Z-HCCI combustion

A new type of combustion having

low emissions and high BMEP

AUMET OY

The Z*-motor company

The Z engine project

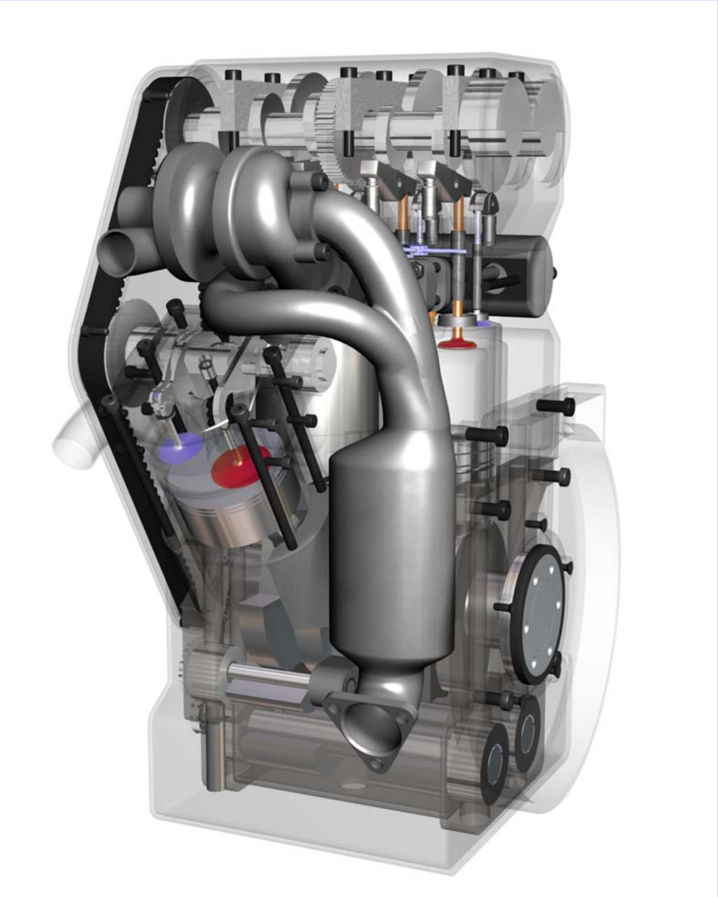
In 1999, Aumet Oy began to research a 4/2-stroke car diesel engine, called the Z engine, in co-operation with the Internal Combustion Engine Laboratory at the Helsinki University of Technology (HUT) and the Energy Technology Department at the Lappeenranta University of Technology (LUT). So far, three master’s theses, two SAE-papers and one Fisita-paper have been completed on the subject. Modern simulation tools, such as Star CD, GT-Power and Diesel RK have been used. Aumet’s research project was part of the Finnish Engine Technology Programme, ProMotor, and it is supported by the National Technology Agency Finland, TEKES. A prototype engine made its first start in December 2003 and testing of the engine started spring 2004. Since then the engine has been in a test bench at VTT (Technical Research Centre of Finland).

The NOx and efficiency measurements of the prototype engine was made at VTT at part load November 2006. The results were: NOx = 0,8g/KWh, efficiency = 35%.

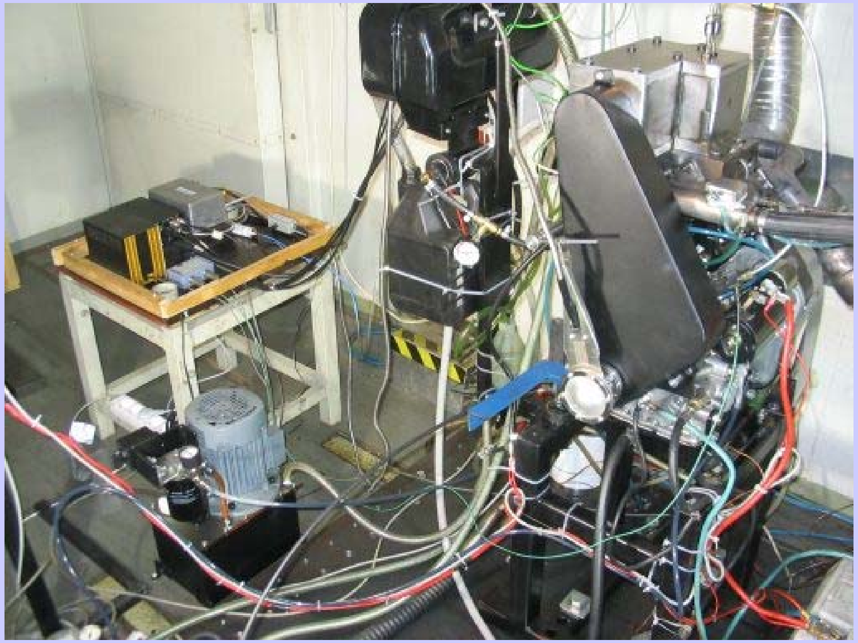
The Z engine has got five international patents until now. Several international patents are pending.

