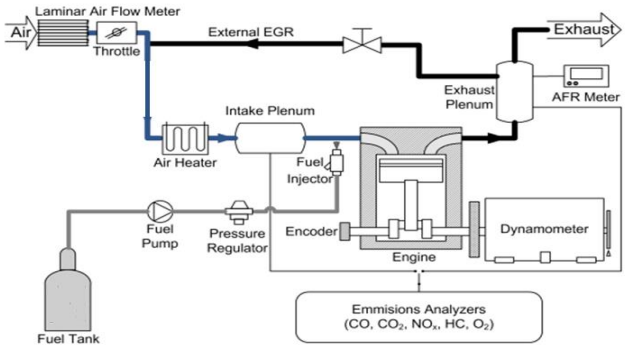
HCCI Engine

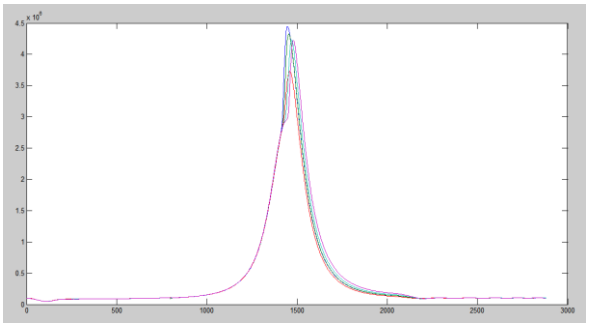
Advancement report.

I/ Presentation of the problem.

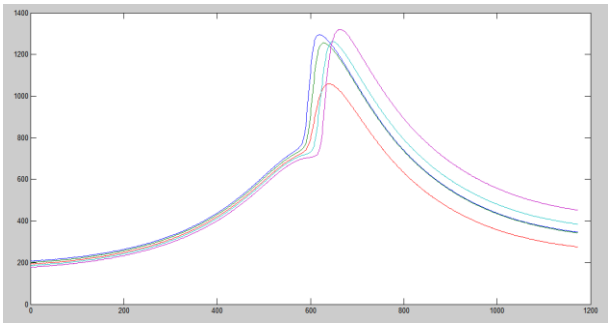
The Ghent University team uses a pressure and a temperature sensor inside the engine in order to acquire valuable data in the test bench.



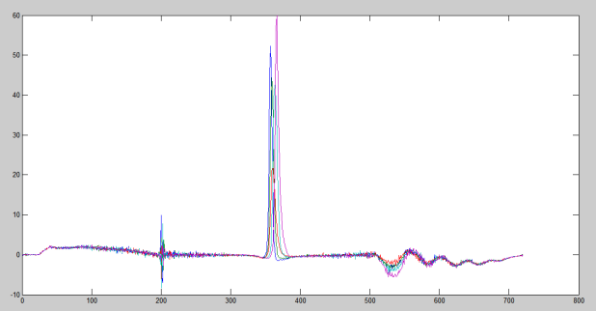
After the reception of the test bench data and a first analysis of it, we started to study the first problem we have to deal with: how to detect the ignition time by using those practical curves.



Cylinder pressure/crank angle



Cylinder temperature/ ?



Dq/Dtheta

Actually the ignition time can't be determined at first sight, in all the curves many particular points and steps can be seen, and we have to determine which one is the ignition point.

The practical data are made up from 5 different tests with different initial conditions, all of this is resume on a table.

Question: TFG

II/ A short review of ignition time detection methods.

Most of the actual detection method for HCCI engine control are focused on the CA50 detection and not the combustion beginning point. Actually the CA50 point is more stable and has a high robustness against noise.

1) Thermal modeling based detection method.

The crank angle of auto-ignition can be determine by using the Arrhenius type condition :

$$\int_{\theta_{\mathrm{IVC}}(k)}^{\theta_{\mathrm{ign}}(k)} f_k(\theta) d\theta = 1$$

Fulfilled with

$$f_k(\theta) = A_a P_{in}^n \mathcal{V}_k(\theta)^{\gamma n} \exp\left(-\frac{E_a \mathcal{V}_k(\theta)^{1-\gamma}}{R T_{1+}(k)}\right)$$

The resulting integral equation is solved for :

$$\theta_{\mathrm{ign}}(k) = \Delta\theta_A + \frac{1}{f_k(\theta_{\mathrm{TDC}})}$$

2) Signal processing based detection methods.

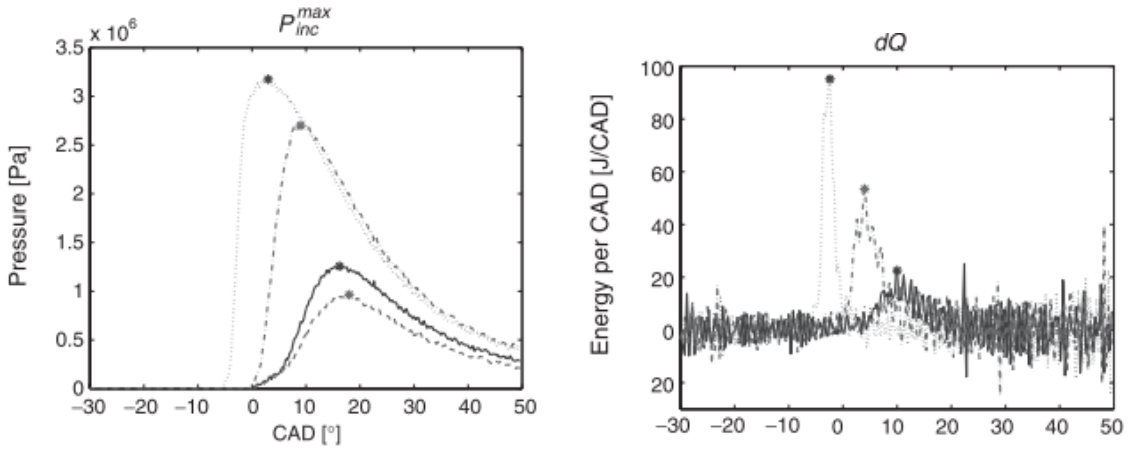
There are some methods to determine the CA50. We can determine it by using one of the following methods on the experimental data.

