CCGEx: Ongoing Projects
Research Area: Compressor Off-Design Operation (CoD)

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11-12 October 2018, CCGEx Research Days, Stockholm
Research Area: Compressor Off-Design Operation (CoD)

GOAL
Increase compressor stable operation range and efficiency, enable silent operation and optimize unit integration with upstream/downstream components

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

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

- Flow & Acoustic characterization
- System diagnostics incl. ICE & Turbocharger

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<td>i-COLD: Mihai Mihaescu</td>
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<td>Bertrand Kerres, PhD student, ICE, EXP/1D</td>
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<td>Elias Sundström, PhD student, Mek, CFD</td>
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<td>Raimo Kabral, PhD student, MWL, EXP</td>
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<td>Asuka Pietroniro, Ind. PhD stud Volvo Cars, MWL/Mek, CFD/CAA</td>
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<td>Valeriu Dragan, Post-doc BW, Mek, CFD on non-axisymmetric diffusers</td>
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<td>Emelie Trigell, PhD student, Mek, CFD. Compressor Response to upstream/downstream installation effects</td>
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<td>Aerodynamically generated noise of Centrifugal Compressors-Experiments, Post-doc, MWL, EXP</td>
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<td>Niloofar Sayyad Khodashenas, Marie Curie Assoc. PhD Project, MWL, Exp/model/Non-linear system ID for TC</td>
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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:

CCGEx Coordinator: Mihai Mihaescu

Reference group:
Habib Aghaali, Volvo Cars Magnus Knutsson, Volvo Cars Magnus Ising, Volvo GTT Per-Inge Larsson, Scania Jonas Holmborn, Scania Tom Heuer, Borg Warner Thomas Lischer, Borg Warner

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i-COLD: Individual projects

Flow instabilities in Centrifugal Compressors at Low Mass Flow Rate

**Doctoral student:**
Elias Sundström (CFD, Mek)

**Supervisors:**
Mihai Mihaescu, Laszlo Fuchs

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On the aerodynamically generated sound of centrifugal compressors

**Ind. Doctoral student (Volvo Cars); started 05/12/2016:**
Asuka Gabriele Pietroniro (CFD/CAA)

**Supervisors:**
Mihai Mihaescu, Mats Åbom, Magnus Knutsson (VCC)

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Compressor response to upstream/downstream installation effects and perturbations

**Proposed PhD student (HT2018):**
Emelie Trigell (CFD), Mek

**Supervisors:**
Mihai Mihaescu, Mats Åbom, Lisa Prahl-Wittberg
Verified and Validated tool
Compressor assessment @ design / off-design

Closed ported Shroud: Stable operating condition (0.28kg/s); LES vs. experiments

Design Condition, 64k rpm; In-plane velocity magnitudes (m/s)

Stable operation

Off-Design (Surge) operation

Experimental data from University of Cincinnati (Dr. Gutmark)

Hurst exponent vs Std Deviation

E. Guillou (2011)

Honeywell GT40 (HD turbocharger, ported shroud), N=64 krpm:
- Hurst exponent (H) gives information about long-term trends in a time-series
- Hurst exponent has better properties as warning indicator

Aeroacoustic performance assessment
Borg Warner Compressor

- Compressor map: good match with experimental data;
- Noise map: produced noise proportional to rotational speed. Higher noise production towards choke line and surge line.

i-COLD: Highlights

- Quantification of flow phenomena and instabilities precursor to surge in a large ported-shroud compressor by means of LES; demonstrated capability of extracting acoustics.

- Validity range established for RANS & theoretical models for predicting compressor maps (Mek-MWL-ICE).

- Acoustic power map obtained based on steady-state CFD data.

- Stability range extension at low mass flow rates explained for a non-axisymmetric hybrid volute-trimmed diffuser arrangement.

- 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.

- Investigation of turbocharger compressor surge inception by means of an acoustic two-port model.

- A surge criterion based on the fractal properties of time-resolved pressure signals was developed.
Competence Center for Gas Exchange

"Charging for the future"