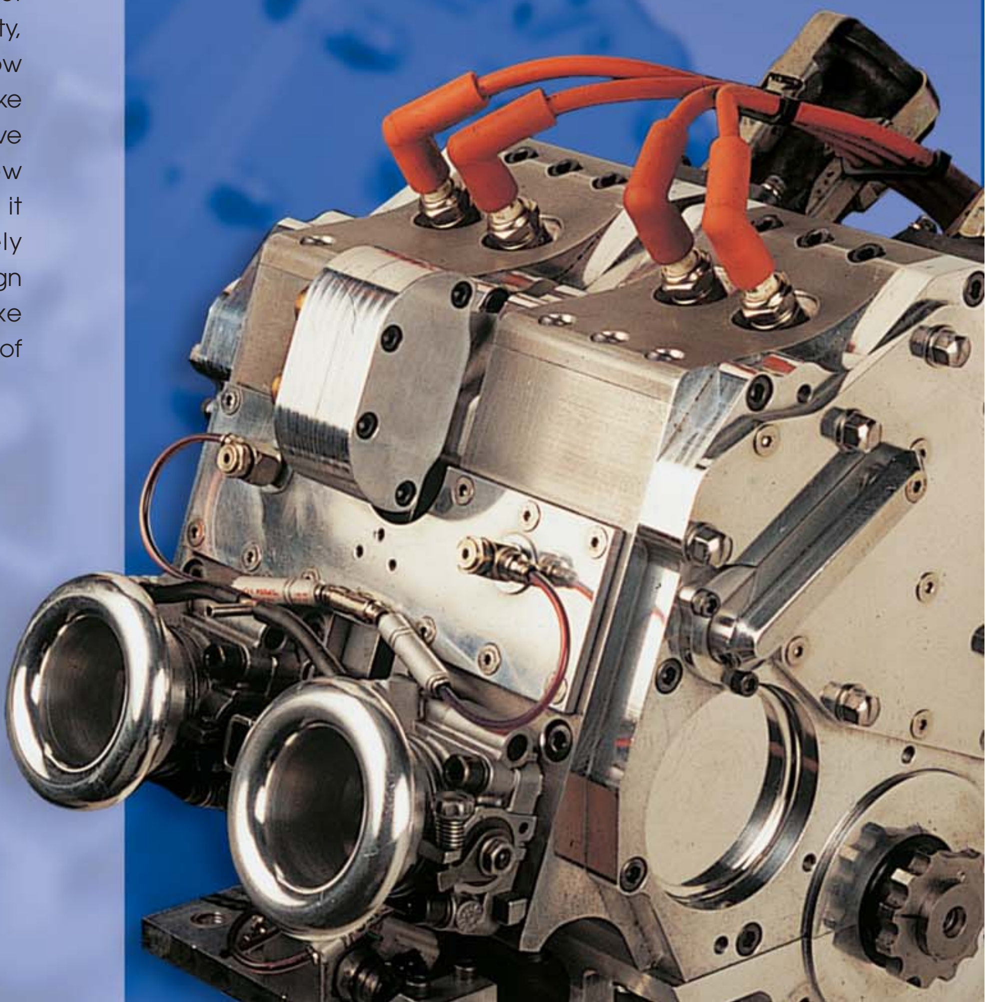
The
High Power Density
Pivotal Engine

This new generation IC engine was designed to take full advantage of the high power density available with the two/stroke engine principle while overcoming the inherent limitations of the conventional design.

Unsatisfactory service life plus reliability and emissions issues have precluded the conventional two/stroke engine from many applications which are the domain of the four/stroke engine. We set out to design a better engine which would meet all the requirements of power density, reliability, longevity, efficiency, low emissions and low cost of manufacture. The two/stroke principle was adopted to achieve high power density and low manufacturing cost. However it was necessary to completely reengineer the mechanical design of the conventional two/stroke engine if we were to achieve all of the criteria that we required.

Complete thermal control of the combustion chamber is essential for a high power density hydrogen ICE.



PIVOTAL ENGINEERING

www.pivotalengine.com

The High Power Density Pivotal Engine

Longevity was our first requirement. To achieve this we needed to change the means by which the piston movement was constrained. A cylinder with large port openings does not satisfactorily restrain the piston or the piston rings when all these components are changing in size and shape.

Thermal control was essential in order to regulate piston expansion and the combustion environment. Conventional engines are limited by their ability to transfer heat from the piston to the cylinder wall.

Reliability demanded that the temperature of the piston be controlled when the engine is operating at a continuous and high load.

Efficiency was another prime requirement. The key to efficiency is to reduce internal friction and improve the internal gas flow. We therefore needed to remove load bearing sliding components and create a displacement driven full loop scavenge pattern to reduce fresh charge and exhaust gas mixing and improve trapping.

