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Opoc Engine An Emerging Technology In I.C. Engine: Review

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Abstract: In this century, most of the fossil fuels like crude oil, natural gas and many petroleum products will become very scarce and costly. Day-to-day, fuel economy of engines is also getting increased. But as the efficiency of an engine is improved it gives rise to another problem which is emissions. Then to control the amount of emissions coming out of the IC engines a fuel is selected which produces fewer emissions after the combustion. Another problem which is faced while designing the IC engine is its bulky size and more energy consumption. Presently, the IC engines which are used in the market produced comparatively less power than which is expected from them. Also there is knocking effect due to improper combustion of fuel in combustion chambers. In this paper it is studied that by what means these problems can be overcome by the implementation of new technology in IC engines. An OPOC engine is one of the key for the today's need of higher power at lower consumption of fuel. It is comparatively much better than the other engines which are presently in the market or still in development phase. An OPOC engine is studied and compared with opposed piston engine on the basis of its performance. Various parts of the OPOC engine is being studied in detail. OPOC's working mechanism is elaborated in detail and compared with opposed piston engine.

Index Terms— OPOC engine, opposed piston engine, Turbocharger, Efficiency, Emissions.

1 INTRODUCTION

In last few decades lots of research has been done on IC engines so as to get the higher efficiency out of it. It can be noted that all these changed has very adverse effect on the environment. So the first diesel engine with opposed piston proto-type had been developed at the Kolomna plant in Russia. The designer Ramond A. Koreyvo on November 6, 1907 patented the engine in France and then displayed the engine at international exhibitions. After these demonstrations similar engines were produced by other companies. [1]

Opposed-Piston, Opposed-Cylinder Engine with Modular Displacement Capability EcoMotor's patented engine design creates a ground-breaking internal combustion engine family architecture that will operate on a number of different fuels, including gasoline, diesel, natural gas and ethanol. The OPOC's new opposed piston-opposed cylinder direct gas exchange operation provides the well known emissions benefits of 4-cycle engines, the simplicity benefits of 2cycle engines, the power density of the less well known opposed piston engine, and the extraordinary developments in electronics and combustion technology all tied together in a new and proprietary engine architecture.

The OPOC engine comprises two opposing cylinders per module, with a crankshaft between them -- each cylinder has two pistons moving in opposite directions. This innovative design configuration eliminates the cylinder-head and valve-train components of conventional engines, offering an efficient, compact and simple core engine structure. The result is an engine family that is lighter, more efficient and economical, with lower exhaust emissions.

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2 LITERATURE REVIEW

a. Professor Peter Hofbauer:

As chief powertrain engineer at Volkswagen in the 1970s, guided a company best known for flat-four "boxer" gasoline engines into a future of small, efficient inline Diesel engines. His basic idea was the essence of simplicity and mechanical elegance: an opposed-piston, opposed-cylinder (OPOC) 2-stroke engine that utilized no cylinder head, no camshafts, no valve train, and no stand-alone combustion chambers.

As Hofbauer put it, "In a conventional engine the pistons and connecting rods fight with the crankshaft; in the OPOC they dance together." This engine configuration is the basis for the ecomotors paradigm

– an alternative to today's traditional internal combustion engine.

b. Deutsche Kraftgas Gesellschaft:

Opposed piston engines using the two stroke cycle are known to have been made by Oechelhäuser as early as 1898, when a 600 hp 2-stroke gas engine was installed at the Hoerde ironworks. These engines were made by Deutsche Kraftgas Gesellschaft from 1899, and by other companies under licence including William Beardmore & Sons Ltd in the UK.[4]

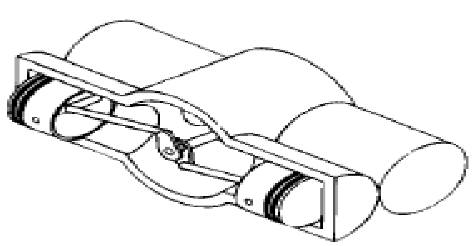
c. Gobron-Brillié:

