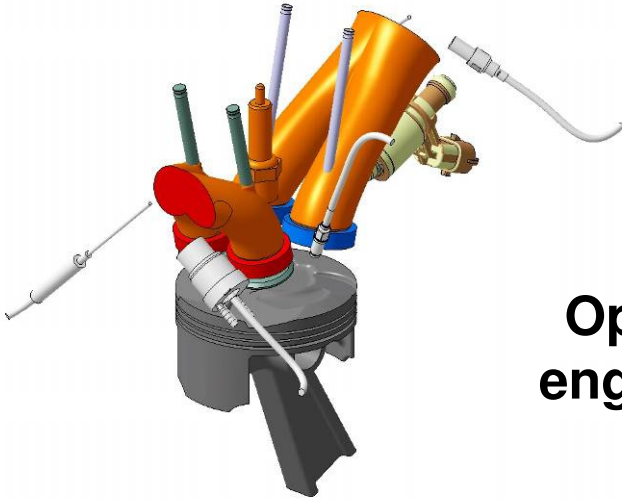


Optimizing the dynamic operation of a gasoline engine with high flexibility by means of AVL-GCA

Dr. Robert Fairbrother, development simulation GCA
Dipl.-Ing. Fernando Moreno Nevado, development gasoline engines
Ing. Kurt Prevedel, development turbo charging
Dr. Thomas Leifert, product management GCA

AVL List GmbH

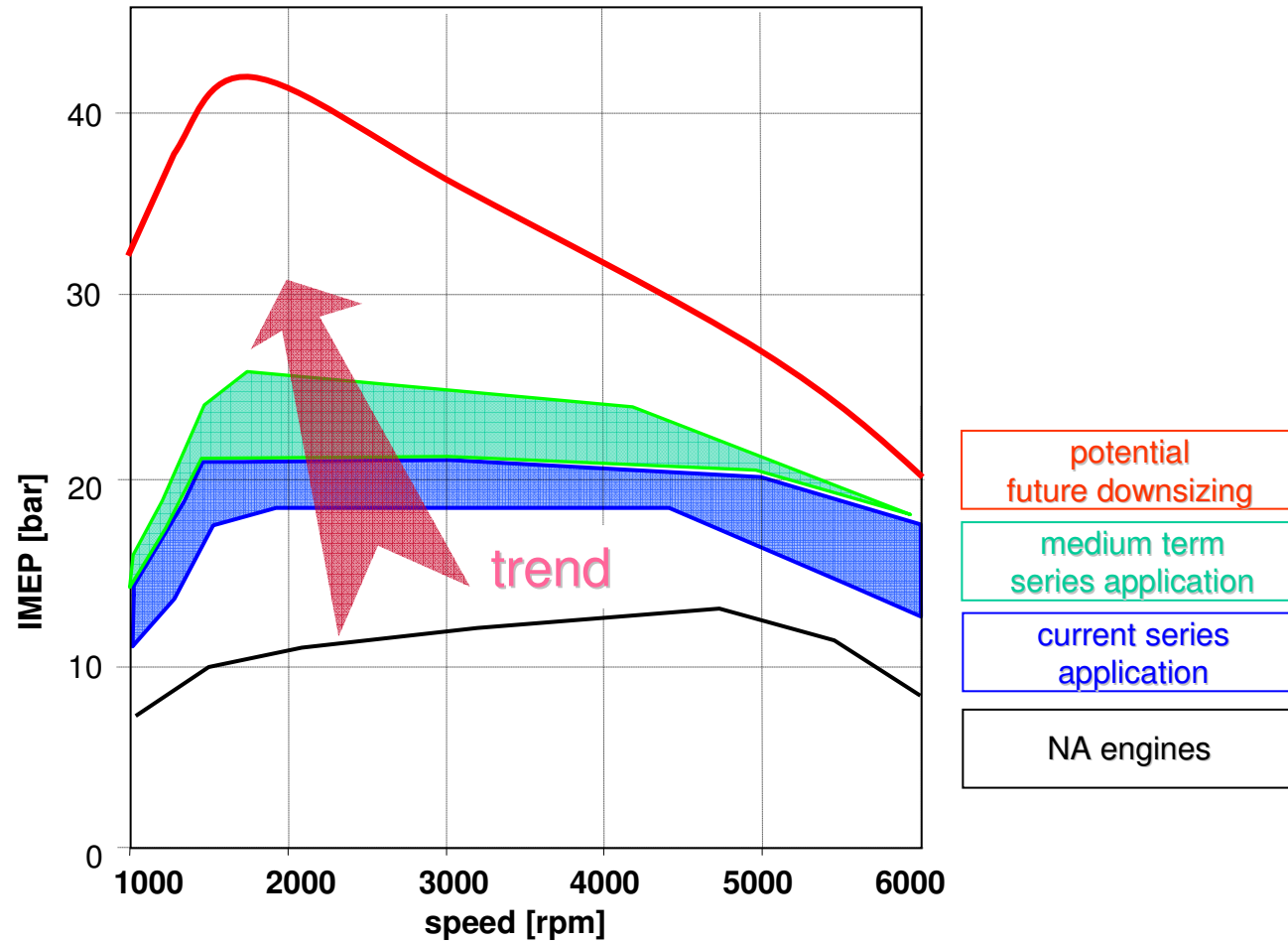


Optimizing the dynamic operation of a gasoline engine with high flexibility by means of AVL-GCA

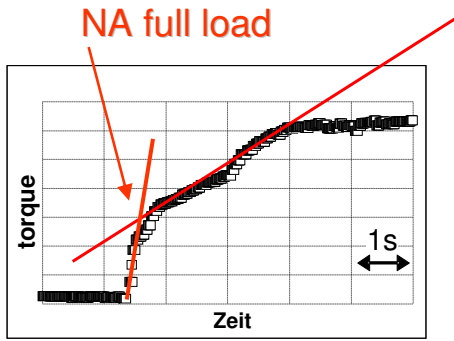
content:

- **state of technology**
- ε and the engine
- GCA
- test bed and test program
- stationary operation
- transient operation
- how to proceed?

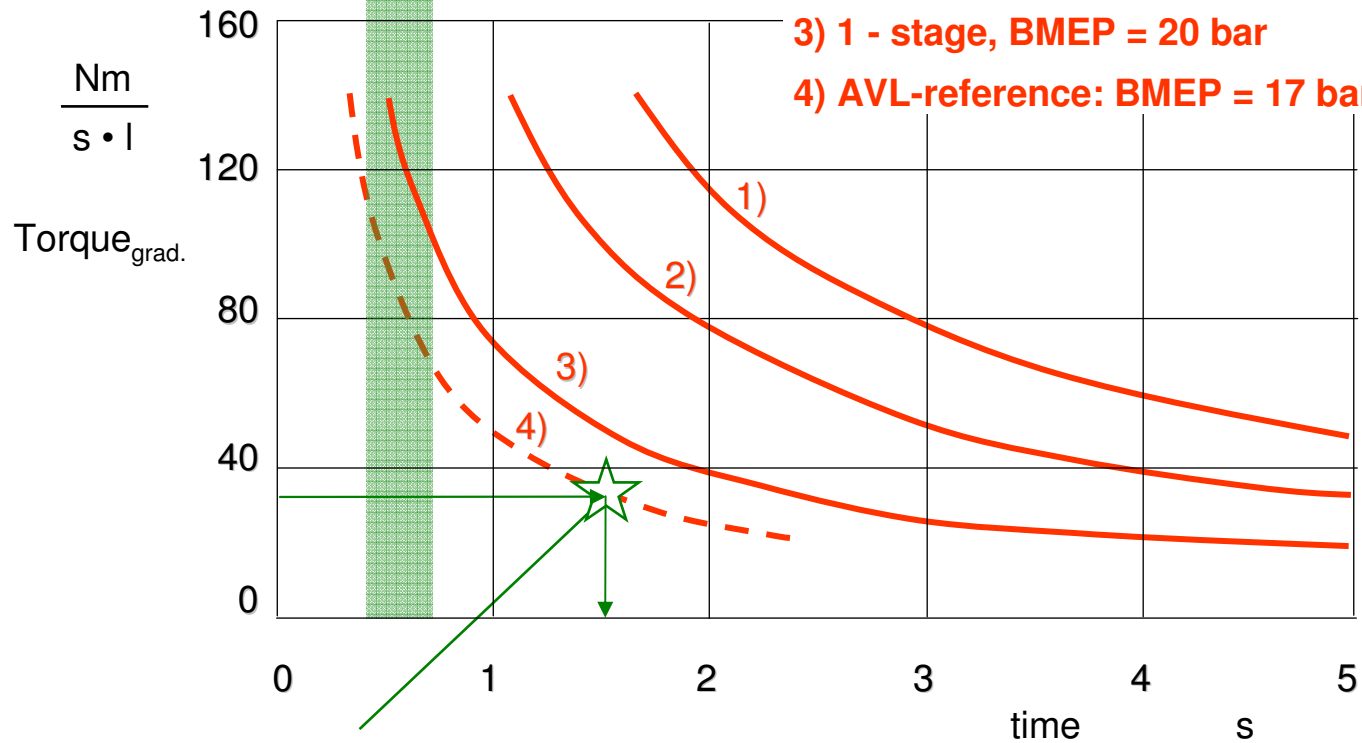
turbocharged gasoline engines full load trend



