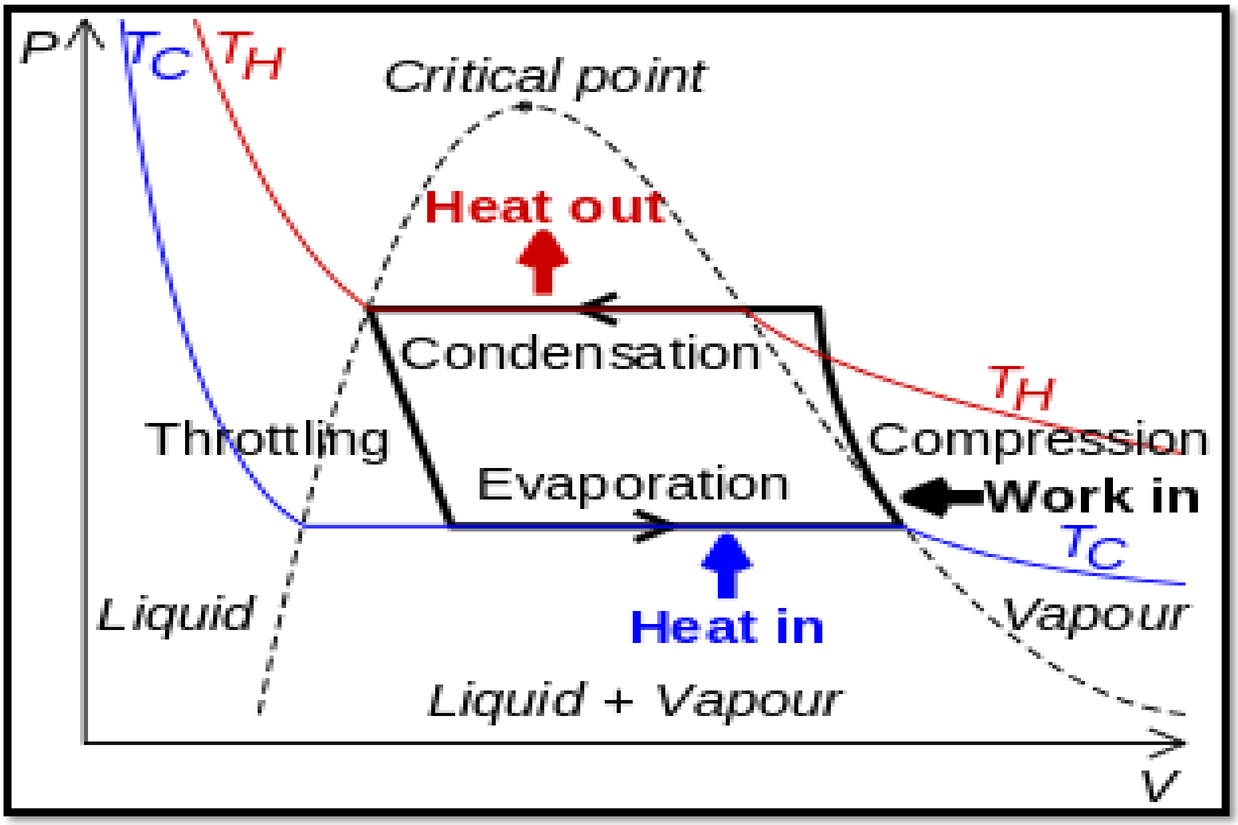


Figure no. 7.4: PV diagram of Heat pump

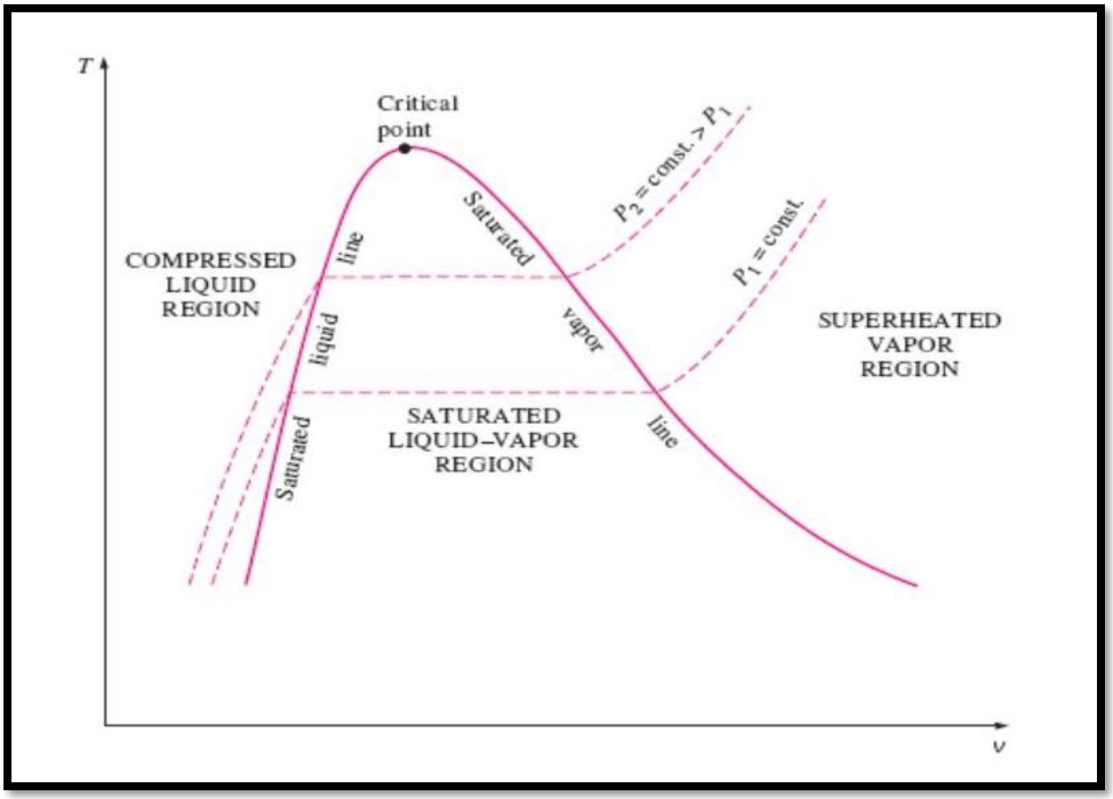


Figure no. 7.5: TV diagram of air conditioning cycle

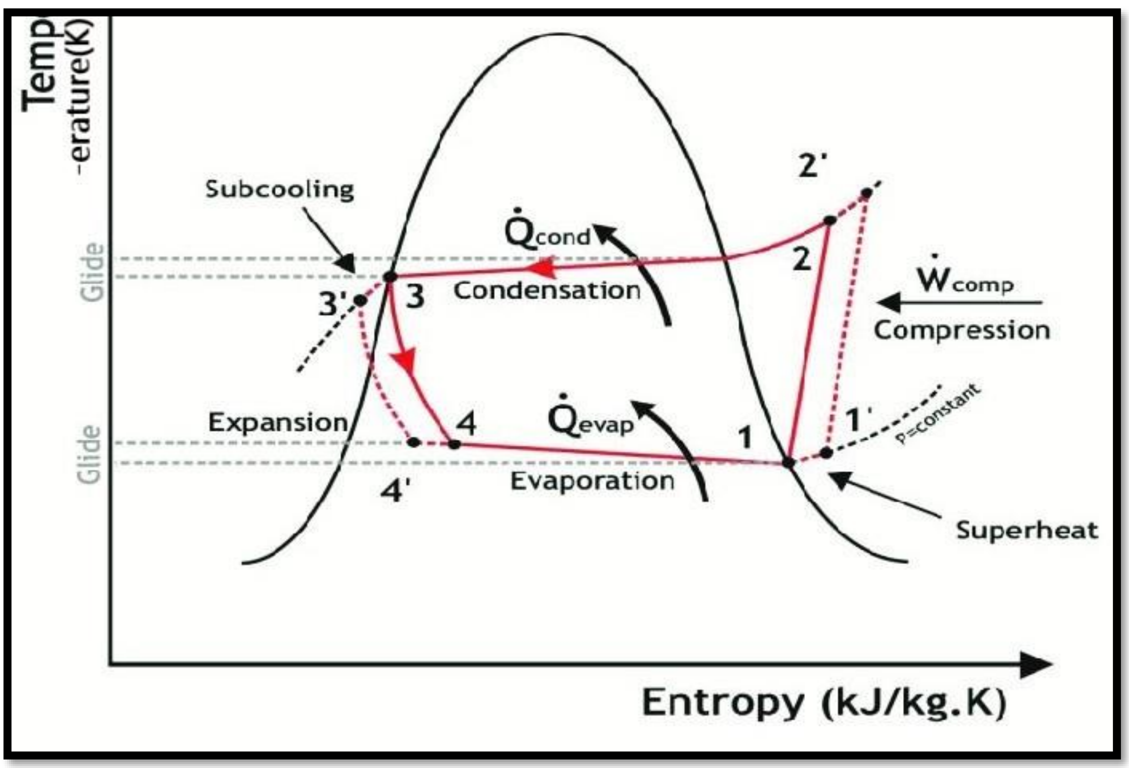


Figure no. 7.6: Ts diagram of Heat Pump

## Application:

They are used in climates with moderate space heating and cooling needs and may also provide domestic hot water.

**Heating, ventilation, and air conditioning:**

In heating, ventilation, and air conditioning (HVAC) applications, a heat pump is typically a vapor-compression refrigeration device that includes a reversing valve and optimized heat exchangers so that the direction of *heat flow* (thermal energy movement) may be reversed. The reversing valve switches the direction of refrigerant through the cycle and therefore the heat pump may deliver either heating or cooling to a building. In cooler climates, the default setting of the reversing valve is heating.

**Water heating:**

In water heating applications, a heat pump may be used to heat or preheat water for swimming pools or heating potable water for use by homes and industry. Usually heat is extracted from outdoor air and transferred to an indoor water tank, another variety extracts heat from indoor air to assist in cooling the space.

**District heating:**

Heat pumps can also be used as heat supplier for district heating. Possible heat sources for such applications are sewage water, ambient water (like sea, lake and river water), industrial waste heat, geothermal energy, flue gas, waste heat from district cooling and heat from solar heat storage. Large scale heat pumps for district heating combined with thermal energy storage offer high flexibility for the integration of variable renewable energy.

