DIESEL ENGINE EMISSION CHALLENGES

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While the diesel engine remains the most efficient power source for transportation work, it can benefit from significant new technologies developed in the future. On-road regulations for both heavy duty and light duty engines will likely remain the pace setters for the technol-ogy selection process.

The future challenges for the diesel create opportunities for new approaches, as well as continued refinement of fuel, air, and combustion technologies. The very nature of combustion, from direct-injection heterogeneous burn to lean homogeneous combustion, lean NO_x aftertreatment systems, rapid-response NO_x sensor technology, along with fuel formulation will need to be researched and developed for suitable application.

As the end-user expectation of engines becomes more demanding relative to reliability, durability, fuel efficiency, and operational costs, the engines will also need to produce lower emissions over a longer useful life. The challenges are significant for the selected and necessary technologies to be well-proven and cost-effective, while remaining customer-accept-able. Partnerships will be needed between engine and oil companies, along with DOE sponsorship.

DIESEL REGULATION
TRUCK

> 1998 (4.0 NOx, 0.10 PM)
- field, preproduction engines started

> 2004 (~ 2.0 NOx, 0.10 PM)
- technology/feasibility research underway

> 2007 / 8
- what new regulation may apply ?
- investigate potential
  - PRODUCTION- VIABLE
  - END-USER ACCEPTABLE technologies

CUSTOMER INPUT

IN ORDER OF PRIORITY

> RELIABILITY

> DURABILITY
- 1 million mile engine
- improved service intervals

> FUEL ECONOMY

>.

>

> *EMISSIONS*
- legal engines, but function the same as before

2004 DIESEL EMISSIONS

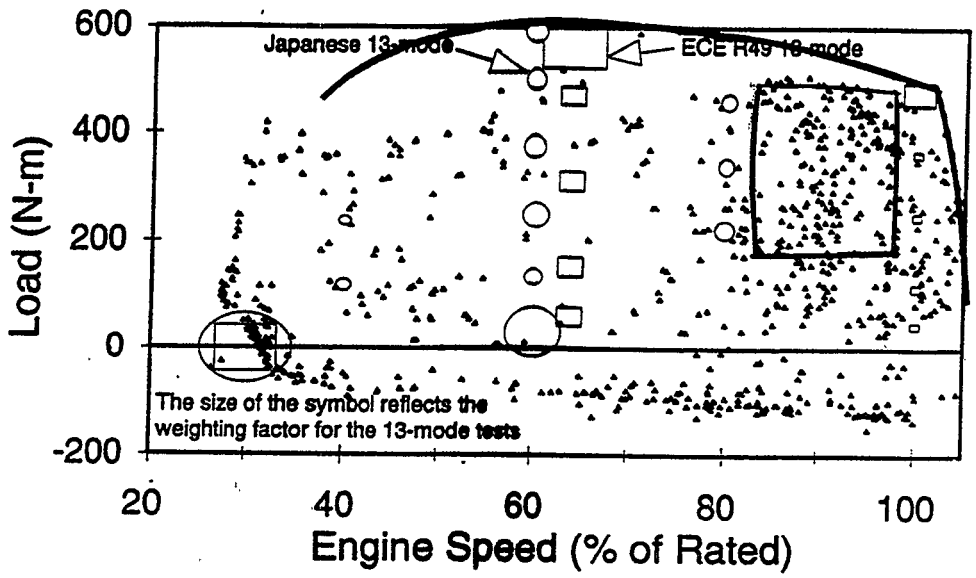
HEAVY & MEDIUM DUTY TRUCK ENGINES

2.0 g/hp.hr NOx, 0.10 Particulates

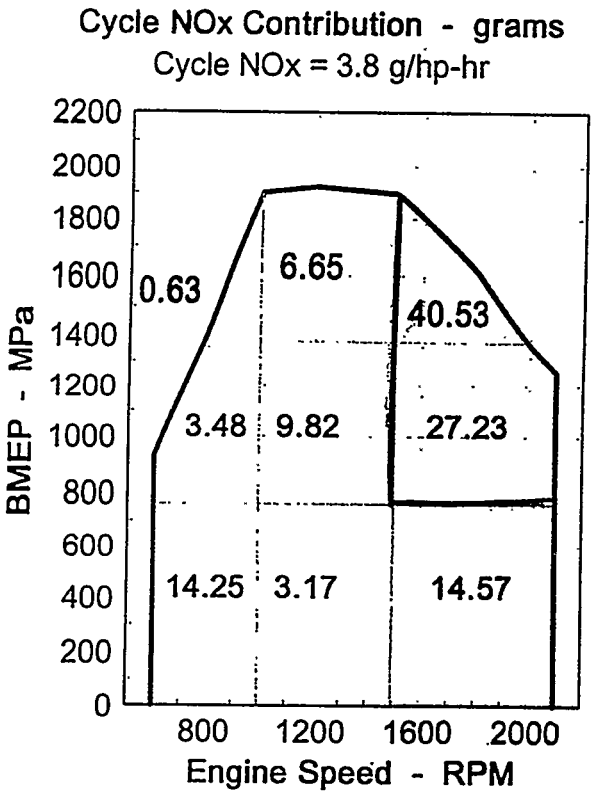
> EGR CONSIDERED KEY TECHNOLOGY
(transient control, durability, cooler efficiency and wear iss
> EUI / HEUI WITH INJECTION RATE SHAPE
(high peak injection pressures)
> SINGLE STAGE TURBOCHARGING (possible VGT)
> PISTON RINGs FOR REDUCED OIL-PARTICULATEs
> AFTERTREATMENT (probably limited to 2-way, medium duty)