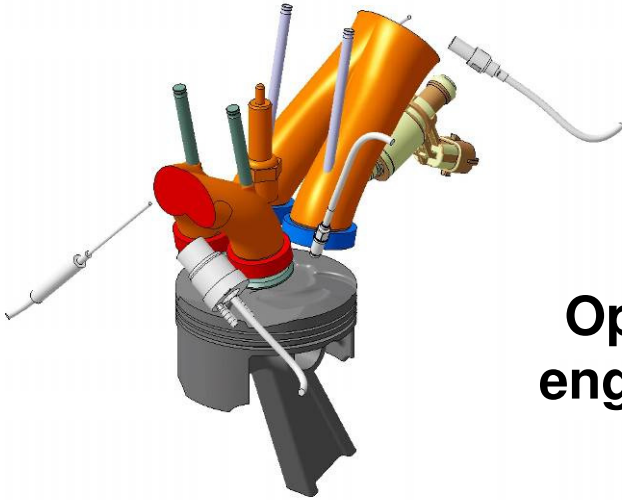
response to torque requirement



NA engine,
time to full load:
0,5 s to 0,75 s



AVL-target when turbo charged:
1,5 s at BMEP = 17 bar, n = 1500 rpm



Optimizing the dynamic operation of a gasoline engine with high flexibility by means of AVL-GCA

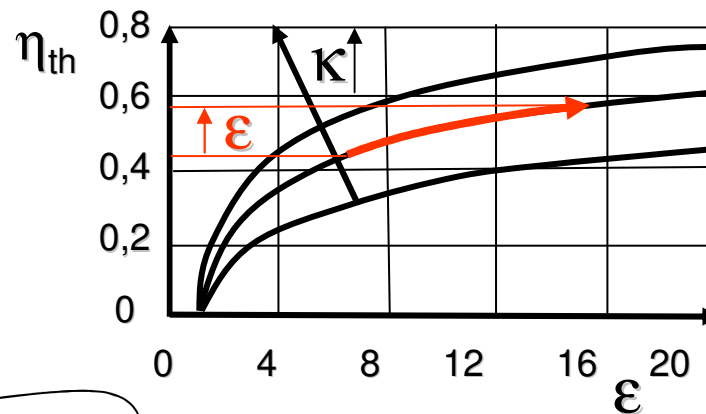
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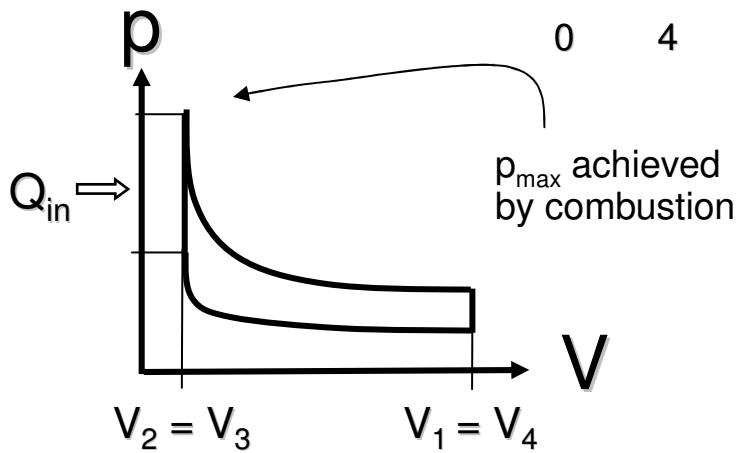
influence of CR at ideal process with isochoric heat input



$$\eta_{th, \text{ isochoric}} = 1 - \frac{1}{\epsilon^{\kappa-1}}$$



Influence of initial compression onto thermal efficiency, described by Nikolaus Otto, 1875



$$\kappa = \text{const}, \epsilon \uparrow \rightarrow \eta_{th} \uparrow$$

THE ENGINE



Manufacturer

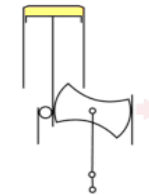
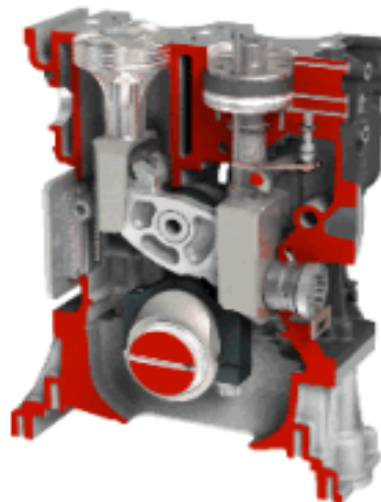
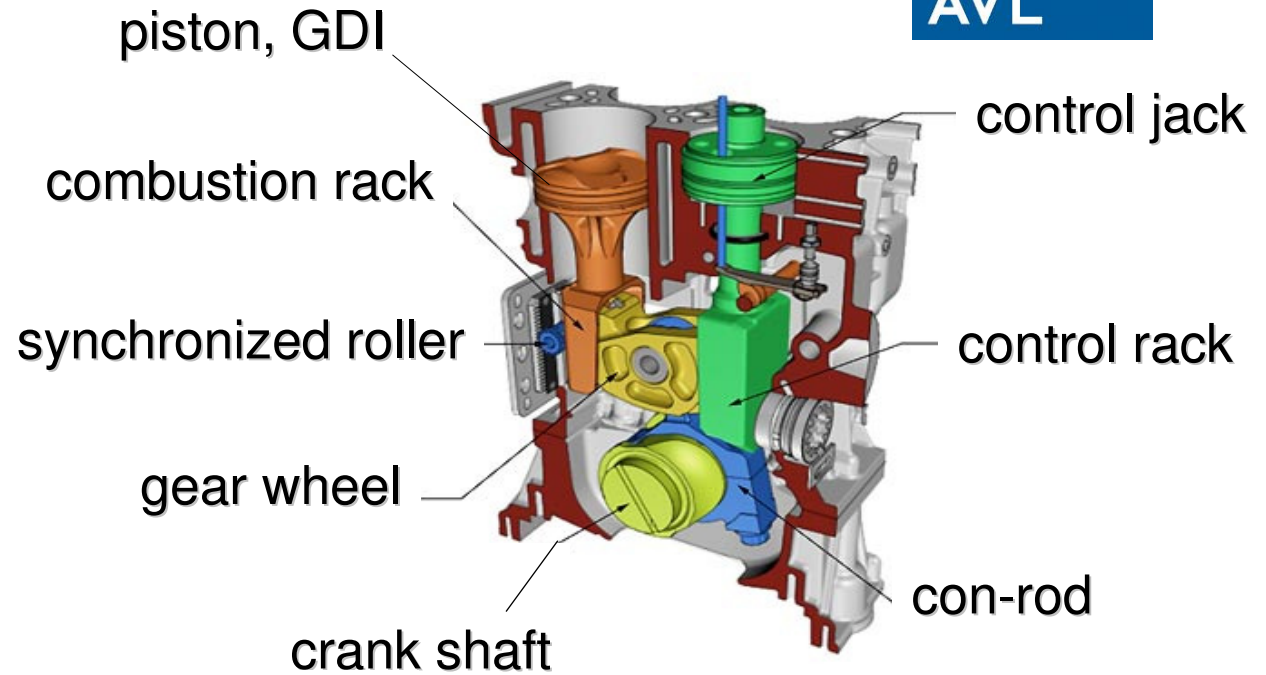
- MCE-5 / Lyon, France

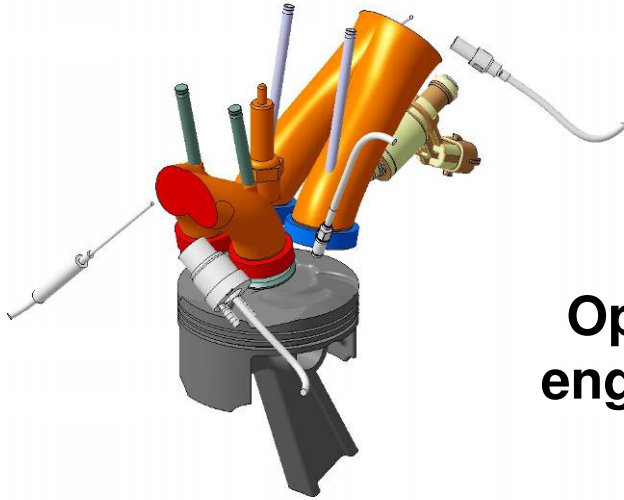
Specification

- 4-cylinder-gasoline, inline, $V = 1.5l$
- direct injection, RON 95
- **crank drive with variable $\epsilon = 6$ to 15**
- 2-stage turbocharged
- 2 cam phaser

