MOMENTARY NOTES ON TURBOCHARGING: FOR BETTER FUEL ECONOMY, EMISSION REDUCTION AND PRONOUNCED PERFORMANCE OF AN ENGINE

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Abstract:* The automotive landscape will increasingly feature smaller, cleaner and better performing powertrains and that the Internal Combustion Engine, whether diesel, gasoline, bio-fuel driven or in a hybrid configuration, will continue to lead the way. This means that for the probable future, turbocharging will remain a key enabling technology. A turbocharger is a machine that recovers exhaust gas energy using a turbine and drives an axial compressor to feed air required for combustion. Turbochargers are extensively used throughout the automotive industry as they can enhance the output of an internal combustion engine without the need to increase its cylinder capacity. The application of such a mechanical device enables automotive manufacturers to adopt smaller displacement engines. The emphasis today is to provide feasible "greener" road vehicles. It is because of these reasons that turbochargers are now becoming much more popular in industry applications. Because turbocharging is proven to help increase fuel efficiency by up to 40 percent for diesel engines and up to 20 percent for gasoline engines compared to non-turbocharged gasoline engines with the same power. It is also a technology that requires relatively modest up-front investment – which goes a long way to explaining why by 2020, close to 70 percent of the entire world's new light vehicles will likely benefit from the turbo advantage. The aim of this paper is to provide a description on the turbocharging techniques, analyses of different turbochargers and their designs, with discussions on future prospective.

***Keywords:* Turbocharger, variable geometry turbochargers, variable nozzleturbocharge, motor assist turbocharger, two stage turbocharger, FGT, HCCI, emission etc.**

I. INTRODUCTION

In recent years the scientific and public awareness on environmental and energy issues has brought in major interests to the research of advanced technologies particularly in highly efficient internal combustion engines. A naturally aspirated internal combustion engine produces large amount of waste heat. The combustion process of fuel within the cylinder releases heat energy and exhausted through the exhaust manifold and finally to the environment. This wasted exhaust energy can be recovered using a turbocharger. The application of turbochargers enables manufacturers to use smaller displacement engines. This is possible because the engine performance is related to the force acting upon the piston which produces work and therefore torque. As passenger car and commercial vehicle manufacturers seek the technology-based solutions that can reduce emissions, turbocharging is acknowledged to be one of the most important enablers in meeting objectives for improved fuel efficiency and better performance. Turbochargers are proven to help smaller engines deliver bigger engine performance and consume up to 40 percent less fuel for diesel engines and up to 20 percent for gasoline engines. These essential benefits along with the cost advantage of turbo application and to lower levels of CO_2 lead this technology towards the mainstream and global. There are two ways of increasing the power of an engine.

Firstly, by using rich fuel-air mixture by adding more fuel. This will increase the power but at the cost of fuel efficiency and increase in pollution levels possibilities. Secondly, by any means increase the volume of air entering into the cylinder and increasing the fuel intake proportionately, increasing power and fuel efficiency without affecting the environment or efficiency. The second proposal is the basic principle of Turbochargers. A turbocharger consists of a compressor and a turbine connected by a shared axle so if the turbine rotates, the compressor also rotates. The turbine inlet receives exhaust gases from the engine causing it to rotate.

This rotation in turn drives the compressor, which compresses the ambient air and delivers it to the intake manifold of an engine at higher pressure, resulting in greater amount of air entering the cylinder. Turbocharger technology make possible for engine downsizing, i.e. smaller in size, small through reducing pump work in SI engines. Also, its ability to increase power density greatly influences the revival of diesel engines into the industry in which most of diesel engines today are equipped with turbochargers. Turbocharging increases the air mass flow rate into the engine which significantly reduces particulates for diesel engines that are released into the atmosphere. Turbocharging was largely adopted in diesel engines and recent motivation for more fuel efficient, economic and high- performance engines. Turbo charging has also slowly been established with gasoline engines although the demands are dissimilar to that of diesel engines.

