EXPERIMENTS IN INTERNAL COMBUCTION ENGINE

SMT. S. R. PATEL ENGINEERING COLLEGE DABHI, UNJHA

PIN- 384 170

DEPARTMENT OF MECHANICAL ENGINEERING

SUBJECT :INTERNAL COMBUCTION ENGINE

SUBJECT CODE: 161902

INDEX

Experiment No:-1 **Date:**

Objective: To Study the construction details & working principal of Two Stroke Internal Combustion Engines.

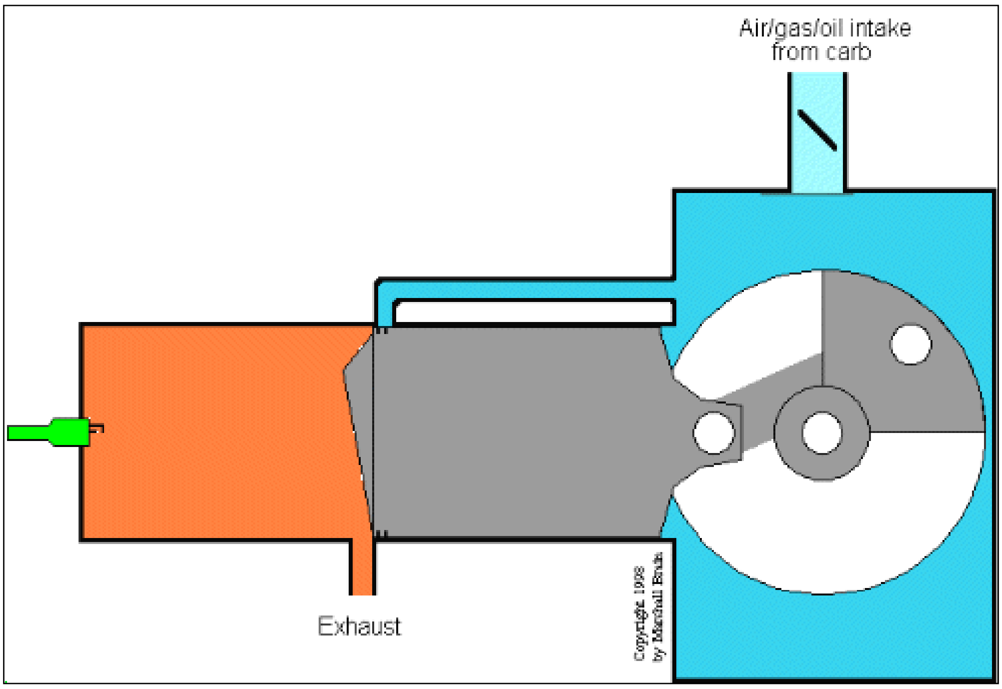
Theory:

This type of engine is commonly found in applications such as;

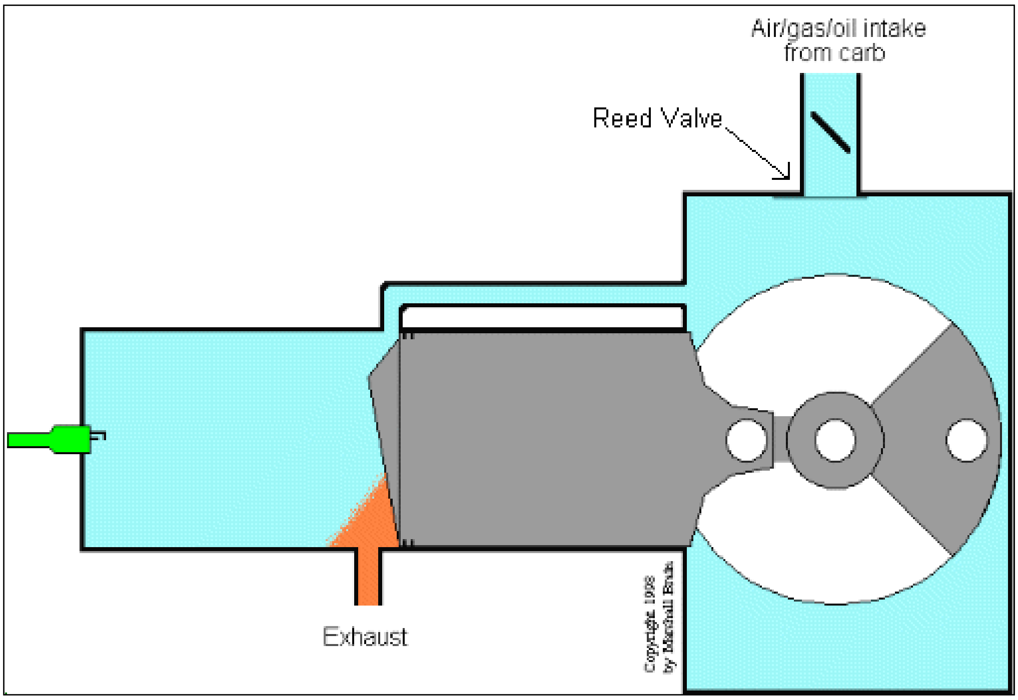
a. lawn and garden equipment
b. dirt bikes
c. small outboard motors

The two stroke engine ignites every revolution of the crankshaft. These engines overlap operations to reduce parts while maintaining power.

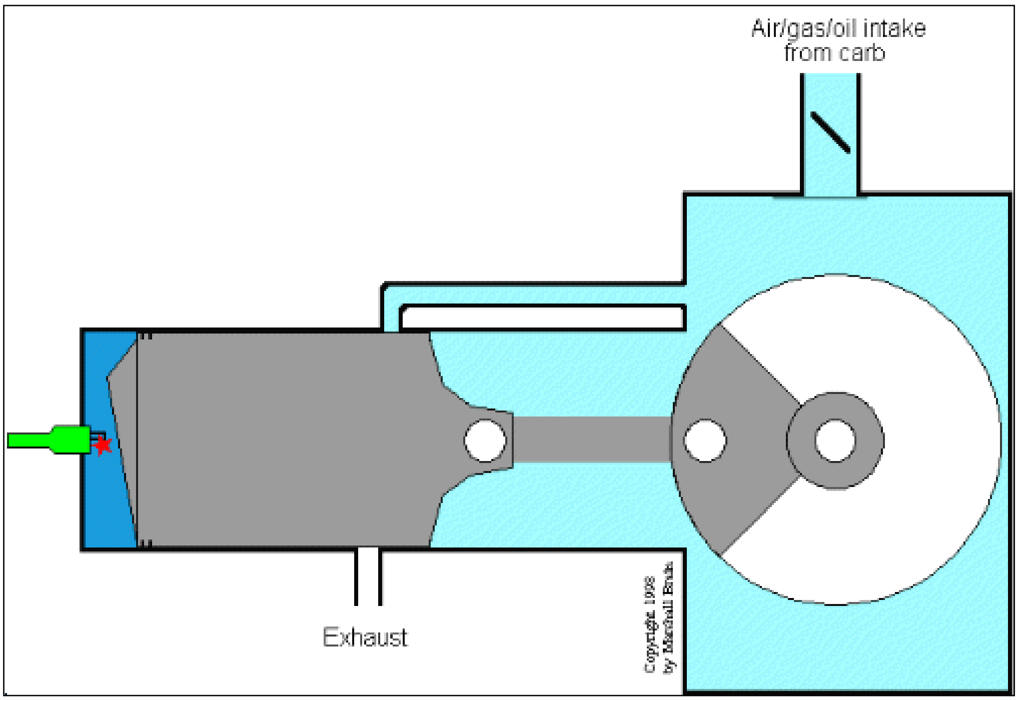
After the fuel air explosion, the piston is driven down. As the piston reached the bottom of it's stroke, the exhaust port is uncovered. Most of the gases are driven out.



- When the piston has bottomed out, the intake port is uncovered. The new fuel enters and is ready for compression and combustion.



- When the fuel mixture is being compressed a vacuum is created in the crankcase. The vacuum opens a reed valve and sucks air/fuel/oil in from the carburetor.



- Simply put, in a two stroke engine you have only:
  - Compression
  - Combustion

Disadvantages of a two stroke

- The engines do not last as long due to poor lubrication.
- You have to mix two cycle engine oil with gasoline.
- The engines do not use fuel efficiently.
- These engines produce a lot of pollution.

Summary

- Two stroke engines are great for the power to weight ratio and their simple design, however, due to there pollution concerns these engines will be harder to find.

Quiz:

1. Explain with the help of good sketch the working of two stroke petrol engine?

2. Draw labeled diagram of two stroke CI engine and its working?

3. Write sort note on valve timing diagram of two stroke system?

Date:	Sign:	Grade:

Experiment No:-2 **Date:**

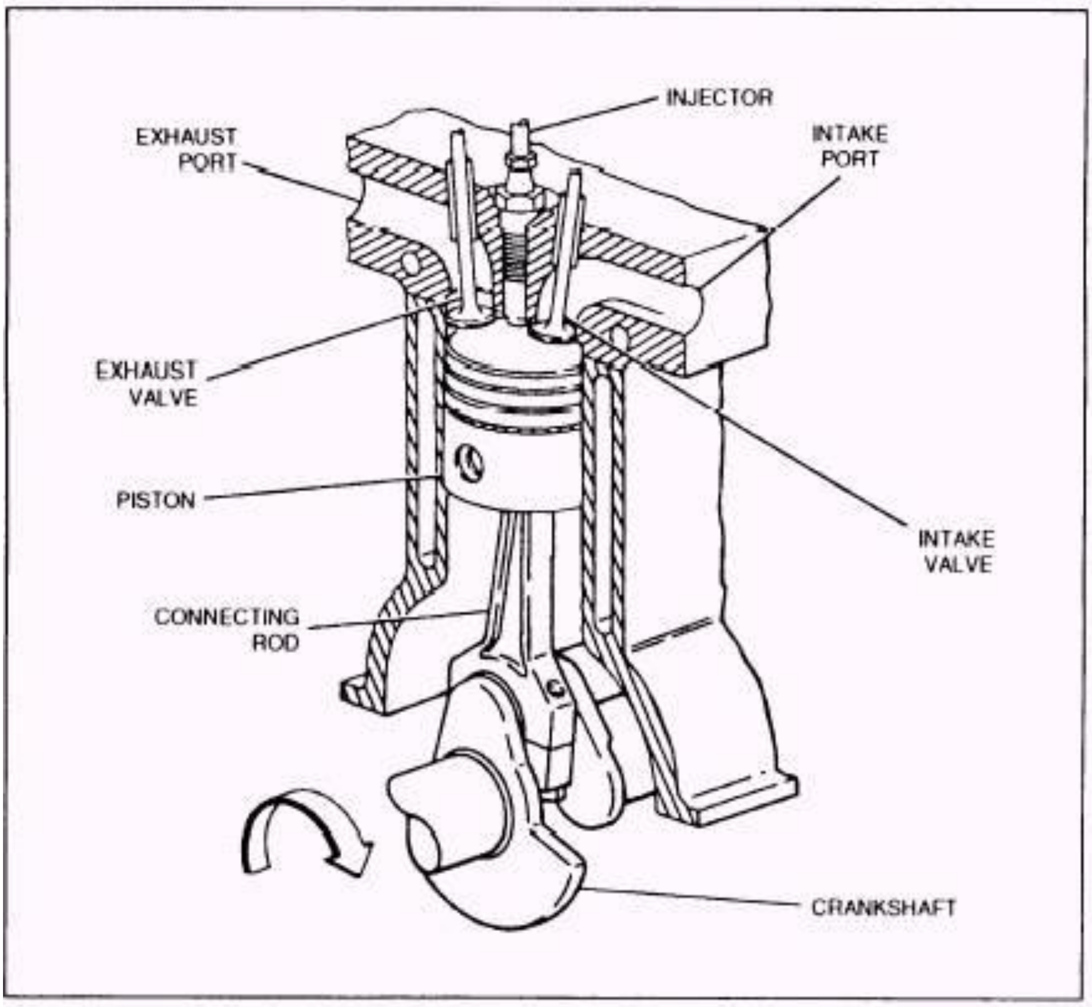
Objective: To study about Four Stroke Internal Combustion Engines.

