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Review of theModern developments in Suction processes of IC Engines

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Abstract
This review paper deals with the evolution of the general processes employed in the suction process of IC Engines. The suction process has evolved from the traditional use of carburettors to much more sophisticated systems like CRDi, MPFi, etc. used in modern days. In doing so, various parameters such as the volumetric efficiency and the turbulence, etc. inside the engine have to be considered. Additional processes such as supercharging and turbocharging are employed to improve these parameters. It is also highly desirable to vary the Air-Fuel ratio effectively according to the speed of the engine for better power output and mileage. Thus researchers have developed several ways over the years to achieve it. Recent research work being carried out in this field is in the areas of Pressure Wave Superchargers, Variable Geometry Turbochargers, Multiple Intake valves, Shrouded Intake Valves, Camless Engines etc. Many of these technologies have been employed in the industry such as the DTS-Si, TDi&i-vtec Engines. Thus, the Automobile Industry has come a long way in evolving the intake processes and further developments will always be on the way.
Keywords: Volumetric efficiency, Turbulence, Swirl, Carburettor, Fuel Injector, Supercharger, Turbocharger.

I. Introduction

The suction process is one of the most basic and yet one of the most important processes in IC Engines. Hence there has been continuous improvement in it over the years. This review paper deals with the evolution of the suction process from the traditional Carburettors to the modern advanced Injection systems. As the process of admitting the charge into the cylinder is completely different for SI and CI engines, i.e. in SI engines Air and Fuel are first Premixed inside the carburettor or the intake manifold and then injected into the cylinder whereas in CI engines Air is alone first taken into the cylinder and compressed and then near the end of the compression process the fuel is injected, hence these two processes have been dealt with separately. But the factors which are to be considered for the suction process remain more or less the same and hence have been accounted for together. At the end the modern developments and processes currently employed in the industry have been discussed.

II. Factors Affecting the Suction Process

2.1 Volumetric Efficiency

Volumetric Efficiency is basically the ratio of amount of air inducted into the cylinder to the stroke volume of the cylinder.Volumetric efficiency varies with engine speeds but it is desirable to obtain maximum volumetric efficiency at the intake of any engine. At a certain speed volumetric efficiency is maximum, decreasing at both higher and lower engine speeds. The relation between the volumetric efficiency and the parameters governing it is in general given by:

$\eta_v = 2m_a/(\rho_{a,0} V_d N)$

where, η_v = volumetric efficiency
m_a = mass flow rate of air
$\rho_{a,0}$ = density of air
V_d = displaced cylinder volume (stroke volume)
N = engine speed in rpm

There are various parameters governing the volumetric efficiency which is mentioned below:

- Fuel
- Heat Transfer
- Valve Overlap
- Fluid Friction losses
- Choked Flow
- Closing intake valve after BDC
- Intake tuning
- Exhaust residual

2.2 Turbulence

Higher turbulence increases the real time rate of fuel evaporation, mixing of the fuel vapour and air and combustion. Thus, higher turbulence is beneficial for an engine cycle.

2.3 Air Fuel Ratio

Air–fuel ratio(AFR) is the mass ratio of air to fuel present in an internal combustion engine. It is highly desirable to vary the air-fuel ratio according to the load on the engine for better fuel efficiency and mileage. But supplying the correct air-fuel ratio for a given speed is a big challenge.

III. Fuel Induction Systems in SI Engines

3.1 Carburettors

Carburettors are the most primitive type of fuel induction system used. The structure of a carburettor is as shown in the figure.
But due to various problems encountered in this system of fuel induction, carburettors are obsolete in modern vehicles and new technologies like MPFi have been adopted.

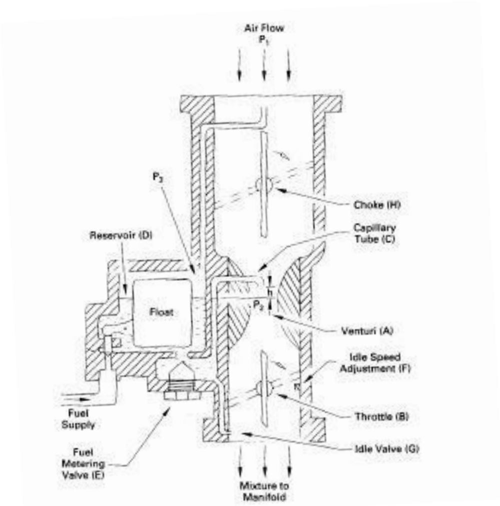

Fig 1-Basic construction of a carburettor

3.2 Fuel Injectors

Fuel Injectors are nozzles that inject a spray of fuel into the intake air.They are electronically or mechanically controlled.A metered amount of fuel is trapped in the nozzle end of the injector at high pressure and is injected into the surrounding air at the proper time.To inject the exact amount of fuel at the right time and as tiny droplets for better mixing and evaporation to occur a variety of fuel injection systems have been evolved, some of them are as follows.

3.2.1 Electronic fuel injection systems (EFIs)

The above fuel injection systems were mechanical and used complex designs and weighed heavier. They have now been replaced by electronic injection systems.

