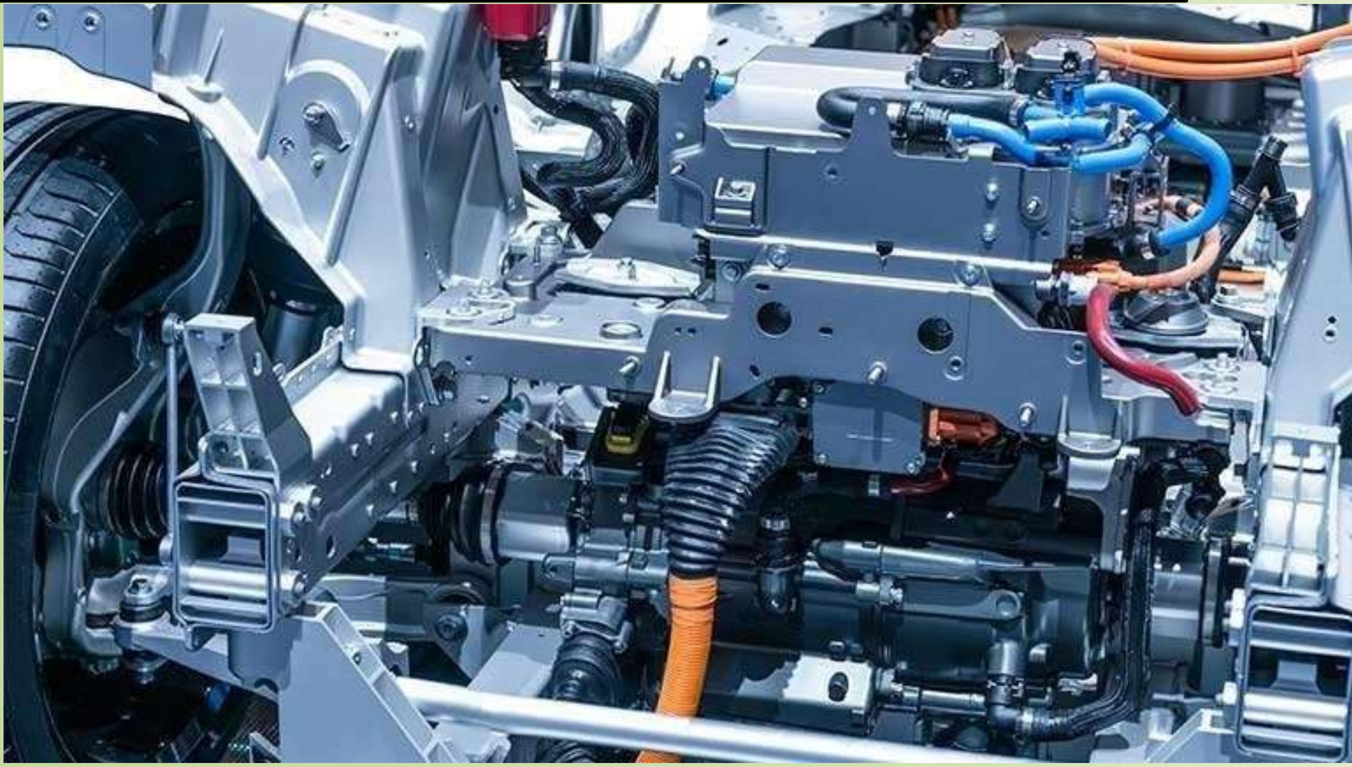
New Systems in Modern Automobiles



Mechanical Engineer

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1. Introduction and Background

It began when people realized animals could carry them from one place to another. As the centuries rolled by, they used this mobility to expand our horizons. While, at the same time seeking even better ways to travel, they harnessed the power of steam and began to replace animals with engines but it was not until the development of the internal combustion engine and the discovery of tools of oil, deep in the earth that we were able to achieve a basic improvement in individual transport. In 1886, two vehicles wereunveiled only months apart by German engineers, Karl Benz and Gottlieb Daimler-the automobile was born. Gottlieb Daimler was the first to see a wide variety of uses for the gasoline burning internal combustion engine. He tried it first in a motorcycle, and when that was a success he was ready to install his engine in a carriage. At the same time Karl Benz, working only 60 miles away was developing his own vehicle. But while Daimler was installing his engine in a carriage, Benz was creating the world's firstautomobile from scratch. It was successfully driven in late 1885 and patented on January 29th automobileDaimler's vehicle made its appearance.

The first automobile was manufactured, but still a much more was needed to be done. The automobiles had to still go through the decades of evolution. As the time passed by, the challenges for the automobiles manufacturers were raised. Engineers started working on the ways and technologies that could surpass the standards, and hence a new era of technologies was started. Many technologies were introduced that could enhance the efficiency and working of the systems.

This report briefly presents some of those modern automobile technologies i.e. Hybrid Technology, CVT system, GDI, EFI, Turbochargers, that are being used, their need, importance and impact on the system and the environment.

Modern Technologies

2. Dual Fuel System

Fundamental concept of dual fuel engine is not new at all. In 1890's Rudolph Diesel experienced with this approach during his research and development of diesel engine. He introduced pipeline natural gas into air intake and observed its effects on the performance of an engine. Modern dual fuel systems are equipped

Figure 2.1-Modern dual fuel engine

with electronic controls to enhance the performance of an engine, lowering operating costs and help to meet emission regulations.

In Dual fuel system, two fuels are used together at the same time in a mixture. However, it usually cranks up on one type of fuel and a governor built in the system is used to gradually introduce the secondary fuel source until optimal mixture of these two fuels is achieved for efficient running of the vehicle. Dual fuel system is capable of operating on one fuel at a time in the absence of other fuel source but in many dual fuel engines, from the combination only one fuel is capable of starting the engine. Thus in order to initiate the engine that particular fuel must be available for consumption.

A typical example of dual fuel system is the use of mixture of diesel and natural gas. Usually 25% diesel and 75% natural gas mixture is preferred for optimal working and efficiency. If load increases, a governor re-adjust the amount of diesel fuel in mixture until engine is operating on its peak efficiency. The engine starts by using diesel fuel and gradually natural gas is added in it. Diesel fuel ignites at 500-700 degrees Fahrenheit; however natural gas does not ignite until temperature reaches 1150-1200 degrees Fahrenheit. So engine can run on either fuel alone but natural gas cannot be used to start the engine because diesel fuel is used to bring the engine temperature up to that point where natural gas ignites.

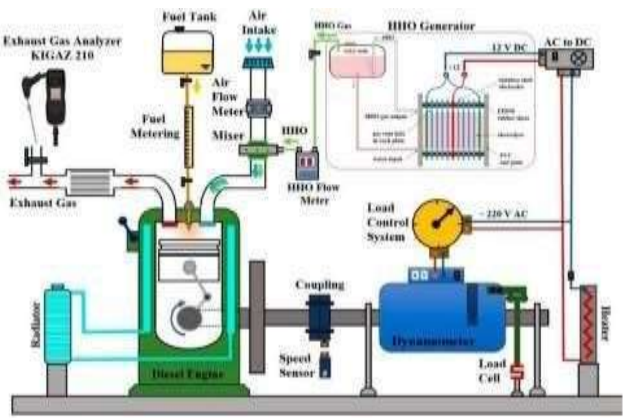

Figure 2.2-Schematic diagram of Diesel Natural Gas Engine

All duel fuel systems do not use a diesel-natural gas mixture. Some, such as the E85 compatible vehicle, consume a mixture of ethanol and gasoline. The optimal mixture of these fuels is 85 percent ethanol to 15 percent gasoline. Dual-fuel systems are also used for non-transportation engines, including generators and drilling rigs. Fewer consumer products use dual-fuel systems because most of these engines are used in industrial applications and as emergency power back-up systems.

There is a big difference between dual fuel system and bi-fuel system. In case of dual fuel system fuel are used in a mixture but in case of bi-fuel system two fuels are available for consumption separately. In bi-fuel system, there is switching between two fuels so that engines always operate on most efficient fuel according to condition.

2.1 Working

Reciprocating internal combustion engines are generally divided in two categories, compression-ignition (CI) and spark-ignition (SI) engines:

•In CI engines (diesel engines), air is compressed at pressures and temperatures at which an easily ignitable fuel fires spontaneously when injected and burns progressively after ignition.

•Whereas, SI engines (Otto engines) running according to the Beau de Rochas cycle, the carbureted mixture of air and gaseous or gasified fuel which does not fire easily (high octane index), is compressed under its ignition point, then fired at a chosen instant, by an independent means.