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**Lab No.8**

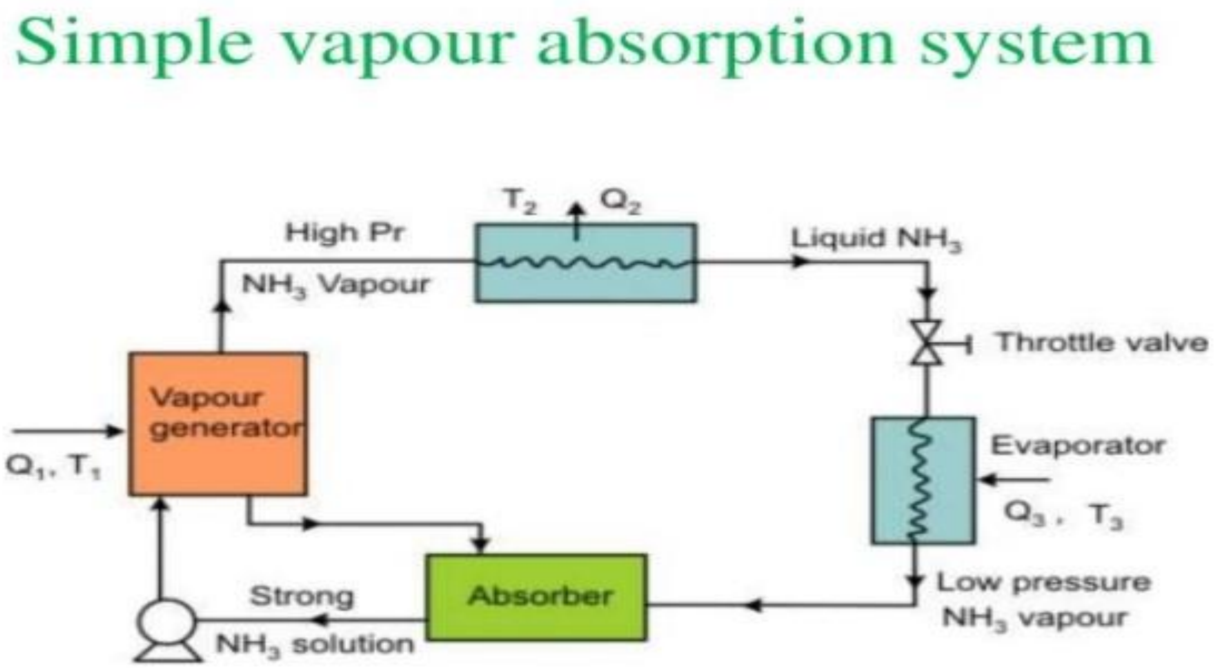
## DEMONSTRATION OF THE WORKING OF VAPOR ABSORPTION CYCLE

**Introduction:**

The vapor absorption refrigeration system comprises of all the processes in the vapor compression refrigeration system like compression, condensation, expansion and evaporation. In the vapor absorption system the refrigerant used is ammonia, water or lithium bromide. The refrigerant gets condensed in the condenser and it gets evaporated in the evaporator. The refrigerant produces cooling effect in the evaporator and releases the heat to the atmosphere via the condenser.

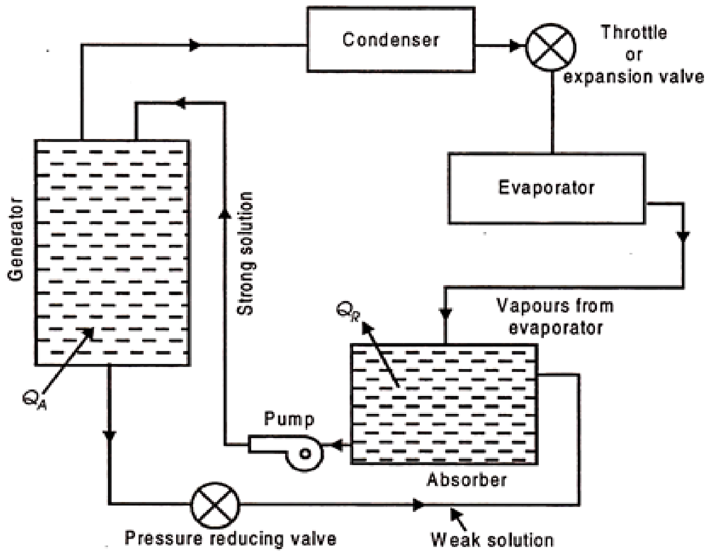
The major difference between the two systems is the method of the suction and compression of the refrigerant in the refrigeration cycle. In the vapor compression system, the compressor sucks the refrigerant from evaporator and compresses it to the high pressure. The compressor also enables the flow of the refrigerant through the whole refrigeration cycle. In the vapor absorption cycle, the process of suction and compression are carried out by two different devices called as the absorber and the generator. Thus the absorber and the generator replace the compressor in the vapor absorption cycle. The absorbent enables the flow of the refrigerant from the absorber to the generator by absorbing it.

