Effects of Turbocharging a Carburetted S.I Engine

B.Seshavenkat Naidu, D.Eswar, U.Sarath Chandra, K.Parameswara Rao, G.Venkata Rama Krishna

B.Tech Mechanical Engineers
V.R Siddhartha Engineering College
Vijayawada-520007

Abstract: Now a day's whole world facing the problem of reducing the fuel. So there is need to reduce fuel consumption. In a conventional IC engine exhaust gases carry a considerable heat away. To recover the waste heat, various methods are being adopted. One of them is turbo charging. In this project an attempt has been made to explore the various chances of exhaust heat energy recovery methods in car. The heat Energy carries in the exhaust gases are recovered in different methods. Thus the principle of turbo generation has been adopted for waste heat recovery. Due to the increase of cars, petrol consumption and emission rate increases. In this project to use the exhaust gas to rotate a turbine thereby rotating a compressor for supplying compressed air to intake. A turbocharger increases the charge air enters the cylinder. In this project we used an 800cc engine for our analysis. Modification of exhaust using the turbocharger exhaust gases removes the turbocharger. Turbocharger is mounted in front of the engine near the exhaust manifold for reduce heat losses and improve the efficiency.

In particular this modification requires many other parts rather than that of a turbocharger. Those parts are used for the proper running of the turbocharger. These are exhaust circulation into the muffler, filtered air intake for compressor unit, Pressurized oil inlet for the lubrication line and a free flow oil outlet for turbocharger delivery line. It is very essential to modify and tune the each and every part setup to draw the best possible results.

The main aim of this project is to minimize the heat loses in the old engines say the engines equipped with a carburetted fuel supply system and to use the waste heat energy to improve the volumetric efficiency and reduce the emissions out of the engine.

The engine used in this experiment is a 1993 model S.I engine with a carburetted fuel supply system producing about 35hp and giving an average of 18km per litre of petrol. After the necessary modifications like re-routing the exhaust line, making the connections for the lubrication of the turbocharger and connecting the delivery line of the turbocharger to the engine oil sump of the system. For the air intake unit a filter is attached so that the compressed air free from the particles that damage the engine. Attaching the turbocharger with all the stated modifications the engine gave an average mileage of 24km per litre volume of the petrol used which is 30% more efficient. There has also been a considerable decrease in the emissions from the engine.

Key words - Turbocharger, Carburettor, S.I Engine, Efficiency, Emissions.

1. INTRODUCTION

1.1 Introduction

Internal Combustion(IC) engines have been in the history of mankind over the past 200 years. Automobiles have been the widely used range of application these IC engines. There was estimation that there are approximately 1.2 billion automobiles on road today across the world. There is also estimation that there will be 2 billion automobiles on road by 2035. Thus there is a large role of automobiles in the day-to-day life of mankind. The fuel consumption of these automobiles is also large in number. An approximated 14 million barrels of oil are being used per day as transportation. Thus the usage of fuel is very large in today's scenario. So there is need to reduce fuel consumption. In a conventional IC engine exhaust gases carry a considerable heat away. To recover the waste heat, various methods are being adopted. One of them is turbo charging.

Emissions are the one common output of every of these automobiles we are using. Thus today, there is a huge quantity of automobile emissions produced. Emission from vehicles especially automobiles is responsible for about two third of air pollution in the urban area. These emissions are by-products from the engine combustion process and from the evaporation of fuel. The major pollutants emitted by motor vehicles including CO, NO_x, sulphur oxides (SO_x), HC, lead (Pb) and suspended particulate matter (SPM), have damaging effects on both human health and ecology. The internal combustion engines need a mixture of air and fuel to burn and produce energy to propel the vehicle. These burnt gases which come out of the exhaust are responsible for pollution. In petrol engines, the gases comprise a mixture of unburnt hydrocarbons (HC), Carbon Monoxide (CO) and Oxides of Nitrogen (NO_x). If these gases are in excess quantities, vehicular pollution is caused.

1.2 Need for Alternative Fuels

Alternative fuels which are renewable and ec-friendly reduce the dependency on fossil fuels and they help to preserve the atmosphere by reducing the emission levels. The burning of fossil fuels create higher levels of CO_2 and other gases in atmosphere affecting the green-house effect. The scarcity of conventional fossil fuels, growing emissions of combustion causing pollutants and their increasing costs will make alternative sources more attractive.

The different kinds of fuels that have been considered as alternative fuels for petroleum based fuel are classified as solid, liquid and gas. The solid fuels are pulverized coal, slurry and charcoal which are not used in IC engines due to their physical properties, handling and storage problems. The liquid fuels are alcohols (ethanol, methanol) and vegetable oils (edible and non-edible). The gaseous fuels are LPG, CNG, H_2 and biomass. Liquid fuels are easy to handle, transport, store and have reasonable calorific values and they are preferred for IC engines.

1.3 Need for Turbocharger

A turbocharged engine can be more powerful and efficient than a naturally aspirated engine because the turbine forces more intake air, proportionately more fuel, into the combustion chamber. So volumetric efficiency of the engine increases. Increased engine power output in the region of 50% increase, improved fuel consumption on improved pressure balance across the engine is achieved because of turbocharging. Better thermal efficiency over naturally aspirated engine and super charged engine is obtained because the engine exhaust is being used to do the useful work which otherwise would have been wasted.

