Unit 2 : ENGINE AUXILIARY SYSTEMS

Module 3 : Turbo chargers (WGT, VGT), Engine emission control by three way catalytic converter system, Emission norms (Euro and BS).

Turbo Chargers

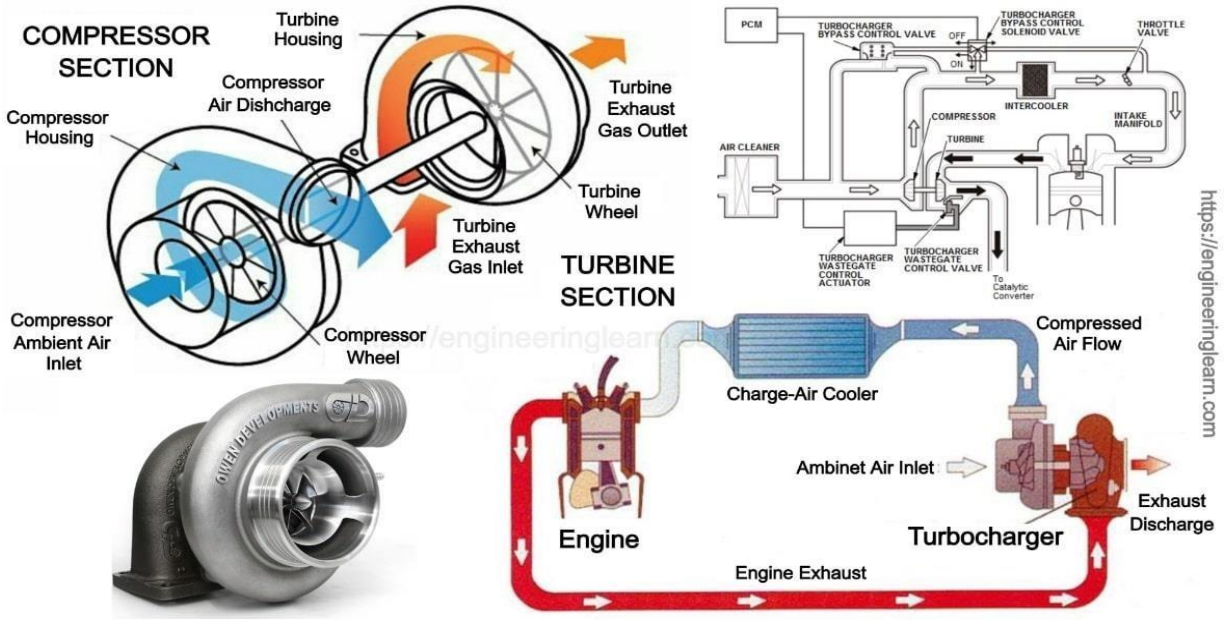

Figure: Working and Line diagram of turbo charger

- The turbo charger utilizes the wasted heat energy in the exhaust system, to run a compressor which compresses the intake air. Compressed intake air has more density and hence more fuel can be injected increasing the power of the engine. Turbo charging is an ideal way to increase the engine power without increasing the engine size.
- It is a turbine-driven forced induction device that increases an engine's efficiency and power by forcing extra air into the combustion chamber. This improvement over a naturally aspirated engine's output results because the turbine can force more air, and proportionately more fuel, into the combustion chamber than atmospheric pressure alone.
- Turbochargers are commonly used on truck, car, train, aircraft, and construction equipmentengines. They are most often used with Otto cycle and Diesel cycle internal combustion engines. They have also been found useful in automotive fuel cells.

Waste Gate Turbo Charger (WGT)

