

Analysis of Five Stroke Internal Combustion Engine - A Review

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ABSTRACT: In Today's world development of automobile technology is boom to the world, in that increasing the engine performance lead a major role in it. Therefore in order to improve the efficiency of an engine different types of material and techniques are used to improve the performance. In this paper a new design of an IC engine is presented which has better characteristic features than its predecessors and can add up to technological advancements in the field. Technically, the concept is to add one more stroke in a classical four stroke cycle in order to extract more work. The four stroke engine exhaust gases at high temperatures having energy which could be used further to extract more work. With this concept of extracting more work, a new design is made with the ultimate target of increased efficiency and decreased structural weight. It is found that, addition of one more stroke in a four-stroke IC engine results in increase of expansion ratio and thermal efficiency. It is made possible with the help of an extended expansion stroke which is carried out in a low pressure cylinder which has larger volume compared to the two high pressure cylinders. The extended stroke helps in producing more power output and torque, consuming less amount of fuel-mixture and hence making it more efficient. The 5 stroke engine which has an additional exhaust gas energy recovery is very interesting from a research point of view.

KEYWORDS: Five-stroke, thermodynamic efficiency, lower emissions, higher ratings, lighter structure

I. INTRODUCTION

The four stroke cycle has expansion and compression ratios which are almost identical and in order to make an engine more efficient we require higher expansion ratios² and lower compression ratios so as to limit the stresses due to mechanical and thermal factors. In order to make a better and efficient IC engine these limitations should be overcome and this was made possible with the help of introduction of a new cycle or a fifth stroke, also called as the recycle³ stroke in the existing four stroke cycle. The higher expansion ratios² help in extracting more and more thermal energy to convert into mechanical energy and lower compression ratios provides a mammoth range of load pressures. The creative and innovative concept of having dual expansion cycles has made possible to develop an engine with high efficiency and large power range extenders which gives lower heat emissions and harmful gases. The engine generates the power output by the help of five strokes which are injection, compression, power, extended expansion (recycle stroke), exhaust³. The engine has two high pressure⁴ (HP) cylinders and one low pressure⁴ (LP) cylinder, the volume of the low pressure cylinder is almost double¹ of that of the high pressure cylinder. The two high pressure compact cylinders help in maintaining lower compression ratios and works on the principle of four stroke cycle. While the low pressure cylinder helps in extracting more work by an additional expansion stroke by taking the burnt fuel mixture from the high pressure cylinders which results in higher expansion ratios and lower temperature of the exhaust emissions. The construction details, working concept and principle and the technical advancements are then discussed in the paper which is followed by the applications and conclusions.

II. CONSTRUCTION DETAILS OF THE NEW CONCEPT ENGINE

The engine consists of three cylinders which are mounted on a single crankshaft which rotates with a predetermined configuration required for the movement of the cylinders during the different strokes at different instants of time. Due to the no real possibilities to build from the ground a prototype the five-stroke engine by the research team in the project's budget, it was decided to introduce far-reaching modifications to fit four-cylinder four-stroke engine so that it can realize the cycle with additional expansion of charge. A throughout modern four-stroke, four-cylinder turbocharged Audi SI engine with suffix BPG was selected as the object of undertaken task. The engine was donated for research purposes for Chair of Combustion Engines Institute of Automobiles and Internal Combustion Engines at Cracow University of technology by Volkswagen AG. The engine made in the four-valve technology has a displacement of 1.984 dm³ and holds a maximum power of 147 kW drop-down in the rotational speed range of 5500 to 6000 rpm.

III. WORKING – CONCEPT AND OPERATING PRINCIPLE

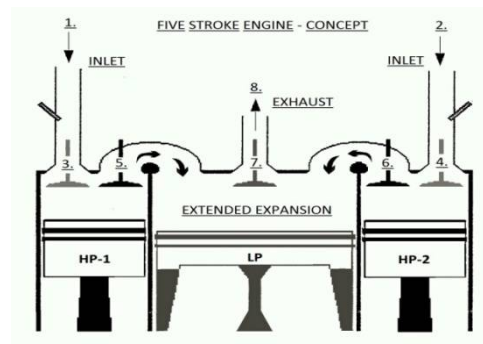


Figure 1: Five Stroke Engine Concept: HP; LP-low pressure cylinder; 1, 2- intake channel; 3, 4-inlet valves for the two HP cylinders; 5, 6-exhaust valves into LP cylinder; 7-exhaust valve; 8-exhaust channel