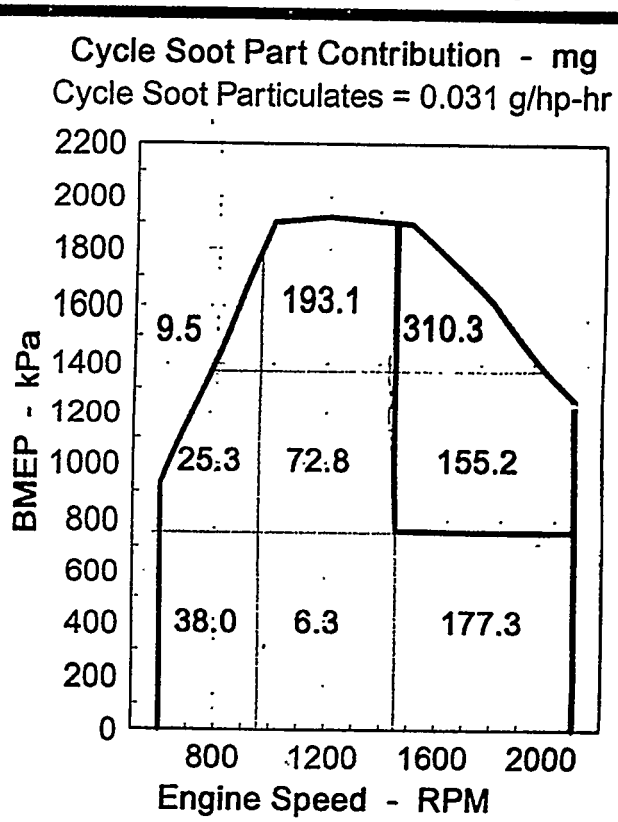
COMPARISON OF EMISSIONS CYCLES

Japanese 13, ECE R49, US FTP Cycles



Speed and Load Distribution of NOx and Particulates Formed During Transient Test Cycle





EGR - 2004

HEAVY & MEDIUM DUTY MOBILE APPLICATIONS

> EGR KEY TECHNOLOGY
> EFFECTIVE NOx REDUCTION TO 2004 LEVELS
> INTERNAL OR EXTERNAL LOOP
> 10 - 50% EGR THROUGH OPERATING RANGE
> COOLING BENEFICIAL

EGR - 2004 ISSUES

> CONTROL THROUGH TRANSIENT CYCLE
> AIR/FUEL RATIO CONTROL (may need vgt)
> BSFC
> PARTICULATES CONTROL (higher inj. press.)
> COOLER EFFICIENCY / SERVICE LIFE
> TURBOCHARGER WEAR (external loop)
> COMPONENT WEAR (short-hour tests encouraging)
> OIL DEGRADATION / SERVICE INTERVAL

