a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

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MECH 493 project: Background-Oriented Schlieren Imaging of In-Cylinder NG Fuel Jets

Background and research goal

Significant research and development efforts towards reducing heavy duty engine fuel consumption and emissions of greenhouse gases has lead researchers to investigate alternative fuels such as natural gas. At UBC's Clean Energy Research Centre (CERC) a long-running research partnership with Westport Fuel Systems has yielded significant advancements in the field of heavy-duty internal combustion engines (ICEs) fueled with natural gas and diesel using conventional engine testing methods. To continue to advance the state of the art in heavy-duty natural gas ICEs, our research group has developed an optically-accessible heavy duty research engine, which permits high-speed photography of the combustion processes within the cylinder during engine operation. With the recorded images, an enhanced understanding of the combustion phenomena across a variety of ICE technologies (*i.e.* diesel, bio-diesel, port-injected natural gas, direct-injected natural gas) is being developed.

To complement existing in-cylinder combustion imaging diagnostics, preliminary development of a background oriented schlieren (BOS) diagnostic to perform in-cylinder imaging of gaseous fuel jets has been undertaken. A bench-top BOS system has been developed using simplified targets and hardware. The current project has two primary objectives: i) adapt and optimize the bench-top BOS system for application on the optical engine facility, ii) develop tools and methods for analysis of the BOS data recorded on the optical engine facility.

Proficiency with MATLAB scripting is mandatory. Experience with image analysis and/or familiarity with internal combustion engines (*e.g.* completion of MECH 478) are assets, but not mandatory.

Tasks to be performed by the student

- Literature review of methods for post-processing BOS and conventional schlieren images to estimate density fields
- Development of a MATLAB script that processes raw BOS image sets and returns fields of refracted light angle for each frame
    - Commented code and supporting documentation to be prepared
- Development of a method to estimate the density field based on field of refracted light angle (this activity to be supported by a post-doc)
    - White paper describing the mathematical/physical basis for the method including known limitations
    - Development of MATLAB analysis tools required to implement the proposed method
- Demonstration of BOS system imaging fuel jets in the optical engine facility (this activity to be supported by a senior PhD student)
    - Design/specification of any hardware needed to apply the bench-top BOS system to the optical engine facility
    - Design of experiments to illustrate the performance of the BOS system on the optical engine facility
- Depending on the degree of project progress and the student's level of interest and ability, co-authorship of a publication on the developed analysis techniques will be possible.

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. It is expected that the bulk of the research activities can be performed using existing datasets, however the student may need to conduct some independent bench-top testing. All on-engine testing will be directly supervised by a senior PhD student. Progress meetings will be held every ~2 weeks, however more frequent informal meetings will be possible when required.