GT-SUITE Users Conference on October 9th, 2006

Improved Scavenging by Individual Valve Cam Phasing

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General description of the Pressure pulsation within the charge air pipe and exhaust gas pipe

- Charge air pipe:
  Pressure pulsation between the compressor and the dead end

- Exhaust gas pipe:
  Pressure pulsation between the dead end and the turbine
  - Different scavenging,
  - different air fuel ratio at each cylinder
Initial state:

Revision of the in-line engine L58/64
⇒ Implementation of a small exhaust gas pipe Ø360mm

Advantages of the small exhaust gas pipe:
• Reduced volume of the exhaust gas pipe
• Impr. acceleration of the turbocharger
• Impr. transient perform. of the engine

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Initial state of 9L58/64CD:

1. Small exhaust gas pipe:
   Large pressure peak from cylinder 9 during valve overlap of cylinder 7
   ...

   ![Graph showing pressure and valve lift over crank angle for large and small exhaust gas pipes.](image-url)
Initial state of 9L58/64CD:

2. ... leads to backflow ...
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Initial state of 9L58/64CD:

3. … and to a high temperature after cylinder 7

Risks at the 9L58/64CD with small exhaust gas pipe:

⇒ Danger of hot corrosion at cylinder 7 at HFO operation due to high temp.

⇒ Customer is not able to evaluate the condition of the cylinder correctly by measurement of the temperature spread after cylinder (< ±30K required)

⇒ Back flow at cylinder 7 may lead to deposits in the inlet port
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Comparison
measurement – calculation
Large exhaust gas pipe

1. Good agreement between measured and calculated pressure waves in the charge air pipe and in the exhaust gas pipe
Comparison  
measurement – calculation  
Large exhaust gas pipe  

2. Good agreement between measured and calculated pressure waves in the exhaust gas pipe
Comparison
measurement – calculation
Large exhaust gas pipe

3. Acceptable agreement between measured and calculated spread of temperature after cylinder

0 = average temperature after cylinder
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Comparison measurement – calculation
Small exhaust gas pipe

4. Acceptable agreement between measured and calculated spread of temperature after cylinder
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Measures to improve scavenging

- Charge air end vessel
- Individual valve cam phasing
  - Outlet valve 9: -15°CA
  - Outlet valve 7: +10°CA
  - Outlet valve 6: -5°CA
  - Inlet valve 6: +5°CA

Objective: Reduction of the spread of temperature after cylinder to a range smaller than ± 30K
Measures to improve scavenging:

- With charge air end vessel higher charge air pressure during valve overlap
- With valve cam phasing exhaust gas pressure peak outside valve overlap and increased valve overlap
Measures to improve scavenging:

- With charge air end vessel no back flow into the inlet port
- With charge air end vessel still drop of the exhaust gas flow
- With valve cam phasing almost no back flow into the inlet port
- With valve cam phasing only positive exhaust gas flow during valve overlap
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Measures to improve scavenging:

- Charge air end vessel leads to reduction of temperature spread after cyl.
- According to measurements and calculations also valve cam phasing leads to an effective reduction of temperature spread after cyl.
- Valve cam phasing implemented due to cost reasons

Graph showing temperature spread after cylinder with different configurations:
- Small exhaust gas pipe, measurement
- Small exhaust gas pipe, calculation
- With charge air end vessel, calculation
- With valve cam phasing, calculation
- With valve cam phasing, measurement

Calculation: -25K  
Measurement: -33K

Limit

0 = average temperature after cylinder
Conclusions:
A small exhaust gas pipe is required at the 58/64CD to improve transient performance. With the implementation of a small exhaust gas pipe the exhaust gas temperature after cylinder 7 of the 9L58/64 increases to an unacceptable level.

The exhaust gas temperature after cylinder 7 of the 9L58/64CD can be reduced to an acceptable level by cost-saving individual valve cam phasing.

Cost-saving:
Once 82 T€
Future 50 T€/a
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