KTH CCGEX

# Turbocharger turbine efficiency in steady and pulsating inlet flow

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Turbocharger turbines are widely modeled under quasi-steady flow assumption despite the fact that its source of energy is a highly unsteady engine exhaust flow. This is attributed to the limitation in both experimental and computational capabilities to resolve the complex aerothermodynamic field surrounding the turbines. This project addresses the issue from experimental side, by developing the measurement techniques with required time resolution. Through the improved performance analysis, it is anticipated to have a better understanding of the interaction between the pulsating flow and the turbocharging components, as well as the way to take advantage of the rich energy in the flow for improved efficiency and operational strategy.

## Introduction and Motivation:

Unsteady performance of turbocharger turbines have been studied by many authors for several decades, and yet remains to be a topic of interest due to its complexity. Despite the advancement in computational resources and methods, obtaining a reliable and predictive model remains a challenge. Part of this is attributed to the lack of experimental capabilities in obtaining necessary time-resolved measurements for unsteady performance assessment.

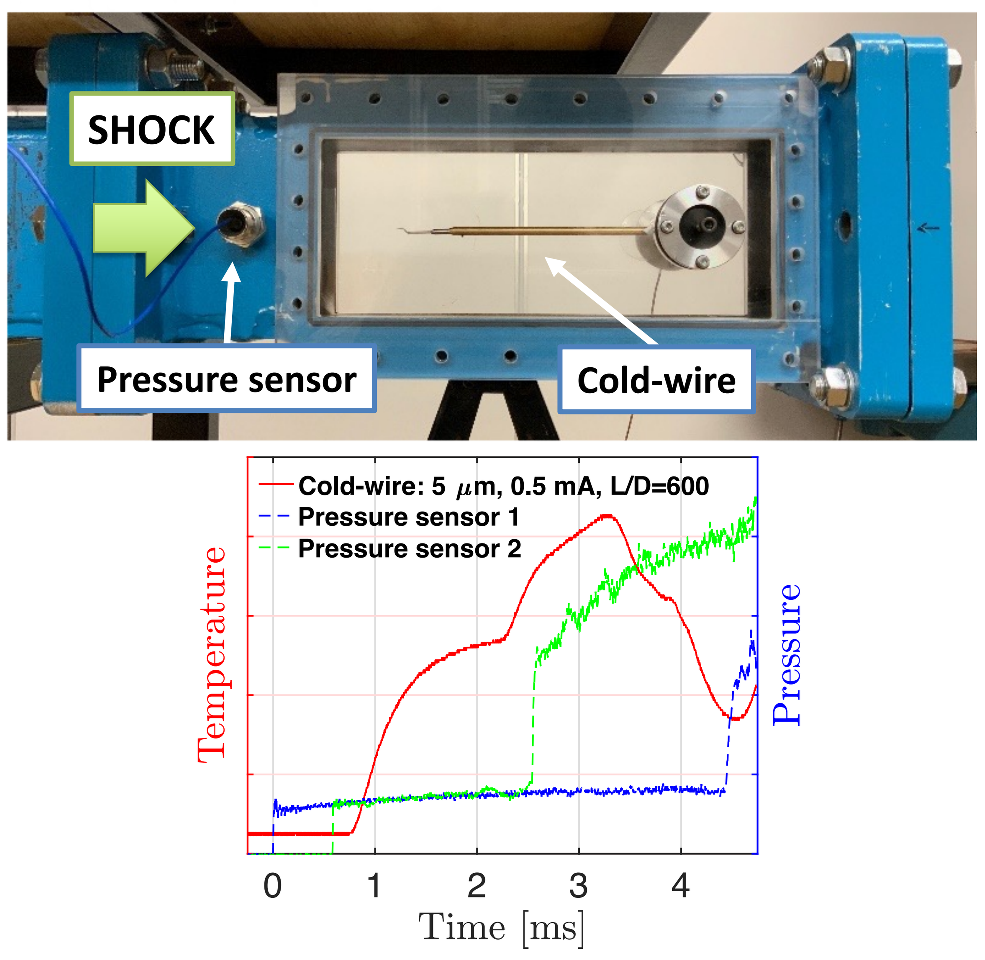
In this project, the time-resolved measurement techniques for temperature and velocity are investigated for both lab-scale and industrial experiments. Together with the well-established pressure measurements, it would be able to obtain all the necessary flow quantities in a time-resolved manner for the turbine performance assessments.