3.2.2 Single-Point Throttle Body Injection

In this system an electronically controlled injector meters the fuel and injects it into the air flow directly above the throttle body.The injector meters the fuel in response to calibration of air flow based on intake manifold pressure,air temperature and engine speed.The main problem with this type of injection system is obtaining equal distribution of fuel to all cylinders and the fuel particles have a tendency to deposit on the walls of the manifold when cold.

3.2.3 Multi-Point Port Injection (MPFi)

In this system the fuel is injected into the intake port of each cylinder just before the inlet valve.It requires one or more injectors per cylinder.The advantages of this system are improved power and torque through improved volumetric efficiency and more uniform fuel distribution to each cylinder and rapid response to the changes in the throttle position and hence an appreciable fuel economy. There are basically 2 types of MPFi systems.

3.2.3(a) D-Jetronic EFI System

This was the first generation of EFI developed at BOSCH. Here the 'D' stands for 'Druck' which means pressure. The name is derived from the fact that one of the main input signals is the intake manifold pressure. As shown in the fig. An electrically driven fuel pump delivers the fuel through a filter to the fuel line.The pressure regulator maintains the pressure in the line at a fixed value(around 2.7 bars).The control unit receives the main input signals from the pressure sensors connected to the intake manifold and receives the speed information from the distributor and thus meters out the required quantity to the injectors.

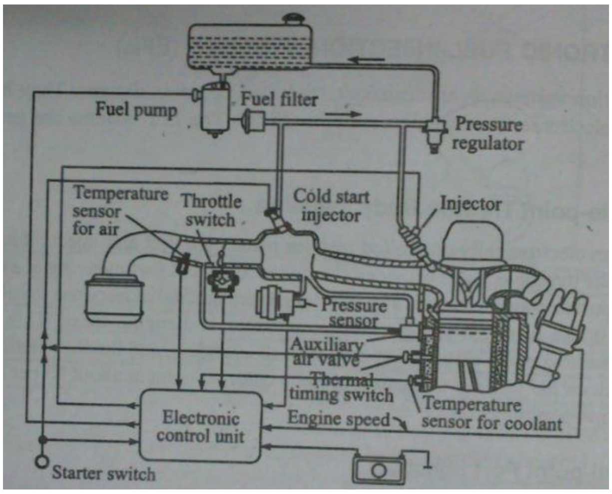

Fig 2- D-Jetronic EFI system

3.2.3(b) L-Jetronic EFI system

This is the second generation EFI system developed at BOSCH. It uses the air-flow rate as one of the basic input signals. Its name is due to the fact that L stands for 'Luftmengenmessung' which means air flow measurement. As shown in the fig. the fuel loop is basically the same as in D-Jetronic system,except that the pressure regulator is connected through a hose to the intake manifold. Thus the fuel pressure is a function of the manifold pressure. The air flow rate is measured by the air flow meter whose movable measuring plate is opened by the air stream against the force of a spring. The position of the measuring plate is sensed by a potentiometer. Its voltage represents the airflow rate, and is one of the main input signals going into the Engine control unit(ECU).

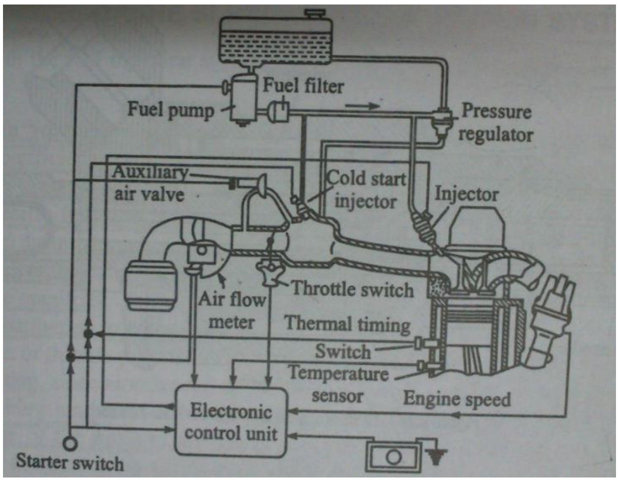

Fig 3-L-Jetronic EFI system with multi-point port fuel injection

IV. Fuel Injection systems in CI Engines

4.1 Individual Pump System

As shown in the fig. Each cylinder is provided with one pump and one Injector. The high pressure pump plunger is actuated by a cam and produces the fuel pressure necessary to open the spring -loaded injector valve at the correct time. This valve is a hydraulically operated automatic plunger valve i.e. no mechanism is required to operate it. The amount of fuel injected depends upon the effective stroke of the plunger. The fuel pump in this system is of reciprocating type and is always accompanied by a jerking noise and is therefore called a jerk pump.

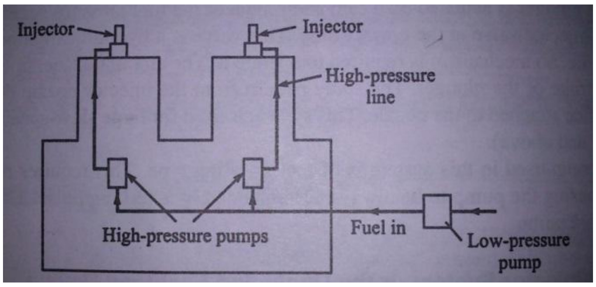

Fig.4- Individual pump system.

