MODULE 4

SYLLABUS:

CO4: Outline the details of components in Intake and Exhaust systems used in engines.

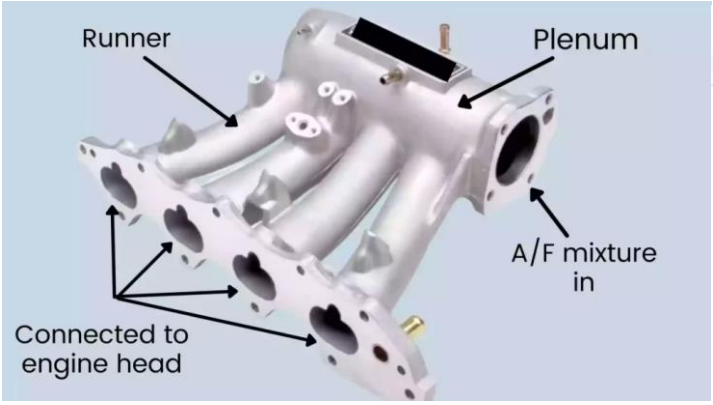
- Intake manifolds, Types, Air Cleaners - Types, Variable intake system, electronic throttle body, VVT, (Variable valve timing) CVVT (Continuously varying valve timing), VTVT (Variable time valve train), VVTI (Variable valve timing intelligent) technologies.
- Exhaust Manifold, Mufflers, Resonator, Catalytic Converter - constructional details and working, Tail pipe - Types of mufflers, construction of exhaust manifold - purpose of mufflers - constructional details of absorber type, baffle plate type, wave cancellation type and resonance type mufflers
- Turbo charging system, Types of Turbo chargers,1) Normal Turbo Charger,2) WGT (Waste Gate Turbo Charger) 3) Turbo - lag (Variable geometry turbo charger).

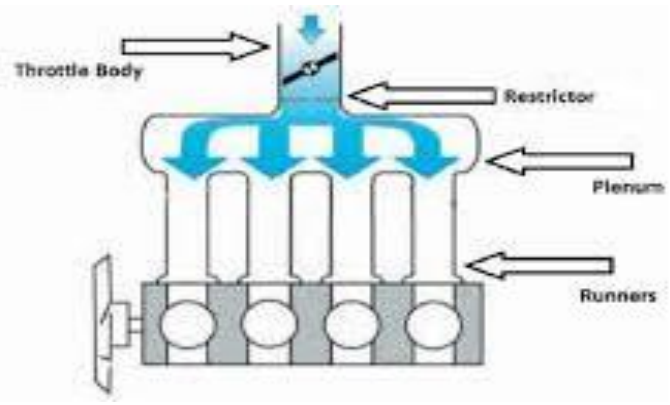
ENGINE MANIFOLD:

- Manifolds are separate sets of pipes connected to the cylinder head which provide the air-fuel mixture and the exhaust gases, these are known as manifolds.
- It is usually made of cast iron so that it is capable to resist the high temperature of the exhaust gases.
- Following are the two types of manifolds used in vehicles:
  1. Intake Manifold
  2. Exhaust Manifold

1. INTAKE MANIFOLD:

- The intake manifold is a cast iron or aluminium tube for carrying the air-fuel mixture from the carburetor/air filter to the engine intake port.
- The intake manifold is constructed so that, when the carburetor is attached to it, the mixture can reach each cylinder.
- The carburetor is mounted on the intake manifold.
- A good design of intake manifold consists of the path from the carburetor to the cylinders as short and short and smooth as possible so that the fuel will not condense and collect on the manifold walls.
- To minimize condensation and to assist in the vaporization of the gasoline in the mixture, the modern intake manifold is heated.
- The heat is usually supplied from the exhaust gases or cooling water, sometimes hot-spot are provided at points where the fuel strikes in the intake manifold.
- The heat supplied is controlled by a thermostat so that all the exhaust gases are deflected to heat the intake manifold when the engine is cold, and less heat is supplied as the engine warms.