Theory:

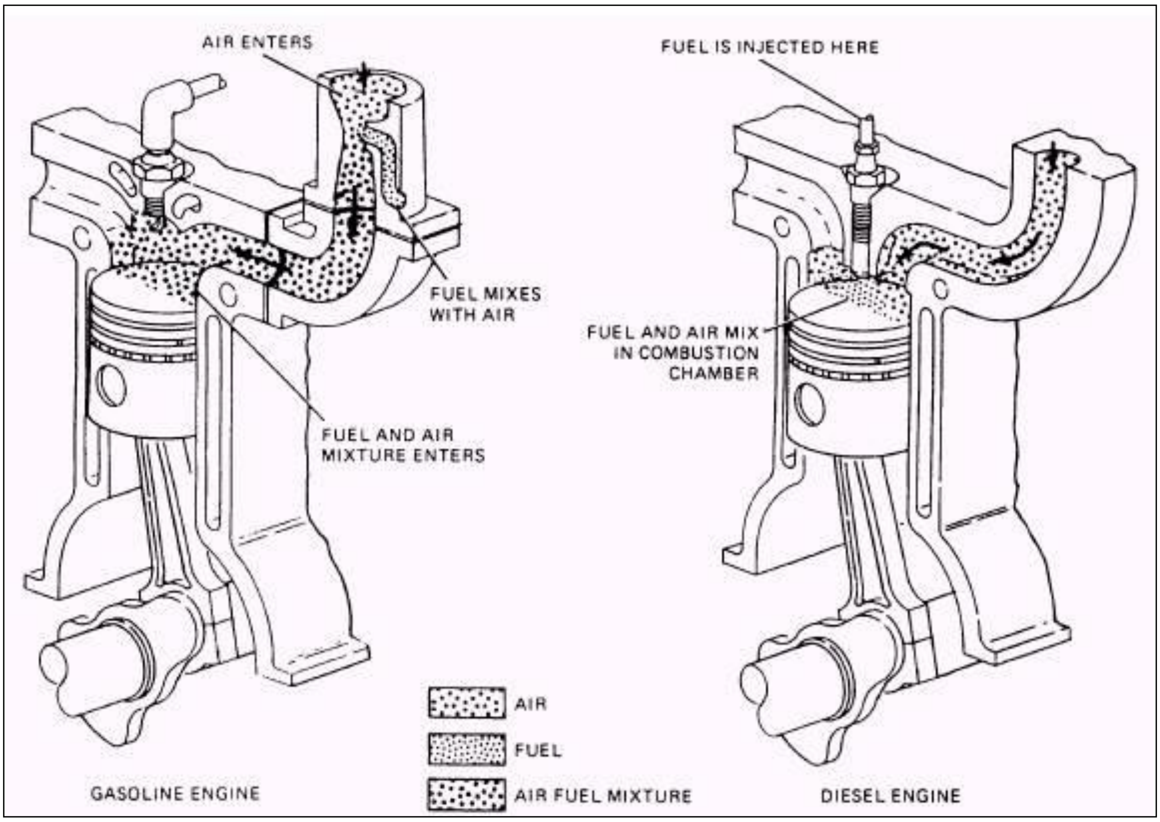
The Four-Stroke Engine

- In 1867, Nikolaus Otto patented the four-stroke engine.
- Found in the vast majority of automobiles today.

The four-stroke diesel engine is similar to the four stroke gasoline engine. They both follow an operating cycle that consist of intake, compression, power, and exhaust strokes. They also share similar systems for intake and exhaust valves.



Diesel and gasoline engines intake strokes:



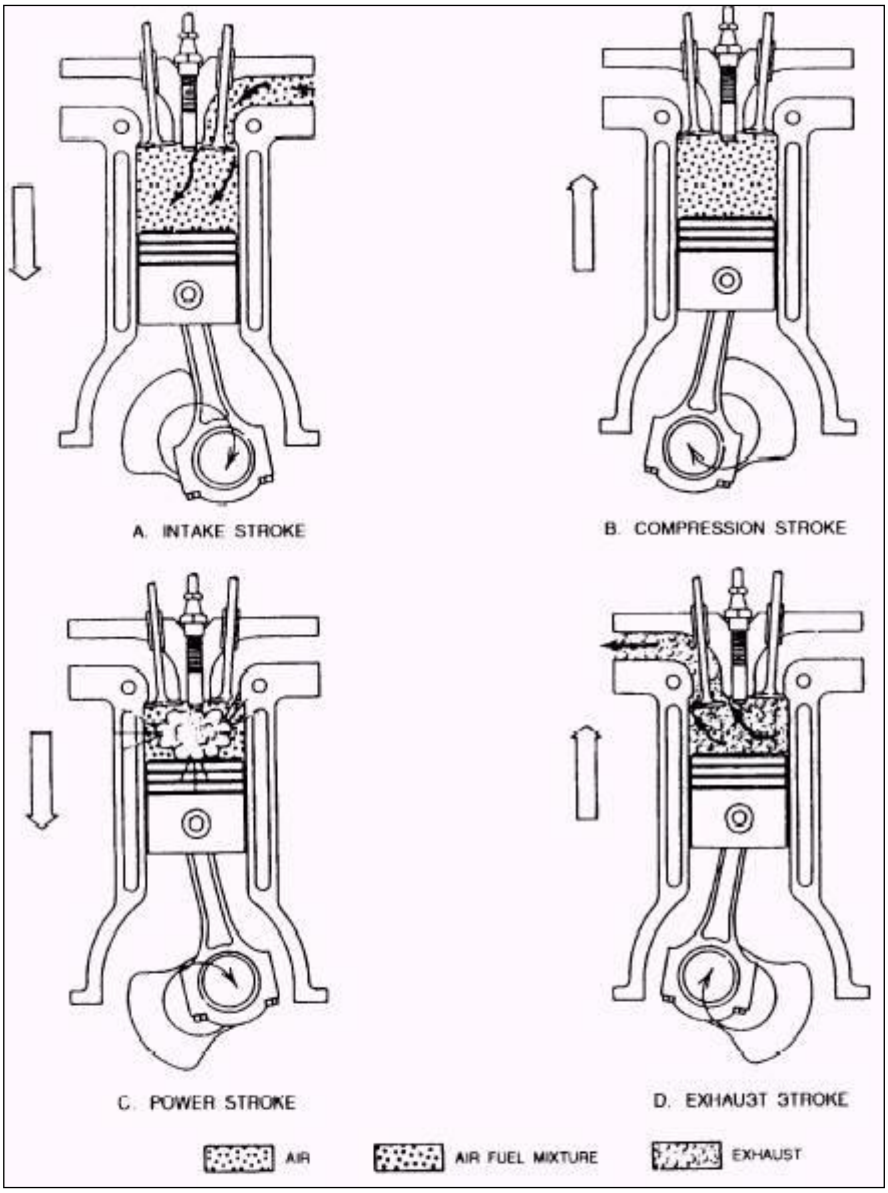
Diesel Engine Strokes

Intake Stroke: The piston is at top dead center at the beginning of the intake stroke, and, as the piston moves downward, the intake valve opens. The downward movement of the piston draws air into the cylinder, and, as the piston reaches bottom dead center, the intake valve closes.

Compression Stroke: The piston is at bottom dead center at the beginning of the compression stroke, and, as the piston moves upward, the air compresses. As the piston reaches top dead center, the compression stroke ends.

Power Stroke: The piston begins the power stroke at top dead center. The air is compressed to as much as 500 psi and at a compressed temperature of approximately 1000°F. At this point, fuel is injected into the combustion chamber and is ignited by the heat of the compression. This begins the power stroke. The expanding force of the burning gases pushes the piston downward, providing power to the crankshaft. The diesel fuel will continue to bum through the entire power stroke (a more complete burning of the fuel). The gasoline engine has a power stroke with rapid combustion in the beginning, but little to no combustion at the end.

Exhaust Stroke: As the piston reaches bottom dead center on the power stroke, the power stroke ends and the exhaust stroke begins. The exhaust valve opens, and, as the piston rises towards top dead center, the burnt gases are pushed out through the exhaust port. As the piston reaches top dead center, the exhaust valve closes and the intake valve opens. The engine is now ready to begin another operating cycle.



Quiz:

1. Write a short note on valve timing diagram for four stroke IC engine?

2. Difference between two stroke and four stroke engine?

Date:	Sign:	Grade:

Experiment No:-3 **Date:**

Objective: To study about Fuel supply systems for S.I engines.

Theory:

3.1 Introduction to the Carburetor

The earliest four-stroke engines used during the 1880's primarily were implemented for industrial applications. Because they were run at constant speeds, three very simple carburation devices were devised: the wick, the diffusion, and the surface type carburetors.

The wick type carburetor worked by absorbing fuel from a reservoir below the air intake. As the air flowed past the upper end of the wick, the fuel was evaporated and carried the fuel vapor into the cylinders for combustion.

The diffusion type carburetor consists of a small reservoir of fuel with two tubes passing through it. The first tube is for the exhaust gases, which is used to warm the fuel in the reservoir, and the second is used to deliver the air, which is released under the fuel through perforations in the walls of the tube. As the air surfaces through the fuel, it mixes and vaporizes at the surface carrying the fuel with it to the cylinders.

