Emerging HD Technologies

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Overview

- Technology to reduce the environmental footprint of transportation has been evolving continuously since its introduction in 1975.

- Reducing GHG emissions is parallel focus along with criteria pollutants for regulators and our customers.

- Next generation technology will continue to produce integrated systems that optimize GHG and criteria emissions performance.

- Technology neutral standards will continue to bring most cost-effective solutions to market.
A HISTORY OF COLLABORATIVE SUCCESS

THE SUPPLY SECTOR
Industry’s History of Success

- 4 decades of emission decreases paired with unprecedented growth in transportation-related productivity
- Key partner with OEMs in dramatic emission reductions to limiting air-pollution from vehicles
- Created high-value jobs for decades
- Established U.S. as world leader in emission control technology
90% (relative to MY2010 levels) HD NOx reduction necessary for Ozone NAAQS attainment by 2031
80% reduction in GHG emissions below 1990 levels by 2050
50% petroleum use reduction target by 2030.
CONTINUOUS INNOVATION

TECHNOLOGIES
Current Technologies Utilize Advanced Design Strategies to Maximize Cost Effectiveness

Pd is zoned in the front to give fast HC light-off. Rh in the back to protect against catalyst poisons.
Technical Challenges

• Multiple emission challenges must be addressed simultaneously – GHG, NOx, PM, N\textsubscript{2}O, CH\textsubscript{4}

• Several strategies to reduce HD engine GHG emissions impact NOx reduction strategies
  – Longer periods of cold-temp operation can impact in-use NOx emissions
  – Lean burn operations increase engine efficiency – but result in more engine out NOx emissions

• Filters increase weight and backpressure – reducing engine efficiency
Optimized Systems to Tackle GHG & Criteria Emission Challenges

**Technology Development**

R&D currently moving far beyond current standards

Requirements for development process:
- Phase II GHG standard is treated as a constant
- Cost conscious – our customers must be able to sell new trucks
- Sizing constraints are integral to concept and design development

**Optimized Technology Strategies**

- NOx storage technologies
  - Could enable greater efficiency optimization of cold-temp operations
  - Could further reduce NOx emissions

- Thermal Management strategies could
  - Utilize waste heat (energy) to reduce fuel demands
  - Utilize exhaust slip-streams to maintain optimal catalyst temps

- New filter substrates could reduce backpressure and reduce weight

- New drivetrain technologies emerging rapidly (braking re-gen, battery reprocessing, fuel cell systems, etc.)
Positive Trends In Certified Engines

Future Enabling Technologies

CO₂ Emissions

NOₓ Emissions
Emerging Engine and Exhaust System Technologies

- Designing with a “both” not an “either/or” approach
- In some cases combining multiple systems allows for optimizations and results not available with a single technology
- Sizing, cost, integration, and other real-world constraints must be addressed at every stage of development
The Technology Innovation Process

Develop, Evaluate, and improve technology concepts

Reduce cost, time, resources needed to produce

Ongoing refinements to ensure market success

Cumulative Profit

Time

Idea

Development

Launch

Time-to-Market

Time-to-Profit
EMERGING CONCEPTS
Technology Opportunity: NOx Storage

Extensive NOx storage at very low temperature
Technology Opportunity: SCR on a Filter

Benefits
- Light Off; Better Thermal Management
- Downsizing
- Low Cost
- High NOx Conversion (~ 98%)

Challenges
- Trade-off between Pressure Drop and SCR Loading
- Particle Number for bare filters (EU6, Stage V)
- Passive Regeneration (HDV)
Technology Opportunity: High-Porosity Substrate

Standard Porosity

High Porosity (HP)

Better NOx conversion at low Temperature (increasing coating amount)

Lower Pressure Drop → Lower CO2 (increasing coating in wall)

More Compact System (reducing catalyst volume)
Technology Opportunity: Exhaust Stream Thermal Management

- Side system pulls hot exhaust from pre-turbo
- Urea is injected into side system, hydrolysis catalyst converts urea to NH₃
- Gaseous NH₃ is delivered to SCRF component inlet at low temperature
- Side NH₃ doser and main urea injection used in tandem during transient cycle
Ongoing Demonstration and Validation: Southwest Research Project

- Demonstrate 90% NOx reduction (0.02 g/bhp-hr) on HD and stoichiometric CNG engines

- Reduction Targets (from 3-4g engine out NOx)
  - 95% efficiency for cold start
  - 99% efficiency for hot start
  - 99% SET

- Engine calibration in parallel with exhaust control development

- System integration and demonstration
  - Full useful life (435K miles, 22,000 hrs.)
  - HD-FTP transient cycle, sustained low-load and low temperature operation
Technology Opportunity: Waste Heat Recovery

- Waste heat recovery systems reduce fuel consumption and CO$_2$ emissions for trucks.

- They convert waste heat from the exhaust gas and the exhaust-gas recirculation system into mechanical or electrical energy.

- Recaptured energy can be used to:
  - Power the vehicle drivetrain
  - Optimize emission control functions
  - Improve vehicle warm-up time
Technology Opportunity: Advanced Engine Systems

- High Pressure Common Rail – Computer controlled high pressure fuel injection ensures a more efficient in-cylinder fuel burn.

- Cutting Edge Electronic Control System – The advanced electronic control system controls air flow, EGR gas flow rate, fuel injection parameters, and after treatment function through intelligent software.
Technology Opportunity:
HD Regenerative Braking Systems
Technology Opportunity: Fuel Cells

- Commercial systems available for 30kW to 180 kW vehicles
- Solution for fleet vehicles such as buses, trucks and forklifts
Technology Opportunity: HD Battery Applications

• Hybrid bus range-extender
  – GPS controlled EV driving mode
  – Vehicle operates only in EV mode until it leaves the EV zone.
  – Target markets would be busy city centre to suburb & immediate surrounding areas

• Lifecycle Battery Management
  – Battery recycling
  – Battery reprocessing
Innovation – A Work in Progress

• Increased attention across the industry to technology development opportunities

• Accelerating experiences through strategic collaborative supplier partnerships

• Rapid advances in new technologies taking place

![Number of patent publications by year](chart)

Development is incomplete

All technical challenges must be addressed before a technology can be considered “proven”

- Cost
- Complexity
- Integration
- Optimization
- Dependability
- Size/space limitations
- New/additional fluids may be required
- New materials must be developed/refined
- Incomplete engineering
View of the Future

• Conventional powertrains will continue to be an important part of the HD fleet for some time to come

• Technology neutral standards will elicit most cost effective solutions to achieve CA’s criteria and GHG reduction goals

• Alternative powertrain technology evolving rapidly and adoption will grow steadily

• The proliferation of technologies will provide customers with increasing options to fit their applications
Thank You

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