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Study of Turbo Charging in Six Stroke Diesel Engine

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ABSTRACT: A turbocharger or turbo is a centrifugal compressor powered by a turbine which is driven by an engine's exhaust gases. Its benefit lies with the compressor increasing the pressure of air entered with internal combustion engines such as four strokes the engine. This results in greater performance in its power &efficiency. They are popularly use engines working on Otto & diesel cycles. The turbocharger was invented by Swiss engineer Alfred buchi in 1905.

The engine is said to have 100% volumetric efficiency if the density of the intake air above the piston is equal to atmospheric. The main objective of a turbocharger 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 of manifold at increasing pressure. This results in greater mass of air entering the cylinder thus increasing power and efficiency. The impeller and turbine are the two main components of a turbo charger.

I. INTRODUCTION

A turbocharger or turbo is a centrifugal compressor powered by a turbine which is driven by an engine's exhaust gases. Its benefit lies with the compressor increasing the pressure of air entering the engine thus resulting in greater performance. They are popularly used with internal combustion

engines. Turbochargers have also been found useful compounding external combustion engines such as automotive fuel cells.

It mainly consists of a turbine, compressor, center housing rotating assembly and other optional features for its better control and efficient working. They provide greater boost and power at high altitudes. It is one of the greater advantages which make the turbocharger more popular. But boost threshold and turbo lag must be controlled efficiently for its effective working.

History. In 1896 Rudolph Diesel tried to increase power of the engine by pre-compressing intake air. But turbocharger was firstly invented by Swiss engineer Alfred Buchi. His patent for a turbocharger was applied for use in 1905.Diesel ships and locomotives with turbochargers began appearing in the 1920's. During the First World War French engineer Auguste Rateau fitted turbochargers to Renault engines powering various French fighters with some success. Turbochargers were first used in production aircraft engines in 1920's. Aircrafts such as B-17, P-47 all used turbochargers to increase high altitude engine power. Turbocharger's first commercial diesel truck application came in 1938 by "Swiss Machine Works Sauer". First production application of turbocharger was in passenger cars. It was in 1962.

Turbo Vs Supercharging. In contrast to turbochargers, superchargers are not powered by a turbine but are connected directly to an engine .Belts ,chains, direct shaft, coupled shaft, gears and electric motors are probably only a few of the many ways this is performed. Successful superchargers were developed and used during the late 1800's.

A supercharger inevitably requires some energy to be bled from the engine to drive the supercharger. For instance, the supercharger uses up about 150 hp. For that 110 hp engine generates an additional 400 hp and delivers 1,000 hp when it would deliver 750hpa net gain of 250 hp. This is where the principal disadvantage of a supercharger becomes apparent; the internal hardware of the engine must withstand generating 1150hp.

In comparison, a turbocharger will also use 150hp to drive the compressor. It has the ability to be more efficient by utilizing the wasted energy extracted from exhaust gas and converting it into useful power to compress the intake air. It actually converts the heat of the exhaust into 150hp used to drive the compressor.

In contrast to supercharging principal disadvantages of turbo charging are the back pressuring of the engine and the inefficiencies of the turbine versus direct drive.

II. OPERATING CYCLE

The power generated by the I.C engine is directly related to the compression force exerted on the air fuel mixture. By pressurizing the intake mixture before entering the cylinder, more fuel and air molecules can be packed into combustion chamber. Keep in mind that any time the amount of air/fuel mix that enters the cylinder is increased there is a substantial increase in power. The process of artificially increasing the amount of airflow into the engine is known as turbo charging. The mechanics of a turbocharger are closely related to the mechanics of a jet engine. A turbocharger harnesses the wasted energy of exhaust gases exiting the engine to spin a turbine that compresses the intake air charge.

All naturally aspirated Otto and Diesel cycle engine rely on the downward stroke of a piston to create a low pressure area 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 piston is equal to atmospheric, then the engine would 100% volumetric efficiency. Unfortunately, most engines fail to achieve this level of performance.

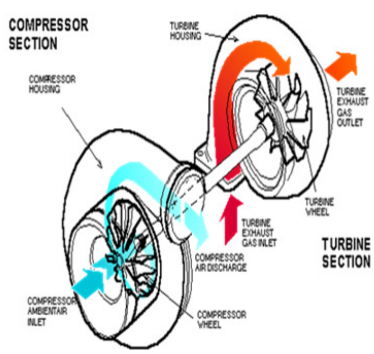


Fig. 1. Operating Cycle.

