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A Review on Turbocharging of IC Engine

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Abstract

Turbochargers are used widely in automotive industries and it increases the output of internal combustion engine (IC) without the need to increase its cylinder capacity. The mechanical device enables automotive manufacturers to adopt small displacement engines known as "Engine downsizing". In earlier days, turbochargers are used to increase the potential of powerful IC engine. In today world is to provide a feasible engineering solution to manufacturing economics and "Greener" road vehicles. The reasons behind turbochargers are becoming more popular in automobile applications. Our aim is to provide the techniques used in turbocharging to increase the engine output and reduce the exhaust emission levels.

Keywords: *Intercooler, IC engine, Turbocharger, Volumetric efficiency*

INTRODUCTION

A turbocharger is a device used to produce more power for an engine of a given size. A turbocharged engine is more powerful and efficient than aspirated engine because the turbine forces intake more air, fuel into the combustion chamber if the atmospheric pressure is only used. The device is to increase the volumetric efficiency of the combustion chamber. In the modern world, the various new technologies have been introduced in turbo charging of IC engine to increase the volumetric efficiency. These include inter-cooling of charged air before going into combustion chamber so that the mass flow rate will increase. The twin charging is the type of engine is boosted by a supercharger and then by turbocharger when the energy of exhaust gas is limited to rotate the blades of the turbine. The various technologies are discussed to increase the volumetric efficiency.

WORKING OF A TURBOCHARGER

Type: Forced induction system

Turbocharger compresses the air flowing into the engine system. Compressing the air is useful because it let the engine release more air into the cylinder, and more air and fuel can be added. By doing this, we can get more power from each explosion in the cylinder. A turbocharged engine produces more power than same engine without charging. This can improve the power to weight ratio for engine. If we want to achieve this boost, the turbocharger uses the exhaust flow from engine to spin a turbine, which in turn spins an air pump. The turbine in the turbocharger rotates at a speed of 150000 rotations / min (rpm), 30 times faster than car engines. It is hooked up to the exhaust, the temperatures in the turbine also very high.

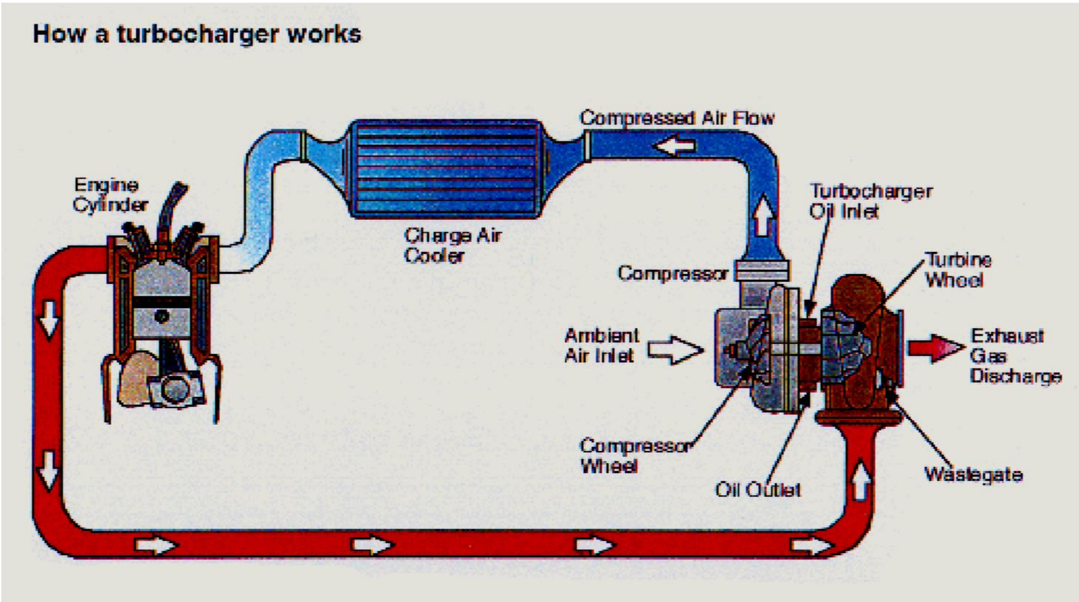

Fig 1: Working of turbocharger

LITERATURE SURVEY

The first functional engine supercharger made by Dugald clerk, who used it for 2-stroke engine in 1878. Gottlieb Daimler received a patent for supercharging an IC engine in 1885. Supercharger is a device which gives high density charge to the engine by compressing it to the compressor driven by engine. The problem in the supercharger is the loss of power used to drive the compressor from the engine output shaft. This can be 15% of output of engine. To avoid the loss of power, the compressor was driven by a turbine utilizing the energy of exhaust gases of the engine by passing through the turbine blades. Then this is the famous technology became popular as turbo charging in early 1980s.

