a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

Supervisor Contact: Prof. Patrick Kirchen, Ph.D.
Department of Mechanical Engineering
Office: CEME 2062 Mail: 2054-6250 Applied Science Lane
The University of British Columbia, Vancouver, B.C. V6T 1Z4, Canada
Email: pkirchen@mech.ubc.ca, Phone: 604-822-8256

MECH 493 project: Internal Combustion Imaging Analysis Method Development

Background and research goal

Internal combustion engines are expected to remain an important energy conversion technology for many years, particularly in heavy-duty applications. 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), internal combustion engines (ICEs) fueled with natural gas and diesel using conventional engine testing methods have been studied. To advance the state of the art in heavy-duty natural gas ICEs, we have 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.

The combustion images are rich in information, however currently only very basic image analysis techniques are being employed to analyze the images – there is much more to be learned from these measurements! In fact, one of the greatest challenges with the combustion image analysis is reduction of the imaging results from many individual combustion cycles into a concise presentation format (*e.g.* mathematical metric, figure, video, or combination of these). This challenge arises from the high degree of variability in each combustion cycle, which leads engine researchers to ask: Is an averaged video representative of the combustion processes (generally, it isn't!) and what DOES a representative cycle look like? The goal of this project is to develop general combustion image analysis techniques that will enhance the conclusions drawn from future optical engine measurement campaigns by identifying appropriate combustion image features and applying statistical analyses to the imaging data.

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 image analysis techniques and statistical analysis of images. Literature review will cover techniques currently used to analyze ICE combustion imaging, but will also extend to other fields of research
- Development of MATLAB image analysis tools, that:
    - Identify or synthesize "representative" combustion cycle(s) given a set of 15+ single-cycle image sequences and other simultaneous high-speed measurements
    - Characterize the relevant temporal and spatial variabilities of a given combustion cycle or portions of a cycle
- Documentation for each of the analysis tools including:
    - Documented and commented MATLAB code
    - The supporting mathematical/physical basis for the method including known limitations (*e.g.* How to justify that a given cycle is the most representative?)
    - Any contributing or similar analyses found in the research literature
- 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. No significant experimental work is expected to be needed to fulfil this project, however if deemed necessary, coordination of experiments on the optical engine facility will be possible under the supervision of a PhD student and Dr. Kirchen. Progress meetings will be held every ~2 weeks, however more frequent informal meetings will be possible when required.