

Modification and Analysis of 125 cc Petrol Engine with Turbocharger

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ABSTRACT: Due to the increase of motorcycles, petrol consumption and emission rate increases day by day. An attempt has been made in this project to use the exhaust gas to rotate a turbine thereby rotating a compressor for supplying compressed air to inlet. A turbocharger increases the pressure at the point where air enters the cylinder, thereby increasing the pressure gradient across the intake valves and thus more air enters the combustion chamber. It allows proper combustion of fuel and increases the efficiency of engine. A turbocharged engine can be more powerful and efficient than a naturally aspirated engine because of the increase in the quantity of intake air into the combustion chamber than if atmospheric pressure alone is used. In this project we used a 125cc engine for our analysis. In our work the turbocharger is mounted in front of the engine near the exhaust ports in order to minimize heat losses and improve turbo response. Front mounting of the turbocharger isolates the heat from the rider, removes the turbocharger from its conventional location behind the engine where it can get hot enough to boil the fuel in the fuel tank.

KEYWORDS: Turbocharger, Smart waste gate, Total fuel consumption.

I. INTRODUCTION

For the past few years the motorcycles sales in India have been growing at faster rates and recently surpassed one million vehicles a month mark. Due to this increase of motorcycles, petrol consumption and emission rate increases day by day. In this project an attempt has been made to use the exhaust gas from the engine to rotate a turbine coupled with a compressor arrangement and compressed air is given to the air inlet. Our fore most aim in selecting this project is to employ efficiency turbo charging.

Emission rate can be controlled by using exhaust energy recovery and providing proper compressed air into the inlet of cylinder. A turbocharger is a device utilizes exhaust gas energy to allow more power to be produced for an engine of a given configuration. A turbocharged engine can be more powerful and efficient when compared to a naturally aspirated engine because of more intake air, proportionately more fuel into the combustion chamber than if atmospheric pressure alone is used.

In this project we are using a 125cc engine for the installation of turbocharger. We mounted the turbocharger in front of the engine very near to the exhaust ports to minimize heat losses and improve turbo response.

II. NEED OF TURBOCHARGER

The power produced by an engine is proportional to the amount of air and fuel that can get into the cylinders. All things being equal, the larger engines flow more air and will produce more power. We want to make our engine produce more power, for that the amount of air intake to the engine cylinder must increase. By installing a Garrett turbocharger, the power and overall performance of an engine can be dramatically increased.

There are two methods for increasing the engine power. One of them would be to increase the proportion of fuel in the fuel-air mixture. This will increase the engine power but at the cost of fuel efficiency and increase in pollution levels. The other method is by increasing the volume of air entering into the cylinder and increasing the fuel intake proportionately, this will increase the power and fuel efficiency without hurting the environment. This is exactly what the Turbochargers do; it increases the volumetric efficiency of an engine in a naturally aspirated engine, during the

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downward stroke the piston creates a low pressure area in order to draw more air into the cylinder through the intake valves. More over if we can increase the difference in pressure across the intake valves by some way we can increase the quantity of air enter into the cylinder and hence the volumetric efficiency of the engine get increased. The turbocharger increases the pressure at the inlet manifold of the cylinder, thereby increasing the pressure difference across the intake valve and hence more air enters the combustion chamber. The additional air makes it possible to add more fuel, and thus the power and torque output of the engine gets increased, particularly at higher engine speeds. If the cylinder pressure goes too high it will cause the fuel to pre-ignite which in turn causes serious physical damage to the engine. To regulate this pressure or boost, a waste gate is provided.

The fuel efficiency of the engine can also be increased with the help of a turbo charger without any attempt to increase power. It does this by recovering waste heat energy in the exhaust and supplies it back to the engine intake. By using this wasted energy to increase the mass of air proper combustion will take place before the combustion product is vented at the start of the exhaust stage. This increases the temperature and pressure and there by produces a higher Carnot efficiency.