Technical data

- $P_e = 160$ kW
- $IMEP > 40$ bar @ $TRQ = 480Nm$



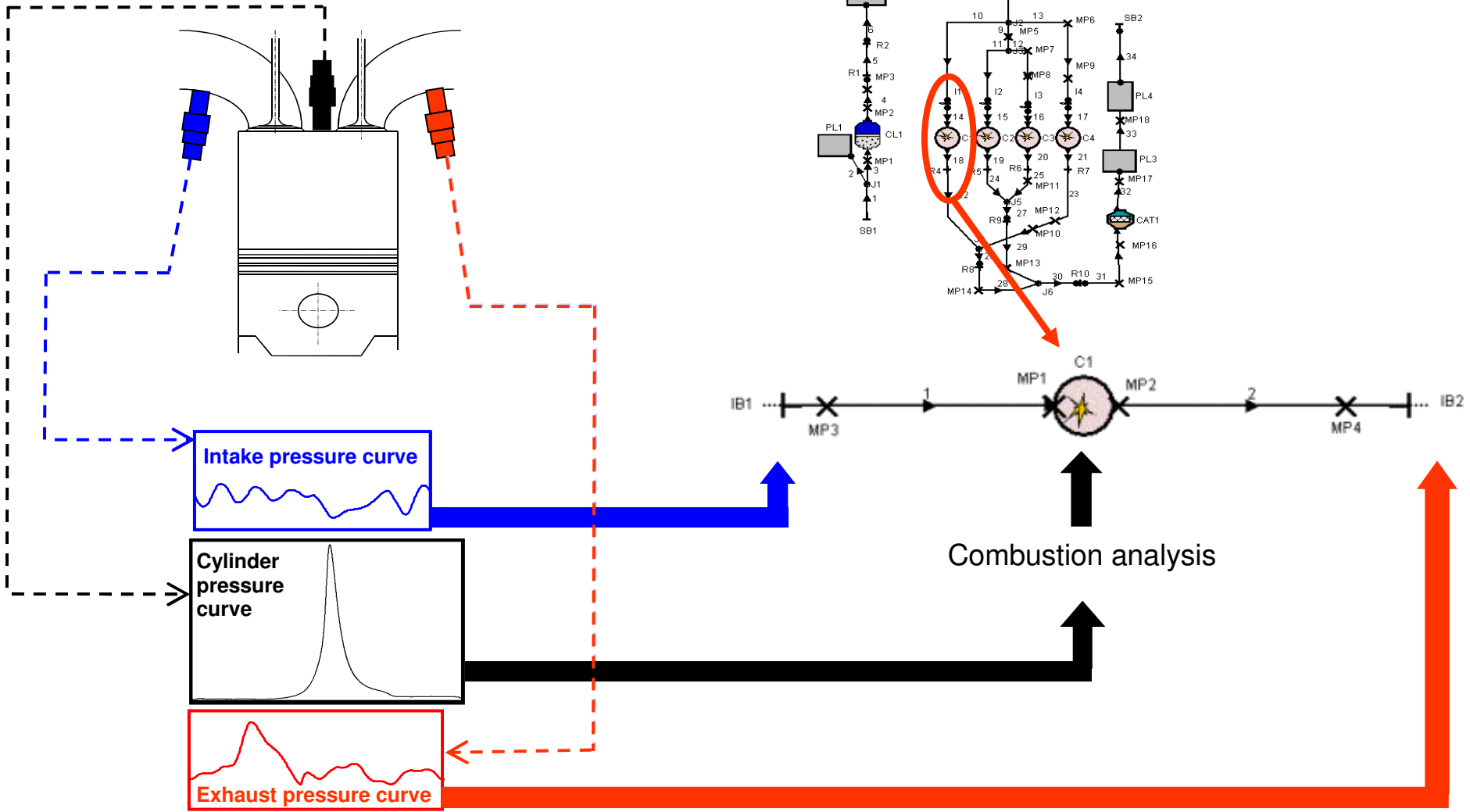


Optimizing the dynamic operation of a gasoline engine with high flexibility by means of AVL-GCA

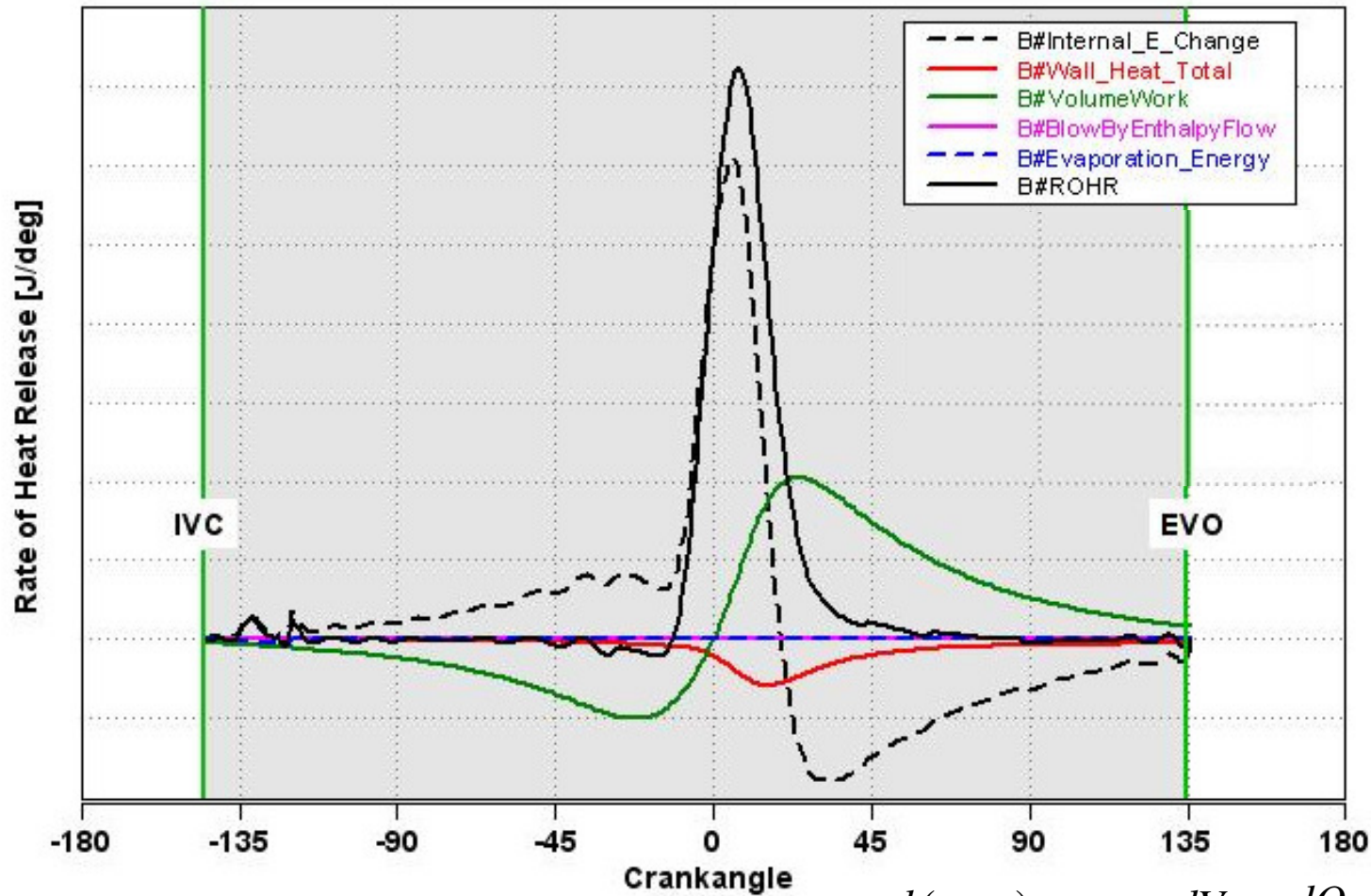
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AVL GCA: WORKING PRINCIPLE AND MOTIVATION



Combustion Analysis



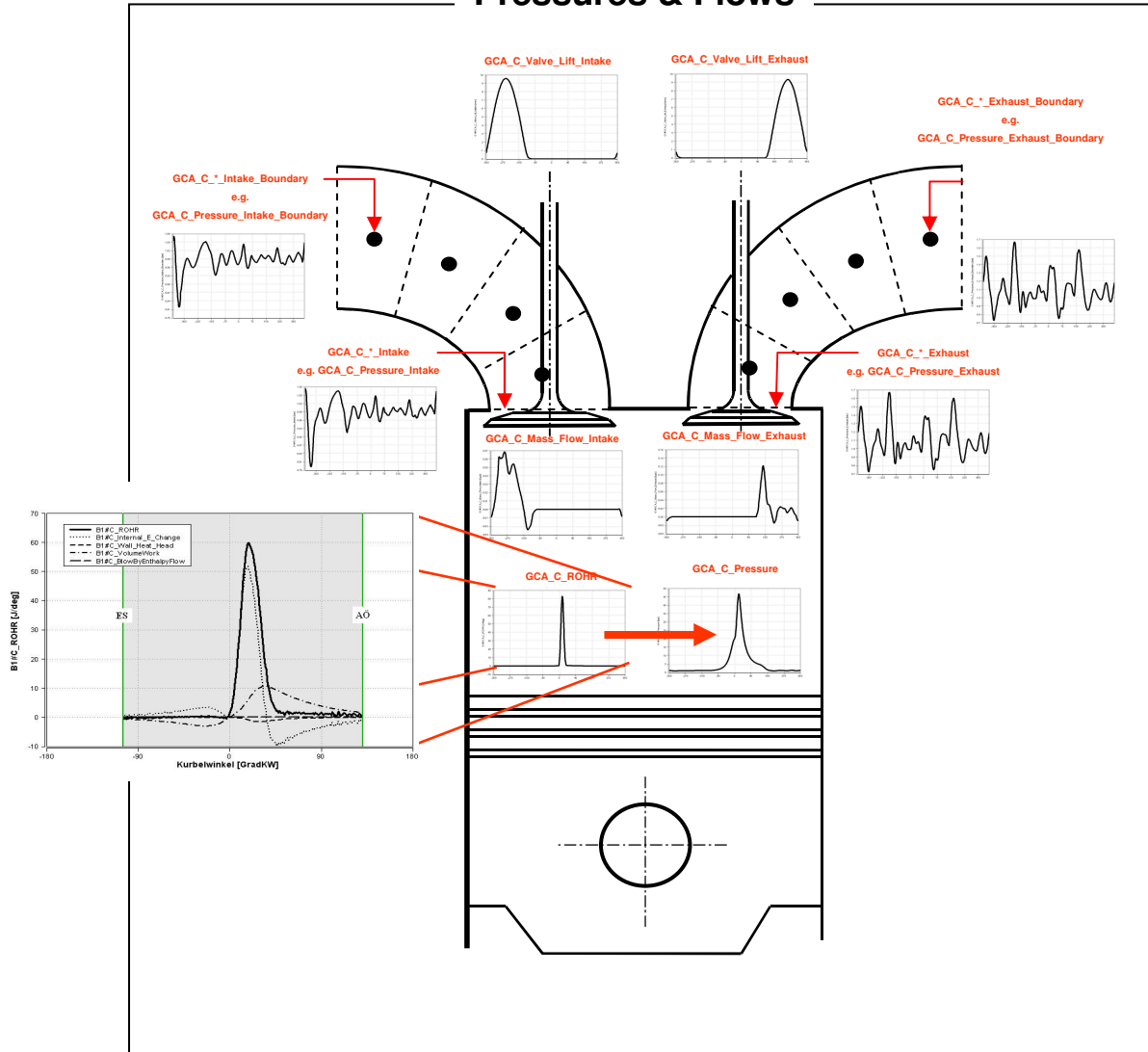
$$\frac{d(m_c u)}{d\alpha} = -p_c \frac{dV}{d\alpha} + \frac{dQ_f}{d\alpha} - \frac{dQ_w}{d\alpha} - h_{BB} \frac{dm_{BB}}{d\alpha}$$

