PERFORMANCE ENHANCEMENT OF ENGINE USING TURBOCHARGER-A REVIEW

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Abstract: This study has been undertaken to show the performance enhancement of engine using turbocharger. Turbochargers multiply the output of an internal combustion (IC) engine without the need to increase its cylinder capacity all over the automotive industries. The application of such a mechanical device enables automotive manufacturers to adopt greater power and high torque applications. There are many inventions done to enhance the performance of IC engines. So most engines nowadays are employed with turbocharger and supercharger. It is known that the power outputs of an engine increases with the increase in amount of air or mixture in the cylinder and supercharger plays an important role in increasing the amount or air. It is because of these reasons that superchargers and turbochargers are now becoming more and more popular in automobile applications. The aim of this review paper is to show importance of turbocharger in automotive sector.

Keywords: *Turbocharger, Engine, Intercooler*

INTRODUCTION:

A turbocharger is a turbine-driven forced induction device that increases an internal combustion engine's efficiency and power output by forcing extra air into the combustion chamber. This improve over a naturally aspirated engine’s power output is due to fact that compressor can force more air into combustion chamber than atmospheric pressure. A turbocharged engine produces more power than any other engine. This can mostly improve the power-to-weight ratio for the engine.. This can mostly improve the power-to-weight ratio for the engine. In order to obtain boost, the turbocharger compressor pull ambient air and compresses it before it enters into the intake manifold at increased pressure. This gives a greater mass of air entering the cylinders on each stroke. The power required to spin the centrifugal compressor derived from the kinetic energy of the engine’s exhaust gases.

1.1 NEED OF TURBOCHARGER

The aim of a turbocharger is to improve an engine's volumetric efficiency by increasing density of the intake gas (usually air) allowing more power per engine cycle. The turbocharger's compressor draws in ambient air and compresses it before it enters into the intake manifold at increased pressure. The purpose of a turbocharger is to increase the power output of an engine by supplying compressed air to the engine intake manifold so increased fuel can be utilized for combustion. The purpose of the altitude compensator is to maintain consistent power output and efficiency of an engine operating at all altitudes.

1.2 HOW A TURBOCHARGER WORKS

‘A turbocharger is a special type of supercharger in which a gas turbine is used to raise the pressure of air or air-fuel mixture that is to be supplied to the engine. Turbochargers are powered by the kinetic energy of exhaust gases from the engine’. Turbochargers are a type of forced induction system. They compress the air flowing into the engine. The advantage of compressing the air is that it lets the engine squeeze more air into a cylinder, and more air means that more fuel can be added. Therefore, we get more power from each explosion in each cylinder. A turbocharged engine produces more power overall than the same engine without the charging. This can significantly improve the power-to-weight ratio for the engine. In order to achieve this boost, the turbocharger uses the exhaust flow from the engine to spin a turbine, which in turn spins an air pump. The turbine in the turbocharger spins at speeds of up to 150,000 rotations per minute (rpm) -- that's about 30 times faster than most car engines can go. And since it is hooked up to the exhaust, the temperatures in turbine are also very high.