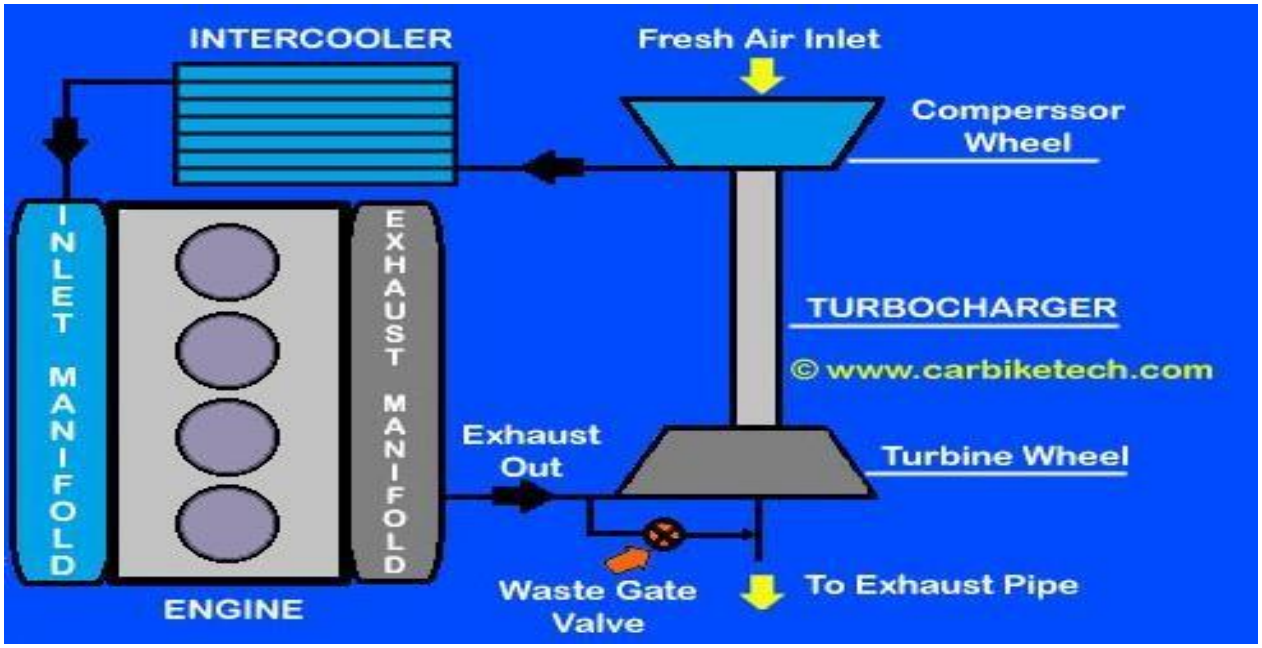

Figure: Waste Gate Turbo Charger

The waste-gate regulates the pressure of the relief valve. It, in turn, limits the boost pressure in the turbocharger system. This is helpful in preventing the engine from potential mechanical damages caused by the high pressure. Furthermore, the system automatically opens the waste-gate valve when thepressure reaches the pre-set levels. Then, it allows all the high-pressure exhaust gases to escape the turbine wheel and enter into the downstream/outlet. Thus, it prevents the exhaust gas pressure from rising more than required.

Advantages

- Needs a smaller space to fit.
- Reduces turbo lag to some extent.
- Installation of compact and simple external exhaust pipe system. Thus, reducing theengine weight.
- Delivers optimum engine performance at all times.
- Avoids mechanical damage to engine parts

Variable Geometry Turbo charger (VGT)