From the earlier days, new technologies are introduced in turbo charging to improve its efficiency and these improvements are as follows:

J. Cheong [3] [2000] Power boosting technology of a High Speed Direct Injection (HSDI) Diesel engine without increasing the engine size had been developed along with the evolution of a fuel injection system and turbocharger. The Variable Geometry Turbocharger (VGT) with adjustable nozzle vanes together has increasingly used, especially for a passenger car in European market. This study describes the first part of experimental investigation that has been undertaken on the use of VGT, in order to improve the full load performance of a prototype 2.5lt Diesel engine, equipped with a common rail system and 4 valves per cylinder. The full load performance with VGT was compared with the case of mechanically controlled waste-gated turbocharger, so that the potential for a higher Brake Mean Effective Pressure (BMEP) is confirmed Compared with the waste-gated turbocharger, it is not possible to increase the boost pressure and a charge air flow rate with VGT at low engine speeds, enabling a higher torque, but also to reduce fuel consumption at higher engine speeds, due to lower pumping losses with full utilization of exhaust flow.

Panting [13] [2001] stated that turbo charging of internal combustion engines was an established technology used for the purpose of increasing both power density and in some cases the cycle efficiency of diesel engines relative to naturally aspirated engines. However, one significant drawback was the inability to match the characteristics of the turbocharger to the engine under full load and also to provide sufficiently good transient response. Under many conditions this results in the reduced efficiency and leads to higher exhaust emissions. The design of the turbocharger components should be compromised in order to minimize the drawbacks of the entire operating range. However, when the shaft power can be either added or subtracted from the turbocharger shaft by means of direct drive motor– generator, an additional degree of freedom is available to the designer to achieve a better turbocharger–engine matching. The author followed the results of a theoretical study on the benefits of hybrid turbocharging in a basic turbocharged engine in both steady state and transient operation. The new system developed and its benefits are described into four different engine – turbocharger systems was analysed in addition to baseline engine. The author concluded that motors were capable of reducing the response times of turbochargers. Resizing the turbine and re-optimizing the valve timing results in a constant increase in thermal efficiency, when an engine is not compounded. The relative improvement appears to be 10 percent.

Rakopoulos [4] [2004] developed a computer analysis for studying the energy and availability performance of the turbocharged diesel engine, operating under a transient load conditions. The availability terms for the diesel engine and its subsystems were analysed and the cylinder for open and closed parts of the cycle, inlet and exhaust manifolds, and turbocharger. The present analysis reveals multiple diagrams; however the available properties of the diesel engine and the subsystems develop during the evolution of the engine cycles, assessing the importance of each property.

Naser [5] [2009] concluded that efficient way which was used that time was to reduce the fuel consumption was based in reduction cylinder volume of internal combustion engine and power to be same or higher. Increased compressor outlet air pressure results in excessively hot intake charge, significantly reducing the performance gains of turbo charging due to decreased density. The intercoolers have a key role in controlling the cylinder combustion temperature in the turbocharged engine. The author, worked out programmed code in MATLAB presented the effect of intercooler (as a heat exchange device air-to-liquid with three different size and overall heat transfer coefficient in one base) at a multi-cylinder engine performance for operation at a constant speed of 1600 rpm. He concluded that the maximum temperature in engine cylinder and decreasing from 1665.6 K at SU =1000 to 1659.2k. Sometimes engine power and volumetric efficiency also increased.