4.2 Common Rail Direct Injection Systems(CRDi)

The CRDi is the most recent and commonly used injection system in CI engines. The fig shows the schematic diagram of a CRDi system. In it, the fuel from the fuel storage tank is drawn through the primary fuel filters by a low pressure fuel feed pump. The discharge from this pump enters the high pressure fuel injection pump. This pump serves only to deliver the fuel under high pressure to a common rail, called the header, with the pressure held constant by a pressure regulating valve. The high pressure in the header forces the fuel to each of the nozzles located in the cylinders. At the proper time, a mechanically operated valve by means of a push rod and a rocker arm allows the fuel to enter into the cylinder through the nozzle. The amount of fuel supplied to the combustion chamber is regulated by varying the length of the push rod stroke.

A very big advantage of the common rail system is that it is self-governing. If the engine speed falls, an increased quantity of fuel is automatically injected, since the time taken for the same crank angle rotation, during which the fuel is supplied, is increased and as the fuel pressure is maintained constant, with increased time, the fuel supply will also be increased.

The disadvantages of the CRDi system are that Very accurate design and workmanship are required in this type of fuel –injection mechanism. The lift of the valve is very small and hence it requires absolute rigidity of the operating mechanism and freedom from vibration and temperature effects and negligible wear.

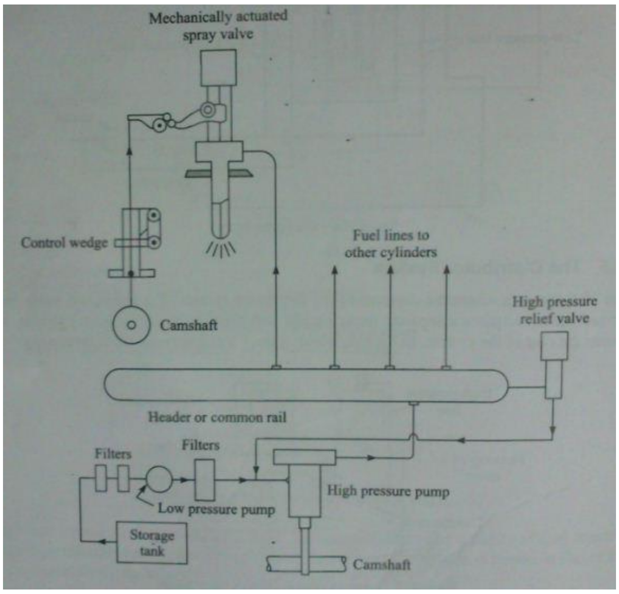

Fig 5- Common Rail Direct Injection System (CRDi)

V. Modern Developments in IC Engines

5.1 Superchargers

Superchargers and turbochargers are compressors mounted in the intake system and used to raise the pressure of the incoming air. This results in an increased volumetric efficiency and hence higher power output. Superchargers are mechanically driven directly off the engine crank shaft. They are generally positive displacement machines running at the same speed as the engine. The power to drive the compressor is a parasitic load on the engine output and hence this is one of the major disadvantages compared to a turbocharger. Other disadvantages include greater weight, higher cost and noise. A major advantage of superchargers over turbochargers is very quick response to throttle changes.

$W_{se} = m_a(h_{out} - h_{in}) = m_a c_p(T_{out} - T_{in})$

where: W_{se}= power needed to drive the supercharger
m_a= mass flow rate of air into the engine
c_p= specific heat of air
h = specific enthalpy
T = temperature

This assumes that the compressor heat transfer, kinetic energy terms, and potential energy terms are negligibly small, true for most compressors. All compressorshave isentropic efficiencies less than 100%, so the actual power needed will be greater than the ideal. In Fig. 6, process $1\text{-}2_s$represents ideal isentropic compression,while process $1\text{-}2_A$is the actual process with an increase in entropy. The isentropic efficiency $\eta_s$of the supercharger compressor is:

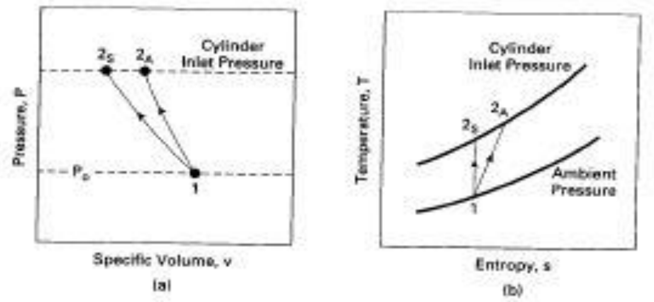

Fig 6- Ideal flow process ($1\text{-}2_S$) and actual flow process ($1\text{-}2_A$) through supercharger or turbocharger compressor

$(\eta_s)_{sc} = W_{isen}/W_{act} = [m_a(h_{2s} - h_1)]/[m_a(h_{2A} - h_1)]$
$= [m_a c_p(T_{2s} - T_1)]/[m_a c_p(T_{2A} - T_1)]$
$= (T_{2s} - T_1)/(T_{2A} - T_1)$

If the inlet temperature and pressure are known as well as the designed outputpressure, the ideal gas isentropic relationship can be used to find T_{2s}:

$T_{2s} = T_1(P_2/P_1)^{(k-l)/k}$

The actual outlet temperature T_{2A}can then be calculated from Eq. (5-14) if the isentropic efficiency is known. When using Eq. (5-15), a value of k = 1.40 shouldbe used because of the lower temperature at this point.

