Ethanol-Gasoline Blends: Fuel Economy and Emissions Benefits

Matthew Brusstar, U. S. EPA

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Overview

- EPA program in alcohol fuels
  - Background on EPA program
  - Neat ethanol fuel and ethanol-gasoline blends
    - Efficiency
    - Criteria, Greenhouse Gas (GHG) Emissions

- Summary & Future Outlook
EPA Program in Alcohol Fuels Research

NVFEL: A “Center of Excellence” for Alcohol Research

- **Fuels research and engine testing programs initiated at EPA in late 70’s/early 80’s**
  - Research in feasibility/safety of alcohols as automotive fuels
  - Successful engine and vehicle demonstrations with methanol

- **Lead role in engine fuel effects studies under PNGV program**
  - Led to development of advanced methanol-fueled engines for hybrid vehicles
  - More recent work with ethanol and ethanol blends
EPA Engine Test Program

Characteristics of EPA alcohol fuel test engine*

- 1.9L Port Fuel Injected, Spark Ignited, Turbocharged (VNT)
- Stoichiometric fueling
- Designed for use with neat alcohol fuels (e.g., E100, E85)
  - 19.5:1 compression ratio
  - 2.0 swirl ratio
- EGR, VNT used to modulate load from 6 to 20 bar BMEP.
  - Throttling at near-idle conditions to 6 bar BMEP
- Control of Intake Air Temperature (IAT)
  - Intercooler
  - EGR cooler
- Conventional FFV injectors, ignition system and three-way catalyst

(*-More Detail: SAE Paper 2002-01-2743)
Results of Neat Alcohol Fuel Testing

- Fuels Tested: Ethanol (E100), Methanol (M100)
  - High Efficiency
    - 42% peak efficiency
    - >40% efficiency down to 6-8 bar BMEP
  - High Specific Power
    - >20 bar peak BMEP (turbocharged)
  - Low Criteria and Greenhouse Gas (GHG) Emissions
    - Criteria emissions on the level of Tier II
    - Use of low-GHG, renewable fuels
Extension to Ethanol-Gasoline Blends

- EPA study to examine emissions/fuel economy benefits of ethanol blends
  - E85, E95: EPAct alternative fuels
  - E50, E30: best benefit/cost ratio?
  - E10: gasohol

- Other Implied Benefits:
  - Homeland security: reduced import dependence
  - Lower greenhouse gas (GHG) emissions
  - Lower air toxics emissions
Brake Thermal Efficiency: Ethanol (E100)

- Over 41% peak efficiency
  - MBT reached with 19.5:1 CR
- Broad regions of high efficiency
  - No throttling over range shown
Upper Limits to Efficiency (E100)

Extended Knock Limit:
- Suppression with EGR
- Management of IAT

Extended Throttling Limit:
- Higher tolerance for EGR
- Management of IAT

Knock Limit
Throttling Limit
Flammability Limits of Ethanol Blends

**Higher Laminar Flame Speed:**
- Extended dilute flammability limit for ethanol compared to gasoline
- Less throttling required at light loads

**Ethanol content** determines EGR tolerance, hence breadth of efficiency islands
Peak Efficiency: Ethanol-Gasoline Blends

EPA Engine: peak efficiency highlights the benefit of higher compression ratio
Criteria Emissions Results

- Engine Out Emissions
  - NOx: lower with increasing alcohol %
  - CO, Soot: ultra-low due to oxygen in fuel
  - HC, aldehydes: High

- Conventional aftertreatment options
  - Stoichiometric operation permits Three-Way Catalyst (TWC)
  - Past work at EPA has demonstrated effective TWC performance on M100 vehicles operating over the FTP
GHG Emissions

Greatest GHG reduction per gallon of ethanol: may lie in the range of 10-50%
Summary & Future Outlook

Benefits of Ethanol-Gasoline Blends

- High efficiency: comparable to state-of-the-art diesel
- Low criteria, GHG and air toxics emissions

Next Steps in Alcohol Engine Research

- Develop a basis for evaluating market tradeoffs of ethanol-gasoline blends
  - Determine best ethanol blend fraction(s)
  - Determine “optimal” engine hardware, calibration
- Demonstrate the technology on a vehicle platform
  - Hydraulic hybrid vehicle
  - Conventional powertrain

Further Information, contact: Matt Brusstar, U. S. EPA
(734)214-4791, brusstar.matt@epa.gov