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Towards 60% fuel efficient engine

The internal combustion engine has great potential for high fuel efficiency. The ideal otto and diesel cycles can easily achieve more than 70% thermodynamic efficiency. The problems come when those cycles should be implemented in a real engine. Extreme peak pressure during the cycle will call for a very robust engine structure that in turn will increase friction and hence reduce mechanical efficiency. A very high compression ratio also increases the surface to volume ratio and promote heat losses, taking away much of the benefits from the theoretical cycle, see Figure 1.

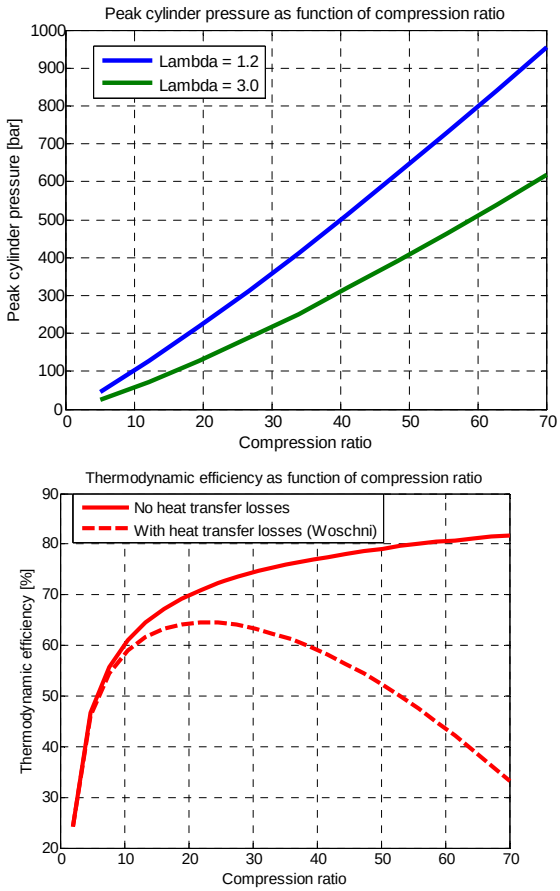

Figure 1: Peak pressure for an ideal cycle and the thermodynamic efficiency of the cycle without and with heat losses.

The presentation starts with a standard SI engine and it's efficiency as a function of load. Then a high compression ratio SI with be introduced and compared with the same engine operated in HCCI mode. The four efficiencies of SI as well as HCCI is shown in Figure 2.

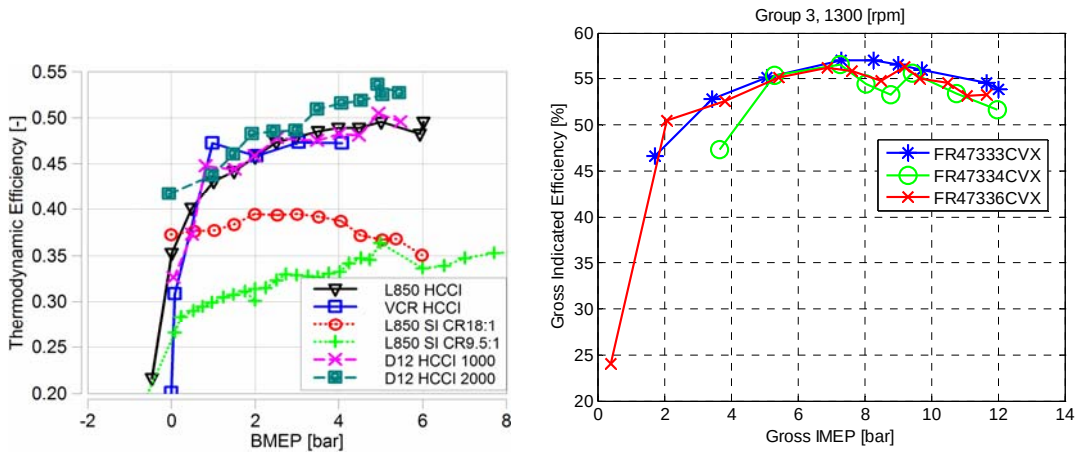

Figure 2: Thermodynamic efficiency of SI and HCCI engines and to the right PPC combustion

A next step is the results with Partially Premixed Combustion. With PPC the indicated efficiency was shown to be up to 57%, thus 10% up from the best HCCI engine of 47%, see Figure 2. However, to get the very high efficiency a high dilution level is needed. This is a challenge for the gas management system and hence gas exchange and mechanical efficiencies can suffer.

The final part of the presentation is giving an engine concept that can enable the conditions for PPC combustion but with much improved gas exchange and mechanical efficiency. It enables an effective compression ratio in excess of 60:1 but with much less cylinder surface area. The concept also enables low friction and hence high mechanical efficiency. The basic concept is explained and initial simulation results are presented. Figure 3 shows the concept with two large and two small cylinders.

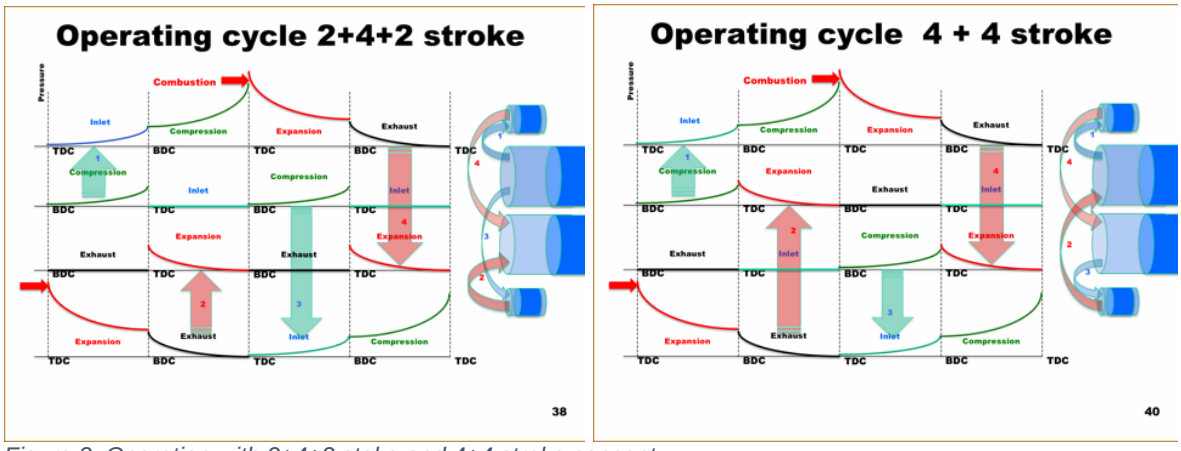

Figure 3: Operation with 2+4+2 stoke and 4+4 stroke concept.

The resulting results are shown in Figure 4. The concept can combine excellent thermodynamic efficiency with good mechanical efficiency and hence can approach 62% brake efficiency.

	Unit	DCEE λ=1.2	DCEE λ=3.0	CI λ=1.2	CI λ=3.0
Combustion efficiency (assumed)	%	100	100	100	100
Thermodynamic efficiency	%	57.7	61.9	48.9	55.9
Gas exchange efficiency	%	98.2	97.5	99.2	99.5
Mechanical efficiency	%	96.1	92.8	86	71.6
Brake efficiency	%	54.5	56.0	41.7	39.8

Figure 4: Results from simulations with GT-Power.