There is also a mechanical efficiency of less than 100% between the power taken from the engine and what is delivered to the compressor:

$\eta_m = (W_{act})_{sc}/W_{from\ engine}$

Thus the supercharger also raises the inlet air temperature by compressive heating as shown in the above equations and hence increases self-ignition and knocking problems in SI engines as al other temperatures will be high. Thus to avoid this many superchargers are equipped with an after cooler to cool the compressed air back to a lower temperature. However there is no such concern about knock problems in CI engines.

5.2 Pressure wave Superchargers(Comprex)

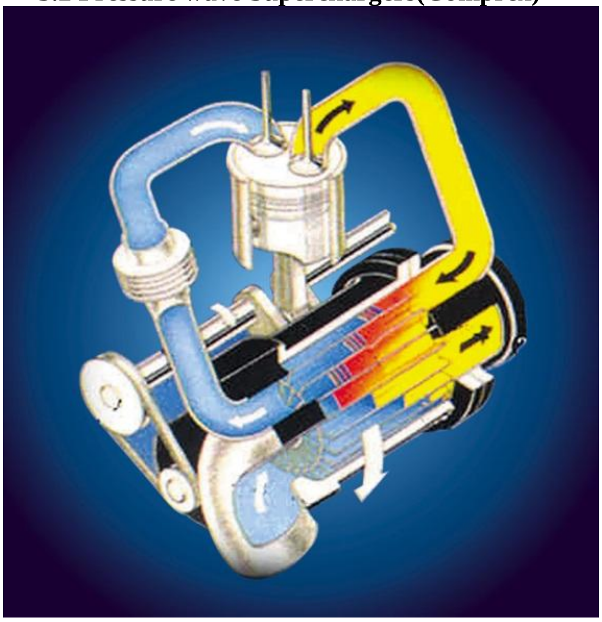

Fig 7- Working of a Comprex Supercharger

Officially called the Pressure Wave Supercharger, a Comprex is basically a stationary drum casing with a lost-wax cast straight-vane rotor spinning inside the drum, creating boost. Think of it as a wide water wheel inside a drum.

Like a turbo, the casing and rotor aren't in contact, but the clearance between the two is kept to a minimum (barring thermal expansion and creep) to prevent boost leakage. The synchronized belt-driven rotor is powered by the crank, moving around four to five times faster than the engine, but only drawing enough to overcome the frictional losses of the assembly. This means the Comprex doesn't suck power away from the engine to do the work of compression. The compression is done by the exhaust gases like a turbo, which is essentially free energy.

In pressure wave supercharging the power of the engine is not used to compress air like a simple supercharger and neither is it compressed by driving the rotating assembly with exhaust gases like a turbo.

This is where the 'pressure wave' portion of the name comes in. Incoming ambient air is compressed by using the pressure wave from the exhaust gas.

Each end of the drum has two different-sized ports, connected by ducts for air or exhaust gas to enter and exit. On one side of the drum, air enters from the intake at near-ambient pressure and exits at boost pressure to the intake manifold, while on the other side, exhaust gas from the exhaust manifold enters at high pressure and exits to the tailpipe at lower pressures. How compression is done is the hard part to explain.

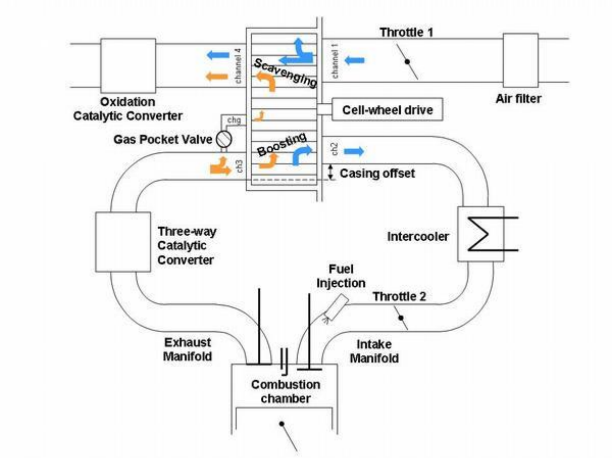

Fig 8- Schematic diagram of a Comprex Supercharger

The process starts as a given channel on the rotor already filled with ambient intake air. Neither end of this channel is lined up with a port, so it's completely sealed off by each end of the drum. As the drum rotates, the port on the right side, a smaller high-pressure exhaust orifice, is exposed first to let in the just-combusted gases, which introduces a compression or shock wave into the channel. The shock wave propagates at the localized speed of sound and pushes fresh air against the left wall of the drum, which is still closed and thus compressing the charge. These compression waves are not on account of the individual pulses of each cylinder firing, just the rapid introduction of two gases at different pressures.

