

Performance Analysis on a Turbocharger in Two Stroke Single Cylinder S.I Engine

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ABSTRACT: As a demand of new efficient and eco friendly engines is increasing new technologies are developing. In present scenario everybody in this world needs to ride a high powered, high fuel efficient and less emission two wheelers. In order to meet the requirements of the people an attempt have been made in this project to increase the power by using the exhaust gas of the engine by passing this gas into turbine compressor arrangement. This compressor compresses the fresh air and it is send to the carburettor. Due to rich air fuel mixture combustion efficiency will be increased, hence by turbocharger, the engine more power can be generated with low environmental emission. Now a days the demand of the fuel is increased, with the help of turbocharger we increase the performance and the fuel efficiency. This paper deals turbocharger and its performance for different conditions in S.I engine. The aim of this project is to provide over view on the techniques used in turbocharger in two stroke single cylinder petrol engine, by this to increase the engine output and reduce the exhaust emission levels.

I. 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. 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. 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 in turn causing serious physical damage to the engine. To regulate pressure or boost, a waste gate is used. The application of a compressor to increase pressure at the point of air intake is also commonly referred to as forced induction. 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

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II. MATERIALS

- Two stroke petrol engine
- Turbocharger

A. TWO STROKE PETROL ENGINE:

A two-stroke, or two-cycle, engine is a type of internal combustion engine which completes a power cycle with two strokes (up and down movements) of the piston during only one crankshaft revolution. This is in contrast to a "four-stroke engine", which requires four strokes of the piston to complete a power cycle. In a two-stroke engine, the end of the combustion stroke and the beginning of the compression stroke happen simultaneously, with the intake and exhaust (or scavenging) functions occurring at the same time.

Two-stroke engines often have a high power-to-weight ratio, power being available in a narrow range of rotational speeds called the "power band". Compared to four-stroke engines, two-stroke engines have a greatly reduced number of moving parts, and so can be more compact and significantly lighter.

1. Cylinder block:

Cylinder is the main body of IC engine. Cylinder is a part in which the intake of fuel, compression of fuel and burning of fuel take place. The main function of cylinder is to guide the piston. It is in direct contact with the products of combustion so it must be cooled. For cooling of cylinder a water jacket (for liquid cooling used in most of cars) or fin (for air cooling used in most of bikes) are situated at the outer side of cylinder. At the upper end of cylinder, cylinder head and at the bottom end crank case is bolted. The upper side of cylinder is consists of a combustion chamber where fuel burns. To handle all this pressure and temperature generated by combustion of fuel, cylinder material should have high compressive strength. So it is made by high grade cast iron. It is made by casting and usually cast in one piece.



Fig1: Cylinder block

2. Cylinder head

The top end of cylinder is closed by means of removable cylinder head. There are two holes or ports at the cylinder head, one for intake of fuel and other for exhaust. Both the intake and exhaust ports are closed by the two valves known as inlet and exhaust valve. The inlet valve, exhaust valve, spark plug, injector etc. are bolted on the cylinder head. The main function of cylinder head is to seal the cylinder block and not to permit entry and exit of gases on cover head valve engine. Cylinder head is usually made by cast iron or aluminium. It is made by casting or forging and usually in one piece.



Fig2: Cylinder head

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3. Piston

A piston is fitted to each cylinder as a face to receive gas pressure and transmit the thrust to the connecting rod. It is the prime mover in the engine. The main function of piston is to give tight seal to the cylinder through bore and slide freely inside of cylinder. Piston should be light and sufficient strong to handle the gas pressure generated by combustion of fuel. So the piston is made by aluminium alloy and sometimes it is made by cast iron because light alloy piston expands more than cast iron so they need more clearances to the bore.



