



Turbocharging and Oil Techniques in Light Motor Vehicles

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Abstract

Earlier the use of turbo charging in two wheelers is not possible this is possible only in heavy engines but now days with the use of technology and high grade machineries the turbochargers can be used in two wheelers with increased power and volumetric efficiency. This article reviews a Range of energy efficiency measures in the transportation Sector and assesses their Potentials for improving fuel efficiency. The primary Focus is on light-duty vehicles because they represent. The largest portion of world transport energy use and Carbon di oxide emissions; freight trucks, a rapidly Expanding source of greenhouse emissions, are also Discussed. Increasing energy efficiency can be achieved by improving the design and technology Used in new vehicles, but vehicle technology is only one component of fleet fuel economy. Measures that Create strong incentives for customers to take energy efficiency into consideration when buying and operating their vehicles will be crucial to policy success.

Key words: Turbocharger, bikes are turbocharged, stock engine, volumetric efficiency, Light-duty vehicles, Fuel economy, Fuel Efficiency, Vehicle technologies, IPCC

Introduction

A turbocharger consists of a compressor and a turbine linked 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. Now to some basics before we go ahead. There are two ways of increasing the power of an engine. One of them would be to make the fuel-air mixture richer by adding more fuel. This will increase the power but at the cost of fuel efficiency and increase in pollution levels prohibitive. The other would be to somehow increase the volume of air entering into the cylinder and increasing the fuel intake proportionately, increasing power and fuel efficiency without hurting the environment or efficiency. This is exactly what Turbochargers do; increasing the volumetric efficiency of an engine in a naturally aspirated engine, the downward stroke of the piston creates an area of low pressure in order to draw more air into the cylinder through the intake valves. Now because of the pressure in the cylinder cannot go below 0 (zero) psi (vacuum) and relatively constant atmospheric pressure (about 15 psi) there will be a limit to the pressure difference across the intake valves and hence the amount of air entering the combustion chamber or the cylinder. The ability to fill the cylinder with air is its volumetric efficiency. Now if we can increase the pressure difference across the intake valves by some way we can make more air enter into the cylinder and hence increasing the volumetric efficiency of the engine. A turbocharger does exactly this, it increases the pressure at the point where air is entering the cylinder, thereby increasing the pressure difference across the intake

valves and thus more air enters into the combustion chamber. The additional air makes it possible to add more fuel, increasing the power and torque output of the engine, particularly at higher engine speeds. If the pressure in the cylinder goes too high it will cause the fuel to pre-ignite (remember more pressure = more temperature) in turn causing serious physical damage to the engine. To regulate pressure or boost, a waste gate is used. A waste gate controls the boost by routing some of the exhaust flow away from the exhaust side turbine. This controls the speed at which the axle rotates and in turn regulates the boost pressure by the compressor at the other end. The application of a compressor to increase pressure at the point of air intake is also commonly referred to as forced induction. The turbocharger application in an engine also introduce 'Lag' which is a symptomatic of the time taken by the exhaust system driving the turbine to come to high pressure and for the turbine rotor to overcome its rotational inertia and reach the speed necessary to supply boost pressure. That is why in turbocharged cars, you feel the turbo kicking in after certain rpm is reached, at which point the exhaust system overcomes the rotational inertia of the turbine and speed it up to supply boost pressure.

Material and Methods

Turbo Charger: Forced induction dates from the late 1800s, when Gottlieb Daimler patented the technique of using a gear-driven pump to force air into an internal combustion engine in 1885. The turbocharger was invented by Swiss engineer Alfred Büchi, who received a patent in 1905 for using a compressor driven by exhaust gasses to force air into a piston engine. During the First World War French engineer Auguste Rateau fitted turbochargers to Renault engines

powering various French fighters with some success.^[4] In 1918, General Electric engineer Sanford Moss attached a turbo to a V12 *Liberty* aircraft engine. The engine was tested at Pikes Peak in Colorado at 14,000 feet (4,300 m) to demonstrate that it could eliminate the power losses usually experienced in internal combustion engines as a result of reduced air pressure and density at high altitude. General Electric called the system turbo supercharging.

Turbochargers were first used in production aircraft engines such as the Napier Lioness in the 1920s, although they were less common than engine-driven centrifugal superchargers. Ships and locomotives equipped with turbocharged Diesel engines began appearing in the 1920s. Many World War Two Aircraft such as the Few 190D 'B-17 Flying Fortress, and P-47 Thunderbolt used turbochargers to increase high altitude engine power.

Operating Principal: All naturally aspirated Otto and diesel cycle 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 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 5,486 m (18,000 ft) the air is at half the pressure of sea level which means that the engine will produce less than half-power at this altitude.

