T&SD Technology & Solutions Division

Division Name

Engine Materials for Clean Diesel Technology An Overview

Diesel Engine Materials Session

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Caterpillar, Inc

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Reduced Friction

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Concept

Reduce fuel consumption by reducing parasitic friction loads in PRL

Technology Challenge

Effective validation of PRL life durability/ reliability goals with new technologies

Potential Degradation Modes

- Coating cracking & spall off
- Corrosion assisted wear of coatings and surfaces.
- Adhesive/Abrasive liner & ring wear- oil film retention.

Material Development Needs

- Low friction, durable liner/ring coatings.
- Enhanced liner surfacing

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21st Century Truck Partnership Goals

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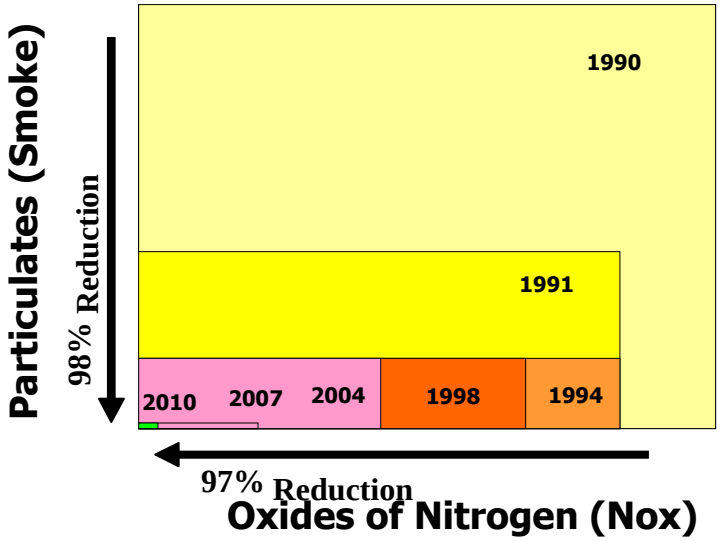
Significantly Higher Efficiency

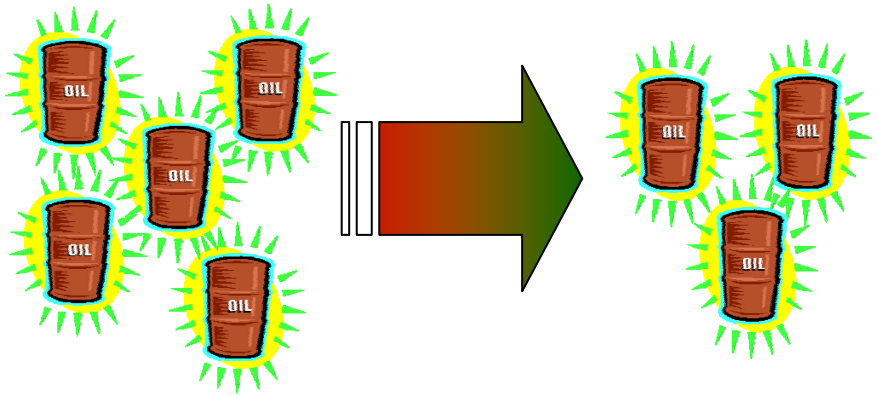
2006: 42% Thermal Efficiency

2010: 50%
2013: 55%
Thermal Efficiency

Emissions Compliance



Displace Petroleum Fuels 5% : 2010



AMT-Engine Materials Technology

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Integrated Technology Systems Development