The surface type carburetor was first introduced by Gottlieb Daimler and Karl Benz in 1885.Similarly to the diffusion carburetor, an exhaust tube runs through the reservoir warming the fuel. However, the air runs vertically down through a tube in which its end opens into a large diameter inverted dished plate. The plate's edge was placed just below the fuel's surface, maintained at a constant level by a float switch mechanism. The incoming air is then distributed radially from beneath the plate and rises through the fuel. The air and fuel vapor then travel into the cylinders for combustion.

But none of these carburetors could overcome the complexities of the modern four-stroke engine. They did not satisfactorily start the engine in the cold, nor did they permit varying working speeds because of their intent for industrial applications.

Over the years, the carburetor slowly evolved into a complex and expensive fuel delivery system.

3.2 Basic Operation

The basic operation of a carburetor can be broken down into several stages. The first stage is providing and regulating the fuel from jets for vaporization into the incoming flow of air. Atomizing the fuel into small droplets to induce evaporation.

Lastly, providing an uniform flow of the fuel mixture to the intake manifold, leading to the cylinders for combustion.

The modern day carburetor, shown in Fig. 3.1, is primarily comprised of a venture tube, a tube which forms a throat to increase the velocity of the incoming air as it passes into the narrowest section and then decreases the velocity once the throat ends. The venturi is mounted with a fuel capillary tube and throttle plate. It also employs a fuel reservoir, idle speed adjustment, idle valve, main metering needle valve, and choke.

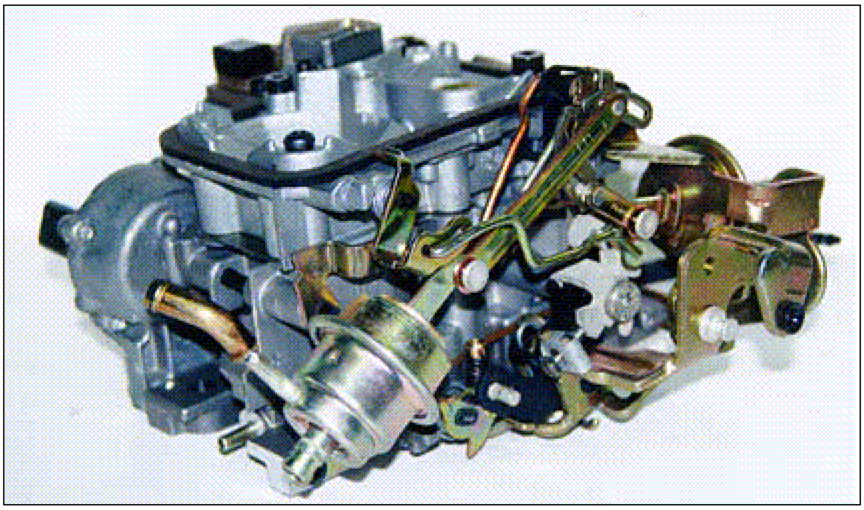


Figure 3.1: Modern Carburetor

Air enters the carburetor due to a pressure differential froma depression caused by the movement of the pistons in the cylinders. As the air travels through the venturi, it is accelerated and absorbs fuel droplets through Bernoulli's principle.

Bernoulli's principle states that as the air is accelerated through the venturi, there is a subsequent drop in pressure. The fuel which is at atmospheric pressure then is pushed through the capillary tube and forces droplets of fuel into the air stream.

These fuel droplets then evaporate into the air stream producing an air and fuel mixture. And if the engine reaches higher speeds, a higher pressure differential will increase the fuel mixture through the same principles, and conversely at slower speeds.

A fuel reservoir is maintained through a float shut off, which meters the entering fuel from the fuel line. The fuel line is fed from the gas tank through either an electric or mechanical fuel pump.

The air flow rate and engine speed is controlled though a throttle butterfly valve, which has a throttle stop acting as the idle speed adjustment allowing for air to enter during idle operation. To deal with the problems from the small pressure differential and subsequent low fuel flow, an idle valve is used to provide better fuel flow control during idle operation.

A choke, a butterfly valve position upstream of the venturi, is implemented during cold engine starts. It works by closing during cold engine starts, which creates a restriction in the air flow, thereby creating a vacuum downstream of the choke in the intake system. The large pressure differential across the fuel capillary tube and idle valve allows for a richer fuel mixture, created by combining the larger quantity of fuel with the reduced air flow. This allows for a greater quantity of fuel to vaporize, thereby allowing for the ignition for combustion even in cold environments.

As time and technology progressed, other feature were added to the carburetor such as the accelerator pump. The accelerator pump provided greater performance during operation by fulfilling the parameters for efficient carburation.

3.3 Air and Fuel Flow

The modern day four-stroke engine's carburetor must overcome several obstacles in order to perform at an optimal level.

The first obstacle to be overcome is that of the flow of the air stream into the venturi. Adverse effects in the mixing of the fuel and air can be cause by turbulent flow through the venturi. To combat this problem, there needs to be little to no interference between the outside air and the venturi besides the air cleaner; subsequently, carburetors were designed so the throttle valve is always down stream of the venturi.

Another obstacles is the need for complete combustion of the fuel mixture in the cylinders. To comply, a stoichiometric mixture is used. This is a mixture with precise proportions of fuel to air. For gasoline, this proportion of air to fuel weight is approximately 14.7:1. This mixture must meet parameters such as ignition under any circumstance. The fuel must be completely oxidized to avoid the production of carbon monoxide. And the maximum amount of chemical energy must be taken from the fuel mixture to be turned into mechanical energy.

The mixture quality is the most important job of the modern carburetor. During the starting process, a rich mixture is needed, especially during cold conditions because the vaporized fuel tends to condense on the walls of the intake manifold.

During idling, an enriched mixture is needed because of condensing of the already small amount of fuel injected during this operation. For cruising, a weaker mixture is needed to ensure complete combustion and highest efficiency. During acceleration, more fuel is needed to combat the condensation of the fuel mixture caused by the sudden opening of the throttle and rise in pressure.

To control the flow of fuel appropriately, many modern carburetor manufacturers use fuel and air metering devices such as the hydrostatic pressure of fuel to force the fuel through the jets in the appropriate proportions. Less complex models may use a needle valve actuated by a float to maintain a constant fuel level.

3.4 Starting and Enriching Devices

When a four-stroke engine is at idle or running slowly, there is only enough air flow moving through the carburetor to provide fuel to overcome the resistance of its part. Consequently, during this operation, there must be an enrichment from the fuel source allowing for instant acceleration, yet also not effect the engines efficiency or decibel level at these low engine speeds.

In order to meet these conditions, an additional jet and air inlet must be added for fixed choke carburetors. The first mechanism used to accomplish this goal was a manual actuated strangler. This was a system comprised of a cable controlled valve up stream of the venturi, which when partially closed, increases the depression above the jets, thereby enriching the fuel mixture. Unfortunately, if the driver forgot to open the valve, the engine would run with an enrich mixture, wasting valuable gasoline. More problems arose during cold weather when the extra fuel wetted the sparkplugs. Eventually, manufacturers developed automatic stranglers which were actuated with thermostatic devices such as bimetal strips.

Similarly to the idling fuel deficiency, another problem exists when there is a sudden acceleration after engine use at low speeds. This is caused by the sudden rush of incoming air flow, which is too short to overcome the drag and inertia of the fuel from the jets. To combat this problem, most carburetors have an added acceleration pump, which is a single diaphragm or plunger type pump with a linkage connected to the throttle. When the throttle is depressed, the linkage opens the pump, which results in a direct injection of fuel into the induction system just above the venturi, where the evaporation process is aided by the low pressure.

This spraying process is further prolonged by a compression spring pushing down a piston which then progressively injects the fuel through an acceleration jet.

Over-enrichment is avoided through a small clearance between the piston and the cylinder walls, where the consequential leak back is adequate to avoid supplying any excess fuel.

Quiz:

1. What are the requirements of a good carburetor?

2. Discuss various types of carburetors.

3. Explain with neat sketch working Simple Carburetor. Also explain Drawback and application of simple Carburetor.

4. Define Supercharging and give its advantages. Also explain the methods of Supercharging and explain any of them.

Date:	Sign:	Grade:

Experiment No:-4 **Date:**

Objective: To study about Fuel supply systems for C.I engines.

Theory:

4.1 Introduction to Fuel Injection

Edward Butler, from Erith, Kent, and Henri Tenting, from Paris, were the first two men to develop a fuel injection system for the internal combustion engine in 1883 and 1891, respectively. During the early stages of production, most of these units were built for application to the aircraft, such asWilbur and Orville Wright's unit for their infamous flight in 1903.

Fuel injection was first introduced to the automotive world in the form of a spline driven, rotary injection pump in the Gobron Brille car. But, it was not until 1940, when Mercedes developed an electric injection system for the Alfa Romeo car, that fuel injection was seriously considered for production vehicles. Further development of fuel injection later took place for racing applications as well as other production vehicles.

In 1970, Bendix implemented the use of the Lambda sensor in the automobile system. This device had one of the most major impacts of the fuel injection industry because it made possible for control on the principle of a closed-loop system. Without this development, it might have been impossible to have met the emissions regulations of today.

Today's fuel injection systems work similarly to a carburetor, by delivering a metered air and fuel mixture to the engine for combustion. The incoming air is controlled through a throttle body, usually controlled with butterfly valves. The incoming air is then metered through a sensing device and an appropriate mass of fuel is added to the air stream through an electrically controlled injector.

Thewhole sequence is monitored and controlled by a small engine management computer, which will be discussed in a further chapter.

4.2 Fuel Delivery Requirements

Similarly to the carburetor, the most important task of the modern fuel injection system is to deliver a stoichiometric mixture of fuel and air to the engine for combustion, no matter the driving conditions; cold starting, idling, economy, or sudden acceleration. This stoichiometric mixture is achieved by electronically controlling the timing of the injectors from the start to the end of fuel injection, which combat the various needs of the engine operation under varying conditions.

To achieve the necessary symmetry in the electronic fuel injection system, the fuel must be delivered to the system continuously and reliably without pulsation at a controlled constant pressure with a fuel pump. The fuel must be closely metered and delivered in an atomized form into the engine manifold through injectors without liquid fuel entering the manifold. And lastly, a multitude of sensors for monitoring the environmental and engine conditions must be able to send accurate information to an engine management computer which must accurately run the whole fuel injection system.

