Study of Improving Mechanical Efficiency and Power for SI (Gasoline) engine using Turbo-charger

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Abstract— Engine is the main or important component of any automobile. Due to rapidly increase in usage of petroleum product supplies, these are depleting at faster rates. Although many researches are working on the reducing the fuel consumption in the vehicle, it's major point for automobile sector. For the engine analysis these is major factor for decrease in volumetric efficiency of the engine is increase in temperature, which in turns decrease volume supplying in the engine chamber. This reduces power developed because of low charge density. Researchers have been finding solution to increase the efficiency (volumetric) for the engines via consuming less fuel. In SI engine, lean-burnt combustion can be a method for increasing fuel efficiency along with lower emission rate of harmful gases. Apart of lean-burnt combustion method, in this project paper we will use turbocharger to increase both efficiency and power of petrol engine. Thus, we can study how to increase the efficiency (volumetric) and power for SI engine using turbocharger over naturally aspirated engine. A turbocharger is basically a turbine-driven forced induction device that helps to increase an internal combustion engine's efficiency and power output by forcing extra amount of air into the engine chamber. This increases charge density by forcing more air and proportionally fuel into the engine chamber. The second thing which turbocharger helps in is to burn the remaining unburnt gases leaving from the engine chamber.

Keywords - I.C. engine, S.I. engine, Turbocharger, Mechanical Efficiency, Volumetric Efficiency, Power, Overall Efiiciency.

1 INTRODUCTION

In todays growing world, we all are interested in having more power output using minimum fuel consumption Altough small engines consume less quantity of fuel , but their power output is not that satisfying. This can be achieved by providing more air to the engine chamber. For understanding this we all need to understand the basic working of an standard IC engine. This is a mechanical device which converts chemical energy (depends on fuel grade) of the fuel into mechanical work which will provide motion to our vehicle. It works basically on 4 major cycles or strokes namely [1] Suction [2] Compression [3] Expansion [4] Exhaust. Initially fuel and air mixure is sucked (brought) into the engine chamber and then it's compressed with the help of piston. Just as it's fully compressed, a high intensity spark is given to the charge to burn, this explosion pushes the piston and we obtain mechanical work which is used. After all charge is burnt all which is left behind are exhaust gases which are then removed from the engine chamber.

There are many ways to improve the power developed in the engine like cylinder reboring, using cold air intakes, ECU remapping, etc. But one of the most productive and most used methods worldwide is turbocharging. By using turbocharger we infact can increase the volume and mass of the air in the engine chamber and also simultaneously allow more fuel to burn thus creating more power. This also increases volumetric efficieny and also increases engines overall efficiency.

Mostly turbochargers are being used in high compression CI engines used in trucks, SUV's, etc. But in the past few years due to introduction of GDi (Gasoline Direct Injection), it has become possible to integrate turbocharging in gasoline engines . But still in India turbochargers are most commonly used in diesel engines as compared to gasoline engines.

Also due to increasing stress on fossil fuels and enviorment , there has been greater importance given to "Downsizing". If a car is having a smaller capacity of engine than its than its other outgoing high capacity model , but it can still provide the same output or also an even better performance, then this phenomena is called as 'downsizing'.

2 TURBOCHARGER

2.1. CONSTRUCTION

A turbocharger is basically a mixture pack of a compressor and a turbine combined together, both supportedon a

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same individual shaft. Turbocharger inturns basically use engine exhaust gas, to rotate the turbine blades which help to move the compressor blades.

Centrifugal compressors are basically used where size of turbocharger used is smaller, for e.g., turbocharger in automotive system.

Axial flow is one of the type of compressors which are most widely used where there are applications of larger radial units in which internal modifications to it can be done as per the need. These are the most efficient compressors with engines using heavy oil.

2.1.1. Main Parts

There are three major parts constituting a turbocharger:

- Turbine
- Impeller / Compressor
- Central Hub

The wheels of both turbine and compressor are implanted/situated in their own conical housing. The quantity of air which is to be provided to the assembly depends on the sizes of wheels. The shaft is being suported in the hub with the help of bearings and therefore connecting the turbine wheel and impeller wheel.Due to high speed of rotation, more amount of heat is generated in the housing. Hence to lower amount of heat, cooling system is provided to prevent temperatures from rising.

To prevent mixing of gases from compressor and turbine some a particular aarangement is done. Before incorporation of exhaust gases into turbine air is first filtered so that impurities could not enter in it.