Smaller versions of opposed piston engines suitable for motor vehicles probably begin with the French company Gobron-Brillié around 1900. In April 1904 a Gobron-Brillié car driven by Louis Rigolly and powered by the opposed piston engine was the first car ever to exceed 150km/h with a "World's Record Speed" of 152.5km/h[4] and on 17 July, again driven by Rigolly, the first to exceed 100 mph for the flying kilometer.[4]

d. Raymond Koreyvo:

The first opposed-piston diesel engines were developed in the beginning of the 20th century. In 1907, Russian Raymond Koreyvo, the engineer of Kolomna Works, built an opposed-piston two-stroke diesel with two crankshafts connected by gearing. Although Koreyvo patented his engine in France in November 1907, the management would not go on to manufacture opposed-piston engines.

2.1 HISTORY OF ENGINES



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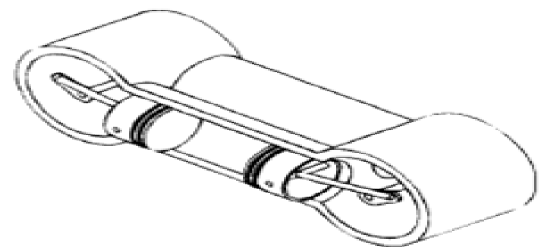

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Fig. 2 Construction of OPOC Engine

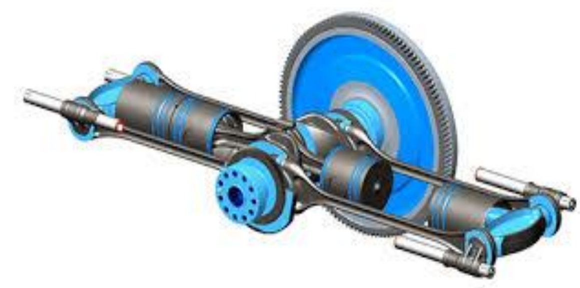

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Fig.1. Classification of engines by cylinder arrangements. (A) Opposed cylinder engine, (B) Opposed Piston Engine, (C) Opposed Piston Opposed Cylinder Engine

Opposed Cylinder Engine: Two banks of cylinders opposite each other on a single crankshaft (a V engine with a 180^{o}V). These are common on small aircraft and some automobiles with an even number of cylinders from two to eight or more. These engines are often called flat engines (e.g. flat four).

Opposed Piston Engine: Two pistons in each cylinder with the combustion chamber that the center between the pistons. A single-combustion process causes two power strokes at the same time with each piston being pushed away from the center and delivering power to a separate crankshaft at each end of the cylinder. Engine output is either on two rotating crankshafts or on one crankshaft incorporating complex mechanical linkage.

Opposed Piston Opposed Cylinder Engine: There are two cylinders oppositely placed in the OPOC engine along with the four pistons two in each cylinder and connected with the light weighted brackets. Engine output is much more than that of the above mentioned two engines.

3 Construction Of Opoc Engine

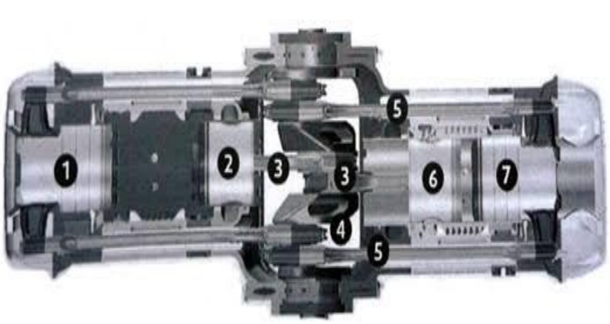
This engine configuration is the basis for the Eco-Motors paradigm – an alternative to today's traditional internal combustion engine. An OPOC engine weighs far less and is much more compact than a conventional engine, and it has about half as many components.