As shown in figure 4 the five stroke engine works with the concept of two high pressure cylinders working in a four stroke cycle and a low pressure cylinder in an alternate cycle to give the power output. The reduction in many components due to limiting the number of cylinders to three on the single shaft, the weight of the engine is reduced significantly and leads to a more compact yet efficient engine. The first stroke comprises of the direct injection of the air-fuel mixture into one of the high pressure cylinder [HP-1] through the inlet channel [1] when the piston is initially at the TDC and the inlet valve [3] is opened, the injection causes longitudinal piston movement and it further moves to the BDC and intake the fuel mixture and further expansion takes place. The piston is then again moved to the TDC to a predetermined distance³ in order to complete the compression stroke which helps in compressing the fuel mixture at the high pressure which is required for the effective burning of the fuel, both valves [3],[5] being closed. After completing the compression stroke, the spark plug ignites the gasoline mixture which is already at a very high pressure and this result into an explosion due to which the piston moves to the BDC and this stroke of burning of the fuel mixture is called as the power stroke. When the mixture is burned, the piston movement takes place and it moves to TDC and the exhaust valve [5] is opened in order to exhaust the burnt mixture. This burnt mixture is taken into a low pressure cylinder [LP] which extracts more heat from the vapors exhausted at very high temperatures from the high pressure cylinder [HP-1] by the help of another stroke which is called as an extended expansion stroke during which the exhaust valve [7] is closed and after completing one cycle the gases are exhausted to the atmosphere through the exhaust channel [8]. Another high pressure cylinder [HP-2] works in the similar manner but alternatively and the burnt mixture is exhausted to the low pressure cylinder [LP] in an alternative cycle. During the intake of the air-fuel mixture in the high pressure cylinder [HP-1], the process of power generation takes place in the second twin cylinder [HP-2] and the process continues vice versa. The low pressure cylinder [LP] consists of only two cycles which are extended expansion and then ultimate exhaust to the atmosphere. This effective process helps in generating a power output of 40kW¹ as the

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upper limit in the working range between 3500-4000 rpm¹ of the engine which is made possible by the high expansion ratio. The peak torque of 160Nm and a horsepower of over 185 per liter can be achieved by a 700cc three cylinder five stroke engine. It can deliver a brake power output of 32.5kW¹ at the working range of 4000rpm with a very low BSFC⁶ of 226g/kW-hr¹ with an overall efficiency of 36.1%¹. The engine delivers a high power density and can deliver the same power output with the volume of 750cc as a 1200cc classical four stroke internal combustion engine could deliver which makes high power density⁵ generation in more compact size and hence it results in the reduction of the overall weight of the engine which can be up to 20% lighter.

IV. CONCLUSION

Engines .It has higher ratings and is 20% lighter has higher expansion ratios and is thermally efficient too. The overall fuel consumption is also decreased and the overall efficiency is increased by 36.1%. This new design can lead to difficulty in designing mass equilibrium due to the cylinders having different masses and needs a carefully designed cooling system because of increased heat loss density in the HP cylinders. The maintenance cost might be high because of requirement of skilled labor to operate the engine. Ultimately, it could be stated that this new concept of five stroke internal combustion engine can be adopted in the automobile industry .A further phase of the study concerned the analysis of operation under partial load and obtaining optimal settings of regulatory parameters .Due to the minimization of fuel consumption, another issue was to determine the emission of exhaust gas components such as carbon dioxide,carbon monoxide, unburned hydrocarbons and nitrogen oxide. The further stages of work on the five-stroke engine will be presented in subsequent publications finally it concluded that tech can be implemented in automobile technology and so that the utilization of unused burnt gases all reduced

This paper presents the new and validated technological development in the design for the internal combustion Stroke Seq.	Working Process in High Pressure Cylinder(HP-1)	Working Process in Low Pressure Cylinder(LP)	Working Process in High Pressure Cylinder(HP-2)
1.	intake of air-fuel mixture	exhaust to outer environment	power generation
2.	compression of the mixture	extended expansion extracting more work	exhaust to LP cylinder
3.	power generation	exhaust to outer environment	intake of air-fuel mixture
4.	exhaust to LP cylinder	extended expansion extracting more work	compression of the mixture
5.	intake of air-fuel mixture	exhaust to outer environment	power generation

REFERENCES

- [1] Alten, H., Illen, M., Schmitz, G., *Thermodynamische Untersuchung eines 4-Taktmotors mitnachexpansion*, Ilmor Engineering Report TD-103, 1999.
- [2] Basshuysen, R. van, Schaefer, F., *Internal Combustion Engine. Handbook, Basics, Components, Systems and Perspectives*, SAE International, Warrendale 2004.
- [3] Fröhn, U., et. al, *Boost to the Max*, Turbo News 01/2011, BorgWarner Turbo SystemsWorldwide Headquarters GmbH, Kirchheimbolanden 2011.
- [4] Postrzednik, S., mudka, Z., *Termodynamiczne oraz ekologiczne uwarunkowaniaeksploatacji tokowych silników spalinowych*, Wydawnictwo Politechniki skiej, Gliwice 2007.



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- [5] Randal, M., *Audi A4 Owners Workshop Manual. Jan 2005 to Feb 2008*, ISBN 978 1 84425885 7, Haynes Publishing, Sparkford 2010.
- [6] Rychter, T., Teodorczyk, A., *Teoria silników tokowych*, Wydawnictwa Komunikacji cznoci, Warszawa 2006.
- [7] Schmitz, G., *Five-stroke internal combustion engine*, United States Patent No. 6553977B2, 2003.
- [8] www.motortrivia.com/section-innovation/0012-ilmor/ilmor.html - accessed on 20.06.2013.
- [9] A. Kéromnès, B. Delaporte, G. Schmitz, L. Le Moyne. Development and validation of a 5 stroke engine for range extenders application. *Energy Conversion and Management*, 2014, 82, pp. 259–67.
- [10] Marcin Noga, Bronisław Sendyka. Determination of the theoretical and total efficiency of the five-stroke SI engine. *International Journal of Automotive Technology*, 26 November 2014, 15(7), pp. 1083-89.
- [11] Lennox G. Newman, Five stroke internal combustion engine, Patent US6776144B1, USA; Aug. 17, 2004.