Another major difference between the vapor compression and vapor absorption cycle is the method in which the energy input is given to the system. In the vapor compression system the energy input is given in the form of the mechanical work from the electric motor run by the electricity. In the vapor absorption system the energy input is given in the form of the heat. This heat can be from the excess steam from the process or the hot water. The heat can also be created by other sources like natural gas, kerosene, heater etc. though these sources are used only in the small systems.



**Part Lists:**

1) **Condenser**
2) **Expansion valve or restriction**
3) **Evaporator**
4) **Absorber**
5) **Pump**




**EXPLANATION OF PARTS:**

**1) Condenser:**

Just like in the traditional condenser of the vapor compression cycle, the refrigerant enters the condenser at high pressure and temperature and gets condensed. The condenser is of water-cooled type.

**2) Expansion valve or restriction:**

When the refrigerant passes through the expansion valve, its pressure and temperature reduce suddenly. This refrigerant (ammonia in this case) then enters the evaporator.

**3) Evaporator:**

The refrigerant at very low pressure and temperature enters the evaporator and produces the cooling effect. In the vapor compression cycle this refrigerant is sucked by the compressor, but in the vapor absorption cycle, this refrigerant flows to the absorber that acts as the suction part of the refrigeration cycle.

**4)Absorber:**

The absorber is a sort of vessel consisting of water that acts as the absorbent, and the previous absorbed refrigerant. Thus, the absorber consists of the weak solution of the refrigerant (ammonia in this case) and absorbent (water in this case). When ammonia from the evaporator enters the absorber, it is absorbed by the absorbent due to which the pressure inside the absorber reduces further leading to more flow of the refrigerant from the evaporator to the absorber. At high temperature water absorbs lesser ammonia, hence it is cooled by the external coolant to increase it ammonia absorption capacity.

**5) Pump:** When the absorbent absorbs the refrigerant strong solution of refrigerant-absorbent (ammonia-water) is formed. This solution is pumped by the pump at high pressure to the generator. Thus, pump increases the pressure of the solution to about 10bar.

**6) Generator:** The refrigerant-ammonia solution in the generator is heated by the external source of heat. This is can be steam, hot water or any other suitable source. Due to heating the temperature of the solution increases. The refrigerant in the solution gets vaporized and it leaves the solution at high pressure. The high pressure and the high temperature refrigerant then enter the condenser, where it is cooled by the coolant, and it then enters the expansion valve and then finally into the evaporator where it produces the cooling effect. This refrigerant is then again absorbed by the weak solution in the absorber.

**Explanation**:

Vapor Absorption Cycle Consists of Following Process

**1: Compression**

**2: Condensation**

**3: Expansion**

**4: Evaporation**

The initial flow of the refrigerant from the evaporator to the absorber occurs because the vapor pressure of the refrigerant-absorbent in the absorber is lower than the vapor pressure of the refrigerant in the evaporator. The vapor pressure of the refrigerant-absorbent inside the absorbent determines the pressure on low-pressure side of the system and also the vaporizing temperature of the refrigerant inside the evaporator. The vapor pressure of the refrigerant-absorbent solution depends on the nature of the absorbent, its temperature and concentration.

When the refrigerant entering in the absorber is absorbed by the absorbent its volume decreases, thus the compression of the refrigerant occurs. Thus, absorber acts as the suction part of the compressor. The heat of absorption is also released in the absorber, which is removed by the external coolant.

When the vaporized refrigerant leaves the generator, weak solution is left in it. This solution enters the pressure reducing valve and then back to the absorber, where it is ready to absorb fresh refrigerant. In this way, the refrigerant keeps on repeating the cycle.

The pressure of the refrigerant is increased in the generator; hence it is considered to be equivalent to the compression part of the compressor.

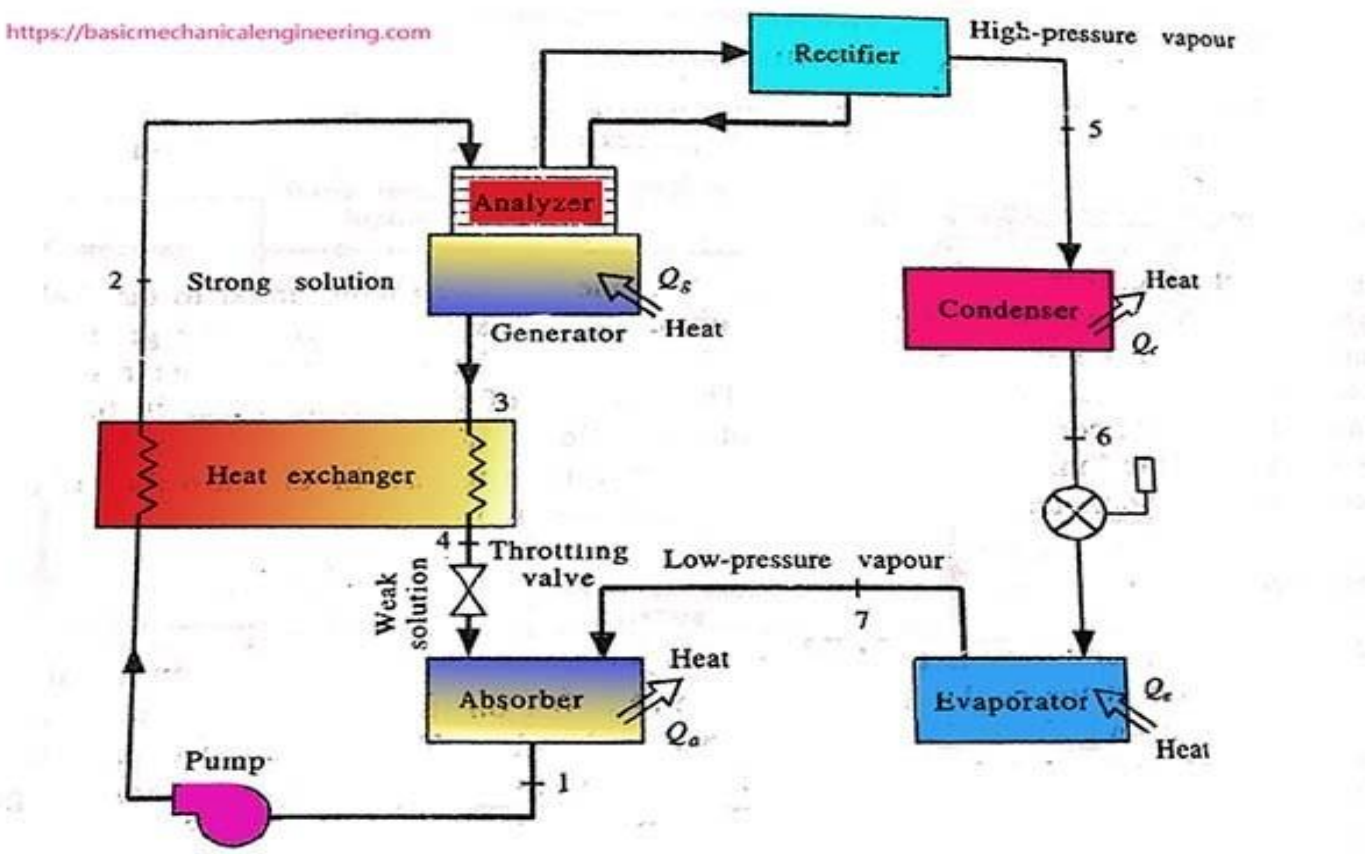



**FIGURE** Aqua ammonia absorption cycle with analyzer and rectifier.

**Applications of VARS differs from VCRS in many ways:**

1. VCRS is usually applied in small applications like home refrigerators and Small capacity AC's but VARS has to be applied for bigger tonnage plants.
2. VCRS doesn't need that much of installation and maintenance as that of VARS.;
3. VCRS applications are simple and compact but applications of VARS are complex and space consuming
4. Energy efficiency ratings of VCRS is less than that of the VARS

Most of the halocarbon refrigerants used in the compression refrigeration system produces greenhouse effect. As per the Montreal Protocol, their use has to stop completely by the year 2020. In the absorption refrigeration system, no refrigerant produces the greenhouse effect, so their use won't be stopped in future.