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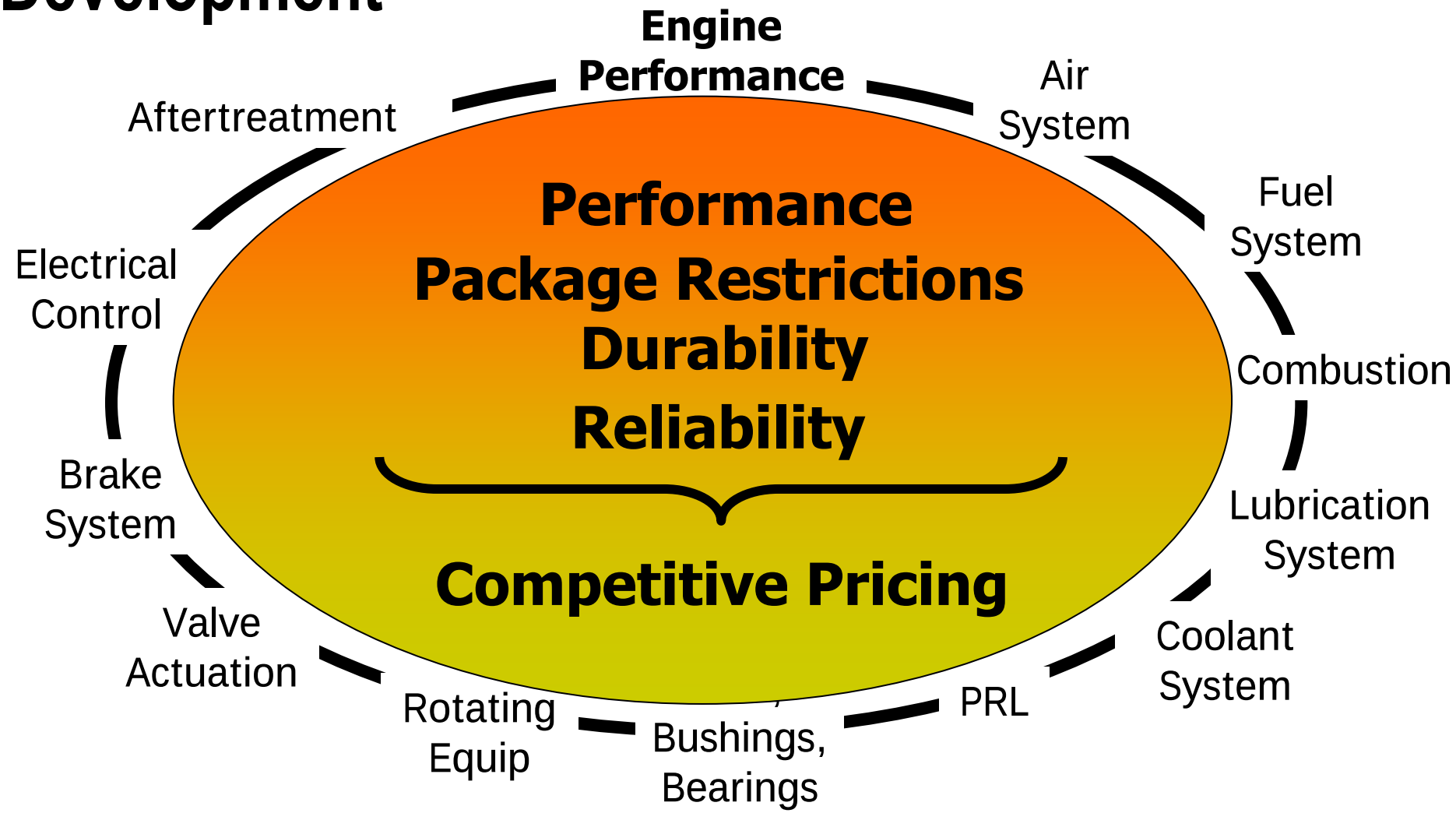

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Building Blocks To 50% Thermal Efficiency