In dual-fuel engines both types of combustion coexist together, a carbureted mixture of air and high-octane index gaseous fuel (natural gas) is compressed and then fired by a small liquid fuel injection which ignites spontaneously at the end of compression phase. The advantage of this type of engine resides in the fact that it uses the difference of flammability of two fuels. In case of lack of gaseous fuel, it is possible to run according to the diesel cycle; switching being possible when running and without load variation. The disadvantage is the necessity to have liquid diesel fuel available. Theoretically, the liquid fuel quantity necessary to fire is tiny (less than 1 %), but, it is not possible to inject with the given pump and injectors assemblies fuel quantities varying from 1 to 100 %. If we do not want the material to be doubled, we must be satisfied by injection of the minimum possible quantity of standard diesel fuel.

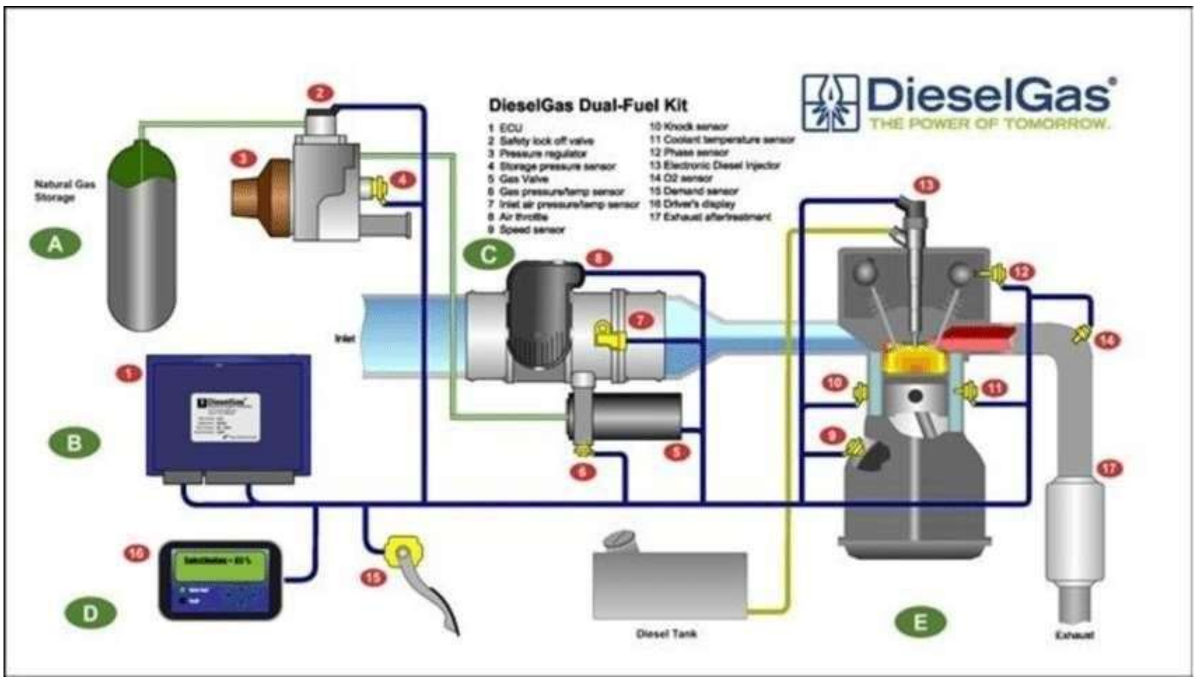

Figure 2.3-Schematic Diagram of dual fuel system

2. Benefits of Dual-Fuel Operation

- **Economic benefits**: As the cost of diesel fuel rising, and dual-fuel engines considerably decreasing diesel fuel usage, converting an engine to operate primarily on a cheaper gaseous fuel is economically attractive. Moreover, spark plugs and an ignition system are not required, eliminating the costly spark plug maintenance associated with traditional natural gas engines, which helps to further reduce overall cost of operation. Depending on the expected number of running hours and the price of diesel and gaseous fuels, the up-front installation cost of retrofittingan existing diesel engine to dual-fuel operation can be recovered quickly.
- **Environmental benefits:** Gaseous fuels and natural gas in particular are much cleaner than diesel. Diesel engines that have been converted to dual-fuel operation have exhibited significant reduction in NO_X and CO_2 over their original diesel operation. This is more important in areas with

increasingly tough emissions regulations. In addition, on-site diesel storage capacity can be minimized.

- **Technical benefits:** Retrofit systems can be installed in the field quickly, reducing engine downtime. No modifications are required to the core engine or to the factory fuel management system. With the engine's main fuel becoming gaseous fuel rather than diesel and the electronic control system maximizing fuel efficiency, installing an alternative fuel system enables the on-site diesel supply to last much longer, extending engine uptime without compromising performance. Replacing diesel fuel with natural gas typically extends engine maintenance intervals and overall engine life. For example, life expectancy of cylinder-head valve seats is improved due to the cleaner combustion that gaseous fuel exhibits over diesel. Benefits of the factory diesel engine, including hardware ruggedness and operational efficiency, are maintained. Returning to operation on 100% diesel fuel is possible at any time.

- **Safety:** Gasoline or petrol is an easily ignited volatile fuel. While diesel fuel is less volatile, it presents the same storage and handling problems. Comparatively, natural gas exhibits many different characteristics. It is buoyant at temperatures above -160 F, does not pool on the ground, and dissipates rapidly in the atmosphere. It is nontoxic, noncorrosive, and environmentally safe.

3. Applications of Dual Fuel Engines

Dual fuel natural gas/diesel engines are becoming popular in many parts of the world. The more expensive, sophisticated computer control systems are being introduced successfully in North America and Australia and are being tested in European in anticipation of market entry. But their use in other parts of the world is expanding, particularly in Latin America, India, Pakistan, China and other parts of Asia. They tend to be used in large vehicles such as buses and refuse trucks, but also have applications in smaller commercial diesel engine vehicles.

4. Importance of Dual Fuel Engines Availability

Diesel engines can be converted as dual fuel natural gas engines relatively easily because typically there are no changes in the engine compression ratio, cylinder heads, or basic operation as a diesel cycle engine. Even the sophisticated computer controlled dual fuel systems are being developed as 'bolt on' technologies that can be removed if necessary, to resell the vehicle as a normal diesel engine. These conversions are easy to install and easy to maintain. This flexibility makes these engines very useful in many global markets

3. Hybrid Technology

The increased awareness that the world's energy resources are limited has stimulated many countries to reexamine their energy policies and take measures in eliminating waste. It has also sparked interest in the scientific community to take a closer look at the energy conversion devices and devise ways to develop new techniques to utilize the existing limited resources.

This led to the development of the most efficient and energy conservation system, Hybrid System. A hybrid car is one that uses more than one means of power transmission i.e. combination of an internal combination engine (petrol or diesel engine) with an electric motor.

3.1 Working of Hybrids

Hybrid cars have a conventional engine (an I.C Engine), an electric motor and a battery. These automobiles operate either on engine or an electric motor a combination of both.

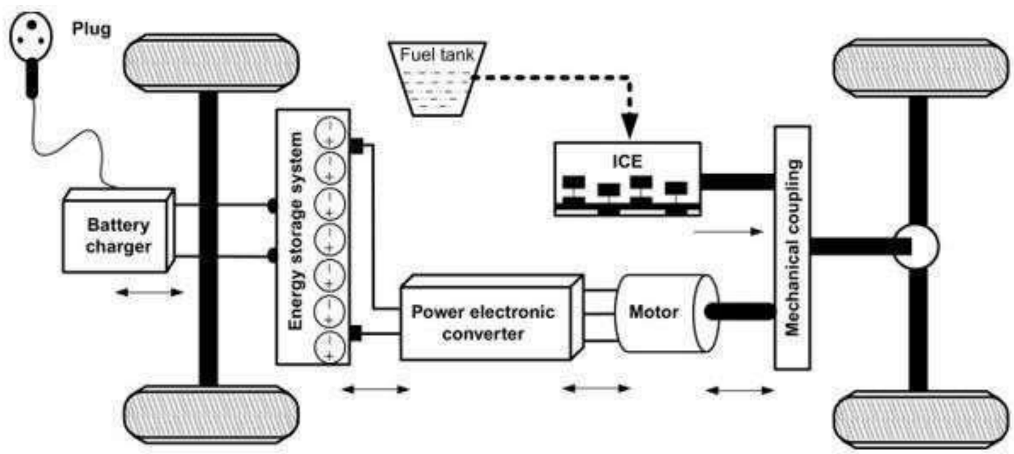

***Figure* 3.1**-Schematic Diagram of Hybrid Car

The above ***Figure*** illustrates the schematic diagram of a hybrid car. There as an engine which runs on fuel. In addition to the transmission system the engine is also attach\
ed with the generator. When the car is running of the engine, meanwhile the generator produces electricity and stores in a lithium battery. This battery can then be used to run the car. Thus, the car has two transmission systems, one which is connected with an engine and other with the electric battery.

2. Types of Hybrids

Based upon the working the hybrid technology has following sub types .