Note: VCRS= vapor compression refrigeration system

VARS= vapor absorption refrigeration system

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# Lab 9

## Experiment no. 7

## Find the effectiveness of Cooling Tower Trainer

## Introduction:

Cooling towers are a special type of heat exchanger that allows water and air to come in contact with each other to lower the temperature of the hot water. It is an important part of power plants. A water store unit called pond is placed at the base of the cooling tower. The basic **working principle of cooling tower** is to cool the hot water with the help of atmospheric air. During this process, small volumes of water evaporate, lowering the temperature of the water that's being circulated throughout the cooling tower. In a short summary, a cooling tower cools down water that gets over heated by industrial equipment and processes to re-use this water again. This hot water is coming from the condenser. In steam power plant, cooling tower first collects hot water from the condenser at a certain height from the ground level, after that the hot water falls down by the radial spray. The atmospheric air which is comparatively cool enters at the bottom of the tower. Now the hot air in the cooling tower expose in the atmospheric air which reduces the temperature of the hot water by partial evaporation. This cooled water is collected in the pond at the base of the tower and pumped into the condenser for further use.

*Figure 1: Model of Cooling Tower trainer*

## Types of cooling tower:

**Cooling tower** can be classified into following categories.

- **Natural draught cooling tower**
- **Forced draught cooling tower**
- **Induced draught cooling tower**

**1. Natural draught Cooling Tower:**

The circulation of air is produced in natural draught cooling tower by the pressure difference of air inside and outside the cooling tower. It is an open direct contact type heat exchanger where hot water from system or condenser gets cooled by direct contact with fresh air. Cooling towers use the principle of evaporation of water against the air flow.

**2. Forced draught Cooling Tower:**

In forced draught cooling tower, the circulation of air is produced by fans placed at the base of the tower. In this system, fan is located near the bottom and on the side. This fan forces the air from bottom to top. An eliminator is used to prevent loss of water droplets along with the forced air.

**3. Induced draught Cooling Tower:**

In this type of Cooling Tower, a fan mounted on the top pulls the air through fills. The air is drawn into the cooling tower via air intake mesh. Induced draft cooling tower comes in square or round shape. The distribution of water may be done either by static branch system or by the sprinkler. It is easy to install and maintain. Cooling tower motor drives the induced draft fan to draw the outside air into the cooling tower, which takes out the vapors resulting in lowering the water temperature.

## Parts list and details:

Following are the parts of Cooling Tower:

**Fills/Columns:**
Cooling Tower Fill is the main heat transfer area available for Heat transfer from Hot water to Cold Air. It reduces the falling speed of hot water and it is similar to beehive.

**Cold Water Basin:**
It has got two functions. One is to collect the cold water from tower and acts as storage. The other is being strong it acts as a foundation for the main structure of cooling tower.

**Fan Deck & Fan cylinder:**
Fan deck provides a platform for the support of the fan cylinders and acts as access way to the fan and water distribution system. Fan cylinder is venture shaped for enhancing the proper flow of air through the tower.

**Condenser Accumulator tank:**

A cooling tower receives warm water from a chiller. This warm water is known as condenser water because it gets heat in the condenser of the chiller.

**Air inlet louvers/Air distributor chamber:**
The primary function of the air intake louvers in a cooling tower is to act as a barrier for sunlight, noise, water splash-out and debris while also improving the airflow of the cooling tower and improving its appearance.

**Cooling Tower Basin heaters:**
Cooling Tower Basin heaters prevent the cold-water basin from freezing up during the winter weather conditions.

**Cooling Tower Sprinkler Head:**
Cooling tower sprinkler head is a device mounted on top of the stand pipe together with the sprinkler pipes on the cooling tower. Through circulating water in the tower, the sprinkler, mainly through its head, is rotated by its pressure.

**Cooling Tower Piping:**
Cooling tower piping chief function is to distribute water in the cooling tower. The magnitude and routing of the water piping between the heat source and the location of the tower depending on the kind of tower, site layout, and the topography.

**Spray Nozzles and Header/Water distributor:**
These parts are used to increase the rate of evaporation by increasing surface area of water.

**Bleed Valve:**
It is used to control the concertation of minerals and salt.

**Mesh:**
When the fan is ON, it uses atmosphere air which contains some unwanted dust particles. Mesh is used to stop these particles and do not allow to enter dust in to cooling tower.

**Float Valve:**
It is used to maintain level of water.

**Make up water tank:**
Make up water tank to a cooling tower is necessary to replace the mechanical carryout of water droplets (windage), evaporation, and the blowdown required to maintain a controlled solids buildup. Makeup water usually is added to the cooling tower basin so in case of over flow it get out of basin and gather in the make up water tank.

**Overflow:**
If the water level in the basin gets too high, it will flow through here and out to a drain.

**Water pump:**
Closed loop cooling systems are essentially designed to remove unwanted heat, and often use water cooling pumps to circulate chilled water around.

**Water filter:**

Side stream *filtration* systems continuously *filter* a *portion* of the *cooling water* to remove suspended solids, organics, and silt particles, reducing the likelihood of fouling and biological growth, which in turn helps to control other issues in the system such as scaling and corrosion.

**Anemometer:**

The anemometer counts the number of rotations, which is used to calculate wind speed. An anemometer is an instrument that measures wind speed and wind pressure. As the wind blows, the cups rotate, making the rod spin. The stronger the wind blows, the faster the rod spins.

