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THE SCUDERI REVOLUTION: A REVIEW

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ABSTRACT

The IC engine has seen numerous modifications over the past few decades. The sole motto behind the modifications was to increase the overall efficiency of the IC Engine. Some recent technologies like the MPFI, CRDI, etc. in the Otto Cycle and Diesel Cycle engines have created a revolution in the automobile industry. In spite of these advances, the efficiencies are not being more than a particular limit. However, the concept of Split Cycle engines has drastically increased the overall performance. The split cycle basically separates the 4 strokes of the conventional cycle. The Scuderi Engine one of the best engines made based on the Split Cycle concept. The Scuderi Engine works on the Split Cycle and gives more efficient output than the conventional IC engines. It also eliminates the problems faced by other engines based on the Split Cycle. Scuderi Engines have one most important advantage over all the other engines and that is the Design Flexibility. This paper throws light on all the points mentioned above and some more of the key points related to the Scuderi Engines.

Keywords: Air Hybrid, Crossover Passage, High Thermal Efficiency, Scuderi Engine, Split Cycle.

I. INTRODUCTION

A Split Cycle Engine is an engine that separates the four strokes of Intake, Compression, Power and Exhaust. This is achieved by using two separate but paired cylinders. The Scuderi Engine is an Engine based on the Split Cycle.

The two paired cylinders of the Scuderi Engine are named as the Compression Cylinder and the Power Cylinder. As the name suggests, the air is compressed into the Compression Cylinder and then it is sent to the Power Cylinder. The system through which the air is transferred to the Power Cylinder is known as Crossover Passage. The air is then mixed with fuel and the combustion takes places in the Power Cylinder.

II. HISTORY

The Scuderi engine was invented by Carmelo J. Scuderi. The Scuderi Engine was formally called the Scuderi Split Cycle Engine. Scuderi Group is an engineering and licensing company founded by Carmelo Scuderi's following generation. It is situated in West Springfield, Massachusetts. The first working prototype engine that was revealed by the Scuderi Group was in the year 2009 (The Company is currently working on the same) [1]. By mid August 2011, Scuderi Group had roughly around more than 476 patent applications worldwide and more than 50 countries have issued around 150 plus applications as patents.

III. WORKING

The Scuderi Engine is an Engine based on the Split Cycle. It has two separate cylinders which are paired together for performing the conventional four strokes. The first cylinder, generally referred to as Compression Cylinder, performs the task of taking the air inlet and compressing it. The compressed air charge is then sent to the other cylinder by a passage known as the Crossover Passage. The other cylinder, generally called the Power Cylinder, serves the purpose of the Power Stroke and the Exhaust [2].

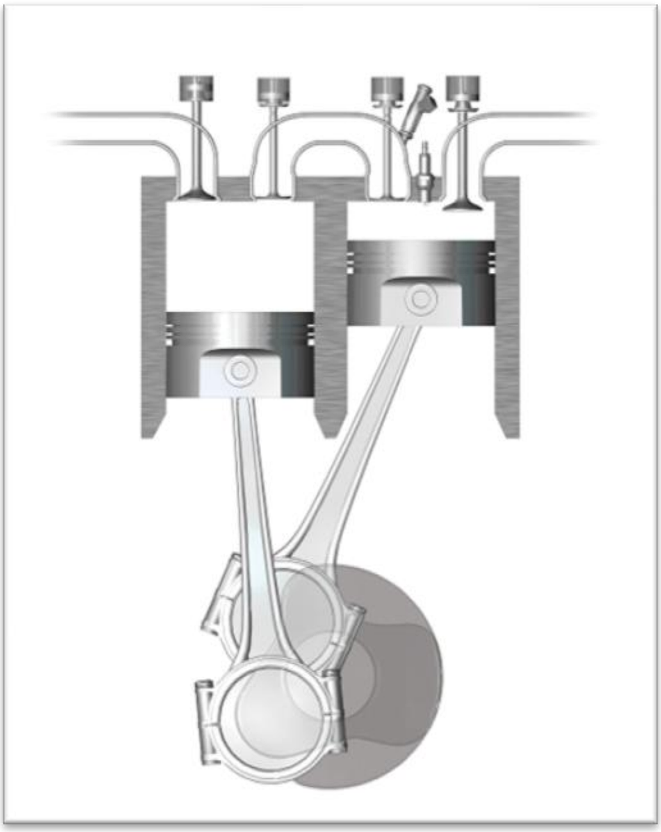

Fig. 1 Cut Section of Scuderi Engine

Other split Cycle engines were designed but they failed to match the efficiency of the conventional IC Engines. This was because of the two predominant reasons viz. Breathing Problems and Low Thermal Efficiency. The Breathing Problems were caused due to the high pressure gases trapped in the compression cylinder. The lower thermal efficiency on the other hand, was a result compressing the gas twice. These problems were overcome by the Scuderi Engine because of its unique and one of the most important concepts of firing After Top Dead Center (ATDC).