*) dQ_f : heat release by combustion after fuel injection

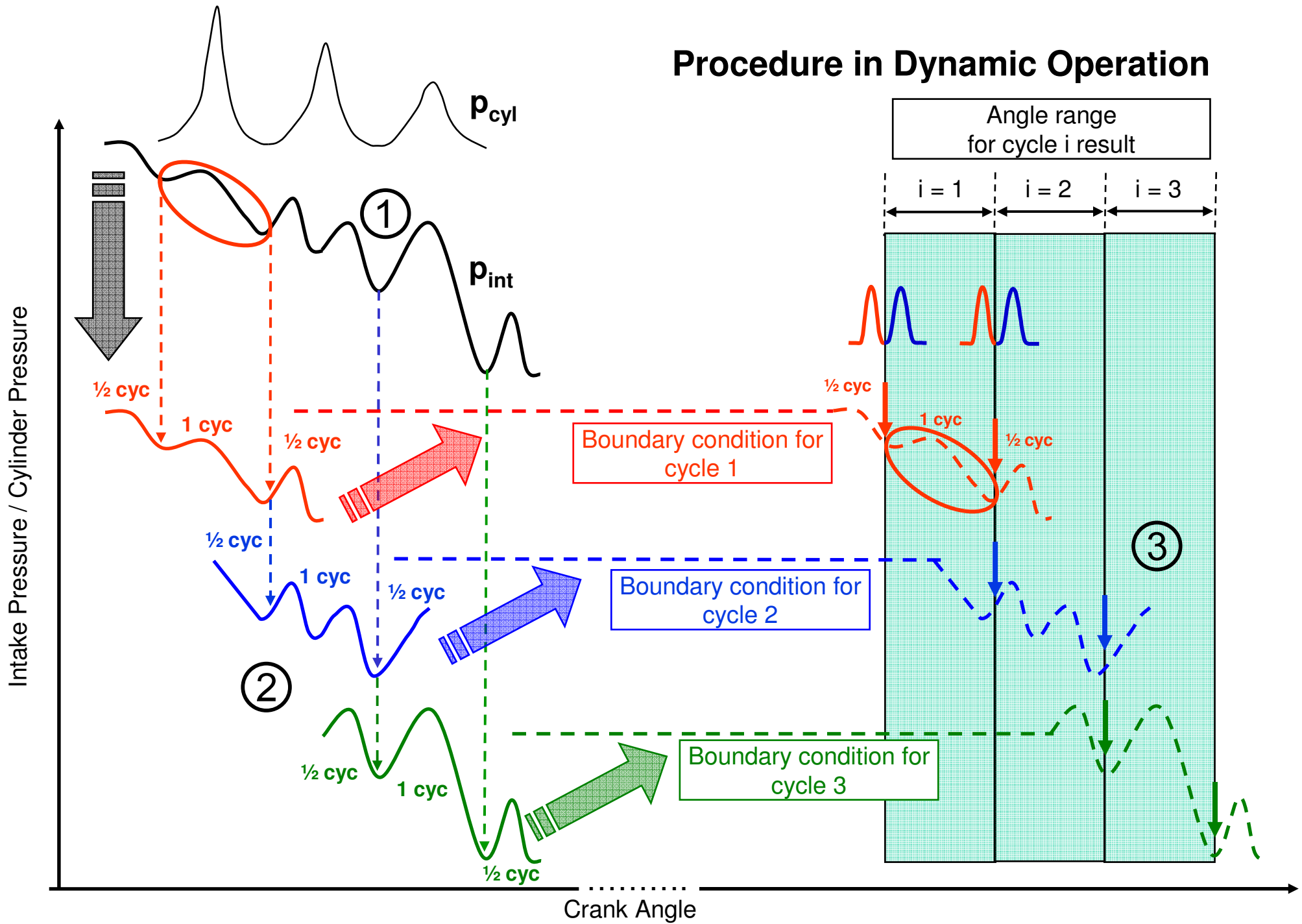
Gas Exchange Analysis

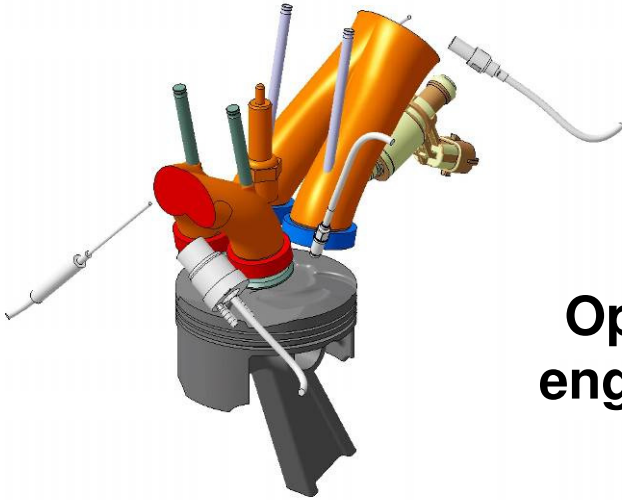


Pressures & Flows



Procedure in Dynamic Operation



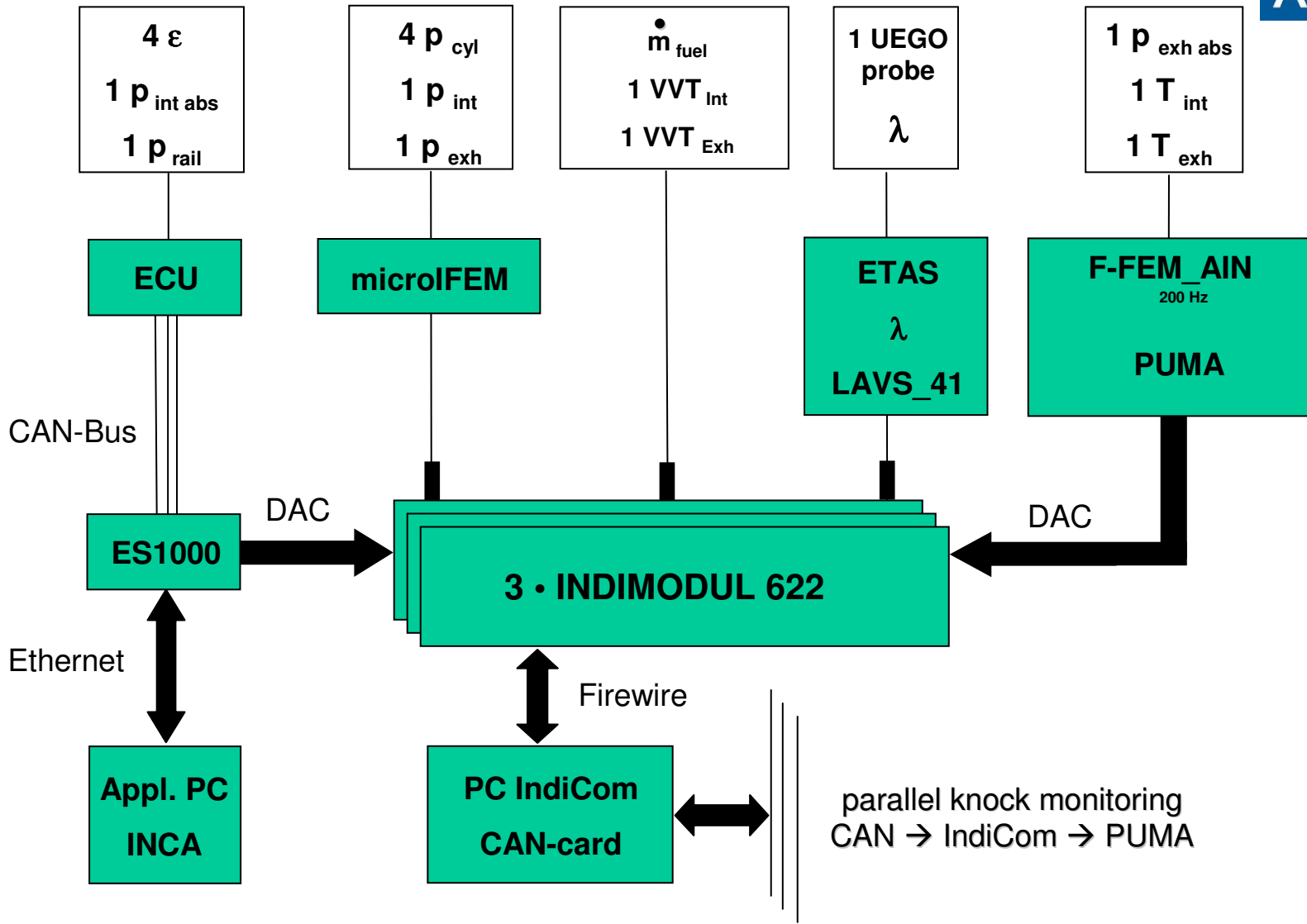


Optimizing the dynamic operation of a gasoline engine with high flexibility by means of AVL-GCA