The Z engine, turbo and compressor

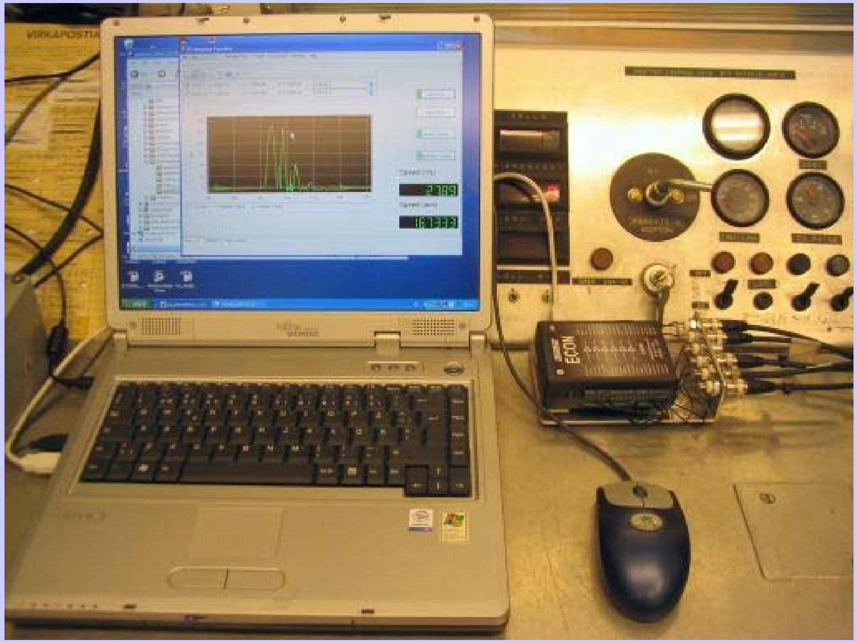
The Z engine has a pulse turbo charger and a super charger (piston compressor)