1. Parallel Hybrid Cars
2. Range Extended Hybrid Cars
3. Plug-in Hybrids

1. Parallel hybrid cars

These are the most common type of hybrid. The car's wheels can be powered in three different ways:

- Directly by the engine
- By the electric motor alone
- Both power sources working together.

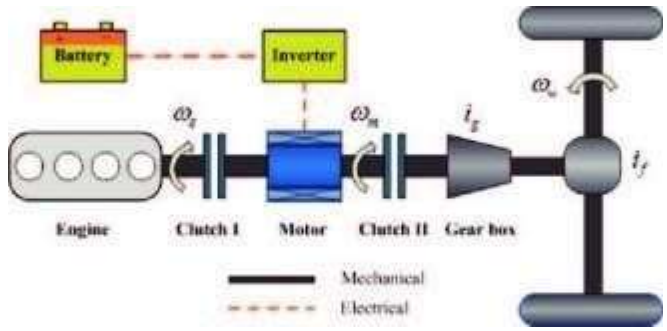

Figure 3.2-Schematic Diagram of Parallel Hybrid

Application

Toyota also uses this system in the Yaris and Auris hatchbacks and Prius+ MPV hybrids. Similarly, Audi, BMW, Mercedes-Benz, Land Rover, Citroen, Lexus, Peugeot, Porsche and Volkswagen work on the same basis.

2. Range extender hybrid cars

- Use their conventional engine to produce electricity for a generator that recharges the batteries
- The engine does not drive the car it only charges the batteries.
- The Car is run by electric motors.

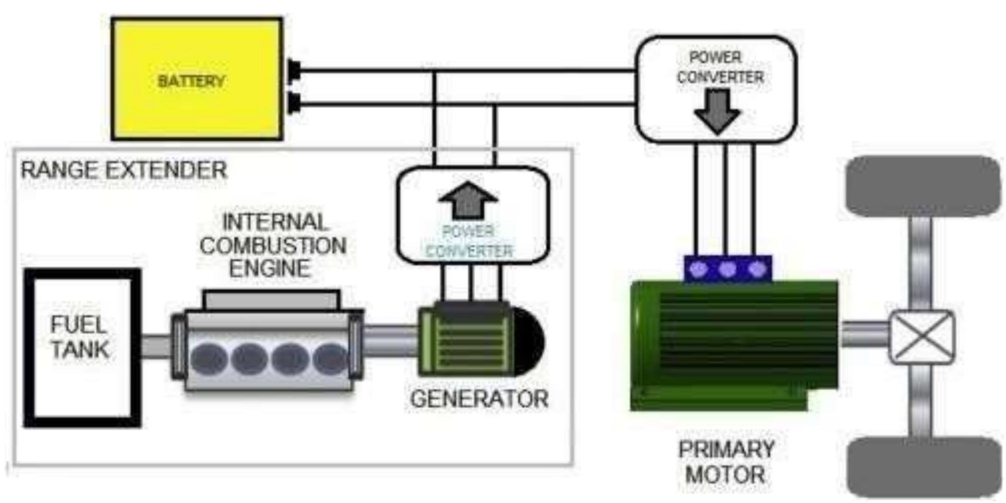

Figure 3.3-Schematic Diagram of range Extender Hybrid

Applications

The BMW i3 with Range Extender is one of the examples. The Honda Jazz Hybrid is another one.

3. Plug-in hybrids

- The type of hybrid can be plugged into an electric outlet to recharge their batteries,
- The batteries can be charged on the move
- They have a conventional engine but also have larger batteries than regular hybrids and can drive longer distances

- Travel up to 30 miles on electric power alone

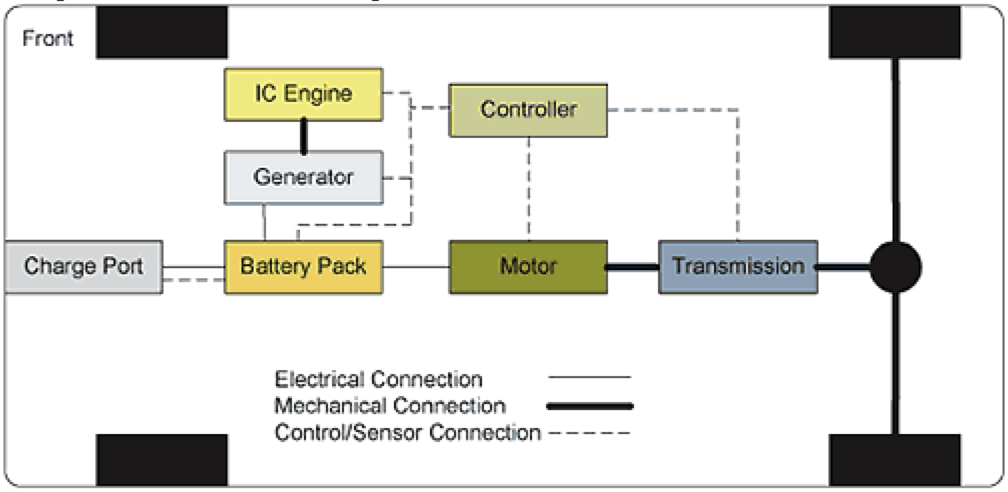

***Figure* 3.4**-Schematic Diagram of Plug-in Hybrid

Applications

There are a growing number of plug-in hybrids on offer, including the Mistubishi Outlander, Toyota Prius and Volvo V60.

3. Advantages:

- **Environmentally Friendly:**

Produce less emissions and harmful gases that pollute the environment, as their run on electric supply.

- **Less dependence on Fossil Fuels:**

A Hybrid car requires less fuel to run which means less emissions and less dependence on fossil fuels. This in turn also helps in reduction of the price of gasoline, and decreases our dependency on these fossil fuels.

- **Regenerative Braking System:**

Hybrid cars have Regenerative Braking System i.e. each time brake is applied while driving a hybrid vehicle recharges battery a little

- **Built from Light Materials:**

Hybrid cars are made up of lighter materials which means less energy is consumed to run. The engine is also smaller, lighter and compact which also saves much energy.

4. Variable Valve Timing (VVT):

The valves in an internal combustion engine are responsible for controlling the intake and exhaust gases into and out of the combustion chambers. In other words, valves are lungs of an Internal Combustion Engine. The timing, duration and lift of these valves is significant and plays principle role in engine's performance.

In an engine, during the intake the piston moves from the TDC to BDC, intake valve open and air flows into the engine. Then in the compression stroke the intake valve closes and gas is compressed. During the power stroke the piston moves towards the BDC. At last, exhaust valve opens and gas is expelled out. But, in actual case, the valves do not open/close at dead center positions but open/close at some degree on either side of the dead centers. The opening of valve occurs earlier and the exhaust continues even at latercrank angles. This is done to draw more air in the intake stroke and thus increases engine's performance.

In this case an engine will have a period of "valve overlap" at the end of the exhaust stroke, when both the intake and exhaust valves are open. The intake valve opens before the exhaust gases completely leave the cylinder, and their velocity aids in drawing in the fresh charge. Engineers aim to close the exhaust valve just as the fresh charge from the intake valve reaches it, to prevent either loss of fresh charge or un-scavenged exhaust gas.

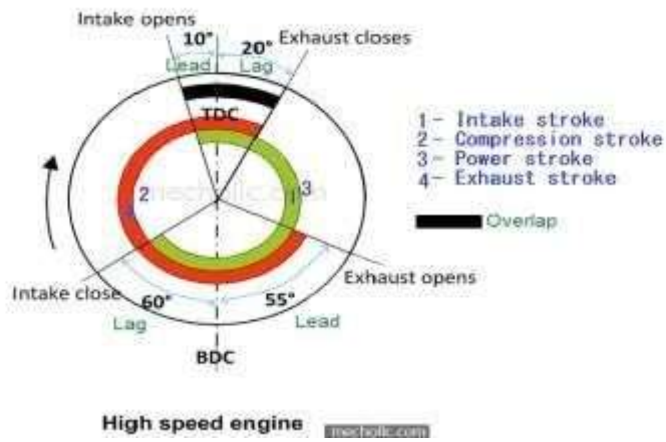

***Figure* 4.1**-Valve Timing Diagram

1. Need for Variable Valve Timing

Without variable valve timing, the valve timing would be the same for all engine speeds and operating conditions. For instance, the engine running at a higher **rpm**s it needs to draw more air, but the intake valves may close before enough air has entered each combustion chamber, reducing performance of the engine. So, a system must be introduced which could alter valve, depending upon the speed and operating conditions. An engine equipped with a variable valve timing actuation system is freed from constraint, which allows performance to be improved over the engine operating range.

In automobiles, the opening and closing of the valves is controlled by camshafts. The cams lift the valves for a certain period of time during each intake and exhaust cycle. The valve timing, relative to the position of the crankshaft, is important. The camshaft is driven by the crankshaft through gears, timing belts or chains.