II. FUNCTIONING OF A TURBOCHARGER

All naturally aspirated gasoline and diesel engines rely on the downward stroke of a piston to create a low pressure area (less than atmospheric pressure) above the piston in order to draw air through the intake system. With the rare exception of tuned induction systems, most engines cannot inhale their full displacement of atmospheric density air. The measure of this loss or inefficiency in four stroke engines is called volumetric efficiency. If the density of the intake air above the piston is equal to atmospheric, then the engine would have 100% volumetric efficiency. Unfortunately, most engines fail to achieve this level of performance. This loss of potential power is often compounded by the loss of density seen with elevated altitudes. Thus, a natural use of the turbocharger is with aircraft engines. As an aircraft climbs to higher altitudes the pressure of the surrounding air quickly falls off. At 5,490 m the air is at half the pressure of sea level which means that the engine will produce less than half-power at this altitude. The objective of a turbocharger, just as that of a supercharger; is to improve an engine's volumetric efficiency by increasing the intake density. The turbine wheel is connected by a shaft to a compressor wheel and the two wheels turn together to suck in and compress large amounts of ambient air. This air is very dense and very hot, so it is passed through a charge-air cooler, where it cools and gains even higher density before entering the engine. The presence of this compressed air makes the fuel burn more efficiently, thereby delivering greater power while consuming less energy. Increasingly, turbos are coupled with high pressure fuel injection systems, a combination that makes for even more thorough, efficient and cleaner combustion. A turbocharger uses an engine's exhaust gas to drive a turbine wheel at speeds up to 280,000 rpm.

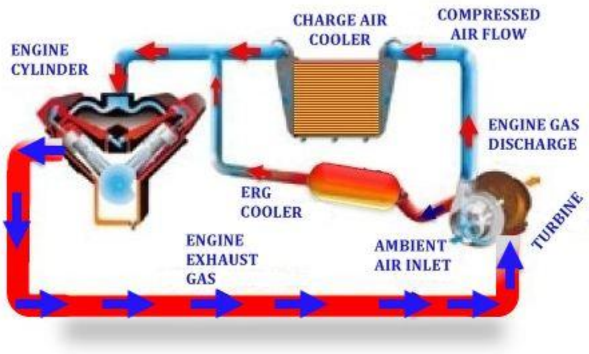


Fig. 1: how a turbocharger works

Engine power is proportional to the amount of air and fuel that can get into the cylinders. All things being equal, larger engines flow more air and as such will produce more power. If we want our small engine to perform like a big engine, or simply make our bigger engine produce more power, our ultimate objective is to draw more air into the cylinder. By installing a turbocharger, the power and performance of an engine can be dramatically increased.

III. A TYPICAL TURBOCHARGER SYSTEM

The air filter (not in fig) through which ambient air passes before entering the compressor. The air is then compressed which raises the air's density. Many turbocharged engines have a charge air cooler / intercooler. That cools the compressed air to further increase its density and to increase resistance to detonation. After passing through the intake manifold the air enters the engine's cylinders, which contain a fixed volume. Since the air is at elevated density, each cylinder can draw in an increased mass flow rate of air. Higher air mass flow rate allows a higher fuel flow rate with similar air-fuel ratio. Combusting more fuel results in more power being produced for a given size or displacement. After the fuel is burned in the cylinder it is exhausted during the cylinder's exhaust stroke in to the exhaust manifold. The high temperature gas then continues on to the turbine. The turbine creates backpressure on the engine which means engine exhaust pressure is higher than atmospheric pressure. A pressure and temperature drop occurs i.e. expansion across the turbine which harnesses the exhaust gas energy to provide the power necessary to drive the compressor.

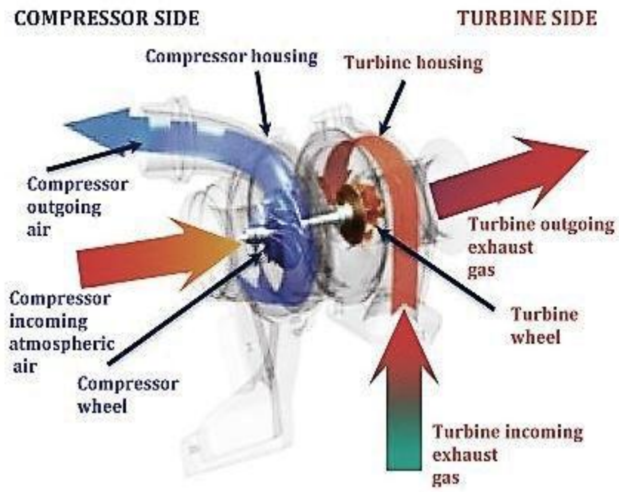


Fig. 2: A typical turbocharger system

Some other components of a turbocharger:

The layout of the turbocharger in a given application is critical to a properly performing system. Intake and exhaust plumbing is often driven primarily by packaging constraints. Apart from turbine and compressor other components of a turbocharger are:

A. Blow-Off valve

The Blow-Off valve (BOV) is a pressure relief device on the intake tract to prevent the turbo's compressor from going into surge. The BOV should be installed between the compressor discharge and the throttle body, preferably downstream of the charge air cooler (if equipped). When the throttle is closed rapidly, the airflow is quickly reduced, causing flow instability and pressure fluctuations. These rapidly cycling pressure fluctuations are the audible evidence of surge. Surge can eventually lead to thrust bearing failure due to the high loads associated with it. Blow-Off valves use a combination of manifold pressure signal and spring force to detect when the throttle is closed. When the throttle is closed rapidly, the BOV vents boost in the intake tract to atmosphere to relieve the pressure; helping to eliminate the phenomenon of surge.

B. Wastegates

On the exhaust side, a Wastegates provides us a means to control the boost pressure of the engine. Some commercial diesel applications do not use a Wastegates at all. This type of system is called a free-floating turbocharger.

However, the vast majority of gasoline performance applications require a Wastegates. There are two configurations of wastegates: internal or external. Both internal and external Wastegates provide a means to bypass exhaust flow from the turbine wheel. Bypassing this energy (e.g. exhaust flow) reduces the power driving the turbine wheel to match the power required for a given boost level. Similar to the BOV, the Wastegates uses boost pressure and spring force to regulate the flow bypassing the turbine. Internal Wastegates are built into the turbine housing and consist of a “flapper” valve, crank arm, rod end, and pneumatic actuator. It is important to connect this actuator only to boost pressure; i.e. it is not designed to handle vacuum and as such should not be referenced to an intake manifold. External Wastegates are added to the exhaust plumbing on the exhaust manifold or header. The advantage of external Wastegates is that the bypassed flow can be reintroduced into the exhaust stream further downstream of the turbine. This tends to improve the turbine’s performance. On racing applications, this Wastegated exhaust flow can be vented directly to atmosphere.

C. Oil and Water Plumbing

The intake and exhaust plumbing often receives the focus leaving the oil and water plumbing neglected. Ball bearing turbochargers require less oil than journal bearing turbos. Therefore an oil inlet restrictor is recommended if you have oil pressure over about 413685.4 Pascal. The oil outlet should be plumbed to the oil pan above the oil level (for wet sump systems). Since the oil drain is gravity fed, it is important that the oil outlet points downward, and that the drain tube does not become horizontal or go “uphill” at any point. Following a hot shutdown of a turbocharger, heat soak begins. This means that the heat in the head, exhaust manifold, and turbine housing finds its way to the turbo’s center housing, raising its temperature. These extreme temperatures in the center housing can result in oil coking. To minimize the effects of heat soak-back, water-cooled center housings were introduced. These use coolant from the engine to act as a heat sink after engine shutdown, preventing the oil from coking. The water lines utilize a thermal siphon effect to reduce the peak heat soak-back temperature after key-off. The layout of the pipes should minimize peaks and troughs with the (cool) water inlet on the low side. To help this along, it is advantageous to tilt the turbocharger about 25° about the axis of shaft rotation.

D. Journal Bearings and Ball Bearings

Both journal bearing and ball bearings are used in turbocharger; however a ball-bearing cartridge is now an affordable technology advancement that provides significant performance improvements to the turbocharger. When driving a vehicle with the cartridge ball bearing turbocharger, you will find exceptionally crisp and strong throttle response. Ball Bearing turbochargers spool up 15% faster than traditional journal bearings. This produces an improved response that can be converted to quicker 0-96 km/h speed.