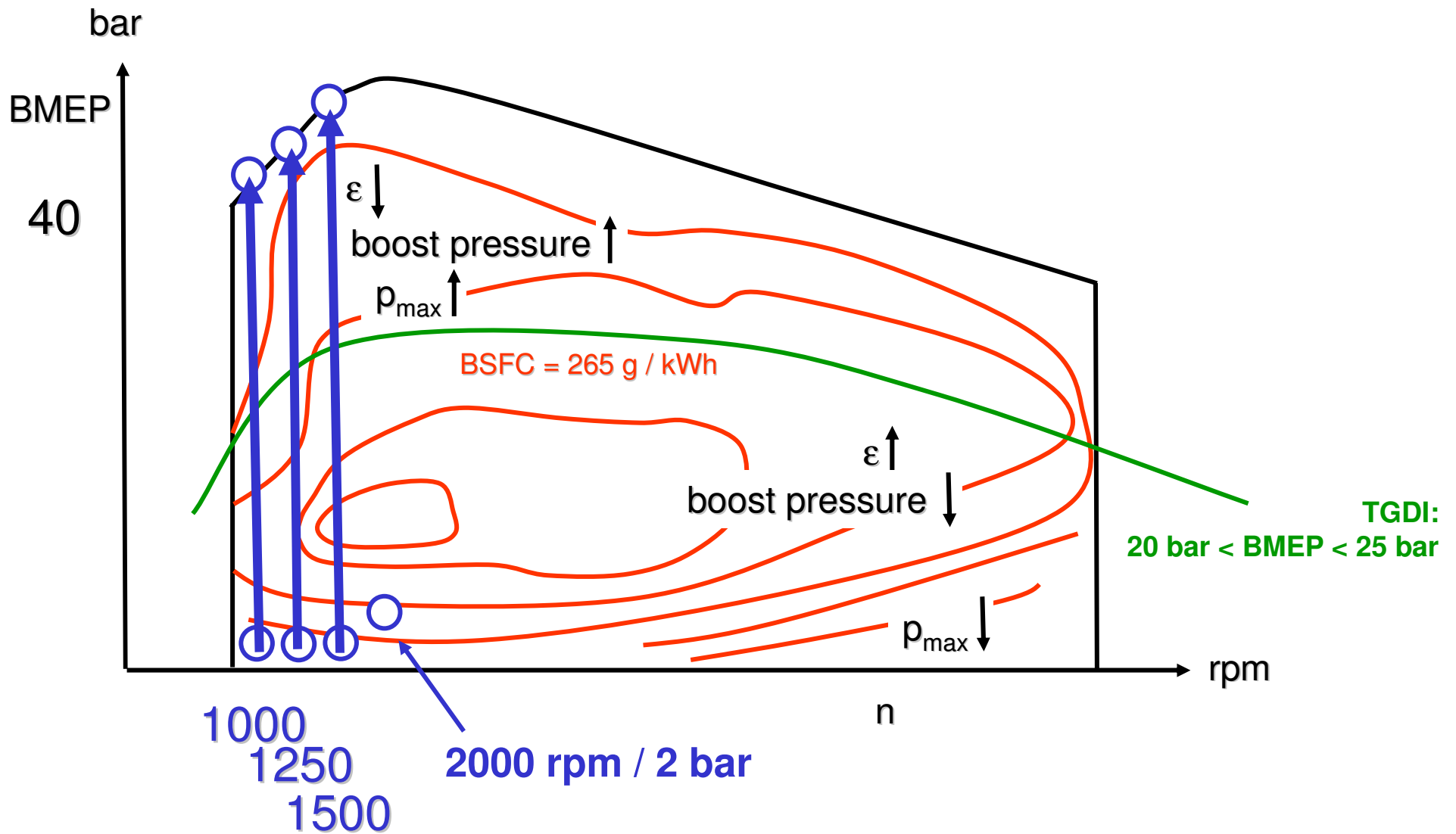
content:

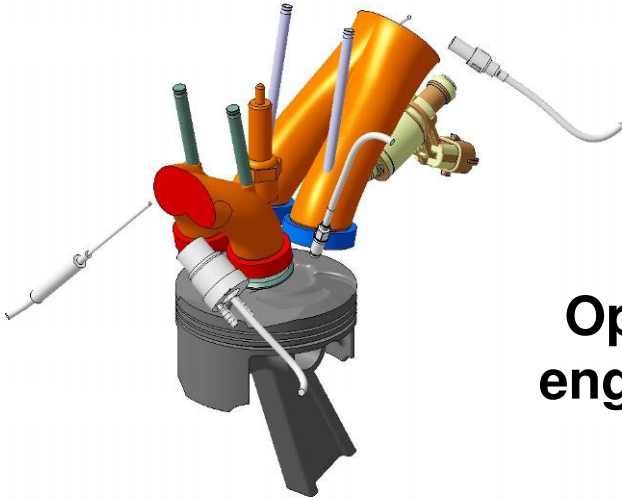
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test bed set-up and measurement



fuel consumption



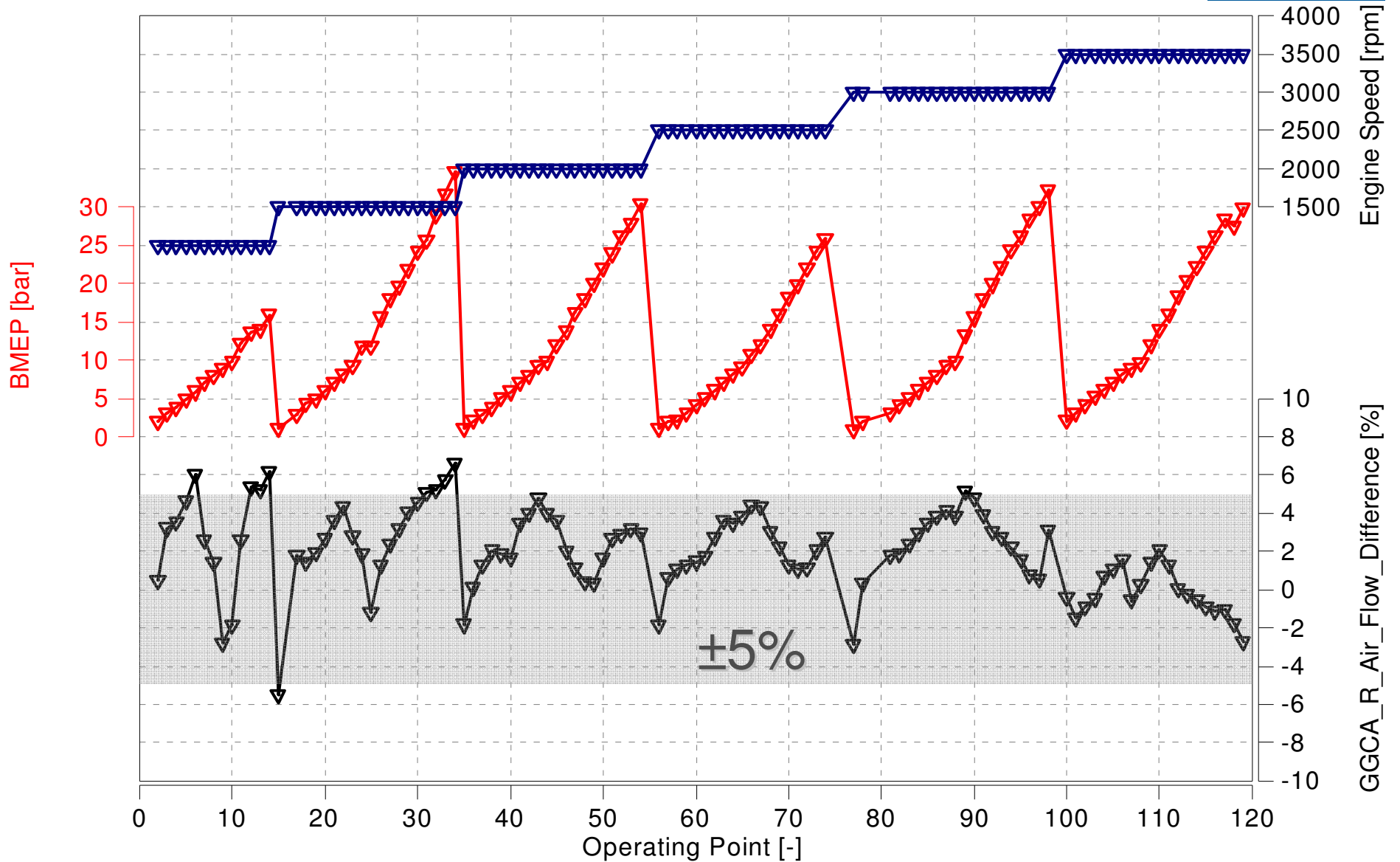


Optimizing the dynamic operation of a gasoline engine with high flexibility by means of AVL-GCA

content:

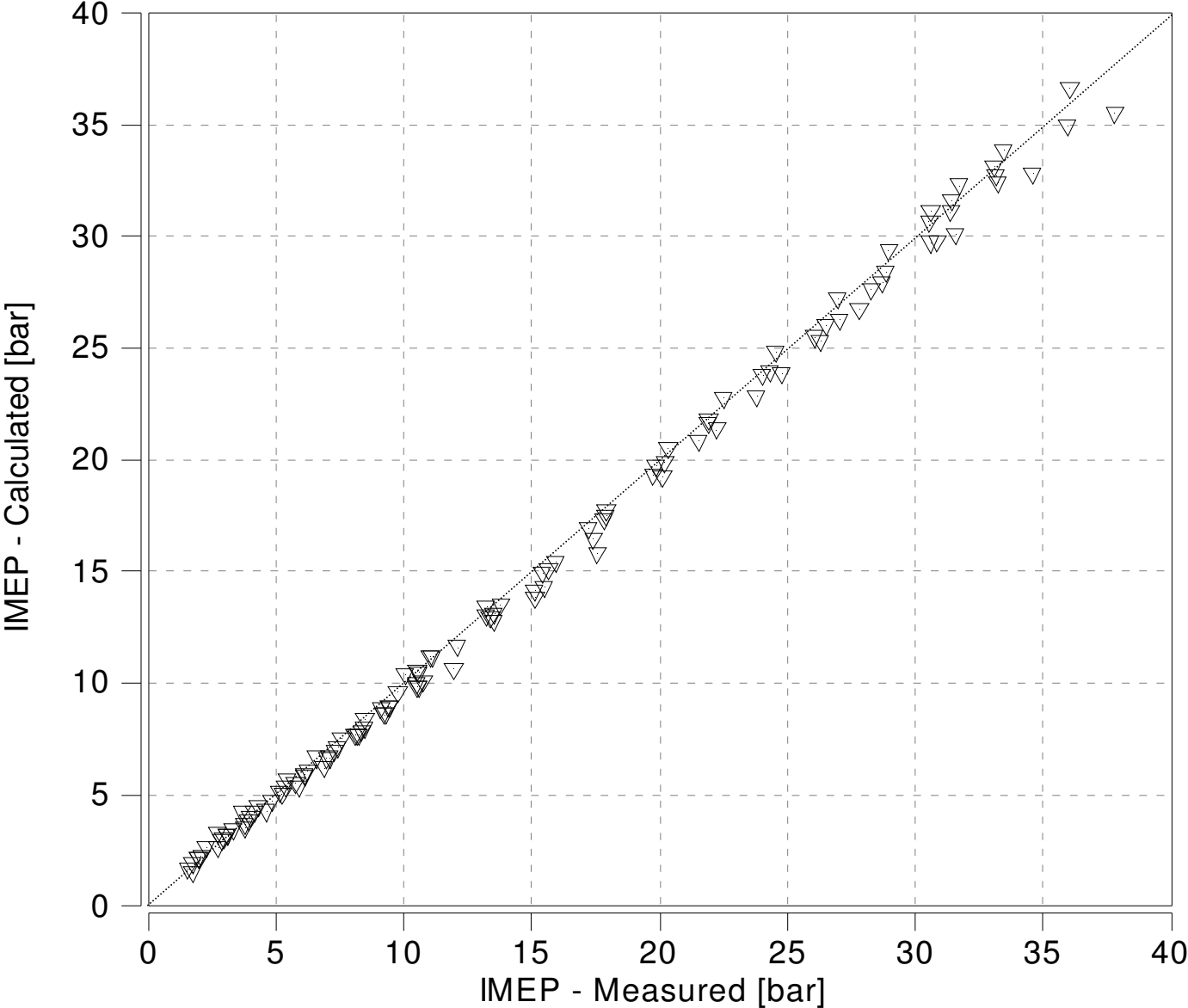
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Air Flow Difference: Measurement - Calculation