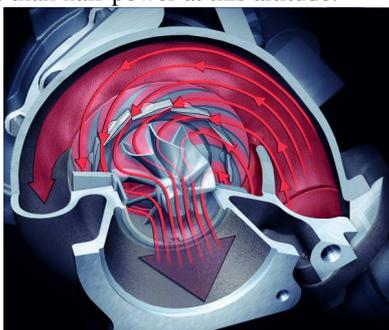


Figure-1
Low Exhaust Flow VGT Position

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 compressor draws in ambient air and compresses it before it enters into the intake

manifold at increased pressure. This results in a greater mass of air entering the cylinders on each intake stroke. The power needed to spin the centrifugal compressor is derived from the high pressure and temperature of the engine's exhaust gases. The turbine converts the engine exhaust's potential pressure energy and kinetic velocity energy into rotational power, which is in turn used to drive the compressor.

A turbocharger may also be used to increase fuel efficiency without any attempt to increase power. It does this by recovering waste energy in the exhaust and feeding it back into the engine intake. By using this otherwise wasted energy to increase the mass of air it becomes easier to ensure that all fuel is burnt before being vented at the start of the exhaust stage. The increased temperature from the higher pressure gives a higher Carnot efficiency.

The control of turbochargers is very complex and has changed dramatically over the 100 plus years of its use. A great deal of this complexity stems directly from the control and performance requirements of various engines with which it is used. In general, the turbocharger will accelerate in speed when the turbine generates excess power and decelerates when the turbine generates deficient power. Aircraft, Industrial diesels, fuel cells and motor-sports are examples of the wide range of performance requirements. Self-induced eddy currents are responsible for the skin effect in conductors. The latter can be used for non-destructive testing of materials for geometry features, like micro-cracks. A similar effect is the proximity effect, which is caused by externally-induced eddy currents

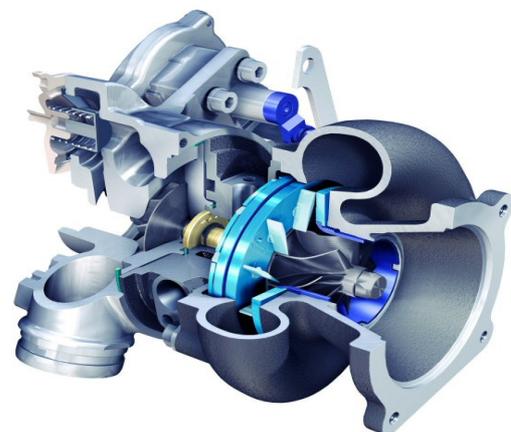


Figure-2
Turbocharger with Variable Geometry Turbine

When a conductor moves relative to the field generated by a source, electromotive forces (EMFs) can be generated around loops within the conductor. These EMFs acting on the resistivity of the material generate a current around the loop, in accordance with Faraday's law of induction. These currents dissipate energy, and create a magnetic field that tends to oppose changes in the current- they have inductance.

Eddy currents are created when a conductor experiences changes in the magnetic field. If either the conductor is moving through a steady magnetic field, or the magnetic field is changing around a stationary conductor, eddy currents will occur in the conductor. Both effects are present when a conductor moves through a varying magnetic field, as is the case at the top and bottom edges of the magnetized region shown in the diagram. Eddy currents will be generated wherever a conducting object experiences a change in the intensity or direction of the magnetic field at any point within it, and not just at the boundaries.

The swirling current set up in the conductor is due to electrons experiencing a Lorentz force that is perpendicular to their motion. Hence, they veer to their right, or left, depending on the direction of the applied field and whether the strength of the field is increasing or declining. The resistivity of the conductor acts to damp the amplitude of the eddy currents, as well as straighten their paths. Lenz's law encapsulates the fact that the current swirls in such a way as to create an induced magnetic field that opposes the phenomenon that created it. In the case of a varying applied field, the induced field will always be in the opposite direction to that applied. The same will be true when a varying external field is increasing in strength. However, when a varying field is falling in strength, the induced field will be in the same direction as that originally applied, in order to oppose the decline.

An object or part of an object experiences steady field intensity and direction where there is still relative motion of the field and the object (for example in the center of the field in the diagram), or unsteady fields where the currents cannot circulate due to the geometry of the conductor. In these situations charges collect on or within the object and these charges then produce static electric potentials that oppose any further current. Currents may be initially associated with the creation of static potentials, but these may be transitory and small.

