LITENS ADVANCED THERMAL MANAGEMENT SOLUTIONS FOR IMPROVING ENGINE WARM-UP AND FUEL ECONOMY

Jason Zheng, Noel Abreu, Bin Cheng
Litens Automotive Partnership
Outline

- Introduction
- Litens Thermal Management Solution (Switchable Water Pump)
  - Hardware Assembly
  - Testing Platform
  - Control Software
  - Calibration
  - System Model
- Model Application
- Vehicle Test Results
- Conclusion
Litens Introduction

Canada
Toronto
✓ Headquarters
✓ Technology Center

Germany
Gelnhausen

China
Suzhou

Brasil
Atibaia

India
Pune

Liaison Offices

Switchable Water Pump

- Capable of achieving zero-flow conditions
- Very quick response time, ~300ms
- Significant reduction of parasitic loss during off-conditions
- Small electrical power consumption to operate the EM coil
- 100% flow fail-safe operation
- Suitable for both accessory/timing belt drives applications, with minimal modifications needed on engine/circuit
Litens’ Advanced Testing Platform (ATP):
- GUI and hardware setup for measurement/calibration
- Open-system, with consistent implementation of the ASAM (Association for Standardization of Automation and Measuring System) standard
- Support data exchange formats based on ASAM
  - ASAM 1 - XCP on USB
  - ASAM 2 - a2l data exchange
  - ASAM 3 - Measurement and calibration automation tool

Overview of Advantages
- Can be used in vehicle, test bench, and office/laboratory environments
- Time-synchronized data acquisition
- Convenient calibration and management of parameters
- End-to-end control solutions for electromechanical products
- Develop control algorithms and embedded software to optimize SWP performance and to meet other control objectives
- Provide control system design specs and/or software depending on customer needs
- Efficient software sharing system developed by working together with ECU suppliers
- Dedicated application support
Switchable Water Pump – Software Calibration

FE Testing
- Assist in the execution of FE tests, data acquisition, analysis, and calibration
- Key to maximizing FE savings

Production Software
- On-site or remote support for calibration of production software using third party tool (ETAS INCA)

Sample FE Test Process Flow
- ATP Preparation
- ATP Installation on Target Vehicle
- Functional Checks
- Data Analysis
- End of Test
- Start NEDC/FTP75 Test
- Calibration Update
- Calibration Support
- EXECUTABLE
- FLASH to ECU
- CALIBRATE
- litens_software.o
- ems_software.o
## Vehicle Info.

<table>
<thead>
<tr>
<th></th>
<th>Vehicle 1 (Completed)</th>
<th>Vehicle 2 (In Development)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass</strong></td>
<td>1300kg</td>
<td>1362kg</td>
</tr>
<tr>
<td><strong>Transmission</strong></td>
<td>5 speed</td>
<td>6 speed</td>
</tr>
<tr>
<td><strong>Engine</strong></td>
<td>PFI NA SI Engine</td>
<td>T-GDI</td>
</tr>
<tr>
<td><strong>Displ.</strong></td>
<td>1796 cm³</td>
<td>996 cm³</td>
</tr>
<tr>
<td><strong>Bore x Stroke</strong></td>
<td>80.5mm x 88.2mm</td>
<td>71.9mm x 81.8mm</td>
</tr>
<tr>
<td><strong>Compression Ratio</strong></td>
<td>10.5</td>
<td>10</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>138HP @ 6000 rpm</td>
<td>123HP @ 6000 rpm</td>
</tr>
<tr>
<td><strong>Torque</strong></td>
<td>129lb-ft @ 4000 rpm</td>
<td>125lb-ft @ 3500 rpm</td>
</tr>
<tr>
<td><strong>TMS Features</strong></td>
<td>Conventional</td>
<td>Split-Cooling, IEM, Aux. WP, etc.</td>
</tr>
</tbody>
</table>
Other temp. measurements include:
• Air/exhaust temp across turbocharger, radiator
• Engine oil temp at block/head gallery, across oil cooler
• Turbocharger metal temp.
• Cylinder head/liner, IEM metal temp.
Model Calibration & Validation – 1.8L Gasoline (NEDC)

- CWP: Head Metal Temperature (°C)
- SWP: Total Coolant Temperature (°C)

- $\Delta t_{\text{metal}}$
- $\Delta t_{\text{coolant}}$

Fuel Economy (L/100km):
- Phase 1
- Phase 2
- Weighted

- SWP
- CWP

FE improvement

SWP reaches target temp.
CWP reaches target temp.
SWP turned off
Model Application - Rapid Warmup in WLTC & Cold Conditions

*Simulated using actual component data
FE Improvement (%)

FE is significantly improved with lower ambient/initial temperature due to greater reduction in engine friction

FMEP Reduction (%)

Friction modelled based on ICMER2013, P176
Model Application – Benchmarking & Control Optimization

Coolant Temperature

Head Temperature

Liner Temperature

Risk of cylinder head overheating due to stagnant flow can be mitigated through optimal WP control strategies

*Simulated using actual component data
Vehicle Test Results – 6.7L Diesel Engine (FTP75)

Quicker engine/coolant warm-up is evident, and leads to better FE

55% reduction in parasitic power consumption

>2% overall FE benefit

Temperatures are physically measured, while IFC is obtained off CAN
• Significant FE improvements have been demonstrated with customer applications for various engine platforms

• SWP control strategies were optimized for each application independently, based on engine system, layouts, and technologies present

>1% FE benefit achieved on most applications
Conclusion

• Litens thermal management solution encompasses:
  ▪ Switchable water pump (SWP)
  ▪ Testing platform
  ▪ Control software
  ▪ Software calibration
  ▪ System modeling and simulation

• SWP enables:
  ▪ Quicker engine warm-up, which greatly improves combustion efficiency and reduces engine friction by limiting the WP output during cold start
  ▪ Drastically reduces parasitic power consumption relating to WP operation (typically >40% reduction)
  ▪ Accurate temperature regulation even after the engine has reached operating temperature, due to fast-responding ON/OFF clutch mechanisms
  ▪ Variable set temperature depending on engine operation, and ambient conditions

• Concerns related to stagnant flow causing engine overheating can be mitigated through better WP control calibration

• >1% FE improvement have been achieved in most applications
Thank you!

Jason Zheng
email: jason.zheng@litens.com

Litens Automotive Partnership
Toronto, Canada