Control of CI Engines for Efficient and Robust Biomass Utilization

Dr. C. R. Koch[1], A. Kumar[2], P. Mussone[3]

BACKGROUND

Internal combustion engines have been a major contributor to climate change. Biomass derived fuels are a reasonable alternative to fossil fuels and represent a closed loop cycle of CO_2 production, with sources being offset by equal sinks.

Characterization of biomass derived fuels is required to ensure that combustion is occurring efficiently. This will allow for proper engine controls to be implemented to minimize fuel consumption and ensure proper catalytic conversion of exhaust emissions. This is especially important in order to avoid combustion regions associated with high emissions production.

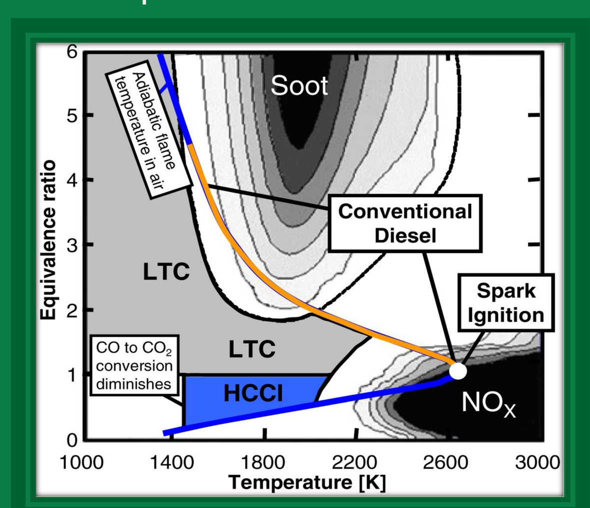
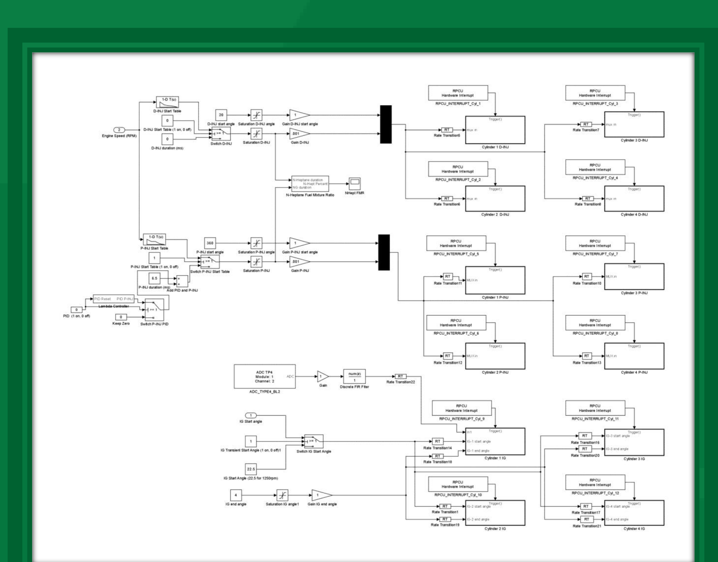


Figure: Regions associated with emission production

SHORT-TERM OBJECTIVES

The objectives of this project are to examine how CI engines can efficiently use biomass generated OME fuels. Short-term objectives include:

- establish a collaboration with RWTH Aachen University in the area of tailor made biofuels
- implement OME biofuel injection system on a single-cylinder engine
- establish a framework for integrated and in-cycle control of biomass derived fuel
- develop in-use fast emission sensors with industrial partners
- formulate a biomass fuel development program for CI engines



PROJECT OVERVIEW

COMBUSTION CONTROL BY VARIABLE VALVE TIMING

HCCI combustion timing will be regulated through the use of Variable Valve Timing (VVT) on a cycle by cycle basis. In this experiment, a single cylinder engine is outfitted with electro-magnetic valves shown below and a fully variable Engine Control Unit (ECU) which allow for the valve lift profile to be varied every cycle.

To control the ignition timing, the cylinder pressure will be measured and used to predict the combustion timing of the following cycle. Using this prediction, the Negative Valve Overlap (NVO) duration of the following cycle will be varied to change the amount of hot exhaust gas that is retained in the cylinder. This directly affects the temperature before combustion and influences when the air and fuel mixture ignites.

Various control strategies will be tested and compared on not only their ability to regulate combustion timing but also combustion stability and operating range of the engine.