Fig3: Piston

4. Piston rings

A piston must be a fairly loose fit in the cylinder so it can move freely inside the cylinder. If the piston is too tight fit, it would expand as it got hot and might stick tight in the cylinder and if it is too loose it would leak the vapour pressure. To provide a good sealing fit and less friction resistance between the piston and cylinder, pistons are equipped with piston rings. These rings are fitted in grooves which have been cut in the piston. They are split at one end so they can expand or slipped over the end of piston. A small two stroke engine has two piston rings to provide good sealing but in a four stroke engine has an extra ring which is known as oil ring. Piston rings are made of cast iron of fine grain and high elastic material which is not affected by the working heat. Sometimes it is made by alloy spring steel.



Fig4: Piston ring

5. Connecting rod:

Connecting rod connects the piston to crankshaft and transmits the motion and thrust of piston to crankshaft. It converts the reciprocating motion of the piston into rotary motion of crankshaft. There are two end of connecting rod one is known as big end and other as small end. Big end is connected to the crankshaft and the small end is connected to the piston by use of piston pin. The connecting rods are made of nickel, chrome, and chrome vanadium steels. For small engines the material may be aluminium.



Fig5: Connecting rod

6. Engine bearing:

Everywhere there is rotary action in the engine, bearings need. Bearings are used to support the moving parts. The crankshaft is supported by bearing. The connecting rod big end is attached to the crank pin on the crank of the

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crankshaft by a bearing. A piston pin at the rod small end is used to attach the rod to the piston, also rides in bearings. The main function of bearings is to reduce friction between these moving parts. In an IC engine sliding and rolling types of bearing used. The sliding type bearing which are sometime called bush is use to attach the connecting rod to the piston and crankshaft. They are split in order to permit their assembly into the engine. The rolling and ball bearing is used to support crankshaft so it can rotate freely. The typical bearing half is made of steel or bronze back to which a lining of relatively soft bearing material is applied.



Fig6: Engine bearing

7. Crankcase:

The main body of the engine to which the cylinder are attached and which contains the crankshaft and crankshaft bearing is called crankcase. It serves as the lubricating system too and sometime it is called oil sump. All the oil for lubrication is placed in it.



Fig7: Crankcase

8. Valves:

To control the inlet and exhaust of internal combustion engine, valves are used. The number of valves in an engine depends on the number of cylinders. Two valves are used for each cylinder one for inlet of air-fuel mixture inside the cylinder and other for exhaust of combustion gases. The valves are fitted in the port at the cylinder head by use of strong spring. This spring keep them closed. Both valves usually open inwards.

9. Spark plug:

It is used in spark ignition engine. The main function of a spark plug is to conduct the high potential from the ignition system into the combustion chamber to ignite the compressed air fuel mixture. It is fitted on cylinder head. The spark plug consists of a metal shell having two electrodes which are insulated from each other with an air gap. When high potential current supply to spark plug it jumping from the supply electrode and produces the necessary spark.



Fig9: Spark plug

10. Injector:

Injector is usually used in compression ignition engine. It sprays the fuel into combustion chamber at the end of compression stroke. It is fitted on cylinder head.

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11. Manifold:

The main function of manifold is to supply the air fuel mixture and collects the exhaust gases equally form all cylinder. In an internal combustion engine two manifold are used, one for intake and other for exhaust. They are usually made by aluminium alloy.

12. Camshaft:

Camshaft is used in IC engine to control the opening and closing of valves at proper timing. For proper engine output inlet valve should open at the end of exhaust stroke and closed at the end of intake stroke. So to regulate its timing, a cam is use which is oval in shape and it exerts a pressure on the valve to open and release to close. It is drive by the timing belt which drives by crankshaft. It is placed at the top or at the bottom of cylinder.

13. Gudgeon pin or piston pin:

These are hardened steel parallel spindles fitted through the piston bosses and the small end bushes or eyes to allow the connecting rods to swivel. It connects the piston to connecting rod. It is made hollow for lightness.



