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Study the Effect of Variable Geometry Turbocharger (VGT) On Diesel Engine

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ABSTRACT: Power boosting technology of the diesel engine without increase in size of the engine has been developed with the evolution of the turbocharger which forces more air in the engine which increases more fuel injection and hence more power output. The turbocharger increases engine efficiency by using the energy of exhaust gases to drive the compressor. Most of the turbocharger previously used was of waste-gate type having drawbacks like volumetric efficiency limit, fix geometry. Hence the Variable Geometry Turbocharger (VGT) is used. The variable geometry (VG) turbocharger is the technique that not only improves engine efficiency and fuel consumption, but also satisfies emission regulations.

KEYWORDS: VGT, Diesel Engine, volumetric efficiency, Engine Performance, A/F Ratio

I. INTRODUCTION

As the world's largest economies focus on reducing greenhouse gases (GHG), energy efficiency and it is ideally placed to help meet the most pressing challenge of making our planet a cleaner and better place to live and work. A turbocharger can meet these challenges. Turbochargers used to increase engine output by forcing more air into the engine via the turbocharger's compressor, more fuel can be injected into the engine thus increasing its output. Variable-geometry turbochargers (VGTs) are usually designed to allow the effective aspect ratio (A: R) of the turbo to be altered as conditions change. This is done because optimum aspect ratio at low engine speeds is different from that at high engine speeds. If the aspect ratio is too large, the turbo will fail to create boost at low speeds; if the aspect ratio is too small, the turbo will choke the engine at high speeds, leading to high exhaust manifold pressures, high pumping losses, and ultimately lower power output. By altering the geometry of the turbine housing as the engine accelerates, the turbo's aspect ratio can be maintained at its optimum. Because of this, VGTs have a minimum amount of lag, have a low boost threshold, and are very efficient at higher engine speeds. VGTs do not require a waste gate. VGTs tend to be much more common on diesel engines as the lower exhaust temperature mean they are less prone to failure.

II. DRAWBACKS OF TRADITIONAL TURBOCHARGER

1. Fixed geometry.
2. Designed as A/R ratio is always constant.
3. Smaller A/R ratio results into higher exhaust manifold pressures, lower pumping efficiencies, higher pumping losses and thus lower power output.
4. A larger A/R ratio will create boost at higher engine speeds, and thus create more power, but it will fail to generate boost at lower engine speeds.
5. A turbo having larger aspect ratio will have a longer lag time than a smaller A/R ratio turbo.

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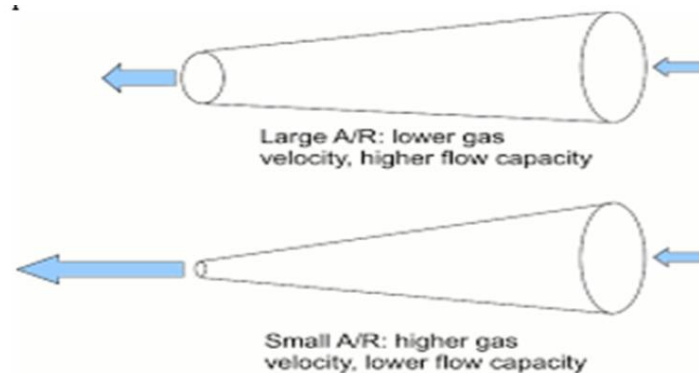


Fig.1. Effect of A/R ratio on speed and flow.

The above figure shows the effect of A/F ratio on speed and flow. If A/F ratio is larger then it creates lower gas velocity and higher flow capacity. If A/F ratio is smaller then it creates higher gas velocity and lower flow capacity.

III.NEED FOR VARIABLE GEOMETRY TURBOCHARGER

Conventional turbochargers have only limited improvement. Charging effect of a conventional turbocharger is too poor in a low flow range. VGT provides the solution for these problems. The VGT has a mechanism by which the inlet area can be varied to obtain the required A/R ratio for a given flow rate by varying positions of a set of aerodynamic guide vanes which direct the exhaust gas flow onto the turbine wheel. Using this variability, turbine of turbocharger can work under virtually all engine speeds.