The ultimate reason that we are interested in turbocharging system for increase efficiency and output power of SI. Engine. All we the concern about Turbocharging system because of following reasons. Today Need to reduce use of fuel all over world. 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. Continual development of this technology has produced an engine that easily meets emissions and fuel economy standards. With current computer controls and reformulated gasoline, today's engines are much more efficient and less polluting than those built 20 years ago.

1.4 Turbo Charger

A turbocharger, or colloquially turbo, 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 improvement over a naturally aspirated engine's power output is due to the fact that the compressor can force more air-and proportionately more fuel-into the combustion chamber than atmospheric pressure alone.

1.5 Operating principle

A turbocharger consists of a turbine and a compressor on a shared shaft. The turbine converts heat to rotational force, which is in turn used to drive the compressor. The compressor draws in ambient air and pumps it in to the intake manifold at increased pressure, resulting in a greater mass of air entering the cylinders on each intake stroke. The output of the engine exhaust gas is given to the input of the turbine blades, so that the pressurized air produced. This power, the alternate power must be much more convenient in availability and usage.

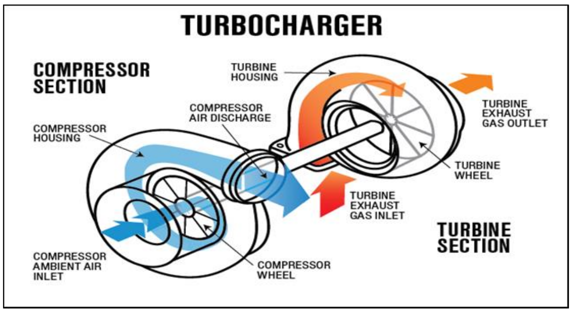


Fig.1 Schematic diagram of Turbocharger

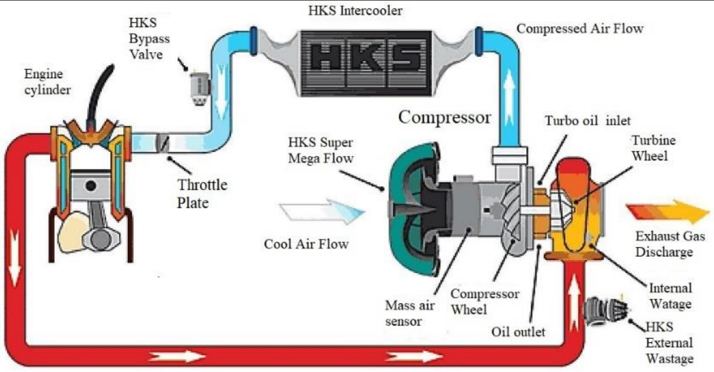


Fig.2 Working Process of Turbocharger

1.6 Turbocharger Attachment Types to Engine

There are various configurations to supply an engine with compressed air, and the matching amount of fuel to that air. These configurations can be divided into two main groups:

1. Draw Through Turbo Setup
2. Blow Through Turbo Setup

Regardless of how the fuel is delivered, whether it be fuel injection, via a carburettor, or from an LPG mixer, the fuel has to enter the airflow in one of the two ways listed above.

1.6.1 Draw through Turbo Setup

When the fuel is delivered before the compressor, such as a carburettor mounted to the front of the turbo, it is said to be in a draw through configuration, as the air/fuel mixture is being drawn through the turbocharger.

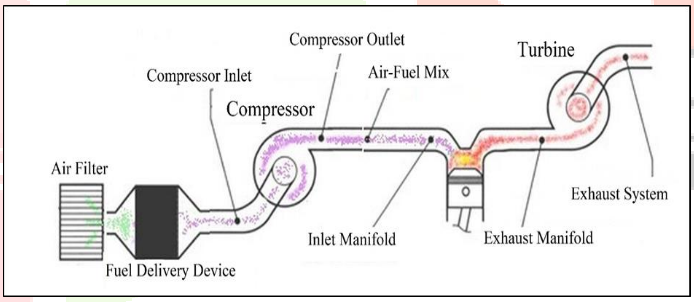


Fig.3 Draw through turbo setup

1.6.2 Blow through Turbo Setup

When the fuel delivery system is mounted in between the engine, and the turbocharger, the configuration is said to be a blow through, as the turbo is blowing through the fuel delivery system. Although blow through usually refers to a carburetted fuel delivery system, technically any fuel delivery system can be in a blow through configuration.

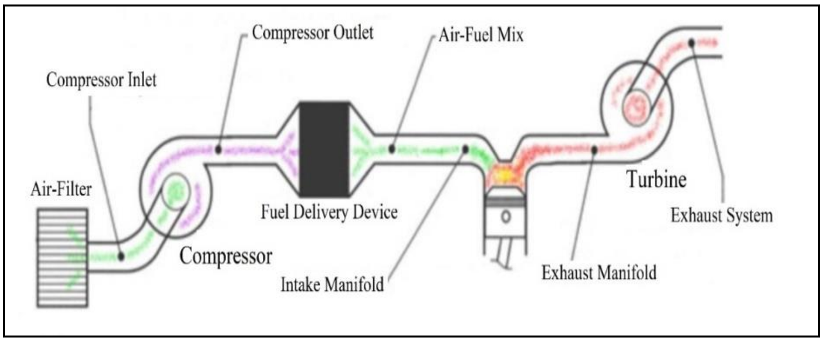


Fig.4 Blow through turbo setup

1.7 Ethanol

Ethanol is also called ethyl alcohol or grain alcohol because it is usually made from grain and is the type of alcohol found in alcoholic drinks such as beer, wine, and distilled spirits like whiskey. Ethanol is a clear, colorless liquid with a characteristic, agreeable odor. In dilute aqueous solution, it has a somewhat sweet flavor, but in more concentrated solutions it has a burning taste. Ethanol (CH_3CH_2OH) is a group of chemical compounds whose molecule contains a hydroxyl group, -OH, bonded to a carbon atom. Ethanol melts at –114.1 °C, boils at 78.5 °C, and has a density of 0.789 g/mL at 20°C.