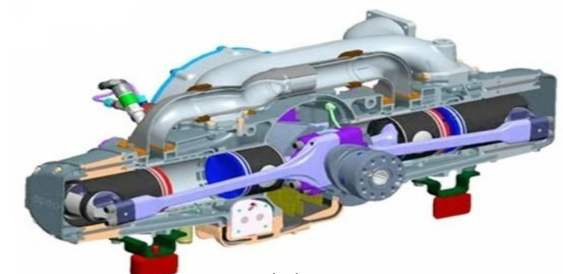
Amazingly, an OPOC engine produces power twice as often – every other stroke, rather than every fourth stroke. The result is a far greater power output than traditional engine of comparable sizes.

Adding to the design's elegance is the arrangement and movement of its pistons, which result in perfectly balanced operation; the outboard pistons move under constant tension, and the inboard ones under constant compression. The net effect is an engine in which the forces acting on the crankshaft constantly cancel each other out. Most importantly, the OPOC engine provides remarkable fuel economy, thanks to its inherently efficient two-stroke design, and because eliminating so many moving parts significantly reduces internal friction.

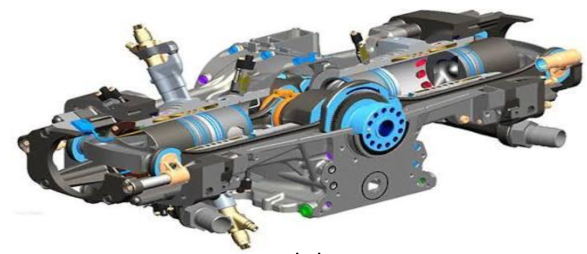
I. COMPONENT LIST

A. Body
B. Cylinder
C. Inner Pistons
D. Outer Pistons
E. Crankshafts
F. Fuel Injectors
G. Valves





(A)



(B)

Fig.3. (A) Preliminary stage (single injector), (B) Advanced stage (dual injector)

4 WORKING OF OPOC ENGINE

This engine can run on a number of different fuels, including gasoline, diesel and ethanol. The OPOC's new opposed piston-opposed cylinder direct gas exchange operation provides the well-known emissions benefit of 4-cycle engines, the simplicity benefits of 2-cycle engines, the power density of the less well known opposed piston engine, and the extraordinary developments in computer and thermodynamics all tied together in a new and proprietary engine building.

It comprises two opposing cylinders per module, with a crankshaft between them; each cylinder has two pistons moving in opposite directions. This innovative design configuration eliminates the cylinder-head and valve-train components of conventional engines, offering an efficient, compact and simple core engine structure. The result is an engine family that is lighter, more efficient and economical, with lower exhaust emissions.

OPOC engine outputs power by a single crank shaft. This type of engine uses the structure of long-short rod ingeniously to put the explosion pressure of internal-external pistons and inertia force on same crank shafts. Compared to the OP engine is has only one crankshaft to the output power. Compared to OC engine, it doesn't have a cylinder head. It is because of this clever design that engine structure is greatly simplified and lighter which makes it compact and efficient.

Analyzing the two stroke scavenging, the side-injection combustion, and the structure of the key components shows the potential of the OPOC concept. It is predicted for the 465 kW (650 hp) OPOC truck engine. The OPOC engine was designed to be modular. Each module is self-contained and delivers 325 hp. The modules are connected together via the Modular Displacement Clutch, which synchronizes the modules for achieving even firing when both modules are functioning. With an optimized scavenging process, the special design features of the OPOC engine offer a significant step towards the potential of the two-stroke engine having double the power density of a four-stroke engine. An estimated 90% scavenging efficiency has been achieved with unique gas exchange characteristics of the OPOC engine and the use of an electric assisted turbocharger. The OPOC engine runs with almost two times the engine speed (3800 rpm) along with a large cylinder stroke (167.53 mm), as a result of the split stroke of the opposed piston.