The prototype engine



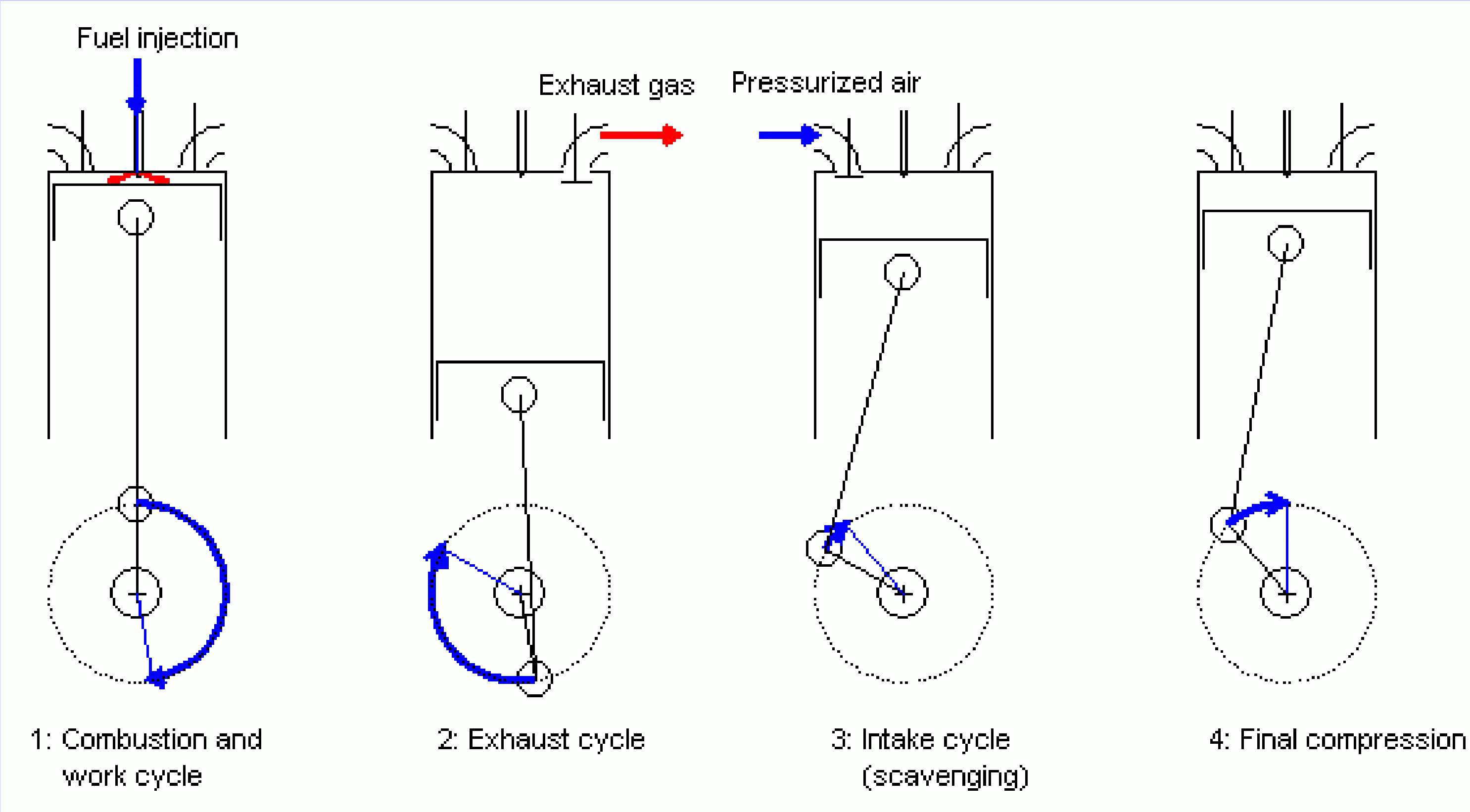
The prototype engine in the test bench



The data acquisition

The gas exchange of the Z engine

The Z engine is a 4/2- stroke engine producing work at every stroke of each piston. The gas exchange is controlled by means of poppet valves. The work cycle of the Z engine is identical to that of a 4-stroke engine.



Combustion chamber

The insulated combustion chamber after tests.

Z combustion

Heath insulated combustion chamber

Low pressure injectors

High swirl (20-40)

Lambda 1,4 – 1,7

Temperature of the combustion chamber 600 – 900 ° C

Ignition easy to control

Combustion duration 30 – 40 °

NOx = 0,8 g/kWh (deNOx phenomen)

