Future Diesel Engine Thermal Efficiency Improvement and Emissions Control Technology

A Detroit Diesel Corporation Perspective

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DDC remains fully committed to support DOE’s strategic goal of developing more energy efficient and environmentally friendly transportation technologies that enable America to use less petroleum.
Near-term Powertrain Evolution

- Improved Thermal Efficiency
- Reduced Emissions
- Advanced Combustion
- Enabling Fuels, Fuel Systems, Controls, Materials...
- Exhaust Energy Recovery
- Increased System Integration
  - Thermal Management, Aftertreatment Regeneration...
- Auxiliary Power Alternatives
- Hybrid Powertrain

Near-term evolution of powertrain options to meet global demand for transportation mobility, fuel consumption, and emissions.

Conventional Combustion
- Conventional Fuels

Today

Time
Global Emissions Regulations

Global heavy-duty emissions regulations are approaching near-zero and present an opportunity for some common technologies to be utilized for global synergy.
DaimlerChrysler Vision for Global Emissions Control
Medium and Heavy Duty

EGR technology experience in the U.S. coupled with SCR technology experience gained in Europe lays a strong foundation for integration of EGR and SCR as part of the NOx control solution in the global market-place.
EPA 2007 Requires Management of Multiple and Conflicting Issues
Significant Effort Required to Minimize Increase in Initial and Lifecycle Operating Costs

Fuel density impact (Fuel economy penalty)
Ultra low sulfur diesel fuel
Diesel particulate filter (DPF)
New oil formulation (low ash) for DPF
Maintenance requirements (oil drain interval)

NTE Limits
In-use emissions testing conducted by manufacturer
Enhanced diagnostics requirements
Anti–idling requirements
Detroit Diesel Heavy-Duty Engine Technology Evolution
1998 through 2007

1998
- Single actuator electronic unit injector
- Wastegate turbocharger
- No exhaust gas recirculation (EGR)
- Combustion system optimized for no EGR

2002 / 2004
- Single actuator electronic unit injector
- Variable geometry turbocharger
- Cooled EGR
- Combustion system optimized for EGR

2007
- Dual actuator electronic unit injector
- Increased flow rates of cooled EGR
- Combustion system optimization with enabling fuel system and EGR
- Model-based controls
- Variable geometry turbocharger
- Closed crankcase breather
- Diesel particulate filter system with active regeneration
2007 Engine and Aftertreatment System Schematic

[Diagram showing engine and aftertreatment system components such as Charge Air Cooler, Intake throttle, EGR valve, EGR cooler, HC doser, DOC, DPF, Temperature, Thermal management, Active DPF regeneration, HC dosing control, and Temperature and pressure sensors.]

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Combustion System (Including Fuel and EGR System) Optimization

14.0 L 6-cyl. Engine, 1800 rpm, 2.5 bar BMEP

Example Operating Condition Representative of Transient Acceleration
Series 60 Legacy and Current Development

- First heavy-duty diesel engine in the world with fully integrated electronic controls
- In 2004, the Detroit Diesel Series 60 was the Class 8 heavy-duty engine market leader (R. L. Polk)
- Combined, the Series 60 and MBE 4000 enjoy 27% of the Class 8 market
- Best selling engine for the last decade - more than 72,000 Series 60 engines will be shipped in 2005 bringing the total of Series 60 engines in operation worldwide to more than 800,000
- Series 60 remains the fuel economy market leader in the competitive heavy-duty diesel engine market
- Backed by extensive dynamometer and vehicle test-beds, including engineering, reliability-growth and customer demonstration vehicles, the Series 60-2007 engine is well-positioned for a successful launch
State-of-the-art Thermal Efficiency and Engine Technology
Contributing Factors

Collaborative DOE-DDC programs lay an ideal technology foundation for subsequent product development and eventual commercialization.

Increasingly stringent emissions regulations and technical complexity require increased emphasis on system (powertrain and vehicle) integration.
- DDC, with its vertically integrated business relationship within the Commercial Vehicles Division of DaimlerChrysler, is well-positioned to meet this challenge.

Ability to leverage global engineering resources and expertise for maximum synergy, while addressing regional issues.
The Next-generation Heavy-Duty Engine Platform

The next-generation HD engine platform is our roadmap for continued success
  - Brand new engine line-up
  - Will meet the stringent standards for 2007 and 2010

Combines DaimlerChrysler engineering and manufacturing resources worldwide
  - Best expertise from all areas to resolve specific regional issues

General Features
  - Wide range of displacement and power ratings
  - Optimized cylinder block for noise / vibration reduction
  - Integral Jake brake with turbobrake option
  - Flexible fuel injection system
  - Advanced air system to optimize thermal efficiency
DDC’s Fuel Economy Improvement Commitment
Includes Development of Hybrid Powertrains and Idle Reduction Technologies

Potential to Improve Fuel Economy up to 16% for a Heavy Hybrid Electric Vehicle for a Hilly City Route

Detroit Diesel’s patented DDEC® Optimized Idle feature is designed to improve fuel economy by optimally controlling engine idle time, based on engine temperature, battery voltage and interior temperature.

Optimized Idle reduces idle time by ~50% resulting in a fuel economy improvement of ~5%

Analytical Results
Technology & Products that Continue to Benefit the Environment

Fuel Economy
- Supplier of the most fuel efficient diesel engines for various applications within the United States for nearly 20 years.
- Engines that help our customers reduce diesel fuel consumption in America by 2.5 million gallons per day.

Emissions
- Detroit Diesel meets the highest clean air standards for today and is a leader in developing clean burning diesel engines for the future.
- 2007 Detroit Diesel engines will emit 70% less pollutants than they did in 1998 – helping to preserve the clean air that Americans breathe.

Hybrid Technologies
- Detroit Diesel and Freightliner are working together to develop diesel hybrid electric engines that will:
  - Improve fuel economy
  - Reduce emissions
- Development of hybrid technologies is gaining momentum and will lead to high quality jobs and industry growth.

Celebrating 20+ Years of DOE & DDC Collaboration