Thermal analysis for high efficiency ICE gas-exchange system

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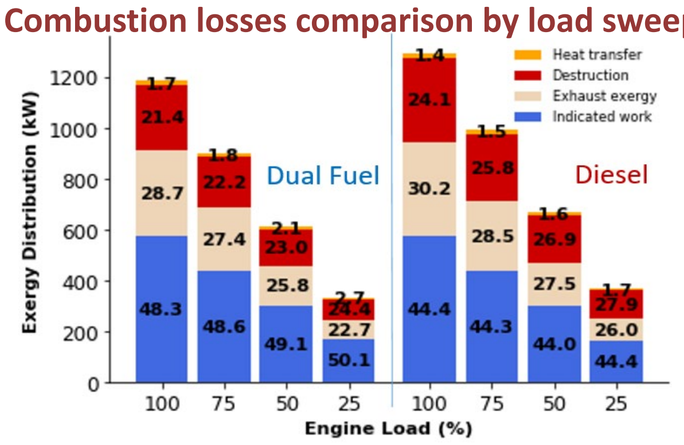
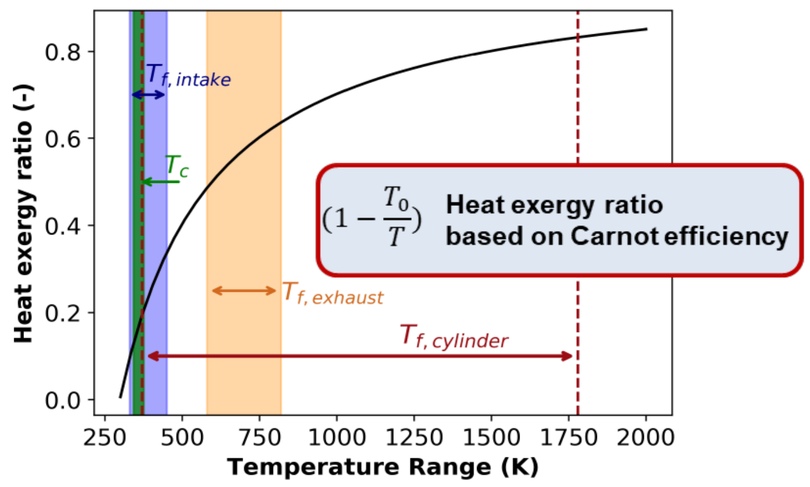
This study is concentrated on thermal analyses of internal combustion engines operation, with special interests on gas exchange, fuels and in-cylinder processes. Current work involves the following topics: (1) aerothermodynamics analysis on gas-exchange systems; (2) exhaust pulses characterization based on fast measurement techniques; (3) energy and exergy assessments of the combustion losses.

Macroscopic view (2019-2020): exergy distributions in a dual fuel marine engine system.

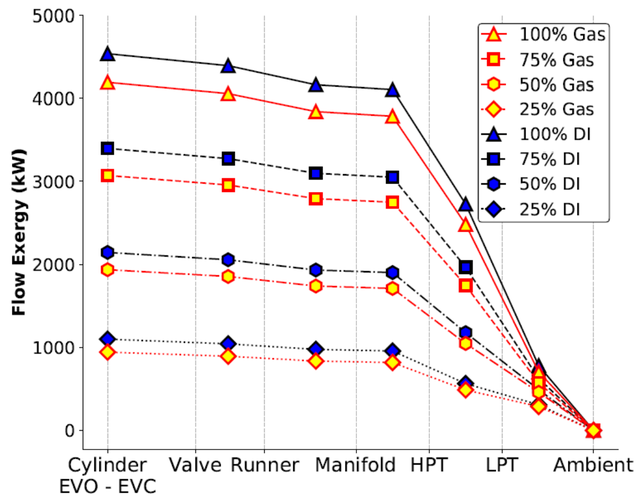
(a) Combustion losses comparison by load sweep