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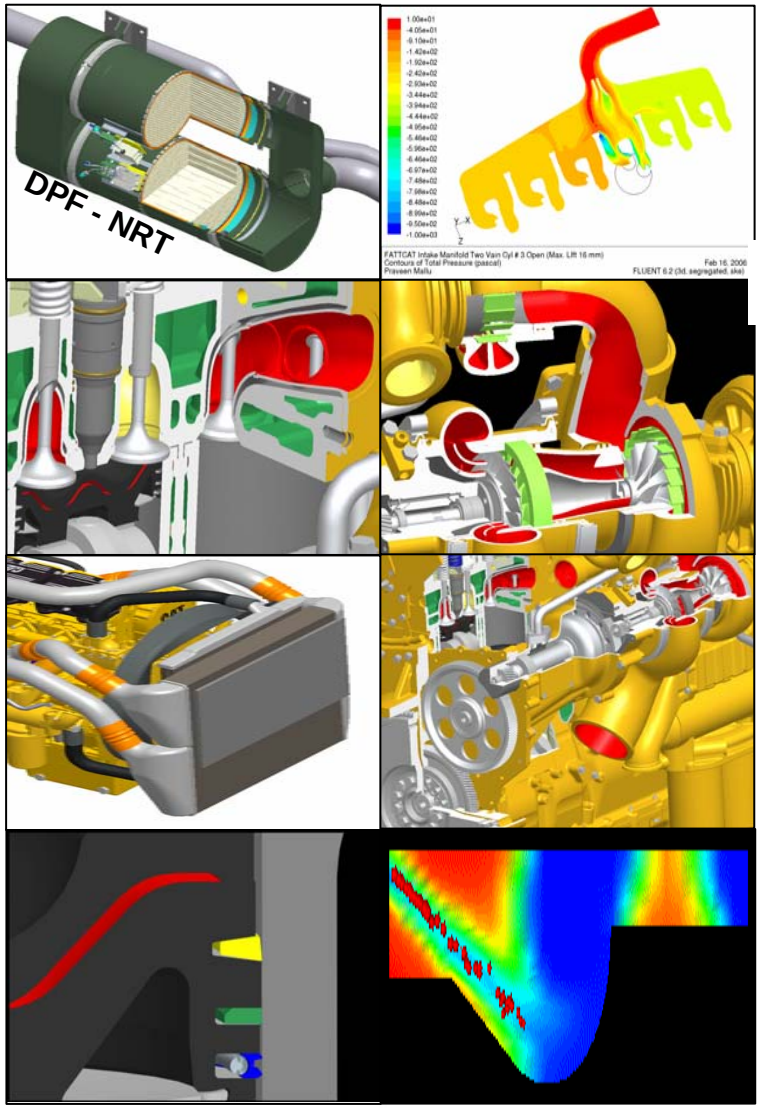
HE Aftertreatment

Reduced Heat Rejection

HE Compact Cooling System

Reduced Friction



Reduced Flow Restriction

HE Air System

Increased Waste Heat Recovery

Optimized Combustion System

AMT-Engine Materials Technology

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High Efficiency Aftertreatment

Nox Reduction Technology (NRT)

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Concept

High NOx Conversion Efficiency

Low Back Pressure PM Treatment

Technology Challenge

Package Size Vs. Conversion Efficiency

Conversion Vs. Temperature

Package Size Vs. Back pressure

Potential Degradation Modes

- NRT core plugging, fracture, catalyst depletion
- Can/Piping corrosion, mechanical and thermal fatigue

Material Development Needs

- Enhanced Joint Technologies (bolting/gaskets/design)
- Lower Cost High Temperature and Corrosion Resistant Alloys and Coating processes.
- Enhanced Ceramic Core Properties and Design

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Reduced Heat Rejection

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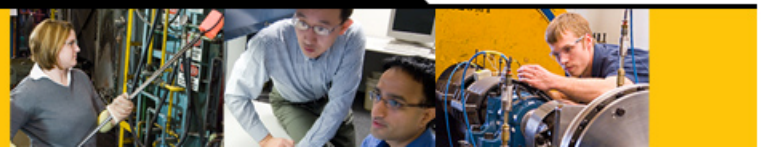
Concept	Technology Challenge
Ceramic inserts	Insulation versus flow resistance
Air Gap Piston	Thermal expansion management
Exhaust Port Liner	Product durability & cost

