Transient Spray Modes

1. Background

Reciprocating combustion engines are the most robust and efficient means of extracting mechanical work using energy dense liquid and gaseous fuel sources. Here, pilot injections play a pivotal role in flexible and highly efficient large scale combustion applications. Phenomenological development of these spray systems have led to extremely short dwell times and contracted spray events which can be dominated by transitional injector performance. Traditionally, these kinds of sprays are avoided due to the complicated transitional behavior of the injector hardware so studies and experimental data in this regime are scarce.

Wärtsilä is a Finnish company that designs and manufactures advanced 4-stroke engine designs. Their main products are capable of running on a variety of liquid and gaseous fuels. Reaching this degree of flexibility while adhering to stringent emission requirements places intense demands on the fuel delivery system. One of the greatest impediments to next generation designs is the ability to predict coupled spray formation, ignition, and the overall impact on emissions. The goals of this project are to deliver experimental observations required for understanding current applications and to develop and validate new models.

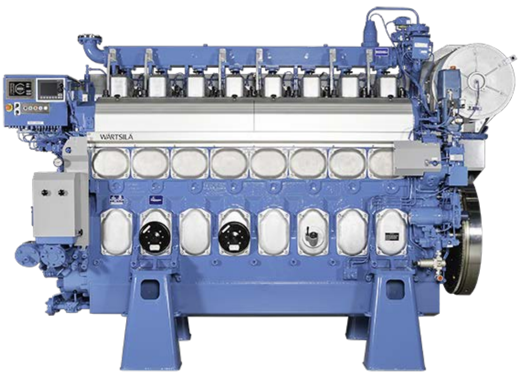

Figure 1. Wärtsilä 20DF, dual fuel 4-stroke engine

2. Method

In this project, the student will investigate a selection of pilot sprays with an emphasis on visualizing transitional spray modes: partially opening, spray start, and end of injection behavior. The rate of injection and injector control signals will be correlated with spray formation in the near field using ultra-fast and time-gated ballistic imaging. These diagnostics mitigate scattering interference in dense sprays to allow detailed visualization of spray structures, even in the presence of intense scattering interference.

The Representative Interactive Linear-Eddy Model (RILEM) is an approach for engine simulations which offers unique capabilities for dual fuel combustion. It covers standard and non-standard engine operating conditions (e.g. low temperature combustion and combustion with both non-premixed and premixed combustion modes). In this project, real engine data from Wärtsilä and observations from the BI diagnostics will be used to setup CFD simulations of dual fuel combustion performed at Wärtsilä. A comparative model using a RILEM approach will be conducted at Chalmers (in an associated CERC project) in order to validate RILEM.

3. Results

Preliminary work in this project has focused on recruitment and planning for BI measurements. Experimental work in project will begin HT-2019.

4. Conclusions and outlook

The main outcome of the experimental work is establishing fundamental knowledge of transient operating modes (opening and closing) in pilot fuel injection. In addition, visualization of pilot injection morphology will be used to set up CFD modeling of dual fuel combustion. The understanding driven by results of this work should enable reduced emissions in large 4-stroke combustion applications.