Now a day the turbo charging of petrol engines is no longer seen from the performance perspective, but is viewed as a means of reducing fuel consumption and emission of harmful gases.

III. DESIGN AND FUNCTION OF TURBOCHARGER

A turbocharger consists of a turbine connected to a compressor with a shared axle. The turbine inlet receives exhaust gases from the engine make the turbine wheel to rotate. This rotation drives the compressor and thereby supplies compressed air to the intake manifold of the engine at higher pressure. It will result in a greater mass of air entering the cylinder. In some cases, compressed air is passed through an intercooler before introduction to the intake manifold.

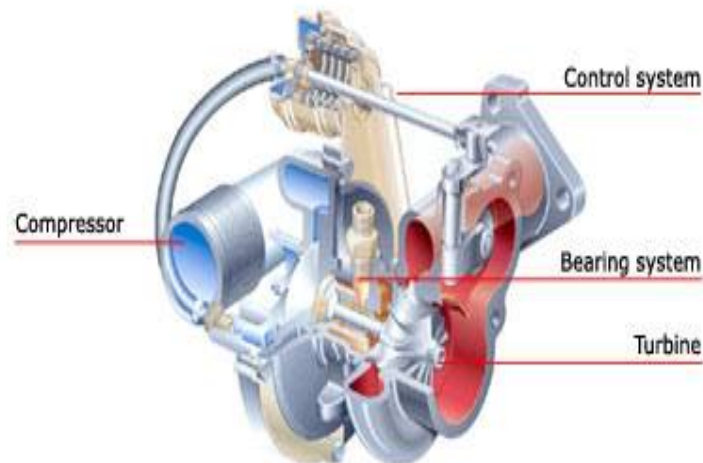


Fig. 1 Turbocharger Cross section

The figure 1 shows the cut section of a turbocharger assembly. The turbine and compressor wheel sizes decide the amount of air or exhaust that can flow through the system, and the corresponding efficiency at which it operates. In general, the larger the turbine and compressor wheel the larger the flow capacity. Parameters like size and shapes as well as curvature and number of blades on the wheels can vary. A turbocharger performance is closely related to its size. Large turbochargers take more heat and pressure to spin the turbine thereby creating a lag at low speed. Small turbochargers spin quickly but may not perform the same at high acceleration.

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A. Compressor



Fig. 2 Compressor wheel

The compressors in turbocharger are generally centrifugal compressors consisting of three essential components: the compressor wheel, the diffuser, and the housing. The figure 2 shows a typical compressor wheel used in the turbocharger assembly. When the compressor wheel rotates air is drawn in the axial direction, accelerated to a very high velocity and expelled it in a radial direction. The function of diffuser is to slow down the high-velocity air without losses, so that both pressure and temperature rise. The diffuser is formed by the compressor back plate and a part of the volute housing, which in its turn collect the air and slows it down further before it reaches the compressor exit.

B. Turbine

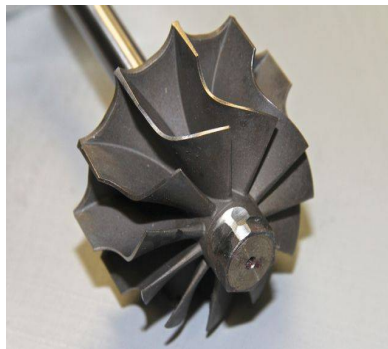


Fig. 3 Turbine wheel

The turbine used in the turbocharger consists of a turbine wheel and turbine housing which converts the kinetic energy of the engine exhaust gas into mechanical energy to drive the compressor. The figure 3 shows a typical turbine wheel used in the turbocharger assembly. There are two main turbine types i.e. axial and radial flow turbines. In the axial-flow turbine the flow through the wheel is only in the axial direction but in the radial-flow turbines, gas inflow is centripetal, i.e. in a radial direction and gas outflow in an axial direction. Up to a wheel diameter of 160 mm, only radial-flow turbines are used. This corresponds to an engine power of around 1000 kW per turbocharger. Only axial-flow turbines are used from 300 mm onwards. Between these two values, both variants are possible.

