MOTORCYCLE COOLING CIRCUIT CALCULATIONS WITH GT-SUITE

GT-CONFERENCE FRANKFURT AM MAIN, 09/10/2017
PRESENTATION OVERVIEW

- COMPANY OVERVIEW
- LAYOUT OF A MOTORCYCLE COOLING CIRCUIT
- OUR WORKFLOW FOR 1D THERMAL CALCULATIONS
- SUMMARY
COMPANY OVERVIEW
HEADQUARTERED IN MATTIGHOFEN (AUT)

2931 EMPLOYEES (BY 31ST DECEMBER 2016)

500 EMPLOYEES IN R&D

203,423 SOLD BIKES (2016)

KTM & HUSQVARNA MOTORCYCLES

ON ROAD- / OFF ROAD-MOTORCYCLES / AUTOMOTIVE
KTM GROUP

KTM SX - Motocross
KTM EXC - Enduro
KTM Freeride E
KTM Adventure - Travel

KTM - RANGE OF MODELS

KTM RC - Supersport
KTM SuperDuke – Naked
KTM SuperDukeGT Sports Tourer
KTM X-Bow RR Supersportscar
LAYOUT OF A MOTORCYCLE COOLING CIRCUIT
LAYOUT OF A MOTORCYCLE COOLING CIRCUIT
LAYOUT OF A MOTORCYCLE COOLING CIRCUIT

- Component Measurements
- Stationary Operating Conditions
- 3D-Calculations

We had all parts but no system to combine them!
LAYOUT OF A MOTORCYCLE COOLING CIRCUIT

Past
Component level development

Present
System level development

Cooling System

1D-Cooling System
LAYOUT OF A MOTORCYCLE COOLING CIRCUIT

CONCLUSION

- 1D-Calculations offer more variance and flexibility to find the optimum faster
- Time dependent system behavior becomes observable
- Optimize in realistic operating conditions for a variety of drive cycle analysis
- Improved our engineering process
OUR WORKFLOW FOR 1D THERMAL CALCULATIONS
OUR WORKFLOW FOR 1D THERMAL CALCULATIONS

**INPUT:**
- Engine Data
- Geometry Data
- Calculation & Measurements
- Operating Conditions
OUR WORKFLOW FOR 1D THERMAL CALCULATIONS
MEASURED DATA INPUT
OUR WORKFLOW FOR 1D THERMAL CALCULATIONS

INPUT:
- Engine Data
- Geometry Data
- Calculation & Measurements
- Operating Conditions

OUTPUT:
- Engine / System Temperatures
- Pressure Drop vs. Volume Flow
- Fan Operating Conditions

BENEFIT:
- Optimized Cooling-System
- Reduced Test Bench Hours
OUR WORKFLOW FOR 1D THERMAL CALCULATIONS
EXAMPLE 450 SX-F

<table>
<thead>
<tr>
<th>KTM SX 450 (M794)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine</td>
</tr>
<tr>
<td>Displacement</td>
</tr>
<tr>
<td>Compression</td>
</tr>
<tr>
<td>Power</td>
</tr>
<tr>
<td>Torque</td>
</tr>
<tr>
<td>RPM max.</td>
</tr>
<tr>
<td>Cooling</td>
</tr>
</tbody>
</table>
OUR WORKFLOW FOR 1D THERMAL CALCULATIONS

EXAMPLE 450 SX-F

Optimization Targets:
- Cooling system $\Delta P$ & $Q$
- Routing structure
- Optimum radiator
- Packaging

Additional:
- Cylinder temperature prediction

<table>
<thead>
<tr>
<th>Engine Load Cases</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Load (Engine Temperature Prediction)</td>
<td>100% Load @ 8500/min</td>
</tr>
<tr>
<td>Stationary Point (Radiator Optimization)</td>
<td>50% Load @ 6000/min</td>
</tr>
</tbody>
</table>
OUR WORKFLOW FOR 1D THERMAL CALCULATIONS
EXAMPLE 450 SX-F – ENGINE TEMPERATURES

- Use the “Customized FE Structure”
- Define identical input for “Customized FE” & 3D calculation
- Evaluate critical Cylinder ”HOTSPOTS”

**Additional:**

Adapt “Simplified-FE” for similar engine projects
OUR WORKFLOW FOR 1D THERMAL CALCULATIONS
EXAMPLE 450 SX-F – ENGINE TEMPERATURES

Customized FE Structure

Heat-Quantity

Piping
OUR WORKFLOW FOR 1D THERMAL CALCULATIONS

EXAMPLE 450 SX-F – 3D-CHT / CFD INPUT

- 3D-CHT HTC
- Water-Jacket & Cylinder
- 3D-CFD Water-Jacket
- Pressure Drop
OUR WORKFLOW FOR 1D THERMAL CALCULATIONS
EXAMPLE 450 SX-F– ENGINE TEMPERATURES

Benefits:

- Time Saving Calculation Duration
- Cylinder Hot-Spot Validation
- Evaluate Engine Warmup Behavior

3D-CFD
22h @ 22 Processors
5 000 000 Cells

Simplified FE
0,2h @ 1 Processors
147 000 Cells
OUR WORKFLOW FOR 1D THERMAL CALCULATIONS
EXAMPLE 450 SX-F– RADIATOR INVESTIGATION
## OUR WORKFLOW FOR 1D THERMAL CALCULATIONS
### EXAMPLE 450 SX-F– RADIATOR INVESTIGATION

<table>
<thead>
<tr>
<th>Initial Settings:</th>
<th>Model Calibration-Process:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine-Speed: 6000rpm</td>
<td>Baseline-Model has to fit Measurements</td>
</tr>
<tr>
<td>Power: 20kW, 50% Load</td>
<td>“As Used” Radiator Scaling</td>
</tr>
<tr>
<td>Temp-Air: 21°C</td>
<td>Define Air-Velocity at Radiator</td>
</tr>
<tr>
<td>Temp-Water: 70°C</td>
<td>Changing Radiators &amp; Piping</td>
</tr>
<tr>
<td>Velocity: 50km/h</td>
<td></td>
</tr>
</tbody>
</table>
OUR WORKFLOW FOR 1D THERMAL CALCULATIONS
EXAMPLE 450 SX-F – RADIATOR INVESTIGATION

Temperature Results

- Standard Testbench T_Water
- Standard GT-SUITE T_Water
- Medium GT-SUITE T_Water
- Small GT-SUITE T_Water
- Testbench T_Air
- 1D Calculation T_Air
SUMMARY

Customized FE Cylinder Structure
- Faster calculation duration as 3D-Calc
- Good accuracy for Temperature distribution

Additionally
- Adapt FE-Model for similar engine projects
- Drive-cycle and warm-up analyses

1D-Thermal-Modelling
- Optimized Cooling-System
- Optimized Structure & Water Temperatures

Additionally
- Pre-Layout radiator; pump; & fan; combinations
- Add complete Motorcycle to 1D-Model
- Temperature controlled Co2 and Fuel-Economy improvements
THANK YOU FOR YOUR ATTENTION!

B.ENG. MAXIMILIAN KOCH, KTM AG – MATTIGHOFEN (AUT)
DIPL.-ING. CHRISTIAN MAYRHOFER / M.SC BENCE SOMOGYI / ING. WOLFGANG GIERBL
M.SC PRATIK MEHTA GOPESH