14. Flywheel:

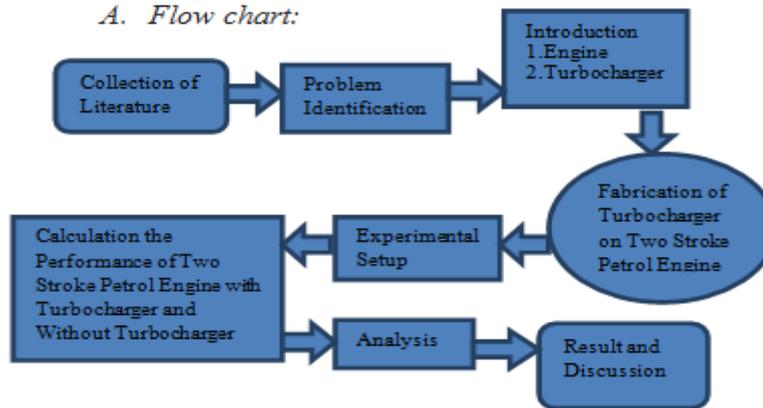
A flywheel is secured on the crankshaft. The main function of flywheel is to rotate the shaft during preparatory stroke. It also makes crankshaft rotation more uniform. This is all about main parts of an internal combustion engine. If you have any query regarding this article ask by commenting.

B. TURBOCHARGER:

Turbocharger is the mechanical device which increases density of air entering into the combustion chamber of IC engine with compressor which is driven by a turbine driven by exhaust gas of same IC engine. Turbocharging increases quantity of air entering into the combustion chamber which promotes lean combustion, this further result into better performance and lower exhaust emissions. From last few years many researchers made effort to improve the power output of an engine and to reduce exhaust gases by making some changes in conventional turbocharger and installing some additional accessories like turbocharger and intercooler. Due to increase in the demand of fuel efficient engines with more power and minimum emissions more research will take place in this field. All these new requirements of IC engine can be fulfilled by making some advancements in turbocharging technology.

III. METHODOLOGY

A. Flow chart:



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B. TURBINE HOUSING:

Turbine housings are manufactured in various grades of spherical graphite iron to deal with thermal fatigue and wheel burst containment. As with the impeller, profile machining to suit turbine blade shape is carefully controlled for optimum performance. The turbine housing inlet flange acts as the reference point for fixing turbocharger position relative to its installation. It is normally the load bearing surfaces.

C. COMPRESSOR WHEEL:

Compressor impellers are produced using a variant of the aluminium investment casting process. A rubber former is made to replicate the impeller around which a casting mould is created. The rubber former can then be extracted from the mould into which the metal is poured. Accurate blade sections and profiles are important in achieving compressor performance. Back face profile machining optimizes impeller stress conditions. Boring to tight tolerance and burnishing assist balancing and fatigue resistance. The impeller is located on the shaft assembly using a threaded nut.

D. BLOW OFF VALVES:

The Blow-Off valve (BOV) is a pressure relief device on the intake tract to prevent the turbo 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. **Waste gates:**-On the exhaust side, a Waste gate provides us a means to control the boost pressure of the engine. Some commercial diesel applications do not use a Waste gate at all. This type of system is called a free-floating turbocharger. However, the vast majority of gasoline performance applications require Waste gates. There are two (2) configurations of Waste gates, **internal** or **external**. Both internal and external Waste gates 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.

IV. EXPERIMENTAL SETUP

A. MAIN COMPONENTS OF FABRICATION OF TURBOCHARGER IN TWO WHEELER :

- Bearing Housing
 - Turbine Housing
 - Bearing System
 - Compressor Housing
 - Shaft and Wheel
 - Impeller
 - Compressor
1. BEARING HOUSING:
 - Typically shell moulded cores to provide positional accuracy of bearing location and seals, shell mould or sand cast outer
 - Machined by a combination of milling, turning, drilling, tapering, honing.
 - Cooled housing and variable geometry turbos
 2. TURBINE HOUSING:
 - Typically spheroid graphite cast iron (ferrite)
 - Typically greensand mould, sand core
 - Profile machining to match the turbine blade shape

