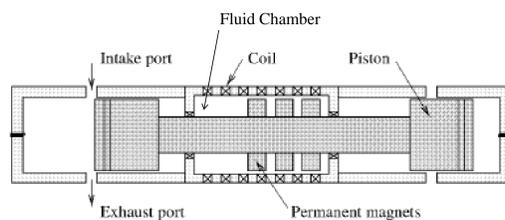


Free Piston Engine CAD Model and Demonstrational Unit

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Introduction

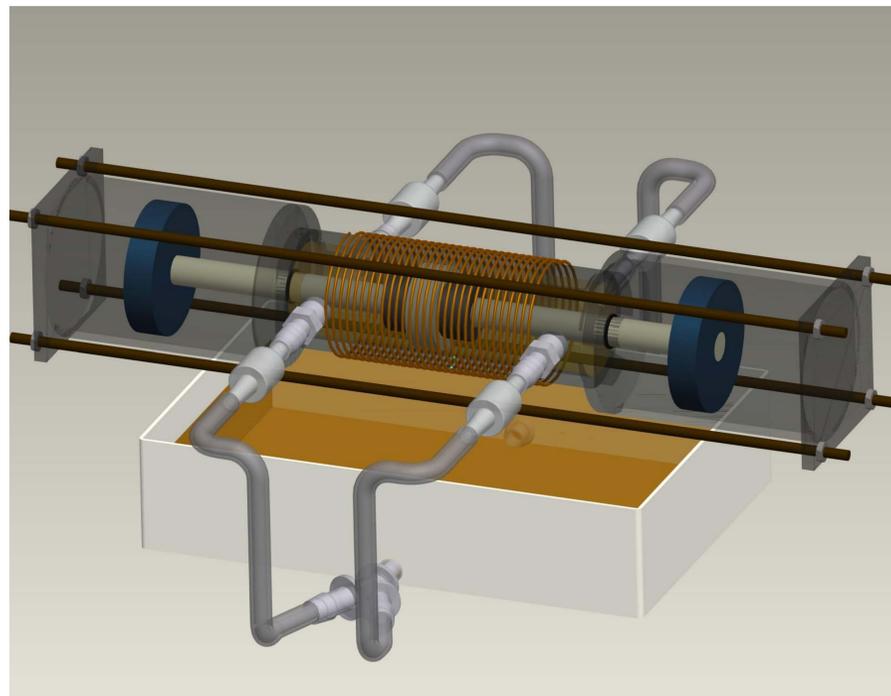
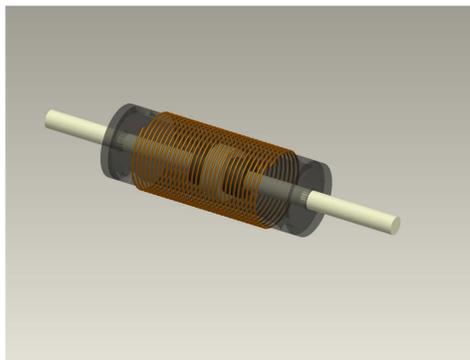
A free piston engine consists of one or more pistons which is/are displaced each in one cylinder through a combustion process followed by a motion which returns the piston back to its pre-combustion location. The free piston engine differs from conventional engines in several ways including the way this return occurs and the result of the power stroke (the motion associated with gas expansion after combustion). Firstly, the conventional engine uses a series of linkages to turn the linear motion of the piston into rotational motion. The free piston engine is different because it uses the linear motion to produce different types of energy which, in the case of this project, would be electrical current and fluid power. Historically, this type of engine has only been used for small commercial products, but with some modifications, it could be developed into an engine which could power vehicles and similar machines currently powered with traditional internal combustion engines. Because of its design, it can operate more efficiently which has become a major advantage in today's fuel economy minded society.



Electrical System

The electrical system of the free piston works through a process called induction. Magnets attached to the connecting rod between the two pistons move back and forth inside a stationary wire coil. By changing the magnetic flux inside the coils, a current is generated. This coil is connected to a battery which it charges during each power stroke of the engine. In principle, this is the same process which runs electric motors except the direction of the energy transfer is reversed so that a battery powers the motor instead of the motor charging the battery. The battery will then be able to power any electronic devices which are connected to it.

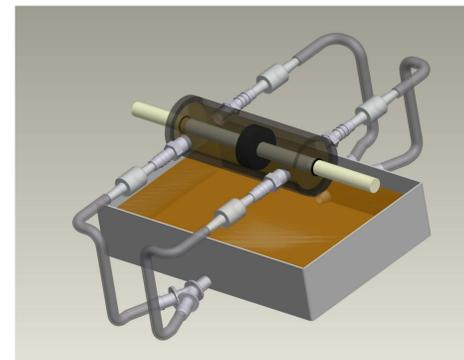
In the actual product, there would need to be a very large number of coils wrappings, numbering in the thousands. For the sake of demonstration however, a much smaller quantity of coils are present.



Hydraulic System

A hydraulic system is another capability of the free piston engine and, like the electrical system, can produce energy through the reciprocating motion of the piston. As seen in the graphic below, a fin which is attached to the moving connecting rod pushes hydraulic fluid inside a chamber. By using a series of check valves which only allow the fluid to move through the pipes in one direction, each stroke can pump a chamber's worth of fluid into an accumulator and at the same time, the motion refills the evacuated part of the chamber. Once the high pressure fluid is stored in the accumulator, it has potential energy which can be used to drive motors (e.g. wheels in a car).

The presence of the fluid can serve to smooth out the motion of the piston because of the resistance created by the viscosity of the fluid. For example, if one power stroke does not generate enough force to push the connecting rod assembly, the resistance of the fluid in the pipe could be temporarily decreased by changing the size of an orifice in the line. This would allow the piston to complete its forward motion and allow the engine to continue running. Additionally, increasing the resistance could be used if a power stroke was larger than expected due to fuel composition or engine vibration.



Advantages

- Increased fuel efficiency. By decreasing the number of moving, and heavy, parts such as the crankshaft and cam shaft, many friction losses are eliminated making the cycle more efficient
- Decreased engine size and weight. Another advantage of eliminating the parts listed above is a decrease in engine size and weight which increases the amount of energy the engine can create per unit volume. This also reduces the cost.
- Variable engine stroke. Unlike conventional internal combustion engines, free piston engine combustion timing can be varied in real time to optimize fuel economy under changing load circumstances.
- Energy storage options. With FPEs, the user has the option to utilize different energy storage devices (fluid and electric) directly unlike conventional internal combustion engines.

Disadvantages

- No direct control over piston motion. One of the best advantages of the free piston engine is also a cause of instability in the system. Since there is no flywheel or equivalent mechanism to directly control the piston, its motion can be unpredictable if proper considerations are not made.
 - Current department research seeks to correct this through control theory and development of hydraulically operated intake and exhaust valves which would offer increased control of the piston assembly.
- Complexity of simultaneously operating system creates the need to have very precise knowledge of what to expect from each system. They must all work together for the entire process to run. The combustion must provide fluid power to operate the valves and the electrical system must power the controlling computer. After these requirements are met, the engine can power external devices

Conclusions

The free piston engine is an exciting innovation which could lead to more efficient internal combustion. This would be a welcome technology to decrease fuel consumption and increase the efficiency of fossil fuel powered machines. There are many challenges to be overcome with the development of this engine as well as its possible incorporation into society one day, but it would be a step in the right direction when dealing with our fuel consuming way of life.

References:

Mikalsen, R, and A.P. Roskilly. "Review of Free Piston Engine History and Applications." [ScienceDirect](#) (2007):