

CO2 neutral Z-engine

Low carbon automotive propulsion systems

Besides of electric cars also other low carbon solutions are needed in order to avoid to put everything on one card. Biofuels and hydrogen are important solutions for the passenger car fuels in this respect. Bio methanol can be produced for example from industrial bio char, made from wood waste and hydrogen with electrolyse from the water. To modify a gasoline car to use methanol as fuel, the costs are about 500 euro. Big tests with methanol were made in California with about 15000 cars during 1980-1990 with no problems. Some combustion engines can reach efficiencies of about 50%, equal of the fuel cells, but being about 3000-4000-euro cheaper solutions in passenger cars than the fuel cells. This is the case also with hydrogen fuelled combustion engines compared to fuel cells.

Aumet Oy have developed about 20 years a 4/2 stroke combustion engine, called the Z-engine, in the begin working with diesel and in the last 5 years with bio methanol and hydrogen. Test engine and modern simulation programs were used in this development. In the Z-engine the combustion phase and the exhaust phase are the same as in a 4-stroke engine until to about 100 deg. ABDC, but at about 100 deg, ABDC the exhaust valves close. After this very rapid intake valves open for about 12 deg. effective valve lift, causing a high turbulence in the cylinder with a good mixing of the gases. The high- pressure intake air is compressed first with a turbo charger, then intercooled, then further compressed to 10 -15 bar with a piston compressor and then intercooled again to about 50 C. After intake valves are closed, hydrogen and water injection to the cylinder. After this the final compression to TDC, compression ratio 5-8. If the gas exchange is made about 10-15 deg. later, water injection is not needed to avoid self- ignition, but efficiency is some percent lower. According to the simulations, the p-T (pressure-temperature) curve of water steam defines, if the injected water droplets (particles) evaporate before the compression, during compression, during combustion, or during expansion. This affects to the combustion of hydrogen and to the ROHR curve.

The hydrogen is injected with about 100 bars during the compression phase in to the cylinder, 130-160 deg. ABDC. The ignition with the spark close at the TDC. The very high evaporation heat of the water and high Cp of the evaporated water steam and the high intercooling rate of the high-pressure intake air makes the TDC temperatures less than 750K possible, also reducing the compression work. Efficiency up to 55% can be achieved in the hydrogen fuelled Z-engine. Expansion ratio in Z-engine is 32:1.

The very rapid valve mechanism, tested two years with the prototype engine in the testbench, makes the unique gas exchange process of the Z-engine possible. Contact pressures between the Cronidur 30 steel cams and silicon nitride cam follower rolls are maximal about 2 GPa, but with Cronidur 30 steel the contact pressure up to 3 GPa with this combination is allowed (FAG). A gas spring is used in intake valve in order to avoid vibrations.

The simulated Z-engine with hydrogen was: 2 cylinder: 80*80 mm, 0.8 l, compressor cylinder :100*90 mm, 2700 rpm, expansion ratio: 32:1, 158 kW, BMEP: 43.7bar, Torque:559 Nm, Tmax: 2103 K, pmax: 247 bar. BTE: 55%, includes heat pump for condensing water from exhaust gases.