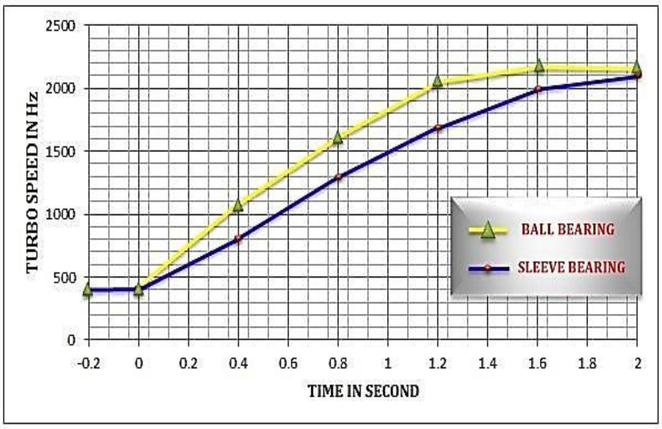


Fig. 3: Speed variation when the throttle is open at 2000 rpm With ball and sleeve bearing

Experiments prove that ball-bearings have up to half of the power consumption of traditional bearings. The result is faster time to boost which translates into better drivability and acceleration. On-engine performance is also better in the steady-state for the Ball Bearing. The ball bearing design reduces the required amount of oil required to provide adequate lubrication. Moreover, ball bearing improves the rotor dynamics and durability. An alternative of ball bearing is the hybrid ball bearing. This consists of replacing only the compressor side journal bearing with a single angular contact ball bearing.

E. Different types of manifolds:

There are two different types of manifolds are used in turbocharger:

- *Log style.*
- *Welded tubular style.*

Cast manifolds are commonly found on OEM applications, whereas welded tubular manifolds are found almost exclusively on aftermarket and race applications. Both manifold types have their advantages and disadvantages. Cast manifolds are generally very durable and are usually dedicated to one application. They require special tooling for the casting and machining of specific features on the manifold. This tooling can be expensive. On the other hand, welded tubular manifolds can be custom-made for a specific application without special tooling requirements. The manufacturer typically cuts pre-bent steel U-bends into the desired geometry and then welds all of the components together. Welded tubular manifolds are a very effective solution. One item of note is durability of this design.

Because of the welded joints, thinner wall sections, and reduced stiffness, these types of manifolds are often susceptible to cracking due to thermal expansion/contraction and vibration. Properly constructed tubular manifolds can last a long time, however. In addition, tubular manifolds can offer a substantial performance advantage over a log-type manifold. A design feature that can be common to both manifold types is a “divided manifold”, typically employed with “divided” or "twin-scroll" turbine housings. Divided exhaust manifolds can be incorporated into either a cast or welded tubular manifolds. The concept is to divide or separate the cylinders whose cycles interfere with one another to best utilize the engine's exhaust pulse energy. For a instance, on a four-cylinder engine with firing order 1-3-4-2, cylinder I is ending its expansion stroke and opening its exhaust valve while cylinder II still has its exhaust valve open In an undivided exhaust manifold, this pressure pulse from cylinder I’s exhaust blow down event is much more likely to contaminate cylinder II with high pressure exhaust gas. Not only does this hurt cylinder II’s ability to breathe properly, but this pulse energy would have been better utilized in the turbine. The proper grouping for this engine is to keep complementary cylinders grouped together-- I and IV are complementary; as are cylinders II and III.
Because of the better utilization of the exhaust pulse energy, the turbine's performance is improved and boost increases more quickly.

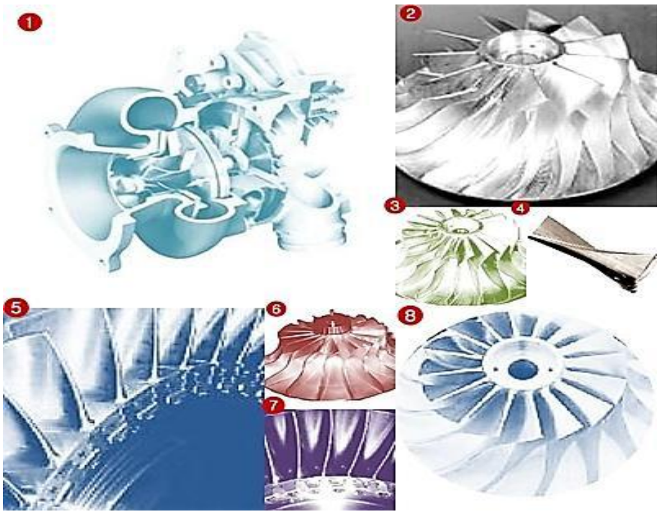
IV. PROS AND CONS OF TURBOCHARGING

Turbocharger makes engines:

- *Additional Efficiency*: turbocharged gasoline engines help deliver up to 20 percent better fuel economy over a non -turbocharged equivalent. A turbo diesel engine of the same power rating helps deliver up to 40 percent better fuel efficiency compared to a non-boosted gas engine.
- *Improved Performance*: turbocharged engines create more power and torque, making vehicles more responsive and safer to drive. Turbos also prevent the loss of power at high altitude, providing significant operational benefits to turbocharged trucks and off-road machinery.
- *Cleaner and Greener*: turbocharged engines optimize engine air supply for cleaner combustion, enabling engines to be downsized without compromising performance, while cutting CO_2 levels and contributing to a reduction in NOx.
- *Advantages:* More power compared to the same size naturally aspirated engine. Better thermal efficiency over naturally aspirated engine and supercharged engine because the engine exhaust is being used to do the useful work which otherwise would have been wasted. Better Fuel Economy by the way of more power and torque from the same sized engine.
- *Disadvantages:* Lack of response called the Turbo Lag. If the turbo is too big, the boost will build up slowly because more exhaust pressure will be needed to overcome the rotational inertia on the larger turbine reducing throttle response but more peak power. If the turbo is too small the turbo lag won’t be as big but the peak power would be lesser. So the turbocharger size is a very important consideration when deciding on it for a particular engine. Non liner rise in power and torque. Cost, Complexity: Turbocharger spins at very high revolutions; so proper cooling and lubrication is essential if it not to destroy the engine.

V. DIFFERENT GEOMETRY OF TURBOCHARGERS

The practice of Super Turbos is a comparatively new technology which is presently not being commercially used by any company. This is because similar results can be achieved using variable geometry turbochargers (VGT) which are commonly used throughout the automotive industry. Variable Geometry Turbocharger (VGT) technology (aka Variable Nozzle Turbo charger, VNT) is a type of turbine where the turbo controls the exhaust flow through the turbine blades by using variable vanes. Variable geometry turbochargers have conventional volute passages but the flow path of the gas is regulated using pivoted nozzle vanes. At low engine speeds, the effective aspect ratio (A/R) is too large and the turbo will not be able to produce boost. On the other hand, at high engine speeds, the A/R ratio is too small for the turbo which will choke the engine. As a result, increase in exhaust manifold pressures, high losses in pumps and eventually lower power output. A turbocharged engine equipped with VGT has small movable vanes to direct the incoming exhaust flow through the turbine blades. At different ranges of speed, the angle of the vanes would vary to optimize the flow of the exhaust gas. The vanes can be manipulated into different angles which determine how much exhaust gas flows into the turbine impeller i.e. how much energy is transferred from the exhaust gas to the turbine impeller. Experiments showed that the VGT unit will decrease the quantity of NOx in the exhaust gas emissions when compared to an FGT unit. The adoption of a variable geometry turbocharger increases the engine performance while reducing NOx emissions. For example, at 2500 RPM the FGT equipped engine produces 360 grams per hour whereas the VGT engine produces less than 60 grams per hour. Experiments revealed that using exhaust gas recirculation (EGR) systems in conjunction with a VGT could reduce the formation of NOx during the combustion cycle. The system implemented is known as a high-pressure EGR loop. During such a cycle, the exhaust gases are cooled down and re-circulated back into the combustion chamber. The cooled re-circulated gas functions as an energy absorber and therefore reduces the combustion temperatures which in turn reduce NOx quantities. The role of the variable geometry turbocharger is very important as it acts as an additional driver for the EGR system. By closing the vanes of the turbocharger unit at low engine speeds, an increase in boost is produced which accelerates the air flow towards the turbine. The extra air flow increases the back pressure on the turbine, creating a pressure difference between the turbine and manifold. This increases the exhaust flow through the EGR loop therefore producing less NOx emission. The torque control of a small gasoline engine that was equipped with a VNT turbocharger having torque improvement of about 27% at lower speed. For six closely matched turbo-charged SI engines that are equipped with VGTs having more than 10% improvement were achieved during low and high engine speed torque for VGT turbochargers compared to FGT. For a Waste Energy Driven Air Conditioning System which uses turbine to produced cold air and where the mechanical energy is then converted into electrical energy by using an alternator, power could potentially be recovered.