C. Bearing System

Radial Bearing System

The sleeve bearing helps the shaft to turn without friction on an oil film in the sleeve bearing bushing. The oil supply for the turbocharger comes from the engine oil circuit. The designed bearing system is such that brass floating bushings rotate at about half the shaft speed is situated between the stationary centre housing and the rotating shaft which enables these high speed bearings to be used such that there is no metal contact between shaft and bearings at any of the

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operating points. In addition to the lubricating function, the oil film in the bearing clearances also has a damping function which also contributes to the stability of the shaft and turbine wheel assembly.

Axial-Thrust Bearing System

Due to the difference in the gas forces acting on the compressor and turbine wheels in axial direction the shaft and turbine wheel assembly get displaced in an axial direction. In the axial bearing a sliding surface bearing with tapered lands is used to absorb these forces. Two small discs fixed on the shaft serve as contact surfaces and the axial bearing is fixed in the centre housing. In order to prevent the oil from entering the shaft sealing area an oil-deflecting plate is used.

D. Sealing

The centre housing is sealed against the hot turbine exhaust gas and against oil loss from the centre housing. On both the turbine and compressor side a piston ring is installed in a groove on the rotor shaft. These rings are stationary and are firmly clamped in the centre housing. This contactless type of sealing, a form of labyrinth seal prevents oil leakage due to multiple flow reversals and thus only small quantities of exhaust gas escape into the crankcase.

E. Exhaust Manifold

The exhaust system for a conventional turbocharged engine consists of a manifold, which collects the exhaust gases and supply it to the turbine. The large volume of this manifold impairs the efficiency of the turbine because it causes an expansion of the gases coming from the cylinder exhaust and entering the manifold thereby reduces the fluctuation of the flow upstream of the turbine and the large surface area promotes heat losses. If we dispense with such a manifold and the turbine is directly mounted on the cylinder head, we could minimize this expansion and cooling phenomena accordingly and would promote the pulsating flow to enter the turbine.

F. Smart Waste gate

The power of a turbocharger is usually controlled by a waste gate valve, which controls the gas pressure at the turbine intake in a static manner. This same pressure is therefore present at the turbine intake and at the cylinder during the exhaust stroke. Therefore traditional waste gate neither delivers ‘highest possible energy’ gases to the turbine nor release the pressure of the upward running piston at the same time. The figure 4 shows the sectional view of smart waste gate.

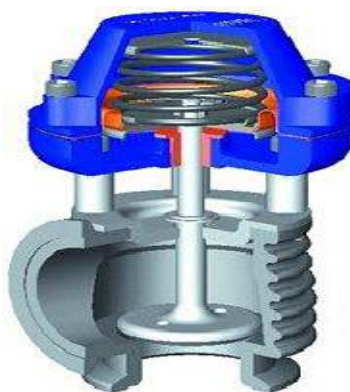


Fig. 4 Smart waste gate sectional view

It is possible to improve this design by considering an additional cylinder exhaust valve, called ‘smart waste gate’, which bypasses the turbine and opens and closes in the same way as a traditional exhaust valve. Thus the main exhaust valve supplies exhaust gas to the turbine and will open and close sooner than the additional exhaust valve. Thus the turbine will receive the exhaust gases at higher energy, while the ‘smart waste gate’ will evacuate the remaining low energy exhaust gases, ensuring that a very lower pressure acts on the piston during its upward stroke.