Generally, firing after the top dead center is avoided as it results is problems like knocking and detonation. But in Scuderi Engines, the firing after top dead center eliminates the losses arising due to recompressing the gas. But the main question is, How to Fire After Top Dead Center?

High pressured air in the transfer passage and higher turbulence in the Power Cylinder is the answer. This results in a Split Cycle engine with a greater efficiency and better performance than a conventional IC Engine [3].

3.1 Energy Output of Scuderi Engines

To calculate the power output from the Scuderi Engine as a whole, the P-V characteristics of the Compression Cylinder and the Power Cylinder need to be studied individually.

3.1.1 P-V Characteristics of the Compression Cylinder

When the piston is at the Top Dead Center (TDC) during the intake stroke, the inlet valve of the compression cylinder opens allowing the air charge to enter into the cylinder. The volume in the cylinder starts increasing as the piston starts travelling from its TDC to BDC (Bottom Dead Center).

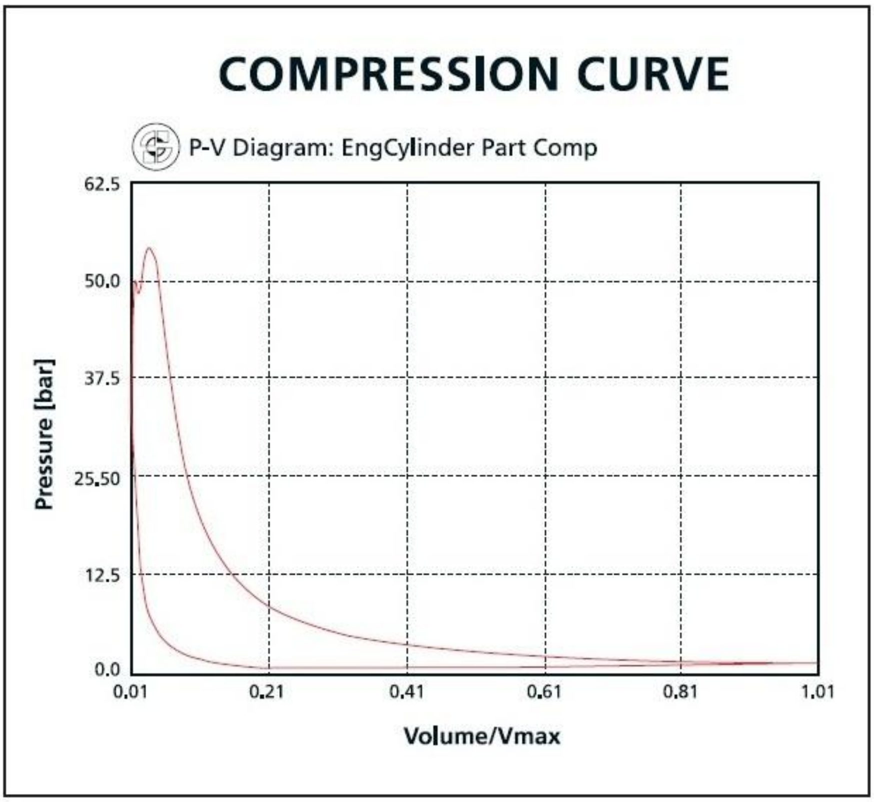

Fig. 2 P-V Curve for Compression Cylinder

The air entering during this travel of the cylinder is at atmospheric pressure (low pressure). When the piston reaches BDC, the inlet valve closes. When the piston starts its travel from the BDC to the TDC, the air entrapped in the volume of the cylinder starts compressing as the volume in the cylinder decreases and there is a pressure rise in the cylinder. When the pressure in the cylinder is high enough (say 50bar), the crossover inlet valve opens and the pressurized air is then transferred to the crossover passage. The inlet valve then opens when the piston reaches TDC and the pressure instantaneously reduces to atmospheric pressure. As the pressure is now atmospheric, the initial process repeats. The graphical representation of this process is plotted on a P-V graph, as shown in figure.