> SYSTEM COST

FUEL INJECTION

> INJECTION RATE SHAPE

> PROGRAMMABLE ENTIRE OPERATING RANGE

> ELECTRONICALLY CONTROLLED FUEL SYSTEM

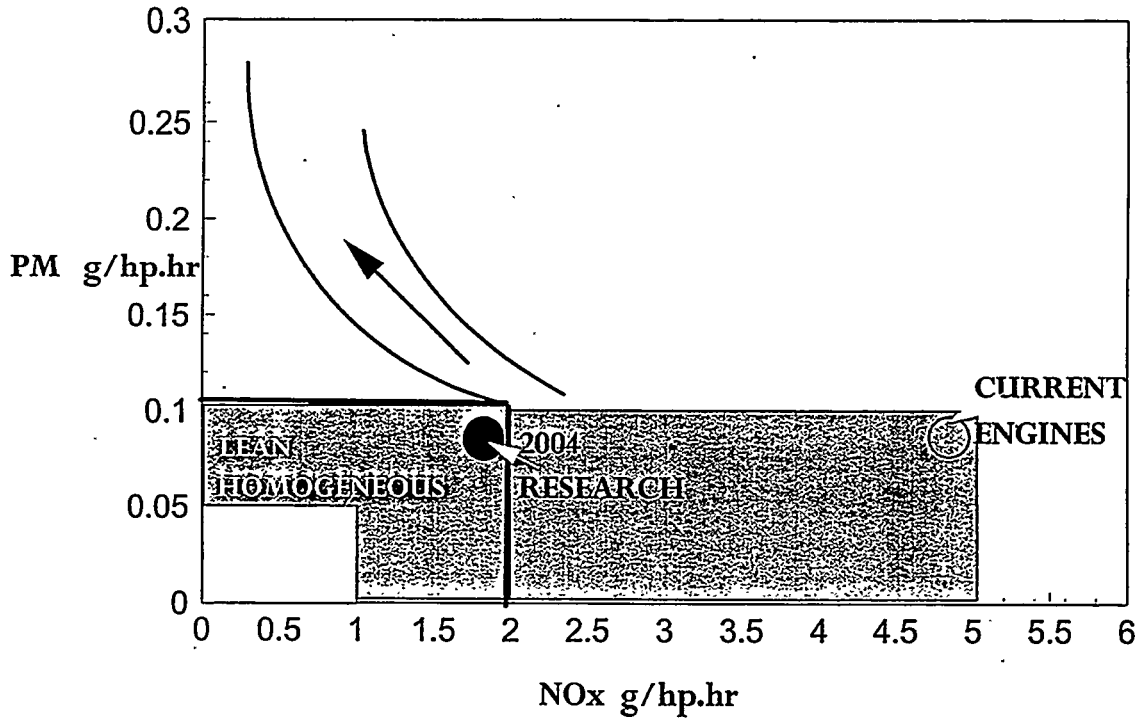
IN-CYLINDER EMISSIONS CONTROL

> NO APPARENT PRODUCTION VIABLE TECHNOLOGY FOR NOx & PM CONTROL

> IN-CYLINDER CATALYSIS
- concerns: available surface area, residence time
- recommending program to Oak Ridge

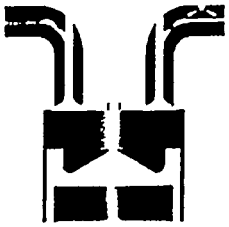
> COMBUSTION
- lean homogeneous

2007/8 DIESEL EMISSIONS COMBUSTION

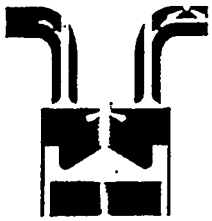


Lean Homogenous Combustion

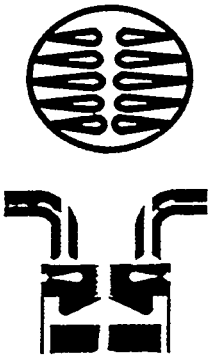
Experimental Configurations



Port Injected Diesel



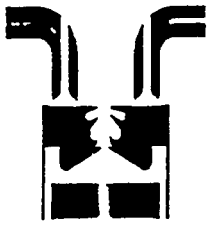
PI Gas, DI Diesel



Multiple Side Injectors

Early Injection

Impingement Plate



Early Pre-Mix/Pilot Ignition

AFTERTREATMENT

> NOx AFTERTREATMENT SYSTEMS
  - scr, storage, denox, plasma
  - parasitic load/effectiveness

> NON-THERMAL PLASMA
  > DOE /CAT SUPPORT
    - NOXTECH, TECOGEN
    - 1997 ASSESS MERITS/POTENTIAL

> PROMISE OF ENGINE THERMAL EFFICIENCY

TOOLS

> PREDICTIVE ANALYSIS CODES
  - NOx, PM
  - KIVA, CHAD, OTHER COMMERCIAL

> NEED TO BE QUANTITATIVELY ACCURATE

> JOINT EFFORT DOE/INDUSTRY

> REDUCE ENGINE DEVELOPMENT, CYCLE

FUEL(S)

> ENGINE COMPANIES HAVE SIGNIFICANT R & D PROGRAMS FOR 2004 AND BEYOND

> BUT *CI FUEL MUST ALSO IMPROVE*
  - sulfur, cetane, aromatics, restructured h-c bonds?

> PARTNERSHIP DOE/ ENGINE/ FUEL COMPANIES NEEDED FOR BETTER CI FUEL

2007 / 8 EMISSIONS

> IN-CYLINDER NOx CONTROL
- NO DEFINED PRODUCTION VIABLE TECHNOLOGY

> IN-CYLINDER CATALYSIS
- proposing program to Oak Ridge

> LEAN HOMOGENEOUS COMBUSTION
- in regimes needed, ignition/comb. control challenges

> LEAN NOx AFTERTREATMENT
- maintain thermal efficiency

> SENSOR(s)
- nox

> DIESEL FUEL PROPERTIES

SUMMARY

> DIESEL ENGINE POWER PLANT OF CHOICE (medium, heavy..)
- efficiency, durability, owning/operating costs

> KEY TECHNOLOGIES WILL NEED ADDITIONAL FIELD-TIME
- more so if fuel, oil changes occur

> EMISSIONS CONTROL TECHNOLOGIES SELECTED
- COST-EFFECTIVE
- IMPROVE FUEL ECONOMY (fleets running 2-3% margin)
- END-USER ACCEPTED
- INCREASED EMISSIONS USEFUL LIFE (> 435,000 miles)