As the charge compresses, it makes space, allowing the exhaust gas to enter the channel. Since the shock wave is traveling so fast, the two gases never mix. By this point, the channel has rotated to the high-pressure air port leading to the intake manifold. Although rated for the same mass flow rate, the smaller port is sized so that the compressed air exits at a much lower velocity. This deceleration of the compressed air causes a secondary shock wave to propagate toward the right (or exhaust) side, which compresses the fresh air further. This way, the boosted air going into the engine is actually at a higher pressure than the exhaust gases.

As this secondary compression wave reaches the right side of the drum, the high-pressure gas port closes, causing the compression wave to reflect back as an expansion wave, pushing most of the compressed air out and closing that port. By now, the low-pressure exhaust port on the right is exposed, letting the now slightly pressurized exhaust out into the tailpipe. This causes another series of expansion and compression waves that ultimately help pull in and completely fill the channel with fresh air, which brings us back to step one.

In its basic form, the Comprex only works well under specific conditions, because the speed of the compression waves depend on EGT (exhaust gas temperature), which fluctuates with torque and not engine speed. To stretch out the operating range to that of most engines, specially designed pockets are added to the intake and exhaust sides of the drum to compensate for the varying range of EGT and thus the wave propagation speed. Boost pressure is controlled by a conventional wastegate on the high-pressure exhaust duct.

The main advantage of the Comprex is the combined effect of response and efficiency. Since these pressure waves travel at the speed of sound, any change in load will cause an instant reaction in boost. Unlike a turbo, which has to wait for the compressor wheel to spin up to speed, it can also achieve apparent compressor efficiencies of up to 75 percent, compared to 60 percent seen in the best positive displacement compressors. The Comprex also turns much slower than a conventional turbo, meaning reduced loads on the rotor.

Comprex has not been able to completely replace Turbos mainly because of packaging. The Comprex cannot be bolted onto a manifold and thrown piping at. Also, the rotor, drum and port dimensions all need to be tailored specifically for a given engine.

Another concern is materials. The Comprex is widely used on diesel applications because of the lower EGTs. Making the Comprex tolerate higher EGTs from a gasoline engine is only now becoming affordable and practical. Flow reversal for the exhaust may also be an issue, although newer cross-flow and radial Comprex superchargers exist for industrial applications.

5.3 Turbochargers

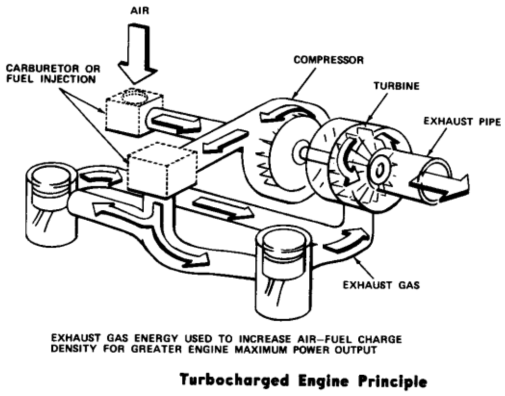

Fig 9- Schematic representation of a Turbocharger

The Compressor of a Turbocharger is powered by a turbine mounted in the exhaust flow of the engine.The advantage of this is that none of the engine shaft output is used to drive the compressor and only the waste energy in the exhaust is used. Since the maximum pressure in an engine exhaust system is only very little above the atmospheric,so there can only be a very small pressure drop across the turbine. Because of this it is necessary to run the turbine at very high speeds so that enough power is produced to run the compressor and speeds of around 100,000 to 130.000 are common. These high speeds and the fact that the exhaust gas is a hot, corrosive environment demands special materials and concern for long term reliability.

A disadvantage of turbochargers is **turbo lag,** which occurs with a sudden throttle change. When the throttle is quickly opened to accelerate an automobile,the turbocharger will not respond quite as quickly as a supercharger. It takes several engine revolutions to change the exhaust flow rate and to speed up the rotor of the turbine. Turbo lag has been greatly reduced by using lightweight ceramic rotors that can withstand the high temperatures and that have very little mass inertia. Turbo lag can also be reduced by using a smaller intake manifold.

Most turbochargers, like superchargers, are equipped with an aftercooler to again lower the compressed air temperature. Many also have a bypass that allowsthe exhaust gases to be routed around the turbocharger when an inlet air pressure boost is not needed.Radial flow centrifugal compressors, turning at high speed, are generally used on automobile-size engines. On very large engines, axial flow compressors are usedbecause of their greater efficiency at the higher air flow rates. The value of the overall efficiency of a turbocharger ranges from 70 to 90%.

5.4 Variable Geometry Turbochargers

Variable Turbine Technology is the next generation in Turbocharger technology where the turbo uses variable vanes to control the exhaust flow against the turbine blades. The problem with normal Turbochargers is that big turbos do not run well at slow engine speeds, while small turbos are fast to spool but run out of steam pretty quickly. Hence a VTG turbo was developed to solve this problem.

A **Variable Turbine Geometry** turbocharger is also known as a **variable geometry turbocharger (VGT)**, or a **Variable Nozzle Turbine (VNT)**. A turbocharger equipped with Variable Turbine Geometry has little movable vanes which can direct exhaust flow onto the turbine blades. The vane angles are adjusted via an actuator. The angle of the vanes vary throughout the engine RPM range to optimize turbine behaviour.