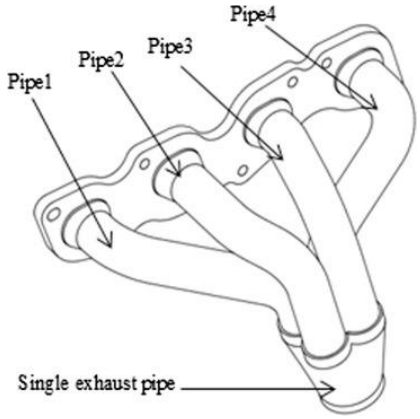


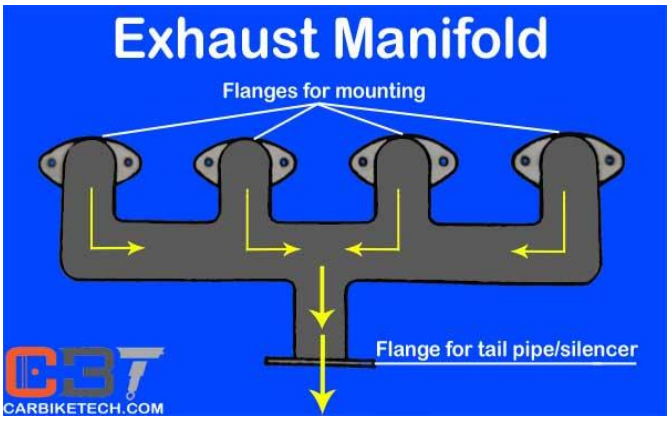


Prepared by: HAFIS P V, Lecturer-Automobile, SSM PTC

2. EXHAUST MANIFOLD:

- The exhaust manifold is a tube for removing the exhaust gases away from the engine cylinders.
- It collects exhaust gases from the exhaust ports of the various cylinders and conducts them to a central exhaust passage.
- The exhaust manifold is usually made of cast iron. It is bolted to the side of the cylinder block.
- The exhaust manifold is designed to avoid overlapping exhaust strokes, as far as possible, thus keeping the backpressure to a minimum. This is often done by dividing the exhaust manifold into two or more branches so that two cylinders will not exhaust into the same branch at the same time.
- Large radius bends are provided in the design to eliminate any restriction to the flow.
- A heat tube may also be provided to furnish heat to the built-in automatic choke unit of the carburetor.





VARIABLE VALVE TIMING (VVT) TECHNOLOGIES:

- VVT is a generic term for an automobile engine technology which allows the lift or duration or timing of the intake or/ and exhaust valves to be changed when the engine is working.
- The optimal valve timing, lift and duration settings at low engine speeds are quite different from those at high engine speeds.
- Any optimal setting of the valve lift, duration and timing at low speeds would cause lesser amount of air and fuel at higher speeds, resulting in loss of engine power output.
- Similarly, valve setting at higher engine speeds would result in difficult idling and very rough engine operation at low speeds.
- These technologies basically enable the valve timing and lift to be varied automatically depending upon the engine operating conditions.

1. ***Phase changing systems:*** With these systems, the timing of the camshaft is changed relative to the crankshaft which causes the timing of the valve opening or closing to be advanced or retarded. With a single camshaft, all the valve events for both intake and exhaust valves are shifted by the same amount, whereas if separate camshafts are used for intake and the exhaust valves, can change the valve events either for the intake or the exhaust valves. However, such systems cannot change the peak valve lift or the duration of the valve events.
2. ***Profile Switching Systems:*** These can change independently the valve timing and the valve lift. There are two camshafts with separate cam-profiles. The system enables the valve-operation to be switched between these camshafts at a particular engine speed. With such a capability very high-power output can be obtained, while keeping the emission level also low. However, these are not suitable for optimising valve-timing parameters under different load conditions.
3. ***Variable Valve Lift:*** Variable valve lift (VVL) is an engine technology which varies the height of a valve opens in order to improve performance, fuel economy or emissions. There are two main types of VVL:

discrete, which employs fixed valve lift amounts, and continuous, which is able to vary the amount of lift. Mainly at higher speed the lift of the valve will be more in order to allow more air fuel mixture.

