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Effect of Pre-chamber Volume and Nozzle Diameter on Ignition Characteristics in a Truck Size Natural Gas Engine

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The presentation started with a new way to express the different practical combustion concepts within a triangle. This triangle has three corners with Spark ignition (premixed flame propagation), Compression Ignition (non-premixed flame propagation) and Homogeneous Charge Compression Ignition, HCCI, (bulk auto ignition) as shown in Figure 1. Also shown are the locations of a number of mixed combustion concepts like Partially Premixed Combustion, PPC, Spark Assisted Compression Ignition, SACI, Reactivity Controlled Compression Ignition, RCCI, the dual fuel concept and prechamber SI. Also diesel pilot Ignition was shown and discussed.

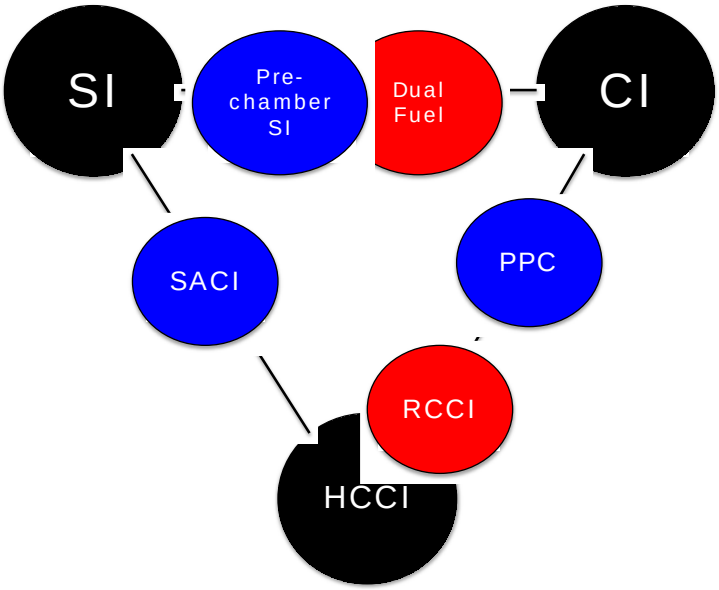

Figure 1: The three corners of combustion and some practical engine concepts within the triangle formed.

The RCCI, dual fuel and diesel pilot are all dual fuel with often natural gas as the high octane fuel and diesel fuel as the low octane part. The difference is the timing of fuel injection. With RCCI the diesel fuel is injected at 60 and 30 BTDC and thus the charge is rather homogeneous at the time of combustion. With dual fuel the diesel injection is close to TDC as in a classical diesel. The third one is diesel pilot in which the diesel is injected as in the classical dual fuel but the natural gas is injected after the combustion started. Thus the combustion will be much like the classical diesel with all the pros and cons of that processes. If a 100% natural gas engine is needed the prechamber SI engine is an option. Here a rich mixture is ignited in the prechamber, a flame is propagating though the prechamber during which jets are shooting out into the main combustion chamber. Here the jets ignite the very lean premixed charge.

The presented results are from a study with different volume of the prechamber and hole sizes from prechamber to main chamber. The results were from a Scania truck size engine with 130 mm bore and 160 mm stroke The Engine and prechamber layout are shown in Figure 2.

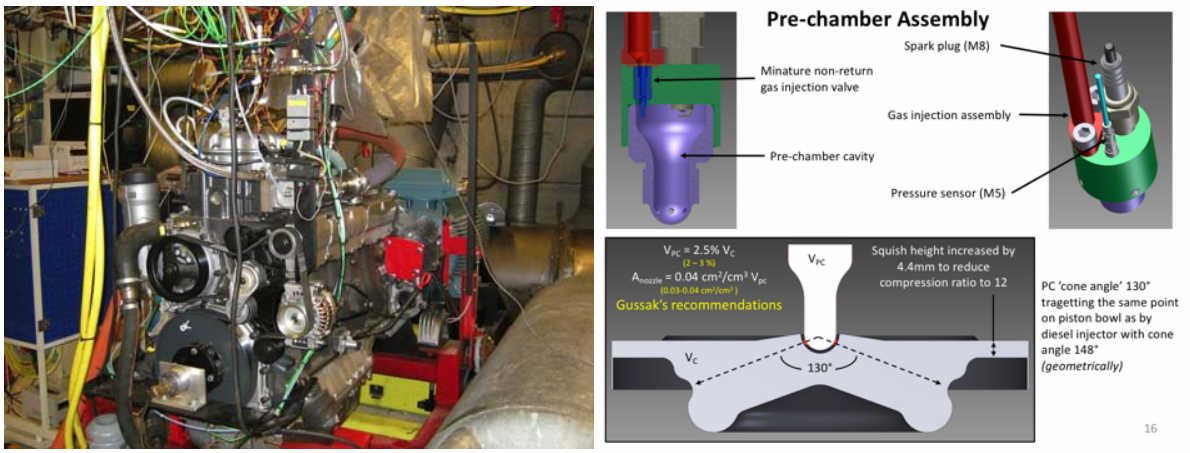

Figure 2: Engine and prechamber layout.