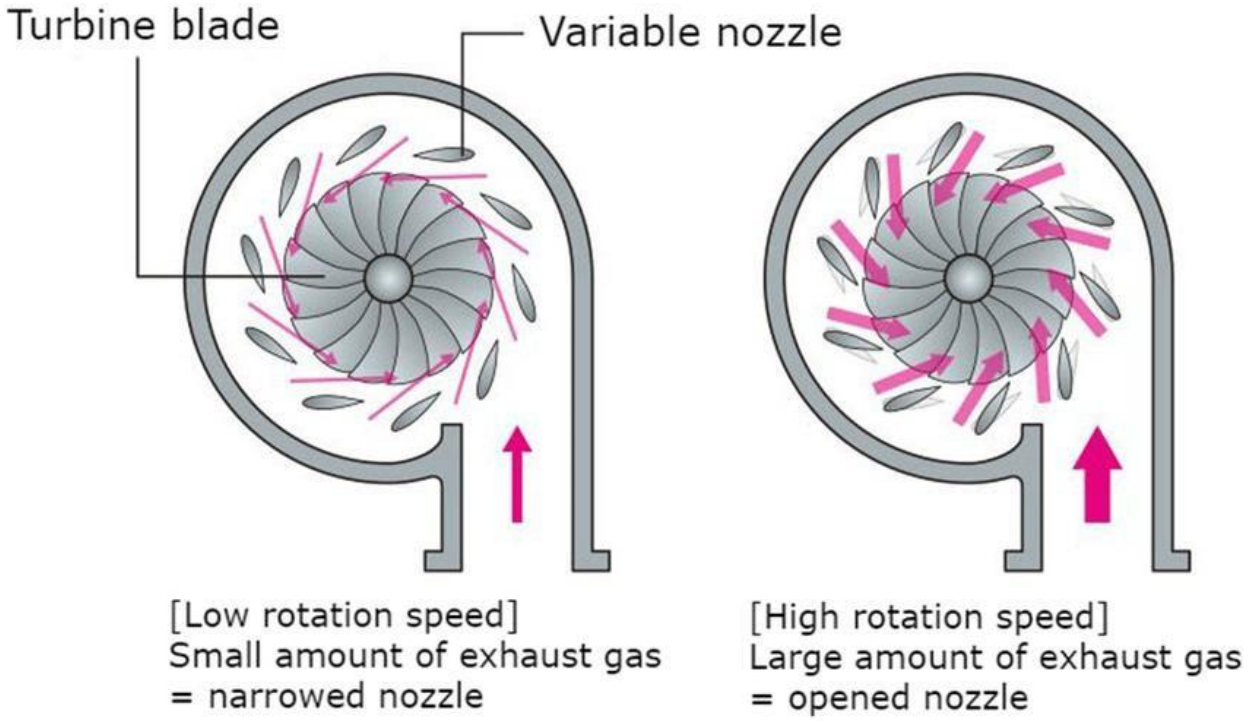

Figure: Variable Gate Turbocharger (VGT)

- VGTs refers to as those types of turbochargers which include a ring of aerodynamically-shaped vanes inside the turbine housing at the turbine inlet. The turbos used in the passenger cars and light commercial vehicles, can rotate in order to vary the gas swirl angle and the cross-sectional area simultaneously. The internal vanes which are present alter the turbos area-to-radius ratio (A/R) in order to match the RPM of the engines, and to also give a peak performance.
- Considering a case of low RPM, a low A/R ratio occurs which helps the turbo to spool up quickly by increasing the velocity of the exhaust gas. At higher revs the A/R ratio increases which is responsible for the increased airflow. These results in a low boost threshold which is responsible for reducing the turbo lag, and also provides a wide and smooth torque band.
- While the VGTs are quite typically used in the diesel engines where the exhaust gases lower the temperature and by then the VGTs were just limited in the petrol engine applications due to their cost and the requirement for components was made from an exotic material.

Types of nozzles:

(a) Depends on the type of combustion chamber,

Open combustion chamber:

-fuel seeks air

-air swirl is created due to inclined induction port
-multi-hole nozzle injects fuel at a pressure of about 200 to 300 bar to slow moving air
-provide good cold starting performance and improved thermal efficiency

Pre-combustion chamber:
-air velocity is very much high
-single hole nozzle with 65 to 100 bar injection pressure is used
-used in high speed engine due to rapid combustion
-external heating device for easy starting of the engine

(b) Open and closed type of nozzle,

Open type:
-consists of fuel orifices and open to burner
-cheap and less efficient
ex- opposed piston two-stroke Junkers diesel engine
Closed type: pressure drop is minimised compared to open type

(c) Different types of nozzle for different combustion chamber

(i) **Single hole nozzle**:
-used in open combustion chamber
-size of hole larger than 0.2 mm
-very high injection pressure required

(ii) Multi-hole nozzle:
-no. of hole varies from 4 to 18 and the size from 1.5 to 0.35 mm
-injection rate is not uniform

(iii) Pintle nozzle:
-a projection or pintle is provided in the nozzle to avoid weak injection and dribbling
-pintle may be cylindrical or conical shape

-cone angle varied from 0 to 60^{o}

-provide good atomisation and reduced penetration

-fuel pressures are lower than single and multi-hole nozzle

(iv) **Pintaux nozzle**:

-injected fuel in upstream of air

-development of pintle nozzle with auxiliary hole drilled in the nozzle body

-reduced delay period and increased thermal efficiency

CATALYTIC CONVERTER

As indicated by the meaning of chemistry, a catalyst is a substance that causes or quickens a compound response without itself being influenced. Catalysts take an interest in the responses, however are neither reactants nor results of the response they catalyze. An exhaust system is a vehicle discharges control gadget which changes over lethal by-results of burning in the fumes of an interior ignition motor to less poisonous substances by method for catalyzed compound responses . It lessens temperature at which CO and HC change over into CO_2 and H_2O. Big and large exhaust systems utilize platinum gathering of respectable metals.