CA50 based on Q^{net}_{HR} : the CA50 can be determined when the Q_{HR} reaches half its maximum value.

CA50 based on p^{MAX} : The CA50 point can be determined when the pressure in the cylinder reaches is maximum value. This method is based on the assumptions that the combustion behaved in a good way.

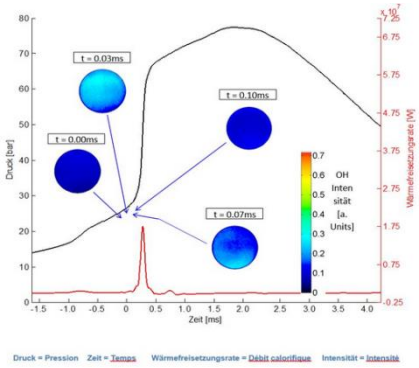
III/ Theoretical working curve.

The literature provides different ways to detect the CA50, based on the study of the pressure and the heat release.



The CA50 crank angle is symbolized by the point at the top of each curve.

Another study allows us to approximately determine the ignition beginning time by using the pressure curve.

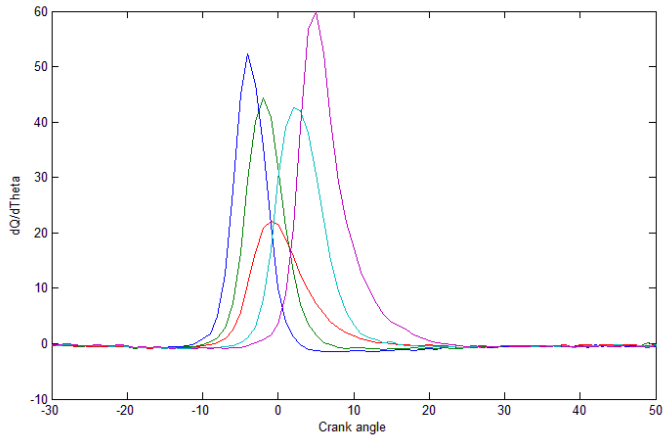


IV/ Experimental results.

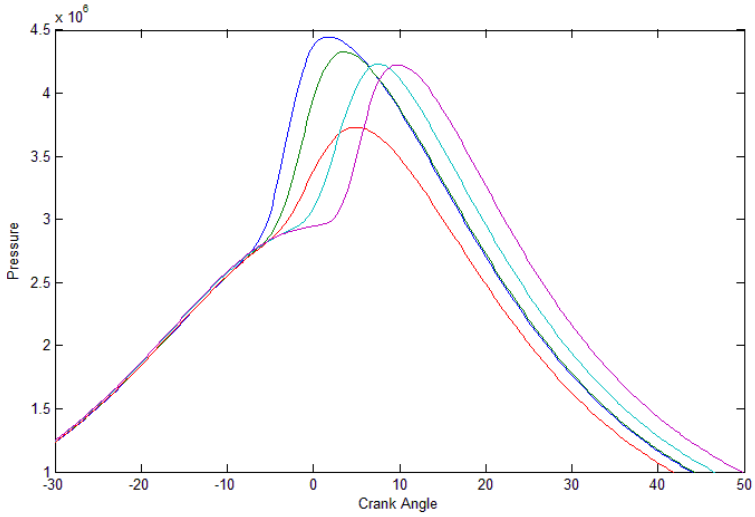
By using the information found in the literature we ca determine the CA50 position on our own curve.

There are different methods to determine the CA50. We can estimate the CA50 by using $Q_{HR,}$ the full heat release, dQ_{HR}, the derivation of Q_{HR}, p^{max}, the maximum pressure. Thank to the data, we have determine the CA50 by using the pressure and the derivation of the heat flux.

N° test	CA50 from pressure	CA50 from dQ/dTheta
1	1.75°	-3°
2	3.5°	-1°
3	5°	0°
4	7.5°	3°
5	9.75°	6°



Experimental data: dQ/dTheta



Experimental data: pressure

We can see that there are differences between CA50 from pressure and CA50 from dQ/DTheta.

Using the pressure to determine the CA50 isn't a good solution because, in cases of early or late combustion, p^{max} fails to give an estimate of the CA50. P^{max} is not sufficient for estimating CA50.

CA50 based on Q_{HR} is assumed to be the real CA50.

Method CUSUM from Basseville and Nikiforov

This method is a sequential analysis technique. It is used for monitoring change detection. We want use this method to detect the auto ignition moment by using an adaptive threshold.

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