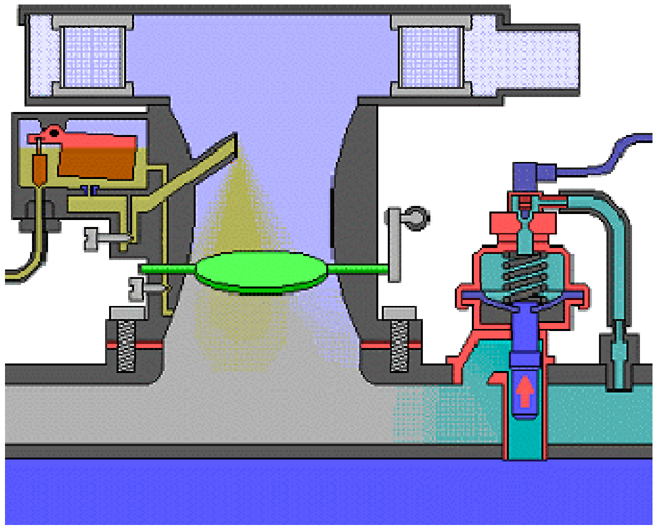
Fuel Intake System



Below is an overview of the fuel system intake operation

Intake Manifolds

An intake manifold is a system of passages which conduct the fuel mixture from the carburetor to the intake valves of the engine. Manifold design has much to do with the efficient operation of an engine. For smooth and even operation, the fuel charge taken into each cylinder should be of the same strength and quality.

Distribution of the fuel should, therefore, be as even as possible. This depends greatly upon the design of the intake manifold. Dry fuel vapor is an ideal form of fuel charge, but present-day fuel prevents this unless the mixture is subjected to high temperature. If the fuel charge is heated too highly, the power of the engine is reduced because the heat expands the fuel charge. Therefore, it is better to have some of the fuel deposited on the walls of the cylinders and manifold vents. Manifolds in modern engines are designed so that the amount of fuel condensing on the intake manifold walls is reduced to a minimum.

In a V-8 engine, the intake manifold is mounted between the cylinder heads. The L-head engine's manifold is bolted to the side of the block, and the I-head manifold is bolted to the cylinder head.

Ram Induction Manifolds

The ram induction manifold system consists of twin air cleaners, twin four-barrel carburetors and two manifolds containing eight long tubes of equal length (four for each manifold).

This system was designed by the Chrysler Company to increase power output by in the middle speed range (1800-3600 rpm). Each manifold supplies one bank of cylinders and is carefully calculated to harness the natural supercharging effect of a ram induction system. By taking advantage of the pulsations in the air intake column caused by the valves opening and closing, sonic impulses help pack more mixture into the combustion chambers.

In the Chrysler system, the air-fuel mixture from each carburetor flows into a chamber directly below the carburetor, then passes through the long individual intake branches to the opposite cylinder bank. The right-hand carburetor supplies the air-fuel mixtures for the left-hand cylinder bank, and the left-hand carburetor supplies the right cylinder bank. The passages between the manifolds are interconnected with a pressure equalizer tube to maintain balance of the engine pulsations.

Manifold Heat Control

Most engines have automatically operated heat controls which use the exhaust gases of the engine to heat the incoming fuel-air charge during starting and warm-up. This improves vaporization and mixture distribution. When the engine is cold, all of the exhaust gas is deflected to and around the intake manifold "hot spot". As the engine warms up, the thermostatic spring is heated and loses tension. This allows the counterweight to change the position of the heat control valve gradually so that, at higher driving speeds with a thoroughly warmed engine, the exhaust gases are passed directly to the exhaust pipe and muffler.

In the ram induction system, there is a heat control chamber in each manifold to operate the automatic choke and to heat the fuel mixture after warm-up. A heat control valve in each exhaust manifold will by-pass the exhaust gas through an elbow to the intake manifold heat control chamber. Heat outlet pipes then carry the gas down to the "Y" connector under the heat control valve.

Heat control is regulated by a coiled thermostatic spring mounted on the exhaust manifold. A counterweight is mounted on the other end of the heat control valve shaft and this counterweight, in conjunction with the thermostatic spring, operates to close and open the heat control valve.

Carburetor

The purpose of the carburetor is to supply and meter the mixture of fuel vapor and air in relation to the load and speed of the engine. Because of engine temperature, speed, and load, perfect carburetion is very hard to obtain.

The carburetor supplies a small amount of a very rich fuel mixture when the engine is cold and running at idle. With the throttle plate closed and air from the air cleaner limited by the closed choke plate, engine suction is amplified at the idle-circuit nozzle. This vacuum draws a thick spray of gasoline through the nozzle from the full float bowl, whose fuel line is closed by the float-supported needle valve. More fuel is provided when the gas pedal is depressed for acceleration. The pedal linkage opens the throttle plate and the choke plate to send air rushing through the barrel. The linkage also depresses the accelerator pump, providing added gasoline through the accelerator-circuit nozzle. As air passes through the narrow center of the barrel, called the "venturi", it produces suction that draws spray from the cruising-circuit nozzle. The float-bowl level drops and causes the float to tip and the needle valve to open the fuel line.