2.1.2. Turbine

Nozzle blades are provided in the turbine housing for following requirement

- To guide the gas into the turbine housing onto the blades of turbine properly on the blade of turbine wheel
- To house the bearings of turbine

The outlet side of the turbine casing constitutes of both blower and air passages for supply of air to labyrinths seals.

2.1.3. Compressor Side

The compressor side is mainly made of aluminum alloys and it also constitutes of two parts. The inlet part draws air from the surrounding areas- i.e engine room or deck spaces, etc. If air is drawn through the deck spaces, special ducting is made for that. The advantage for this drawing of air from the deck spaces is both low air temperature and humidity. While the advantage for this drawing of air from the engine space is that the air obtained is pressurized and there is no special need for those long and complex ducting arrangements.

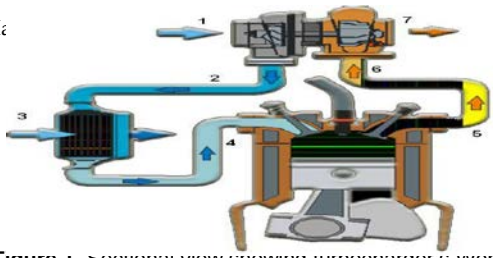

Figure 1. Sectional view showing turbocharger's working System

1. Compressor inlet part
2. Compressor output part
3. Transition from air cooler
4. Intake valve
5. Exhaust valve
6. Turbine inlet part
7. Turbine output part

2.2 Working

The turbine uses heat energy and velocity from the exhaust gases to convert heat energy into rotational motion. This rotational motion of turbine drives the compressor, which sucks in ambient air from the surrounding atmosphere and compresses it and pumps compressed air with high density and pressure output into the intake manifold.

The exhaust gas from engine chamber enters the inlet side of turbine of the turbocharger through a pressurized chamber and a series of consecutive filters. The nozzle blade rings helps to concentrate the exhaust gas on to the turbine wheel. The movement of the turbine wheel due to pressurized gasses rotates the shaft which in turn rotates the impellor of the compressor as it is connected. A portion of this air goes to the labyrinths seal from the outlet side of turbine.

As the impeller starts rotating, air is sucked in via the centre of the impeller casing and due to the heavy rotational movement, centrifugal force is created and it experiences circumferential velocity which pushes it outwards towards casing. A radial velocity is gained by these which force the air further outwards to the inducer. Relative to this additional resultant velocity is gained/obtained due to the accurately designing of inducer inlet angle which provides max. Compressor efficiency.

Excessive pressure obtained leads to spoiling or fouling of the both impeller and inducer surfaces. This results in the change of angle of incidence and thus dropping efficiency.

All heavy fuel engines are subjected to heavy load variations hence results in fluctuation of exhaust gas pressure. A prolonged fluctuations occurring in pressure may lead to detrimental effects on the internal parts of the compressor. For this above reason, an constant pressure chambers are provided in most of the engines. The exhaust gas coming from engine, instead of entering directly, first enters the pressure chamber and from there it is been taken to the turbine at constant pressure. This leads to reduction of the excessive stress that is created on the shaft bearing and sealing.

2.3: TYPES OF TURBOCHARGERS:

2.3.1 SINGLE

It is the majorly used type of turbocharger. It provides low boost pressure (upto 18psi). Single small turbos have advantage over large turbos as they spin faster and also accounting of ball bearing helps to obtain less friction for turbine and compressor to spin easily.

2.3.2 PARALLEL

Some of the engines, that are V-type engines, utilize two identical sized turbos, each is given a separate set of exhaust outlet streams from the engine. Having of two smaller turbos gives advantage to produce the same aggregate amount of boost required as a larger single turbo gives them to reach their optimal higher rpm, quickly, hence it improves boost delivery.Such an arrangement made of turbos is typically known to as parallel twin-turbo system. The first production automobile which used the parallel twin turbochargers was theMaserati Biturbo of the early 1980s.

2.3.3. SEQUENTIAL

Another type of twin-turbo arrangement obtained is "sequential", where one turbo is always in action across the entire rev/rpm range of the engine and the other will activates at higher rpm.Under this rpm range,both exhaust and air inlet ports of the secondary turbo will be shut. The turbos being individually smaller in size they have reduced lag and the second turbo operating at a higher rpm range allows it to get to full rotational speed before it is been required. Such combinations of turbos are known to as a sequential twinturbo. Cars using sequential twinturbos are as follows the Porsche 959, Mazda RX-77, Toyota SupraS and Subaru Legacy. Sequential twin-turbos are usually more complex than a single or parallel twinturbo systems because they usually require three sets of intake and waste gate pipes and valves to control the proper direction of the exhaust gases.