2. CALCULATIONS & SELECTION

There are numerous types of turbochargers produced in the market. Proper selection of turbocharger is very important. Turbochargers are designed based on the horse power, volumetric efficiency and air flow rate. So proper calculations are to be done to identify the requirements of turbocharger for experimentation. The corresponding calculations later. After the sufficient calculations selection of turbocharger needs to be done based on some key parameters, and then finally proper specification of the turbocharger required is selected.

Calculations made for selecting the turbo

1. *Performance gain required*

Performance gain $= \left(\frac{Desired\ HP}{Actual\ HP} - 1\right) * 100$

Performance gain $= \left(\frac{45}{36} - 1\right) * 100$

Performance gain = 25%

2. *Boost required for performance gain*

Boost pressure (psi) = (Atmospheric pressure) x (Performance gain)

Boost pressure (psi) = (14.7x0.25)

Boost pressure (psi) = 3.63

3. *Calculation of air flow rate (CFM)*

Cubic Inch Displacement of engine = Engine Displacement x 61.02

= 0.8 x 61.02 (Where 61.02 is constant for CFM)

= 48.812

Airflow rate $= \left(\frac{CID * RPM *}{2 * 1728}\right) * \eta_v$

$= \left(\frac{48.812 * 6000 * 0.8}{2 * 1728}\right)$... η_v =80%

= 67.5CFM

Air flow rate (lb/min) = 67.5*0.076

Air flow rate (lb/min) = 5.31(lb/min)

4. *Pressure ratio*

Pressure ratio $= \left(\frac{boost\ required + atmospheric\ pressure}{atmospheric\ pressure}\right)$

$= \left(\frac{3.6 + 14.7}{14.7}\right)$

= 1.24

5. *Turbo air flow rate*

Turbo airflow rate = air flow rate * pressure ratio
= 5.31 * 1.24
= 6.36 lb/min

From the above calculations to increase the 25% of the performance of engine we need 3.63 psi boost pressure. So in order to achieve this boost pressure by turbocharger we had calculated the required parameters i.e. air flow rate, pressure ratio and air flow rate. From calculations, 1.24 pressure ratio is required to get3.63PSI of boost pressure. The air flow rate from the engine is 5.31 lb/min, with this air flow rate speed the turbine wheel of turbocharger has to run at the same time it has to pressurize the intake air to 1.24. So with these parameters we have to choose the turbocharger.

3. Selection of Turbocharger

3.1 Selection the turbocharger

The turbocharger is selected by comparing the pressure ratio and air flow rate on the on the compressor map of the turbo. Special care must be taken while plotting. The points should not fall under the surge and choke region on the compressor map. The compressor map is shown in the below figure.

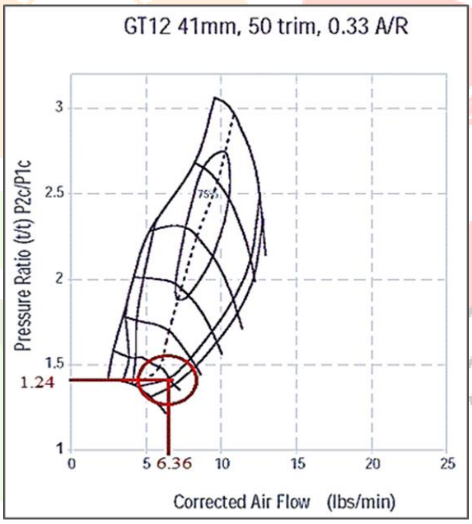


Fig.5 Compressor map

By plotting the pressure ratio and air flow rate on the compressor map the point is present in between the surge line and choke line. So this turbocharger or similar to this kind of turbochargers are suitable for our requirements. GT12 turbocharger is not available in india. We are selected the model number “ST-9403” which is similar to the GT12 turbocharger. ST-9403 turbocharger is using in the Maruti swift dzire cars.

3.2 Seletion of the turbocharger attachment

There are various configurations to supply an engine with compressed air, and the matching amount of fuel to that air. These configurations can be divided into two main groups:

1. Draw through setup
2. Blow through setup

To run the turbine wheel of turbocharger it needs a certain amount of force caused by the exhaust gases. So the turbocharger is attached to the engine where sufficient amount of force is available. Exhaust gases force is high nearer to the engine exhaust. So the turbocharger is attached to the engine exhaust. Next step is choose the type of turbocharger setup.

If we choose the draw through setup the air-fuel mixture is supplied to the inlet of the compressor. It is an easy setup. But causes the waste of fuel. If the engine oil line of turbocharger damages there may be a chance of combining the engine oil with the air-fuel mixture which reduces the clean burn and emissions.