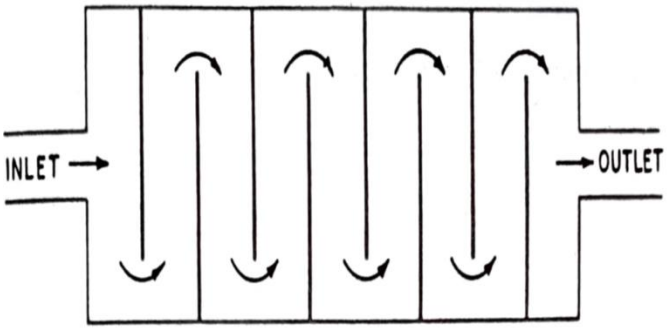
MUFFLERS:

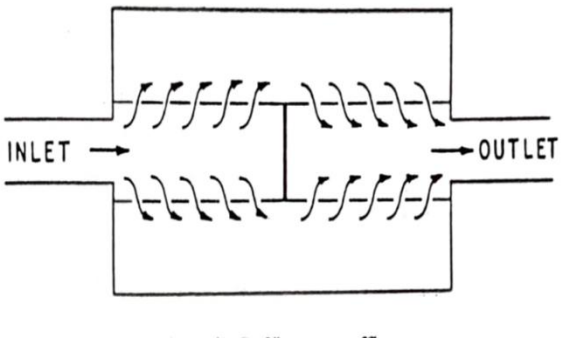
- When the exhaust valve opens, high-pressure exhaust gas is released, which causes a pressure wave in the air causing an explosion.
- Since high pressure gases are released rapidly one after the other in an engine the explosions occurring very fast combine together to form a steady noise.
- To reduce the noise, the engine exhaust is connected via exhaust pipe to the silencer, which is also called muffler.
- A tail pipe carries the exhaust gases from the muffler to the rear or side of the vehicle near the wheel.

TYPES OF MUFFLERS:

1. Baffle type
2. Wave cancellation type
3. Resonance type
4. Absorber type
5. Combined resonance and absorber type

1. BAFFLE TYPE MUFFLER:





- It is generally cylindrical in shape with a number of baffles spot welded inside.
- There are many designs of baffles, but the principle in all cases is the same, i.e. closing any direct passage for the gas. Figure shows two such mufflers.
- Major drawback of the mufflers is their low efficiency. Because of the restriction provided to the flow by the baffles, the back pressure is increased, thus causing loss in engine power.
- From the crankpin it reaches piston pin bearing through a hole drilled in the connecting rod.
- The cylinder walls, piston and piston rings are lubricated by oil spray from around the piston pins and the main and connecting rod bearings.

2. WAVE CANCELLATION TYPE MUFFLER:

- In this type, exhaust gases are divided into two parts.
- The lengths of these paths are so adjusted that after they come out of the muffler, the crests of one wave coincide with the troughs of the second wave, thus cancelling each other and reducing the noise to Zero theoretically.
- In practice this type of muffler does not eliminate noise completely, because this is possible only at one frequency for which muffler is designed, whereas the noise is a combination of different frequencies.

- However, appreciable noise reduction is achieved. One such type of muffler is shown in Fig. In this the resistance to the main gas flow is very small as compared to the baffle type.

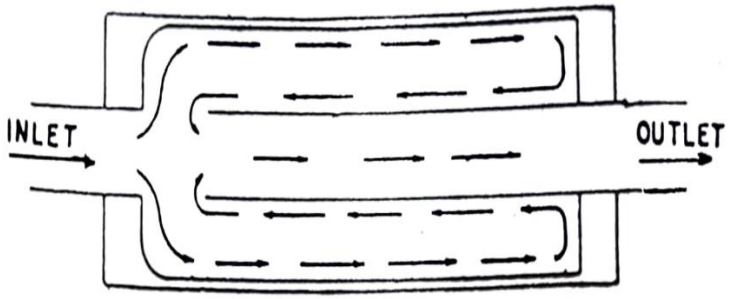


Fig. 3.65. Wave cancellation type muffler.