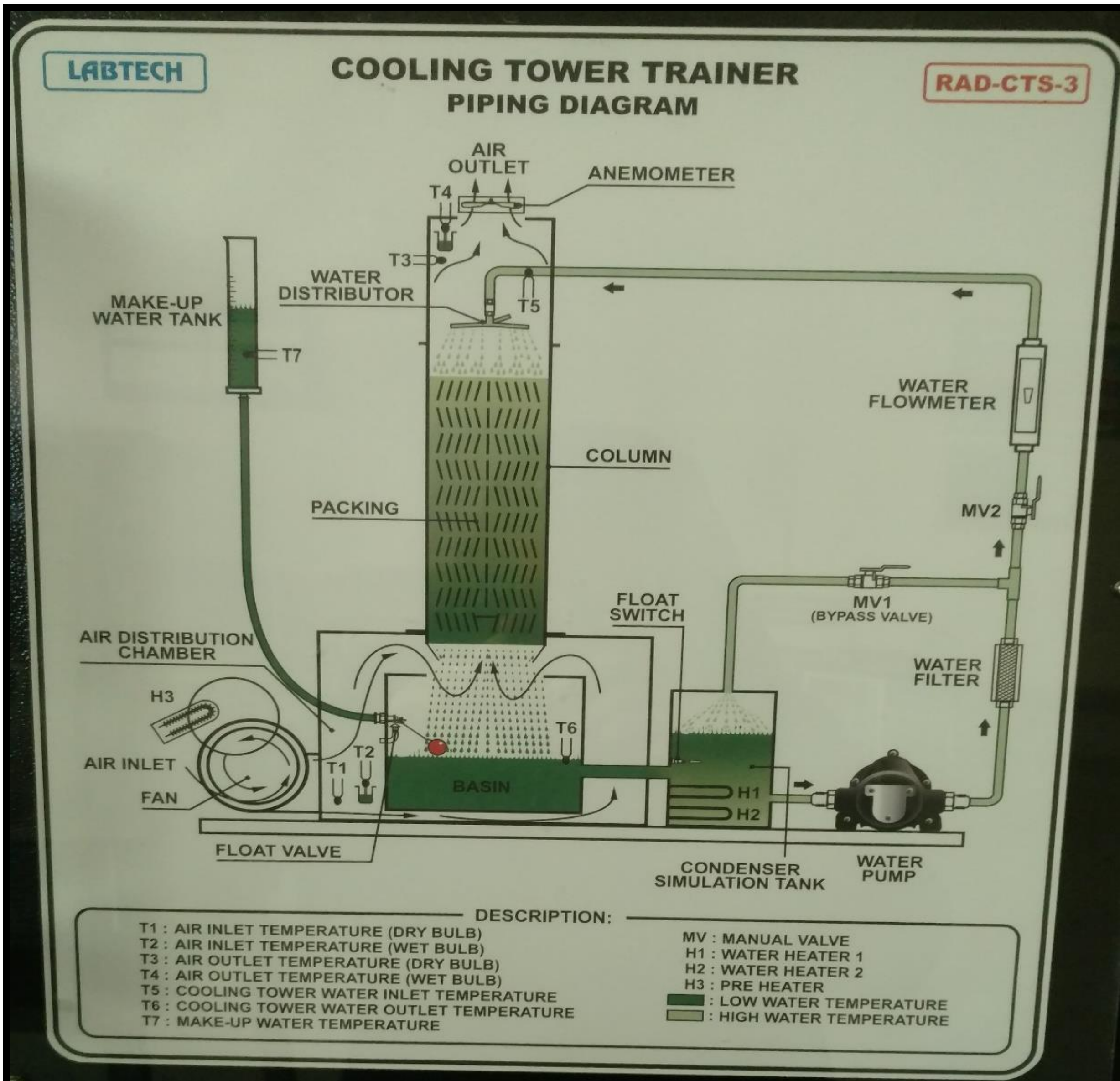


*Figure 2:Parts of Cooling Tower*

## Explanation:

Cooling towers are used to reject heat through the natural process of evaporation. Warm recirculating water is sent to the cooling tower where a portion of the water is evaporated into the air passing through the tower. As the water evaporates, the air absorbs heat, which lowers the temperature of the remaining water. This process provides significant cooling to the remaining water stream that collects in the tower basin where it can be pumped back into the system to extract more process or building heat, thereby allowing much of the water to be used repeatedly to meet the cooling demand.

The hot water is usually caused by air conditioning condensers or other industrial processes. That water is pumped through pipes directly into the cooling tower. Cooling tower nozzles are used to spray the water onto to the “fill media”, which slows the water flow down and exposes the maximum amount of water surface area possible for the best air-water contact. The water is exposed to air as it flows throughout the cooling tower. The air is being pulled by an motor-driven electric “cooling tower fan”.

When the air and water come together, a small volume of water evaporates, creating an action of cooling. The colder water gets pumped back to the process/equipment that absorbs heat or the condenser. It repeats the loop over and over again to constantly cool down the heated equipment or condensers. Evaporative cooling is the process where warm water from an industrial process is pumped up to the top of the cooling tower where the water distribution system is. The water then gets distributed by cooling tower nozzles to the wet deck. At the same time, air is being drawn through the air-inlet louvers forcing water to evaporate. Evaporation causes the heat to be removed from the make up water. The hot air naturally rises out of the tire.

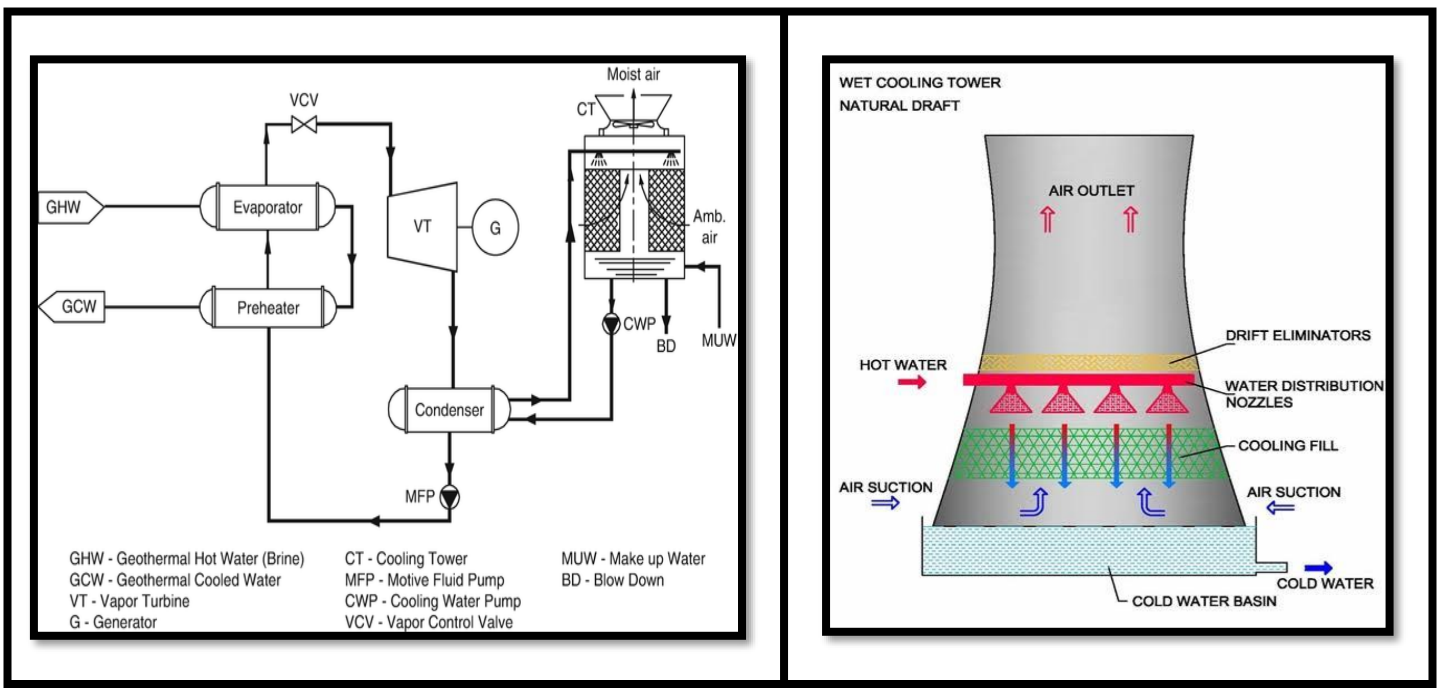


Figure 3:Working of Cooling tower

## Readings:

T1= Air inlet temperature (Dry bulb)
T2= Air inlet temperature (Wet bulb)
T3= Air outlet temperature (Dry bulb)
T4= Air outlet temperature (Wet bulb)
T5= Cooling Tower water inlet temperature
T6= Cooling Tower water outlet temperature
T7= Make up water temperature
Range= T5-T6
Approach= T6-T2
Effectiveness= range/range+approach

| Velocity (m/s) | Flow rate ($m^3/s$) | Temperature (°C) | | | | | | | Range (°C) | Approach (°C) | Effectiveness |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | T1 | T2 | T3 | T4 | T5 | T6 | T7 | | | |
| 6.5 | 7 | 12 | 12 | 15 | 17 | 18 | 15 | 11 | 4 | 2 | 66% |
| 7.8 | 8 | 14 | 13 | 16 | 16 | 17 | 16 | 17 | 1 | 3 | 25% |