The contaminations have negative effect on air quality, environment and human wellbeing that leads instringent standards of poison outflow. Quantities of option innovations like change in motor plan, fuelpretreatment, utilization of option energizes, fuel added substances, fumes treatment or better tuning of the ignition procedure and so forth, are being considered to lower the release levels of the engine. Out of various progressions available for auto vapor radiation control a fumes framework is found to best choice to control CO, HC and NO_X discharges from petrol driven vehicles while diesel particulate channel and oxidation forces converter or diesel oxidation impulse have so far been the most potential other option tocontrol particulates outpourings from diesel driven vehicle [5]. An exhaust system (CC) is put inside the tailpipe through which destructive fumes gasses containing unburnt fuel, CO, NO_X are transmitted .

Three-way Catalytic Converter

Similar to the oxidation converter, the reduction catalytic converter helps to eliminate hydrocarbons and carbon-monoxide emanations, in addition to oxides of nitrogen discharges, or NO_X. NO_X outflows are created in the motor burning chamber when it reaches extremely high temperatures more than 2,500 degrees Fahrenheit, approximately. In this type of converter, a reduction reaction also occurs in addition to two oxidation reactions same as two-way converter. The reduction reaction occurs during the conversion of oxides of nitrogen to nitrogen and oxygen. So this type of converter is also known as reduction typecatalytic converter.

Conversion Reactions in Three Way Catalytic Converter

$C_XH_{4X} + 2xO_2 \rightarrow xCO_2 + 2xH_2O$ (conversion of hydrocarbons)$2xCO + O_2 \rightarrow 2xCO_2$ (conversion of carbon mono-oxides)

$2NO_X \rightarrow N_2 + xO_2$ $[O_2 + 2H_2 \rightarrow 2H_2O]$ (Decomposition of oxides of nitrogen).

Emissions

- Emission Norms are emission standards instituted by the Government of a nation to regulate the output of air pollutants from internal combustion engines and Spark-ignition engines equipment, including motor vehicles.
- In india the standards and the timeline for implementation are set by the Central Pollution Control Board under the Ministry of Environment, Forest and Climate Change
- All new vehicles manufactured after the implementation of the norms have to be compliant with the regulations

European Emission Standards

- **European emission standards** define the acceptable limits for exhaust emissions of new vehicles sold in EU member states.
- Currently, emissions of nitrogen oxides (NO_x), total hydrocarbon (THC), non-methane hydrocarbons (NMHC), carbon monoxide (CO) and particulate matter (PM) are regulated for most vehicle types, including cars, lorries, trains, tractors and similar machinery, but excluding seagoing ships and aeroplanes.
- For each vehicle type, different standards apply. Compliance is determined by running the engine at a standardised test cycle. Non-compliant vehicles cannot be sold in the EU, but new standards do not apply to vehicles already on the roads. **No use of specific technologies is mandated to meet the standards, though available technology is considered when setting the standards.** New models introduced must meet current or planned standards,

CO_2 emission

- Within the European Union, road transport is responsible for about 20% of all CO_2 emissions, with passenger cars contributing about 12%.
- The target fixed at Kyoto Protocol was an 8% reduction of emissions in all sectors of the economy compared to 1990 levels by 2008-2012.
- Relative CO_2 emissions from transport have risen rapidly in recent years, from 21% of the total in 1990 to 28% in 2004,

European emission standards for passenger cars (Category M*), g/km

Tier	Date	CO	THC	NMHC	NO_x	HC+NO_x	PM	P***
Diesel								
Euro 1†	July 1992	2.72 (3.16)	-	-	-	0.97 (1.13)	0.14 (0.18)	-
Euro 2	January 1996	1.0	-	-	-	0.7	0.08	-
Euro 3	January 2000	0.64	-	-	0.50	0.56	0.05	-
Euro 4	January 2005	0.50	-	-	0.25	0.30	0.025	-
Euro 5	September 2009	0.50	-	-	0.180	0.230	0.005	-
Euro 6 (future)	September 2014	0.50	-	-	0.080	0.170	0.005	-
Petrol (Gasoline)								
Euro 1†	July 1992	2.72 (3.16)	-	-	-	0.97 (1.13)	-	-
Euro 2	January 1996	2.2	-	-	-	0.5	-	-
Euro 3	January 2000	2.3	0.20	-	0.15	-	-	-
Euro 4	January 2005	1.0	0.10	-	0.08	-	-	-
Euro 5	September 2009	1.0	0.10	0.068	0.060	-	0.005**	-
Euro 6 (future)	September 2014	1.0	0.10	0.068	0.060	-	0.005**	-