3.1.2 P-V Characteristics of the Power Cylinder

When the power piston is almost at TDC, the crossover valve opens. High pressure air thus enters the power cylinder through the crossover passage. Now the power piston begins its downward travel which is the Power Stroke. During this stage, fuel is injected into the power cylinder and combustion initiates after power piston has displaced by around 10° to 15° form the TDC.

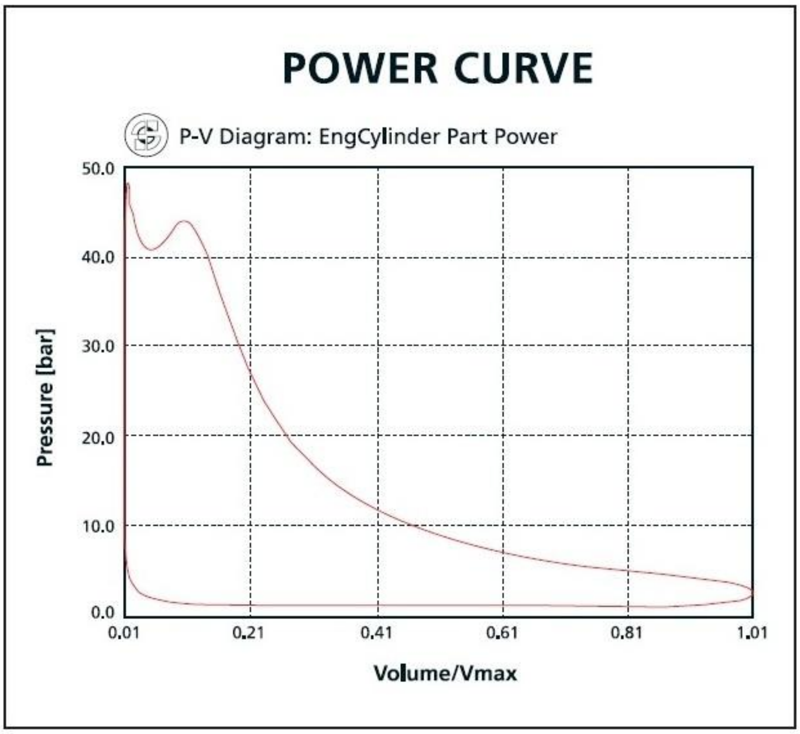

Fig. 3 P-V Curve for Power Cylinder

After this, the crossover outlet valve closes and the pressure in the power cylinder increases even though the volume is also increasing. The downward movement of the piston continues and the volume is constantly increasing with the pressure starting to reduce. When the power piston reaches the BDC, the exhaust valve opens. The piston starts is return travel from BDC to TDC to push the exhaust gases out of the system. During this process, the pressure inside the cylinder is at atmospheric pressure. When the piston reaches TDC, all the exhaust gases are expelled out and the first process repeats.

The net energy thus produced by the Scuderi Engine is the difference between the two P-V Curves.

IV. THE CROSSOVER PASSAGE

To enable the compression piston to begin pushing air into the crossover passage as the crossover passage is moving air into the power cylinder; the compression piston and the power piston are so arranged on the crankshaft that the power piston leads the compression piston by about 20°. At any given time, the mass of air flowing in to the crossover passage is same as the mass of air flowing out of the crossover passage. Due to this, the air pulled into the engine during the suction stroke is not the same air used in combustion during that cycle of the engine. The air has to travel through the crossover passage to be used for combustion. This process enables the crossover passage to remain at relatively constant pressure. This results in a drastic reduction in the Pumping losses through the crossover passage.

V. THE AIR HYBRID SCUDERI ENGINE

The Air Hybrid design is a very simple and cost effective design and can be achieved by simply adding an air storage tank in the engine configuration.

