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Performance and Emission Improvement of Automobile Engine by Using Supercharging and Turbocharging: A Review

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Abstract – IC Engine has always proved its worth in human life from time to time by making it simpler and progressive in almost all aspects. But along with advantages there are disadvantages also such as harmful emission of gases like Nitrogen Oxides, Hydrocarbons, and Carbon Monoxide etc. In today's world the challenge is to provide most feasible engineering solutions over the problems created due to emissions to the environment. The objective of this study is to review and improve the performance and emissions of automobile engine by using super-charging and turbo-charging. In polluting elements Nitrogen oxides (NOx) contribute to a wide range of environmental effects including the formation of acid rain, destruction of ozone layer and also various effects on human health. Turbo charger helps to reduce these harmful emissions from entering into atmosphere.

Keywords: IC Engine, Super-Charging, Turbo- Charging, Engine Performance, Emission

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INTRODUCTION

Automobile mainly uses petrol and diesel as fuel. The population of automobile vehicles is increasing rapidly due to economic development of developing countries. In IC engine, combustion of fuel takes place in a confined space, producing expanding gases that are used directly to provide mechanical power. Such engines are classified as reciprocating or rotary, spark ignition or compression ignition, and two-stroke or four-stroke. Diesel engines have high thermal efficiencies, resulting from their higher compression ratios and fuel lean operation. The high compression ratio produces high temperatures required to achieve auto-ignition, and the resulting high expansion ratio makes the engine discharge less thermal energy in the exhaust. The extra oxygen in the cylinders is necessary to facilitate complete combustion and to compensate for non-homogeneity in the fuel distribution. However, high flame temperatures predominate because there are locally stoichiometric air–fuel ratios in such heterogeneous combustion processes. Consequently, Diesel engine combustion generates large amounts of NOx because of the high flame temperature in the presence of abundant oxygen and nitrogen **[1].** NOX reacts with ammonia, moisture, and other compounds to form nitric acid vapor and related particles. Small particles can penetrate deeply into sensitive lung tissue and damage it, causing premature death in extreme cases. Inhalation of such particles may cause or worsen respiratory diseases such as emphysema, bronchitis. It may also aggravate existing heart disease. NOX reacts with volatile organic compounds in the presence of sunlight to form Ozone. Ozone can cause adverse effects such as damage to lung tissues and reduction in lung function mostly in susceptible populations (children, elderly and asthmatics). NOX destroys ozone in the stratosphere. Ozone in the stratosphere absorbs ultraviolet light, which is potentially damaging to life on earth. **[2, 3]** External exhaust gas recirculation (EGR) is a well known in-cylinder method to reduce NOx emissions.

SUPER-CHARGING:

It is known fact that the power output of an engine increases with an increase in amount of air or mixture in the cylinder at the beginning of compression stroke because it allows the burning of more quantity of fuel. The amount of air induced per unit time can be increased by increasing engine speed or increasing air density during suction stroke.

Supercharging is a process which helps to increase the suction pressure of I.C. Engines above the atmospheric pressure. The main object of supercharging is to increase the air charge per cycle and permit the burning of a larger amount of fuel and thus increase the power output of the engine.

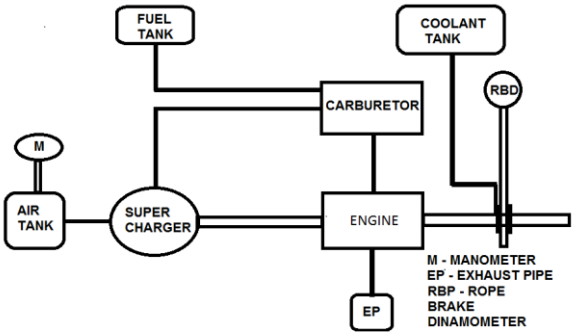

Fig. 1 Layout of Super Charger [2]

Fig. 2 SuperCharger [8]

TURBO-CHARGER: A turbocharger is a device used to allow more power to be produced for an engine of a given size. 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 than if atmospheric pressure alone is used. Its purpose is to increase the volumetric efficiency of the combustion chamber. Various new technologies have been introduced to assist the turbocharging of internal combustion engine so that the volumetric efficiency can improve further. These technologies include inter-cooling of the charged air before going in to the combustion chamber so that its mass flow rate increases.

In turbocharging, the turbocharger is being driven by a gas turbine using the energy in exhaust gases. The major components of a turbocharger are turbine wheel, turbine housing, turbo shaft, compressor wheel, compressor housing & bearing housing.