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IV. ENGINE SPECIFICATION

Type	:	Air cooled, 4 stroke single cylinder
Displacement	:	124.7 cc
Max power	:	9 Bhp @ 7000 rpm
Maximum Torque	:	10.35 Nm @ 4000 rpm
Max. Speed	:	90 Km/h
Bore	:	52.4 mm
Stroke	:	57.8 mm
Cooling	:	Air Cooling

V. EXPERIMENTAL SETUP

The Figure 5 shows the experimental setup in which the turbocharger is installed. The turbine inlet of turbocharger is connected with engine exhaust manifold with the help of stud nut and welding. The turbine shaft is coupled to a compressor, which draws in atmospheric air, compresses it, and then supplies it to the engine. An air filter is connected with turbocharger compressor inlet section to prevent other foreign particle from entering the intake system. The turbocharger compressor outlet is connected with a hose pipe to the carburetor air inlet. The whole assembly is installed on a GI frame. We have designed and fabricated a prototype of the Turbocharger implemented in a 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. This type of engine will be more efficient than existing engines.



Fig. 5 Experimental setup

In this set up the output of the engine exhaust gas is given to the input of the turbine blades; the turbine shaft is coupled to the compressor. The compressor draws in ambient air and pumps it in to the intake manifold at increased pressure, resulting in a excess amount of air entering the cylinders on each intake stroke there by producing proper combustion. The next important reasons for the search of effective, unadulterated power are to save the surrounding environments including humans, machinery and materials of both the existing and the next generation from pollution.

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More over the additional oxygen makes it possible to add more fuel and thereby increasing the power and torque output of the engine.

VI. RESULT AND DISCUSSION

A. Performance Analysis

Performance test is done on the 4-stroke, single-cylinder petrol engine to study and compare its performance under various loads with and without turbocharger. The test rig consists of a 125 cc SI engine which is fitted on a skeleton body made with GI rectangular pipes which has loading arrangement using rope brake drum dynamometer with drum diameter 0.144 m and rope diameter 0.016 m. A weight hanger is provided to add the weights and is connected to a rope and the other end of the rope is connected to a spring balance. The engine is load due the friction produced between the rope and drum. The engine is started on no load and allows to run at a speed of 2500 rpm. Then the time taken to consume 10 cc of fuel is taken from the burette which is connected to carburetor with small hose and is recorded. Then load the engine step by step up to a particular load below its maximum capacity. The time for 10 cc fuel consumption is noted for each load at a speed of 2500rpm. The experiment is repeated with and without turbocharger at different loads.

Table 1 Load test without turbocharger

SI No.	Weight added to the hanger	Spring balance reading	Time for 10cc fuel consumption	Brake power	Total fuel consumption	Specific fuel consumption	Brake mean effective pressure	Brake thermal efficiency
	W	S	T	BP	TFC	SFC	BMEP	η_{bth}
	kg	kg	Sec	kW	kg/hr	kg/kWhr	kN/m ²	%
1	0	0	47.77	0	0.565	-	0	0
2	4	1.25	44.48	0.57	0.607	1.074	94.66	7.70
3	8	3	43.81	1.03	0.616	0.599	172.10	13.79
4	12	4.5	36.05	1.54	0.749	0.486	258.16	17.03
5	16	6	32.43	2.05	0.833	0.405	344.21	20.42

Table 2 Load test with turbocharger

SI No.	Weight added to the hanger	Spring balance reading	Time for 10cc fuel consumption	Brake power	Total fuel consumption	Specific fuel consumption	Brake mean effective pressure	Brake thermal efficiency
	W	S	T	BP	TFC	SFC	BMEP	η_{bth}
	kg	kg	Sec	kW	kg/hr	kg/kWhr	kN/m ²	%
1	0	0	49.43	0	0.546	-	0	0
2	4	1	47.53	0.62	0.568	0.922	103.2632	8.98
3	8	2	46.47	1.23	0.581	0.471	206.5263	17.56
4	12	4	45.84	1.64	0.589	0.358	275.3684	23.09
5	16	5	43.47	2.26	0.621	0.275	378.6316	30.11

The tables 1 and 2 shows the data obtained during the performance test of the engine with and without turbocharger.

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From the tables it is clear that the total fuel consumption and specific fuel consumption decreases with the usage of turbocharger. More over the implementation of turbocharger results in an increase in brake mean effective pressure and brake thermal efficiency.

