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A Review on Difference between Turbocharger and Supercharger and Effect of Supercharger on IC Engine Performance over Turbochargers

[1]V. Satyendra, [2]A. Lakshumu Naidu

[1]Student, GMR IT, Mech Department, Rajam, India.
[2]Assistant Professor, GMR IT, Mech Department, Rajam, India

ABSTRACT –

This paper aims that the comparison between the turbocharger and the super charger and the effect the Pressure Wave Supercharger (PWS) in both theoretical and practical using the engine simulation software AVL Boost, version 2010.grahps were extracted using AVL(Aerodynamics and extended vortex lattice) Impress and implementation of PWS in Hydrogen fueled engine, it also has more demand in due to does not have any carbon products and Supercharger is used to boosts the power and having lower energy losses. In general, practical engines are always compromised by trade-offs between different properties such as efficiency, weight, power, heat, response, exhaust emissions, or noise. Ethanol is that it can be manufactured from natural products or waste materials, compared with gasoline, which is produced from non-renewable natural resources. Methods like the use of supercharger in I.C. Engine supercharger to increase the air intake. Miller cycle makes the expansion ratio larger than effective compression ratio by early or late closing intake valves thereby improving the thermal efficiency. So, all these are discussed by the in this paper.

Keywords – IC Engine, Pressure Wave Supercharger, Turbocharger, Inlet Air, Exhaust Temperature.

I. INTRODUCTION

In the automobile sector every engineer always should be trying to improve the efficiency of the IC engines along with that they are trying to decrease the exhaust emissions and for this purpose they are still lots of experiment are conducting and has led to research intensifications in terms of combustion improvement and geometrical optimization. The parameters which are influencing the performance of the IC engine is the volume of the intake air and the exhaust gas temperature, for this purpose they are introducing the turbochargers, the common element which are using to improve the engine performance and these are compresses the intake air and increase the mass flow rate and density through the inlet Port by utilizing the exhaust gas energy, but these turbochargers have some disadvantages like Turbo lag and overheating, so finally they are introducing the superchargers.

The main to classification of the superchargers are:

1) Positive displacement supercharger

a) Roots

b) Vane

c) Rotary

2) Dynamic superchargers

a) Centrifugal

b) Axial

c) **PWS**

The Pressure-Wave supercharger (PWS) is giving the best results when it is installed to the IC engine among all the superchargers and the turbochargers. the world is zeroing in on a successful use of

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II. Turbocharging: -

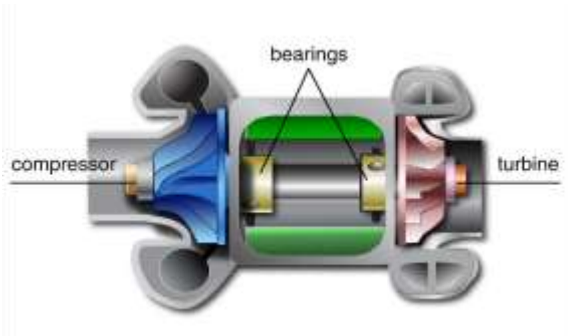

Fig .1. Turbocharger

A compressor is powered with an exhaust turbine using energy from the exhaust gases, such that the engine is only fluidically connected to the turbocharger. The exhaust gas of the internal combustion engine flows through the exhaust manifold to the turbine and spins it. A compressor sitting on the shaft of the turbine, can convert the drive power of the turbine into compressing power itself compresses fresh air, raises its temperature, which must be cooled by an intercooler. Via the manifold, the compressed air enters the engine. In the case of highly unsteady applications the power of the turbine should be controlled.