4.3 Types of Fuel Injection Systems

The first method for fuel injection is the direct injection into the cylinders, but unfortunately it suffers from an extraordinarily high back-pressure due to its placement, as well as other severe disadvantages. Because of the close proximity of the injectors to the pistons in the cylinder chamber, fuel must be injected progressively to allow for atomization of the fuel and mix with the air before the spark. The fuel must also be able to enter the cylinder chamber flowing against the rising back pressure. Because of the exposure of the injector tips to the combustion process, a carbon build-ups easily clog the injector tips.

Lastly, a complete atomization and mixing of a homogeneous air and fuel mixture are almost impossible because of the short time frame. With all of these potential problems, this method of injection is avoided for more efficient systems.

Throttle body injection, also known as single-point injection or central fuel injection, has been a favorite of manufacturers because of its simplicity and low cost compared to its major competitor, the multi-point injection systems. This system relies on a single jet fuel injector down stream of the throttle valve, which reduces the effects of the air flow, or a dual jet fuel injector setup, upstream on each side of the butterfly valves. However, there are several disadvantages to the single-point injection system. In a single-point injection system, the fuel has the tendency to condense on the walls of the intake manifold, and then vaporize again in an uncontrolled fashion, partially taking away control of the system.

Similarly to the carburetor, the single-point injection has difficulty distributing the fuel mixture accurately to the different cylinders. Lastly, there must be a hot spot in the throttle body to aid in the atomization of the injected fuel as well as preventing icing during cold conditions.

Multi-point fuel injection is the most widely used fuel injection system employed in today's automobiles. This system works by injecting fuel into the intake manifold directly into the cylinder head ports. Implementing this direct injection to the cylinder head ports, the multi-port system avoids the previously mentioned disadvantages of the single-point system. The fuel injector is directed to spray onto the hot inlet valves, preventing condensation of the fuel in the port as well as decreasing the likeliness of the fuel mixture being drawn into an adjacent cylinder due to the effects of back pressure. The only real disadvantage of this system is the extra cost from specialized intake manifolds and extra components such as fuel rails, which are outweighed by the better performance achieved.

4.4 Flow Types in Fuel Injection Systems

Continuous injection is the simplest and least costly method of injecting fuel from injectors. Continuous injection works by injecting a fuel mixture spray into the intake manifold, where it is ready to flow into the individual cylinders when the inlet valves open. The fuel mixture is controlled through variation in the pressure of the fuel sent to the injectors from the fuel pump. In multi-point injection, the fuel is made into a homogeneous mixture through the turbulence in the cylinders.

The more favored method of fuel injection is through sequential or timed injection, which injects the fuel for limited time periods, usually once for every revolution of the crankshaft. Fuel is maintained at a constant pressure combating
the difficulty related to the small time lag in the electronic control between receiving and sending signals between sensors, the computer, and then the fuel pump.

Generally, the timing of the opening of the fuel injectors is fixed and changes are produced from varying durations of time before the closing of the injectors. With almost instant responses from the electronic control computer, the air to fuel mixture can be closely controlled.

Further development produced the simultaneous double-fire injection, or phased injection system which allows for extremely accurate regulation of the air to fuel mixture. This is accomplished by an injection of fuel into the ports as the inlet valves open, consequently only once every two revolutions of the crankshaft.

The numerous advantages of sequential and phased injection arise from the accurate monitoring from the engine management computer system which help avoid numerous problems of engine operations, through the implementation of themultitude of sensors such as the detonation sensor and crankshaft angle sensor.

4.5 Flow Sensors

There are four types of flow sensors implemented in electronic fuel injection systems:the suspended-plate type flow sensor, the swinging-gate type flow sensor, the manifold absolute pressure (MAP) sensor, and the mass-flow sensor. The suspended-plate type flow sensor is comprised from a circular plate pivoting on the opposite end of an arm, balanced by a small weight, which suspends the plate in the horizontal plane within a circular throat. When the engine is turned off, the plate then returns to its equilibrium position in the narrowest section of the complex tapered throat. The entering air then pushes the plate against the resistance produced from a hydraulically actuated control plunger, which depresses a roller on a small level arm thereby controlling the idle setting for the engine with a screw stop.

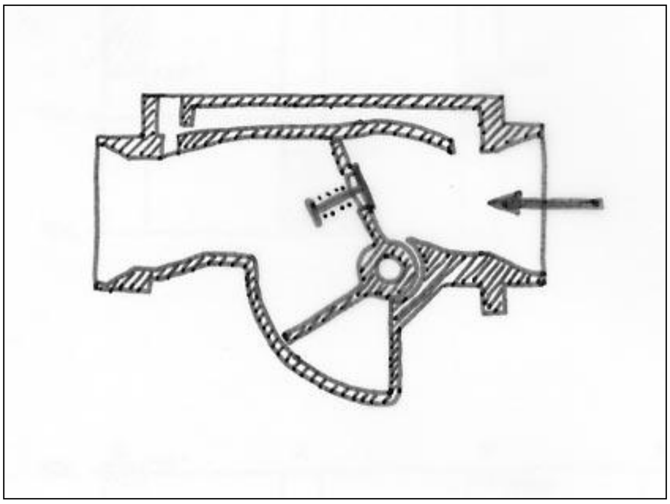


Figure 4.1: Swing Gate Volume Flow Sensor

During sudden acceleration, the plate momentarily over swings, increasing the supplied mixture, and then returns to the equilibrium position.

The second type of flow sensor, the swinging-gate sensor, or air vane sensor, illustrated in Fig. 4.1, is comprised of a housing and internal vane which is deflected by the incoming air into the engine. The vane is spring loaded lightly and pivots from the force of the incoming air. The sensor incorporates a damper which pivots with the vane to negate the effects of pulsing air distorting the reading of the actual air flow through the sensor.

The third flow sensor, the MAP sensor works by theoretically calculating the mass of the air entering the intake system. The manifold absolute pressure sensor sense the absolute pressure in the intake manifolds, and then through calculations in the engine management system, finds out the air mass traveling through the intake. The disadvantage to this type of sensor is that it has general calculations which rely on standard conditions, such as temperature, which fluctuate in real world conditions.

The forth flow sensor, the mass-flow sensor is perhaps the best method in measuring the incoming air flow because it senses the incoming air mass whereas the other sensors measure the incoming air volume and must have additional sensors to compute the mass due to varying conditions such as cold weather.

This sensor operates on the principle that the temperature loss in a heated element is a function to the density and velocity of the air passing it. The engine management system then calculates the mass flow from the flow density and velocity as well as the known diameter of the passage of the sensor.

There are two types of mass-flow sensors: hot wire and hot film, illustrated in Fig. 4.2. The simplest is the hot wire, but due to accumulated deposits on the wire, it must be cleaned off by momentarily raising the temperature each time the engine is turned off. The hot film elements are placed on a ceramic plate parallel to the air flow, which is shaped to shead any deposits, keeping the film clean. Both types are subsequently controlled through a wheatstone bridge circuit.

4.6 Miscellaneous Sensors

The lambda sensor, whose name came from the Greek letter lambda, used represents the air to fuel ratio, is implemented to detect differences in the air ratio by measuring the oxygen content in the exhaust gases. This is accomplished by using a thimble shaped oxygen sensitive component made of zinconium oxide, which then is coated in a thin layer of platinum. The thimble acts like an electric cell. When a oxygen concentration inside is different from the outside, an electric potential between the platinum coatings relays a measurement of the difference between the two oxygen concentrations.

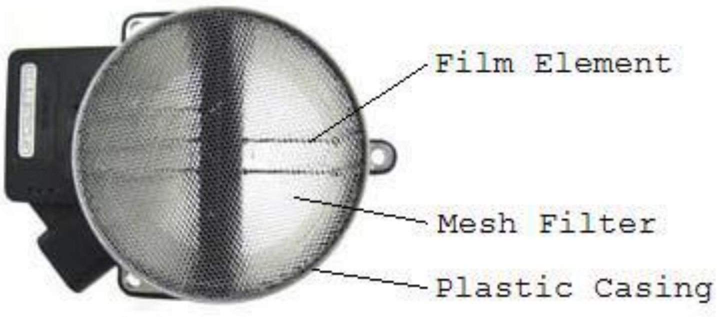


Figure 4.2: Hot Film Mass Flow Sensor

The engine temperature sensor and the air temperature sensor both operate on a similar principle. They are composed of thermistors, semi-conductor resistors.

They are frequently referred to as NTC I or II because they operate on a negative temperature coefficient, meaning, as the temperature goes down in the sensor, the actual temperature of the environment is increasing.

4.7 Air and Fuel System

The fuel injector, illustrated in Fig. 4.3, is the most important component of the fuel injection system because it delivers the atomized fuel to the cylinders for combustion. All injectors are electronically controlled by the engine management system by sending an electric signal which energizes a solenoid. The resulting magnetic force then over comes the force of a spring and hydraulic pressure, which then opens an armature or pintle, allowing the fuel to flow from the injector. The end of the injector is shaped into a nozzle to atomize the out-flowing fuel.

To deliver the fuel to the injection system, an electric fuel pump is employed, usually near the tank allowing for pressurization of the majority of the fuel line, which prevents vapor lock. The high pressure fuel then flows through a check valve keeping the pressure even when the pump is turned off. The fuel pump is also used in conjunction with a fuel filter composed of a paper element, containing pore sizes of roughly 10 micrometers, which is then backed with a strainer to catch any loose particles.

To control the high pressured fuel delivered from the fuel pump, a pressure regulator may be implemented. The regulator holds the fuel in the injection system at a constant pressure. A spring normally keeps the regulator valve closed except when excess fuel pressure builds up, resulting in the opening of the valve, which leads the fuel back to the tank.

Fuel rails are used to distribute the pressurized fuel from the pump and regulator to the individual injectors in a multi-port injection system. While it distributes the fuel to the injectors, it also stabilizes fuel pressure fluctuates at the injectors, caused from the rapid opening and closing of the injectors, which could affect the amount of fuel injected. This problem is elevated by increasing the size of the fuel rails, thereby storing more fuel and stabilizing the system.