To cause a liquid to flow, there must be a high pressure area (which in this case is atmospheric pressure) and a low pressure area. Low pressure is less than atmospheric pressure. The average person refers to a low pressure area as a vacuum. Since the atmospheric pressure is already present, a low pressure area can be created by air or liquid flowing through a venturi. The downward motion of the piston also creates a low pressure area, so air and gasoline are drawn through the carburetor and into the engine by suction created as the piston moves down, creating a partial vacuum in the cylinder. Differences between low pressure within the cylinder and atmospheric pressure outside of the carburetor causes air and fuel to flow into the cylinder from the carburetor.

Supercharger

A supercharger is a compressor. Hence, a supercharged engine has a higher overall compression than a nonsupercharrged engine having the same combustion chamber volume and piston displacement and will burn more fuel. Unfortunately, the increase in power is not proportional to the increase in fuel consumption. There are two general models of superchargers, the Rootes type and the centrifugal type. The Rootes "blower" has two rotors, while the centrifugal uses an impeller rotating at high speed inside a housing.

Superchargers can be placed between the throttle body of the carburetor or fuel injection system and the manifold; or at the air inlet before the throttle body. Racing cars usually have it located between the throttle body and the manifold. This design has the advantage that the fuel can be supplied through the throttle body without modification to any part of the system. If the supercharger is placed in front of the throttle body, fuel must be supplied under sufficient pressure to overcome the added air pressure created by the supercharger. The advantage of a supercharger over a turbocharger is that there is no lag time of boost; the moment the accelerator pedal is depressed, the boost is increased.

Turbocharger

A turbocharger, or supercharger, can boost engine power up to 40%%. The idea is to force the delivery of more air-fuel mixture to the cylinders and get more power from the engine. A turbocharger is a supercharger that operates on exhaust gas from the engine.

Although turbochargers and superchargers perform the same function, the turbocharger is driven by exhaust gases, while the supercharger is driven by belts and gears. The turbocharger has a turbine and a compressor, and requires less power to be driven than a supercharger. The pressure of the hot exhaust gases cause the turbine to spin. Since the turbine is mounted on the same shaft as the compressor, the compressor is forced to spin at the same time, drawing 50%% more air into the cylinders than is drawn in without the turbocharger. This creates more power when the air-fuel mixture explodes.

A turbocharged engine's compression ratio must be lowered by using a lower compression piston, since an excessive amount of pressure will wear on the piston, connecting rods, and crankshaft, and destroy the engine. All of these parts then, as well as the transmission, must be strengthened on a turbocharged engine or it will be torn apart by the increased horsepower.

Breathers

The breather is the positive crankcase ventilation system directing atmospheric pressure to the crankcase. The atmospheric pressure then pushes the blowby gases to a low pressure area. The air that is directed into the crankcase must first be filtered; if it is not, the dust and sand particles will destroy the engine parts. When there is too much blowby, it is routed back through the crankcase breather element. It then enters the carburetor or throttle body with the incoming fresh air to be burned in the cylinders. In addition, the breather helps to keep the regular air filter cleaner for a longer period of time, since blowby contains oil vapor from the crankcase.

Float Circuit

Fuel in the carburetor must be maintained at a certain level under all operating conditions; this is the function of the float circuit. The needed fuel level is maintained by the float. When its attached lever forces the needle valve closed, the flow of fuel from the pump is stopped. As soon as fuel is discharged from the float bowl, the float drops. The needle valve opens and fuel flows into the bowl again. In this way, the fuel is level to the opening of the main discharge nozzle. The float level must be set with a high degree of accuracy. If the level is too low, not enough fuel will be supplied to the system and the engine will stall on turns; if the level is too high, too much fuel will flow from the nozzle.

Metering Rod

A metering rod varies the size of the carburetor jet opening. Fuel from the float bowl is metered through the jet and the metering rod within it. The fuel is forced from the jet to the nozzle extending into the venturi. As the throttle valve is opened, its linkage raises the metering rod from the jet. The rod has several steps, or tapers, on the lower end. As it is raised in the jet, it makes the opening of the jet greater in size. This allows more fuel to flow through the jet to the discharge nozzle. The metering must keep pace with the slightest change in the throttle valve position so that the correct air-fuel mixture is obtained in spite of engine speed.