4.1 Electrically Controlled Turbocharger

Eco Motors intellectual property also includes an electrically controlled turbocharger technology which incorporates an electric motor in the turbo assembly to regulate boost pressure resulting in a long list of unique advantages:

- ✓ Improved combustion efficiency to meet emissions
- ✓ Electrically controlled variable compression ratio
- ✓ Improved vehicle fuel economy
- ✓ Enhanced vehicle drivability due to improved low-end torque
- ✓ Eliminates Turbo lag
- ✓ Waste heat recovery by generating electricity

4.2 Power Density

The internal combustion piston engine has been the primary means of automotive propulsion for more than a century. Today, thousands of engineers around the world are hard at work trying to improve this 19th century invention. Some are striving to make incremental gains; some are hoping for a breakthrough. For all of them, one measuring stick is the "acid test" for any engine -- power density. As greater power density is achieved, a range of critically important attributes will result, including:

- Lower weight
- Smaller size
- Lower material costs
- Lower friction
- Greater fuel efficiency
- Lower emissions
- Lower heat rejection

Eco-Motors' OPOC engine has a number of distinct advantages over traditional internal combustion engines. The OPOC engine has very high power density of nearly one horsepower per pound resulting in an unprecedented lightweight and compact engine. The OPOC engine is perfectly balanced enabling stackable power modules. This unique modular displacement capability is one of the long standing, but elusive goals of engine engineers' quest for high efficiency. In addition, it also results in much less NVH (Noise, Vibration & Harshness) than a conventional engine of comparable power. Its elegantly simple design allows for low cost, efficient manufacturing and increased operating durability:

- 50 percent fewer parts than a conventional engine
- Straightforward assembly
- No cylinder heads or valve-train
- Uses conventional components, materials and processes

4.3 Electrically Controlled Turbocharger

Eco-Motors' intellectual property also includes an electrically controlled turbocharger technology which incorporates an electric motor in the turbo assembly to regulate boost pressure resulting in a long list of unique advantages:

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- Improved vehicle fuel economy
- Enhanced vehicle drivability due to improved low-end torque
- Eliminates Turbo lag
- Waste heat recovery by generating electricity

4.4 Electrically Controlled Clutch

The development in clutch technology enables customers to take advantage of the engine's modular displacement capability. The clutch assembly is housed between two engine modules, and is engaged when vehicle power demands require both modules to deliver power. When the power of the second module is not needed, the clutch is disengaged, allowing the second engine to stop completely. This not only improves fuel economy dramatically by reducing parasitic losses, but also improves the efficiency of the primary module.

5 About Opposed Piston Engine

Opposed piston engines using the two stroke cycle are known to have been made by Oechelhäuser as early as 1898, when a 600 hp 2-stroke gas engine was installed at the Hoerde ironworks. These engines were made by Deutsche Kraftgas Gesellschaft from 1899, and by other companies under licence including William Beardmore & Sons Ltd in the UK.

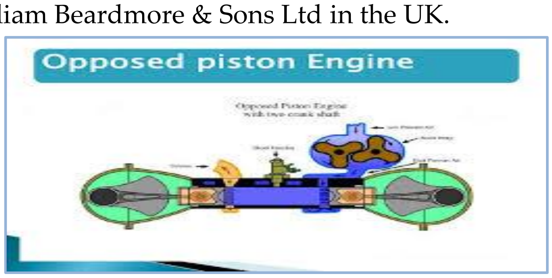

Fig. 1. Opposed piston engine

The first opposed-piston diesel engines were developed in the beginning of the 20th century. In 1907, Russian Raymond Koreyvo, the engineer of Kolomna Works, built an opposed-piston two-stroke diesel with two crankshafts connected by gearing. Although Koreyvo patented his engine in France in November 1907, the management would not go on to manufacture opposed-piston engines.
The first Junkers engines had one crankshaft, the upper pistons having long connecting rods outside the cylinder. These engines were the forerunner of the Doxford marine engine, and this layout was also used for two- and three-cylinder car engines from around 1900-1922 by Gobron-Brillié. There is currently a resurgence of this design in a boxer configuration as a small aircraft Diesel engine, and for other applications, called the "OPOC" engine by Advanced Propulsion Technologies, Inc. of California. Later engines, such as the Junkers Jumo 205 diesel aircraft engine and today's Achates Power engine, use two crankshafts, one at either end of a single bank of cylinders. There are efforts to reintroduce the opposed-piston diesel aircraft engine with twin geared crankshafts for general aviation applications, by both Dair and PowerPlant Developments in the UK.