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.

III. WORKING PRINCIPLE

The turbocharger is located to one side of the engine, usually to the exhaust manifold. An exhaust pipe runs between the engine exhaust manifold and the turbine housing to carry the exhaust flow to the turbine wheel. Another pipe connects the compressor housing intake to an injector throttle body or a carburettor. The typical boost provided by a turbocharger is 4.2 to 5.6N/cm^2.

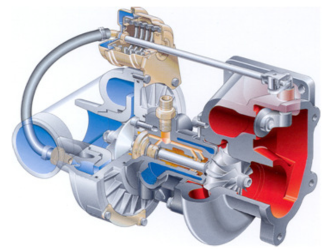


Fig. 2. Model of Turbocharger.

Exhaust gases are directed into the turbocharger through the square inlet in the exhaust housing of the turbo .The exhaust flows through the exhaust housing spinning the exhaust turbine. After going through the exhaust housing, the gases flow out through the exhaust housing outlet. The turbine is connected to the compressor wheel on the intake side of the turbo through the centre bearing housing. The centre housing will have ports for oil to flow in to and out of to lubricate and cool the shaft, and it may or may not have ports for water to go in to and out of. Fresh air is brought into the turbocharger through the air inlet. The air is compressed by the compressor and the now pressurized air flows out through the compressor housing.

Exhaust gases leave the engine via a turbo manifold; this replaces the stock exhaust manifold or header. The waste gate is used to control boost levels by allowing exhaust gasses to bypass the turbo, thereby decreasing the volume of exhaust available to spin the turbocharger's turbine.

After moving through the turbo, exhaust gasses exit the turbo through a down pipe which connects to the rest of the exhaust system. Fresh air, after being compressed by the turbo, passes through some intake piping and into an intercooler. An intercooler works exactly like a radiator except pressurized air passes through it instead of water.

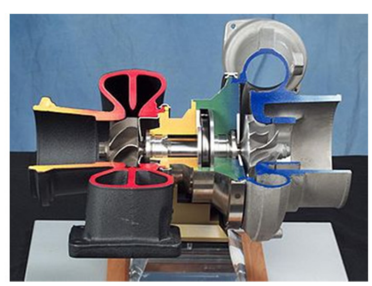
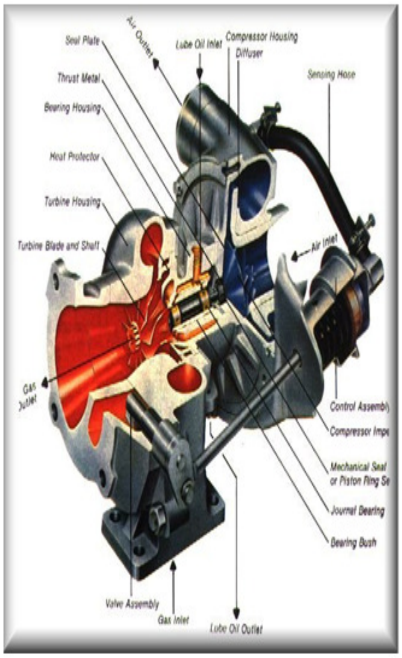


Fig. 3. Model of Chamil Klitas Anil.



The intercooler is mounted on the front of the car so air flows through it as the car moves down the road. This cools the pressurized intake air charge. This is necessary because when air is pressurized it heats up. The blow off valve vents pressurized air when the throttle plate is closed. This prevents a pressure surge from building up in the system and possibly damaging the compressor wheel and the turbocharger's bearings.

The typical boost provided by a turbocharger is 4.2 to 5.6N/cm^2.Since normal atmospheric pressure 10N/cm^2 at sea level; you can see that you are getting 50% more air into the engine. Therefore, you would expect to get 50% more power. It's not so perfect, so you might get a 30-40% improvement instead.

A. Components Used

The turbocharger has three main components. First a turbine, which is almost always a radial inflow turbine. Second a compressor, which is almost a centrifugal compressor. These first two components are the primary flow path components. Third, the centre housing / hub rotating assembly (CHRA). Then, depending upon the exact installation and application, numerous other parts, features and controls may be required, such as

- Engine
- Turbo manifold
- Westgate
- Turbocharger
- Anti-Surge valve
- Boost controller

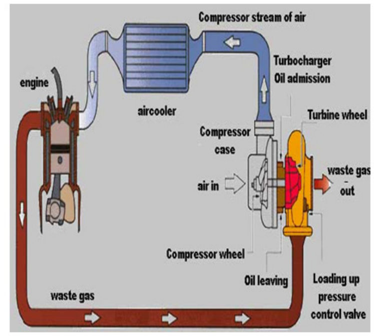


Fig. 4. Centre Housing / Hub Rotating Assembly (CHRA).