2. Valve Timing Terminologies

1. **Valve Timing:** At what time during the engine's working, the valve will open
2. **Valve Duration:** For how long the valve will open
3. **Valve Lift:** How much valve will move above valve seat

4.3 Methods for implementing Variable Valve Timing

4.2.1 Cam switching

- Uses two cam profiles, with an actuator to swap between the profiles (at a specific engine speed).
- Provides variable valve lift and variable duration**.**

The drawback is adjustment is discrete rather than continuous.

Application

Honda's VTEC system. VTEC changes hydraulic pressure to actuate a pin that locks the high lift, high duration rocker arm to an adjacent low lift, low duration rocker arm(s).

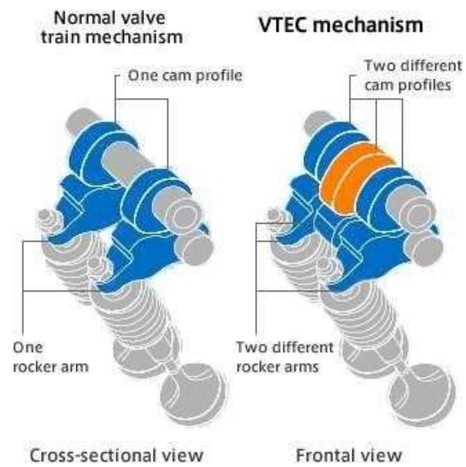

***Figure* 4.2**-Cam Switching

4.2.2 Cam phasing

- Most common used method for implementing Variable Valve Timing.

•Uses a device called variator which allows continuous adjustment of the cam timing

The draw back of the system is that the duration and lift cannot be adjusted.

Applications

Mostly automobile's manufacturers use this method of VVT.

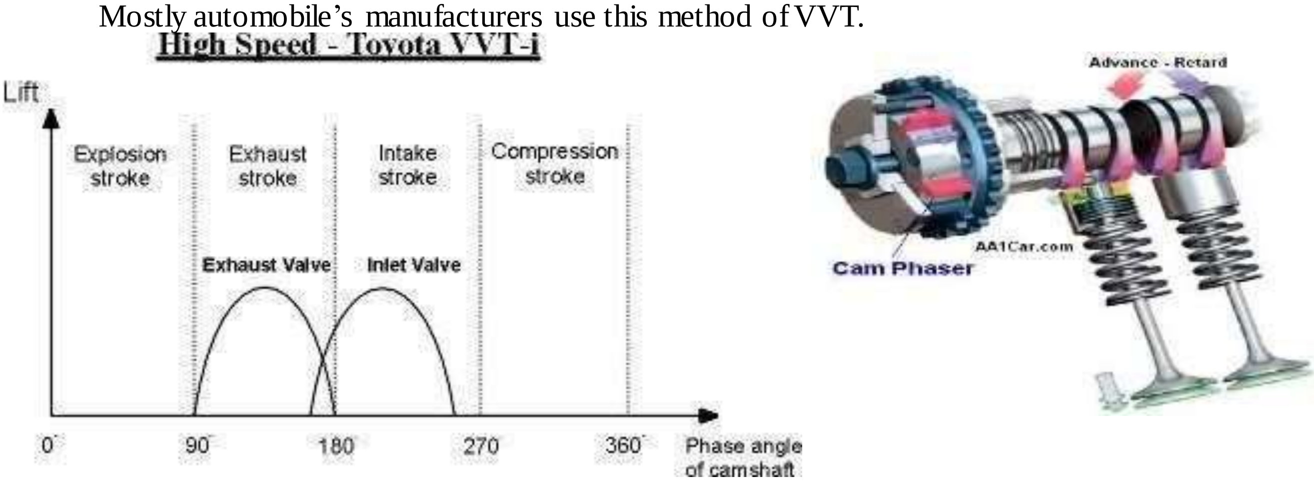

***Figure* 4.3**-Cam Phasing

4.2.3 Oscillating cam

- Uses an oscillating or rocking motion in a part cam lobe, which acts on a follower.
- Follower then opens and closes the valve.
- Some oscillating cam systems use a conventional cam lobe, while others use an eccentric cam lobe and a connecting rod.
- The major advantage is adjustment of lift and duration is continuous.

In these systems, lift is proportional to duration, so lift and duration cannot be separately adjusted.

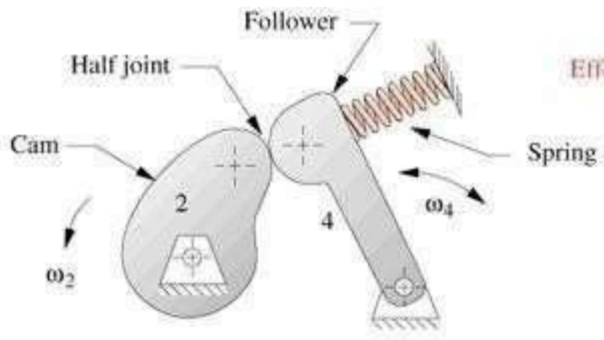

***Figure* 4.4**-Oscillating Cam

Applications

The BMW (valvetronic), Nissan (VVEL), and Toyota (valvematic) oscillating cam systems act on the intake valves only.

4.2.4 Eccentric cam drive

- Eccentric cam drive systems operate through an eccentric disc mechanism
- The mechanism slows and speeds up the angular speed of the cam lobe during its rotation.
- The advantage of this system is that duration can be varied independent of lift.

The drawback is two eccentric drives and controllers are needed for each cylinder, which increases complexity and cost.

Applications

MG Rover is the only manufacturer that has released engines using this system.

***Figure* 4.5**-Eccentric Cam

5. Exhaust gas recirculation (EGR) system:

1. Background:

In case of complete combustion in an internal combustion (IC) engine the only products which will be expelled out from exhaust are water vapors and carbon dioxide. Both of these products are harmless. CO_2 is an inert gas and is not directly harmful to human beings. In reality, air-fuel mixture does not burn completely and incomplete combustion generates several harmful products (i.e. pollutants). Nitrogen oxide (NO_X) is one of these pollutants. Prolonged exposure of these oxides of nitrogen is dangerous to health. Nitrogen and oxygen react at very high temperature. High peak temperature and availability of oxygen in the engine cylinder are main cause of NO_X formation. In the present of oxygen inside the combustion chamber at high combustion temperatures the following chemical reactions will takes place behind the flame.

$$N_2 + O_2 \xrightarrow{yield} 2NO$$

$$N_2 + 2H_2O \xrightarrow{yield} 2NO + 2H_2$$

Balanced chemical equations show that a significant amount of NO will be formed at the end of combustion. The majority of NO produced will however decompose at the low temperatures of exhaust. But, due to very low rate of reaction at the exhaust temperature, a part of NO formed remains in exhaust. The NO formation will be less in rich mixtures than in lean mixtures. The concentration of oxides of nitrogen in the exhaust is closely related peak combustion temperature inside the combustion chamber.

In order to control the amount of NO_X forming during combustion oxygen content resent in the cylinder and temperature of the cylinder should be reduced. There are number of ways to do so. Among these one method is to introduce an inert gas or non-combustible substance in the engine cylinder which will perform dual function. It will take some space in the cylinder volume and thus less amount of air (oxygen) will come inside the cylinder during intake stroke. Secondly, it will absorb some of the heat produced during the combustion. Reduction in two main reasons of nitrogen oxides formation limits the amount of NO_X formed. The following method is used for reducing peak cycle temperature and thereby reducing NO_X emission.

5.2 Exhaust gas recirculation:

In the internal combustion engines, exhaust gas recirculation (EGR) system is basically a simple method of reducing Nitrogen Oxides (NO_X). This system recirculates some of the exhaust gases back to the Engine cylinder. These exhaust gases dilute O_2 incoming air stream and include some inert gases which can absorb excessive heat generated in the engine cylinder, thus limiting the peak in-cylinder temperatures. At low temperature NO_X are not produced in the engine cylinder.

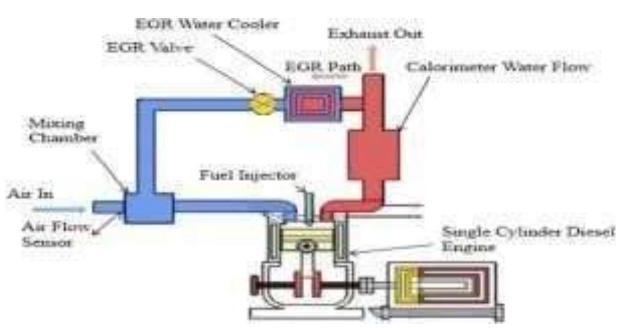

***Figure 5.1**-Schematic diagram of EGR*

Exhaust gases re-circulated to the engine should be 5-15% only in the total intake volume. This maximum quantity is limited by the need to sustain continuous flame during combustion. Excessive EGR in poorly set up applications can cause misfires and partial burns.