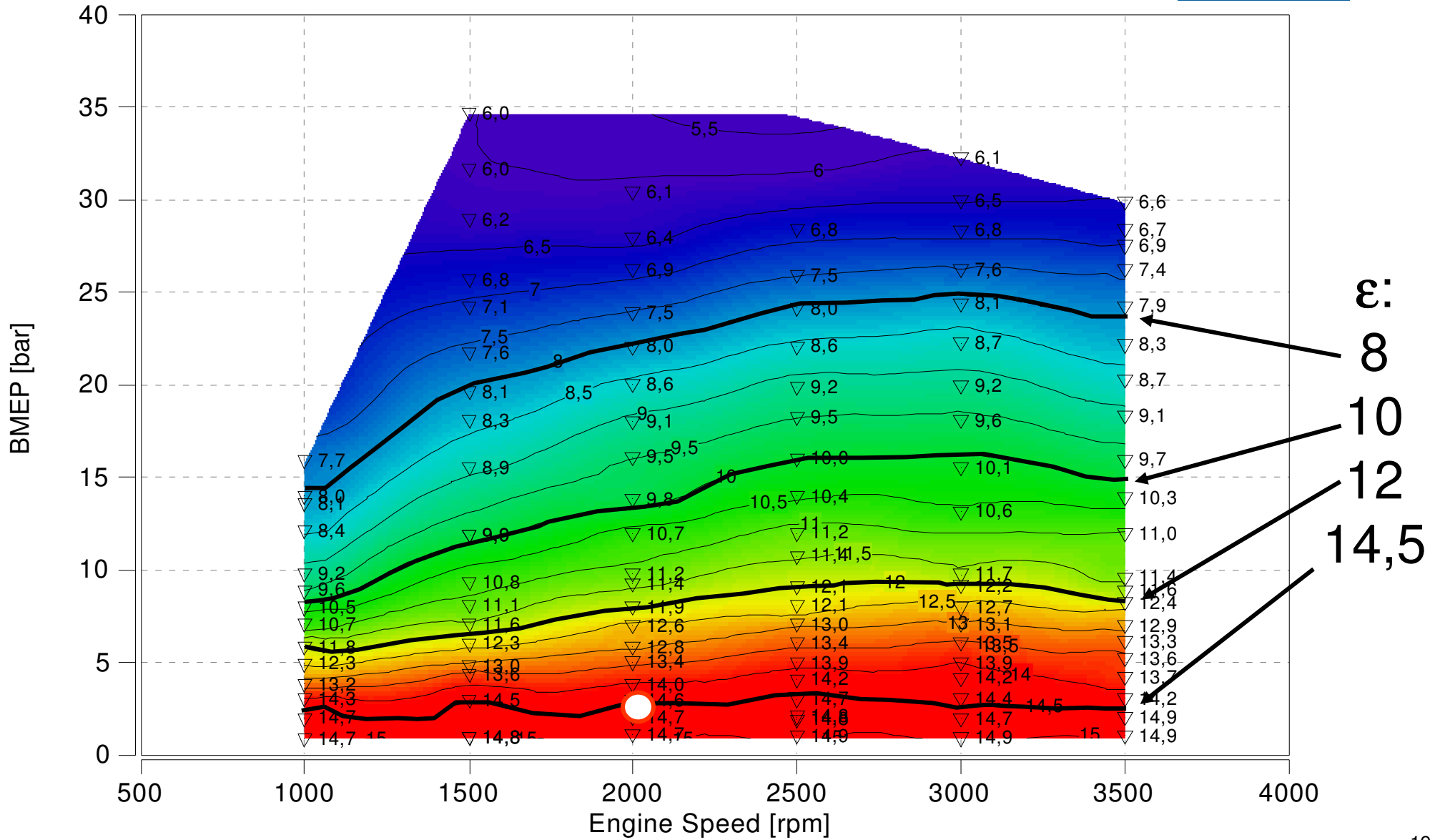


Energy Balance: Measurement - Calculation



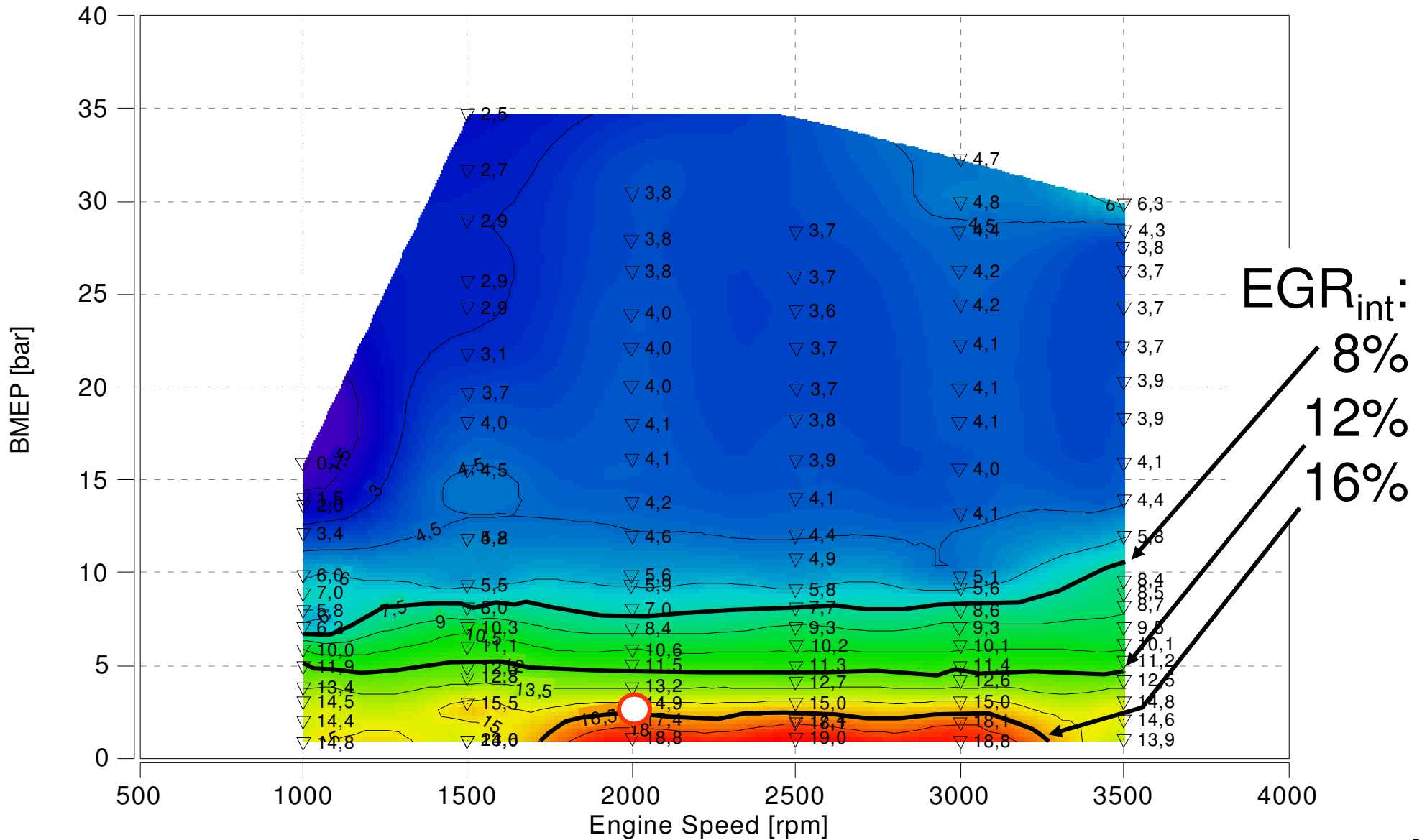


Compression Ratio, ○ 2000 rpm / 2 bar

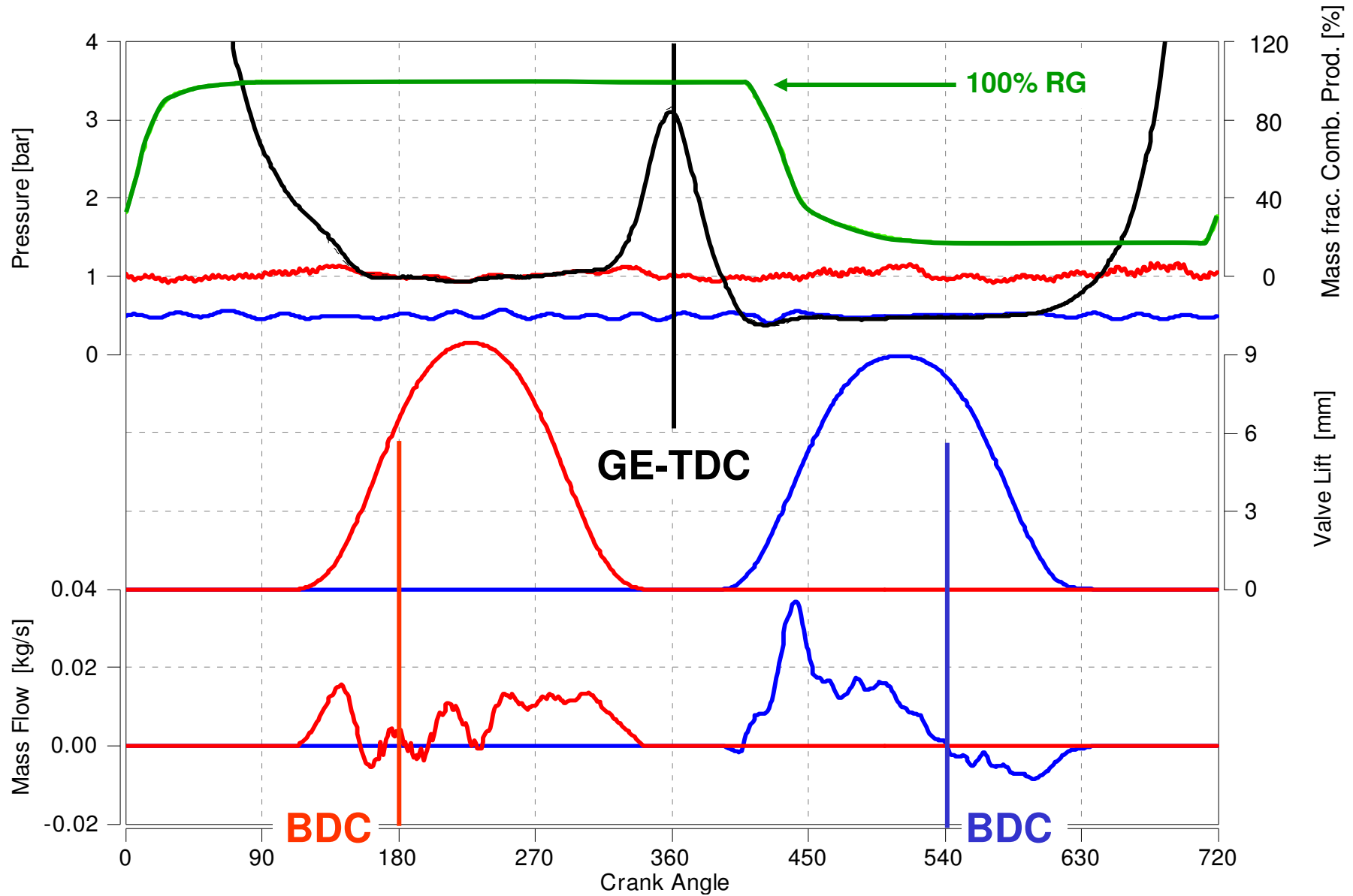


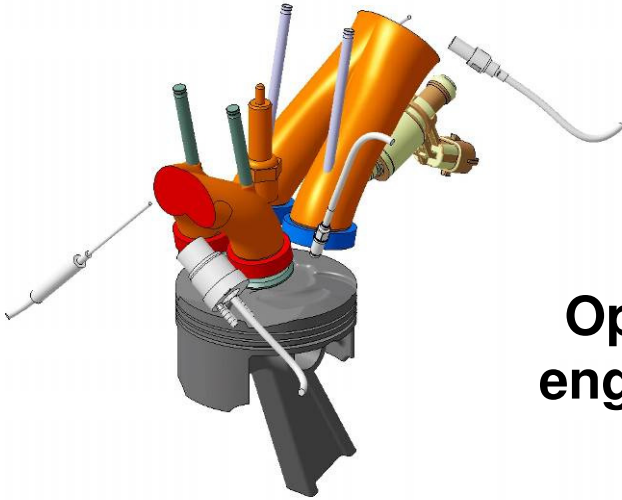


Residual Gas Content, ○ 2000 rpm / 2 bar



Compression of Residual Gas @ 2000 rpm / 2 bar



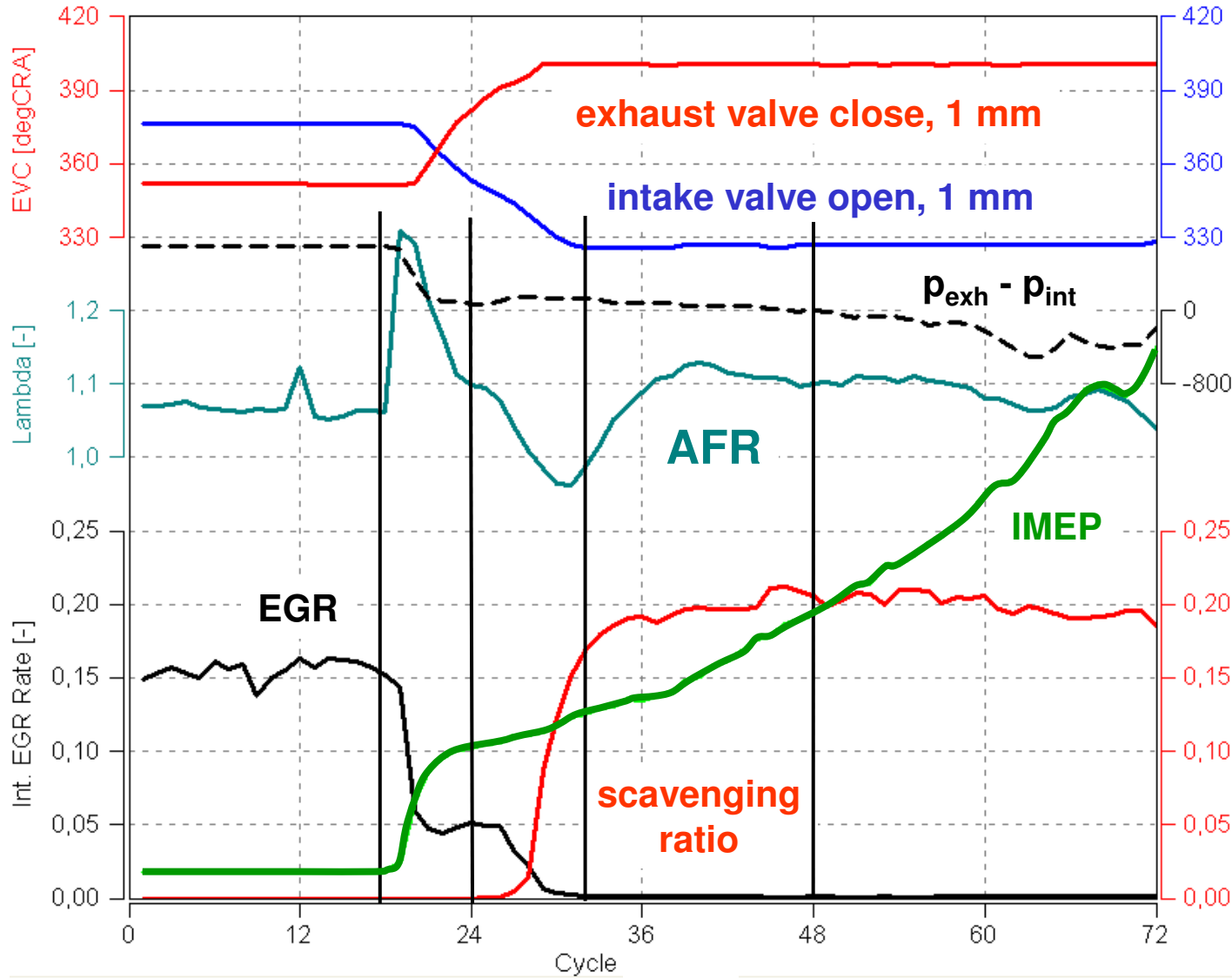


Optimizing the dynamic operation of a gasoline engine with high flexibility by means of AVL-GCA

content:

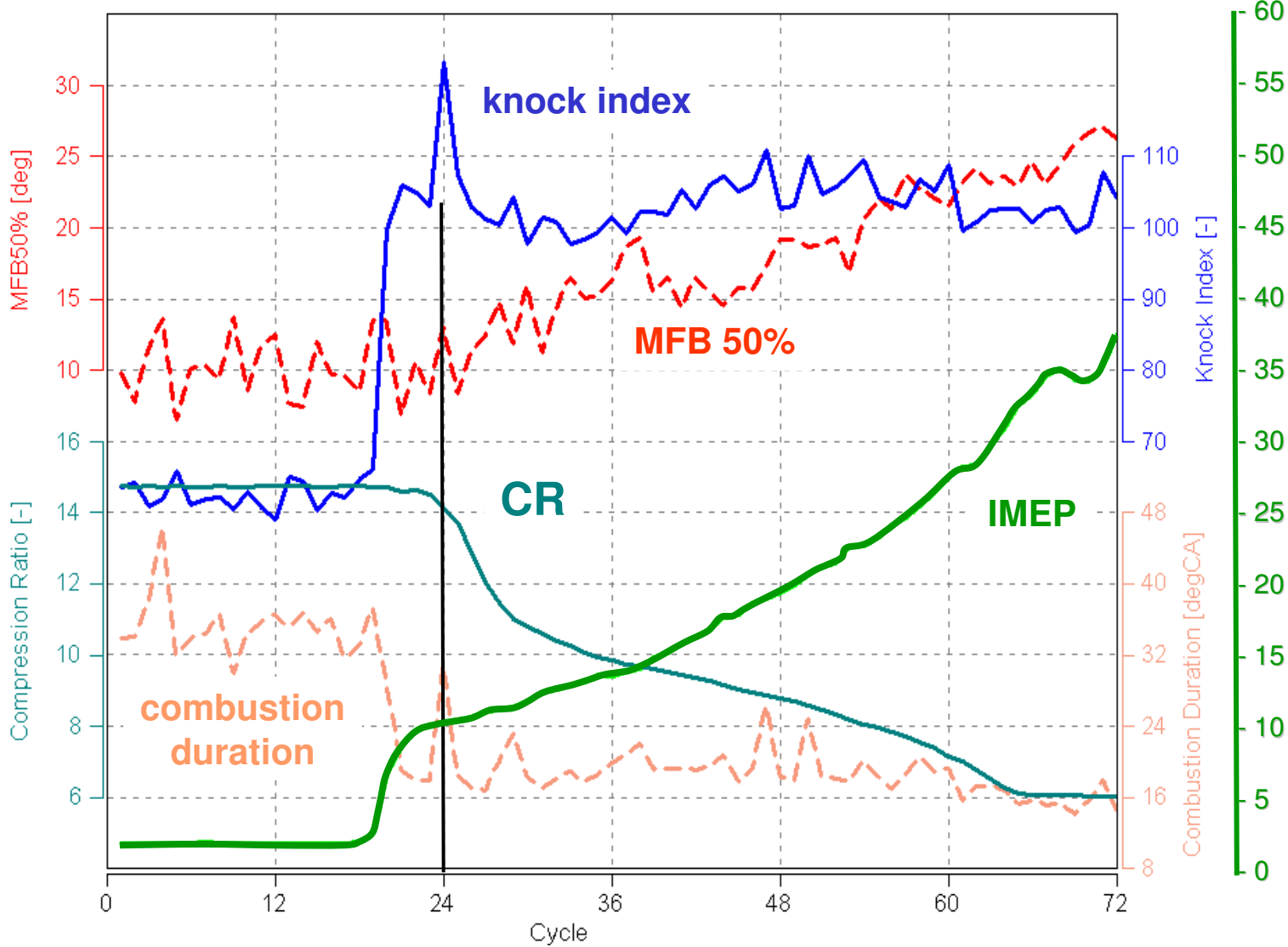