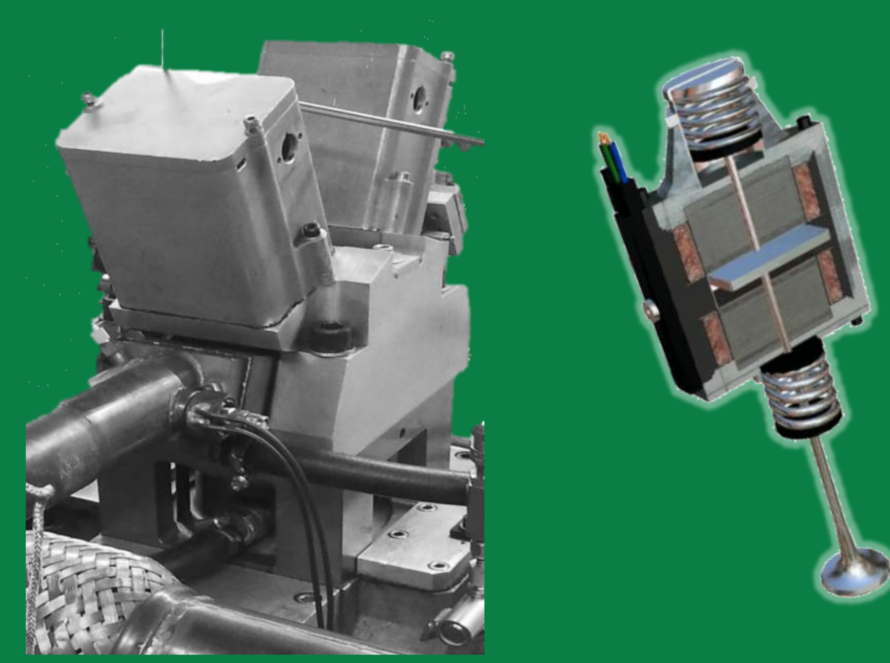


Figure: Electro-magnetic valves for VVT

CATALYST TESTING

Automotive catalysts are required to reduce exhaust emissions and to meet increasingly stringent regulations. Catalysts are highly susceptible to operating conditions, including the exhaust temperature and composition, which can have a significant effect on the conversion efficiency.

In order to maximize the conversion efficiency of the catalyst, the catalysts need to be tested using biomass derived fuels to ensure.

HOMOGENOUS CHARGE COMPRESSION IGNITION

Homogenous Charge Compression Ignition (HCCI) is a combustion method utilizing a lean burning low temperature combustion. The premixed air and fuel charge is ignited though increased cylinder pressure and temperature. As no direct ignition method is utilized, control of combustion timing is very difficult.

The benefits of HCCI combustion include significantly reduced NOx and soot emissions and decreased CO2 production and fuel consumption. HCCI is a promising method of meeting increasingly stringent government emissions regulations.

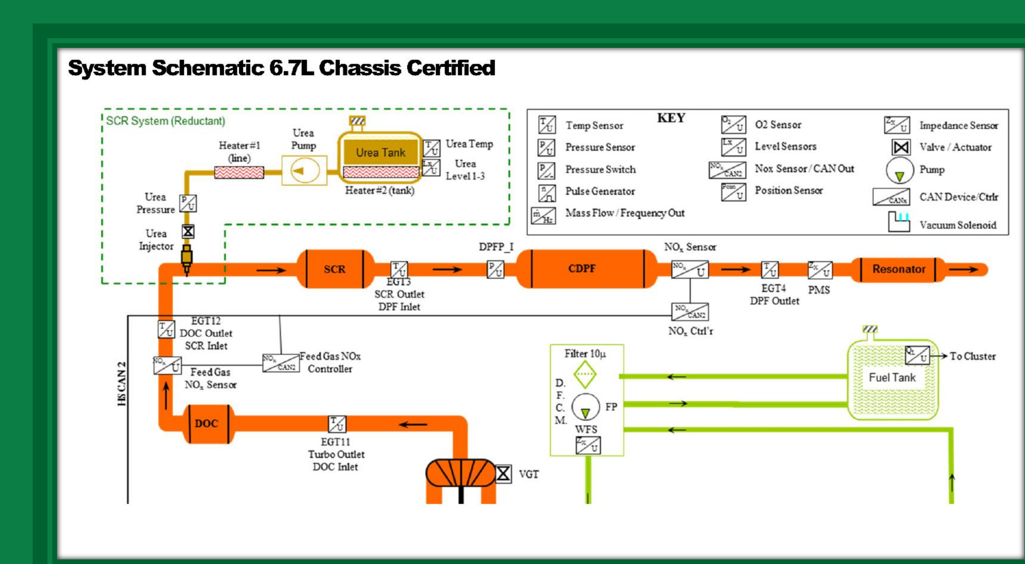


Figure: Exhaust after treatment for a CI engine

THEME OVERVIEW

Biomass

We already know how to create fuels from certain types of biomass, but many other feedstocks can potentially be transformed in a similar manner. In order to identify new viable sources, we must develop more a sophisticated understanding of the technological processes that might be used to convert biomass to fuel, and assess the potential business cases for adopting certain sources that might have other economic uses, or compete with established cash crops. We can also explore the potential for tailor-made fuels for the transportation sector, developed from biological sources.

EXPECTED OUTCOMES

The project aims to increase the use of biomass derived OME fuels. The objectives of the research are to accomplish the following:

- Optimize combustion for high efficiency/high load OME compression ignition engines
- Optimize exhaust after treatment, including catalyst and exhaust sensors, for OME fuels
- Help establish OME fuel supply
- Road testing of OME fuels with collaborating partners

The project aims to generate proof of concept for a pathway to efficient and low emission biomass utilization in compression ignition engines. This would allow product diversification and a method for the biomass conversion industry to enter the market.

http://hardwoodbiofuels.org/news-and-events/feature-stories/understanding-the-carbon-balance-of-biofuel-production/

EXTERNAL PARTNERS

vka Lehrstuhl für Verbrennungskraftmaschinen | RWTH AACHEN UNIVERSITY

ECM ENGINE CONTROL AND MONITORING

[1]Univeristy of Alberta, Mechanical Engineering, Edmonton, [2]University of Alberta, Mechanical Engineering, Edmonton, AB, [3]NAIT, Edmonton, AB

UNIVERSITY OF ALBERTA FUTURE ENERGY SYSTEMS

CANADA FIRST RESEARCH EXCELLENCE FUND

This research has been undertaken thanks in part to funding from the Canada First Research Excellence Fund.