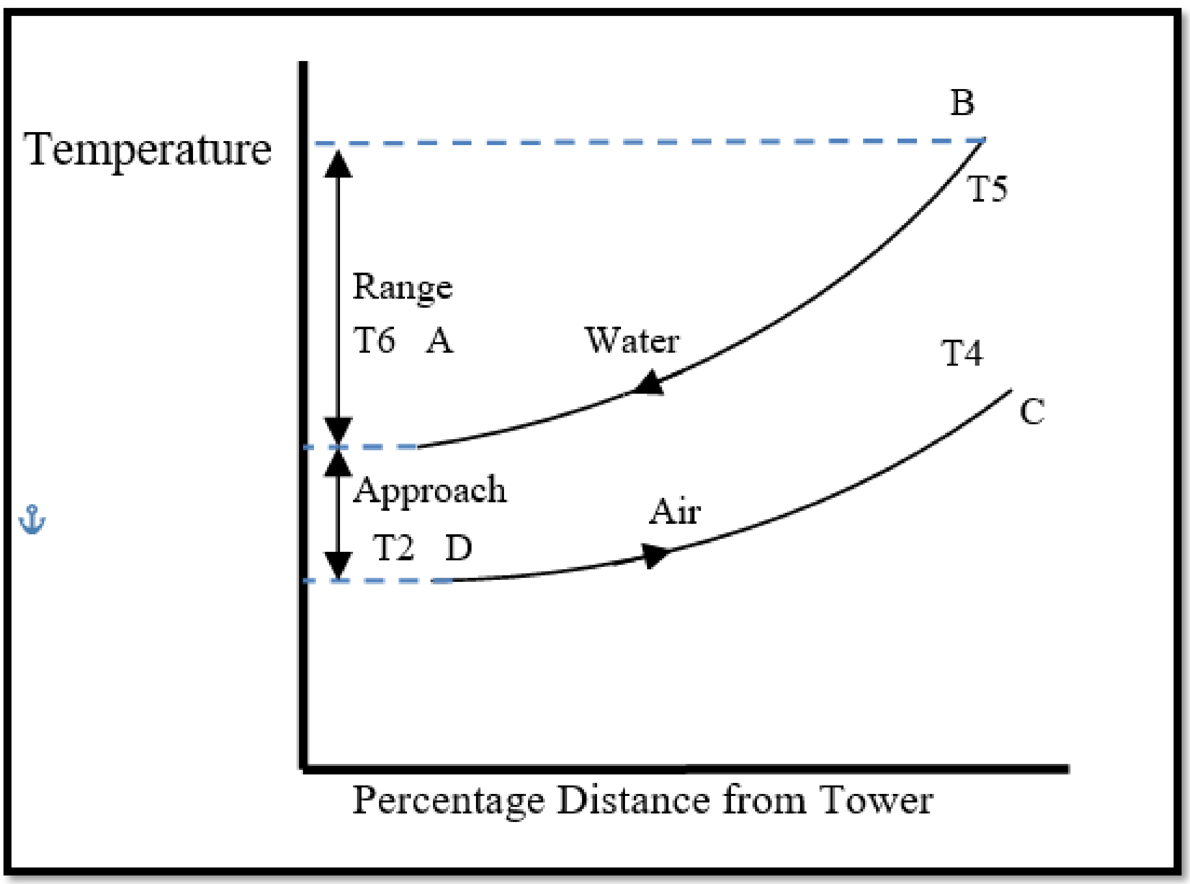


Figure no. 8.4: Temperature Relationship Between Water and Air in Cooling Tower

**<u>Difference b/w Wet bulb and Dry bulb:</u>**

The wet-bulb temperature (WBT) is the temperature read by a thermometer covered in water-soaked cloth (wet-bulb thermometer) over which air is passed. At 100% relative humidity, the wet-bulb temperature is equal to the air temperature (dry-bulb temperature) and it is lower at lower humidity. It is defined as the temperature of a parcel of air cooled to saturation (100% relative humidity) by the evaporation of water into it, with the latent heat supplied by the parcel. A wet-bulb thermometer indicates a temperature close to the true (thermodynamic) wet-bulb temperature. The wet-bulb temperature is the lowest temperature that can be reached under current ambient conditions by the evaporation of water only.

The dry-bulb temperature (DBT) is the temperature of air measured by a thermometer freely exposed to the air, but shielded from radiation and moisture. DBT is the temperature that is usually thought of as air temperature, and it is the true thermodynamic temperature. It indicates the amount of heat in the air and is directly proportional to the mean kinetic energy of the air molecules. Temperature is usually measured in degrees Celsius (°C), kelvins (K), or degrees Fahrenheit (°F).

## Application:

Common applications include cooling the circulating water used in:

- Oil refineries
- Petrochemical plants
- Thermal power stations
- Nuclear power station
- HVAC systems
- Ventilation purposes

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# Lab 10

# Investigate the performance of Rankine cycle

## Introduction:

The **Rankine cycle** was named after him and describes the performance of **steam turbine systems**, though the theoretical principle also applies to reciprocating engines such as steam locomotives. In general,

- **Rankine cycle** is an idealized thermodynamic cycle of a constant pressure heat engine that converts part of heat into mechanical work. In this cycle the heat is supplied externally to a closed loop, which usually uses water (in a liquid and vapor phase) as the working fluid. In contrast to the Brayton cycle, the working fluid in the **Rankine cycle** undergo the **phase change** from a liquid to vapor phase and vice versa. This cycle produces 90% of the total electricity of world.
- The **Rankine cycle** or **Rankine** Vapor **Cycle** is the process widely used by power plants such as coal-fired power plants or nuclear reactors. In this mechanism, a fuel is used to produce heat within a boiler, converting water into steam which then expands through a turbine producing useful work.
- The ***Rankine cycle*** is a model used to predict the performance of ***steam turbine*** systems. It was also used to study the performance of reciprocating ***steam*** engines. The ***Rankine cycle*** is an idealized thermodynamic ***cycle*** of a heat engine that converts heat into mechanical work while undergoing phase change

*Figure 1:Model of Rankine cycle steam turbine*

**Parts list and details:**

Following are the parts of Rankine cycle steam turbine:

- Boiler
- Turbine
- Condenser
- Pump
- Steam Pressure
- Condenser Pressure
- Tachometer
- Temperature Indicator
- Break Load Indicator
- Break Cooling water control
- Steam Solenoid Valve
- Steam Outlet After Boiler
- Throttle Valve
- Belt Break
- Tachometer Optical Sensor
- Impulse Turbine
- Break Cooling water outlet
- Three pipe steam
- Gauge
- Boiler Pressure
- Pressure Leave valve
- Boiler leave indicator

## Parts Explanation:

**Boiler:**

The pump delivers liquid water to the boiler. The boiler heated by the solar heat converts water to superheated steam. This steam is used to run the turbine which powers the generator.

**Turbine:**

A turbine is a rotary mechanical device that extracts energy from a fluid flow and converts it into useful work. The work produced by a turbine can be used for generating electrical power when combined with a generator.

a) Nozzle b) Blade c) Rotor

**Nozzle:**

A **nozzle** is a device designed to control the direction or characteristics of a fluid flow (specially to increase velocity) as it exits (or enters) an enclosed chamber or pipe. A nozzle is often a pipe or tube of varying cross-sectional area, and it can be used to direct or modify the flow of a fluid (liquid or gas). Nozzles are frequently used to control the rate of flow, speed, direction, mass, shape, and/or the pressure of the stream that emerges from them. In a nozzle, the velocity of fluid increases at the expense of its pressure energy.