6 Comparison Of Opposed Piston And Opoc Engine

PERFORMANCE	**OPPOSED PISTON ENGINE for heavy duty**	**OPOC ENGINE**
Power Density	0.35HP per round	0.9HP per round
Cylinder Inline Needed (For Heavy Duty)	3	2
Engine Speed	1450-2500	1500-6000 RPM
Number Of Pistons	6	4
Number Of Injectors	6	4

The above table shows that the comparison between the OPOC engines is better than that of the opposed piston engine various performance parameters. The OPOC engine is very efficient than that of the opposed piston engine.

7 Performance Of Opoc Engine

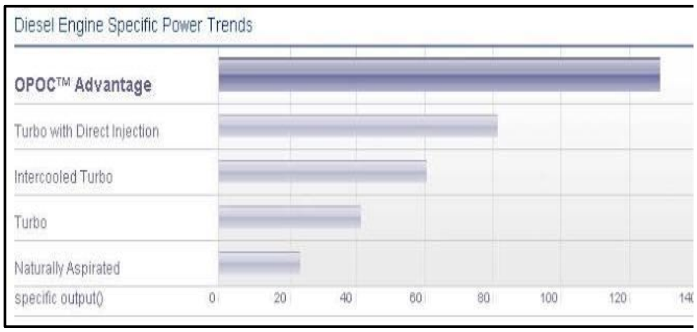

Fig.2. Analysis of performance

8 Merits And Demerits Of Opoc Engine

8.1 MERITS

- ✓ OPOC engine could deliver about 45% greater fuel efficiency
- ✓ High power density
- ✓ Lower weight
- ✓ Lower material cost
- ✓ Smaller size
- ✓ Lower emissions
- ✓ Lower friction
- ✓ Lower heat rejections
- ✓ Electrically controlled turbocharger is used
- ✓ No cylinder heads or valve trains

8.2 DEMERITS

- ✓ Due to complex design production cost is high.
- ✓ Sometimes high temperature and pressure can cause knocking effect.
- ✓ If valve timing is not set properly then it may cause adverse effect on engine efficiency.

8.3 APPLICATIONS OF OPOC ENGINE

- ✓ Used In Military Vehicles
- ✓ Used In Sub-Marines
- ✓ Used In Light Transport Vehicles
- ✓ Used In Commercial Vehicles
- ✓ Used In Aerospace
- ✓ Used In Agriculture, Auxiliary Power Units, Generators

8.4 FUTURE SCOPE OF OPOC ENGINE

This technology, abbreviated as OPOC, is essentially a combination of the operating principles of a gas engine and a diesel. When high power is required, an OPOC engine operates like a conventional gasoline engine, with combustion initiated by a spark plug. At more modest loads, it operates more like a diesel, with combustion initiated simply by the pressure and heat of compression.

In a diesel engine, combustion starts when the fuel is injected with the piston near the top of the compression stroke, and the combustion is controlled by the speed at which the fuel is injected. With OPOC, however, the fuel has already been injected and mixed with the air before the compression stroke begins.

Since compression alone initiates combustion, it's more of a big bang than even a diesel's hard-edged power stroke. Making the engine sturdy enough to avoid blowing apart makes an OPOC at least as heavy as a diesel. The key is achieving sufficient combustion control so that the OPOC cycle can be used over as wide a speed and load range as possible to reap the efficiency benefits.

9 Conclusion

After studying the research work on OPOC engine we conclude that it is comparatively better than opposed piston engine. Also there is a chance of future development in it. The OPOC engine is having better performance and used for military purposes since in future it would be a part of automobiles. Therefore the OPOC engine is reliable and more efficient.

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