The developed experimental capability not only improves the accuracy of performance tests, but also opens up a possibility to investigate some research questions in the turbocharger community, such as the influence of pulse shape and isentropic flow assumption to the turbine performance.

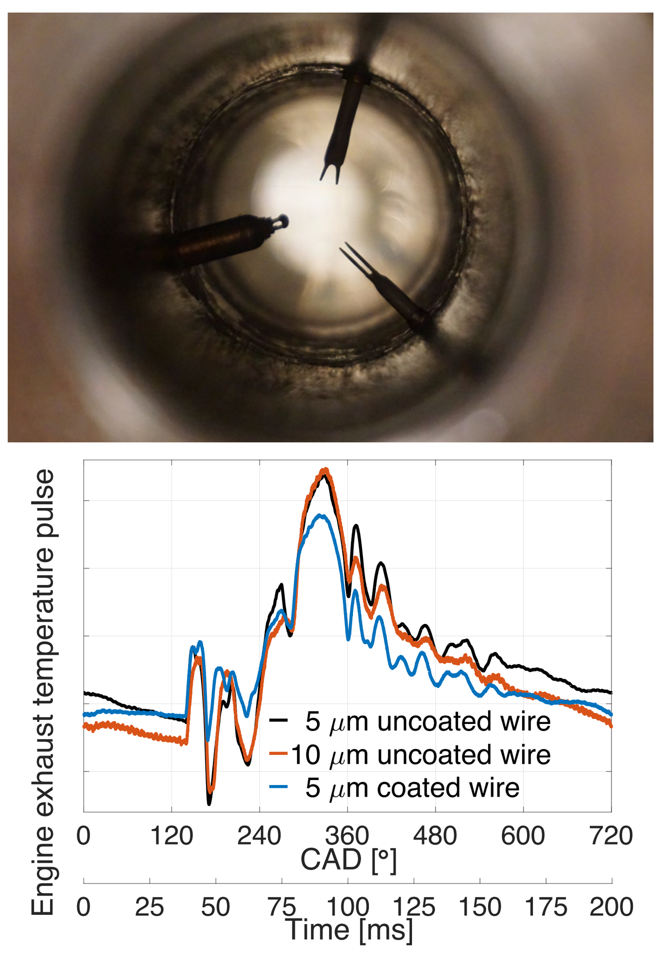
## Setup:

1. **Time-resolved temperature measurement with cold-wires**
   - Dynamically calibrated sensors with improved design for durability are implemented in the measurements
   - The new design considers its application in harsh environment, such as exhaust flow measurements in engine testings
   - Further studies on the influence of design assumptions, such as isentropic flow condition, can be made
2. **Time-resolved mass flux measurement using laser diagnostics**
   - Laser Doppler Velocimetry (LDV) is considered to obtain time-resolved velocity measurements
   - From direct time-resolved velocity, temperature and pressure measurements, the challenge in obtaining time-resolved mass flux is addressed
   - Comparison with other indirect flow metres can be made
3. **Pulse generator to simulate engine-like pulses**
   - Controllable pulse generators to assess the influence of pulse shapes on the turbine performance