Low oil consumption was needed to ensure that both the cost of operation and the level of emissions met the expectations for engines of the future. Keeping the oil separate from the fuel and from mixing with the induction air was clearly essential.

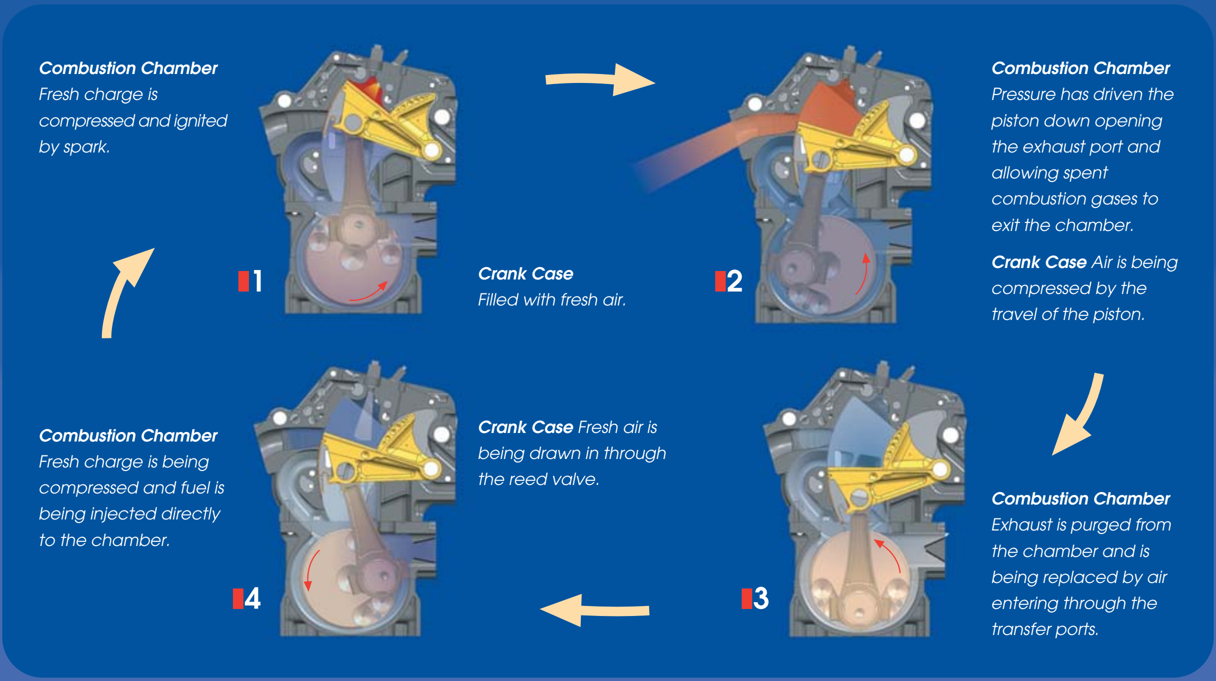
To achieve these objectives we designed the 'Pivotal' engine.

Cutaway of Pivotal Piston showing water gallery accessed via pivot shaft.

A number of new and unique features have been optimised in the course of the 'Pivotal' engine project. These features combine to make a device well suited to future engine requirements.

The piston movement is now controlled by pivot bearings and this eliminates piston rocking and the wear associated with the cold start-up phase in a conventional two/stroke engine. The exceptionally low level of mechanical noise is immediately apparent. The pivoted piston also ensures that the compression seals are held at a normal orientation to the surface of the chamber and do not protrude into the port openings. The pivot shaft also provides access for water which circulates through the piston to directly cool the piston crown. These features are important because the piston is no longer at risk of being damaged when the engine is cold or from over heating during sustained periods of high load. With the piston temperature maintained at an optimal level by its own water circuit the chamber walls are freed from the task of cooling the piston allowing their temperature to be optimised for combustion.

The 'Pivotal' engine is a long life design. Because the piston movement is controlled it does not rock or thrust against the chamber walls. In a 'Pivotal' engine the only components subject to wear are the chamber surfaces, the compression seals and the bearings. Modern surface coating technology provides a wide range of material choices making it possible to achieve the service life required in almost any engine application. By pivoting the piston we have



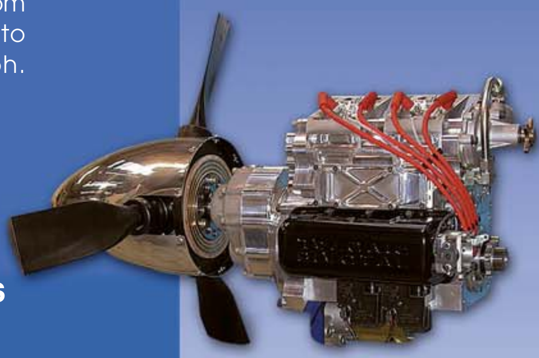
removed the high lubrication demand that is associated with the sliding piston of a conventional two/stroke engine (the cause of excessive oil loss out of the exhaust). Oil can be metered by the engine management system directly to the surfaces of parts where it is needed.