III. Supercharging and solutions

Supercharger compresses the intake gas, forcing more air into the engine in order to produce more power for a given displacement. Superchargers and turbochargers are compressors mounted in the intake system and used to raise the pressure of the incoming air. This results in more air and fuel entering each cylinder during each cycle. This added air and fuel creates more power during combustion, and the net power

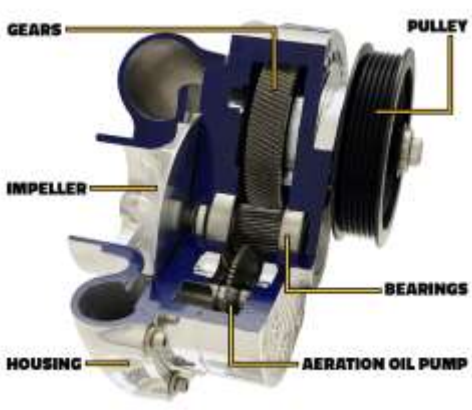

Fig.2. Supercharger

Output of the engine is increased .The internal combustion engines (ICE) can be supercharged in various ways, but he most common way to do this is to use a turbocharger .A very rare type of supercharger ,but pretty promising ,is the pressure wave supercharger and used to raise the pressure of the incoming air .This results in more air and fuel entering each cylinder during each cycle .This added air and fuel creates more power during combustion, and the net power output of the engine is increased.

We already know that the IC combustion products contain the carbon contaminants and other elements which causes the global warming, but IC engines play major role in transporting due to its high-power density and hydrogen cells doesn't have that contaminants caused by the global warming and nearly zero emissions. A Miller engine with variable compression ratio proved to be much more efficient than the Otto engine for most of the working range, and compared with the Diesel engine. When the intake valve closes before BDC, the mass in the cylinder expands with the descent of piston and the in-cylinder temperature decreases. It can be seen from the knock model proposed by Douaund & Eyzat [15] that temperature plays a significant role in the occurrence of knock and hence, Miller cycle has better anti-knock properties than Otto cycle. A study conducted by Wan [18] showed that combining over-expanded cycle with high geometry CR, LIVC can optimize combustion phasing and reduce knock tendency of gasoline engines. The decrease of in-cylinder temperature can restrain the formation of NOx. Wang [19] carried out a study on the application of the Miller cycle to reduce NOx emissions from a petrol engine. The results showed that the lowest reduction rate of NOx emission is 46% with an engine power loss of 13% at full load compared with that of standard Otto cycle. A slight mixture enrichment and spark advance regulation allow to keep also NOx emissions at acceptable levels. For the same reason, gaseous fuels allow higher compression ratios even in super- charged configuration, resulting in increased engine efficiency and power density .The naturally aspirated SI engine, a fuel mixture with a gas mass percentage of about 30% produced the maximum torque, while a mass concentration of 50% allowed to obtain the best engine efficiency .The addition of gaseous fuel (LPG or NG) to gasoline is particularly easy to implement in bi-fuel engines, where a double injection system is already available and a simple software modification of the electronic control unit (ECU) is required to inject both gasoline and gaseous fuel within the same engine cycle. The simultaneous combustion of gaseous fuel and gasoline has been named double fuel (DF), being quite different from the well-known dual fuel combustion, in which, instead, the auto-ignition of a small quantity of one of the two fuels (the most reactive) ignites the flame propagation combustion of the second fuel.