In the figure notation 1 shows the Variable Geometry Turbine (VGT) turbocharger and notation 2 to 8 shows different compressor impellers and turbine blades. 2-one body impeller with split blade, 3- two pieces, backward impeller, 4- high efficiency turbocharger turbine blade, 5- free standing blade, wide chord, 6-two pieces wheel and non-backward impeller, 7- free standing blade, 8-one body impeller.

VI. EFFECT ON VARIOUS PARAMETERS DUE TO TURBOCHARGING

When turbocharger is used in an IC engine it influences various parameters of engine. Some of them are listed below:

A. Effect of Turbocharging on the Volumetric Efficiency

With the increase of boost pressure more air is available for the combustion which further increases the combustion efficiency. At higher boost pressures excess air doesn't improve the combustion efficiency. So it is concluded that at optimum boost pressure, drop in volumetric efficiency is compensated with turbocharger. Because of the increased backpressure with turbocharging conditions, the inlet boost pressures are higher for compensating the volumetric efficiency drop in normal engine. It requires nearly 4% of intake boost pressure under turbocharging conditions for compensating the maximum efficiency drop of 10% in the normal engine.

B. Combustion Parameters

With the turbo charging more air will be available for the combustion and this will change the combustion parameters. It is observed that the peak pressures are higher with turbocharged engine then that of naturally aspirated engine. With the turbocharging more amount of air enters into the chamber which increases the combustion process and reduces the ignition delay. But at higher loads due to the high latent heat of alcohol, the ignition delay is slightly increased. So it will be beneficial to increase the turbocharging pressures in order to have a shorter ignition delays. There is an increase in the exhaust temperatures with turbocharging .This is due to the increase of mass flow rate of air, reduction in the ignition delay and hotter combustion chamber which further increases the combustion process. With turbocharging, a significant reduction in smoke level in turbocharged engine compared to normal engine without turbocharging at rated load condition due to complete combustion. The increase in combustion pressure and temperature values of IC engine with turbocharger compared to IC engine without turbocharger are mainly due to introduction of air into an engine cylinder at higher density than ambient at higher operating temperature. This allows a proportional increase in the fuel that can be burned and hence raises the in cylinder gas pressure and temperature of engine with turbocharger.

C. Air/Fuel Ratio

Proper 'Air/Fuel Ratio' (AFR) calibration is critical to performance and durability of the engine and it's components. The AFR defines the ratio of the amount of air consumed by the engine compared to the amount of fuel. A 'Stoichiometric' AFR has the correct amount of air and fuel to produce a chemically complete combustion event. For gasoline engines, the stoichiometric, A/F ratio is 14.7:1, which means 14.7 parts of air to one part of fuel. The stoichiometric AFR depends on fuel type-- for alcohol it is 6.4:1 and 14.5:1 for diesel. A lower AFR number contains less air than the 14.7:1 stoichiometric AFR; therefore it is a richer mixture. On the other hand, a higher AFR number contains more air and therefore it is a leaner mixture. Leaner AFR results in higher temperatures as the mixture is combusted. Generally, normally-aspirated SI gasoline engines produce maximum power just slightly rich of stoichiometric. However, in practice it is kept between 12:1 and 13:1 in order to keep exhaust gas temperatures in check and to account for variances in fuel quality. This is a realistic full-load AFR on a normally-aspirated engine but can be dangerously lean with a highly-boosted engine. As the air-fuel mixture is ignited by the spark plug, a flame front propagates from the spark plug. The now-burning mixture raises the cylinder pressure and temperature, peaking at some point in the combustion process. The turbocharger increases the density of the air resulting in a denser mixture. The denser mixture raises the peak cylinder pressure, therefore increasing the probability of knock. As the AFR is leaned out, the temperature of the burning gases increases, which also increases the probability of knock. This is why it is imperative to run richer AFR on a boosted engine at full load. Doing so will reduce the possibility of knock, and will also keep temperatures under control.