* Before Euro 5, passenger vehicles > 2500 kg were type approved as light commercial vehicles N_1-I
** Applies only to vehicles with direct injection engines
*** A number standard is to be defined as soon as possible and at the latest upon entry into force of Euro 6
† Values in brackets are conformity of production (COP) limits

Emission standards for light commercial vehicles

European emission standards for light commercial vehicles ≤1305 kg (Category N_1-I), g/km

Tier	Date	CO	THC	NMHC	NO_x	HC+NO_x	PM	P
Diesel								
Euro 1	October 1994	2.72	-	-	-	0.97	0.14	-
Euro 2	January 1998	1.0	-	-	-	0.7	0.08	-
Euro 3	January 2000	0.64	-	-	0.50	0.56	0.05	-
Euro 4	January 2005	0.50	-	-	0.25	0.30	0.025	-
Euro 5	September 2009	0.500	-	-	0.180	0.230	0.005	-
Euro 6	September 2014	0.500	-	-	0.080	0.170	0.005	-
Petrol (Gasoline)								
Euro 1	October 1994	2.72	-	-	-	0.97	-	-
Euro 2	January 1998	2.2	-	-	-	0.5	-	-
Euro 3	January 2000	2.3	0.20	-	0.15	-	-	-
Euro 4	January 2005	1.0	0.10	-	0.08	-	-	-
Euro 5	September 2009	1.000	0.100	0.068	0.060	-	0.005*	-
Euro 6	September 2014	1.000	0.100	0.068	0.060	-	0.005*	-
* Applies only to vehicles with direct injection engines								

History of Emission Standards in India

- It was in the early nineties that the first emission standards were introduced in the country.
- Other regulatory norms followed in the form of making the catalytic converters mandatory for petrol vehiclesand then, by the introduction of unleaded petrol.
- In 1999, the apex court of the country made it mandatory for all vehicles to meet the India 2000 norms byJune 2000, in a ruling.
- In 2002, the Mashelkar Committee report was accepted by the Indian Government.
    - The committee had recommended a roadmap for the implementation of the Euro norms basedemission standards for India.
    - It also recommended that the roll-out of the norms be implemented in major cities first to be followedby the rest of the country in a phased manner.
    - Based on the committee‘s recommendations, in 2003, the government released the National Auto FuelPolicy.

Bharat Stage Emission Standards

- Bharat Stage or BS Emission Standards are government-instituted emission standards that all motorvehicles have to comply with if they are to be sold and driven in India.
- Currently, all new vehicles sold and registered in India should be compliant with the BS-VIiteration of emission standards.
- The standards and timelines for their implementation are set by the Central Pollution Control Board(CPCB) under the Minister of Environment, Forests and Climate Change.

- The BS norms are based on the European Emission Standards (Euro norms) and were first set in2000. Equivalent to the Euro-1, the first iteration was known as _India 2000', and not BS-I.
- Subsequent emission standards were called BS-II, BS-III, and BS-IV.
- The government decided to jump directly from BS-IV to BS-VI skipping BS-V in view of the longtime it took to move from BS-III to IV.

- With the implementation of the new norms, pollution levels are expected to reduce to a large extent as the particulate matter (PM) concentration should decrease. About one-third of the air pollution is caused by motor vehicles and cars.
- At present, BS-IV auto fuels are being supplied in over 30 cities, and the rest of the country has BS-III fuels.
- Earlier, the government planned the implementation of BS V and BS VI emission norms nationwide by 2020 and 2024 respectively. However, the government decided to advance the dates.

The following table gives the timeline of the BS norms being implemented in India starting from the India 2000 till the latest BS-VI norms.

Standard (Reference)	**Year/Region**
India 2000 (Euro 1)	**2000 – Nationwide**
BS II (Euro 2)	**2001 – Metro cities** **2003 – 10 more major cities** **2005 – Nationwide**
BS III (Euro 3)	**2005 – Metros and major cities2010 – Nationwide**
BS V (Euro 5)	**Skipped**
BS VI (Euro 6)	**2018 – Delhi** **2019 – NCR** **2020 – Nationwide**