Choke Valve

Chokes perform the fuel mixture adjustments necessary to start a cold engine. When the fuel-air mixture is too cold, the engine won't start properly, or will stall out periodically. The choke when engaged (closed) the choke causes the fuel air mixture to be increased, or "enriched". The choke is a special valve placed at the mouth of the carburetor so that it partially blocks off the entering air. When the choke plate closes, the vacuum below it increases, drawing more fuel from the fuel bowl. The rich fuel mixture burns even at lower temperatures, allowing the engine to warm up.

The manual choke is a knob on the dash, usually the push-pull type, which extends from the choke on the carburetor to the instrument panel. The driver closes the choke when starting the engine. The main thing to know about a manual choke is to push it back in when the engine has reached normal operating temperature. The trouble with the manual choke is that the driver often forgets to open it fully. This results in a rich fuel mixture which causes carbon to form in the combustion chambers and on the spark plugs. To correct this problem, the automatic choke was developed.

The automatic choke relies on engine heat. The choke valve is run by a thermostat which is controlled by exhaust heat. When the engine is cold, the valve will be closed for starting. As the engine warms, the exhaust heat will gradually open the choke valve. An automatic choke depends on a thermostatic coil spring unwinding as heat is supplied. As the engine warms up, manifold heat is transmitted to the choke housing. The heat causes the bimetal spring to relax, opening the valve.

An electric heating coil in the automatic choke shortens the length of time that the choke valve is closed. As the spring unwinds, it causes the choke valve in the carburetor air horn to open. This lets more air pass into the carburetor. The coil is mounted in a well in the exhaust crossover passage of the intake manifold. Movement of the bimetal spring is relayed to the choke valve shaft by means of linkage and levers.

Fuel Injection

The carburetor, despite all it advances: air bleeds, correction jets, acceleration pumps, emulsion tubes, choke mechanisms, etc., is still a compromise. The limitations of carburetor design is helping to push the industry toward fuel injection.

Direct fuel injection means that the fuel is sprayed directly into the combustion chamber. The fuel injected nozzle is located in the combustion chamber.

Throttle Body injection systems locate the injector(s) within the air intake cavity, or "throttle body". Multi-point systems use one injector per cylinder, and usually locate the injectors at the mouth of the intake port.

The fuel injector is an electromechanical device that sprays and atomizes the fuel. The fuel injector is nothing more than a solenoid through which gasoline is metered. When electric current is applied to the injector coil, a magnetic field is created, which causes the armature to move upward. This action pulls a spring-loaded ball or "pintle valve" off its seat. Then, fuel under pressure can flow out of the injector nozzle. The shape of the pintle valve causes the fuel to be sprayed in a cone-shaped pattern. When the injector is de-energized, the spring pushes the ball onto its seat, stopping the flow of fuel.

Mechanical Fuel Injection

Mechanical fuel injection is the oldest of the fuel injection systems. It uses a throttle linkage and a governor. It is now used mainly on diesel engines. Hydraulic fuel injection is used by some of the imports. Hydraulic pressure is applied to a fuel distributor as a switching device to route fuel to a specific injector. The fuel from the tank is carried under pressure to the fuel injector(s) by an electric fuel pump, which is located in or near the fuel tank. All excess is returned to the fuel tank.

Electronic Fuel Injection

The principle of electronic fuel injection is very simple. Injectors are opened not by the pressure of the fuel in the delivery lines, but by solenoids operated by an electronic control unit. Since the fuel has no resistance to overcome, other than insignificant friction losses, the pump pressure can be set at very low values, consistent with the limits of obtaining full atomization with the type of injectors used. The amount of fuel to be injected is determined by the control unit on the basis of information fed into it about the engine's operating conditions. This information will include manifold pressure, accelerator enrichment, cold-start requirements, idling conditions, outside temperature and barometric pressure. The systems work with constant pressure and with "variable timed" or "continuous flow" injection. Compared with mechanical injection systems, the electronic fuel injection has an impressive set of advantages. It has fewer moving parts, no need for ultra-precise machining standards, quieter operation, less power loss, a low electrical requirement, no need for special pump drives, no critical fuel filtration requirements, no surges or pulsations in the fuel line and finally, the clincher for many car makers, lower cost.

Throttle Valve

All gasoline engines have a throttle valve to control the volume of intake air. The amount of fuel and air that goes into the combustion chamber regulates the engine speed and, therefore, engine power. The throttle valve is linked to the accelerator (gas pedal). The throttle valve is a butterfly valve that usually consists of a disc mounted on a spindle. The disc is roughly circular, and it has the same diameter as the main air passage in the throat or "venturi". In a carburetor, the throttle valve is usually located at the bottom of the carburetor, between the jet nozzle and the intake manifold. The throttle spindle is connected to the accelerator in such a manner that when the pedal is depressed, the valve opens. When the pedal is released, the valve closes. Fuel injected engines use throttle valves to regulate engine power, even though the fuel is also regulated through the injectors.