**Blade:**

A **turbine blade** is the individual component which makes up the turbine section of a gas turbine or steam turbine. The blades are responsible for extracting energy from the high temperature, high pressure gas produced by the combustor. The turbine blades are often the limiting component of gas turbines.

**Rotor:**

In a **turbine**, **rotor** blades are the means by which thermal/kinetic energy is transformed into rotating mechanical energy. **Rotor** blades are blades that are attached to a rotating shaft that runs through **turbines**, generators and sometimes air compressors.

**Brake:**

A counter steam **brake** is a **brake** on a **steam** locomotive that uses the **engine** (specifically the cylinders) to help **break** the locomotive.

**Pump:**

The **pumps** which are used in boiler feed applications increase the suction pressure of feedwater.

**Tachometer:**

A tachometer is an instrument measuring the rotation speed of a shaft or disk, as in a motor or other machine. The device usually displays the revolutions per minute (RPM) on a calibrated analogue dial.

**Temperature indicator:**

A simple digital temperature indicator designed to indicate temperature using a sensor.

**Steam solenoid valve:**

The name given as solenoid valve to the electromagnetic valve used to control fluids such as water, air, steam, gas etc

**Throttle valve:**

Throttling valve designed to regulate the supply of a fluid (as steam or gas and air) to an engine and operated by a handwheel, a lever.

**Impulse turbine:**

An impulse turbine is a turbine that is driven by high velocity jets of water or steam from a nozzle directed on to vanes or buckets attached to a wheel.

**Break load indicator:**

Steam flow to the turbine can be throttled by a hand valve and the boiler turbine inlet and condenser pressures are indicated on gauges. The impulse turbineis driven by a convergent divergent nozzle and turns a brake wheel with speed sensor and digital indicator allowing true shaft power to be determined.

**Boiler leave indicator:**

A water column is used on a steam boiler to reduce the turbulence and fluctuation of the water level so the gage glass can provide a steady, accurate water level reading. A gage glass is the most common form of level indicator found on steam boilers.

**Gauge:**

A gauge or gage, in science and engineering, is a device used to make measurements or in order to display certain dimensional information.

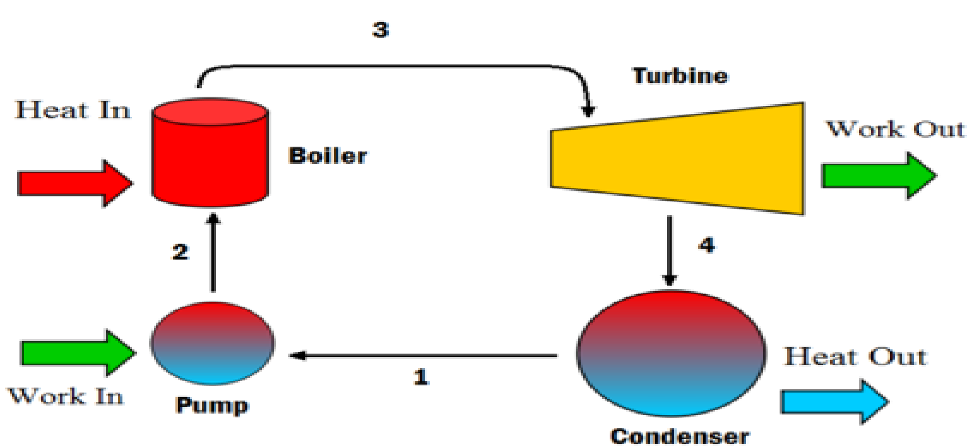
**Safety Valve:**

A transducer assists in regulating boiler pressure by cycling the burner on and off. A poppet valve, located on top of the boiler, serves as a safety valve.

## Basic Principle:

- The **Rankine cycle** is an idealized thermodynamic **cycle** of a heat engine that converts heat into mechanical work while undergoing phase change.The heat is supplied externally to a closed loop, which usually uses water as the working fluid.
- The ***Rankine cycle*** is a model used to predict the performance of ***steam turbine*** systems. It was also used to study the performance of reciprocating ***steam*** engines. The ***Rankine cycle*** is an idealized thermodynamic ***cycle*** of a heat engine that converts heat into mechanical work while undergoing phase change as shown in figure.

## Diagram:




Rankine Cycle

# Explanation:

In an ideal Rankine cycle, the system executing the cycle undergoes a series of four processes: two isentropic (reversible adiabatic) processes alternated with two isobaric processes:

## Process:

- **Process 1–2:** [Isentropic compression in pump]

The working fluid is pumped from low to high pressure. As the fluid is a liquid at this stage, the pump requires little input energy.

**Process 2–3:** [Constant pressure heat addition in boiler]

- The high-pressure liquid enters a boiler, where it is heated at constant pressure by an external heat source to become a dry saturated vapor. The input energy required can be easily calculated graphically, using an enthalpy–entropy chart (h–s chart, or Moliere diagram), or numerically, using steam tables.
- Input is that material which is most common in the region or country.

**Process 3–4:** [Isentropic expansion in turbine]

- The dry saturated vapor expands through a turbine, generating power. This decreases the temperature and pressure of the vapor, and some condensation may occur. The output in this process can be easily calculated using the chart or tables noted above.

**Process 4–1:** [Isentropic expansion in turbine]

- The wet vapor then enters a condenser, where it is condensed at a constant pressure to become a saturated liquid by cool water.

