

Free-Piston 4th Generation Engine Range Extender

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Abstract - The vehicle market is slowly adapting to the facts that there is a rising amount of consumers that would like to have real alternative cars. The vehicle concepts that would really have an influence to the CO₂ output are battery electric vehicles with or without range extenders as well as vehicles specifically designed as series hybrids. A range extender (REX) is an auxiliary power source of an electric vehicle (EV) to increase travel-distance. Free-piston 4th generation engine range extender is a new kind of engine which characterize and optimize the engine performance when support optimization of future design to improve low carbon vehicle. two free-piston engine unit located to improve mechanical balance engine. it help to reduce noise and vibration range extender has been design to linear generator with spark plug injector valve hosing in store at either ends. the electronic control of piston position is major advantage of operation and fuel flexibility these ultra-high efficiency and lower cost of manufacture, maintenance means major improvement for next generation a range extender technology.

Key Words: Free-piston, connecting rod, combustion chamber, permanent magnet, stationary coils. noise pollution.

1 . NTRODUCTION

The vehicle market is slowly adapting to the facts that there is a rising amount of consumers that would like to have real alternative cars. The vehicle concepts that would really have an influence to the CO₂ output are battery electric vehicles with or without range extenders as well as vehicles specifically designed as series hybrids. A range extender (REX) is an auxiliary power source of an electric vehicle (EV) to increase travel-distance. Crankless mechanism which facilitates variable stroke length and a piston can be controlled on each stroke by proper fuel injection timing. Unlike conventional engines that the piston motion is determined by the crank system, the piston motion of

free piston engine is determined by the immediate force balance on the mover, which the piston motion may vary for different operational conditions. The conservative crankshaft and piston rods are replaced by two engine blocks, each with six cylinders arranged around a main shaft. Six double ended, free floating pistons shuttle backward and forward between the cylinder blocks, and fit over a sinusoidal cam which is keyed to the central shaft. The idea of converting chemical energy into electrical energy by means of a combustion process is not new and free piston concepts themselves have been around for a while.

2. LITERATURE REVIEW

2.1 Literature Survey

Sir Joseph Swan(2016) had stated that the free-piston engine generator (FPEG) is a linear energy conversion system, which is known to have greater thermal efficiency than an equivalent and more conventional reciprocating engine. The piston motion of a FPEG is not restricted by a crankshaft-connection rod mechanism, it must be controlled to overcome challenges in the starting process, risk of misfire, and unstable operation. A Cascade control strategy is proposed for the piston stable operation level, and PID controllers are used for both of the outer loop and inner loop.

Boru Jia et.al (2014) had described that free piston linear generator as an alternative to conventional engines, free-piston engine generator (FPEG) is a promising power generation system due to its simplicity and high thermal efficiency. The new method to start the engine by mechanical resonance. A closed-loop control model was developed and implemented in a prototype FPEG which was driven by a linear machine with a constant driving force.

Un-Jae Seo, .et al (2015) had explained that the free piston linear generator is a new range extender concept for the application in a full electric vehicle. The

free piston engine driven linear generators can achieve high efficiency at part and full load which is suitable for the range extender application.

Washington (2001) had justified that the FPE was finally abandoned due to low controllability. The advantages of the FPE are obtained mainly from the freely moving piston, with which a variable compression ratio can be easily achieved. With many alternative fuels, such as biofuels under development to replace the traditional gasoline or diesel fuel.

Roman Virsik .et al (2013) had explained that the free piston linear generator is a new range extender technology. It converts chemical energy into electrical energy by means of a combustion process and linear generator. Thereby the technology aims to have better properties than other range extenders.