If we choose the blow through setup the fresh air is supply to the compressor inlet and the pressurised air is coming out from compressor and it will supply to the engine by adding the fuel. In carburetted setup the fuel is adding to the pressurised air based on pressure. i.e. when the air is blows to the carburettor based on the pressure the carburettor is adding the fuel. This type of carburettor is costly.

Of both the setups of turbocharger attachments, blow through setup has higher efficiency. Thus, blow through setup is used here for attaching turbocharger to the engine. In the blow through setup we can also use the intercooler to reduce the temperatures of air.

4. TURBOCHARGED ENGINE SETUP :

The turbine intake of the turbocharger is attached to the exhaust manifold of the engine and the outlet is connected to the muffler which lets out the exhaust into the atmosphere.

Fig.6 Turbocharger Attached to the Engine

To the cold air intake unit a performance air filter is fitted to free flow of air and to prevent the entering of the dust particles. The air drawn through the turbocharger is sent to the inlet manifold of the carburetor.

Fig.7 Air Filter

Fig.8 Carburetor

The exhaust coming out of the turbocharger is made to deviate using two long bends made of iron each with an angle of 90 degree angle. These long bends are furhter connected into the muffler to reduce the engine sound. This redirection can be seen the below figure.

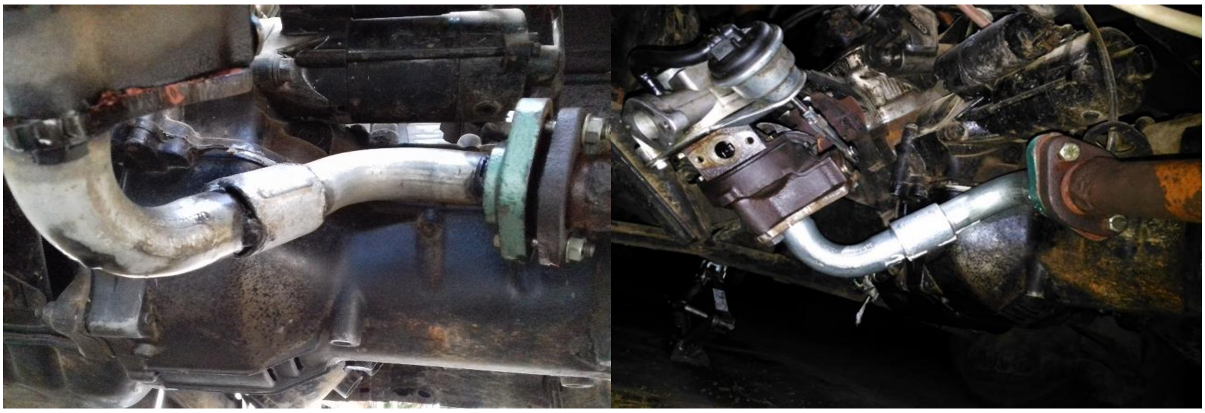


Fig.9 Exhaust Line from the Turbocharger

The shaft inside the turbocharger rotates at a high speed to compress the air. While rotating so friction will be developed, which can lead to breaking of the shaft. To prevent this lubrication of the turbocharger is needed. This is done by drawing the engine oil pressure line into the turbocharger and routing the delivery line into the sump of the engine.

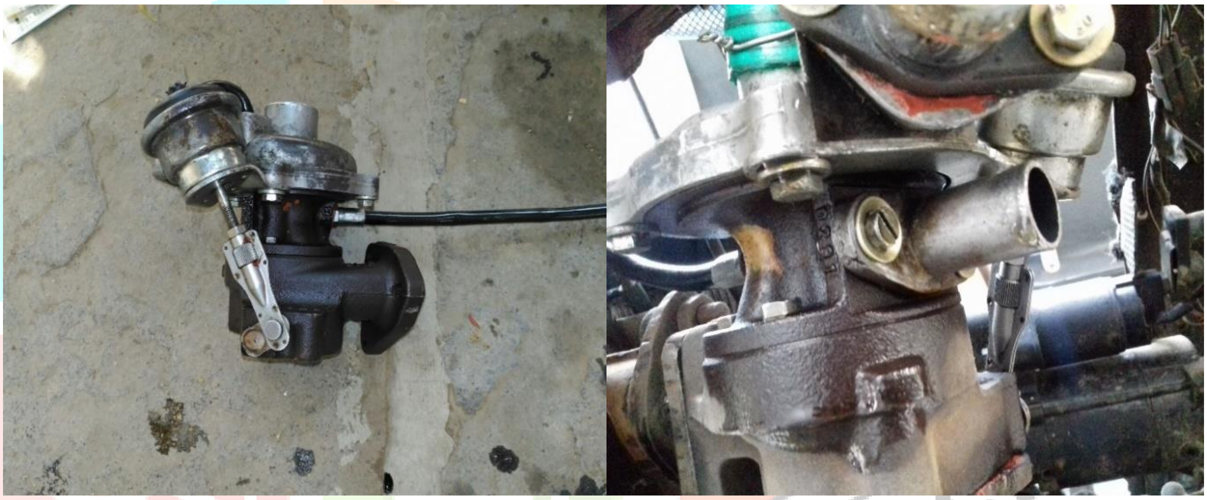


Fig.10 Lubrication line for the Turbocharger

5. RESULTS

The engine is tested with turbocharger setup and stoke engine setup. Both are compared with the help of Mileage and Emission results. Later E10 is used as fuel and conducted the both the tests. The mileage and emission results are noted. The values obtained from the experimentation are neatly presented in the form of figures, in order to compare the values for different parameters. The results are divided into Mileage & emission values.