Eddy currents generate resistive losses that transform some forms of energy, such as kinetic energy, into heat. This Joule heating reduces efficiency of iron-core transformers and electric motors and other devices that use changing magnetic fields. Eddy currents are minimized in these devices by selecting magnetic core materials that have low electrical conductivity (e.g., ferrites) or by using thin sheets of magnetic material, known as laminations. Electrons cannot cross the insulating gap between the laminations and so are unable to circulate on wide arcs. Charges gather at the lamination boundaries, in a process analogous to the Hall Effect, producing electric fields that oppose any further accumulation of charge and hence suppressing the eddy currents. The shorter the distance between adjacent laminations (i.e., the greater the number of laminations per

unit area, perpendicular to the applied field), the greater the suppression of eddy currents.

Motorcycle turbo charger: Using turbochargers to gain performance without a large gain in weight was very appealing to the Japanese factories in the 1980s. The first example of a turbocharged bike is the 1978 Kawasaki Z1R TC. It used a Ray jay ATP turbo kit to build 0.35 bar (5 lb) of boost, bringing power up from c. 90 hp (67 kW) to c. 105 hp (78 kW). However, it was only marginally faster than the standard model.

In 1982, Honda released the CX500T featuring a carefully developed turbo (as opposed to the Z1-R's bolt-on approach). It has a rotation speed of 200,000 rpm. The development of the CX500T was riddled with problems; due to being a V-twin engine the intake periods in the engine rotation are staggered leading to periods of high intake and long periods of no intake at all. Designing around these problems increased the price of the bike, and the performance still was not as good as the cheaper CB900 (a 16 valve in-line four) during these years, Suzuki produced the XN85, a 650 cc in-line four producing 85 bhp (63 kW), and Yamaha produced the Seca Turbo. The XN85 was fuel injected, while the Yamaha Seca Turbo relied on pressurized carburetors. Since the mid 1980s, no manufactures have produced turbocharged motorcycles making these bikes a bit of an educational experience; as of 2007 no factories offer turbocharged motorcycles (although the Suzuki B-King prototype featured a supercharged Hayabusa engine). The Dutch manufacturer EVA motorcycles builds a small series of turbocharged diesel motorcycle with an 800cc smart cdi engine. Laminated materials so that currents cannot circulate reduced Higher resistance materials (silicon rich iron etc.)

A Tale of Two Wheels: A turbocharger is basically an air pump. Hot exhaust gases leaving the engine after combustion are routed directly to the turbine wheel side of the turbocharger to make it rotate. That turbine wheel is connected by a shaft to a compressor wheel. As the turbine wheel spins faster and faster, it causes the compressor wheel to also spin quickly. The rotation of the compressor wheel pulls in ambient air and compresses it before pumping it into the engine's chambers.

As you may have guessed, the compressed air leaving the compressor wheel housing is very hot as a result of both compression and friction. So what's needed is a way to cool that air down before it enters the chambers. That's where a charge-air cooler (or "heat exchanger") comes in. It reduces the temperature of the compressed air so that it is denser when it enters the chamber (heat causes things to expand, as we all learned in science class). The charge-air cooler also helps to keep the temperature down in the combustion chamber. All together, the engine, turbocharger and charge-air cooler form what is known as a "charge-air system"

Some systems also include a tip turbine fan which draws air across the charge-air cooler to further reduce the temperature of the compressed air generated by the turbocharger.

In recent years, the cost of inappropriate drain intervals to the economy, to the environment and to car owners has received closer inspection. In the United States, the average car owner changes his/her oil at just less than 5,000 miles. Conversely, in Europe the average oil change interval is more than 10,000 miles. Assuming 10,000 miles is a more optimum interval; approximately 300 million to 400 million gallons of engine oil (worth about \$1.5 billion, not including labor) in the United States are consumed unnecessarily. With increasing environmental and economic pressures, the potential waste can no longer be easily glossed over.

There are, however, negative consequences to overextended oil drains. In diesel engines for instance, overextended oil drain intervals have been shown to increase engine wear by more than 20 percent with a corresponding reduction in horsepower and fuel consumption. One could safely project that overextended drains in passenger car applications would have a similar negative outcome. This of course presents a real dilemma to the car owner. What exactly is the correct interval? In the quest for optimum lubrication, car owners often receive conflicting advice from vehicle owner's manuals, mechanics, quick-lube operators and auto parts merchants. Some of this advice is peppered with strong admonishments for bucking conventional wisdom.

As a practical matter, we must consider a range for an oil change from around 2,000 miles to well over 15,000 miles. Most car makers generally recommend changing the oil for automobiles and light trucks burning gasoline once a year or every 7,500 miles, whichever occurs first. For diesel engines and turbocharged gasoline engines, the recommendation is typically a more accelerated 3,000 miles or six months.