Avinash Warade, et al (2016) had investigated the piston engine concept is more efficient than traditional conventional engine in our day to day life. After in the mid of the 20th century the number of research work are going on the free piston engine. so there will be change in the conventional engine by changing the crank shaft system by another techniques like air compressed system, hydraulic system and cam system (in revetec engine) etc. as this changes made there will be increase in the efficiency of the engine

2.2. Points to be taken away

- Main pollutants contribute by Automobiles are
 - i. Carbon-monoxide (CO)
 - ii. Carbon-dioxide (CO₂)
 - iii. Unburned Hydrocarbon (UBHC)
 - iv. Oxides of Nitrogen (NO_x)
 - v. Sulphur-dioxide (SO₂)
 - vi. /Lead (pb)
- This gives the possibility of high compression ratio with high efficiency and the flexibility of burning different fuels.
- Free-piston engine generator (FPEG) is a promising power generation system due to its simplicity and high thermal efficiency.
- A novel method to start the engine by mechanical resonance. The advantages of the FPE are obtained mainly from the freely moving piston, with which a variable compression ratio can be easily achieved..

3. OBJECTIVE AND METHODOLOGY

3.1 Objective

The vehicle market is slowly adapting to the facts that there is a growing amount of consumers that would like to have real alternative cars. Most Hybrid cars do not create the benefit that could be expected by the spec sheet, as they are mainly optimized to benefit in the standard cycles. An engine of a series hybrid electric vehicle does not deliver mechanical energy to the wheel but electrically converted energy by a generator is delivered to the electric motor.

3.2 Methodology

It is basically a structure of particular system or the ideas from which we can make judgement/decision. It includes the various steps such as Literature review, free piston engine etc.

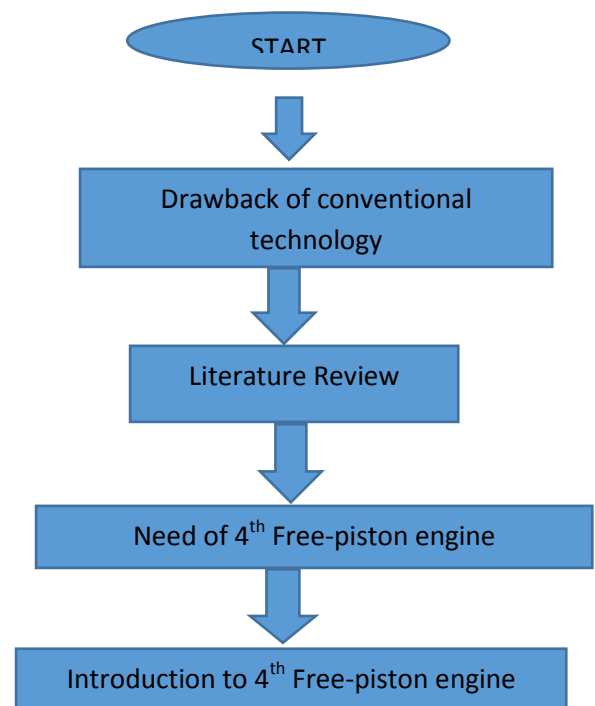


Fig-Project Methodology

4. CONSTRUCTIONAL DETAILS

The free-piston linear generator is consists of a piston rod connected with a piston on either side, cylinders around the pistons and a linear generator. At one end the cylinder forms the combustion chamber which is powered by a liquid or gaseous energy carrier. The gas exchange of the combustion chamber is controlled by

electrically actuated valves in the cylinder head. The opposite cylinder creates an adjustable gas spring. The spring rate of the gas spring is adjusted by means of regulating the air mass in the cylinder. The linear generator sits between the two cylinders. Its mover is mounted on the piston rod. The mover consists of permanent magnets glued into a plastic matrix and additionally secured by a fibre glass reinforced bandage. Stators with integrated generator windings and a cooling system enclose the mover and complete the linear generator. It comprises of inlet and exhaust valves fitted on both side on combustion chamber head. Two bearing are used to hold the piston ends between two combustion chamber. These whole construction is normally placed in horizontal direction as per axial direction