D. Effect of Turbocharging on Emissions

Always a car and commercial vehicle manufacturers seek the technology-based solutions that can reduce emissions, turbocharging is acknowledged to be one of the most important enablers in meeting objectives for improved fuel efficiency and better performance. And it's easy to see why. Turbochargers are proven to help smaller engines deliver bigger engine performance and consume up to 40 percent less fuel for diesel engines and up to 20 percent for gasoline engines. This will reduce the levels of CO_2. The turbo revolution that started with diesel in Europe in the 1990s is now rapidly gaining ground in gasoline powertrains and reaching every region of the world. Currently, over 20 percent of light vehicles sold in the world are turbocharged – by 2020; this figure is likely to rise to almost 70 percent.

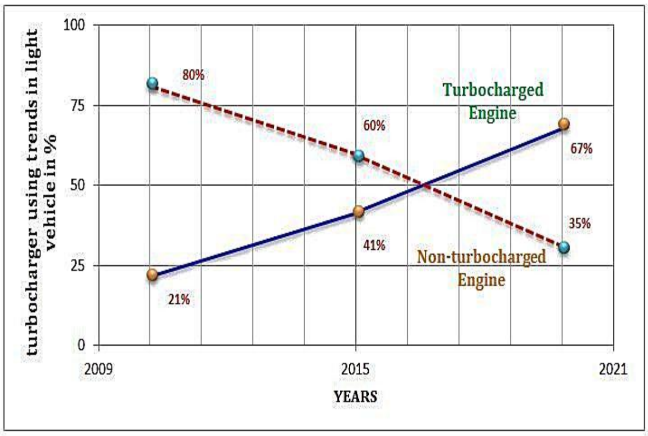


Fig. 4: To maintain high emission standards 70 percent of all new light vehicles using and going to use turbocharged engine.

As the trend is expected to continue in the coming years, the development of fuel-efficient vehicles is recognized as being fundamental to CO_2 reduction strategies.

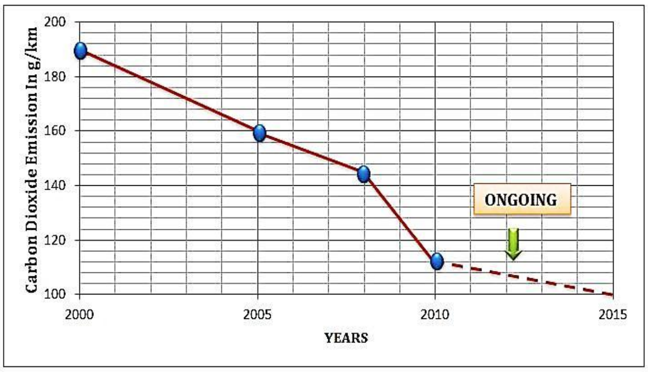
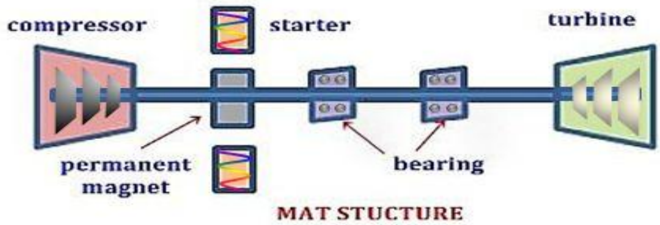


Fig. 5: CO_2 emission and the effect of turbocharging

VII. CURRENT DEVELOPMENTS

Currently engine downsizing has become an important technology especially for passenger to reduce the engine size as well as to lower the carbon dioxide emission. Many Japanese and European manufacturer uses VNT, VGT, motor assist turbocharger (MAT) and two stage turbocharger. For a turbocharged engine with VNT widely used in diesel engine where boost pressure can be increased by controlling VN at low engine speed. But the increase of pressure is limited due to low exhaust energy such that back pressure will increase. MAT can increase the boost pressure at low engine speed and at high speed it can act as a dynamo and recover the exhaust energy.



