



Competence Center for Gas Exchange



”Charging for the future”



VOLVO

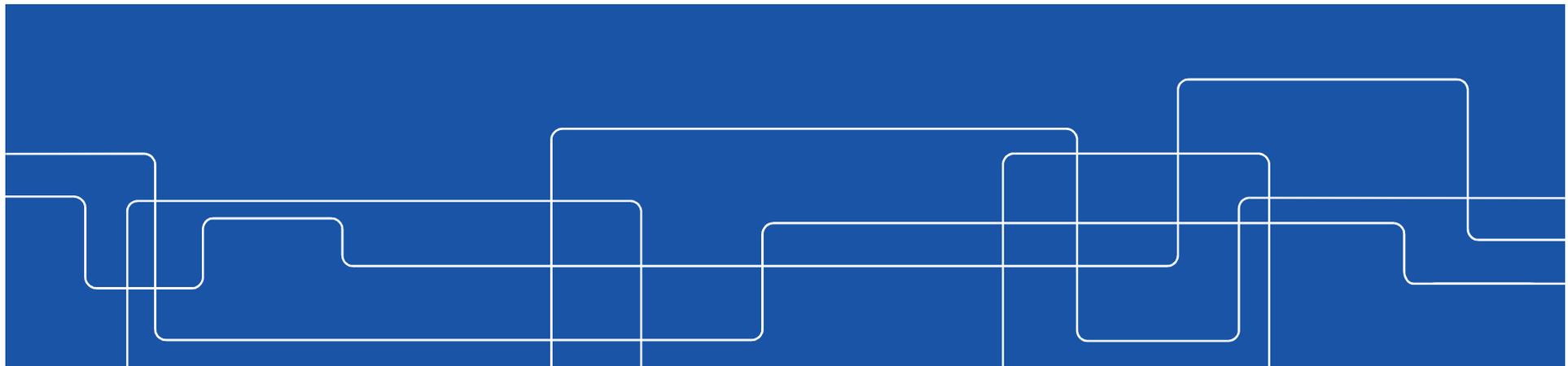


BorgWarner



Research Area: Compressor off-Design Operation

Coordinator: Mihai Mihaescu



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BorgWarner



Overview: Compressor off-Design (CoD)

GOAL

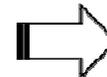
Increase compressor stable operation range, improve inter-cooling performance, enable silent operation and optimize unit energy efficiency

STRATEGY

From physics-based understanding, build knowledge on critical operation conditions & enable viable control to mitigate flow instabilities and surge

TOOLS

- High-fidelity simulations & detailed experiments
- Methods for stall/surge identification



- Flow & Acoustic characterization
- System diagnostics in ICE & Turbochargers

Compressor & ICE

Bertrand Kerres, PhD stud, Exp, CICERO/ICE; surge modeling

Activities

Compressor inlet piping

VT 2017

HT 2017

CFD, surge, piping (Mek)

Elias Sundström, PhD stud
High-fidelity LES, models

Turbomachinery response

- compressor map
- flow instabilities
- aeroacoustics
- flow control

VT 2017

back pressure / pulses

Intake engine manifold

Internal Combustion Engine

Industry Input

Volvo Cars (engine maps)
Borg Warner (geometry, maps) SCANIA & Volvo GTT

CFD non-axisymmetric vaneless diffuser (Mek)

Valeriu Dragan, BW Postdoc

Acoustics (MWL)

Raimo Kabral, PhD stud
Exp. Acoust. & 1D modeling

Aeroacoustics (MWL/Mek)

Asuka G. Pietroniro, Ind
PhD stud Volvo CC
CAA & 1D modeling



CoD: Overall aims

- ❑ Improve understanding of the compressor flow at off-design conditions
 - high-fidelity simulations and experiments
 - quantify the flow instabilities with advanced mode decomposition techniques
- ❑ Quantify the geometry installation effects on the on-set of flow instabilities and surge
 - effect on compressor performance
- ❑ Aeroacoustics characterization of compressor surge
- ❑ Develop and /or adopt methods for stall/surge identification
- ❑ Surge inception scenario definition

PhD Students / Postdoc:

Elias Sundström, (CFD), Mek
Bertrand Kerres (Exp), ICE
Raimo Kabral, (Acoustics), MWL
Asuka Pietroniro, (Aeroacoustics), MWL/Mek
Valeriu Dragan (CFD), Mek

Reference group:

Habib Aghaali, Volvo Cars
Magnus Knutsson, Volvo Cars
Magnus Ising, Volvo GTT
Per-Inge Larsson, Scania
Tom Heuer, Borg Warner



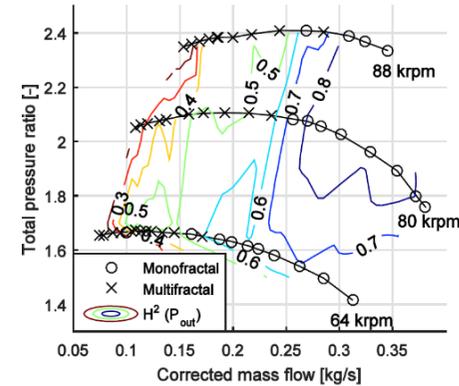
CoD: Individual projects



Experimental and modelling efforts towards assessing compressor surge and performance

Doctoral student:
Bertrand Kerres (Exp, 1D), ICE

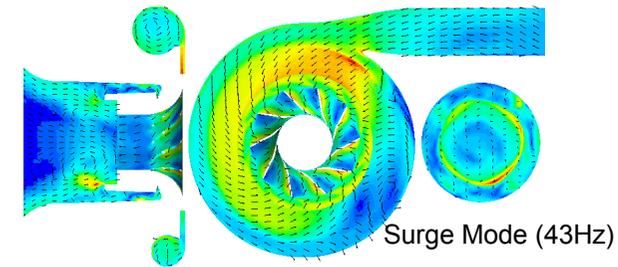
Supervisors:
Andreas Cronhjort, Mihai Mihaescu



LES of Centrifugal Compressor Flows at Low Mass Flow Rate

Doctoral student:
Elias Sundström (CFD), Mek

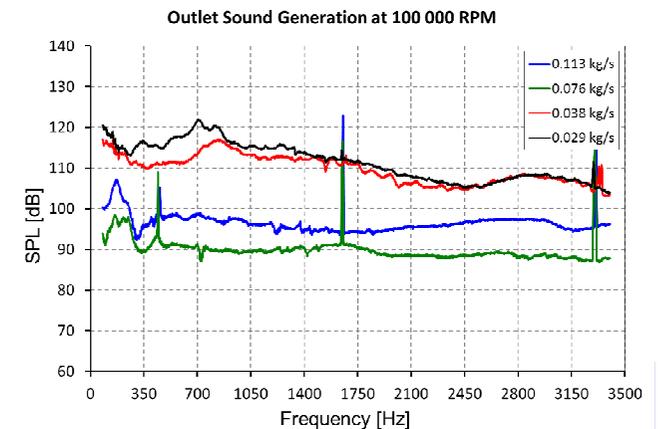
Supervisors:
Mihai Mihaescu, Laszlo Fuchs



Experimental Aeroacoustics of Rotating Machines and Innovative Noise Control

Doctoral student:
Raimo Kabral (Exp/Sim), MWL

Supervisors:
Mats Åbom, Hans Boden





CoD: Highlights

- ❑ Demonstrated capability for extracting acoustics from the LES data
- ❑ Upstream installation effects on surge line quantified
- ❑ Determination of aeroacoustic coupling and system's characteristics (compressor-piping arrangement) @ design and off-design
- ❑ An efficient and compact noise control solution, based on the optimal flow channel wall impedance was developed and proposed
- ❑ Validity range established for RANS & theoretical models for predicting compressor maps; comparisons with gas-stand experimental data (Mek-MWL-ICE)
- ❑ A surge criterion based on the fractal properties of time-resolved pressure signals was developed



CoD: Near-future Plans

- ❑ Asuka G. Pietroniro, Ind. PhD stud. Volvo Cars - CAA (to start 05/12)
- ❑ Valeriu Dragan, Postdoc BorgWarner - CFD of compressor flows with non-axisymmetric diffusers (to start 14/11)
- ❑ PhD defenses: Raimo Kabral (Mar 2017); Bertrand Kerres (Jun 2017)
- ❑ Experimental & computational efforts on the BorgWarner geometries (flow & acoustics)
- ❑ Noise generation mechanisms; quantification of the acoustic noise sources at off-design; develop noise suppression technologies
- ❑ Evaluation / calibration /development of improved compressor surge models & assess the mechanisms for losses in centrifugal compressors
- ❑ New programm period & funding opportunities, e.g. Marie Sklodowska-Curie actions, Innovative Training Networks (ITN/ETN); H2020-MSCA-ITN-2017; focuss on **FUTURE** power train systems



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