(b) Heat exergy ratio and exergy loss due to heat transfer



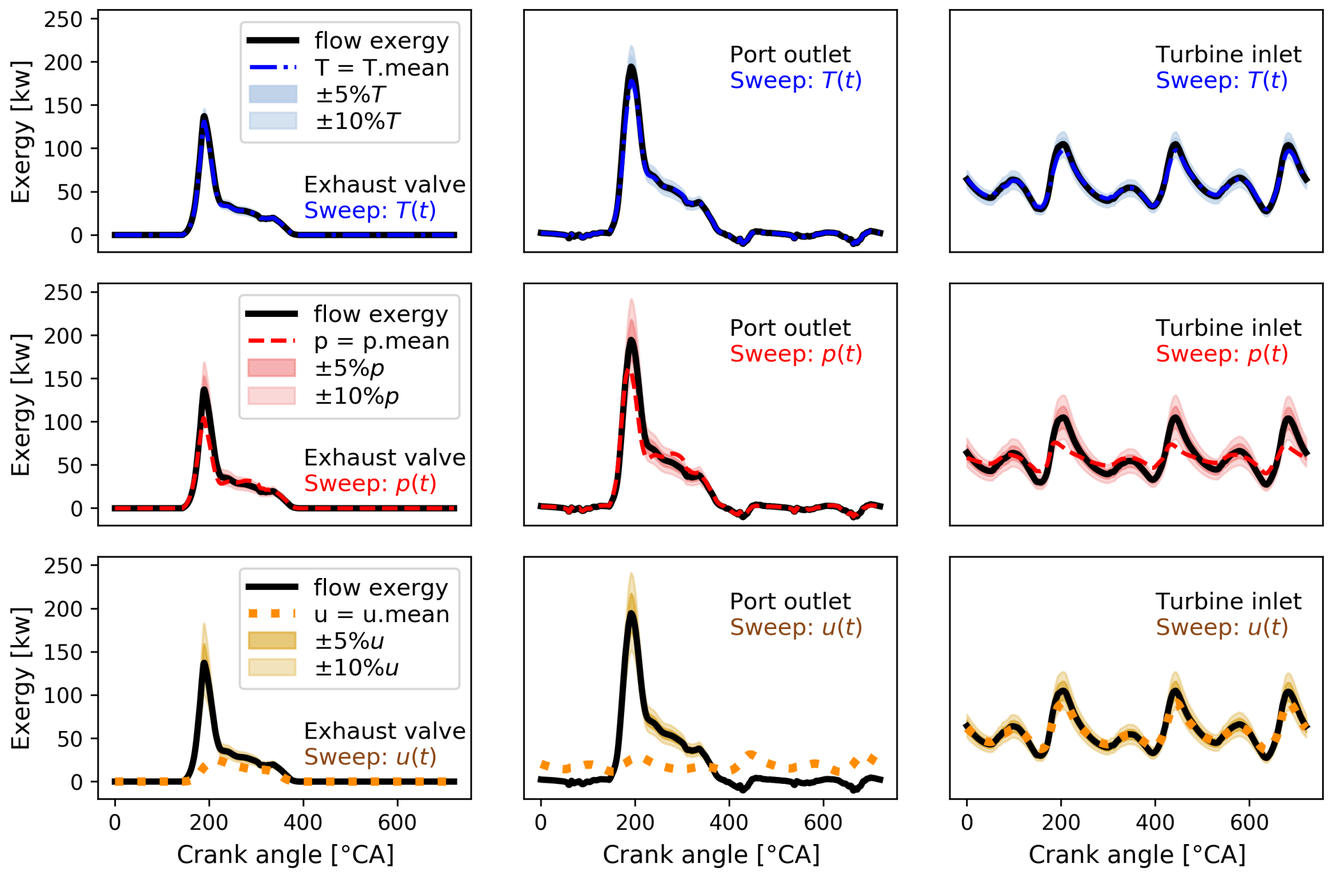
(c) Flow exergy destruction in gas-exchange



Preliminary thermal analyses are conducted in a dual-fuel marine engine to indicate the different energy and exergy losses due to combustion, heat transfer, and flow losses. Meanwhile, further works are planned for more detailed quantification of engine losses using the crank-angle-based on-engine measurement.