1 TRIPLE-TURBO

BMW's diesel N57S is the only tri-turbo engine currently available.

1 QUAD-TURBO

The Bugatti Veyron uses a quad-turbo W16 engine. The Bugatti EB110 from 1991 uses a quad-turbo V12.

3 Intercooler

Intercooler, a cooling element is used to the cooling of heated air to the turbo compression results in turbocharged engines.

If coldest air enters in the engine, highest power gets from it. This is the reason for the larger or bigger size of the intercooler always means more amount of air molecules can send into the engine.

Thus, by providing an increased volume of air get some benefits; the increasing of fuel economy, the engine power, increasing engine durability and reduction of a gas harmful emissions. Intercooler is fixed with various geometric shapes of fins. To compare and check the performance of finned surfaces, two factors should be taken into consideration those are

Intercooler valuations are taken into account when making design limitations are determined by the properties of the motor vehicle manufacturing companies. These are: ingoing and outgoing temperatures, size, airflow passing, cooling power, compressor efficiency and turbine efficiency

4 Problem Definition

In an normally aspirated engine there are more occurence of pumping losses as compared to turbocharged engine, this will decrese the efficiency of respected engine thus it is only fair that we can use the full potential of engine in order to obtain the best significance output possible.

Also due to inadequate compression in the combustion chamber its not possible to get a high torque curve in all conditions. Due to this the powerband shortens which reduces the usability of particular engine

The engine we are being using for this project is a naturally aspirated engine: in short which means a stock engine developed by the company itself which runs on its original power and torque figures and it doesn't have any external means to run it. Due to this it has a drawback that all the power developed doesn't reach on the wheels which reduces its efficiency.

It reduces its volumetric efficiency that is the ratio of air intake through manifold in cylinder to engine volume capacity is less.

5 Proposed Methodology

In order to overcome the above listed problems definition discussed a turbocharger can be used. It gets power from the pressurised exhaust gas from engine. Exploding a mixture of fuel and air in the engine chamber, the mixture turns into gas due to combustion and is pushed into the exhaust manifold. At this stage, the gas pressure tailpipe along a path rotates the turbo propeller and a significant portion of the gas goes in turbine.

6 Test Engine

Bike name	CBR250R
Model	Honda MC 41
Engine type	CS250RE,liquid cooled 4
Displacement (cm^3)	249
Bore×stroke (mm)	76×55
Compression ratio	10.5
Fuel supply system	PGM-FI
Starter type	SELF STARTER
Ignition type	FULL TRANSISTER IGNITION
Lubricating type	WET SUMP
Reduction G.R	2.808/2.714
Caster angle/trail (mm)	25°/95
cylinder arrangement	Single cylinder inclined at 20° from vertical
valve train	Chain driven DOCH with rocker arm
intake valve opens at	20° BTDC
Intake valve closes at	35° ABDC
Exhaust valve opens at	40° BBDC
Exhaust valve closes at	0° TDC
Oil pump type	Trochoid
Air filtration	Viscous paper filter
Engine dry wieght	35.4 kg(78 lts)

Fig 2. Engine Specification (Service Manual)

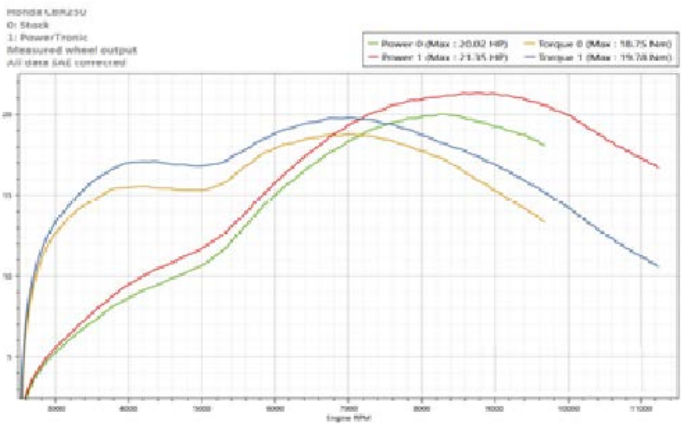

Fig 3. Stock Engine Power Curve

7 Conclusion

In this study, to improve the performance value of the existing engine, made of HONDA CBR 250, originated from JAPAN, has been modified with turbocharger unit and inter-cooler system

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