3. <u>RESONANCE TYPE MUFFLER:</u>

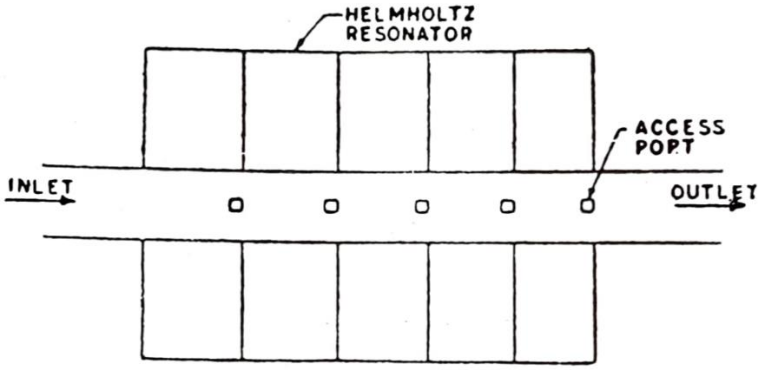


Fig. 3.66. Resonance type muffler.

- It consists of a number Helmholtz resonators in series, through which a pipe containing access ports passes.
- The exhaust gases flow through this type and thus experience no resistance.
- Series of resonators eliminate the fundamental and higher harmonics of the engine noise.

4. <u>ABSORBER TYPE MUFFLER:</u>

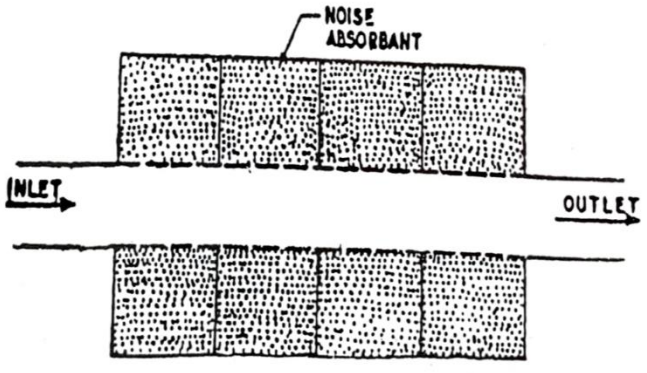


Fig. 3.67. Straight through absorber muffler.

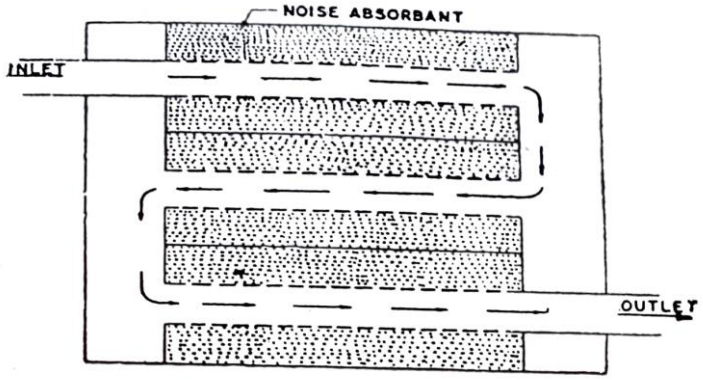


Fig. 3.68. Reserve flow absorber type muffler.

- The sound absorbing material, usually fibre glass, is placed in this case around the perforated tube through which the exhaust gases pass.

- During high pressure fluctuations the gases pass through the perforations to the sound absorbing material, when these fluctuations (which are the main cause of the noise) are reduced and thus the noise gets reduced in intensity.
- These mufflers may be straight-through type or reverse flow type.

5. <u>COMBINED RESONANCE AND ABSORBER TYPE MUFFLER:</u>

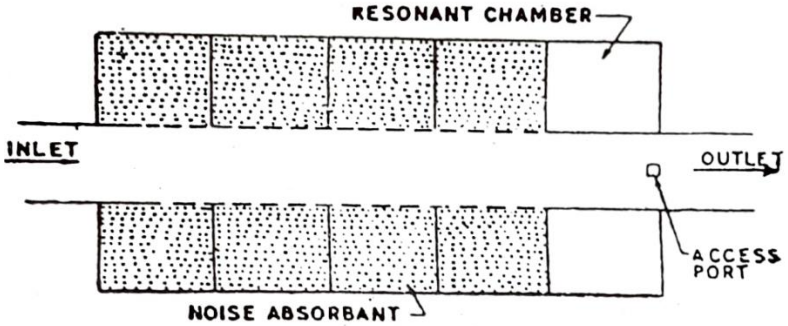


Fig. 3.69. Combined resonance and absorber type muffler.