5.1 Comparison of Stock Engine & Turbocharged Engine running with Petrol

5.1.1 Mileage Results

S .No	Stock Engine[kmpl]	Turbocharged Engine[kmpl]
1	18.94	16.9
2	18.35	23.8
3	18.9	24.1

Table.1

The above table shows Mileage Testing results of Stock Engine & Turbocharged Engine running with Petrol

The following graph represents the mileage results of Stock Engine and Turbocharged Engine by running with Petrol.

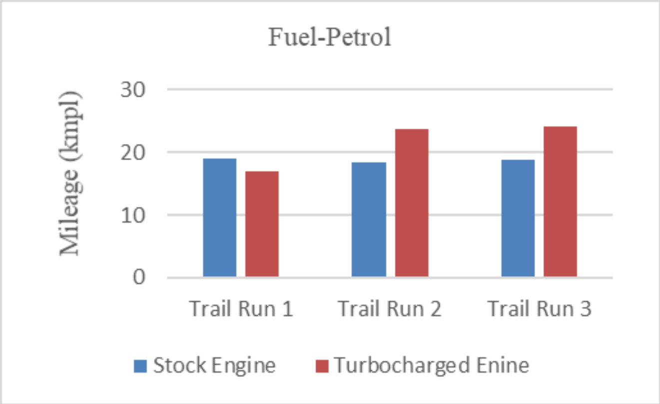


Fig.11 Fuel Consumption

Fig.11 Mileage of Stock Engine and Turbocharged Engine running with Petrol

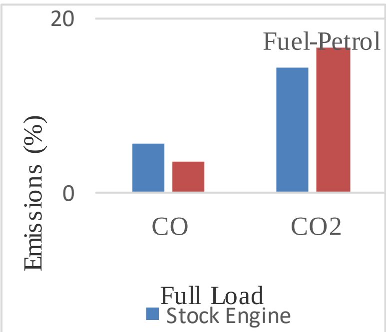
The Mileage of the vehicle is decreased initially due to the turbo lag. Later the mileage is increased. In the trail run 1 the mileage decreased by 10.77%, then in trial run 2 and 3the mileage increased to 29.70% and 27.51% with respect to the initial condition of the vehicle.

5.1.2 Emission Results

Gases	Stock Engine	Turbocharged Engine
CO%	5.67	3.56
CO_2%	14.54	16.75
HC ppm	351	330

Table.2

Table above shows Emission Testing results of Stock Engine & Stock Engine running with Petrol. The following graphs represents the emission results of E10 blend in the stock and Turbocharged engine



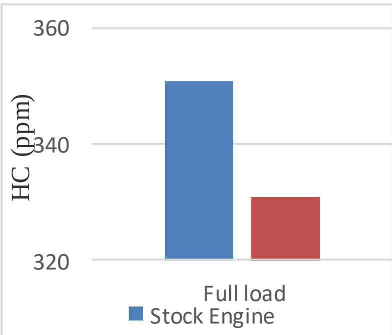


Fig.12 (a) Fig.12 (b)

Fig.12 a. Emissions of CO, CO_2 (%), 12 b. Emission of HC (ppm) In Stock engine & Turbocharged Engine with Petrol

Due to running of the vehicle with turbocharger the emission values are decreased. The CO % is decreased by 37.2% with respect to the stock engine. The CO_2 is increased by 15.19%. The HC is measured in ppm. The HC is decreased by 5.98%.

5.2 Comparison of Stock Engine & Turbocharged Engine running with E10 blend

5.2.1 Mileage Test

S .No	Stock Engine [kmpl]	Turbo charged Engine[kmpl]
1	17.5	14.2
2	16.9	15.6
3	17.5	16.1

Table.3

Table above shows the Mileage Testing results on Stock Engine & Turbocharged Engine with E10 blend

The following graph represents the mileage results of Stock Engine and Turbocharged Engine by running with E10.