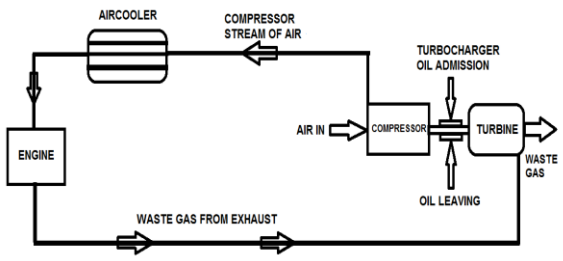

Fig. 3 Layout of Turbo Charging [7]

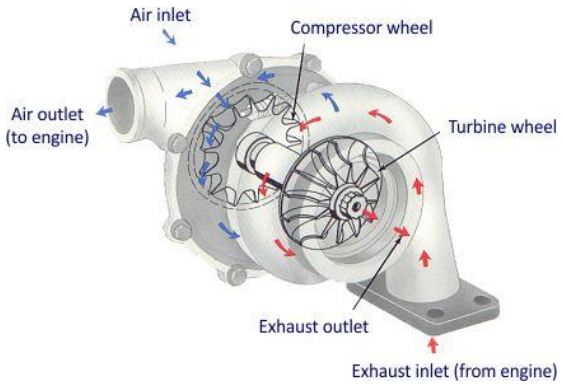

Fig. 4 Turbo Charger

LITERATURE REVIEW

Various studies are carried out on engines. Few researchers' work on supercharging & turbo charging is referred in this study and literature survey is carried out.

Mohebbi et al.**[1]** presented the study of EGR system and improve the efficiency, and a very effective way of reducing NOX emission from a diesel engine (via reduction of these parameters), particularly at high load of engine operating condition. EGR reduces NOX emissions whereas PM emissions are increased. Prashant N. Pakale et al**.[2]** an attempt has been made in this paper to show the exhaust gas is used to rotate the turbine and then it is further worked with supercharger and turbocharger. Nowadays it is desirable with applications of new technology with regard to economic considerations and engine efficiency. T. Polonec et al**.[3]** presented the methodology for upgrading the turbocharging and fuel injection system to increase engine power, parameter modifications of engine components. Mohammad Israr et al. **[4]** analyzed the intercooling system and tested the final design in the vehicle. P Balashanmugam et al. **[5]** carried the analysis of Exhaust emission [(Carbon monoxide (CO), Hydro carbon (HC), Carbon dioxide (CO2) and Oxides of Nitrogen (NOX)] of Suzuki engine (100 cc) using MEXA-584L Gas analyzer for gasoline powered vehicles. Mohd Muqeem et al. **[6]** discussed the review on various applications of turbocharging technology and types of turbochargers, their performance for different conditions in IC engine and turbocharger installations on different type of engines and vehicles. Vidit Saxena et al.**[7]** describes that exhaust gas is utilized to rotate the turbine and then it is further worked with supercharger and turbocharger. P. Podevin, G, Descombes et al.**[9]** shows the result that boosting of pressure has no influence on emission except NOX which increases for engine speed between 2000 and 2500 rpm. Considering specific emissions, low level of pollutants are obtained for low equivalence ratio because of brake specific fuel consumption with increase of boost pressure.

A. Benefits Of Supercharging:

Following are the benefits of supercharging:-

1) Due to lower volumetric displacement of the supercharged engine, frictional & thermal losses are very less.

2) Brake power will enhance by about 30-45 percent because of incrementation in supercharged pressure as more amount of fuel will be burnt within the same period as the mass taken per stroke is incremented.

3) The puissance-to-weight ratio, i.e. kilowatt (power output)/kilograms (engine weight); of the supercharged engine is much better than that of the naturally aspirated engine.

4) The supercharged engine‘s installation space requisite is more minuscule than that of a naturally aspirate engine with the same power output.

5) The high altitude performance of a supercharged engine is significantly preponderant. Because reduction in engine is more diminutive; it is consequently less strepitous than a naturally aspirated engine with identical output.

6) It is very simple for high speed engine. **[7]**

B. **Benefits Of Turbocharging:**

Following are the benefits of Turbo charging:-

1. More power compared to same size naturally aspirated engine.

2. Better thermal efficiency over naturally aspirated engine and super charged engine, because the engine exhaust is being used to do the subsidiary work which otherwise would have been wasted.

3. Better Fuel Economy by way of more power and torque from the same sized engine.

4. Better volumetric efficiency.

5. Continual development of this technology has engendered an engine that facilely 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. **[7]**

C. Limitations Of Supercharging:

1) Power for crankshaft rotation of supercharger gets consumed from engine’s horsepower which is nearly 20%.

2) Maximum performance gets restricted due to physical limitations of supercharging system. **[2]**

D. **Limitation Of Turbocharging:**

1) Heavy in weight, requires more space, hence overall weight of engine will increase.

2) Turbo lag may occur if proper maintenance and care is not taken.

3) Engine cost will increase. **[2]**

Turbochargers were originally known as turbo superchargers when all forced induction devices were classified as superchargers. Nowadays the term "supercharger" is usually applied to only mechanically driven forced induction devices. The key difference between a turbocharger and a conventional supercharger is that the latter is mechanically driven by the engine, often through a belt connected to the crankshaft, whereas a turbocharger is powered by a turbine driven by the engine's exhaust gas. Compared to a mechanically driven supercharger, turbochargers tend to be more efficient. Turbochargers are commonly used on truck, car, train, aircraft, and construction equipment engines.

CONCLUSION

This study of turbocharging and supercharging shows positive influence on IC engine power characteristic and emission characteristic. The air fuel ratio is always constant. So there is scope to vary the air fuel ratio and obtain the best suited air fuel ratio and that can be optimized. Also improve the power output of an engine and to reduce its emissions by making some changes and installing some additional accessories like intercooler in the turbocharging technology. To achieve higher performance of the engine in future, it will be necessary to set up boost pressure of turbocharger to higher level, upgrade camshafts and also to upgrade the fuel system.

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