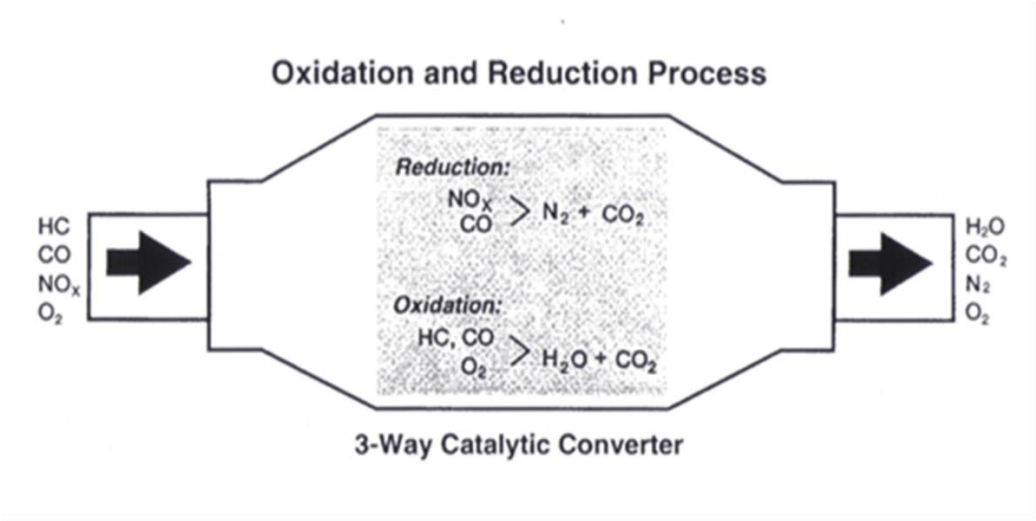
- It is seen that the absorber type muffler, has a drawback in that it is not efficient in reducing noise of low frequency.
- To obviate this defect, this is combined with a resonant chamber. It has been found that this type is more efficient than either the simple resonance or the absorber types.

CATALYTIC CONVERTER:

- A catalytic converter is a cylindrical unit about the size of a small silencer and is installed into the exhaust system of vehicle such as a car.
- It is placed between the exhaust manifold and the silencer.
- Inside the converter there is a honeycomb structure of a ceramic or metal, which is coated with alumina base materials and thereafter a second coating of precious metals platinum, palladium or rhodium or combinations of the same. This second coating serves as a catalyst.
- As a result of catalytic reaction, as the exhaust gases pass over the converter substrate, toxic gases such as CO, HC and NOx are converted into harmless CO_2, H_2 and N_2.
- There are two types of catalytic converters:
  - ***Two - way converter*** will convert the CO into CO_2 and HC into water or H_2O. It means Two-way Converter converts only two harmful compounds. So it is named the two-way converter.
  - ***Three-way converter*** will convert 3 compounds into harmless gases compared to the Two-way. The third gas that the three-way converter will convert is Nitrogen oxides. It means that it will split the Nitrogen oxides into Nitrogen and oxygen.

