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THE UNIVERSITY OF BRITISH COLUMBIA

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MECH 493 project: Development of a Laser Based Emission Sensor for Dynamic Engine Testing

Background and research goal

The emissions and fuel consumption of internal combustion engines are a key development consideration as these have significant impacts on human health, air quality, and resource consumption. The reduction of emissions and fuel consumption is an integral goal of engine research; however much of this development happens in laboratory conditions under steady state operating conditions – far from how the majority of engines are used. The emissions and fuel consumption during dynamic operation (e.g., acceleration or load changes) are very different than those during steady state operation and significantly impact the overall performance of the engine. Characterizing the emissions and combustion events on a cycle-by-cycle basis is very challenging, and the lack of suitable emission instrumentation is a limiting factor for engine development.

Engine researchers and developers require instrumentation capable of characterizing engine pollutants and engine operating conditions with very high temporal resolution, ideally on a cycle-by-cycle basis. One potential technology for providing such information is the characterization of gas phase concentrations using Tuneable Diode Laser Absorption Spectroscopy (TDLAS). TDLAS is a light extinction measurement technique which can provide gas specific concentrations with sufficient temporal resolution; however, its reliable application to internal combustion engines requires a robust and self-cleaning sensor design. The goal of this research project is to design a TDLAS system for the measurement of exhaust stream methane emissions from a natural gas engine.

Tasks to be performed by the student

- Literature review of TDLAS applied to combustion systems, engines, and methane measurement
- Development of an analytical model for determination of system parameters (wavelength, modulation frequency, beam length, etc.) and estimation of system performance (temporal resolution, signal to noise ratio, detection limits, etc.)
- Sourcing of suitable optical components (diode lasers, control electronics, detectors, optical fibers, etc.)
- Proposal for a calibration strategy
- Design of mounting system for use in engine exhaust, including provisions for minimizing contamination of optical components
- If time permits, assembly/fabrication of prototype sensor for bench top testing.
- Documentation of the above in a technical report and final presentation

Facilities and team:

This project will be carried out within the Clean Energy Research Center (CERC), in the Engine and Combustion Research Group. The activities will be supervised by Dr. Kirchen, though the student will be integrated into the research group and is expected to collaborate with graduate students working in the area of natural gas engines. Any experimental work will be carried out in CERC, under supervision of a PhD student and Dr. Kirchen. Progress meetings will be held every ~2 weeks. Depending on the progress of the design and analysis of the sensor system, a suitable budget will be made available for purchasing of components for the prototype system.