Thermal management –
Hot on the trail of emissions reduction

Alex Morein
Michael Weiss
Combustion energy

> 80% of energy lost

Schaeffler Symposium 2014
Alex Morein
Usual suspects

**Engine Losses:** 70% - 72%
- thermal such as radiator, exhaust heat, etc. (60% - 62%)
- combustion/enrichment (3%)
- friction (3%)
- pumping (4%)

**Parasitic Losses:** 5% - 6%

**Drive train Losses:** 5% - 6%

**Power to Wheels:** 17% - 20%

US Dept. of Energy

[Click here for more information](http://www.fueleconomy.gov/feg/atv.shtml)
Thermal management: why now?

- Global regulations
- Downsizing
- High heat output components
- Downspeeding
- Increased cooling system flexibility
- Lean assembly
Shrinking ideal operation zone

Ideal Zone

Temperature flexibility

Thermal Mass

System temperature limit

Nominal temperature

Traditional temperature

Temperature

Downsizing

Ideal Zone

Traditional temperature limit

Nominal temperature

Temperature
Outdated thermostat

Oct. 1, 1934

Downsizing?  ❌

Flexibility?  ❌
Schaeffler thermal management module

First on the market

SOP
- July 2011, Audi EA888 Gen.3

Function
- Coolant control
- Flow distribution

Advantages
- shorter warm-up phase
- increased thermal efficiency
- CO2- and fuel consumption reduction
- increased interior comfort
video here

Block return

To block

To radiator

Engine oil HX

Trans HX, cabin return

Radiator return
Audi performance

2-4% CO₂ Reduction

Flexibility
Precision: +/- 2°C
System flexibility

- Customizable
  - Number ports
  - Flow rates
  - Diameters

Commonized actuator components

- Bypass / EGR
- Radiator feed
- Sensor & Drive
- Engine connection
- Interior heating
CAFE demonstration vehicle
Comparing warm up strategies

Test Point: 1500min⁻¹ / 93Nm 10°C

Warm-up time reduction 30%

S. Grams, KIT
Increasing cabin comfort

- Seat temperature $T$ in °C
- Time $t$ in s

- Pump on
- Pump pulsating
- Pump delayed 120s
- Pump delayed 210s
System simplification
1.0L Gasoline engine, split cooling

Split cooling thermostat
1.0L Gasoline engine, split cooling
Engine performance test bench setup
Expectations

Exhaust valve bridge

Upper cylinder liner

Middle cylinder liner

No thermal management

Zero flow

Zero flow & oil heating

S. Grams, KIT
Engine performance test results

- Exhaust Valve Bridge
- Cylinder Liner-top end
- Cylinder Liner-center
- Engine Oil Temp.

Valve angle

- Zero-Flow
- Head open
- Block open
- Radiator Control
Exhaust temperature test results

- Higher exhaust gas temperature: faster catalytic converter light-off
Retrofit and measurement of a 1.6L I4
Measurement results-1.6L I4

Temperature $T$ in °C

Time $t$ in s

Zero flow | Rapid warmup | Hot operation | Flexibility

Base engine
Retrofit
Emission Benefit in NEDC (warm-up only)
Solving the puzzle

- Cooling systems growing in complexity
- Higher level of vehicle integration, including powertrain
- Push for lean assembly efforts
- System-level solution required
There is nothing more deceptive than an obvious fact.

Sherlock Holmes
per Sir Arthur Conan Doyle
1859-1930