GT-SUITE for cooling circuit & engine heat balance
Hans-Carsten Göttzsche-Götze

The engine company.
Deutz Applications for Diesel engines

AGRI Power

Construction machines

Generator sets

Automotive
Engine spec with key components from customer

<table>
<thead>
<tr>
<th>Emission state</th>
<th>Tier4f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Power [HP] @ 2.200 rpm</td>
<td>50</td>
</tr>
<tr>
<td>Rated Power [kW] @ 2.200 rpm</td>
<td>37.3</td>
</tr>
<tr>
<td>Peak Torque [Nm] @ 1.500 rpm</td>
<td>210</td>
</tr>
<tr>
<td>Torque [Nm] @ 1.000 rpm</td>
<td>176</td>
</tr>
<tr>
<td>Torque Rise [%]</td>
<td>31</td>
</tr>
</tbody>
</table>

- FIIE common rail
- Externally cooled EGR
- Charge air cooler
- Turbo charger
- Dual stage turbo charger
- EAT
Cooling system development

**Customer data to Deutz**
- Engine spec
- Vehicle package
- Operation limits

**Data to Customer**
- Heat Rejection
- Coolant flow
- Charge Air flow

**Deutz Cooling Team**
- Heat rejection, Cooler size, coolant flow
- Thermostat setting
- System configuration

**Cooling components**
- Diameters, Roughness
- Maps of pump, hx, Fan
- Thermostat valve curve
- Pressure losses

**Use of GT Suite MP**
Development structure

First engine heat balance → Required coolant flow

Hx temperature difference

Experience → First model w/o hx w/o pump map → pressure level, losses, flow distribution
Engine coolant circuit

Measure requirements for coolant system calculation

Measurement required $p$, $\Delta p$, flow

Known $\Delta p$, flow $\Delta p$
Development structure

First engine heat balance → Required coolant flow

Hx temperature difference → First model w/o hx w/o pump map → pressure level, losses, flow distribution

Experience → First model w/o hx w/o pump map → Interaction with testing

CFD calculations testing results → Pump map and more detailed model
CFD of difficult geometries

Result: pressure resistance

\[ \Delta p = 436 \text{ mbar} \]
Example: full circuit w/o heat exchangers

Result: pump performance
coolant flow distribution
Development structure

First engine heat balance → Required coolant flow

Hx temperature difference

Experience → First model w/o hx w/o pump map → pressure level, losses, flow distribution

CFD calculations testing results → Pump map and more detailed model → Interaction with testing

Engine test results → Circuit with HX: Oil, EGR, coolant, CAC → Confirmation of heat rejection and system performance
Heat Balance Schematic

Fuel

- Oil
- EGR
- Coolant

Radiation
Convection
Exhaust after Turbine
Power
Q CAC
Q Coolant

GT-SUITE for cooling circuit 25.11.2009
Deutz AG, Thermal&Fluid Engineering, TE -TT
Hans -Carsten Göttsche -Götze

GT-SUITE for cooling circuit 25.11.2009
engine heat balance
Heat balance calc for full circuit

Principle:
\[ Q_{\text{fuel}} = Power + Q_{\text{Exhaust}} + Q_{\text{Coolant}} + Q_{\text{CAC}} + Q_{\text{amb}} \]
\[ = \text{BSFC} \times \text{Power} \times \frac{\text{Fuel Heat}}{3600000} \]
\[ Q_{\text{Exhaust}} = f(\text{heat cap Exh, mass flow, Temperature after Turbine}) \]
\[ Q_{\text{CAC}} = f(\text{heat cap Air, mass flow, Temperature after compressor}) \]
\[ Q_{\text{amb}} \approx 4\%Q_{\text{fuel}} \]

\[ Q_{\text{Coolant}} = Q_{\text{Engine}} + Q_{\text{oil}} + Q_{\text{EGR}} \]
\[ Q_{\text{EGR}} = f(\text{heat cap Exh_EGR, mass flow, Temp diff over EGR cooler}) \]
\[ \text{EGR mass flow} = f(\text{EGR rate, air mass flow}) \]
\[ Q_{\text{Oil}} = f(\text{heat cap, mass flow, Temp diff over oil cooler}) \]
Measure requirements for heat balance

Condition with and w/o EGR
Calculation of heat rejection with GT controls

6 value maps out of measures
4 condition values out of case setup

Result out:
Q_Coolant
Q_CAC
EGR rate

Maped Values XYZ points
Map generation with XYZ points

Example: charge air flow over speed and BMEP
Full cycle with heat exchangers

Oil circuit, EGR flow, CAC flow, Cooling Air flow

Result: Coolant flow
Temperature distribution
System behavior
Full cycle with heat exchangers
Detail: Oil module
Full cycle with heat exchangers
Detail: Cooling pack

Air side of water circuit

Coolant

Charge air

Cooling air
Development structure

First engine heat balance

Hx temperature difference

Required coolant flow

Experience

First system w/o hx
w/o map pump

pressure level, losses,
flow distribution

CFD calculations

testing results

Pump map and
more detailed circuit

Interaction with testing

Engine test results

Circuit with HX: Oil,
EGR, coolant, CAC

Confirmation of
heat rejection and
system performance

GT Power calculation

Circuit with coupling

More detailed
heat distribution to oil
Split coupling with GT Power: model 4cyl-2V
Result of coupling with GT Power
Cooling system development

**Customer data to Deutz**
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- Heat Rejection
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**Deutz Cooling**
- Heat rejection
- Hx size, ATB, coolant flow
- Thermostat setting
- System configuration

**Cooling components**
- Diameters, Roughness
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**Use of GT Suite MP**
Vielen Dank