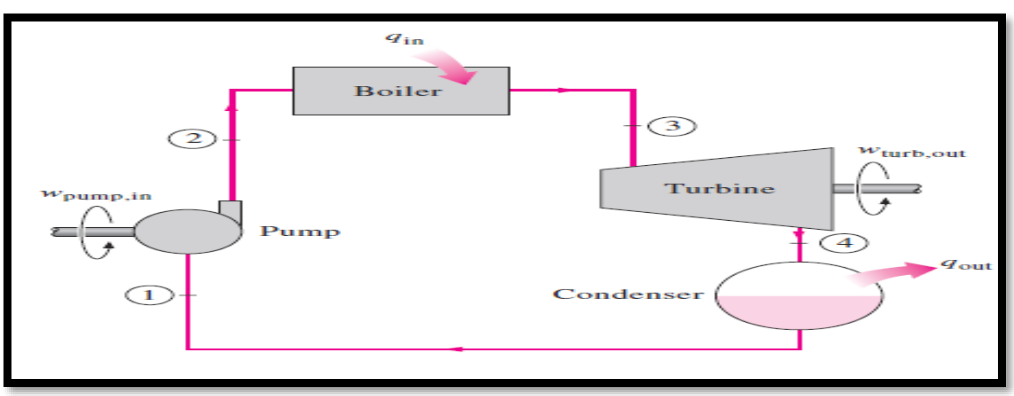



Figure 2: Cyclic diagram of Rankine Cycle

**PV and Ts diagram of Rankine cycle:**

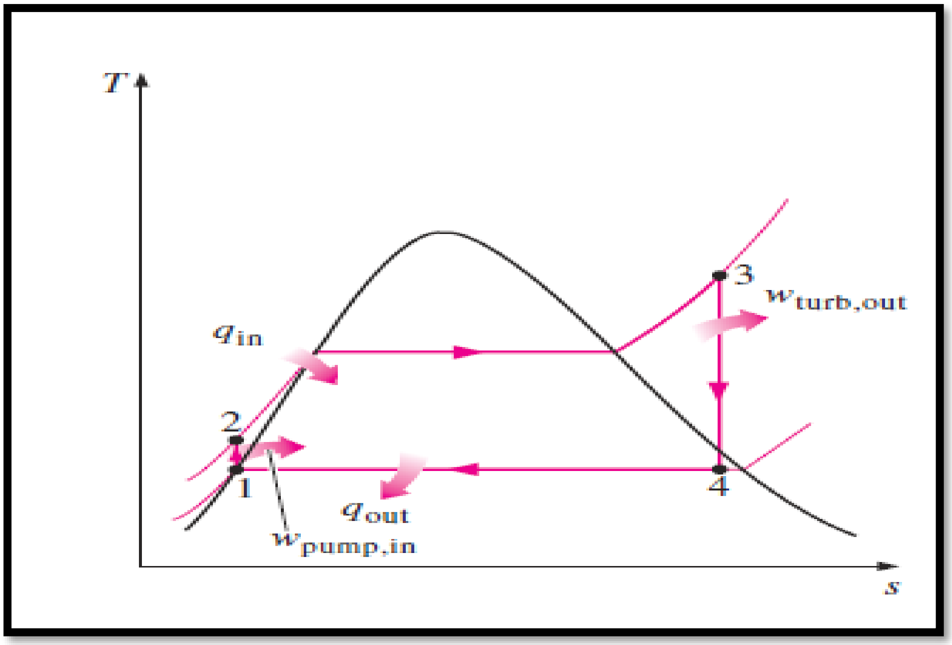



Figure 3: Ts diagram of Rankine cycle

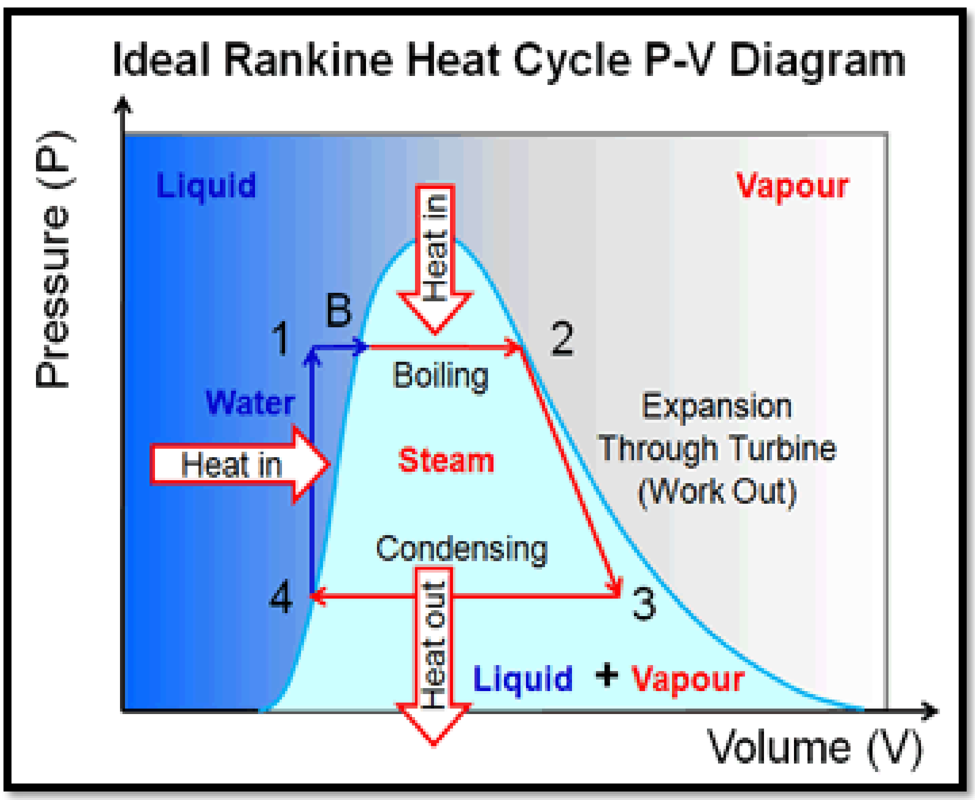



Figure 4: PV diagram of Rankine cycle

**Application:**

Steam turbines are a part of various industries, from medium to large scale, and include dozens of institutional applications.

- Chemical Industry: Providing heat and electricity to drive different processes in the chemical and pharmaceutical industries, steam turbines are integrated in the process of producing power.
- Waste Plants: Steam turbines help generate the power needed to harness energy from wastes.
- Oil & Gas: Used as a pump drive or a compressor, steam turbines support dozens of operations in the oil and gas industry.
- Sugar Mills: Offering high levels of efficiency and sustainable operations, steam turbines are used to produce green carbon-dioxide energy from bagasse.

Some of the most popular applications of a steam turbine in different industries include the following:

1. Combined Heat and Power
2. Driving Mechanical Equipment
3. District Heating & Cooling Systems
4. Combined Cycle Power Plants

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# Lab No.11

## Evaluate Factors Effecting the Performance of Rankin Cycle

Factors Affecting the efficiency of Rankine cycle

Following are the thermodynamic variables which effect the efficiency and work output of a Rankine cycle.

**(1) Super heating of steam,**
**(2) Boiler pressure or inlet steam pressure to turbine**
**(3) Exhaust steam pressure or condenser below**

**(1) Effect of super heating of steam**

1. The heat supplies to steam is also increased.
2. However, the ratio of increase in work output to increase in heat supplied to steam is more than the ratio of work done to heat supplied. Which the cycle efficiency increases.
3. Due to the superheating of steam the average temperature of heat addition to the cycle increases while the average temperature of heat rejection from the cyle remains same. So there should be an increase in the thermal efficiency compared to the cycle using dry and saturated steam.

**(2) Effect Increase in Boiler pressure**

1: Due to increase in maximum pressure, the net-work increases.

2: The both works done are approximately the same but the heat rejected in the condenser decreases.

3: Since heat rejection is reduced in the case of increasing boiler pressure, so the Rankine cycle efficiency increases with the increase in the maximum pressure of the cycle.

**(3) Effect of condenser pressure**

1: With reduce condenser pressure have the same boiler pressure.

2: Net work done is increased due to the reduced condenser pressure and the heat supplied during the cycle increases.

3: So, the net result is an increase in the cycle thermal efficiency. It should be expected because the thermal efficiency increases with decreases in exhaust pressure because the average temperature of heat rejection decreases with decreases of exhaust pressure.

## Determination of torque, power and specific steam consumption in Rankin Cycle:

**Torque:**

**Torque = Force x Radius**

a) Force=1.32 N

   Radius= 0.023 m
   T= 1.32 x 0.023
   **T= 0.03036 Nm**

b) Force= 0.77 N

$T = 0.77 \times 0.023$

**$T = 0.0177$ Nm**

**<u>Power</u>:**

**Power= Torque x angular velocity**

$P = T \times 2 \times pi \times N/60$

$N = 6.6 \times 10^3$

$P = 0.030362 \times 3.1416 \times 6.6 \times 10^3/60$

**P=20.98 W or 0.02098 kW**

**<u>Mass Flow rate</u>:**

**Mass flow rate= m/t**

density=mass/volume

$m = V \times d$

$m = 200 \times 10^{-3}\text{liter} \times 1000\text{kg/m}^3$ ⟶ $1\ m^3 = 1000$ liter

$m = 200 \times 10^{-3} \times 10^{-3} \times 1000$

m=0.2 kg

mass flow rate= 0.2/117

**mass flow rate=0.0017 kg/s**