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- Normally the primary mounting point and load bearing interface for the whole turbo
3. BEARING SYSTEM:
- Journal bearings:**
- Fully floating ring bearings- allows higher clearances, so higher oil flows for cooling
 - Brass or leaded bronze
 - Allow high degree of imbalance
- Thrust bearing**
- Taper land bearing
 - Phosphor bronze or sintered iron
4. COMPRESSOR HOUSING:
- Typically cast aluminium alloy-various grades
 - Gravity die cast or sand cast
 - Profile matching to match impeller blade shape
 - Operation can be up to 200°C
5. SHAFT AND WHEEL:
- High nickel super alloy
 - Blade profile machined
 - Friction welded to forged steel shaft
 - Very sensitive to balance grooves, and defects or damage
6. IMPELLER:
- Typically cast aluminium alloy cast by a variant of investment casting process, using rubber formers and plaster moulds
 - Started using this process in 1976 to allow the production of wheels with back sweep on the blades
 - Operation up to more than 200°C possible

B. OPERATING PRINCIPLE:

1. TURBOCHARGER WORKING PRINCIPLE:

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. The objective of a turbocharger is the same as that of a supercharger, to improve an engine's volumetric efficiency by solving one of its cardinal limitations. A naturally aspirated automobile engine relies mostly on the downward stroke of a piston to create an area of low pressure in order to draw air into the cylinder through one or more intake valves. Since the turbocharger increases the pressure at the point where air is entering the cylinder, a greater mass of air (oxygen) will be forced in as the inlet manifold pressure increases. The presence of additional air mass in the cylinder makes it possible to create a bigger explosion if more fuel is injected, increasing the power and torque output of the engine.

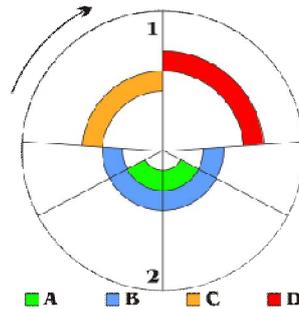
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2. WORKING CYCLE OF TWO STROKE PETROL ENGINE:



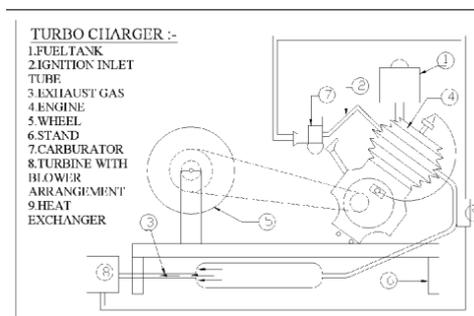
The two-stroke cycle

1. Top dead centre (TDC)
2. Bottom dead centre (BDC)

- A: Intake/scavenging
- B: Exhaust
- C: Compression
- D: Expansion (power)

C. EXPERIMENTAL SETUP:

A Spark Ignition (SI) engine runs on an Otto cycle most gasoline engines run on a modified Otto cycle. This cycle uses a homogeneous air-fuel mixture which is combined prior to entering the combustion chamber. Once in the combustion chamber, the mixture is compressed, and then ignited using a spark plug (spark ignition). The layout of turbocharged engine with parts is shown in Figure.



The SI engine is controlled by limiting the amount of air allowed into the engine. This is accomplished through the use of a throttling valve placed on the air intake (carburettor or throttle body). Mitsubishi is working on the development of a certain type of SI engine called the gasoline direct injection engine. The fabricated turbocharger engine (Suzuki) is shown in Figure

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V. CONCLUSION

We have designed and fabricated a prototype of the Turbocharger was implemented in Two-wheeler, in which the efficiency of the Engine can be increased. Thus we have developed a method to increase the efficiency of the engine and at the same time to control the Emissions from the engine. The experimental setup of block diagram is shows the arrangement of turbocharger in two-wheeler. This type of engine will be more efficient than existing engines. It is also good with regard to economical considerations and engine efficiency. The future scope of turbocharger arrangement in the two stroke single cylinder petrol engines are improved fuel economy, reduced HC and CO emission, reduced noise due to lower rate of pressure rise and higher energy in the exhaust gases.

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