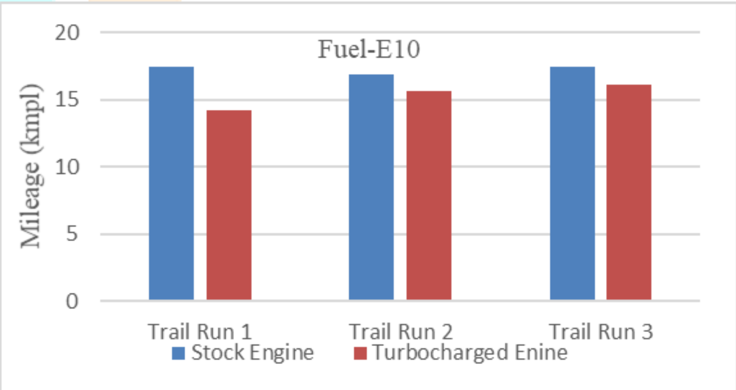


Fig.13 Mileage of Stock Engine vs. Turbocharged Engine running with E10

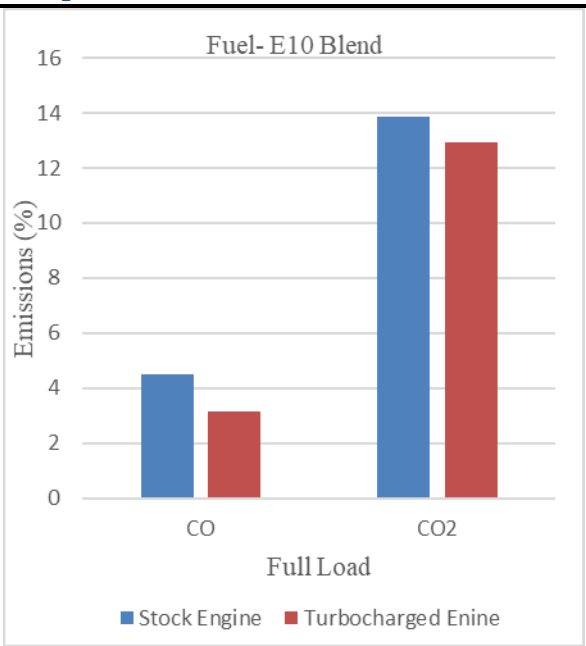
The Mileage of the vehicle is decreased by running the E10 as fuel. In the trail run 1 the mileage decreased by 18.85%, then in trial run 2 and 3the mileage decreased to 7.69% and 8% with respect to the stoke engine.

5.2.2 Emission Test (E10)

Gases	Stock Engine	Turbocharged Engine
CO%	4.5	3.161
CO_2%	13.88	15.6
HC ppm	301	267

Table.4

The table above shows Emission Testing results of Stock Engine & Turbocharged Engine running with E10 blend



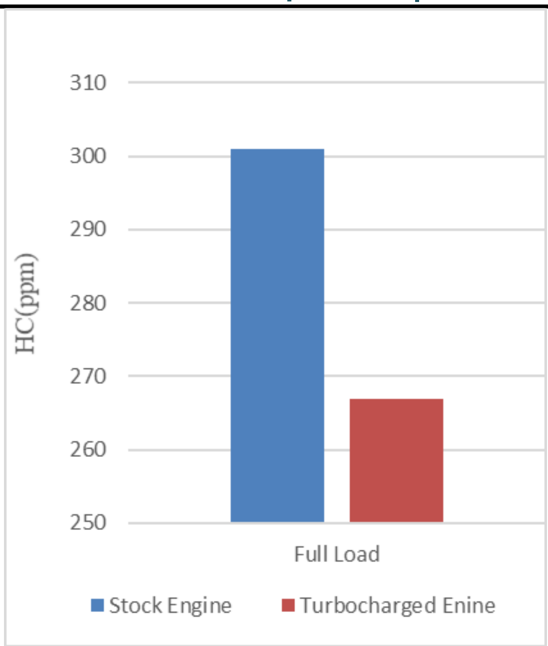


Fig.14 (a) Fig.14 (b)

Fig 14 a. Emissions of CO, CO2 (%) b. Emissions of HC (ppm)

In Stock engine & Turbocharged Engine with E10

By running the Engine with E10 blend the emission values are decreased from stoke engine to turbocharged engine. The CO, CO_2 and NO_x decreased by 29.7%, 6.7% and 11.29%.

5.3 Comparison of Petrol & E10 in Stock Engine

5.3.1 Mileage Testing

S .No	Petrol	E10
1	18.94	17.5
2	18.35	16.9
3	18.9	17.5

Table.5

Table above shows the Mileage Testing results of Petrol & E10 in Stock Engine

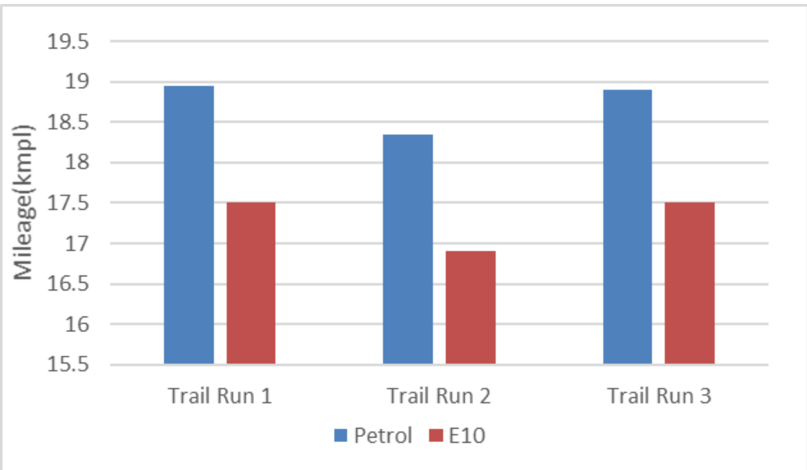


Fig.15 Petrol vs. E10 mileage results on Stock Engine

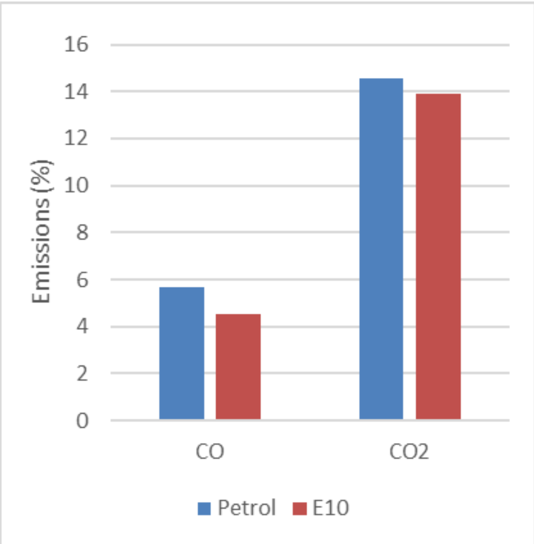
By running the vehicle with Petrol and E10 as fuels the mileage is measured. By comparing the E10 with Petrol the mileage is decreased in all the trail runs. In the trail run 1, 2 and 3 the mileage is decreased by 7.6%, 7.9% and 7.4 %.