5.2.1 Cooling system for Exhaust Gas Recirculation:

The exhaust gas drawn off for recirculation has a temperature of around 650 degrees Celsius. It is therefore far too hot to be fed directly into the cylinders; it would increase the temperature of the combustion chamber even further, thereby defeating its actual purpose — that of reducing nitrogen oxide formation by lowering the combustion temperature. For this reason, the exhaust gas is first cooled to around 120 degrees Celsius.

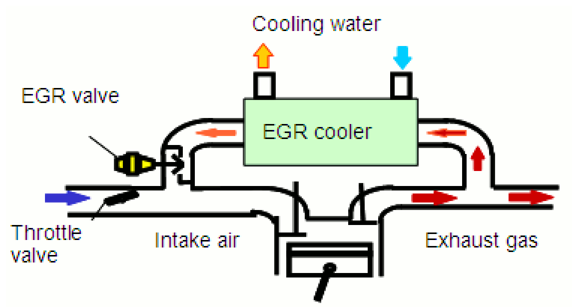

***Figure 5.3**-Cooling of EGR*

5.3 Effect of EGR on NOX and HC formation:

Exhaust gas recirculation system limits the amount of NO_X by lowering the temperature of the engine. While performing its function EGR system deposits more carbon (C) content due to reduction in oxygen intake. These effects are clearly shown in fig (2).

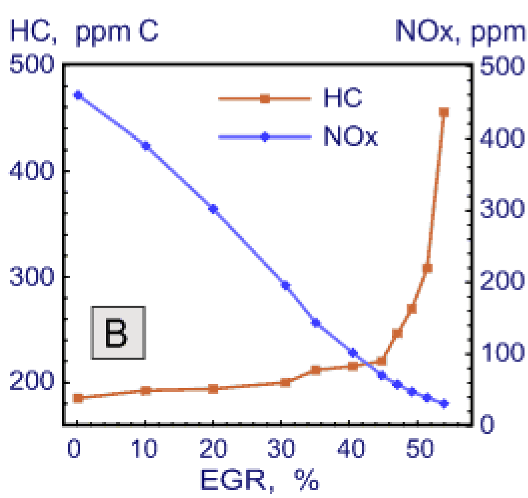

***Figure 5.4**-Percentage EGR vs. NO_X and C*

From the graph it is concluded that as the percentage of EGR increases nitrogen oxide formation reduces and formation of Carbon content in the engine increases.

4. Advantages of EGR:

- NO_X formation reduces.
- Reduction in cylinder temperature improves the engine lifetime (especially exhaust valve life).
- There is potential reduction of throttling losses on spark ignition engines at part load.

6. Continuously Variable Transmission (CVT):

1. Background:

In automobiles power is generated by the engine and available at the crank shaft for usage. Problem is that we cannot supply power generated directly from source engine to the wheels because we need to alter speed and torque of the vehicle. Initially, we need high torque but low speed to start the automobile but as the vehicle continue its journey we need to switch from low speed to high speed of vehicle and less torque. Thus we need a system which will enable us to perform this function, such a system is called is called transmission system. Basic job of transmission system is switching between high and low speeds, and corresponding torque.

Transmission system is simply refers to as gearbox which consists of gears and gear trains in order to accomplish the conversion of speed and torque from rotating power source to other device. When an automobile starts, engine rotates at very high speed. This high speed is inappropriate for starting, stopping and slower travel. Transmission limits this high speed to the low speed increasing torque in the process by altering the gear number.

In transmission system, there are certain numbers of gears which can be switched in order to perform its job. Switching of gears can be done manually or automatically. In case of manual transmission system there is driver operated clutch which is engaged or disengaged by foot pedal in automobiles and thus regulates torque transfer from engine to transmission, and gear selector operated by hand. Schematic diagram of Manual transmission system is shown in fig (4).

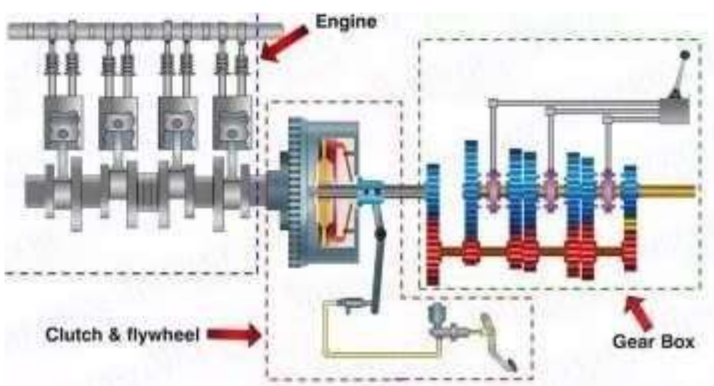

Figure 6.1- Schematic diagram of Manual transmission system

Main disadvantage of manual system is that for every gear change, jerk is felt. Driving in bumper-to-bumper traffic in large cities can be both a nuisance and a wallet-breaker if you own a manual transmission. Those familiar with driving a manual transmission in urban areas often complain about leg cramps and increased workload when driving in traffic. With a third pedal to actuate during shifts, a manual transmission can quickly become annoying. Automatic transmissions are considerably easier and more convenient to drive in stop-and-go traffic.

6.2 CVT:

Continuously variable transmission is an automatic transmission which can change gear seamlessly through a continuous rage of effective gear ratios. It does not offer fixed number of gear ratios like manual transmission system. It allows the automobile's engine to run at its most efficient revolutions per minute for a range of vehicles speed. When power is more important than economy, the ratio of the CVT can be changed to allow the engine to turn at the RPM at which it produces greatest power. This is typically higher than the RPM that achieves peak efficiency. In low-mass low-torque applications (such as motor scooters) a belt-driven CVT also offers ease of use and mechanical simplicity

Figure 6.2*-Engine connected with CVT*

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6.3 Working of CVT:

Conventional automatic transmissions use a set of gears that provides a given number of ratios (or speeds). The transmission shifts gears to provide the most appropriate ratio for a given situation: Lowest gears for starting out, middle gears for acceleration and passing, and higher gears for fuel-efficient cruising.The CVT replaces the gears with two variable-diameter pulleys, each shaped like a pair of opposing cones, with a metal belt or chain running between them. One pulley is connected to the engine (input shaft) and the other to the drive wheels (output shaft). The halves of each pulley are movable; as the pulley halves come closer together the belt is forced to ride higher on the pulley, effectively making the pulley's diameter larger.

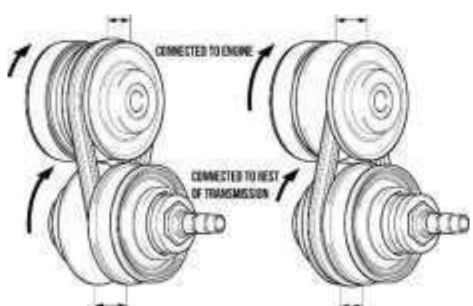

Figure 6.3*-variation in pulley diameter*

Changing the diameter of the pulleys varies the transmission's ratio (the number of times the output shaft spins for each revolution of the engine), in the same way, that a 10-Speed bike routes the chain over larger or smaller gears to change the ratio. Making the input pulley smaller and the output pulley larger gives a low ratio (a large number of engine revolutions producing a small number of output revolutions) for better low-speed acceleration. As the car accelerates, the pulleys vary their diameter to lower the engine speed as car speeds rises.

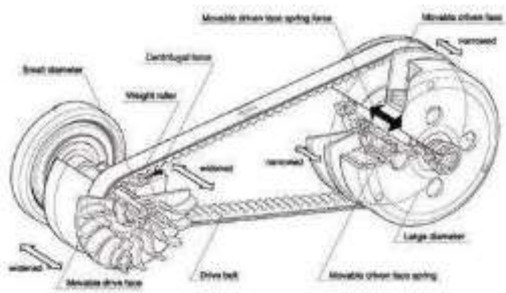

***Figure** 6.4-Schematic diagramof CVT*

This is the same thing a conventional transmission does, but instead of changing the ratio in stages by shifting gears, the CVT continuously varies the ratio -- hence its name

6.3.1 Effect of CVT on vehicle speed and fuel consumption:

In case of manual transmission system gears are to be changed alternatively, thus at every gear change there is decrement of speed and then increment which causes inconvenient. In auto transmission although there is no need to change gears manually but a jerk is felt during gear change due to fluctuation in engine speed. Following ***Figure***s shows comparison between CVT and Auto/Manual transmissions