An electrifying progress of turbocharger technology is the introduction of an innovative two stage turbocharger. Fundamentally, a two-stage turbocharger has two different sized turbochargers assembled in serial configuration. The smaller sized turbocharger responds at lower speed by producing a higher torque that will reduce fuel consumption on the road. Additionally, the larger unit delivers boost at higher engine speeds. Based on the cluster of engines, different characteristic ranges of different engines can be deduced. Cost-effective engines or Base Engines utilized conventional technologies for example port fuel injection, one or none inlet cam phaser and simple mono-scroll turbines . Secondly, Peak Power Engines group that have higher specific engine power range expense low-end torque for high performance goals. Then, Peak Torque Engines group have achieved to increase their low-end torque at low specific power by using direct injection technology and one cam phaser. These VTG equipped Diesel engines can provide almost the same performance as the Peak Torque Engines thus revealing the potentials of gasoline engines for higher specific engine-power.

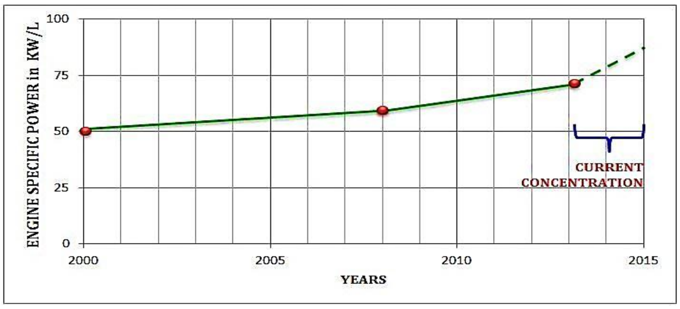


Figure shows that the trend is to increase the engine specific power above 80 Kw/Hr by using VNT, VGT, MAT and staged turbocharger. Current concentration is to use reduce the CO_2 emission by downsizing engine.

VIII. FUTURE PROSPECTIVE

Future goal is acceleration of CO_2 reduction. Next five year prospect is downsizing & down speeding by increased low end torque and this is achieved by integration of turbo machinery, high speed motors, power electronics, energy management, & energy recuperation. Turbocharger technology has also been simulated in a new type of engine concept called Homogenous Charge Progressive Combustion (HCPC) that permits reduction in soot and NO_X emissions in all operating conditions (during high and low engine loads). A formation of pre-compressed homogenous charge is progressively transferred into the cylinder to control the transfer flow rate and increasing pressures without relying on exhaust gas recirculation (EGR). This method is closely based on standard Homogenous Charge Compression Ignition (HCCI). A novel 3-phase sequential turbocharging system with two parallel unequal-size turbochargers reduced BSFC. A three-phase sequential turbocharging system with two unequal-size turbochargers is developed to improve the fuel economy performance and reduce the smoke emission of the automotive diesel engine, and it has wider range of application than the current two-phase sequential turbocharging system. Global fuel consumption & CO_2 emission reduction targets will continue into the future and internal combustion engines will remain dominant & improve meet these demands. Turbocharging plays a huge role in meeting current & future fuel economy and performance goals and driver performance expectations will be met. Automotive oil condition monitoring technology progresses and becomes more popular in the automotive industry; there will be many generations of sensors developed to improve accuracy and range of capability. While some vehicles come standard with oil change technologies today, the majority do not. The companies developing these sensor technologies must be able to convince the automotive industry and the public of their general reliability and value. If this is successful, we may see condition-based oil changes become the latest trend in vehicle technology over the next few years.

IX. CONCLUSION

Based on the achievements of conventional turbochargers, the turbocharger turbine was improved to ensure a drastic improvement in efficiency .Various attempts were made to improve the power output of an engine and to reduce its emissions by making some changes and installing some additional accessories like intercooler in the turbocharging technology.

This will carry on in the future because in coming days there will be increase in the demand of fuel efficient engines with more power and minimum emissions and this is possible with some advancements in turbocharging technology. Using suitable down-sized engines can generally achieve better engine outputs and fuel economy. Furthermore, different turbocharger designs used in conjunction with the down-sized engines becomes a global trend that will grow to become tidal wave of turbo technology. By 2015, close to 50 percent of all turbocharged engines will be 1.7L or smaller – compared to 40 percent today. By using turbocharged engine better fuel economy, reduction of emissions and great performance is achieved.

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