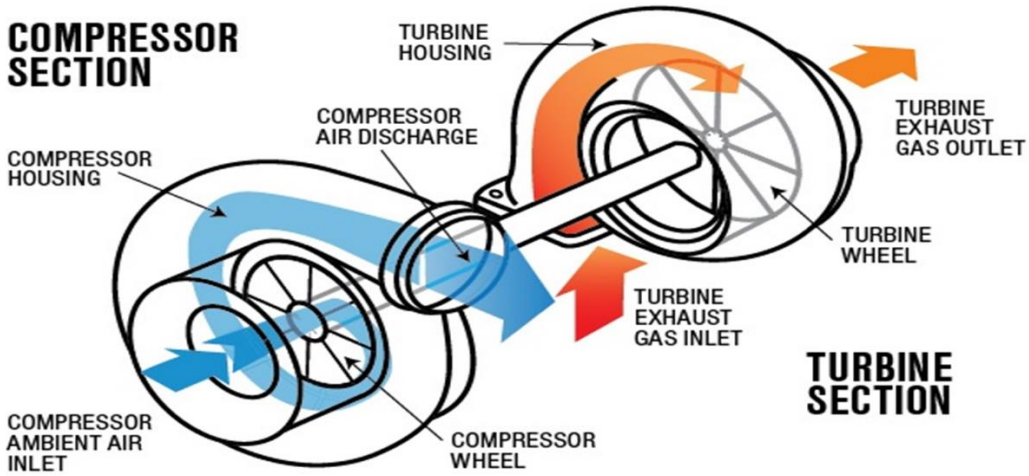
<u>3 WAY CATALYTIC CONVERTER:</u>

- Three-way converters (TWC) are now commonly being used for petrol engines and operate in two stages.
- The first converter stage uses rhodium to reduce the NOx in the exhaust into nitrogen and oxygen.
- In second converter stage, platinum or palladium acts as oxidation catalyst to change HC and CO into Water and CO2.
- For supplying the oxygen required in the second stage, air is fed into the exhaust after first stage.



TURBO CHARGER:

- In engine, about 35-40% of the energy contained in the fuel goes waste in the outgoing exhaust gases.
- A turbocharger, which employs a centrifugal compressor as a supercharger and a turbine wheel makes use of a part of the energy contained in the exhaust gases.
- The energy extracted from the exhaust gases is also utilized to drive the compressor.



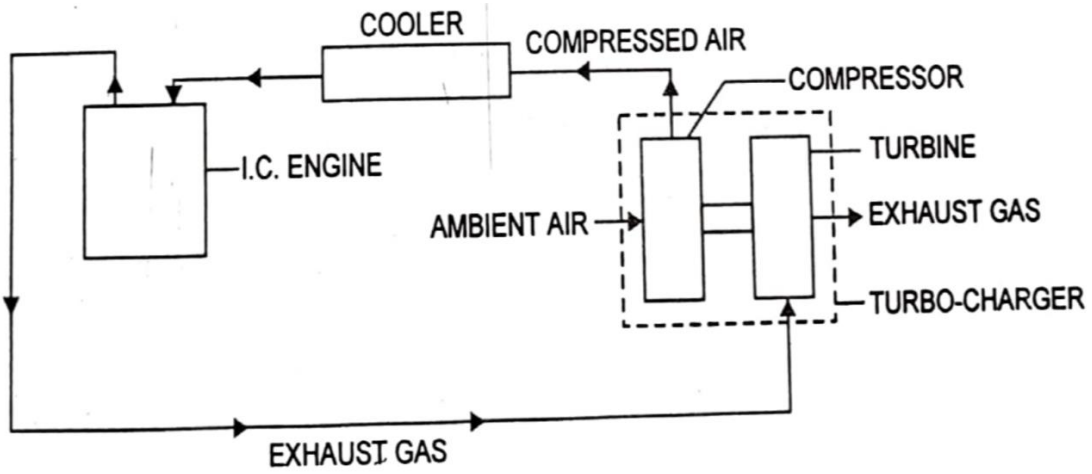


Fig. 9.74. Working of a turbochager

- The turbocharger includes a turbine and a centrifugal compressor coupled together.
- The exhaust gases from the engine enter into turbocharger and run the turbine, which further drives the compressor.
- The atmospheric air enters into compressor which raises its pressure by about 0.5 bar (50 kPa).
- which means about 50 percent more air by weight (for the same engine volume, i.e., engine size) which would increase the power by 50% from the same engine.
- In practice, we able to achieve 30 to 40 percent increase in power.
- There is no mechanical linkage between the engine and the turbocharger.
- During engine operation, hot exhaust gases blowout through the exhaust valve opening into the exhaust manifold.
- The exhaust manifold and the connecting tubing route these gases into the turbine housing. As the gases pass through the turbine housing, they strike on the fins or blades on the turbine wheel.
- When the engine load is high enough, there is enough gas flow and this makes the turbine wheel to spin rapidly.
- The turbine wheel is connected to the compressor wheel by the turboshaft. As such, the compressor wheel rotates with the turbine which sucks air into the compressor housing.
- Centrifugal force throws the air outward. This causes the air to flow out of the turbocharger and into the engine cylinder under pressure.
- In the case of turbocharging, there is a phenomenon called turbo lag. It refers to the short delay period before the boost or manifold pressure increases. This is due to the time the turbocharger assembly takes the exhaust gases to accelerate the turbine and compressor wheel to speed up.
- In the turbocharger assembly, there is a control unit called waste gate. This unit limits the maximum boost pressure to prevent the maximum pressure and engine damage. It is a diaphragm operated valve that can bypass part of the gases around the turbine wheel when manifold pressure is quite high.