5.3.2 Emission Test

Exhaust Gases	Petrol	E10
CO (%)	5.67	4.5
CO_2 (%)	14.54	13.88
HC(ppm)	351	301

Table.6

Table above shows the Petrol and E10 Emission Testing results in stock Engine



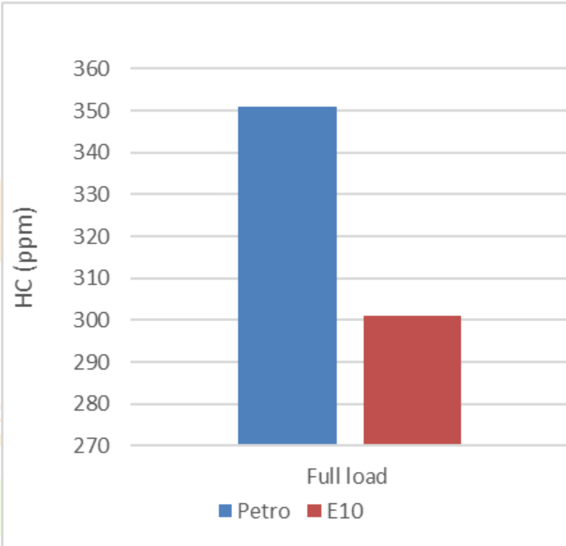


Fig.16 (a) Fig.16 (b)

Fig 7.6 a. Emissions of CO, CO2 (%), b. Emissions of HC (ppm) in Stock Engine with Petrol & E10

5.4 Comparison of Petrol and E10 with Turbocharged Engine

5.4.1 Mileage Test

S .No	Petrol	E10
1	16.9	14.2
2	23.8	15.6
3	24.1	16.1

Table.7

Table above shows the Mileage testing results in Turbocharged Engine with Petrol& E10

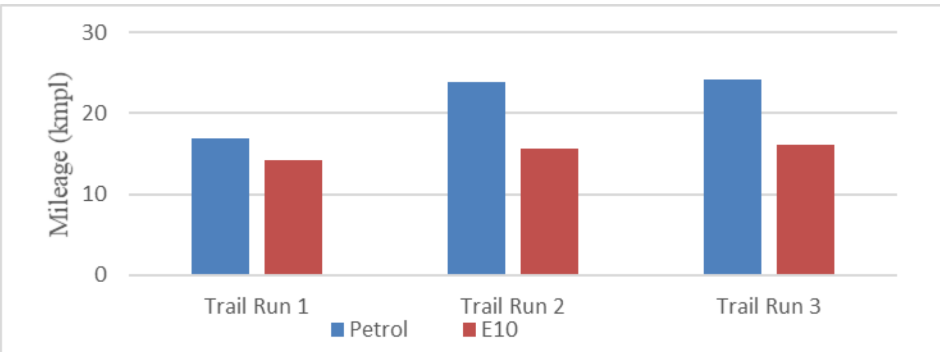


Fig.17 Petrol vs. E10 mileage results on Turbocharged Engine.

By comparing the petrol and E10 in the turbocharger engine, the mileage is decreased at the beginning of the vehicle. Later the vehicle is increased its mileage over a long drive. But as compared to the petrol the E10 is decreased in 3 trails. The mileage drops in the 3 trail runs as 15.9%, 34.45% and 33.19%.

5.4.2 Emission Test

Exhaust Gases	Petrol	E10
CO%	3.56	3.161
CO_2%	16.75	12.95
HC ppm	330	267

Table.8

Table above shows the Emission testing results in Turbocharged Engine with Petrol & E10