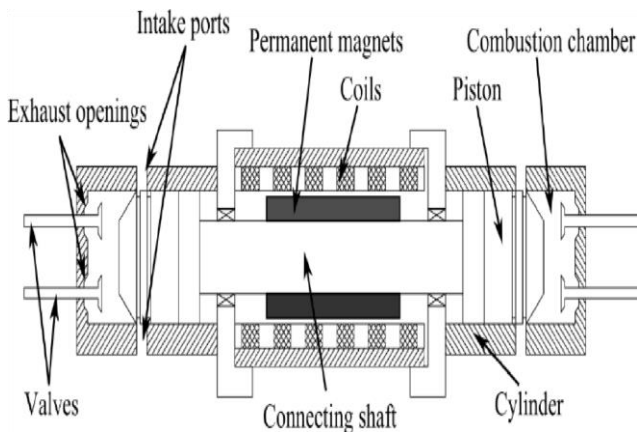


Fig-costruction detail of Fourth Generation FPE

These whole rigid construction is known as free-piston engine. These also comprises of battery is essential for storing the power generated. Battery is rigidly fixed to back of vehicle so that the balance will be maintained and gives less vibration and good stability.

5. WORKING PRINCIPLE

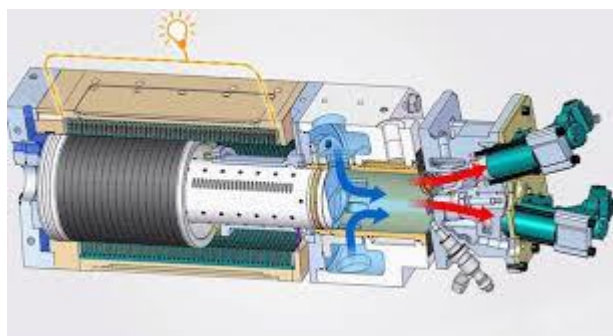


Fig-working of fourth generation piston engine

The load cycle begins with the combustion piston at the top dead centre (TDC). The chamber is filled with a compressed, flammable mixture previously introduced into the combustion chamber which is ignited by a spark plug. The two pistons, the rod and the mover (double piston system) move towards the bottom dead centre (BDC, direction of gas spring). The motion of mover and its magnets induces a voltage in the coils of the stator which drives a corresponding electric current. About half of the energy released in the combustion is converted during the movement from TDC to BDC by the linear generator. The other half is stored in the gas spring and extracted on the return stroke (BDC to TDC) of the double piston system.

While the gas spring is compressed (the combustion piston is at its BDC) the combustion chamber is actively scavenged with charged, fresh air. After injection of fuel the mixture is compressed and as the double piston system arrives at the TDC, the next load cycle can begin. The variation of the output power can be achieved by adjustment of the inlet pressure and injection period in combination with the stroke. Thereby the stroke is controlled by the air mass in the gas spring. The mechanical frequency of the double piston system only varies slightly between multiple operating points. The piston dumps its kinetic energy into the fixed windings which surround it, generating a shot of three-phase AC electricity. It can be run sparkless through a diesel cycle or run on standard gasoline. What has folks excited is the claimed thermal efficiency for the device.

A two-cylinder model would be self-balancing and have much reduced vibration. Not surprisingly, the valves are electrically operated and can therefore be better used to fine tune the power delivery through the full range of the stroke. Speaking of strokes, of the two stroke design, which might present a few problems for a road-worthy design. For one thing, emissions would be suspect. Linear generators and linear combustion engines are nothing new. while single-acting direct power pistons have also seen action in Considering that the piston is decelerated and re-accelerated at each end of the stroke, any mismatch between combustive power input and electromagnetic power extraction needs to be absorbed somewhere. Mechanical or air springs can help although there is still likely to be some efficiency loss.

6. CHARACTERSTICS

A FPLG system for use as range extender would consist of two of the above described modules, to allow for a full mass compensation. Schematic the system would look like.The most advanced solution is the central

combustion chamber. For such systems in depth analysis, simulation and estimation were carried out during the REXEL study. Yet since the proof of concept of the module new estimates are being made in the DLR. Due to the measurements and information gathered some properties can now be described with higher precision.

6.1 EFFICIENCY.

The regarded system has a central combustion chamber with integrated gas springs, and takes all auxiliaries into consideration. Additionally the beneficial efficiency is not limited to one optimal point. Due to the variability of the system, lower load points do not lead to a large reduction of efficiency.