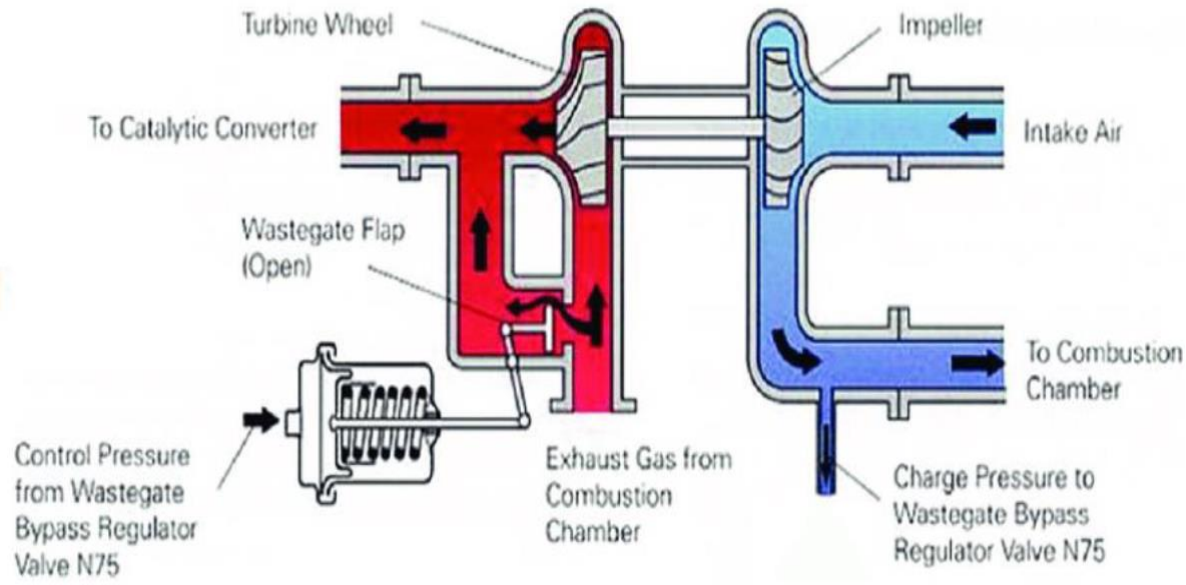
TURBO LAG:

- Turbo lag is the time required to change power output in response to a throttle change.
- Noticed as a hesitation or slowed throttle response when accelerating as compared to a naturally aspirated engine.
- This is due to the time needed for the exhaust system and turbocharger to generate the required boost which can also be referred to as spooling.
- Engine designs reduce lag in a number of ways:
  - Lowering the rotational inertia of the turbocharger by using lower radius parts and ceramic and other lighter material.
  - Increasing upper-deck air pressure (compressor discharge) and improving waste gate response
  - Reducing bearing frictional losses.
  - Using multiple turbochargers sequentially or in parallel
  - Using a turbocharger spool valve to increase exhaust gas flow speed to the (twin- scroll) turbine.