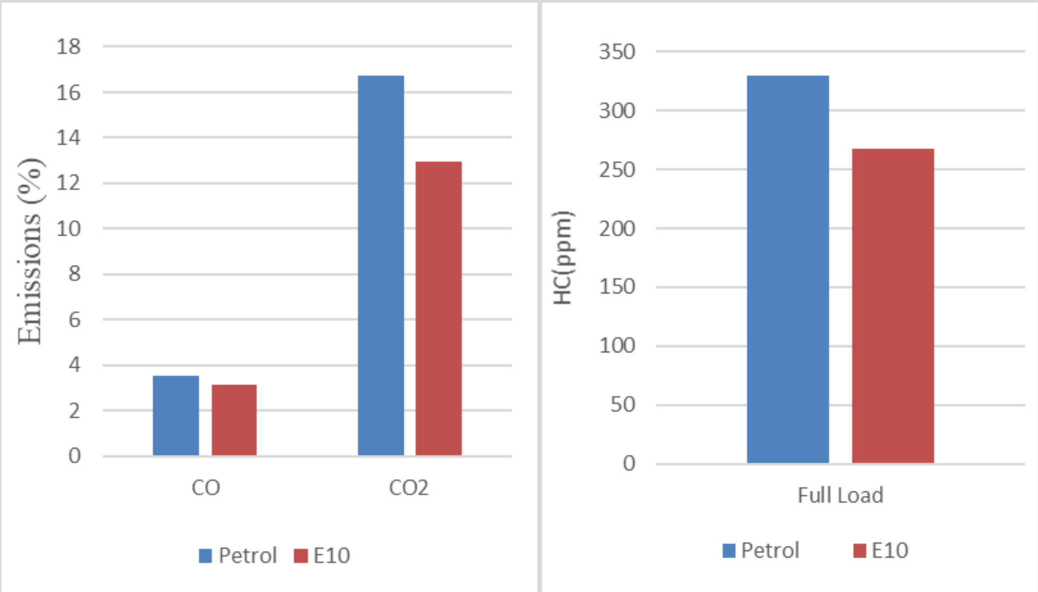


Fig.18 (a) Fig.18 (b)

Fig.18 a. Emissions of CO, CO_2 (%), b. Emissions of HC in Turbocharged Engine with Petrol & E10

As comparing the E10 with Petrol the emissions are deceased. The CO, CO2 and HC are decreased as 11.2%, 22.68% and 19.89%.

6. CONCLUSION

In this project we tried to improve the volumetric efficiency of the engine with a basic carbureted fuel supply system, we intended to achieve this by sending more pressurized air into the air intake chamber. Thus this air channelization is done by the usage of a turbocharger, which uses exhaust air to create the pressurized boost required for the engine. This way we have achieved an overall 30% rise in the fuel economy and 15% decline in the emissions of the engine. The usage of the alternating fuel E10 reduced the emissions but also has a great effect on the decrease of the engines volumetric efficiency.

Suggesting people use alternative fuels which will produce less emissions and give less mileage at a cost which is higher than that of the normal petrol is not a practical solution. Thus we can use a turbocharger which gives more mileage, emits less pollutants and runs on the normal fuel used. Thus the usage of alternative fuel is not only a best option in the practical world but also the turbocharger can be used to improve the volumetric efficiency of the engine. This way more output can be drawn out of the basic engines also.

7. SUMMARY

The following conclusions can be made from the experimental results obtained:

- Turbocharger attachment decreases the fuel consumption of the vehicle.
- Petrol shows better mileage when compared to E10 blend.
- E10 blend shows lower level of emissions when compared to petrol.
- Turbocharger attachment leads to reduce in emission levels.

Thus, from the observations it can be concluded that turbocharger can be attached to SI engine in-order to reduce fuel consumption as well as emission levels. Though, E10 shows lower level of emissions it is not suggestible to use in SI engine due to its very low fuel efficiency.

8. REFERENCES

[1]. Pathak Sunil, "Turbocharging and Oil Techniques in Light Motor vehicles" Research Journal of Recent Sciences Vol. 1(1) Jan. (2012) published by ISCA International Science Congress Association. Page No.(60-65)

[2]. Dr .Manoj Kumar , "Turbocharging of IC Engine" International Journal of Mechanical Engineering and Technology Volume 4, Issue 1, January- February (2013). Pg. No(142-149)

[3]. Waadysaaw Mitianiec, Aukasz Rodak, "Control Problems in A Turbocharged Spark-Ignition Engine" Journal of KONES Powertrain and Transport, Vol. 18, No. 3 2011. Page No. (269-277).

[4]. Abhishek Saini, "Turbocharged Single Cylinder SI Engine, "International Journal of Advanced Technology & Engineering Research, IOCRSEM 2014, Page No. (110-116).

[5]. Prashant S. Jadhav, "Performance Evaluation of Single Cylinder Four Stroke S. I. Engine Using Turbocharging System", International Journal of Advanced Technology & Engineering Research, Volume 6, Issue 1, January 2017 Pg. No.(71-76).

[6]. Mohammad Israr, Amit Tiwari and Mahendra Labana, "Performance Analysis and Fabrication on a Turbocharger in Two Stroke Single Cylinder Petrol Engine" IJETI International Journal of Engineering & Technology Innovations, Vol.2 Issue 2, March 2015(ISSN 2348-0866). Page No. (14-21).

[7]. Norbert Zsiga, Christoph Voser, Christopher Onder and Lino Guzzella, "Intake Manifold Boosting of Turbocharged Spark-Ignited Engines" Energies 2013, 6, DOI:10.3390/en6031746 Pg. No. (1747-1763).

[8]. Wladyslaw Mitianiec, Lukasz Rodak, "Control Problems in A Turbocharged Spark-Ignition Engine" Journal of KONES Powertrain and Transport, Vol. 18, No. 3 2011 Page. No. (269-2

[9]. https://auto.howstuffworks.com/turbo.htm

[10]. https://www.turbodynamics.co.uk/technical/understanding-turbochargers

[11]. https://en.wikipedia.org/wiki/Turbocharged_petrol_engines

[12]. https://www.carwow.co.uk/guides/glossary/how-turbos-work-superchargers-explained

[13]. http://www.gnttype.org/techarea/turbo/turboflow.html

[14]. http://www.cimac.com/cms/upload/Publication_Press/Recommendations/Recommendation_27_rev_081007.pdf