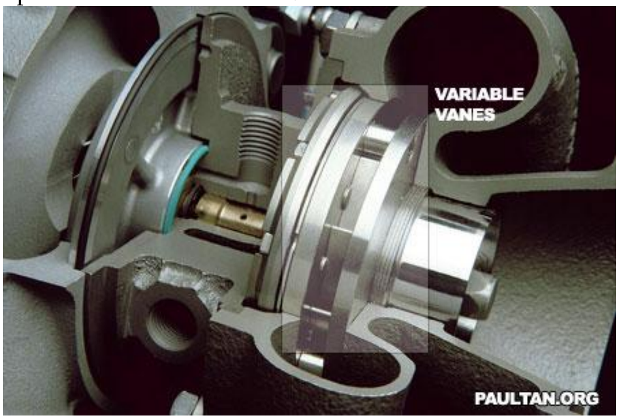

Fig 10- 3-D illustration of a Variable Blade Geometry Turbocharger

In the 3D illustration above, it can be seen that the vanes are in an angle which is almost closed. The variable vanes have been highlighted to distinguish them. This position is optimized for low engine RPM speeds, pre-boost.

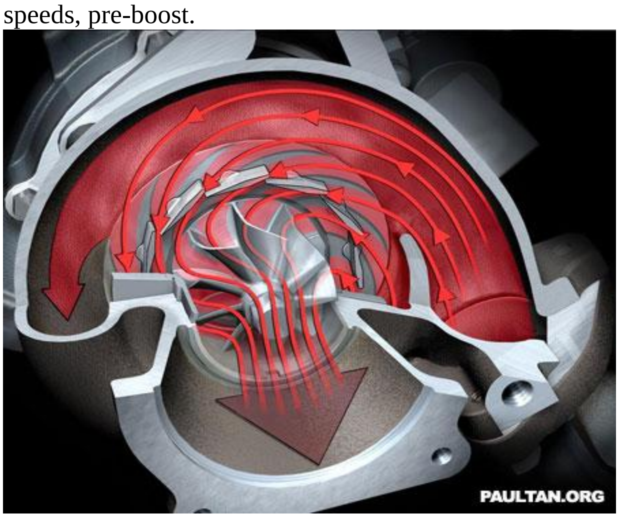

Fig 11-Cut-through diagram with the variable vanes almost closed

In the above cut-through diagram, the direction of exhaust flow is shown when the variable vanes are in an almost closed angle. The narrow passage of which the exhaust gas has to flow through accelerates the exhaust gas towards the turbine blades, making them spin faster. The angle of the vanes also directs the gas to hit the blades at the proper angle.

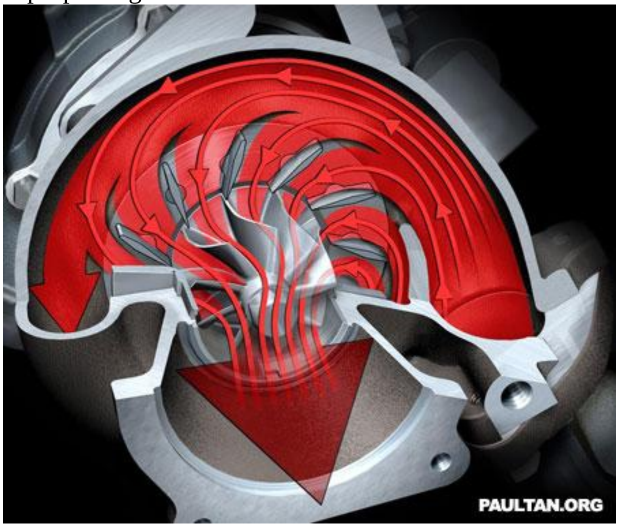

Fig 12- Cut-through diagram with the variable blades completely open

This cut-through diagram shows the exhaust gas flow when the variable turbine vanes are fully open. The high exhaust flow at high engine speeds are fully directed onto the turbine blades by the variable vanes.

Variable Turbine Geometry has been used extensively in turbodiesel engines since the 1990s, but it has never been on a production petrol turbocharged car before until the new Type 1997 Porsche 911 Turbo. This is because petrol engine exhaust gases are alot hotter than diesel engine exhaust gas, so generally the material used to make VTG turbos could not stand this heat. The 1997 911 Turbo uses a BorgWarner VTG turbocharger which uses special materials derived from aerospace technology, hence solving the temperature problem.

5.5 Turbocharged Direct Injection(TDi)

The TDI engine uses direct injection, where a fuel injector sprays atomised fuel directly into the main combustion chamber of each cylinder, rather than the pre-combustion chamber prevalent in older diesels which used indirect injection. The engine also uses forced induction by way of a turbocharger to increase the amount of air which is able to enter the engine cylinders, and most TDI engines also feature an intercooler to lower the temperature (and therefore increase the density) of the 'charged', or compressed air from the turbo, thereby increasing the amount of fuel that can be injected and combusted. These, in combination, allow for greater engine efficiency, and therefore greater power outputs (from a more complete combustion process compared to indirect injection), while also decreasing emissions and providing more torque than the non-turbo and non-direct injection petrol engined counterpart from VAG.