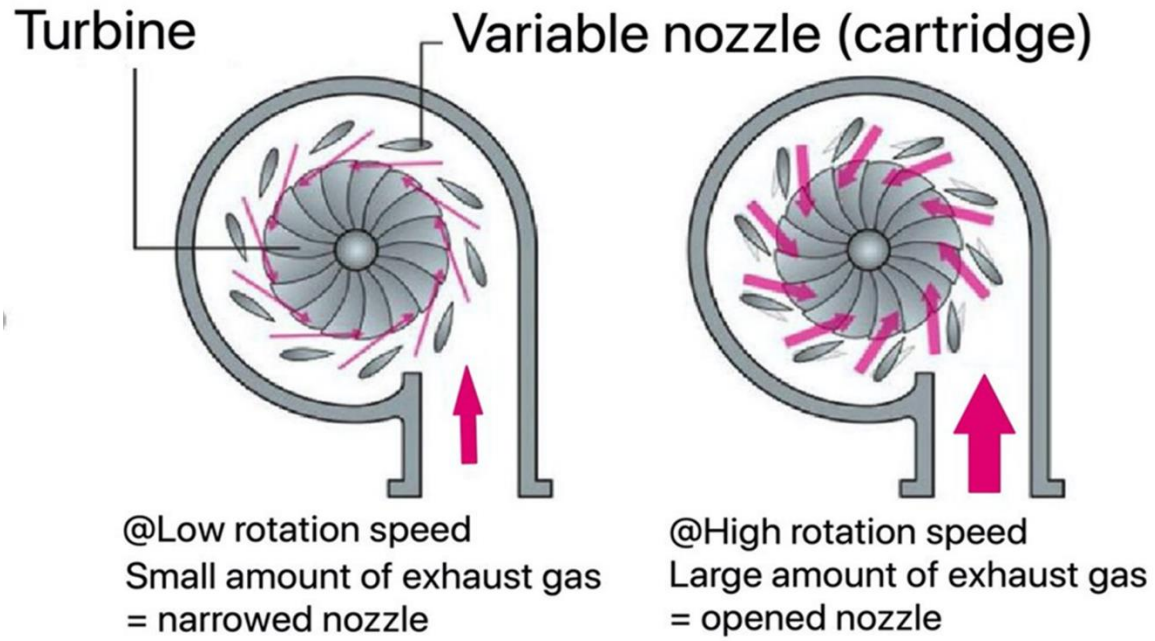
WASTE GATE TURBOCHARGER(WGT):

- A turbocharger wastegate is a small valve, which is used to control the amount of boost the turbo makes.
- It opens at a predetermined limit, to allow surplus exhaust gas to bypass the turbine and disappear straight down the exhaust pipe once the boost limit is reached.
- Most engines can handle a small amount of additional boost but the temptation is to keep going, as it's relatively easy power.

- For a given turbo, the boost pressure is dependent in the amount of exhaust gas going through the turbine.
- This is controlled by a small valve, known as the wastegate. This opens at a pre-determined limit to allow surplus exhaust gas to bypass the turbine and disappear straight down the exhaust pipe once the boost limit is reached.
- Normally, a wastegate will have a spring on one side of the diaphragm and boost pressure on the other side. At the point where boost exerts force greater than the spring pressure, the gate opens to bleed off the exhaust gases.
- If too much exhaust gas is sent through the turbine, the unit can over-speed, which puts mechanical stresses on it and can lead to all sorts of problems, such as breaking shafts or compressor wheels failing.



VARIABLE GEOMETRY TURBOCHARGERS (VGT):



- Charging effect of turbocharger is too poor in a low flow range at a low engine speed region.
- But VGT is now used in High-speed direct injection (HSDI) Diesel engines, which raise the boost pressure even at lower rpm of engine, along with the reduction of pumping losses at higher engine speeds compared to a waste gated turbocharger.
- Variable Geometry Turbochargers are also called as Variable Nozzle Turbine (VNT).
- A turbocharger outfitted with Variable Turbine Geometry has small movable vanes pivoted on the supporting ring, which can direct exhaust flow gases from exhaust to the turbine blades.
- The vane angles of VNT are adjusted with the help of an actuator. The actuator can be hydraulic or pneumatic or mechanically operated.
- The angle of the vanes varies throughout the engine RPM range to optimize behaviour of the turbine.
- For low engine speeds, the vanes are nearly closed position, i.e., gap between vanes are narrow. Thus, the exhaust gas flows through the narrow passage, which accelerates towards the blades of the turbine. Therefore, the turbine rotates faster. The angle of the vanes is adjusted in such a way the gas to hit the blades at the accurate angle.
- When the engine is at high rpm, the exhaust is also high. Therefore, to take the full advantage of this high exhaust flow, the vanes are fully opened. This also helps to release the exhaust pressure that is generated in the turbocharger, which saves the need of wastegate.