The test matrix is shown in Figure 3 together with the pressure buildup in the prechamber with different hole sizes. It is clear that small holes enable a larger pressure difference between prechamber and main chamber. This gives a significant effect on the main combustion duration (10-90% HR) as shown in Figure 4. The early combustion (0-10%) is more affected by the size of the prechamber. A large prechamber gives more ignition energy and hence faster early combustion. With a larger prechamber more NOx was generated but combustion was also more stable enabling a leaner mixture.

		A	B	C	D	E
		Pre-chamber volumes [cm3]				
		2,68	3,65	4,64	5,84	7,25
% Vc		1,40	1,90	2,40	3,00	3,70
Area ratio Apc/ Vpc		Hole diameters [mm]				
1	0,025	1,0	1,2	1,4	1,5	1,7
2	0,030	1,1	1,3	1,5	1,7	1,9
3	0,035	1,2	1,4	1,6	1,8	2,0
4	0,040	1,3	1,5	1,7	1,9	2,1
5	0,045	1,4	1,6	1,8	2,0	2,3
Rc		12.1	12.04	11.98	11.92	11.84

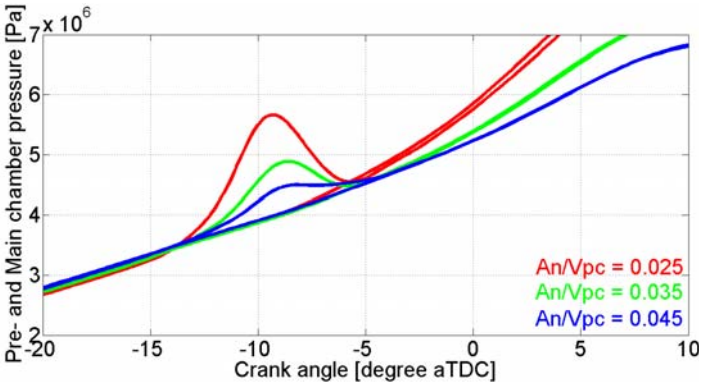

Figure 3: Experimental setup and pressure buildup with different hole sizes.

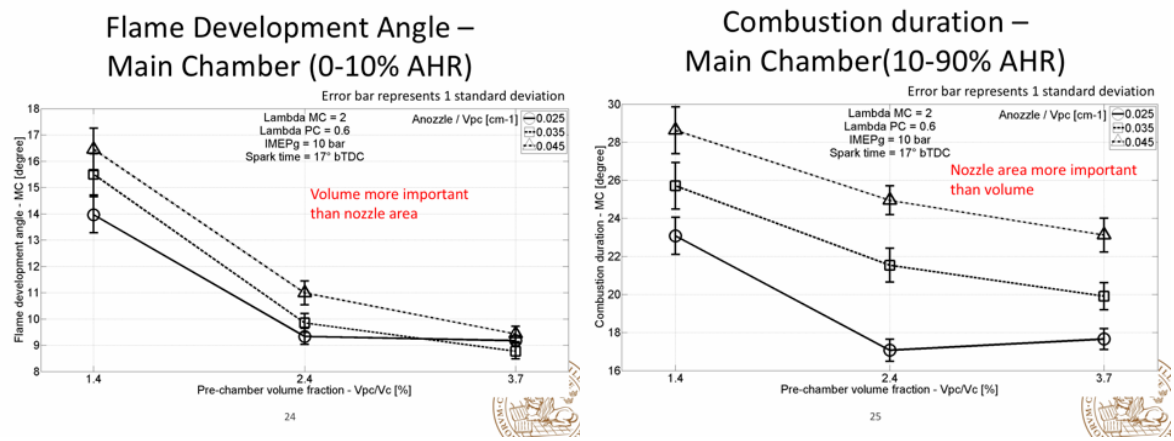

Figure 4: Early combustion and later parts affected by volume and hole size.