Some problems in HCCI combustion

How to produce homogenous mixture

How to avoid wall wetting

How to control ignition

Short combustion duration

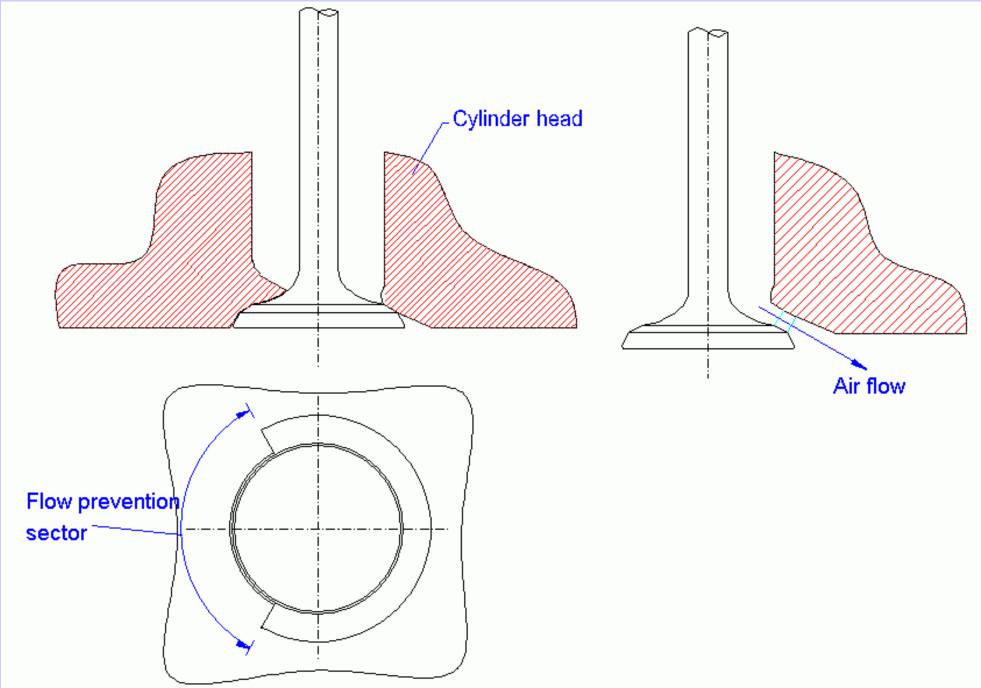
High combustion noise

CO and HC emissions

Lower efficiency

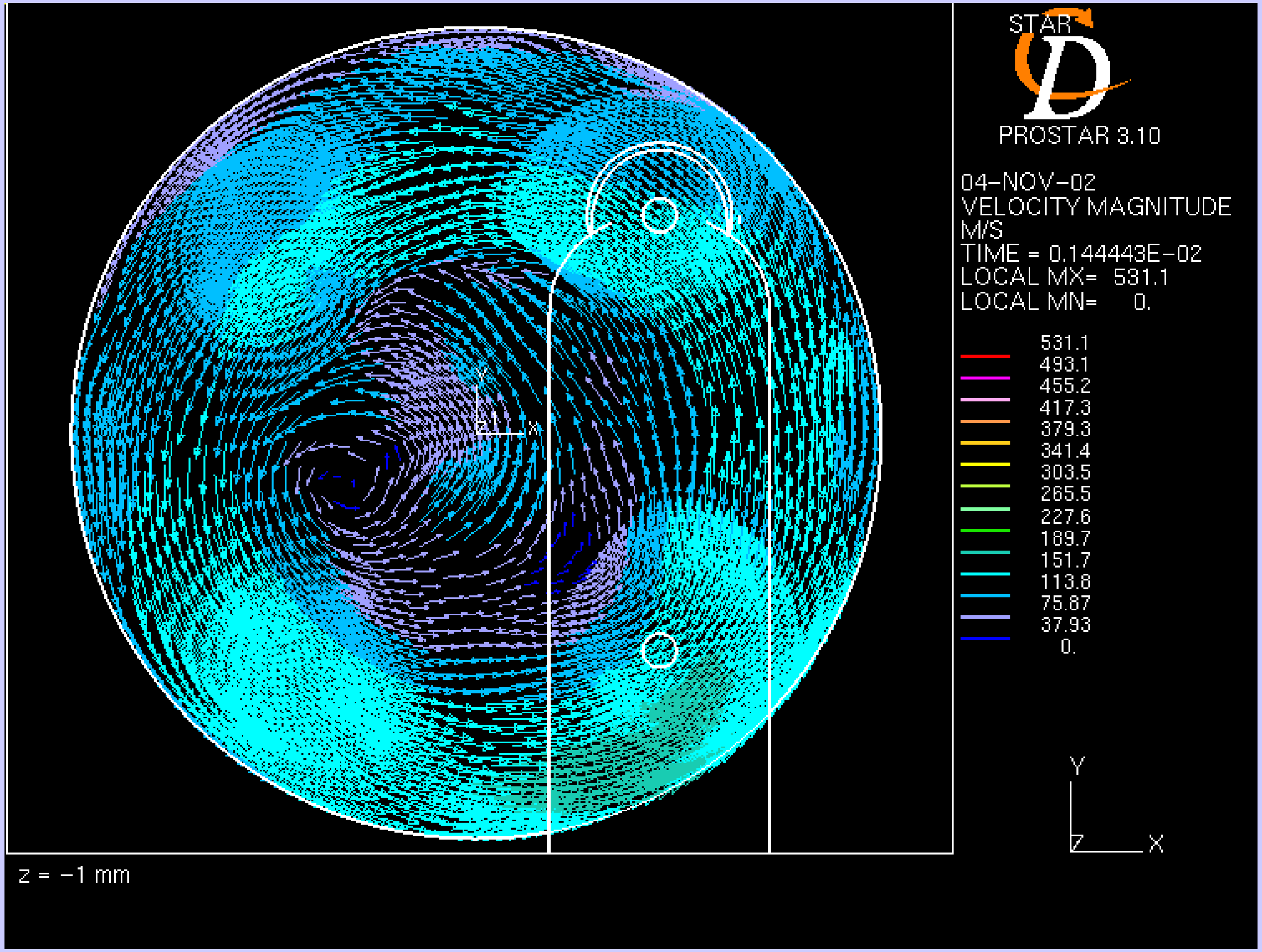
Low BMEP