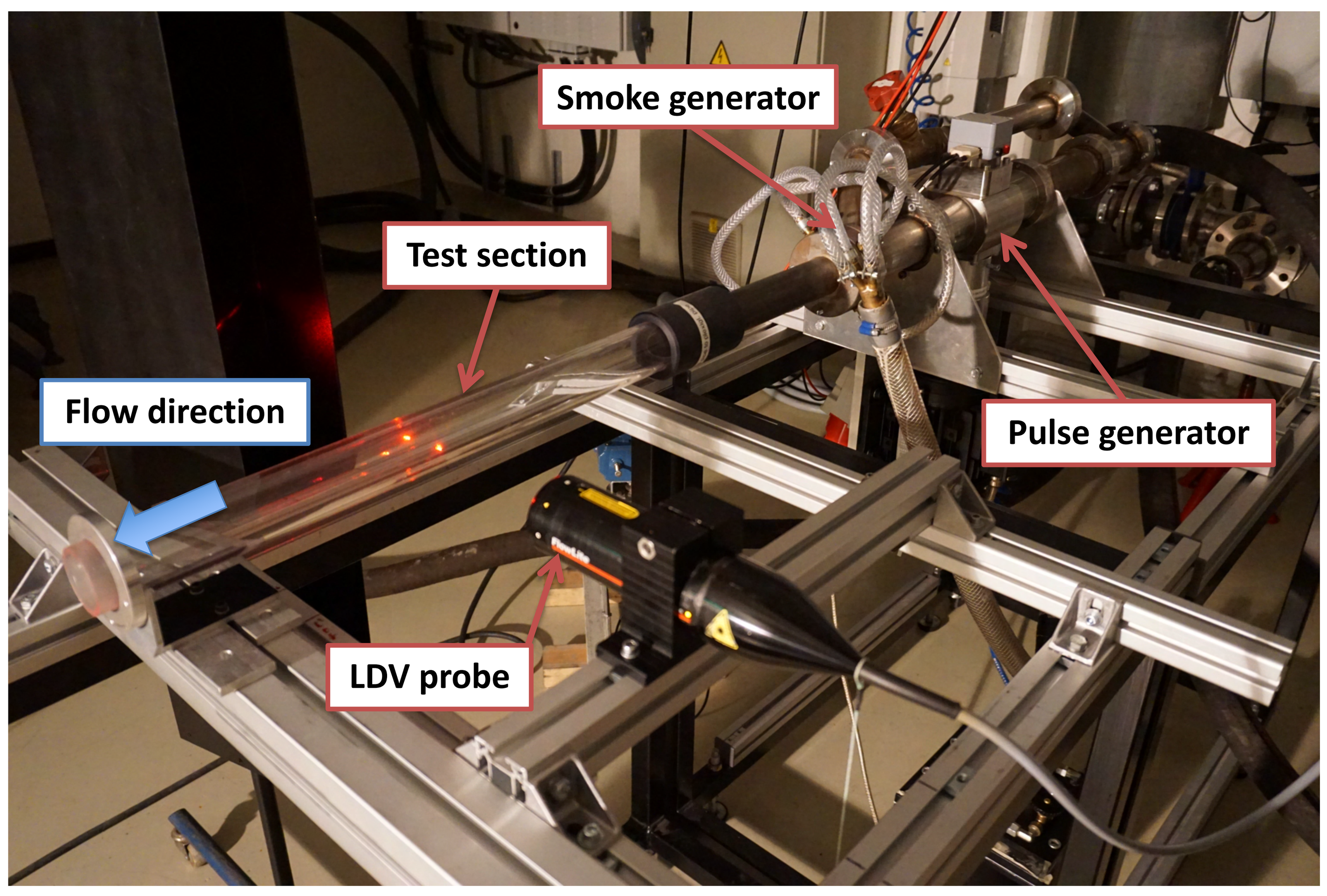
## Research Activities:




Dynamic calibration of cold-wires in shock tube




Temperature pulse measurement using cold-wires




Laser Doppler Velocimetry (LDV) measurement downstream of conventional pulse generator

## Summary and Conclusion:

The project aims to provide a new capability for time-resolved measurements under the typical condition for turbocharger tests, in both lab and industrial scales. Using the developed techniques, the results from unsteady performance assessment should deepen the understanding of interaction between the turbocharger turbines and pulsatile inlet flows. Such knowledge will be beneficial for building a reliable and predictive model for turbocharged internal combustion engines, which play a key role in realising a sustainable society in the near future.

## Acknowledgement:

Supervisors: Jens Fransson, Ramis Örlü, Michael Liverts

VOLVO SCANIA WÄRTSILÄ VOLVO BorgWarner Swedish Energy Agency