Potential Degradation Modes

- Thermal shock - ceramic liners.
- Thermal oxidation/fatigue - exhaust port liners.
- Mechanical fatigue (piston crown air gap liners)

Material Development Needs

- Durable, low cost, thermal barrier coating process.
- Ceramic alloys resistant to thermal cycling.
- Easily assembled, durable exhaust port liners



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High Efficiency Cooling System

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Concept

Intercooling Intake air

Reduce air pressure drop

Improve thermal heat transfer

Technology Challenge

Coolant/Oil temp management

Validation of system assembly, durability, and reliability

Potential Degradation Modes

- Condensate corrosion
- TMF - exchanger tubes
- Coolant system cavitation/corrosion
- Wear of oil lubricated components

Material Dev. Needs

- Enhanced corrosion resistant Al exchanger materials & coatings
- Lower cost substitute for austenitic stainless steel.
- Enhanced thermally conductive plastics and fabrication tech.
- Improved piping connection technologies

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Reduced Flow Restriction

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Concept

Reduce Resistance to Air Flow in Head and Exhaust Manifold Passages

Technology Challenge

Maintaining head stiffness, soundness, strength, and durability

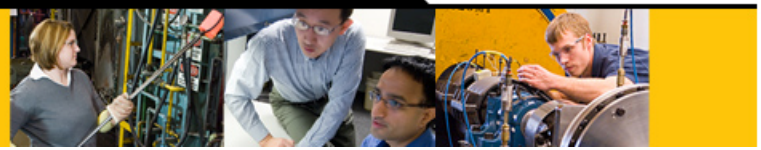
New casting process development & product validation.

Potential Degradation Modes

- Head distortion & cracking.
- Valve and seat insert wear
- Exhaust manifold TMF cracking

Material Development Needs

- Higher strength head material (DI or CGI)
- New lighter, stronger, corrosion resistant valve materials



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High Efficiency Air System

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Concept

Advanced turbine, housing, and compressor design

Technology Challenge

Turbine/Compressor response, efficiency/durability/cost

Potential Degradation Modes

- HCF/LCF compressor blade
- Bearing wear & seizure
- TMF cracking of housings
- Turbo wheel creep, corrosion

Material Development Needs

- Low cost high temperature alloys for manifolds & housing material.
- Robust bearing system
- High strength-low weight turbo wheel materials
- Higher temperature capability aluminum wheel cast alloys

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Increased Waste Heat Recovery

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Concepts	Technology Challenge
Turbo-Compound	Coupling technology
Brayton Cycle	Compact effective heat exchanger technology
Organic Rankine Cycle	

Potential Degradation Modes

- Gear train wear & fatigue
- Ht Exchanger corrosion, erosion, TMF
- Attachment (bolt) fatigue

Material Development Needs

- Enhanced gear strength & wear
- Light weight-high strength efficient exchanger materials
- Supporting fabrication processes

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Optimized Combustion

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Concept

Increased PCP, Compression Ratio, UI pressure

Optimized Exh Gas recirculation

Optimized nozzle/ bowl design

Technology Challenge

System integration

ECM program complexity

Virtual model correlations

Potential Degradation Modes

- Block/bearing cap overload
- Bushing, pin, bearing wear.
- Cylinder head distortion/cracking
- Injector erosion/cavitation/wear
- PRL wear/corrosion/cavitation
- Valve seat/insert wear

Material Development Needs

- Lighter stronger valves
- Deposit resistant pistons/valves
- Enhanced injector materials
- Thermal barrier coatings
- Stronger head & block
- Improved heat transfer materials.
- Reduced friction materials

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SUMMARY

T&SD Technology & Solutions Division

- Caterpillar is working on technology to enable engine efficiencies of 50% and on to 55%.
- Many of the technologies are materials enabled.
- Advances in current engine materials will be necessary to reach the final outcome.
- DOE **has been** and **will continue to be** a great Caterpillar collaborator to increase engine efficiency.

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