LaVision
FOCUS ON IMAGING

In Application

In-Cylinder Time-Resolved Air/Fuel-Ratio Measurement

ICOS - CNG System

Introduction

New engine developments for significant carbon dioxide reduction are focused on using methane or **Compressed Natural Gas** (**CNG**). The stratification of these gases with fresh air is different compared to liquid fuels due to the mixture formation. So knowledge about highly time-resolved air/fuel-ratio evolution within each cycle is necessary for fitting of engine parameters.

Measurements with LaVision´s **ICOS-CNG** system show the possibility of analyzing the gas/air-mixture formation by using ultrafast infrared absorption technique. In-cylinder air/fuel ratio evolution in gas engines is measured with crank angle resolution.

Principle

Methane is a well-known molecule and its light absorption is documented in spectral databases (see Figure 1). Absorption lines in the spectrum show diverse response to temperature and pressure changes. The **ICOS-CNG** system uses two detection units with different filters to select parts of the spectrum with unequal infrared light absorption. At a given pressure the correlation of the detector signals with database values gives the absolute molecule density and with this the air/fuel-ratio is derived. For methane calibration measurements in a pressure cell with known gas concentration corrects the spectral influences of optical components in the system.

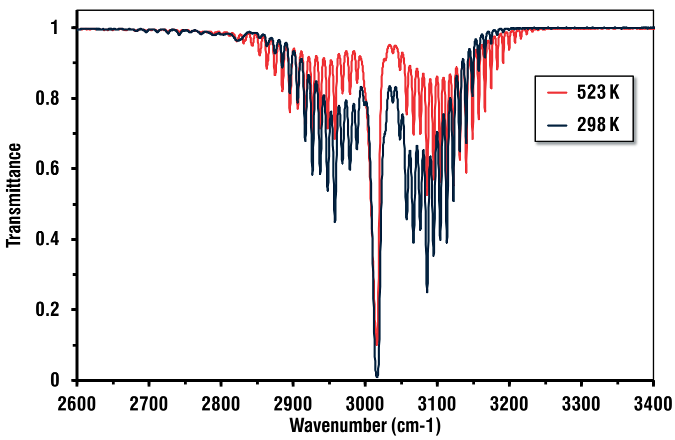

Figure 1*: Infrared spectrum of methane at different temperatures*

Engine Measurements

Measurements inside a gas engine with direct port injection were done with the **ICOS-CNG** system using a spark plug probe. First methane was used as fuel and the engine runs at constant conditions. Figure 2 shows the evolution of the air/fuel-ratio at the spark plug with an early injection at different applied air/fuel-ratios. The fuel concentration is not constant but changes from lean to rich before stabilizing at the time of ignition. This is an indication of the mixture formation.

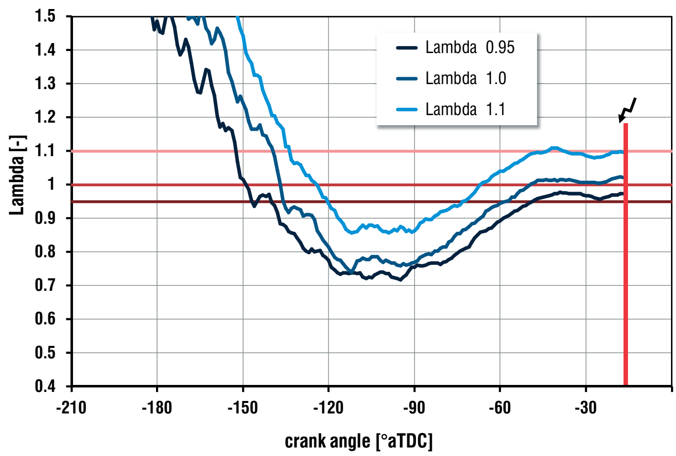

Figure 2*: Crank angle resolved air/fuel-ratio at methane gas engine with injection*

Engine Parameter	
Engine	one-cylinder test engine
Bore diameter	74.5 mm
Stroke length	86 mm
Rod length	140 mm
Compression ratio	8
Inlet valve closing	-184°aTDC
End of injection (EOI)	-334°aTDC
Inlet air temperature	295 K

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Calibration of CNG

In contrast to methane the molecular composition of **Compressed Natural Gas** (**CNG**) is not defined. Therefore, there is no individual spectral database for this gas. But the database of its major component methane can be used for the correlation process of the detection signals. Only one constant well-known engine condition has to be used for the recalibration of the system. Figure 3 shows the effect of this step. Using the methane calibration the calculated air/fuel-ratio for CNG fuel is incorrect (dark curve). When the parameters are adapted the air/fuel-ratio corresponds to the measurement with methane fuel.

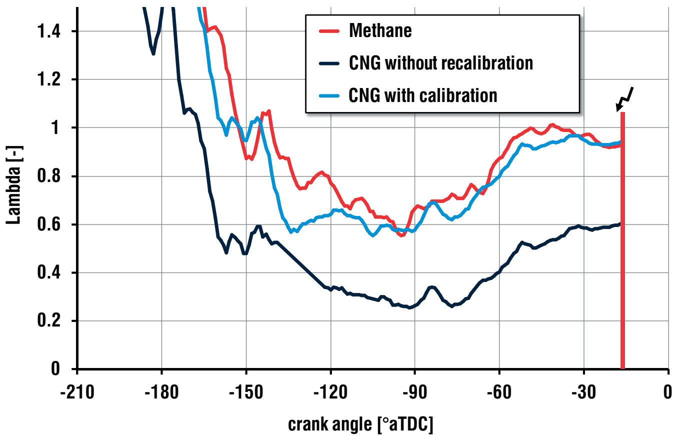

Figure 3: Recalibration of the ICOS system for CNG fuel

System Features

- no gas sampling, measures directly inside the cylinder
- no modifications of the engine needed
- precise single cycle analysis
- fully resolved consecutive cycles for measurement of transient phenomena
- crank angle resolution

Application

- crank angle resolved air/fuel-ratio measurement in gas engines
- investigations of highly dynamic engine conditions
- analysis of gas mixture formation

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