Eyub [6] [2010] concluded that there were three main problems in automotive applications that cause environmental effect, cost and comfort problems. Therefore, internal combustion engines are required to high specific power output but also to release less pollutant emissions. For those reasons, the time light and the medium duty engines are highly turbocharged because of the negative environmental effects of internal combustion engines. Due to the facts, there are studies going on to improve the internal combustion engine performance. The supercharging system is also included in this range and air with high temperature cause detonation at spark ignition engines. Various methods are developed to cool down the charge air which was heated during supercharging process. Additionally, the denser air helps to reduce the chances of knock. The inter-cooling concept was introduced and the performance increase of a vehicle is by adding inter-cooling process to a conventional supercharging system in diesel or petrol engine. Pressure drops, air density and engine revolution are used as input parameters to calculate the variation of the engine power output. Also, it is possible to downsizing opportunities of the cylinder volume is presented. It was found that the engine power output is increased by 154%.

Abdullah [7] [2010] concluded that fuel economy and thermal efficiency is mostly important to all IC engines. Efficiency can be increased with cooled air by using of intercooler. The experimental researches are quite expensive and time consuming. In the last decades, Neural Networks (NN) had been used increasingly in a variety of engineering applications. The objective of the study was to investigate the adequacy of neural networks (NN) as a quicker, more secure and more robust method to determine the effects of inter-cooling on performance of a turbocharged diesel engine’s specific fuel consumption. The data was obtained from experimental research that was performed by the author. NN based model was developed trained and tested through a based MATLAB program by using of these data.

Yashvir [8] [2011] aimed at the work to increase the torque and power of the two wheeler by supercharging the vehicle. For this LML freedom 125 cc was analysed for the work and certain parameters like torque, power, and specific fuel consumption vs rpm were calculated. The data calculated was used in the software engine analyser for analysis purpose with the data of supercharger. It can be seen that the power and torque of the engine increases 7 to 12 KW and 9 to 14 NM at 7600 and 9000 rpm.

Wladyslaw [9] [2011] studied that the main problem in charged spark ignition engine was control of air-fuel ratio near stoichiometric values at different boost pressure in order to obtain higher torque at the same level of specific fuel consumption and exhaust gas emission. Charging of engine was connected with the problem of knock in the medium and high values of load at low engine speeds. High voltage of knock signal was given to the electronic control unit (ECU), where it is transformed by fast Fourier transform (FFT) procedure, which gave a distribution of knock signal in the range 2000-8000 Hz. Control signal from "knock" was obtained in the range 0 – 0.01 V and it is transferred to the control unit for regulation of mass flow rate of exhaust gases into the turbine by VGT and WG. When the output signal from FFT was greater than 0.01 V, then the valve in WG was opened much more in order to reduce mass flow rate of exhaust gases through the turbine, which will decrease rotational speed of the turbocharger and decreases the pressure ratio behind the compressor.

Kusztelan [10] [2012] In this study, one-dimensional analysis using AVL Boost software had been carried out on a series of compression and spark ignition engines utilizing a manufacturer fitted single-entry turbocharger and a modified twin-entry variety, the latter adopting two turbine housing inlet ports. The model reconstruction by using AVL Boost parameters that accurately represent the physical engine conditions includes manifold geometry, turbocharger flow maps and combustion chamber characteristics. The engine performance comparisons between single and twin entry turbochargers in terms of torque, shaft speed and compressor efficiency and at low engine speed conditions in a range of 1000-2500 rpm. It was found that on average engine response has been increased by 27.65%, 5.5%, 5.5% in terms of turbine shaft speed, engine power and torque respectively, which improves "drivability" of the vehicle. The study reveals that potential benefits of adopting a twin-entry turbocharger and the findings are useful for both industry and academic communities.

Vishal [13] [2012] examined the current and the future trends in the development of gasoline direct injection engine and attempts at identifying the turbocharger requirements for such systems. Predicted engine performance data from the various reputable published sources used to identify the air flow requirements. The software used is a steady state energy balance between the required compressor work and turbine work. The findings of the simulation and the turbocharger matching are subsequently analysed. From the analysis of the simulation, it can be deduced that the turbocharging of the GDI engine offer considerable challenges to the air handling system. The control mechanism of the switch from the low speed turbocharger to the high speed needs to be calibrated and ensure the transition and there is no loss of boost pressure and loss of torque.

CONCLUSION

From this literature survey, it is concluded that last two decades of various attempts were made to improve the power output of an engine and to reduce its emissions by making some changes and installing some of the additional accessories like intercooler in the turbocharging technology. This will carry the future because in coming days there will be increase in the demand of fuel efficient engines with more power and minimum emissions and this will be possible with some advancements in turbocharging technology.

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