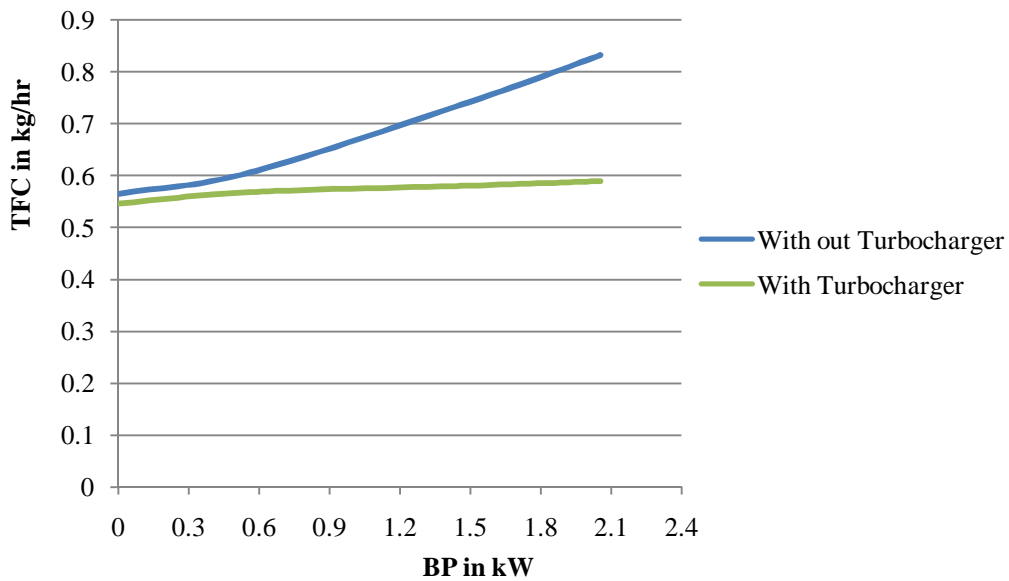


Fig. 6 Variation of Total fuel consumption

The figure 6 shows the variation of Total fuel consumption with brake power. From the graph it can be observed that the value of total mass of fuel consumption per hour get reduced due to the installation of turbocharger.

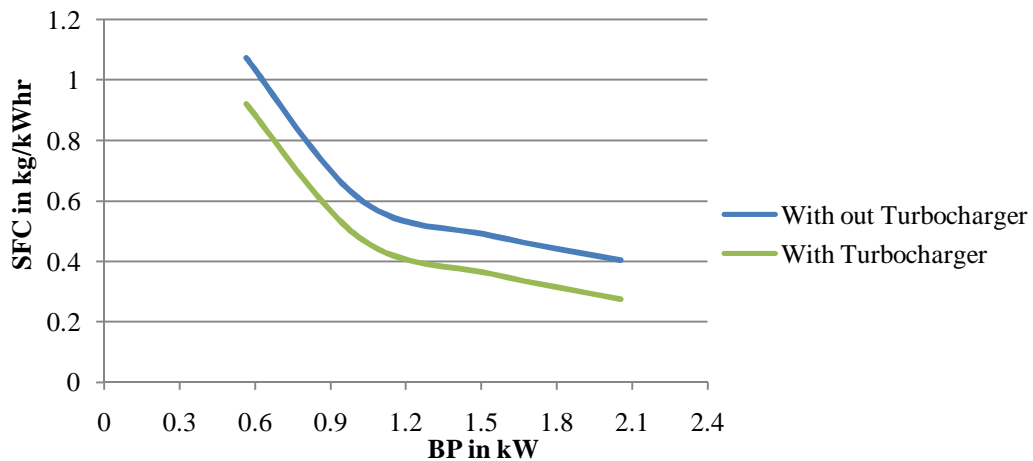


Fig. 7 Variation of specific fuel consumption

The figure 7 shows the variation of specific fuel consumption with brake power. SFC gives the mass of fuel consumed per hour, in order to develop a brake power of one kilowatt. From the graph it is observed that the value of the fuel flow rate per unit power output per hour also get reduced in the case of engine with turbocharger due to proper combustion of the fuel air mixture.