Microscopic view (2020-2021): quantifying the flow energy and exergy of ICEs exhaust pulsations and their related measurement techniques.

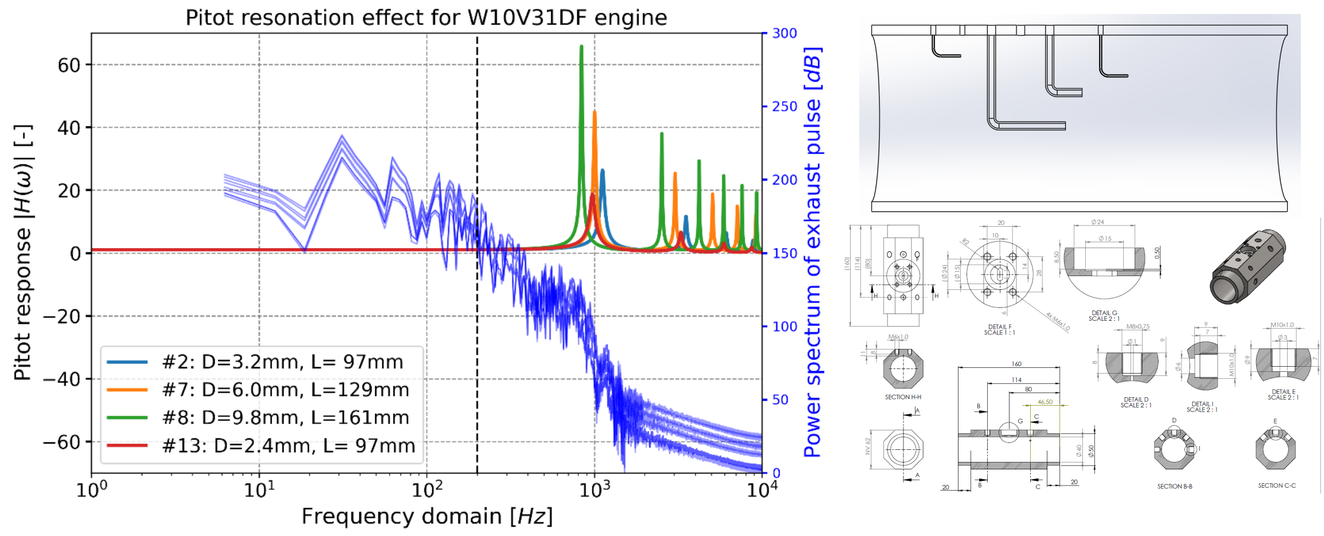
- **Sensitivity analysis of exhaust flow parameters for measuring pulsating flow enthalpy and exergy**



Exergy rates of truck engine exhaust pulsations (1300rpm/17.8nIMEP) at (a) one siamese port closed to exhaust valve, (b) port outlet of one cylinder, (c) turbine inlet.

The analysis indicates that when considering the mass specific enthalpy and exergy, flow temperature is the dominant parameter and demands high bandwidth for sufficient resolution of the temperature pulse. However, when considering the absolute flow enthalpy and exergy, flow velocity is the most significant parameter requiring high-resolution measurement technique.

- **Flow velocity measuring of exhaust pulses by pitot tube:**



Responses selected pitot tubes and marine engine exhaust pulses in frequency domain

Pitot-tube-based measurement is implemented to capture the crank-angle-based flow velocity of engine exhaust pulsations. The corresponding calibration and on-engine test campaigns are planned in both truck and marine engines in 2021 Q4.

Research activities (2020-21)

- Sensitivity analysis to identify the significance of different flow parameters for the energy and exergy assessment of exhaust pulsation.
- Pitot-tube-based technique to measure the velocity of pulsating flow.

Research questions (2021-22)

- How to measure the flow energy and exergy of engine exhaust pulsations?
- Can the pitot-tube-based method capture the flow velocity of the engine pulses?

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