Idle Circuit

The fuel delivery in a carburetor tends to lag behind the motion of the throttle. The basic carburetor operates when the throttle valve is fully open or partially open, but not when it's closed. No driver wants the engine to stop every time the foot leaves the accelerator; such a car would be tiring and stressful to drive, even in the best of road conditions, let alone in a traffic situation. To keep the engine running smoothly and evenly when no power is needed, the idle circuit was added inside the carburetor. The idle jet admits fuel on the engine side of the throttle valve. Additional air is mixed with this fuel through an air bleed. The result is an entirely separate carburetor circuit which operates only when the throttle valve is closed.

Venturi

"Barrel" is a popular term for the carburetor throat. There is one venturi in each throat. A two-barrel carburetor has a primary venturi for part-load running and a secondary venturi for full-throttle; a four-barrel carburetor has two primary and two secondary venturis. The venturi tube is important in carburetion. A "venturi" is a tube with a restricted section. When liquid or air passes through the venturi tube, the speed of flow is increased at the restriction, and air pressure is decreased, creating an "increase in vacuum" (a reduction in ambient pressure). This causes fuel to be drawn into the barrel. The venturi action is used to keep the correct air-fuel ratio throughout the range of speeds and loads of the engine.

Cetane Rating (Ether)

The delay between the time the fuel is injected into the cylinder and ignition is expressed as a cetane number. Usually, this is between 30 and 60. Fuels that ignite rapidly have high cetane ratings, while slow-to-ignite fuels have lower cetane ratings. A fuel with a better ignition quality would help combustion more than a lower cetane fuel during starting and idling conditions when compression temperatures are cooler. Ether, with a very high cetane rating of 85-96, is often used for starting diesel engines in cold weather. The lower the temperature of the surrounding air, the greater the need for fuel that will ignite rapidly. When the cetane number is too low, it may cause difficult starting, engine knock, and puffs of white exhaust smoke, especially during engine warm-up and light load operation. If these conditions continue, harmful engine deposits will accumulate in the combustion chamber.

Pressurized cans of starter fluid are available in emergencies, but are not desirable, because they tend to dry out the cylinders, and are dangerous if used improperly. There are also liquid forms of starter fluid available which can be added to the gasoline.

Fuel Additives

Tetraethyl lead was used in some gasolines to reduce or prevent knocking. However, in 1975, it became illegal to use leaded gasoline except in cars built prior to this time. Methyl Tertiary Butyl Ether (MTBE) is used in unleaded fuel to increase the octane. Gasoline exposed to heat and air oxidizes and leaves a gummy film. Detergents are now added to gasoline to prevent this. The detergents keep the carburetor passages and fuel injectors free from deposits, which could cause hard starting and problems in driving. Deposits also restrict the flow of fuel and cause a rough idle, hesitation of acceleration, surging, stalling, and lack of power.

Alcohol is frequently used as an additive to commercial gasoline, because it will absorb any condensed moisture which may collect in the fuel system. Water will not pass through the filters in the fuel line, so, when any water collects, it will prevent the free passage of fuel. It also tends to attack and corrode the zinc die castings of which many carburetors and fuel pumps are made. This corrosion will not only destroy parts, but also clog the system and prevent the flow of fuel. By using alcohol in gasoline, any water present will be absorbed and pass through the fuel filter and carburetor jets into the combustion chamber. Alcohol additives are often purchased and added separately into the gas tank to prevent gas-line freeze and vapor lock.

Alcohol as a Fuel

The increasing cost of gasoline, and the new laws requiring alternative fuels have turned the attention of car and truck designers to substitutes. Chief among alternative fuels is alcohol. Considerable research has been done, and is still carried out, for alcohol in spark ignition engines. Alcohol fuels were used extensively in Germany during WWII, and alcohol blends are used in many vehicles at the present time.

Methanol and ethanol are the forms of alcohol receiving the most attention. Both are made from non-petroleum products. Methanol can be produced from coal, and ethanol can be made from farm products such as sugar cane, corn, and potatoes. Both alcohols have a higher octane number than gasoline. High heat of vaporization, however, indicates that the use of alcohol could give harder starting problems than gasoline, which means a need for a larger fuel tank and larger jet sizes in the carburetor. It requires less air for combustion, though, which compensates for the high calorific values. In proportion, this could result in practically the same air-fuel ratio for all three.

Experimental tests have shown that alcohol-fueled spark ignition engines can produce as much or slightly higher power than gasoline. Alcohol fuels have a higher self-ignition temperature than gasoline, which rates them better from a safety standpoint, but this same quality bars them from use in a diesel engine which depends on the heat of compression to ignite the fuel. At the present time, only ethanol can be blended in small concentrations (10%%) with gasoline. Because of the high octane rating, alcohols can be used in relatively high compression ratios, and experiments indicate that emissions from engines fueled by alcohol would require the use of exhaust gas recirculation controls.