IV. Pressure wave supercharger

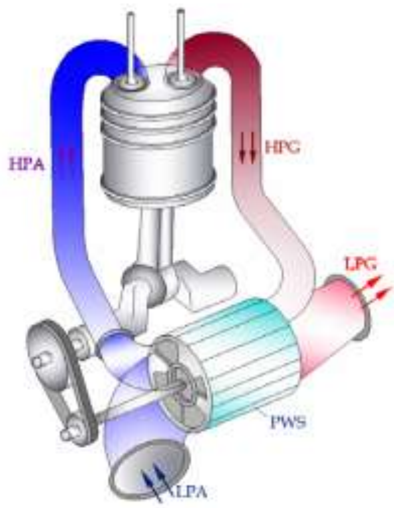

Fig.3. Pressure Wave supercharger

(PWS) utilizes exhaust gas to build up air pressure like classic turbo charging. If two fluids (Inlet & Exhaust) having different pressures are brought into contact, equalization of pressure occurs faster than fluid mixing exhaust gas directly during one phase of the cycle. As the rotor makes one revolution, the ends of each cell are alternating either nearly hermetically closed or widely open toward the passages of the casings. These alternative open and close of cells result in serial shock waves, compression waves and expansion waves, e air. The shock wave moves much faster than the gases. The compression waves build up the pressure. The expansion waves cause the exhaust gas pressure to go down hence there is no so-called 'turbo lag' this unique direct contact may also cause internal exhaust gas recirculation (EGR) usefully for reducing the NOx emission.

V. MATERIALS AND METHODS: -

The process of theoretical of the AVL compress Analysis process by using formulae

Volumetric efficiency:

$\eta_v = \frac{2 \cdot m^{\cdot} a}{\rho a . Vh . N}$

ma - mass flow introduced into the engine

ρa - air density

N - engine speed

V_{ah} - engine displacement

Flow velocity:

$v_{ps} = \frac{1}{Am} \cdot \frac{dV}{d\theta} = \frac{\pi \cdot B2}{4 \cdot Am} \cdot \frac{ds}{d\theta}$

- V - cylinder volume
- B - cylinder bore
- S - distance between crank axis and wrist pin
- Am - valve area

Equivalence ratio:

$\varphi = \frac{\left(\frac{A}{F}\right) actual}{-\left(\frac{A}{F}\right) theoretical}$

- A/F - Air-fuel ratio

Intake mass speed:

$P_{atm} - P_c = \sum P_{j\,=}\, \rho_a \cdot s_p^2 \sum p_j \cdot \left(\frac{Ap}{Aj}\right)^2$

- p_{atm} - atmospheric pressure
- Pc - cylinder pressure
- Sp - mean piston speed
- Ap - piston area
- Aj - component minimum flow area
- ΔPj - total quasi steady pressure loss

Mass flow rate:

$\frac{dm}{dt} = A_{eff} \cdot p_{0I} \cdot \sqrt{\frac{2 \cdot \psi}{R0\ T0I}}$

- A - effective flow area
- p0I - port upstream static pressure
- T0I - port upstream static temperature
- R0 - gas constant

Combustion model:

$\frac{dx}{da} = \frac{a}{\Delta\alpha c} \cdot (m + 1) \cdot ym \cdot e^{-a \cdot y \cdot (m+1)}$

- Q -total heat amount received

- α rank angle degree
- α0 corresponding angle for beginning of combustion
- Δαc combustion duration
- m form coefficient
- A 6.9, vibe coefficient

To explore the combustion characteristics of the supercharger in hydrogen engines, a 2.4 L N/A SI engine (Theta, Hyundai Motor Company) was modified to operate with hydrogen by using natural gas fuel injectors (NGI2, Bosch)

A ROTREX C18 compressor was installed to enable higher supercharging pressures

VI. Different methods of improving Engine Performance

The various methods which can be employed for improvement of performance of an engine are:

1. Increasing speed of the engine,

2. Use of higher compression ratio,

3. Utilization of exhaust gas energy,

4. Use of two stroke cycle.

5. Improving volumetric efficiency of the engine,

6.Increasing the charge density.

Objectives of super charging

It is preferred to fulfill the following requirements:

I To overcome effect of high attitudes

II To reduce the weight of engine per kW

III To reduce the size of the engine to fit into limited space

IV To increase the power of an existing when the greater power demand occurs.