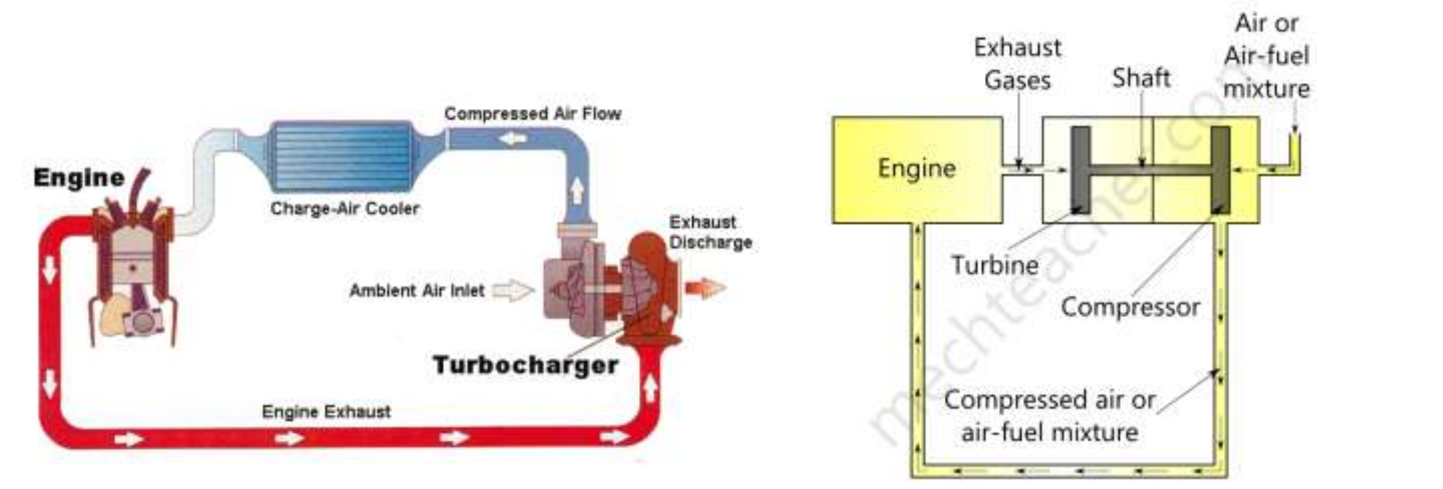

Fig 1.1 Circuit diagram of turbocharger

1.3 OPERATING PRINCIPLE

In normally aspirated piston engines, intake gases are pushed into the engine by atmospheric pressure filling the volumetric void caused by the downward stroke of the piston (which creates a low-pressure area), similar to drawing liquid using a syringe. The amount of air actually sucked, compared to the theoretical amount if the engine could maintain atmospheric pressure, is called volumetric efficiency. The objective of a turbocharger is to improve an engine's volumetric efficiency by increasing density of the intake gas (usually air). The turbocharger's 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 kinetic energy of the engine's exhaust gases. The pressure volume diagram shows the extra work done by turbocharging the diesel engine [1.3].

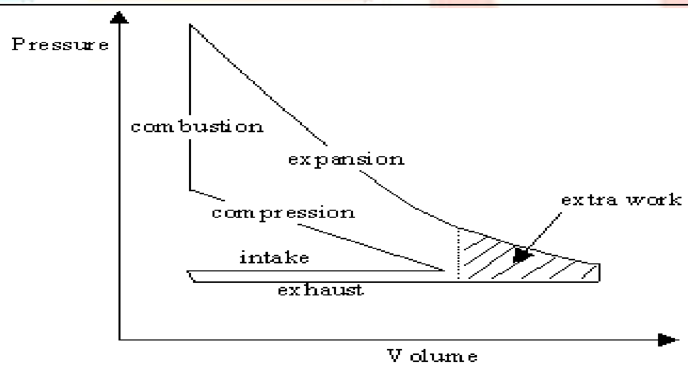

Fig 1: Pressure volume diagram of diesel engine with turbocharging [2]

1.4 BENEFITS OF USING A TURBOCHARGER

A) Turbocharger increases the volumetric efficiency of the engine

Volumetric efficiency in internal combustion engine engineering is defined as the ratio of the mass density of the air-fuel mixture drawn into the cylinder at atmospheric pressure (during the intake stroke) to the mass density of the same volume of air in the intake manifold. Turbocharger runs by exhaust gases, it utilizes the energy of exhaust gas to compress the air and send it to Inlet manifold via intercooler. Now inside cylinder mass density of air is more relative to natural breathing of engine. As air is compressed, so inside the cylinder amount of air is more after using turbocharger.

B) It increases the output power produced

The only time an engine really needs the extra power is when it is accelerating hard or pulling a load. A turbo is perfect for this kind of application because it is exhaust-driven and draws no power from the engine like a belt-driven supercharger. Superchargers can deliver right-now boost at low RPM, but the trade-off is a constant drain on the engine when the extra boost pressure isn't needed. A turbo, on the other hand, is just along for the ride and doesn't develop any boost pressure until the throttle opens and exhaust flow increases. It then spools up and starts pushing more air into the engine. Turbos can rev up to 140,000 to 160,000 RPM or higher, but it can take a few seconds to reach these speeds. Because of this, engineers design the turbo system so it can reach maximum boost pressure with minimum lag. Proper sizing of the turbo is essential to reduce lag. A smaller turbo will spool up more quickly at low engine speeds than a large turbo, but a large turbo can flow more air and develop more boost pressure and power. Since the emphasis now is more on fuel economy than all-out performance, most of the new passenger car turbo engines are equipped with relatively small turbos that deliver just enough boosts to offset the smaller displacement of the engine. Boost pressure is controlled by a device called a "wastegate." The waste gate valve opens a bypass circuit that controls how quickly boost pressure builds. It also limits peak boost pressure so the engine doesn't go into detonation. Too much boost pressure can destroy an engine that isn't designed to handle it. The operation of the wastegate is controlled by the Powertrain Control Module (PCM), so it is possible to tweak the turbo's output by reprogramming the PCM. An aftermarket "tuner" scan tool can load new programming that turns up the boost pressure for more power. These have been a popular item for turbo diesel engines in pickup trucks, but recently General Motors said it will not honor any engine or drivetrain warranty claims on trucks that have been modified with a performance tuner.

C) It reduces the intake of fuel or air-fuel mixture.