Because these engines are relatively low displacement and quite compact they have a low surface area. The resulting reduced surface area of the direct injection diesel engine reduces heat losses, and thereby increases engine efficiency, at the expense of slightly increased combustion noise. A direct injection engine is also easier to start when cold, due to more efficient placing and usage of glowplugs.

Turbocharged Direct Injection is a design of turbodiesel engines developed and produced by the Volkswagen Group. These TDI engines are widely used in all mainstream Volkswagen Group marques of passenger cars and light commercial vehicles produced by the company (particularly those sold in Europe). They are also used as marine engines - Volkswagen Marine, and Volkswagen Industrial Motor applications.

5.6 Multiple Intake Valves

On many newer engines with overhead valves and small fast-burn combustion chambers, there is often not enough wall space in the combustion chambers to fit the spark plug and exhaust valve and still have room for a large enough intake valve. For this reason, most engines are now built with more than one intake valve per cylinder. Two or three smaller intake valves give more flow area and less flow resistance than one larger valve, as was used in older engines. At the same time, these two or three intake valves, along with usually two exhaust valves, can be better fit into a given cylinder head size with enough clearance to maintain the required structural strength; shown in fig.

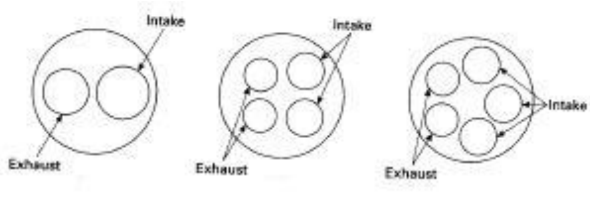

Fig 13- Possible valve arrangements for cylinders having multiple intake valves

Some engines with multiple intake valves are designed so that only one intake valve per cylinder operates at low speed. As speed is increased, less time per cycle is available for air intake, and the second (and sometimes third) valve actuates, giving additional inlet flow area. This allows for increased control of the flow of air within the cylinder at various speeds, which results in more efficient combustion. In some of these systems, the valves will have different timing. The low-speed valve will close at a relatively early point at BDC. When operating, the high-speed valve(s) will then close at a later position (up to 20° later) to avoid lowering the volumetric efficiency.

5.7 Shrouded Intake Valve

The intake system is so designed as to a give a tangential component to the intake flow as it enters the cylinder. This is done by shaping and contouring the intake manifold, valve ports and sometimes even the piston face. An offset port configuration is used which produces the required swirl. The swirling motion of the incoming charge decays itself into turbulence as the piston moves in the latter strokes. The turbulence achieved in this way is substantially higher than that of straight port cylinder head. The swirl produced greatly enhances the mixing of air and fuel to give a homogeneous mixture in the very short time available for modern high speed engines. This system was used by Bajaj for their DTS-Si (Digital twin spark-swirl Induction) engine currently used in their Pulsar and Discover models. Shown below is a way of producing Swirl.

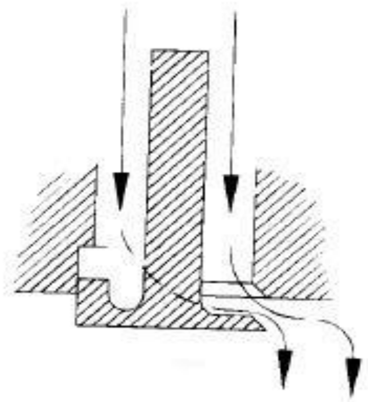

Fig 14- Shrouded Intake Valve

5.8 Variable Timing Electronic Control (VTEC)

VTEC (Variable Valve Timing and Lift Electronic Control) is a valvetrain system developed by Honda to improve the volumetric efficiency of a four-stroke internal combustion engine. The VTEC system uses two camshaft profiles and hydraulically selects between profiles.

The VTEC system provides the engine with multiple camshaft profiles optimized for both low and high RPM operations. In basic form, the single cam profile of a conventional engine is replaced with two profiles: one optimized for low-RPM stability and fuel efficiency, and the other designed to maximize high-RPM power output. The switching operation between the two cam lobes is controlled by the ECU which takes account of engine oil pressure, engine temperature, vehicle speed, engine speed and throttle position. Using these inputs, the ECU is programmed to switch from the low lift to the high lift cam lobes when the conditions mean that engine output will be improved. At the switch point a solenoid is actuated which allows oil pressure from a spool valve to operate a locking pin which binds the high RPM cam follower to the low RPM ones. From this point on, the valves open and close according to the high-lift profile, which opens the valve further and for a longer time. The switch-over point is variable, between a minimum and maximum point, and is determined by engine load. The switch-down back from high to low RPM cams is set to occur at a lower engine speed than the switch-up (representing a hysteresis cycle) to avoid a situation in which the engine is asked to operate continuously at or around the switch-over point.