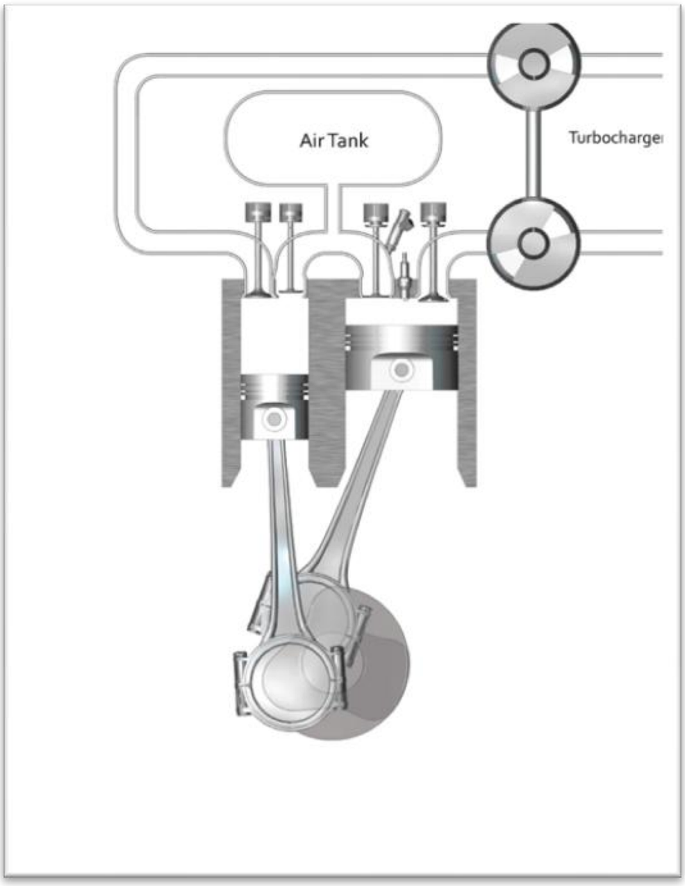

Fig. 4 An Air Hybrid Scuderi Engine with Turbocharger

The air tank is required to store and recapture the energy that is lost during the normal operation of the engine. The different ways in which the air hybrid can be used efficiently are discussed below:

- Normal running of the Scuderi engine: As the name indicates, the air hybrids can also be used for the normal operation of the Scuderi Engine.
- Regenerative Braking: In this, during the braking of or the idle running condition of the vehicle, the power cylinder is turned off and the contact between the vehicle and engine is maintained. The force obtained from stopping of the vehicle continues the running of the compression cylinder and the energy output received from it is stored into the air storage tank to utilize it for further use [4].
- High Efficiency Mode: In this mode, the compression cylinder is turned off. The pressurized air from the air storage tank is fed to the power cylinder for the operation. This eliminates the losses incurred during compression of air in the compression cylinder which in turn increases efficiency.
- Cruising Mode: In the mode, the engine operates as a normal engine. The charge from the compression cylinder is not completely utilized for the combustion process. Instead, partial charge from the compression cylinder is used to charge the air storage tank and the rest is used for combustion purpose. Whenever the tank becomes full, the compression cylinder is turned off and the vehicle operates in High Efficiency Mode.

VI. ADVANTAGES

- The Scuderi engine has many advantages over the conventional engines. One of the most important and key advantages of Scuderi engine is the design flexibility of the engine. Many of the features that are very difficult to implement or need additional equipments in a conventional engine can be easily achieved in a Scuderi Engine. For example, the Miller effect can be achieved by simply changing the length of the power cylinder; the piston friction can be easily reduced by giving an offset to the cylinders and the change in compression cylinder area gives a Supercharging effect.

- Due to the split cycle incorporated, the emissions from the Scuderi engines are much cleaner.
- Higher thermal efficiencies are achieved with the help of Scuderi Engines.
- Scuderi engines are compatible with additional devices like Turbochargers that in turn increase the overall efficiency.

VII. LIMITATIONS

- One of the most important limitations of the Scuderi engines is that the engines are still not used in practice. These engines are still to be incorporated in all the vehicles.
- The additional number of cylinder increases the cost of the engine.
- The additional cylinder also adds up to increase in frictional losses.
- The power density of the Scuderi Engines is same as that of the other Otto Cycle Engines. This is because of the compression cylinder.

VIII. FUTURE SCOPE

The concept being a patented and a revolutionary one, many of the automakers are turning towards this concept. Hence, it can be expected to have Scuderi Engine powered vehicles by leading automakers and on a large scale.

IX. CONCLUSION

From the above data, it can be concluded that the overall performance of the Scuderi Engines is on the higher side as compared to the conventional IC Engines. The Scuderi Engines lead the IC engines in overall terms of thermal efficiency, torque, work done per cycle, power output, etc. The area under the P-V curves is also greater than that of the conventional IC engines. Therefore, it can be concluded that the Scuderi Engines are overall more efficient than the conventional IC engines.

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