The high swirl intake valves of Z combustion



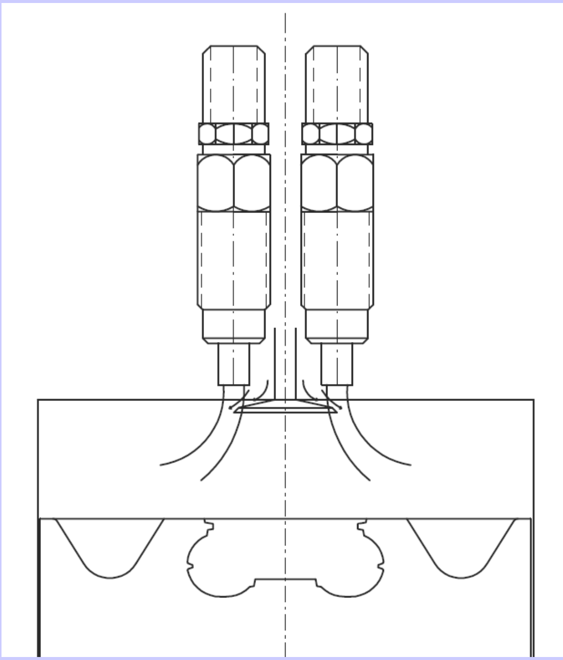
- The valves form a narrowing / widening nozzle that allows supersonic flow speed.
- The flow is prevented on certain sector to direct the combustion air tangentially into the cylinder to make a high swirl.