B. Compressor Assembly

The compressor mainly consists of an impeller and spiral casing. It is usually located between air filter and intake manifold. The rotation of the impeller creates suction. This draws in air in at the center. The impeller flings radially outwards and compresses the air. The outlet pressure is greater than inlet.

The flow range of a turbocharger compressor can also be increased by allowing air to bleed from a ring of holes or a circular groove around the compressor at a point slightly downstream of the compressor inlet (but far nearer to the inlet than to the outlet).

For all practical situations, the act of compressing air increases the air's temperature along with pressure. This temperature increase can cause a number of problems when not expected or when installing a turbocharger on an engine not designed for forced induction. Excessive charge air temperature can lead to detonation, which is extremely destructive to engines.

Fig. 5. Compressor Assembly.

C. About Six Stoke Diesel Engine

The C.K. Anil was developed six stroke engine in 4th July 2012 and in India VELOZETA engine was developed by Trivandrum College of engineering students. The six-stroke engine adds two more strokes after the exhaust stroke. Air is injected, and as it turns into steam, it pushes the piston down. Then the piston comes back up to force out the steam.

It's really simple. A six-stroke engine combines an internal combustion engine with a steam engine to turn some of the waste heat into power. The only catch is that you have to add a air tank to your car that's about the same size as the gas tank.

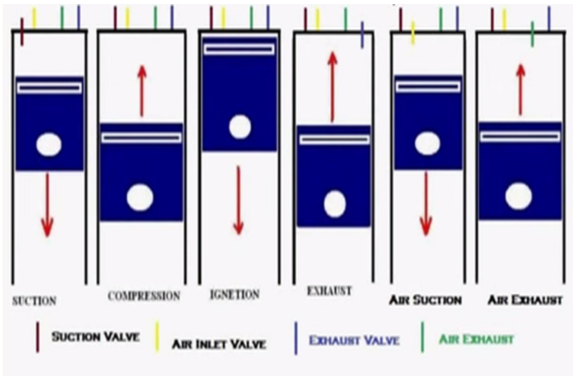


Fig. 6. Six-Stroke Diesel Engine.

Advantages of Six-Stroke Diesel Engine

- A turbocharger harnesses the wasted energy of exhaust gases exiting the engine. Thus the velocity and heat energy carried by the exhaust gas is partially utilized by turbocharger. Large amount of heat energy is lost in the form of exhaust gases. Thus it is greater benefit for the engine. The exhaust gas is used to spin the turbine which is connected to the compressor wheel. Therefore we should except to get 50% power, but might get a 30-40% improvement instead.
- A turbocharger may also be used to increase fuel efficiency with-out attempt to increase power. It does this by increasing waste energy in the exhaust and feeding it back into the engine intake. By using this to increase the mass of air it becomes easier to ensure that all fuel is burnt before vented at the start of the exhaust stage. This increased temperature from the higher temperature gives higher Carnot efficiency.
- One of the most important advantages is that they give power to the engine at high altitudes. In such cases the duty of turbocharger is to maintain manifold pressure as altitude increases. Since atmospheric pressure reduces as the aircraft climbs, power drop will occur. The turbochargers operate and maintain manifold pressure. With such systems, modern high performance piston engine aircraft can cruise at altitudes above 20,000 ft. where low air density results in lower drag and higher true air speeds.

Disadvantages of Six-Stroke Diesel Engine

- It is less responsive than supercharger.
- Cost and complexity.
- Detonation and Space.
- Turbo lag or spool time.
- Mechanical damage of vane wheels.
- So avoid these problems a combination of turbocharger and supercharger can mitigate the weaknesses of both.
- This technique is called twin-charging.

IV. CONCLUSION

The six stroke engine with turbo charger promises the reduction in pollution and fuel combustion of internal combustion engine. The fuel efficiency of the engine can be increased and also the valve timing can effectively arranged to extract more work per cycle. Better scavenging can be possible as air intake occur during fifth stroke and exhaust during sixth stroke. Due to more air intake cooling system can be improved. By this we can lower the engine temperature and increases the overall efficiency.

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