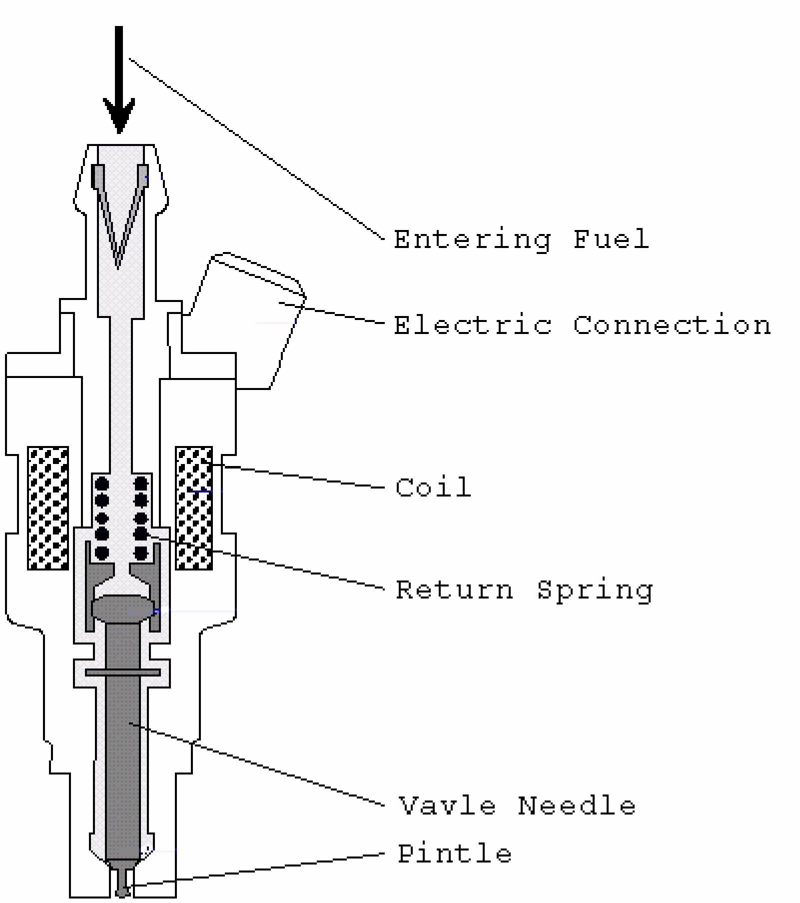


Figure 4.3: Fuel Injector

To overcome the problems associated with the mechanical drag of a cold engine, additional air flow is produced with an auxiliary air valve. The valve bypasses the throttle, but not the air flow sensor, so that the required fuel still is delivered to the engine. The resulting extra air and fuel allows the engine to overcome the extra resistance forces. They work by either being electrically or coolant heated. A blocking plate opens to allow the flow of air when the valve is cold, and then closes once the valve become warm.

Quiz:

1. Discuss the types of fuel injection system used in C.I. engine. Why air injection system not used now-a-days?

2. Explain with the help of neat sketch the working of diesel engine fuel injection pump.

Date:	Sign:	Grade:

Experiment No:-5 **Date:**

Objective: To study about Fundamentals of Supercharging.

Theory:

5.1 Introduction

The supercharger's origins do not lye in the automotive industry, but rather primarily in the airplane industry. During WWII, airplanes started to push their physical limits, especially in their engines because of the reduction in atmosphere at higher altitudes, which adversely effected the combustion process of the internal combustion engine. The supercharger assisted aircraft engines by compensating for the reduced atmosphere by forcing the extra needed air into the cylinders.

After the success of the supercharger in the airplane industry, hot rodder's could not resist the extra power implications that the supercharger offered. The automotive industry first used a fixed displacement Roots supercharger and later, the screw compressor and centrifugal supercharger.

Today there are three major types of superchargers: the Roots, centrifugal, and screw compressor superchargers. These can then be reduced into two categories, the fixed displacement and the variable displacement types. The Roots and crew compressor both fit into the fixed displacement category, because they pump a specific volume per revolution and block any reverse flow. The centrifugal supercharger lies in the variable displacement category, which forces a unspecified amount of air, meaning there is the possibility of a reverse flow.

These three types of superchargers can further be divided into one's with or without internal compression ratios. The Roots does not have an internal compression ratio, while the centrifugal and screw compressor both possess one.

5.2 Fundamentals

What is it about superchargers that add power? The power output from an engine is limited by the amount of fuel that can be combusted in the cylinders, which is dependent on the amount of air present to complete the combustion chemical reaction.

In natural aspirated engines, the air is forced into the cylinders through atmospheric pressure forces. Unfortunately, due to viscous drag in the intake system, not all the potential air that theoretically could enter the cylinders actually does, resulting in a pressure in the cylinders below atmospheric, on the induction stroke. As a result of the lower air pressure in the cylinders, the mass consequently is lower.

The supercharger is able to increase the power output of an engine because of the forcing of *extra* air into the induction system. With the addition of the extra air mass, more fuel can undergo the combustion process. With this device, not only can atmospheric pressure and density be reached, but for more power, high pressure and densities can be attained.

Unfortunately, the supercharger is less than perfect, because they obey the laws of thermodynamics. At closer observation, it is seen that as a result of the added boost, rise in pressure and density, there is also a rise in the temperature of the air forced into the cylinders. As a result, the ratio between the forced pressure and density becomes skewed due to the ideal gas law. This law leads to the reality that as the pressure rises in a constant volume with an increasing temperature, the resulting gas's density will decrease proportionally. What this means is that supercharger's have certain efficiencies which relates the theoretical mass of air to the actual air forced into the cylinder. The efficiencies can be estimated for Roots, centrifugal, and screw superchargers as 55, 75, and 70 percent respectively.

Another draw back to superchargers is that they also require power to run. The power is taken from the engine usually through the means of a belt connecting the supercharger to the crankshaft. Further losses occur in the actual belt movement because of the overcoming of friction in the system, which is needed to turn the supercharger's compressing mechanism.

Some superchargers may also need additional equipment for better performance, such as bypass valves. These allow for any extra buildup of pressure in the induction system to be alleviated. But these devices can hamper the advantages of superchargers with internal compression ratios because they keep the boost at a specified value.

5.3 Roots Supercharger

The Roots type of supercharger, illustrated in Fig. 7.1, is constructed of two lobes which mesh together, revolving in opposite directions. Reducing the need for lubrication, there is a small, but precise clearance between the outer shell and the lobes, as well as between the two lobes themselves.

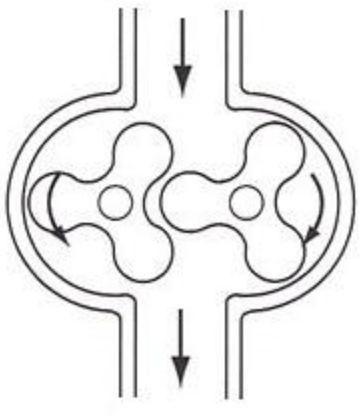


Figure 5.1: Roots Supercharger Design

This particular design results in its best performance at low to medium pressure boost where thermal inefficiencies do not have as great an effect on the power output. Since it does not compress the incoming air, but rather delivers it at atmospheric pressure at a constant pumping capability, it can deliver large amounts of power and torque at low engine speeds. However, speeds too low may also hamper the efficiency of the blower because air can escape through the clearances of the lobes. This is not a problem at speeds generally higher than 1000rpm because the air leakage is a function of time, which decreases with faster revolutions. Further disadvantages from the design include a small carry back of air from the induction system, from trapped air in the clearance space of the lobes. The trapped, now heated air then heats up the incoming air which then is forced into the induction system.

The roots type supercharger generally is not used in today's modern vehicles because generally they limit the vehicles emissions through addition needs of fuel mixture to flow through the lobes for cooling characteristics, stopping thermal expansion.

Secondly, they also tend to produce large amounts of noise from the gears
and the movement of the air into the intake.

5.4 Centrifugal Supercharger

The centrifugal type of supercharger, illustrated in Fig. 7.2, is constructed similarly to a turbocharger. The outside air forced is into the engine intake through a rotating impeller which takes air molecules and forces them from the center of a impeller to the outside, collecting into a snail-shell shaped collector, which directs the compressed air into the intake system. The inner impeller is driven by a shaft connected to a pulley, which ultimately is driven by a belt between it and the

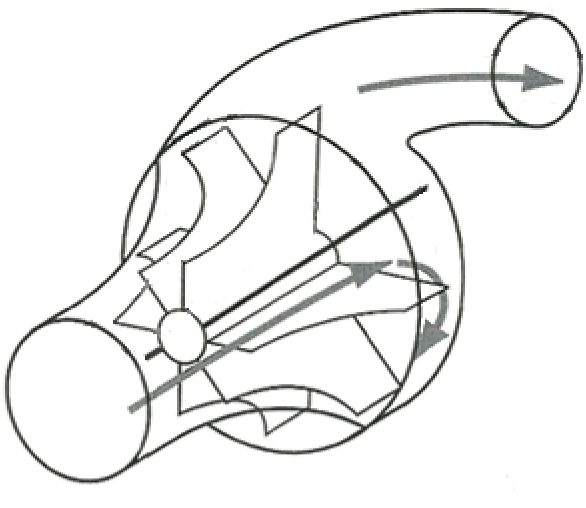


Figure 5.2: Centrifugal Supercharger Design crankshaft.

Because the speed of the impeller depends on the speed of the engine, low boost is produced at low speeds and high boost is produced at high engine speeds. As a result, the engine receives extra boost at high revolutions and speeds.

This type of supercharger enjoys many advantages. The first is the greater thermal efficiency due to its internal compression of the air. It also can be easily installed on engines because it has no need to be directly mounted to the engine, but rather can be remotely mounted as an engine accessory and connected with pipes and a drive belt. Lastly, the drive powers tend to be lower than those of Roots or screw superchargers.

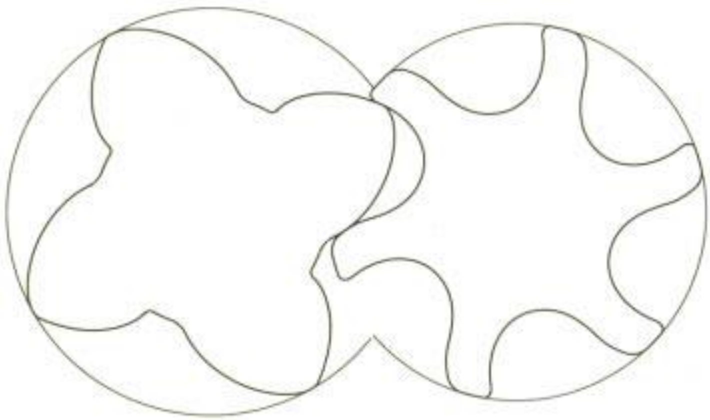


Figure 5.3: Twin Screw Supercharger Design

The centrifugal supercharger also has several disadvantages. The first is the noise produced by the unit's gear drive. Secondly, this type does not provide high power outputs at low speeds, thus only being effected at mid/high speeds.

5.5 Screw Supercharger

The screw type of supercharger, illustrated in Fig. 7.3, is constructed similarly to the Roots supercharger. The difference is that the internal rooters are spiraled; one having female indentions, the other male lobes. The two rooters are geared and positioned to never tough each other, but have tight clearances, thereby eliminating the need for special lubrication.