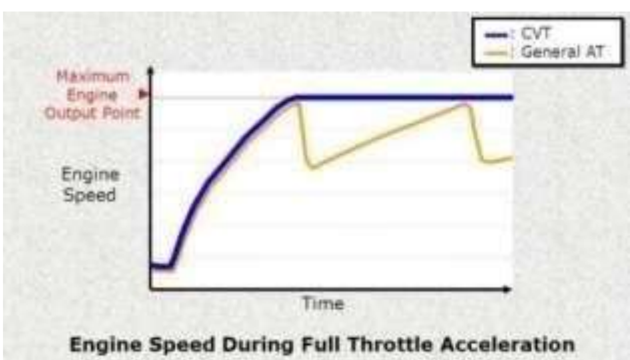

Figure **6.6**-variation in speed for CVT and General AT

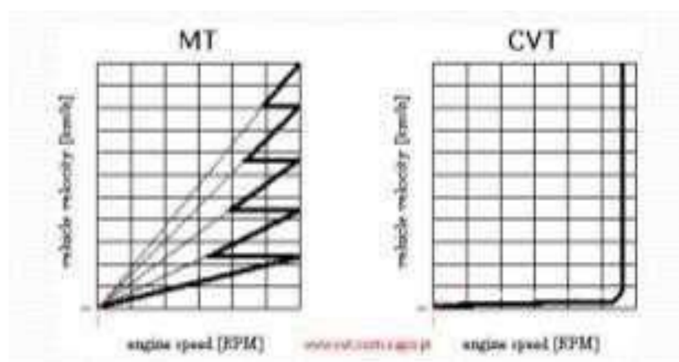

Figure **6.5**-Variation in speed for CVT and Manual Transmission

CVT not only improves speed variation over time but also it makes automobile fuel efficient. An automobile having CVT consumes less fuel than manual transmission system. This is because, in CVT there are not number of gears mounted on shaft rather pulley-belt arrangement is present which offers less frictional effects and thus less fuel is consumed. Comparison is shown below for CVT and Manual systems over years.

***Figure 6.7**: Fuel Consumption for CVT and Manual systems*

7. GDI (Gasoline Direct Fuel Injection)

It is a Fuel injection system in which gasoline is directly injected into the cylinder of a gasoline automobile engine. Usually we know that gasoline is injected into the engine after mixing it with air in carburetor.

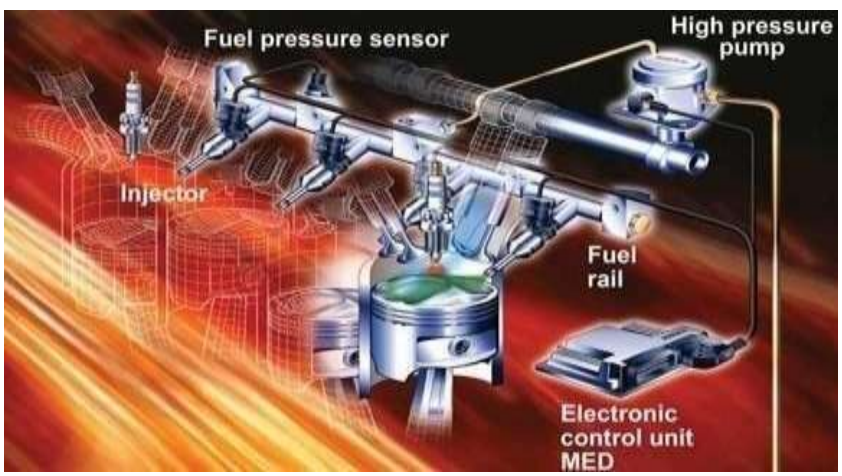

***Figure* 7.1**- Fuel injection system using GDI

7.1 Working of GDI

Gasoline engines work by sucking a mixture of gasoline and air into a cylinder, compressing it with a piston, and igniting it with a spark. The resulting explosion drives the piston downwards, producing power. This conventional sort of system has some drawbacks as well which are being discussed in section. Therefore, some modifications in the fuel injection system of gasoline automobile system was made and gasoline direct injector was introduced. In this system the gasoline is directly injected into t6he engine while compressed air is drawn either by supercharging, by turbocharging or using any air induction method.

After filtering the fuel from the fuel filter the pressure of the fuel must be raised. This is being done by a fuel pump which is connected to the ECU (Engine control unit). The pressurized fuel is now ready to be pumped into the engine via an electrically operated fuel injector.Schematic diagram of GDI system is shown

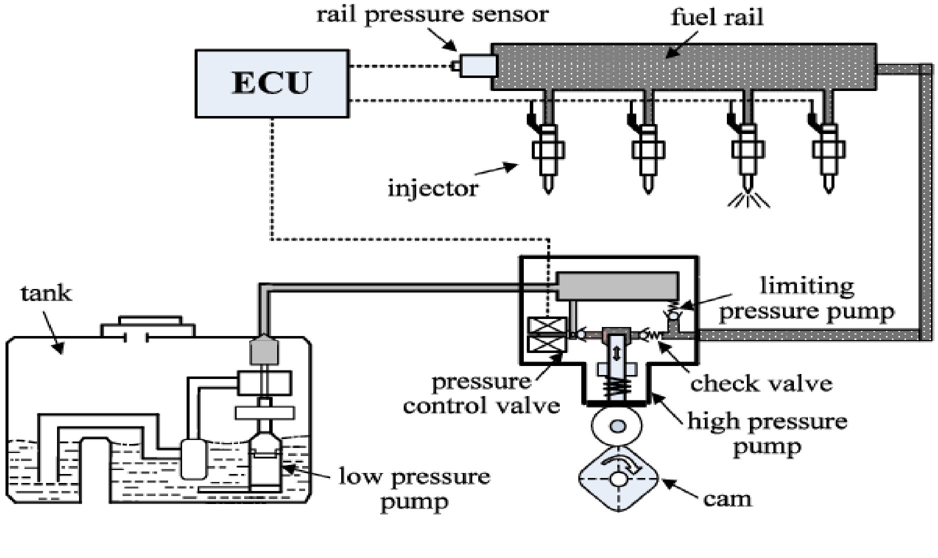

***Figure* 7.2**-Schematic diagram of GDI system

7.2 Need of GDI system:

•At low speed or while cranking, the mixture supplied by a carburetor is not much enriched so it will not ignite properly and for its enrichment, at such conditions some arrangement in the carburetor was required.
•Atmospheric pressure can change the working of carburetor because at different atmospheric pressures the amount of air entering the carburetor may vary.
•It gives the proper mixture at only one engine speed and load, therefore, suitable only for engines running at constant speed.
- Maintenance costs of carburetor are higher .

Above mentioned problems can be solved by using Gasoline direct injector system which controls emission level, improves the fuel consumption efficiency of engine and increase the power output of the automobile.

3. Comparison between GDI system and Carburetor:

1. Speed vs. Power output:

The speed vs. power output curves of engines with carburetor and with GDI system have been shown below:

7.3.2 Speed vs. Power output:

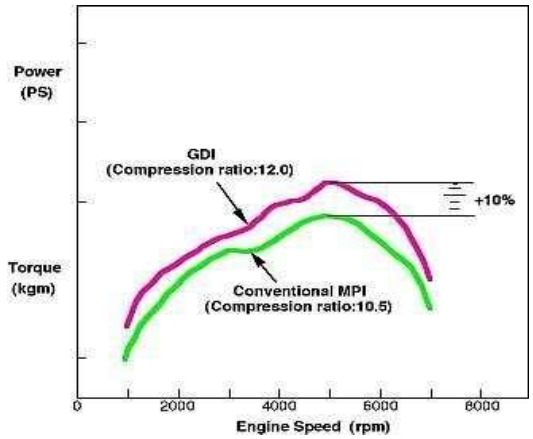

Figure 7.3:showing RPM vs. power relation

7.3.3 Speed vs. Fuel consumption Graph:

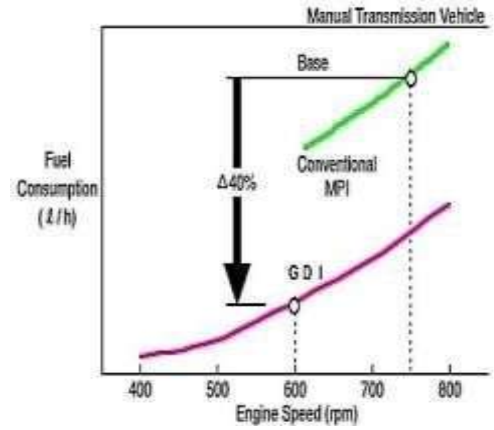

***Figure* 7.4**: showing RPM vs. Fuel consumption relation

4. Advantages of GDI system:

1. Power Output

With the exception of some high end modified vehicles, fuel injection usually offers a much better power output and performance than a standard carburetor-based vehicle.

2. Fuel Efficiency

Because fuel injection is usually controlled by a vehicle's electronic control unit or car computer, fuel consumption is usually managed much better than with a carburetor. It almost always results in better fuel efficiency.