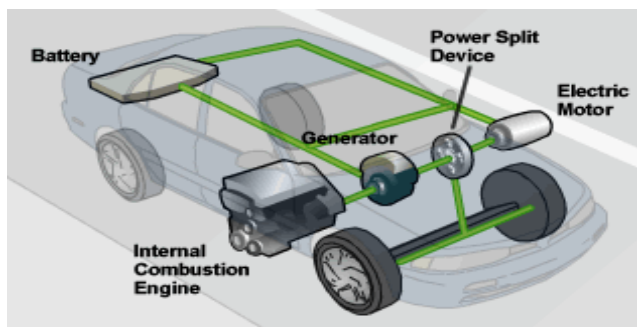
6.2 FLEXIBILITY OF FUELS.

As the FPLG has no crankshaft the compression ratio is adjustable. An appropriate fuel supply system therefore would allow many sorts of fuels (petrol, diesel, natural gas, sun fuel, synthetic fuel, hydrogen, etc.). The fuels can be used without any constructional changes in the combustion unit, as the adaption of the compression ratio is design inherit.

6.3 Emission:

The challenges 2-stroke petrol combustion process face in regards to emissions are the mixture preparation and the avoidance of HC emissions during the simultaneous opening of the intake and exhaust valves. To prevent the HC emissions the FPE uses direct injection after all valves are closed. With a stoichiometric combustion a standard three-way catalytic converter can be used. For this purpose the short circuit flow has to be minimized. Otherwise a NO_x storage catalytic converter is necessary. As mentioned above the FPLG has more degrees of freedom than normal engines. This allows the implementation of selfignition combustion (HCCI). For part load points HCCI has the advantages of very high efficiency and very low emissions.

7. ACTAL POSITIONING IN FOUR WHEELER



As FPLG is simple device which can be easily fitted in the anywhere .by considering balancing purpose it is fitted in front of steering in the place of radiator to provide natural cooling of the component which result in increase in efficiency of the vehicle. Other component supporting like batteries in at its original place which is common in other vehicle. Only the size of the battery is more as to store the charge developed and can be used for further requirement of power if needed.

8. MERITS AND DE-MERITS

8.1 MERITS :

1. Simple design with few moving parts, giving a compact engine with low maintenance costs and reduced frictional losses.
2. The operational flexibility through the variable compression ratio allows operation optimisation for all operating conditions and multi-fuel operation. The free-piston engine is further well suited for homogeneous charge compression ignition (HCCI) operation.
3. High piston speed around top dead centre (TDC) and a fast power stroke expansion enhances fuel-air mixing and reduces the time available for heat transfer losses and the formation of temperature-dependent emissions such as nitrogen oxides (NO_x).
4. Free-piston linear generator that eliminate a heavy crankshaft with electrical coils in the piston and cylinder walls.
5. A variable compression ratio can be easily achieved. This gives the possibility of high compression ratio with high efficiency and the flexibility of burning different fuels.
6. It produces maximum torque at a lower rpm than conventional engine.
7. Slower turning propeller that produces less noise.

8.2 DE-MERITS :

1. The indicated thermal efficiency of the engine was lower because less heat was released around the piston top dead centre (TDC).
2. The demanded power of electric motor becomes high .when a vehicle climbs up a hill. In this case, both battery and REX deliver power to the electric motor, depleting the battery energy continuously.

9. CONCLUSION

Free- piston linear generator system can cover a large amount of tasks that are heading towards the automobile industry in the next decades. The FPLG can be used in a variety of vehicle concepts in a more efficient manner than other technologies. The constructional features of the free- piston engine gives variable compression ratio to be achieved while combustion of fuel in combustion chamber. Which gives high efficiency and also allow to use different fuel in combustion chamber which leads to wide range of fuels to be used.it offers high specific power to range extender engine these leads to ultra-high efficiency which is improvement for next generation. These technology can be viewed as a technology to bridge the gap between present and future.

10. FUTUER SCOPE

Influence of cycle-to-cycle variations in the combustion process and engine performance during transient operation in dual piston engines are topics that need further investigation. These can be replaced with other engine application where these can be applied to reduce friction , cost and increase efficiency.

The design will to control process automated used in air bus which is electrical vechicle alos it applicable to be built in hybrid cars for conservation of energy.

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