The screw has many advantages from its design. The first is it has a high thermal efficiency, close to those of centrifugal superchargers or turbochargers, which is largely due to its internal compression ratio. It also has the unique characteristic, in that it produces more heat when it is off boast, rather than when it is under boost. This is partially due to the heating of the outer casing when no boost is produced through the lobe's movement. It also enjoys a high volumetric efficiency, especially at low pressures where it approaches 95 percent. Lastly, similar to the Roots supercharger, the screw compressor can produce high pressures at low engine speeds.

The disadvantages of the screw type are that, like the Roots supercharger, it also has problems with leakage at engine speeds lower that 1000rpm. Another disadvantage is the noise produced by the unit due to its fixed displacement and internal compression ratio characteristics, which produced a popping sound when the compressed air is released into the induction system.

5.6 Miller Cycle

The Miller Cycle is an interesting cycle which can be employed through the use of a supercharger, especially the twin screw. It revolves around the premise that the expansion ratio and compression ratio can be **different**. The expansion ratio can be defined as the ratio of volumes, independent of other factors, which is also the same for the compression ratio. But if the intake valve is held open for a longer period of time, the piston can not compress the air in the cylinder until the intake valve closes. Consequently, the volume above the cylinder remaining after the intake valve closes becomes the new cylinder volume. Through the high density of air mass produced from the supercharger, the greater density will make up for the lost compression, resulting in a compression ratio substantially smaller than that allowed by standard valve timing. This reduces further the heat of compression, which in turn allows for a much high boost level. This principle allows for a naturally aspirated engine with 10:1 compression to have the power generated from high boost pressure, but have the anti-knock characteristics of a 7:1 compression engine.

Quiz:

1. What do you understand by the terms “Supercharging” And “Superchargers”?

2. Discuss the objectives of supercharging the I.C. engine?

Date:	Sign:	Grade:

Experiment No:-6 **Date:**

Objective: To study about Turbocharging.

Theory:

6.1 Overview

When matched properly to an appropriate internal combustion engine, turbochargers provide a great means to efficiently increase the power output of any engine. Naturally aspirated engines are limited to the amount of air/fuel charge that can be combusted efficiently. The amount of air that makes its way to the combustion chamber can be greatly increased through turbocharging. By effectively increasing the mass flow rate of air into the cylinder and simultaneously increasing the amount of fuel supplied (through engine management techniques), substantial power gains may be realized. One advantage of turbocharging is that it increases the efficiency of a properly matched engine by converting previously wasted byproducts into useful sources of energy.

6.2 Theory of Operation

There are two main types of turbochargers: radial flow turbines and axial flow turbines. The most commonly used turbochargers in automobile applications are the radial flow turbines. The radial flow turbine has a compressor and a turbine wheel. The exhaust gas propels the rotor (turbine wheel) which is mounted on the same shaft as the compressor (impeller) wheel. The impeller wheel draws air from the intake tract of the engine and accelerates it towards the compressor housing.

Once the air is compressed, it then enters the diffuser section of the housing. The compressed air then slows and the pressure increases. Note that with the pressure increase, the temperature also increases.

Note that in the radial flow turbine, there is some loss associated with the gap between the turbine blades and the turbine and compressor housings. Note that this gap becomes less of a factor when larger turbines are used. This particular loss becomes less relevant with larger turbines; therefore, larger turbines are deemed to be more efficient. However, this does not imply that a larger turbine will always make the most power as the turbine must be carefully selected to match the particular engine in question.

Note that for this discussion, the operation of the turbocharger will be treated as adiabatic. That is, there is no heat transfer in or out of the system. While real world applications prove otherwise, the amount of heat dissipated by the turbine is insignificant as compared to the amount of heat energy within the system. The approximation remains rather suitable for very short time periods as well. Since the compressor is assumed to be reversible as well, it can also be assumed that it is isentropic (the entropy of the system remains constant).

The T-s plot above remains a good method to better understand the turbocharger. The irreversible processes are associated with an increase in entropy. The isentropic processes are represented by vertical lines.

Eq. (6.1) provides an expression for the work per unit mass flow of the turbine.

$$h_{in} + Q = h_{out} + W \qquad (6.1)$$

Eq. (6.2) shows the adiabatic assumption used in this analysis

$$W = h_{in} - h_{out} \qquad (6.2)$$

These equations can be used to determine the work associated with a specific turbine.

6.3 Turbocharger Efficiency

The isentropic efficiencies of the compressor and the turbine can be found using the following equations from Richard Stone:

Eq. (6.3) shows the efficiency of the compressor:

$$\eta_c = \frac{(T_{2s} - T_1)}{(T_{2s} - T_1)} \qquad (6.3)$$

Eq. (6.4) shows the efficiency of the turbine:

$$\eta_c = \frac{(T_{3s} - T_4)}{(T_3 - T_{4s})} \qquad (6.4)$$

Note that the isentropic efficiency of a turbocharger is usually a good method to compare the real work of the turbine to the actual work produced from the system.

The isentropic efficiency of a radial flow turbocharger is usually 75 percent for the compressor and 70-85 percent for the radial flow system.

A useful equation to determine the output temperature of the turbine is given below as Eq. (6.5)

$$T_2 = T_1[1 + \frac{\frac{p_2}{p_1}^{(\frac{\gamma-1}{\gamma})} - 1}{\eta_c}] \qquad (6.5)$$

Note that the temperature of compressed air that leaves the system is rather important for it plays a large role in the density of the exiting pressurized air. As temperature increases, the density of the pressurized air decreases and thus the system becomes less efficient.

In addition, the mechanical efficiency of the turbine can be defined as the following: Eq. (6.6) shows the efficiency of the turbine:

$$\eta_m = \frac{W_c}{W_t} = \frac{m_{12}C_{p12}(T_2 - T_1)}{m_{34}c_{p34}(T_3 - T_4)} \quad (6.6)$$

6.4 Performance

The performance of a particular turbocharger can be determined by looking at a turbocharger compressor map. The compressor flow map gives the amount of air compression as a function of the mass (or volume) flow of the uncompressed air entering the turbo itself. At first glance, these charts may seem quite difficult to read.

The curved lines on the map with numbers ranging from 46,050 and 125,650 represent the rotational speed of the turbine in RPM. The isentropic efficiency of the compressor is represented by the elliptical curved lines which range from 50 percent to 73 percent for this particular turbocharger. The pressure ratio on the vertical axis is the ratio of the exiting air pressure to the incoming ambient air pressure. The air flow rating on the horizontal axis gives an output of *lb/min*.

An interesting side note concerning thewheel speed of the compressor is that at certain high wheel speed values, it becomes very difficult to raise the output pressure of the turbine. At these speeds (which are faster than the speed of sound), the diffuser in the housing becomes choked and does not permit notable increases in flow. At this point, the turbine has become inefficient and a larger unit may be required. In addition, when the turbine is spun to a very high speed, engine damage may occur. This danger is usually overcome through the use of a wastegate valve. Wastegate operation may vary depending on its design. One of the simple and common mechanical wastegate designs involves the use of a calibrated spring which regulates manifold pressure by directing flow around the turbine wheel and directly into the exhaust system.

6.5 Turbocharger-related Sources of Engine Failure

The damage that may occur from a turbocharger usually concerns pre-ignition or ”engine knock.” This sometimes occurs from setting the timing of the spark ignition system at a value which is too far advanced. The combonation of increased cylinder pressure and early ignition causes combustion substantially before the piston has reached TDC. This early ignition produces a knocking sound and is accompanied by very high pressures. This high pressure causes high stress on the piston and ring assembly as well, and has been known to crack ringlands and severely damage piston assemblies, along with other internal parts. In addition to advanced spark timing, a high compression engine will be less effective at making power than a lower compression engine if a turbocharger is applied. This stems from pre-ignition due excessively high cylinder pressures. A lower compression motor will accept a larger amount of the highly dense intake charge produced by the turbocharger. It is important to also note that an engine running lean will also be susceptible to knock and pre-ignition.

Besides reducing the compression ratio and retarding the timing, it is also effective to reduce the probability of knock and increase performance through the use of an intercooler to reduce the temperature of the incoming intake charge. The power level of the engine may be increased with an intercooler since the density of the incoming charge may be increased substantially. If the inlet temperature is reduced, there will be less thermal loading on the engine. The equation showing the efficiency associated with an intercooler is shown below as Eq. (6.7) from Richard Stone.

$$\epsilon = \frac{\text{actual heat transfer}}{\text{maximum possible heat transfer}} \tag{6.7}$$

The cooling medium used in intercoolers is usually air or water. Sometimes water in the form of ice for high performance applications such as drag racing where the car will travel short distances. In some cases, engine coolant is used; however, due to its high temperature, it is not the best choice as a cooling medium.

Note that with an intercooler, some losses in flow might be present through the intercooler. As such, it is sometimes necessary to increase the output pressue of the turbocharger itself to compensate. Also, due to the increased mass flow rate of air into the engine, the fueling system must be altered to provide more fuel to the engine.

6.6 Turbocharger Sizing

Richard Stone notes that large turbochargers provide a poor transient response. However, as previously noted, a larger turbocharger will be more efficient at high operating speeds. Conversely, a smaller turbocharger has less inertia and will provide a better transient response and low speed efficiency. As such, it is very important that the operating conditions be taken into consideration when selecting a turbocharger.

It should also be noted that while internal combustion engines operate over a large range of speeds, turbines are very sensitive to operating speed. This high sensitivity is due to the fact that the angle of the gas flow and angle of the blades themselves must be matched for a specific operating speed/range. Stone notes that a flow rate provided by a manufacturer corresponds to one operating speed.

Therefore, it is very important that care is taken in selecting a turbocharger for a specific application.

In order to select a turbocharger, one must first calculate the volume air flow of the engine. The equation from Lucius [6] expressing this value is shown below as a function of engine displacement (in cubic inches), volumetric efficiency, and engine speed:

$$\mathrm{VAF} = \frac{\mathrm{CI}}{1728} * \frac{\mathrm{RPM}}{2} * \mathrm{VE} \tag{6.8}$$

It is sometimes useful to use the mass flow rate of the air:

$$\dot{m}_a = \rho * N * V_s * \mathrm{VE} \tag{6.9}$$

The volume air flow and the mass flow rate of the air may be used to choose a turbocharger based on its workable range. Based on the engine load characteristics and operating environment, the compressor will be chosen. Of course, the most obvious choice will be a compressor which will operate in its most efficient region as much as possible. For the times that the compressor is not operating near its efficient range of operation, it must be operating at a location on the compressor map substantially distant from the surge line. Finally, a turbine will be chosen to match the compressor. Note that the output of the turbine is a function of effective flow area.