3. Emissions Performance

With better fuel efficiency comes better emissions performance. Fuel injected vehicles produce far fewer carbon based emissions than vehicles with carburetors.

4. Ability to Accommodate Alternative Fuels

Vehicles that use direct fuel injection are better equipped to handle alternative fuels, and fuels with additives that are designed to help keep your car engine clean.

5. Drivability and Smooth Operation

Vehicles that use fuel injection rather than a carburetor usually drive much smoother, because fuel flow is better managed and more consistent.

6. Diagnostic Capability

Because direct injection is regulated by your car's computer, problems with fuel injection can easily be diagnosed with a simple computer diagnostic test

5. Automobiles using GDI technology:

- Sport car 9
- In 1955, launch of Mercedes 300 SL with direct injection.
- First serial application with 4 stroke engine.

- 1996: First stratified gasoline direct injection on Mitsubishi Galant
- 1998: Toyota D4
- 1999: Renault IDE (Lambda 1 with high EGR rate)
- 2000: First Bosch gasoline direct injection VW « FSI » engine
- 2000: PSA HPI engine
- 2005: PSA Prince engine THP
- The Audi R8 4.2l FSI gained the victory in 2001 of the famous race “24 heures du Mans” with the gasoline direct injection technology.

8. EFI (Electronic Fuel Injection) System

Fuel injection is defined as the introduction of fuel in the automotive engine by the means of a fuel injector. Fuel injectors are mechanically operated as well as electronically operated. Mechanically operated fuel injectors have some disadvantages. In 1967, first serial application of the indirect injection controlled by electronics (VW 1600). By the introduction of electronic control system in automobiles, the problems of emissions and fuel wastage has been reduced .

1. Functions:

It can be considered as the brain of the automobile. Engine Control Unit (ECU) performs four basic operations in the smooth running of an automobile:

- ECU controls the fuel mixture.
- ECU controls idle speed.
- ECU is responsible for ignition timing
- ECU controls valve timing.

2. Working:

ECU can be considered as a black box. Several receivers and sensors collect data for ECU and there is a microprocessor which is actually the part of ECU which processes the data provided by the various sensors then it sends the information to actuators. Following fig

It can be seen form fig that there are several sensors like oxygen sensor, Air temperature sensor, Engine temperature sensor, MAP sensor and other receivers and sensors are there. Similarly there are some actuators which are performing useful work. All sensors and actuators are linked by a microprocessor. Microprocessor receives data from the sensors and then gives instructions to various actuators to perform useful work.

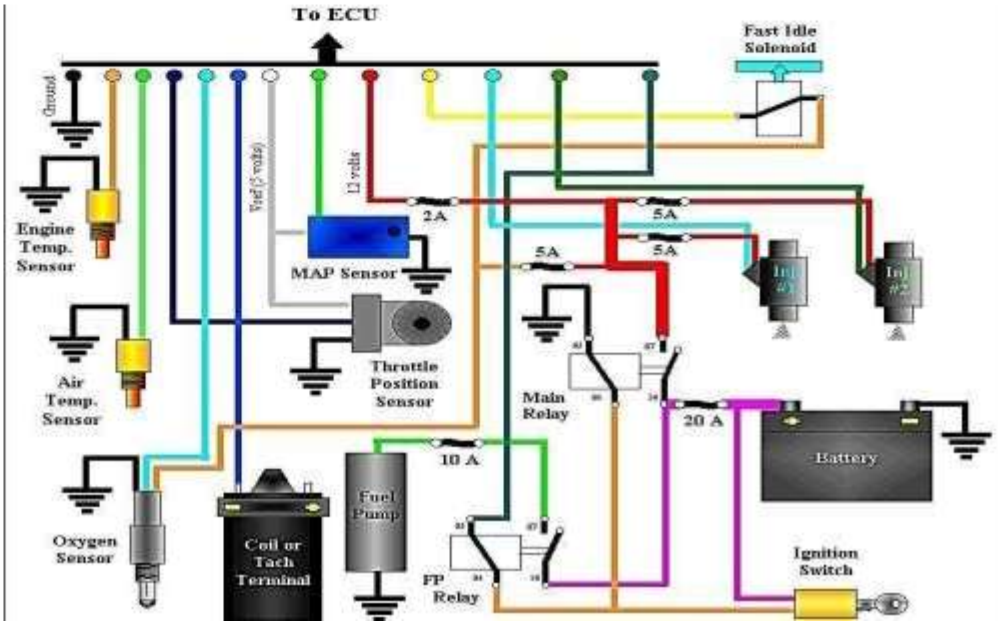

Figure **8.1**: showing schematic diagram of ECU

3. Disadvantages of Mechanical fuel injection system:

Mechanical fuel injectors are operated on the principal that pressurized fluid exerts pressure on the valve to open it. They have the limitation on delivering optimal fuel to the engine. Their incompetency to provide optimum amount of fuel is due to the fact that these injectors are affected by following parameters:

- Engine's speed and
- Load
- Atmospheric and engine temperatures
- Altitude
- Ignition timing

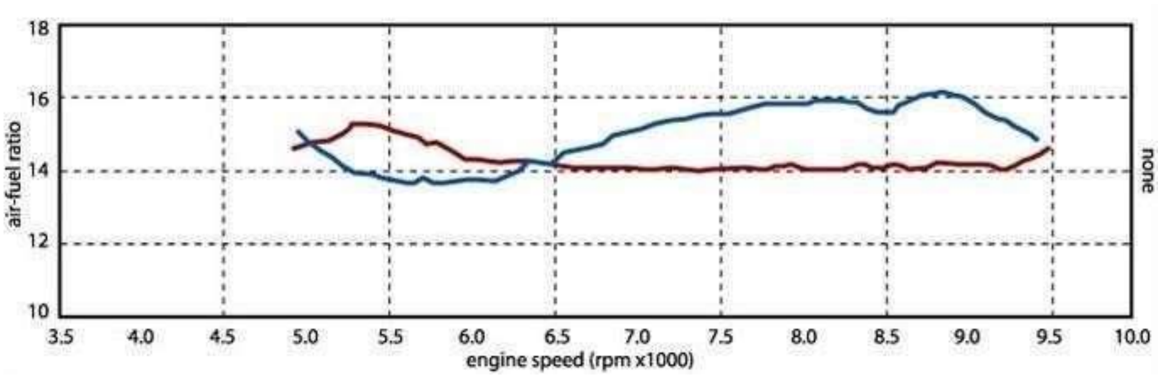

Figure **8.2**-Relation between A/F and RPM

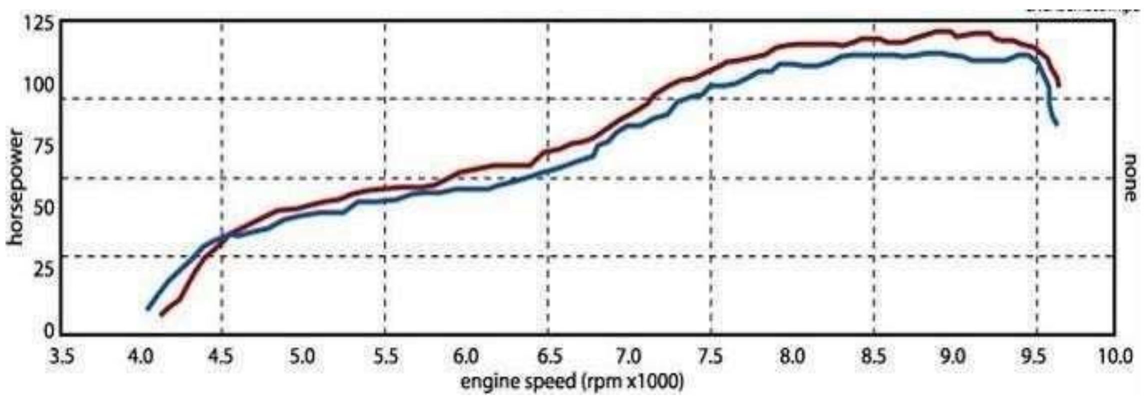

***Figure* 8.3**-Power vs. Rpm relation

9. Turbocharging and Supercharging:

Turbocharging and supercharging are two important processes through which sufficient air is forced in the cylinder of an engine. These are forced induction systems. Both these processes provide air to the engine which produces more power as the volumetric efficiency of the engine.

1. Turbocharger:

It is a forced induction system which forces the incoming air of the atmosphere by the push provided by the outgoing exhaust gases. It is actually a turbine based forced induction part of the automobile engine that increases the efficiency of the engine.

***Figure* 9.1**-Turbocharger

9.1.1 Need of turbocharger:

As we know that the efficiency of engine depends upon the volumetric efficiency of the engine. The volumetric efficiency of the engine can be increased using multiple solutions. We can use supercharger

We can use following means to achieve our goal:

- By ducting intake air from outside of the engine compartment
- By changing the time for which the valves opens
- By supercharging

- By turbocharging

All the above-mentioned methods except turbocharging does not give efficient system . They can maintain the system to some extent but they are not much effective ways therefore the invention of turbocharger took place. We can have volumetric efficiency close to 100%.