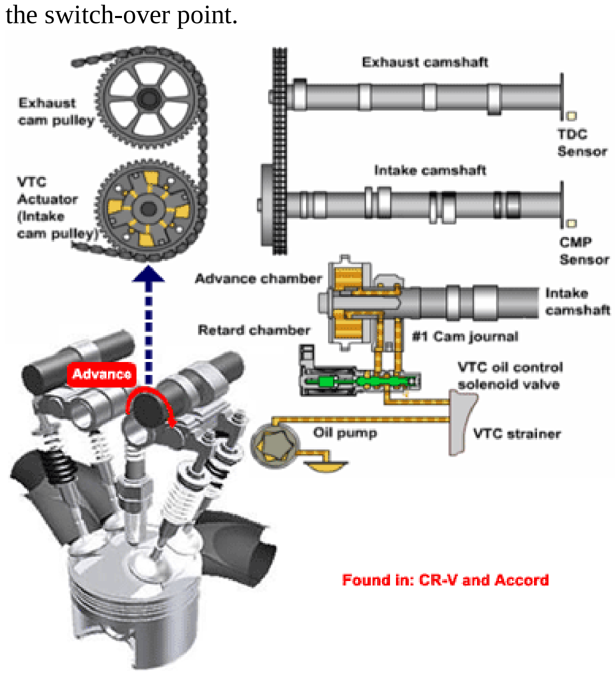

Fig 15- Working of VTEC

5.9 Camless valve Engines

On 13th of April,2005, at the 100th SAE Congress in Detroit, USA, Powertrain Ltd. presented its Intelligent Valve Actuation (IVA), a technology to develop a camless engine prototype. The technology results from an 18-month joint research and development programme with Camcon Technology, the UK inventor and developer of binary actuation technology. Since October 2004 Powertrain and Camcon have joined forces to develop the technology in the automotive sector.

The Camless engine technology utilizes several solenoids to open and shut the intake engine valves and the exhaust. The immense diversity prevails via solenoid, which comes in place of the old camshafts which had several timing limitations.

The employment of solenoid valve rids the limitation and providing the capability of limitless timing, which translates to utmost efficiency in power, fuel consumption, and torque, which are controlled by the inbuilt computer.

This technology uses armature attached to the valve system of the engine. Magnetic and solenoid attraction and repulsion actuates the ferromagnetic iron armature thus pulling it up and hence in turn closing the valve. When the current in the solenoid is then disrupted, the armature falls down due to its weight thus opening the valve. Springs attached to the valve stem help in the easy and vibration free movement of the armature and its returning back to its original position.

Depending on the direction of current applied to the solenoid, this valve is driven either towards the open or close position. The ECU has the knowledge of the precise armature location and adjusts the current in the magnetic coil thus getting the most wanted valves motion.

Mainly five sensors are used in connection with the valve operation. One for sensing the speed of the engine, one for sensing the load on the engine, exhaust gas sensor, valve position sensor and current sensor. The sensors will send signals to the electronic control unit.

The electronic control unit consists of a microprocessor, which is provided with a software algorithm. The microprocessor issues signals to the solid-state circuitry based on this algorithm, which in turn controls the actuator, to function according to the requirements.

This Camless engine has a number of benefits including an increment in a torque cohort of 40%, which transpires at the engagement of the clutch for the vehicle to speed. This leads to a fast start and smooth acceleration. The engine and supplementary parts last longer. There is no engine noise including hydraulic actuation that controls the closing rate, plus the valves which close gently.

Camless engines are not without their problems though. Common problems include high power consumption, accuracy at high speed, temperature sensitivity, weight and packaging issues, high noise, high cost, and unsafe operation in case of electrical problems.

Camless valve trains have long been investigated by several companies, including Renault, BMW, Fiat, Valeo, General Motors, Ricardo, Lotus Engineering and Ford. Some systems are commercially available, although not in production car engines.

The 2007 W204 Mercedes Benz C-Class is expected to be the first car from German marque to use a camless engine. Mercedes calls it the technology KDI EVT. The KDI EVT is supercharged, with direct injection and uses an electronically controlled cam-less valvetrain. KDI EVT is likely to stand for "Kompressor Direct Injection Electronic Valve Train".

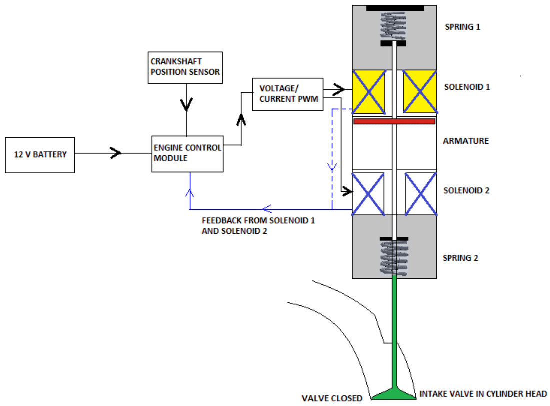

Fig 16- Camless Valve Engines

VI. Conclusion

Thus the automobile industry has come a long way in the process of evolution of the Suction processes in IC engines with the most modern cars having a combination of more than one systems such as Variable geometry Turbochargers along with MPFi or CRDi. Cars with Multiple intake valves with one or more of them being shrouded are also very common.TDi, i-VTEC are very common in these days in Volkswagen and Honda cars respectively. As the suction process is one of the most important processes in IC engines, the process of its evolution will always remain continuous with more and more impetus from the industry.

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