Engines can achieve more power if more air and fuel can be forced into the cylinders for each combustion cycle. Turbochargers compress air into the intake manifold, which is then forced into the cylinder of the engine. This feature provides two benefits. First, there is more air and fuel, which provides a larger combustion reaction and more power. Second, it is easier for the piston to pull the air and fuel mixture into the combustion chamber. Turbochargers use the otherwise wasted pressure and energy from the exhaust to drive a turbine that is attached to a compressor Turbochargers allow a smaller-capacity engine to achieve the same performance as a larger displacement, naturally aspirated engine, thereby reducing fuel consumption.

D) More power compared to the same size naturally aspirated engine.

E) Better thermal efficiency over naturally aspirated engine and super charged engine, because the engine exhaust is being used to do the useful work which otherwise would have been wasted.

F) Better Fuel Economy by the way of more power and torque from the same sized engine. A century of development and refinement—for the last century the SI engine has been developed and used widely in automobiles.

G) Low cost–The SI engine is the lowest cost engine because of the huge volume currently produced.

H) High Thermal efficiency.

I) Better Volumetric efficiency.

J) High speed obtained.

K) Better average obtained.

L) Eco-friendly

2.0 LITERATURE REVIEW

In 1987 the world's first two-stroke functional engine supercharger was made by Dugald Clerk. Gottlieb Daimler received a German patent for supercharging an internal combustion engine in 1885. Supercharger supplies high density charge to the engine by compressing it through the compressor driven by the engine mechanically. Main problem with it is the loss of power used to drive the compressor from the engine output shaft. This loss can be up to 15% of engine output. Technology became popular by the name as Turbocharging in early 1980s by eliminating loss of power, compressor was driven by a turbine utilizing the energy of exhaust gases of the engine by passing them through the turbine blades.

From that day, various new technologies are introduced in turbocharging to improve its efficiency and this improvement was carried out as follows:

Mohd Muqeem et. al., [1] concluded that without increasing the cylinder capacity Turbochargers enhance the output of an internal combustion engine. The application of such a mechanical device enables automotive manufacturers to adopt smaller displacement engines, commonly known as engine downsizing. Turbochargers were used to increase the potential of an earlier powerful IC engine, e.g. those used in motorsport. Importance of today is to provide a comfortable engineering solution to manufacturing economics and "greener" road vehicles. Due to these reasons turbochargers are now becoming most popular in automotive industry applications. The goal of this paper is to provide a review on the current techniques used in turbocharging to improve the engine efficiency and exhaust emissions as much as possible.

Prashant.N.Pakale et. Al., [2] for increasing the performance of IC engine there are so many inventions. That's why most of the engines todays are employed with turbocharger and supercharger. To increase amount of air or mixture in the cylinder supercharger plays an important role. Without the need to increase its cylinder capacity, Turbochargers enhance the output of an internal combustion (IC) engine. The emphasis today is to provide a feasible engineering solution to manufacturing economics and "Greener" road vehicles. It is because of these reasons that superchargers and turbochargers are now becoming more and more popular in automobile applications. The aim of this paper is to provide a review on the techniques used in supercharging and turbocharging to increase the engine output and reduce the exhaust emission levels.

J. Cheong et. al., [3] Power boosting technology of a High Speed Direct Injection (HSDI) Diesel engine without increasing the engine size had been developed along with the evolution of a fuel injection system and turbocharger. Most of the turbochargers used on HSDI Diesel engines had been a waste-gated type. That time, the Variable Geometry Turbocharger (VGT) with adjustable nozzle vanes was increasingly used, especially for a passenger car in European market. This study shows the exhaust smoke was reduced and the fuel consumption was improved with the same fuel delivery and start timing of injection.

Panting et. al., [4] stated that turbocharging of internal combustion engines was an established technology used for the purpose of increasing both power density and in some cases the cycle efficiency of diesel engines relative to naturally aspirated engines. However, one significant drawback was the inability to match the characteristics of the turbocharger to the engine under full load and also to provide sufficiently good transient response. Under many conditions the study results in reduced efficiency and leads to higher exhaust emissions.

Naser et. al., [5] concluded that efficient way which was used that time was to reduce the fuel consumption was based in reduction cylinder volume of internal combustion engine and power to be same or higher. Key component was turbocharged diesel internal combustion engine. Increased compressor outlet air pressure can result in an excessively hot intake charge, significantly reducing the performance gains of turbo charging due to decreased density. Author concluded that maximal temperature in engine cylinder was decreasing from 1665.6 K at SU =1000 to 1659.2 K at SU (surface area*heat transfer coefficient)=1600, sometimes engine power and volumetric efficiency was increased. Also intercooler performance was increased with increased the design parameter.

3.0 CONCLUSION

In last two decades various new advancements are done 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. From above reviews apparently shows there is need of turbocharging so that efficiency of engine increases and control of toxic gases emitted from automotive vehicle can be control.

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