In cylinder flow simulation, intake valves closed

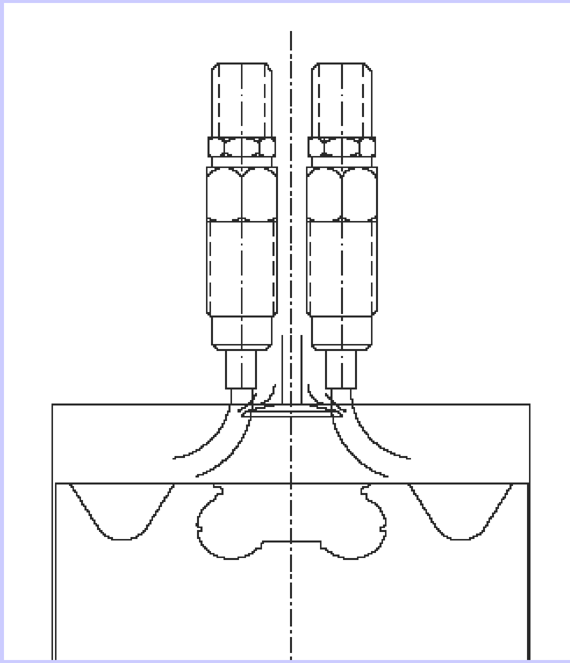


How to produce homogenous mixture in Z engine

HCCI injection starts 55° BDTC

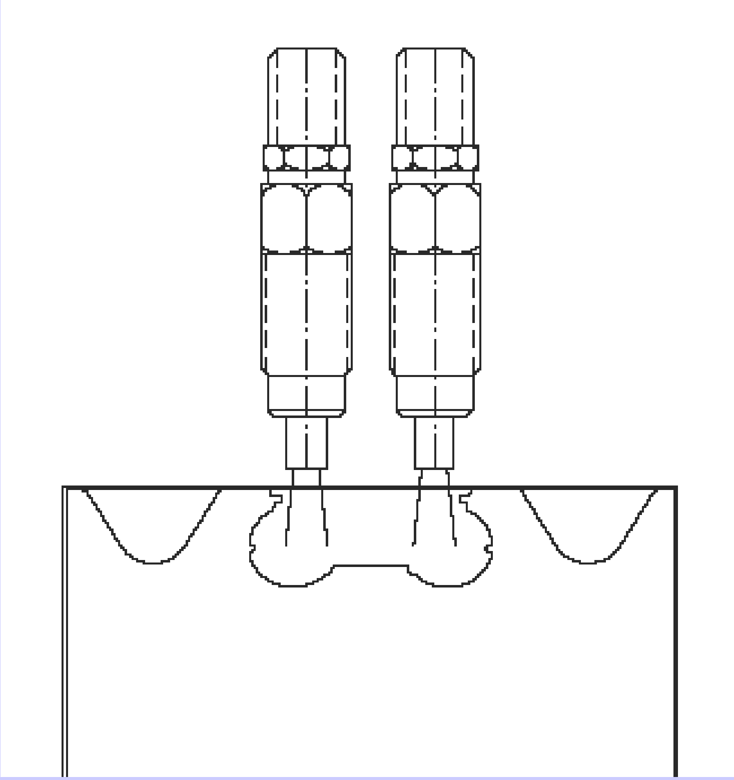


HCCI injection ends 50° BDTC



How to ignite homogenous mixture in Z engine

Z combustion ignites homogenous mixture 10° ATDC



Picture of modified piston of test engine

The three ribs brake the outer swirl down and produce high turbulence for better mixing of fuel and air

How to reach high BMEP and high power output in Z engine

Low EGR = 20%   (Tmax = 2000 K)

Low average Lambda = 1,5 – 1,7

Low compression ration = 14 – 15

Late HCCI combustion, 10 – 20° ATDC

Expansion during combustion lowers combustion noise

Expansion during combustion lowers Tmax

Slow Z combustion damps combustion noise of HCCI combustion

Right timing of combustion increases efficiency

Low heath losses

Good mechanical efficiency

Work at every piston stroke in Z engine

Comparison with Split combustion

Two combustions at the same time

Combustions in separate spaces

Easy ignition control

Late HCCI combustion possible

Very low NOx in HCCI combustion

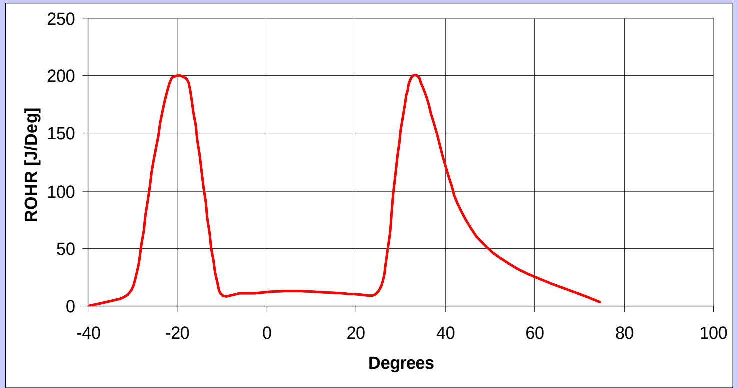
Low NOx in Z combustion (deNOx phenomen)