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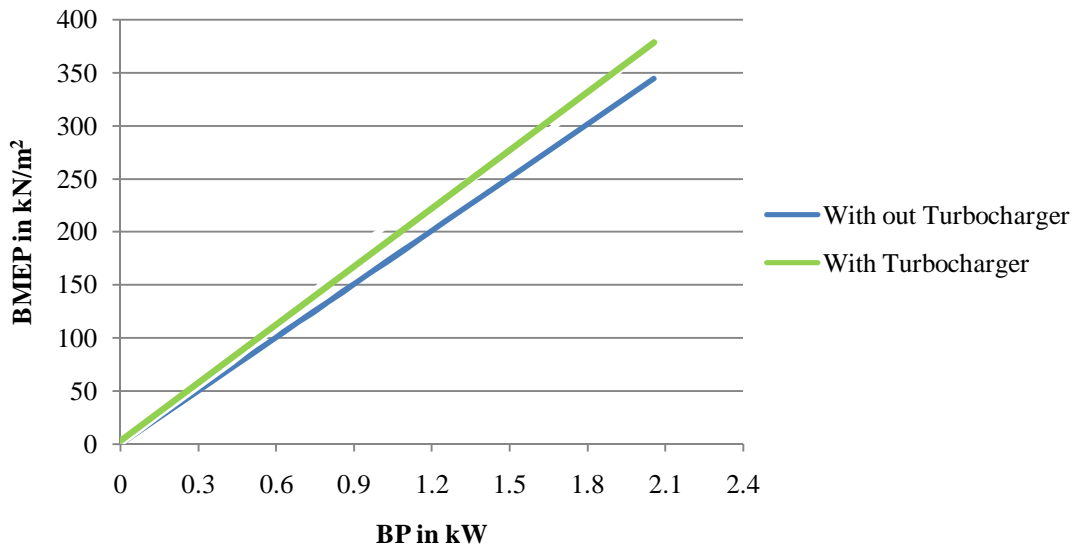


Fig. 8 Variation of Brake mean effective pressure

Figure 8 shows the variation of Brake mean effective pressure with brake power. From the graph it is observed that there is an increase in the brake mean effective pressure when the turbo charger is installed. The oxygen rich compressed air maximise the energy released during combustion. As a result, the average pressure on piston from top to bottom on power stroke increases and hence higher BMEP. The variation of mean effective pressure shows a true indication of the relative performance of different engines.