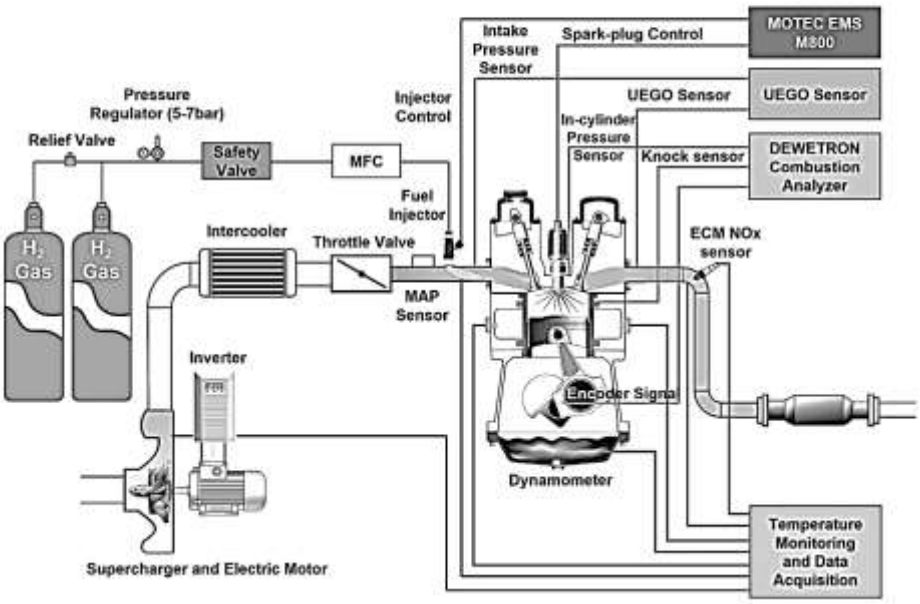

Fig.4. supercharger employed with hydrogen engine

Measuring range, accuracy, and uncertainty of measuring devices.			
Parameter and analyzer	**Measuring range**	**Specification**	**Uncertainty**
Load cell and torque	0-1200 Nm	±0.25% of full scale	±1.7 Nm (±95% confidence level, k ¼ 2)
High-performance pressure transducer	0-0.3 MPa (absolute)	±0.25% of full scale	±0.0004 MPa (±95% confidence level, k ¼ 2)
Wide band oxygen sensor	0.8 - 80	±4.2% of full scale	±0.05 (±95% confidence level, k ¼ 2)
Mass flow meter	0 - 240 kg/h	±0.1% of full scale	±0.02 kg/h (±95% confidence level, k ¼ 2)
In cylinder high-performance transducer	0 – 20 MPa	±0.5% of full scale	±0.06 MPa (±95% confidence level, k ¼ 2)
Thermocouple	-200 - 1250 C	±0.75% of full scale	±2.2 C (±95% confidence level, k ¼ 2)
NOx emission sensor	0 - 5000 ppm	±3% of full scale	±30 ppm (±95% confidence level, k ¼ 2)

Parameters for Miller cycle engine Test: -

Main parameters of the original engine.	
Type	Gasoline, 4 stroke, 4 cylinders in line
Bore/Stroke	86/86 mm
Displacement	2.0 L
Connecting rod length	142.8 mm
Compression ratio	10
Bore/Stroke	86/86 mm

Experimental Setup for Economy Test and Efficiency Test: -

SI engine specifications	
Number of cylinders	4
Displacement (cc)	1242
Bore (mm)	70.80
Stroke (mm)	78.86
Compression ratio	9.8
Rod to crank ratio	3.27
Intake valve/cylinder	1
Exhaust valve/cylinder	1
Gasoline injection system	PFI, Bosch EV6
NG injection system	PFI, Bosch EV1

CONCLUSION

Pressure wave supercharged engine also it is more expensive due to integration of VVT. The pressure wave supercharged engine is a little bit heavier than the turbocharged one, but overall has a better weight/power ratio.

- Output Power of hydrogen internal combustion engine with supercharger is improved by 10% on average 28% is the highest when compared to the turbocharger boosting engine.
- The NOx emissions, the measured data of this study was lower than the previous finding which turbo-charged system was used.
- Brake power increases about 2-5% with rpm using ethanol blend supercharged engine.

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