Model-Based Evaluation of Litens Thermal Management Technologies with GT-SUITE
Agenda

• Objective
• Litens Technology
• Model Overview
• Validation/Results
  o NEDC
  o FTP75
  o Real World Cycle
  o WLTC
• Conclusion
Objective

To develop engine thermal management analysis capability using GT-SUITE:

• Develop understanding of the heat transfer process in the vehicle thermal management system

• Calibrate, verify and validate the system model with measurements from instrumented vehicle

• Demonstrate and quantify benefits of Litens advanced thermal management strategies for both regulatory cycles and real-world drive cycles
Litens Technology – Switchable Water Pump

- **Conventional Water Pump (CWP)** – water pump is belt-driven by engine, with pump speed at a fixed ratio to engine speed

- **Switchable Water Pump (SWP)** – water pump output can be controlled based on the engine cooling need
  - Clutch mechanism to engage/disengage water pump from the engine
  - Can achieve zero-flow, full flow (equivalent of CWP), and partial flow
  - Significant speed up of engine warm-up
  - Reduction in water pump parasitic loss
# Vehicle/Engine Specifications

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>C-Segment 5-Door Hatchback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>1300 kg</td>
</tr>
<tr>
<td>Transmission</td>
<td>5-Speed Manual</td>
</tr>
<tr>
<td>Engine Type</td>
<td>PFI NA SI Engine</td>
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<tr>
<td>Displacement</td>
<td>1796 cm³</td>
</tr>
<tr>
<td>Bore x Stroke</td>
<td>80.5 mm x 88.2 mm</td>
</tr>
<tr>
<td>Compression Ratio</td>
<td>10.5</td>
</tr>
<tr>
<td>Maximum Power and Torque</td>
<td>138 hp @ 6000 rpm, 129 lb-ft @ 4000 rpm</td>
</tr>
</tbody>
</table>
Model Overview

Vehicle Speed Profile/Gear Shift Schedule

Vehicle
Transmission
Engine - Combustion

Virtual Driver
ECU

Model Predictions – T, P, FlowRate, etc.

Underhood
Engine – Heat Transfer
Coolant Circuit
Oil Circuit
Cabin
With Litens SWP:
• Engine/coolant warmup are much quicker
• Operating metal temperature is typically higher than CWP counterpart
CWP vs. SWP Temperature Differential - NEDC

- Cylinder head temperature differential
  - Maximum temperature differential achieved during warm up phase
  - Higher steady-state coolant temp. than baseline
  - Temperature converges shortly after engaging CWP operation
FMEP/WP Power Reduction

- SWP leads to friction reduction through quicker engine warm-up
- SWP provides significant reduction in water pump power consumption
Demonstrates fuel saving using SWP

Majority of saving comes from phase 1, due to rapid engine warm-up

SWP beneficial even in phase 2, due to less over-cooling
Most of the FE benefit occurs during phase 1 and 2 of the cycle.

Some FE improvement during HWY phase.
• 23.7km – 15.3km City, 8.4km Highway
• Mild traffic, early afternoon
• ~25°C ambient temperature
Coolant & Oil Temperature – Real World Cycle

- Vehicle test under SWP operation
- Model matches test data well in general
- Engine warm-up improvement predicted using model (comparing SWP vs. CWP)
- FE improvement predicted
• Used model to evaluate SWP at 3 ambient temperatures:
  ○ -20°C
  ○ -7°C
  ○ 25°C
• Significantly improve engine warm-up
• SWP is especially beneficial at cold weather condition
• Off-cycle credit potential
SWP offers OEMs the ability to optimize engine warm-up while meeting cabin heating requirement.
Conclusion Remarks

- Litens developed in-house thermal system analysis capability to evaluate the impact of its advanced thermal management technologies in improving engine fuel economy
- SWP drastically improves the engine warm-up on cold engine start
  - For both regulatory cycles and real-world cycle
  - The effect is even more pronounced at sub-freezing ambient temperature
  - Lead to fuel economy improvement through FMEP/auxiliary power consumption reduction
- SWP offers the capability in optimizing engine warm-up, while meeting cabin heating requirement
Thank You

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