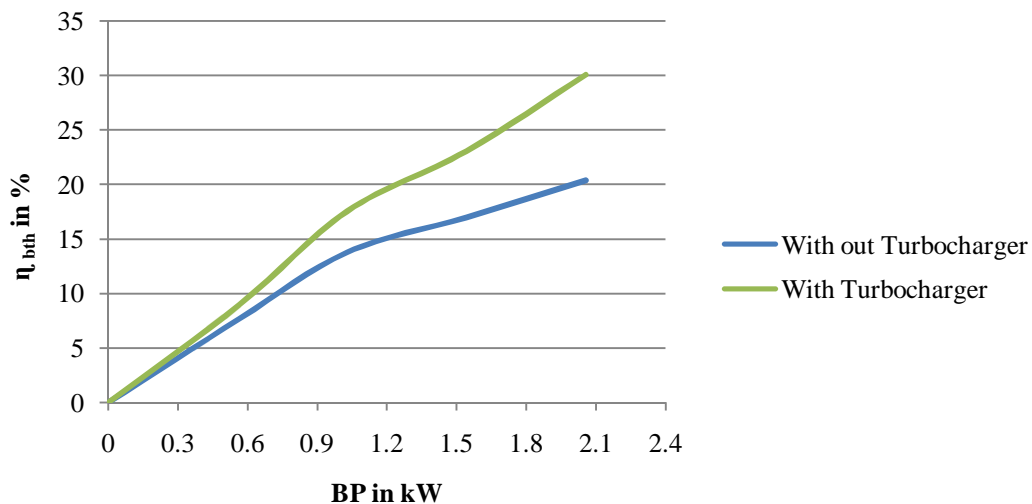


Fig. 9 Variation of Brake thermal efficiency

Figure 9 shows the variation of Brake thermal efficiency with brake power. From the graph we can observe an increase in the efficiency in the case of engine with turbo charger. It is due to the fact that proper combustion takes place as oxygen rich mixture is introduced.

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Turbocharger helps to increase the overall performance of the petrol engine. It allows proper mixing of compressed air with fuel and avoids wastage of fuel. Maximum energy of fuel can be explored with the usage of turbocharger. Thus the power and fuel efficiency can be increased. The performance test done on the 125 cc petrol engine suggests the addition of turbocharger is essential for the better performance of engine.

B. Emission Test

The levels of hazardous materials that released from a motor vehicle during combustion have been checked with the aid of emission test. Although emissions in new vehicles have been greatly reduced over the last few decades, the threat to human safety and the environment remains a great concern.

The figure 10 shows the image of a portable engine exhaust analyser. A Nova portable engine exhaust gas analyser can measure oxygen (O₂), carbon dioxide (CO₂), nitrogen oxide (NO), nitrogen dioxide (NO₂), carbon monoxide (CO), and hydrocarbons (HC's).



Fig. 10 Portable engine exhaust analyser

The analyser includes a gas extraction probe which is sometimes called the “cool handle” probe because it has a coiled section made of stainless steel tubing that is effective in dissipating the heat before it continues on to the analyser. The probe handle is fitted with a built-in filter to removes soot and oil vapours from the sample gas. The probe has a retainer clip to anchor it in the vehicle exhaust pipe. A flexible tip or a bendable straight tip can be provided with the probe handle.

The exhaust emission of 125 cc SI engine is analysed using Portable engine exhaust analyser with and without turbocharger at 2000 rpm. The data obtained for emission test with and without turbocharger is shown in the table 6.3.

Emission test measurements taken by engine exhaust analyser shows variation in the readings with and without turbocharger. It is so clear from the readings that the emission rate of different harmful gases can be reduced using the installation of turbocharger in petrol engine. Turbocharger helps in proper combustion of fuel in engine cylinder and reduces the amount of unburnt fuels. It is done so by allowing compressed air flow in to the carburetor of petrol engine and allows proper mixing of air with fuel and thus favours complete combustion. This reduces the production of harmful gases in engine cylinder.

Table 3 Emission measurement with and without turbocharger.

Gases	Without turbocharger	With turbocharger
CO % volume	5.24	4.23
CO ₂ % volume	2.19	2.58
O ₂ % volume	20.20	21.20
NO % volume	54	30
HC PPM volume	185	156

It can be seen from the table 3 that the amount of harmful gas in the combustion product gets reduced with the implementation of turbocharger. Turbocharger reduces pollution by exploring maximum amount of energy from fuel via combustion. It rectifies the problem of unburnt fuels. Emission test shows the need of turbocharger in two wheelers for the reduction of emission which causes pollution and hazards to the environment.

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VII. CONCLUSION

In this work we have installed a Turbocharger in the four stroke SI engine. The efficiency of the engine can be increased by introducing a turbo charger. Thus we have developed a method to increase the efficiency of the engine and at the same time to reduce the Emissions from the engine. The various plots drawn from the results of load test show the significance of turbocharger in power generation, fuel economy and emission. A turbocharged engine will have more break thermal efficiency than existing engines. This work is an attempt to minimize our dependency on foreign oil and reduce the tail pipe emission from automobiles. It was an effort to design and implement this new technology that will drive us into the future. Use of turbo charger will reduce smog forming pollutants over the current national average.

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