IV.VGT PARTS AND THEIR FUNCTION

1. Turbine

It is the main part of the turbocharger. The turbine is driven by exhaust gases. The turbine wheels are continuously in the contact with the high speed gases. Therefore the turbine must be of high alloy steel and low in weight to reduce the inertia of the wheel so that it can move freely.



Fig.2. Turbine.

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2. Compressor

It is connected to the turbines by the shaft. As the turbine rotates compressor also rotates and Compressor forces air having more temperature than the ambient temperature. Therefore it creates high pressure on the compressor wheels.



Fig.3. Compressor

3. Bearing shaft system, Actuator, flow control valves and speed sensors are also very important parts in the VGT. They are useful in changing the vane angle of the turbocharger as per the speed of the engine.

V. OPERATION OF VARIABLE GEOMETRY TURBOCHARGER

A turbocharger equipped with Variable Turbine Geometry has little movable vanes which can direct exhaust flow onto the turbine blades. The vane angles are adjusted via an actuator. The angle of the vanes varies throughout the engine RPM range to optimize turbine behaviour.



Fig.4. Vanes Open

Above figure shows that how the vanes look when they are opened. According to engine speed the vanes are opened.

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Fig.5. Vanes Closed

Above figure shows that how the vanes look when they are closed, depending on engine RPM the vanes of VGT Closed

VI. BENEFITS OF VARIABLE GEOMETRY TURBOCHARGER

1. No throttling loss of the waste gate valve.
2. Higher air-fuel ratio, higher peak torque at low engine speeds.
3. A better ability to cover a wider region of low BSFC in the engine speed-load domain.
4. Ability to provide engine braking.
5. Ability to raise exhaust temperature for after treatment system management.

VII. LITERATURE REVIEW

In 1938, The Swiss Company, Saurer brought the first turbocharged commercial diesel engine in the market. In 1950s, the idea of using a variable geometry turbine was discovered. From that day, various new technologies are introduced in turbocharging to improve its efficiency.

J. Cheong et al [1] 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.

Zoran Filipi et al [2] in this work, he responds to the need to study system-level aspects of the use of VGT on modern diesel engines utilizing a virtual vehicle simulation environment. The objective is to develop a new methodology capable of modelling a variable geometry turbine, and appropriate for integration within a fully featured engine-in-vehicle system.

Srinivasan. C1 et al [3] the purpose behind this study of variable geometry turbocharger is to overcome the fundamental drawback of the internal combustion engine, its volumetric efficiency limit. Here, The VGT with no waste

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gate increase the volumetric efficiency and simultaneously increasing the expansion ratio, power output, Output Torque and to get the increased results on an IC Engine.

Amey Dahad et .Al [4]This study describes the improved full load performance of 2.5 liter DI diesel engine and its comparison with the waste-gated turbocharger and how VGT increases expansion ratio, output power, output torque.

1Akshay Pawar et .Al [5] concluded that Because of the Variable Geometry Turbochargers, it is possible to increase the charge air mass by about 10% to 20 % at a low speed range. As a result of this, the exhaust smoke is reduced and the fuel consumption is improved with the same fuel delivery and start timing of injection.

VIII.CONCLUSION

Because of the VGT, it is possible to increase the charge air mass by about 10% to 20 % at a low speed range. When the boost pressure is increased and also the fuel delivery is increased, more torque can be obtained. The application of VGT could provide HSDI Diesel engines with a great potential for full load performance, especially at low engine speed. Future scope in the VGT is in the use of the light weight material for the turbine and the compressor so that it can handle more temperature and more pressure so that it can used for the gasoline engines. Research should be carried out to reduce the size of the turbocharger.

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