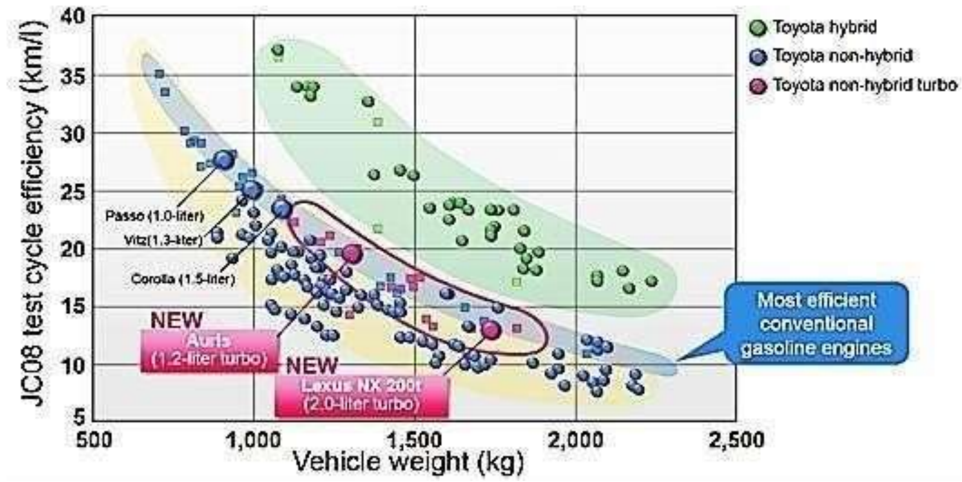

***Figure* 9.2**-Efficiency of various automobile engines

9.1.2 Parts:

Turbocharger consists of following parts:

- Compressor
- Turbine
- Control system
- Bearing system

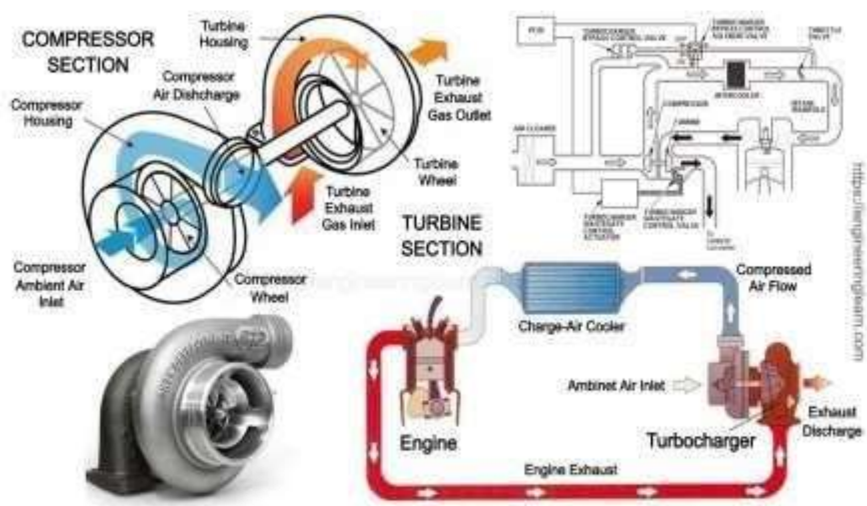

***Figure* 9.3**-Schematic diagram of Turbocharger

9.1.3 Working:

The spindle of turbo charger is attached with two wheels one is compressor wheel and the other one is the turbine wheel. When outgoing air is passed through the turbine wheel it makes the spindle rotate and the compressor wheel forced the incoming air to come into the cylinder.

9.1.4 Future work:

In future we are looking for the replacement of gasoline with some other fuels. In some countries

RPM vs. Power curves for turbo charged and ordinary engine:

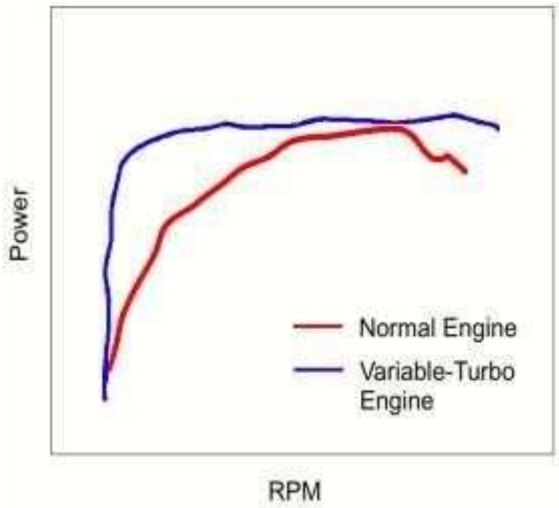

Figure **9.4**:-Showing RPM vs. Power

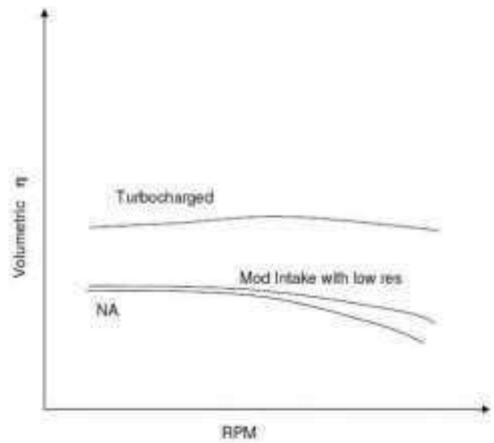

Figure **9.5**-RPM vs. vol. efficiency curve

gasoline has been partially been replaced by ethanol but all over the world gasoline is still a fuel which is being used in excess. The following graph sows the consumption of ethanol in US.

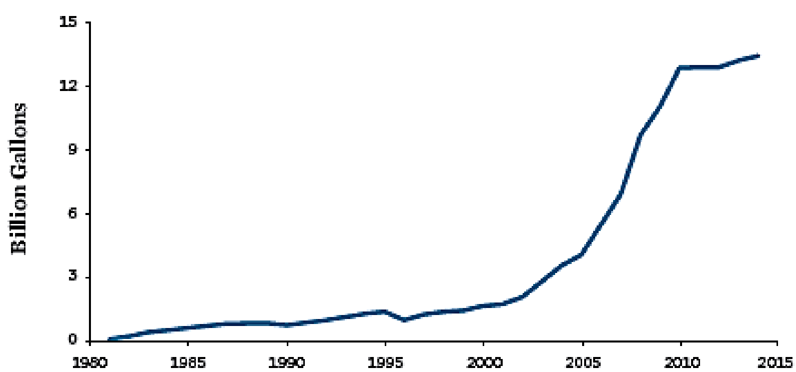

Figure **9.6**-Consumption of ethanol in US.

We want to replace gasoline because of a number of factors.Gasoline increases the emission rate of CO_2.The following graph clearly shows this claim.

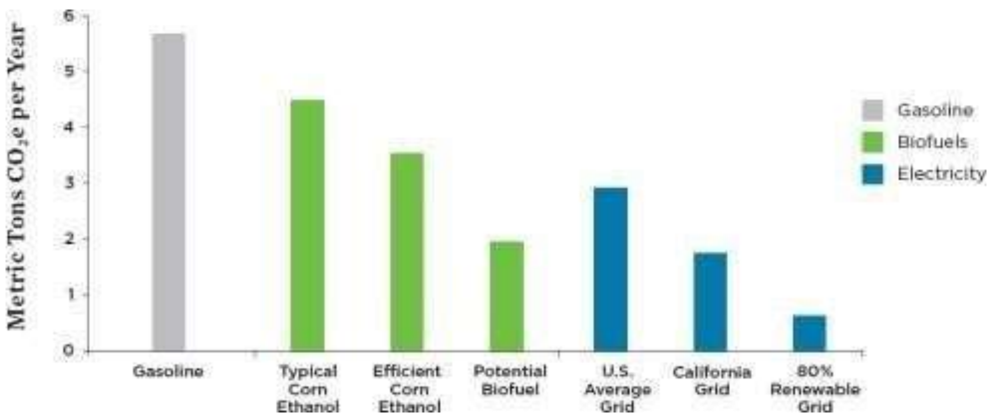

***Figure* 9.7**-Production of carbon dioxide through various sources

Oil and Gasoline Are Not the Only Things Causing Climate Change, but They Are Among the Biggest.

Other improvements in fuel systems are as follows:

1. Fuel Pump Relays
2. Modern Fuel Pumps, Filters, and Regulators
3. Pulse-Modulated Fuel Pumps
4. Fuel Delivery System Sensors
5. Fuel System Diagnostics.