Due to this low lubrication requirement, the 'Pivotal' engine oil usage is only 10% of the level required in a conventional two/stroke engine. This rate of oil consumption is comparable with the oil consumption of a four/stroke engine before the additional saving from not having oil changes is factored in.

Creating a new concept engine takes time. The development of the 'Pivotal' design started with the construction of a single chamber 264cc engine. This engine responded well running up to 7,000 rpm. This was followed by a 400cc twin chamber motorcycle engine. This engine ran up to 11,500 rpm and drove the motorcycle to speeds exceeding 160 kph.

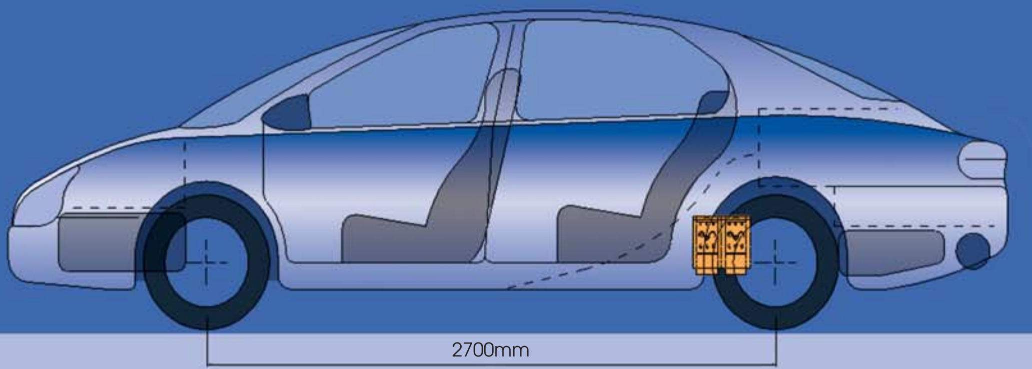
Development was then focused on the 500cc single chamber module which formed the basis for the one litre twin chamber demonstration engine.

We are currently engaged in the optimisation of a light weight engine for use in experimental aircraft. This is one of many fields where the Pivotal Engine's high power density and ability to sustain high load operation offer an advantage.



The 'Pivotal' engine is a modular design which offers real manufacturing cost reductions. A wide range of multi chamber engines can be assembled from a common supply of mass produced single chamber modules

2 Litre opposed chamber 'Pivotal' engine, located (to scale) in a modern 2 litre car. This engine position aids weight distribution (made possible due to the compact design) and reduces mechanical noise.



High power density brings many flow on benefits to vehicle efficiency, among which are a reduction in vehicle size and weight. Each component, body, engine bay, sub-frame, suspension and brakes can be reduced in size and weight giving more space for passengers and luggage. This also paves the way for improved fuel economy and a reduction in emissions by means of a decrease in power required to meet current performance criteria.

A compact and mechanically quiet engine can be ideally placed to optimise both weight distribution and space. The Pivotal Engine offers an increase in power for weight and size of around 100% over a current four/stroke automotive engine. This offers advantages to vehicle designers and can aid in compensating for the extra weight of hybrid systems or reduced power outputs of engines that utilise fuels such as military diesel and hydrogen.

In rapid response situations where emergency services or the military require heat, light, communications and water, physical size and weight are important logistical considerations as generation equipment must be transported to the location where it will be utilised.

Pivotal Engineering Ltd.

Mace Engineering Ltd.
P.O. Box 4049,
Christchurch, New Zealand
Phone +64 3 379 5750
Fax +64 3 366 3528
Email: pivotal@mace-eng.co.nz

PIVOTAL ENGINEERING

Pivotal Engineering is pursuing further development with 'direct to chamber' fuel delivery, combustion control, performance improvements, component design and materials investigations. The 'Pivotal' engine is suited to operating on alternative fuels and we are confident that the 'Pivotal' design will make a compact, high power diesel engine. The absence of mechanical noise makes it particularly suited for use in power co-generation and other auxiliary engine and military applications. We have developed a dedicated 'Pivotal' engine simulation tool and this allows us to more accurately predict the performance of a prototype engine.

www.pivotalengine.com

Patents Granted, New Zealand, Australia, China, USA, Brazil, United Kingdom, Germany, France, Italy, India.
Patents Pending, Japan, South Korea, Canada.