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gas exchange phase



CYC 24
EGR high:
 knock tendency ↑
 spark timing later
 energy conversion ↓
 exhaust gas enthalpy ↓

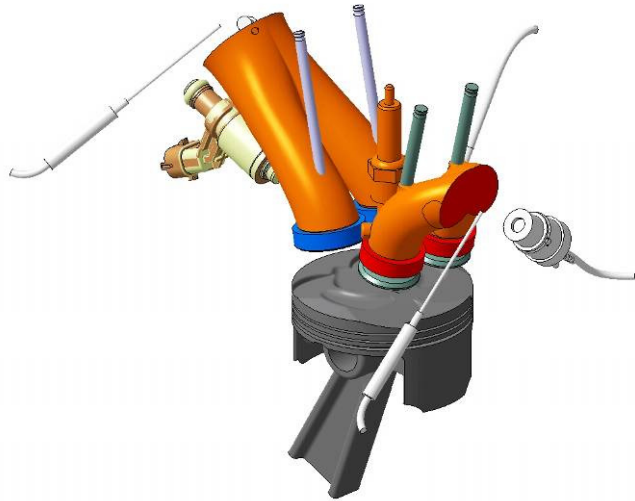
high pressure phase



CYC 24
operation @ knock limit:
 η_{HP} ↑
Exhaust Gas Enthalpy ↓

Torque progress:

actual

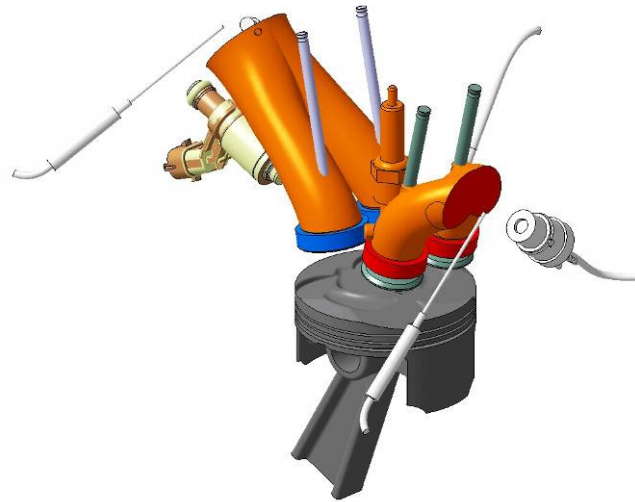


IMEP

• how to proceed?



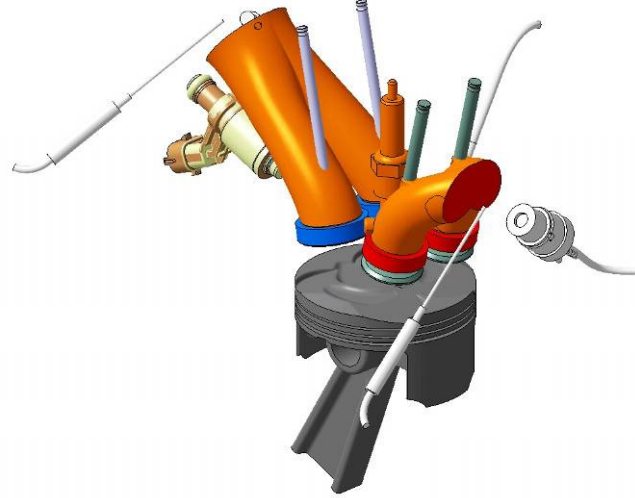
Torque progress:



TARGET

IMEP

• how to proceed?



Thank You For Your Attention!