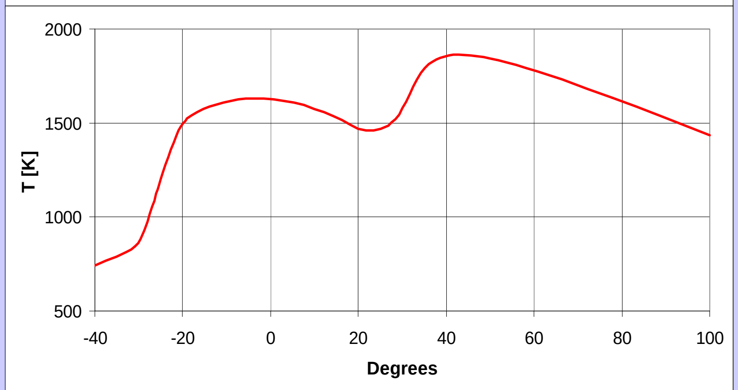
Injection rates at part load 90/10

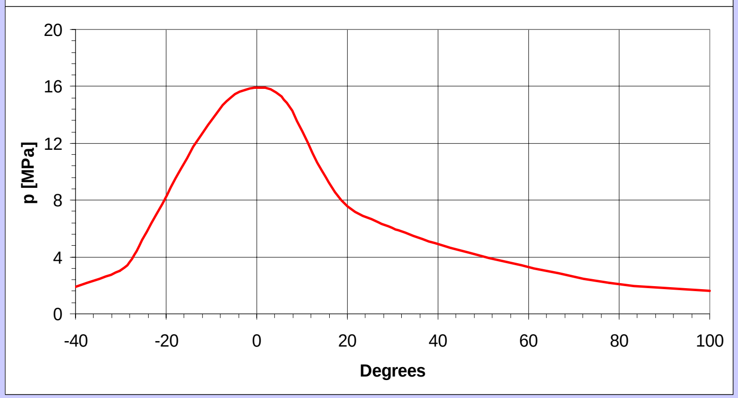
Injection rates at full load 50/50

Low injection pressure

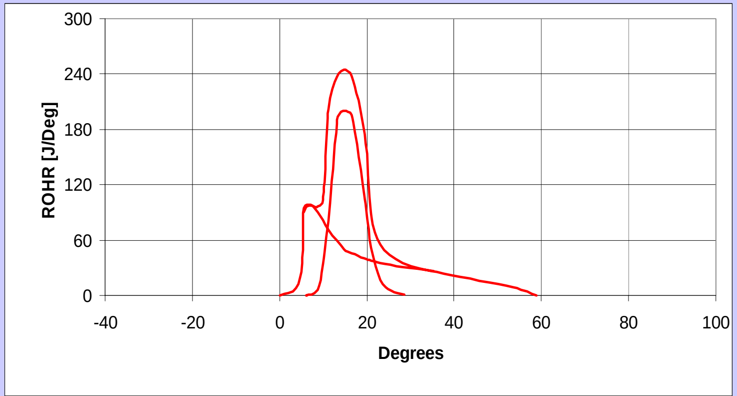
Split combustion

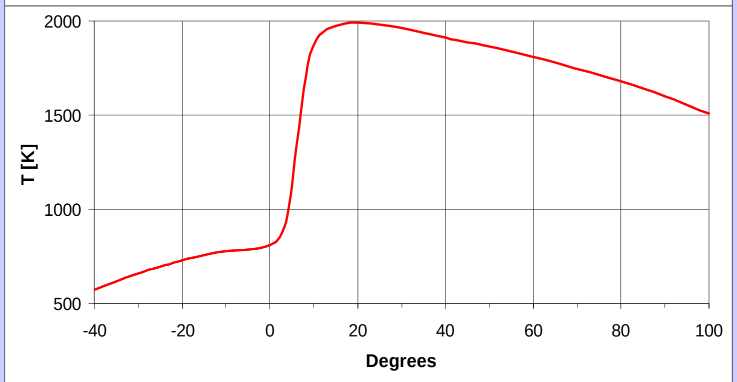


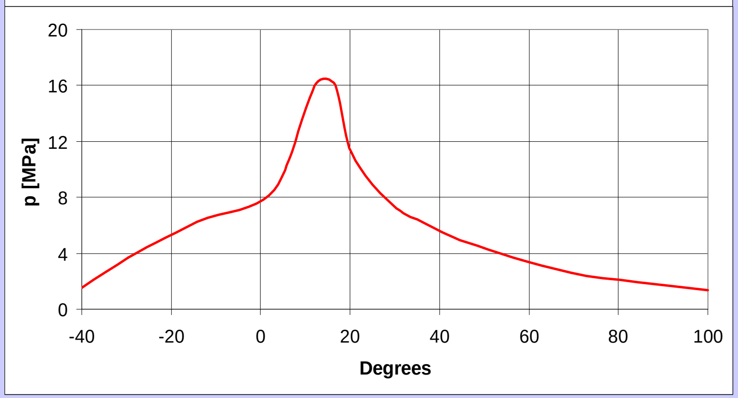




Z-HCCI combustion







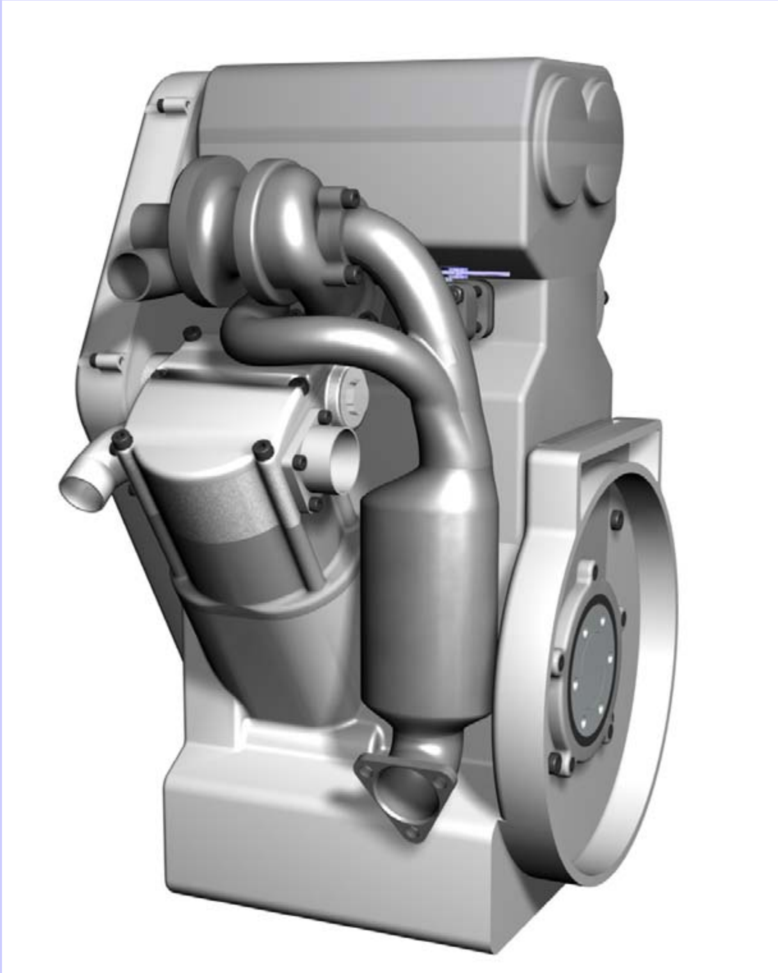
The advantages of the Z engine

- high turbulence combustion having a low NOx and particulate emission.
- low air/fuel ration independently of the load.
- high efficiency especially at part load (Atkinson cycle)
- good balancing, equal to a 4-cylinder, 4-stroke diesel engine
- small size, 30% smaller than an equal 4-cylinder, 4-stroke diesel engine
- low weight, 30% lower than an equal 4-cylinder, 4-stroke diesel engine
- low cost, 30% lower than an equal 4-cylinder, 4-stroke diesel engine
- quick warming
- good cold start behaviour (bypass of the intercooler after the compressor)
- short crankshaft, no torque vibrations
- normal components, no need to any changes in the supply chain

Comparison: the Z engine versus a hybrid system

- better overall efficiency, higher than 35% (hybrid system 25 – 28%)
- lower weight
- smaller size
- lower cost, less complex to manufacture

The Z engine, an economical alternative to a hybrid system



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