Quiz:

1. Enumerate the method of turbo charging.

2. Explain briefly constant pressure and pulse turbo charging.

Date:	Sign:	Grade:

Experiment No:-7 **Date:**

Objective: To study about Intake Manifold Design.

Theory:

7.1 Basic Operation and Design

An intake manifold, is comprised of a main trunk which diverges into separate passages leading to the individual intake valves for each cylinder, which routes the incoming air from the throttle body or carburetor to the cylinder head.

The basic intake manifold will be designed for minimum resistance to air flow, light weight, and ease to manufacture at a relatively low cost. Minimum resistance is achieved through relatively straight runners, the individual ducts leading to the cylinders. If turns must be present in the ducts of the manifold, they should be generally designed with big radii, unless a right angle is desired to promote fuel vaporization by shattering fuel droplets against the interior walls.

The manifold design should distribute the incoming air equally to each of the cylinders for optimal performance and incorporate smooth inner surfaces to aid in laminar flow. Smooth walls reduce the viscous friction, but some designs may use a slightly rough wall to assist in evaporation of the fuel from the accompanying turbulence. Roughness may also be desired to reduce the speed of flow near the inner radius of bends in the ducts.

7.2 Air Distribution

A main design constraint for a carbureted or throttle body fuel injected system is for equal distribution of air and fuel to each of the cylinders, which is not necessary in multi-port injection because the alternative fuel delivery method. Distribution is further complicated through the use of multiple carburetors. To combat the problem of some cylinders receiving a lean or rich mixture, a mixing box may be designed to assist in more equal distribution.

Another potential problem arises from the suction created by the opening of the intake valves, which may rob neighboring tubes of their fuel mixture. To combat this problem, manifolds may be divided into two subsections separating the runners for opposing cylinder induction strokes.

Another important design consideration is to avoid depositing of liquid gas on the walls of the manifold. For example, at idle, the manifold walls are dry and the air is virtually saturated with vapor. If the throttle is suddenly depressed, the density of the air suddenly rises which effectively squeezes the fuel vapor from the air leading to condensation on the manifold walls.

In a cold starting engine, the fuel may not fully evaporate because of the lower temperatures causing for pools of fuel to form in the manifold. The liquid fuel can not be allowed to drip into the cylinders in order to prevent misfiring and dilution of the lubrication. To prevent these conditions, a well beneath the riser can be designed to capture the liquid fuel as well as assist in the re-evaporation of the fuel. Some runners may also be slightly sloped down from the cylinder head to prevent entering liquid fuel into the cylinder. Buffered ends also assist in straight rake type manifolds to lead the condensed fuel into the well. Lastly, to ensure fuel is not deposited on the walls of the manifold, in general the runners should be sized so the velocity of the incoming air is no less than 70 m/s.

7.3 Manifold Heating

Manifold heating is important to intake manifold design to assist in the vaporization of the fuel. To accomplish this, a hot spot is designed beneath the fuel well in the manifold. These hot spots are attained through various means, either water, exhaust, or electrical heating or a combination of them.

One problem with water heating is that it may be difficult to deflect the water flow from the hot spot after the engine is warm, which could lead to variations in the volumetric efficiency. To achieve a more stable temperature, a thermostat can be used. The thermostat will allow the hot water to heat the manifold until the liquid reaches a set temperature, when it will open and allow the water to flow to a radiator for cooling.

An effective way to heat the manifold quickly is by using exhaust fumes. This will produce heat quickly because of the high temperatures of the gases which have been recently combusted in the cylinders.

The biggest leap in technology for manifold heating came after the development of the engine management system. Now electrical heaters could be implemented and kept at a constant temperature through the feedback received by the computer from temperature sensors. This system can be even more effectively implemented when combined with a thermostat regulated water heating system.

7.4 Effects of Resonance andWaves

There are four basic phenomena which can be taken advantage of or avoided in the manifold design: Inter-cylinder charge robbery, inertia of flow, resonance, and the Helmholtz effect. The first phenomena is perhaps the most important of the four because failure to take its effects into consideration can lead to low power output from the engine.

To explore inter-cylinder charge robbery, valve timing and cylinder layouts needs to be explored. The depression in the cylinders alternates similarly to that of the motion of the piston in the cylinder. As a result, the opening of the intake valve creates a suction wave, and when it closes, it creates a pressure wave to form in the runners. When the intake valve is closed, the fuel mixture in the runner tends to stagnate.

Because of a possible over lap time or period of different cylinders in a multiple cylinder engine, overlapped induction phases can cause charge robbery between the cylinders. This is cause by one cylinder running rich while the other runs lean due to the suction of the newly opening intake valve. This phenomena decreases with increasing engine speeds because there is less time for flow reversal to occur between different runners. The adverse effect can partially be solve by designing a plenum chamber, which would connect all of the runners. Another partial solution is to arrange runner orientation into the plenum in a fashion that cylinders with overlapping induction strokes are not next to each other.

As discussed above, it is important to have the correct placement of runners for cylinders with overlapping induction strokes. Fig. 7.1 to Fig. 7.3 illustrates the firing order and overlap for inline three, four, and six cylinder engines. Acknowledgement of these factors are important in the design to prevent charge robbery from the overlapping strokes. An example of a manifold design to solve this problem is shown in Fig. 7.4. These overlaps can also be incorporated into V-engines because they are treated as two side by side inline engines, although there may be some variations in individual cylinder positioning. A solution for the intake manifold layout for a V6 engine is illustrated in Fig.

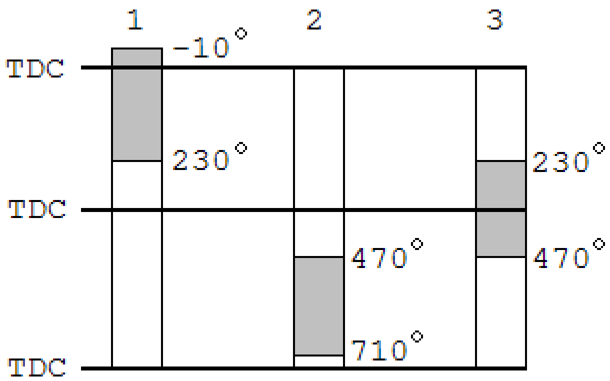


Figure 7.1: Inline Three Cylinder Firing Order

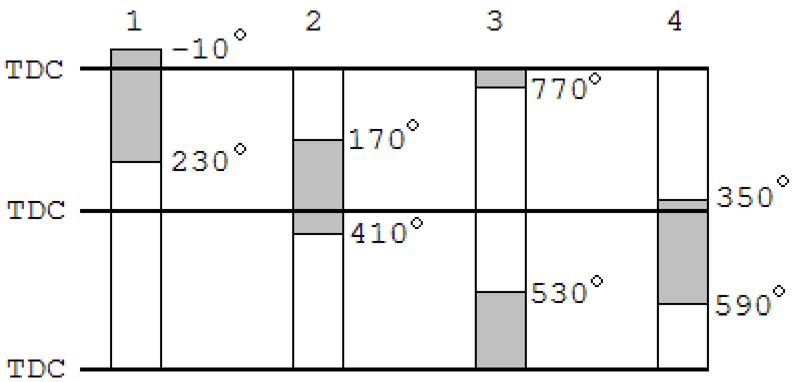


Figure 7.2: Inline Four Cylinder Firing Order

The pressure wave inside the runners can be broken into several stages. The first is when the fuel mixture is drawn into the cylinder causing a depression in the runners.

When the intake valve closes at the end of the stroke, the depression wave is reflected against the valve sending it back up the runner, where it is then reflected again back towards the intake valve. The amplitude of the pulse increases as the engine speed gets higher. The larger the area of the runner, the greater the effect of the depression from the greater effects of inertia.

As a result, it is important to take advantage of these properties so that the returning wave reaches the intake valve again when the new stroke starts. There is also an important ratio of the runner volume to the piston-swept volume which needs to be considered in the design of the manifold.