Diesels tend to generate much more soot and acidic combustion blow-by in the crankcase. Turbochargers subject motor oils to high temperatures and are more prone to form engine deposits. A turbo can spin at speeds exceeding 100,000 rpm (about the same speed as a dentist's drill). When an engine is shut off, the heat inside the turbo bearing housing builds from the high frictional heat and hot exhaust gases. The oil in contact with these hot bearing surfaces can crack, forming coke (hard carbon deposits) and hydrogen. This can lead to bearing damage.

If you read the fine print in your car owner's manual, you will see that the 7,500-mile change interval is for vehicles driven under normal or ideal conditions. This is where the

problem lies. What exactly are these ideal conditions and what are the consequences of not ideal with respect to motor oil condition and engine wear? What many perceive to be "normal" driving is actually "severe service" driving from the standpoint of the oil. For instance, the following are examples of severe service driving: frequent short trips (especially during cold weather), stop-and-go driving, driving in dusty conditions (gravel roads, etc.), and high-temperature conditions. Under such conditions, the general recommendation found in owner's manuals is to change the oil every 3,000 miles or six months.

The real problem rests in the attempt to generalize. In reality, there are many unique conditions and factors that influence the decision. For illustration purposes, these conditions and influencing facts can be categorized in two ways as shown in the lists below:

Factors and Conditions That "Shorten" the Oil Change Interval: Short-trip Driving - The problem is most pronounced for frequent trips under five miles in cold wintertime conditions. Water and fuel have a tendency to accumulate in the crankcase when the oil temperature doesn't reach the thermostat setting.

Road Dust - Driving in dusty conditions (dirt/gravel roads) with an economy-grade oil filter can turn your motor oil into more of a honing compound than a lubricating medium. The dirty oil generates more wear metals which increase the risk of sludge formation and corrosion from acids.

High-Mileage Engine - Engines with more than 75,000 miles generate more blow-by gases, unburnt fuel and corrosive agents that enter the crankcase oil.

Diesel Engines - Diesels produce more soot and acidic blow-by products.

Flex Fuels - Alcohol-gasoline blends are prone to accumulate water in the crankcase.

Turbo-charged Engines - High temperatures distress the base oil and additives.

High Oil Consumption - While on one hand high oil consumption replenishes additives, on the other hand the affliction is also associated with high blow-by of combustion gases into the crankcase.

Hot Running Conditions - Hot running conditions, including desert terrain, in general can lead to premature oil oxidation, volatility problems and rapid additive depletion.

Desire for Long Engine Life - Shorter drain intervals increases the safety margin in the event of premature oil failure.

Towing/Heavy Loads - Generally relates to hot running conditions, thin oil films, higher shearing of viscosity index improvers and more wear metals in the oil. Wear metals catalytically shorten oil life, causing premature oxidation, sludge, acids and deposits.

Factors and Conditions That “Lengthen” the Oil Drain Interval: Synthetic Lubricants - Premium synthetic lubricants have excellent oxidation stability, thermal stability and shear stability.

High-Capture Efficiency Oil Filter - Controls catalytic wear metal production. Highway Miles (predominate) - Lower average engine revolutions and fewer operating hours per distance traveled (miles) compared to slow-speed urban driving.

New Engines - Low levels of engine blow-by after the first 500 to 5,000 miles and less than 50,000 miles (unless oil consumption is high).

Frequent Oil Inspections - Simple and frequent oil inspections can be effective at identifying various motor oil problems. Refer to the article titled “Dipstick Oil Analysis” in the November-December 2003 issue of *Practicing Oil Analysis* magazine.

Environmental Concerns (waste oil) - Emphasis on reducing waste oil generation.

Low-value Vehicle - Many owners of automobiles with low resale value prefer extended drains to keep their costs low. Others use frequent oil changes as a strategy to limp along a car in its twilight years.

For most of us, distilling all this down to an optimum oil change interval is like trying to nail Jell-O to the wall - too many variables and too much guesswork. There has long been a need for a practical and effective workaround. Rather than attempting to quantify the collective impact of these many conditions and factors, the best approach might simply be for the oil to tell us when it needs to be changed. Oil analysis - now there's a fresh idea!

More and more oil analysis laboratories are targeting passenger car owners to grow their market. However, as a practical matter, laboratory oil analysis is out of reach for nearly all except for hardcore car enthusiasts. This has led to a flurry of new onboard sensors and related technology being advanced by companies with sizeable research budgets,

eyeing the huge transportation industry. The following is a review of these many new and evolving innovations.

Results and Discussion

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 (1 lakh + per minute!!!) so proper cooling and lubrication is essential if it not to destroy the engine.

Conclusion

By the use of turbo charging in two wheelers the power can be enhanced. A properly tuned turbo engine can produce 20% + more power compared to stock, but expect an increase in fuel consumption. 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. Automotive oil condition monitoring is far from a mature technology. As this 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.

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