The Pivotal Hydrogen Engine

There is a growing awareness of the catastrophic environmental and life style cost of ignoring climate change issues. It is a global issue creating the need to develop new power systems and vehicles that do not release further global warming emissions.

The world cannot ignore the hydrogen fuel option. Read the hydrogen economy report from George Crabtree / Argonne Laboratory-
http://www.aip.org/pt/vol-57/iss-12/p39.html#cap3

Hydrogen is recognized as the cleanest and most sustainable fuel option for the long-term survival of our lifestyle on this planet. It is the only CO2 / green house gas emission free fuel available.
Hydrogen is an energy carrier as opposed to a resource such as is oil or CNG. While it needs to be produced and this requires energy or an energy resource fuel it is potentially sustainable and the means to produce it are vast. The cost of supplying hydrogen for fuel is currently high but can be significantly reduced. Hydrogen can be used to power a vehicle by burning it in an ICE (internal combustion engine) or defusing it through a fuel cell to produce electricity and drive the vehicle with electric motors.

What makes the water-cooled pivotal piston technology essential for hydrogen powered mobility?

Since the design of an ICE is dictated by the characteristics of the fuel that it operates on why are we still trying to adapt gasoline and diesel engines to operate on hydrogen? Ask engineers - to run an engine on hydrogen and they will endeavour to overcome the difficulties that the conversion of the current gasoline engine demands. If asked – to design the ideal hydrogen engine, they would study the characteristics of hydrogen combustion and design a device that meets those demands. It would not be the same outcome.

Hydrogen is very different, so the ideal device to harness hydrogen combustion to power transportation will be different.

Hydrogen requires a low energy spark to ignite it. This particular combustion characteristic inhibits the use of the conventional gasoline or diesel engine as the combustion chamber surfaces must be thermally controlled with

absolutely no hot spots. This requirement eliminates the use of the conventional exhaust poppet valve.

The current automotive engine cannot be converted to an efficient hydrogen engine as hydrogen presents very different combustion characteristics to gasoline or diesel.

The Pivotal engine with its water-cooled piston has a fully controlled, (thermally smooth) combustion chamber surface. This allows for a rich and more thermally efficient hydrogen/air ratio to be employed without suffering from pre-ignition. With full control over the ignition timing it becomes possible to make full use of the extremely fast combustion of a stoichiometric hydrogen ratio. The pivotal engine optimized for hydrogen fuel on a direct to chamber fuel delivery system can provide a power density that far exceeds the current level of gasoline automotive engine.

The pivot shaft of the Pivotal piston gives access to a water-cooling gallery within the piston itself. This provides a means of cooling the piston directly so that it is no longer dependent on engine temperature. As the piston temperature is now independently controlled it allows the engine to be operated at a higher, more thermally efficient temperature. Internal water-cooling of the piston permits a new level of thermal control for an internal combustion engine enabling the use of a wide range of alternative fuels.

The water-cooled pivotal piston engine offers the most compact and viable design for harnessing hydrogen combustion for mobility power. This, along with its suitability to run on CNG, ethanol and other alternative fuels makes this technology the most suitable option for a wide range of future mobility applications.

The potential output of the high power density Pivotal hydrogen engine will reduce engine size to less than 40% of the size and weight of the conventional engine **converted** to hydrogen. This will influence many other design aspects of the vehicle. The compact opposed four-chamber, Pivotal hydrogen engine is expected to deliver the same power as the V12 BMW engine that has been converted to run on hydrogen.

The total mass of a vehicle dictates the amount of energy required to move it. More mass – more energy / more energy - more fuel / more fuel - more emissions. High power-density is therefore, a fundamental requirement of any mobility power unit. The size and weight of the powertrain dictates the design criteria for many other aspects of vehicle

design and in particular the scale of the chassis, suspension, wheels and brakes.

Even when hydrogen is compressed into a storage tank @ 7,000 psi it is still a bulky fuel, and so to get performance, utility and range from a vehicle, the power density of the powertrain will be extremely important. There may yet be better options in the future for hydrogen storage but the current choice is to compress the gas in a high-pressure, cylindrical tank or to cool it down to minus 260 degrees centigrade and store it in liquid form in a highly insulated tank. Either option requires energy and both have advantages and disadvantages. It may be that a combination is adopted although cost will be a major factor prohibiting this option. What is absolutely clear is that the power density of the complete vehicle will make the difference in providing the performance and range that the buyer demands.

It is also reasonably clear that the common hydrogen vehicle of the future will be a PHEV (plug in hybrid electric vehicle) and the success of the PHEV will depend on the power density of the complete vehicle. This means that every aspect of the vehicle (not just the battery) will be designed to reduce mass.

The portable military 'stand alone' generator is a natural first step for the Pivotal engine before developing a demonstration hydrogen PHEV. The development of a viable PHEV is not dependent on the development of high power density batteries; it can be achieved by utilizing technologies that are currently available. The Pivotal hydrogen PHEV is within the capability of automotive OEMs.

Investigating the efficiency of **the ideal** Hydrogen ICE is a fundamental step in exploring the viability of the hydrogen transportation economy. This investigation starts by assessing the character of hydrogen and optimizing the engine that has the thermal control and power density to make the difference. To fail to explore this potential is to fail in the timely introduction of the hydrogen economy.

We have discussed the Pivotal engine advantages with hydrogen ICE development engineers at the major automotive OEMs and we are confident that the Pivotal engine has the fundamental requirements for the ideal hydrogen ICE. This is a key technology to establish the hydrogen transportation era and reduce CO2 emissions from vehicles.