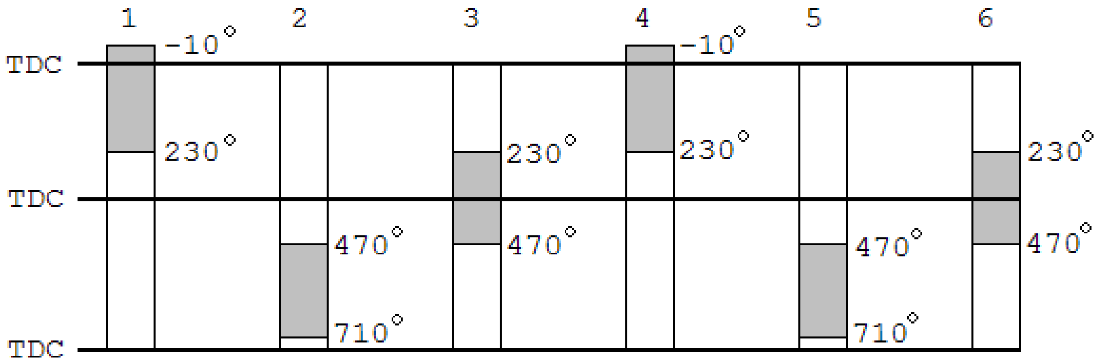


Figure 7.3: Inline Six Cylinder Firing Order

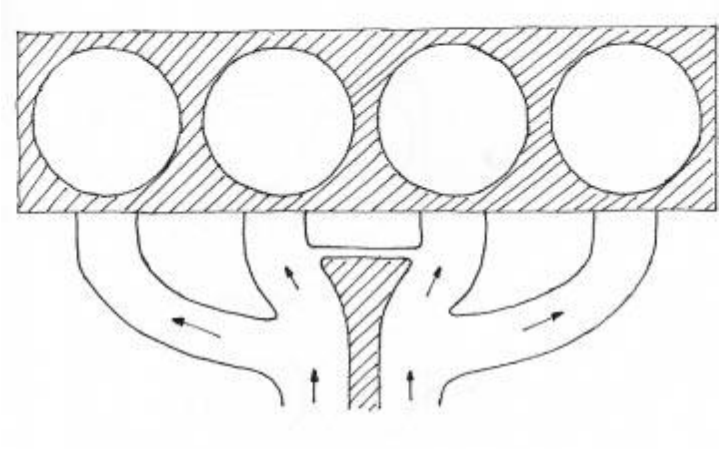


Figure 7.4: Manifold Design

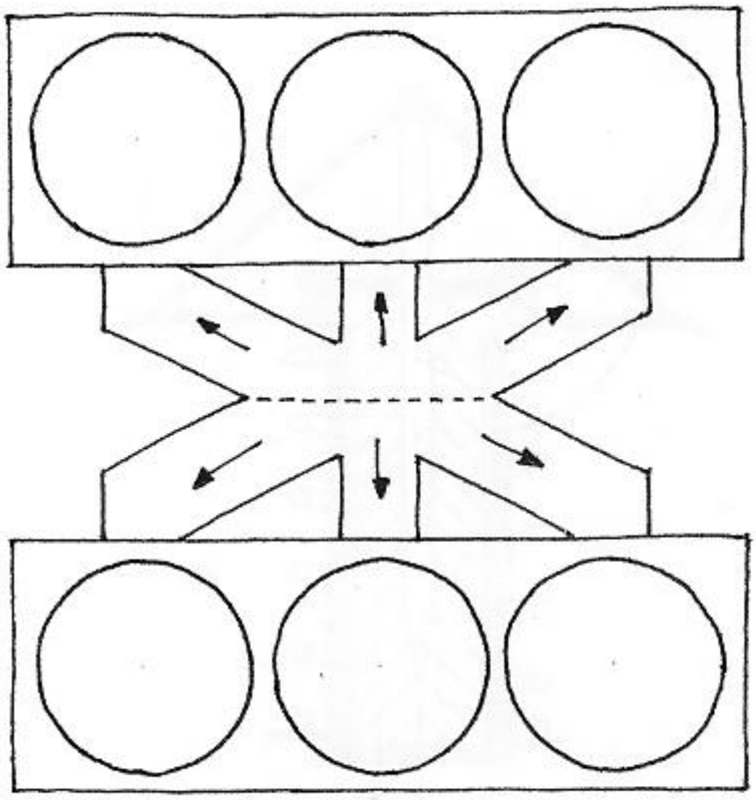


Figure 7.5: V6 Manifold

Because of the natural changing characteristics of the internal combustion engine, certain compromises must be made to make the engine as powerful and efficient at certain engine speeds. This is particularly true for the intake manifold characteristics, like the length of the runners being dependent on the engine speed.

Compromises must also be made to add features, such as a reducing taper of the runners from the plenum to the cylinder heads; but care must also be given not to disturb the laminar flow.

As previously discussed, it is important to design a runner length which will cause the depression wave to return to the valves when the valve opens again.

More to the point, the wave should return to the end of the runner when the intake valve opening period is about half way through for optimum performance.

If the wave arrives too early, the pressure might fall before the intake valve closes again, which could cause a reverse flow. But if the wave arrives too late, it will fill the cylinder at the end of the stroke and cause turbulence when the valve closes, reflecting the new depression wave.

At low speed operation, the depression waves move at a slower velocity comparatively to that of high speed operation. As a result, for lower speed operation, a shorter pipe is more beneficial for creating optimal influx of fuel mixture, where as with the high velocity waves at high speeds, runner lengths should be increased to yield the optimum setting.

The runner endings need to also be considered in the design because of the effects on the incoming and out going air flow. Because of the influx of air and the variations in the depression waves, the ends of the runners have increased turbulence, which adversely effects the efficiency of the engine. If the ends of the runners are flared out like the end of a trumpet, it guides the air in a smoother fashion into the runners and increases the coefficient of inflow by as much as 2 percent. And as mentioned before, a tapered runner will also reduce the end turbulence effects.

A good example of an efficiently designed intake manifold is the GM Dual Ram. This system works by using variable runner lengths through the implementation of a dividable plenum. When the plenum is divided into two separate chambers, it effectively make the runners long which is good for the high speed operation. But when the plenum is not separated, the runners are then turned into short a length which optimizes efficiency at low speed. The valve in the plenum is usually controlled by the engine management system for optimal operation.

Quiz:

1. Define a Manifold. Differentiate between intake and exhaust manifolds.

2. What is scavenging and what is its importance? Discuss the various types of scavenging arrangements used in two stroke engine.

Date:	Sign:	Grade:

Experiment No:-8 **Date:**

Objective: To study about Emission of pollutants from SI & CI engines.

Theory:

8.1 Introduction

Los Angeles, in 1947, was the first place to call attention to atmospheric pollution problems, which in 1952, Dr. Arie J. Haagen-Smit blamed the rise on the automobile, which was backed by his research.

In a complete combustion process, for every kg of hydrocarbon fuel burnt, 1.3 kg of H_2O and 3.1 kg of CO_2 is produced. The undesirable exhaust emissions, NOx, HC, CO, CO_2, polyaromatics, soots, lead salts, nitro-olefines, and aldehydes ketones, are produced in very small quantities. And of these toxins, only NOx, HC, and CO are produced in large enough quantities to cause environmental problems.

CO_2 caused concerns because it was suspected of allowing ultra-violet rays to penetrate the atmosphere. CO causes problems by being absorbed into red corpescles of the blood, preventing the absorbtion of oxygen. Lastly, Nitric acids and nitrogen dioxide along with HC caused smog.

8.2 Controlling Emissions

The first method used for controlling emissions produced by the automobile was to have precise control over the carburetor or fuel injection system, which provided accurate mixtures of fuel and air for complete combustion. During idling, the fuel mixture was either made to be completely combustible, or was cut off. Devices that were sensitive to manifold pressure, tapped immediately downstream of the throttle, were employed to retard the ignition during slow engine speeds. Gulp valves were produced to compensate for the lack of air when the throttle is suddenly closed, allowing for the fuel to be completely combusted. High temperature thermostats were employed to improve cold whether combustion. PCV, positive crankcase ventilation, was employed to eliminate the crankcase fumes. To combat the problems with NOx, ERG, exhaust gas recirculation, was used to lower the temperature of combustion. This was needed because to production of NOx took place generally above 1350 degrees Celsius.

8.3 Catalytic Conversion

General Motors was the first automotive company to employ the catalytic converter as a standard feature on their automobiles to meet the rising emissions regulations during the early 70's. They chose this approach to comply with regulations, while keeping the durability of their engines. In addition to this change, they also argued the benefits of unleaded gasoline, which would eliminate lead oxyhalide salts, reduce the combustion chamber deposits, further reducing HC due to additional oxidation with the lack of lead. Basic maintenance on the vehicle was reduced, and it assisted in the use of the catalytic converter and overlooked the alleged toxic effects of leaded salts in the environment from leaded gas going through the converter.

The two way catalytic converter is made up from a container, constructed of stainless steal, and the catalysts and supporting features inside the container. Around the converter, a aluminum heat shield protects nearby parts of the automobile from potential damaging heat. The two catalysts usually used are platinum and palladium, or in some cases, just platinum. In the two way converter, HC and H2O are oxidated and converted to form H2O and CO2.

The support piece for the catalysts were developed into a one piece honey comb structure, which had large surface areas on which the catalysts were deposited.

They operated at 550 degrees Celsius under normal working conditions. This type has the advantage over pellet type converters because of their more compact form.

Later improvements lead to the use of metals instead of ceramics for use as the monoliths, support pieces, to meet the needs of durability and very high, changing temperatures. The new accepted metal was Emicat, which met all the necessary conditions for the support of the catalyst in the converter.

In 1978, General Motors developed the three way catalytic converter, which now dealt with the NOx part of the emissions. The three way converter now employed two stages opposed to the one stage in the two way converter. An additional chamber now used Rhodium for the reduction ofNOx. With this advance, 95 percent of NOx in a 0.1 percent rich mixture could be removed.

This additional step had to be placed before the oxidation of HC and CO because of the needs to reduce atmosphere call for a rich mixture. For this, a closed loop system must be employed to regulate the supply of fuel accurately according to the incoming air mass, which can be accomplished with the lambda sensor.

8.4 Engine Management

When an engine is cold starting, it must be switched from a closed to an open loop system, which will then provide the necessary rich mixture for ignition. During this operation, the air supplied to the second chamber in the three way converter is diverted to the exhaust manifold, which then avoids a rapid rise in temperature and overloading in the second stage of the converter. And because of the low temperature in the cylinders, there is minimalNOx produced, so it is not necessary to worry about the first stage of the converter during the starting sequence.

8.5 Evaporative Emissions

The evaporative emissions is mostly composed of HC, generally from 4 sources: fuel tank venting system, carburetor venting system, permeation through plastic tanks, and through the crankcase vent. To combat the fuel tank vent problems, a carbon canister is employed to catch the exiting fumes, which periodically needs to be cleaned. The permeation through the tank walls can be solved with one of several methods: sulphur trioxide treatment, fuel system lamination, fluorine treatment, or the Du Pont one-shot injection molding.All of these methods act as barriers which successfully block the emissions.

From the total HC pollution, the crankcase used to account for 25 percent of the total. To prevent this source of toxins, the crankcase fume are vented into the induction manifold through a close circuit by a positive ventilation system.

Then the excess HC is burnt in the combustion process in the cylinder. The positive flow is provided through a venting system into the cylinder heads, which is capped off with an air filter. In order to prevent the back flow of the HC fumes, a valve is employed to stop back flow, limit suction in the crankcase, and lastly to avoid upsetting the flow at slow engine speeds.

Additional parts have been employed to reduce emissions, such as the gulp valve. The gulp valve is used to account for conditions such as a sudden release of the throttle. In a situation like this, the fuel mixture momentarily is still delivered to the engine, but the air needed for complete combustion is taken away. The gulp valve is used to provide the necessary additional air to allow for the complete combustion of the fuel, thereby reducing emissions.

Quiz:

1. what is EGR system? Why is it needed? Discuss its working with the help of a diagram.

2. with the help of diagram, discuss working of a 3- way catalytic converter.

Date:	Sign:	Grade:

Experiment No:- 09 **Date:**

Objective: Performance on Two stroke two cylinder petrol engine test rig.

Observation table:-

Sr.No	T_1	T_2	T_3	T_4	Flow rate of water (LPH)	Load (kg) M_1	RPM	Time (sec)	hw (mm)	M_2
1										
2										
3										
4										

Calculation:-

Conclusion:-

Date:	Sign:	Grade:

Experiment No:- 10 **Date:**

Objective: To study on Multi point fuel injection system for SI engine.

Quiz:

1.Classification of Multi point fuel injection system.
2.Explain Multi point fuel injection system components.
3.Explain fuel injection control.
4.Give advantages and disadvantages of Multi point fuel injection system.

Date:	Sign:	Grade:

Experiment No:- 11 **Date:**

Objective: Performance on Four stroke four cylinder diesel engine test rig.

Observation table:-

Sr. No	T_1	T_2	T_3	T_4	T_5	T_6	Manometer head difference (mm)	Fuel consumption (10 ml *4) petrol/sec	Engine water jacket flow rate (LPH)	Calorimeter flow rate (LPH)	Load (N.m)	RPM Engine speed
1												
2												
3												
4												
5												

Calculation:-

Conclusion:-

Date:	Sign:	Grade: