Coupled CFD Simulation of a Variable Valve Actuation System

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Agenda

- Fuel Saving Technologies
- Dethrottling: The Principle
- GT-Power: A Concept Tool
- Modeling of VVA Systems in GT-Power
- Results
- Summary
Fuel Saving Technologies

Data from one Engine Family
Operation Point: 2000/2

BSFC, g/kW-h

VVA
DI

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**Dethrottling Principle: 2000rpm@2bar**

- EIVC-Strategy: Same RTG Content leads to no decrease of PMEP
- Distinct PMEP Reduction for Small Lift Curve at high RTG Contents
Engine Simulation: A Concept Tool

- Variable Valve Lift Curves
- Combustion

Requirements
Gas Exchange
And Combustion

GT-Power Model
Combustion Modeling

- Combustion strongly dependent on RTG
- Valve Lift Curve Shape has influence on Comb.
- Operation Point: 2000 rpm @ 2bar BMEP
Modeling Misfire Limit

- Strong Correlation bt. RTG and COV
- Linking of Burn Duration and RTG Content

![Graph showing strong correlation between residual trapped gas and COV, with burn duration and residual trapped gas on the x-axis and COV on the y-axis.](image-url)
Data Input by RLT Dependence

- Burn Duration Map for each Valve Lift Curve
- Max. Residual Trapped Gas Content (COV-Limit)

Low Values  High Values
Results – Cam Positioning Strategies

- Constant int. RTG Content
- Standard Lift Curve requires LIVC
- Small Lift requires EIVC
Results @ 2000rpm/2bar

BSFC, g/kW-h

Residual Gas, %

2.0 mm-max.OVLP 3.0 mm-max.OVLP 4.0 mm-max.OVLP 9.5 mm-max.OVLP 9.5 mm-LIVC 9.5 mm-105/115

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25% RTG @ 2000rpm/2bar

BSFC, g/kW-h

Base
Opt.

NET PMEP, bar

2.0 mm-max.OVLP
3.0 mm-max.OVLP
4.0 mm-max.OVLP
9.5 mm-max.OVLP
9.5 mm-105/115
3D Flow Field Analysis

- Unsteady Boundaries from GT-Power as Input Data for Star CD
- One Phase Flow
- Walls are assumed to be adiabatic
- For Fluid, Material Properties of Air are taken
- 1800 rpm @ WOT with 4mm max. Valve Lift
- Suction and Compression stroke modeled
Results - Flow Field Analysis

VELOCITY MAGNITUDE
M/S
*PRESENTATION GRID*
100.0
50.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
KW = 322.0 Grad
Summary

- Simulation of Variable Valve Actuation
  - Gas Exchange
  - Combustion

- Combustion Modeling by means of available Tools in GT-Power

- Coupled Simulation for Flow Field Analysis
  - Small Valve Lift can deflect Flow significantly
  - Short Cam Duration decreases Charge Motion

- Evaluation of Technology Steps possible