Research in Alcohol-Fueled Engines at EPA NVFEL

NEVC Annual Meeting

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Presentation Overview

- Historical overview of alcohol research at EPA
- Significance of EPA research
- EPA engine operating with methanol/ethanol:
  - Design and operation advantages of alcohol fuels
  - Efficiency benefits
  - Low Criteria Pollutant Emissions
- Economic Impact
- Technical challenges
- Summary

EPA Program in Alcohol Fuels Research

- **Research and engine test programs initiated at EPA in late 70's/early 80's**
  - **Successful methanol-fueled engine and vehicle demonstrations**
- **More recently, EPA had the lead in fuel effects studies under PNGV program**
  - **Development of advanced methanol-fueled engines**
  - **Demonstration of clean diesel and DME engines**
- **Recent transition to ethanol research, due to market/legislative interest**

- **Mission: Provide market with clean alternatives**

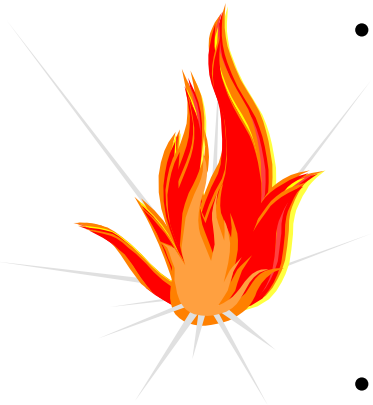
Significance of EPA Research

- **Legislative Push:** on renewable fuels market
  - **EPAct (1992):**
    - **Objectives for non-petroleum fueled fleet vehicles:**

MY	Fleet FFV %
2000	10%
2010	30%

    - **2000 objective not achieved (~2%)**
    - **Significant percent of fleet FFVs use gasoline**
  - **Energy Policy Act (2002), Renewable Fuels Standard:**
    - **Pending mandate of renewable fuels, particularly ethanol.**
- **Technology Pull:** Clean, high-efficiency engines
  - **Creates economic incentive to operate with alcohols**

Design Advantages with Alcohol Fuels



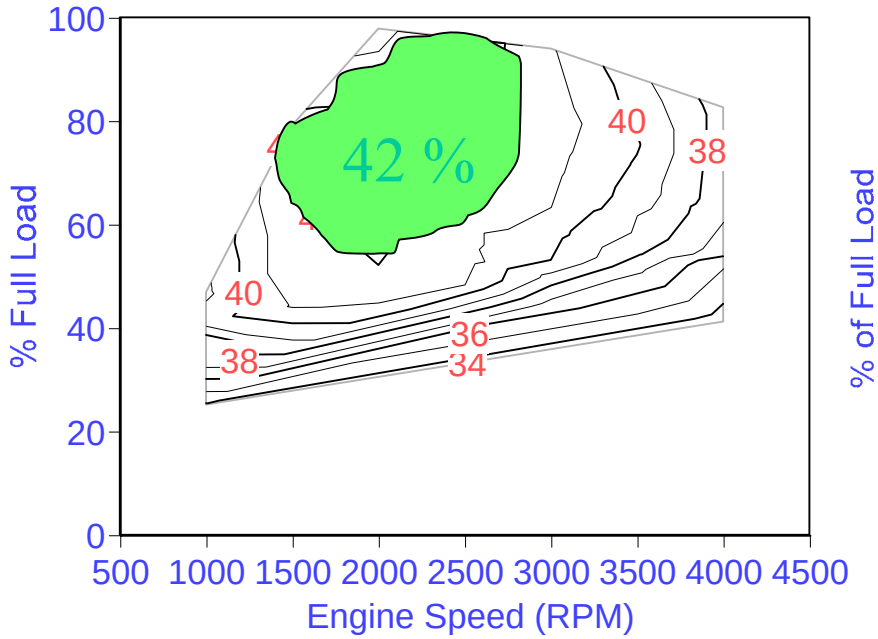
- **Alcohol advantages over gasoline/diesel fuels:**
  - **High octane number**
  - **Higher heat of vaporization**
  - **Higher flame speed**
  - **Cooler combustion**
- **Potential benefits to engines:**
  - **Low NOx emissions**
  - **Higher thermal efficiency, especially at low power**
  - **More power output capacity**

Description of EPA Engine*

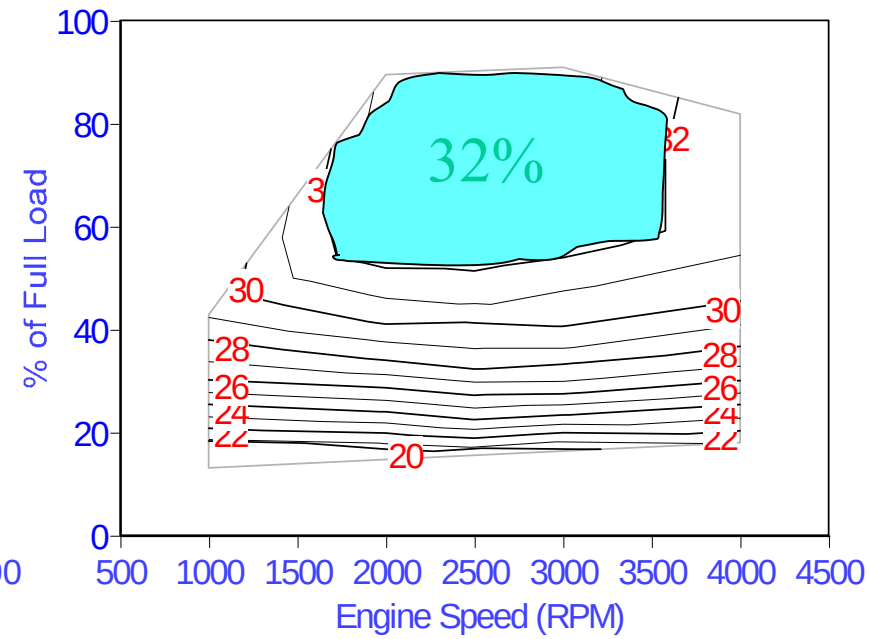
- **Characteristics of EPA alcohol engine**
  - **Optimized for use with alcohol fuels**
  - **Conventional FFV injection, ignition and exhaust after-treatment systems**
  - **Combined traits of gasoline and diesel engines**
- **Objectives**
  - **Low criteria emissions: demonstrate Tier II-level**
  - **High efficiency: >1/3 better than gasoline engine**

- **(*-More Detail: SAE Publication: upcoming Powertrain & Fluid Systems Conference, October, 2002)**

Efficiency: Methanol



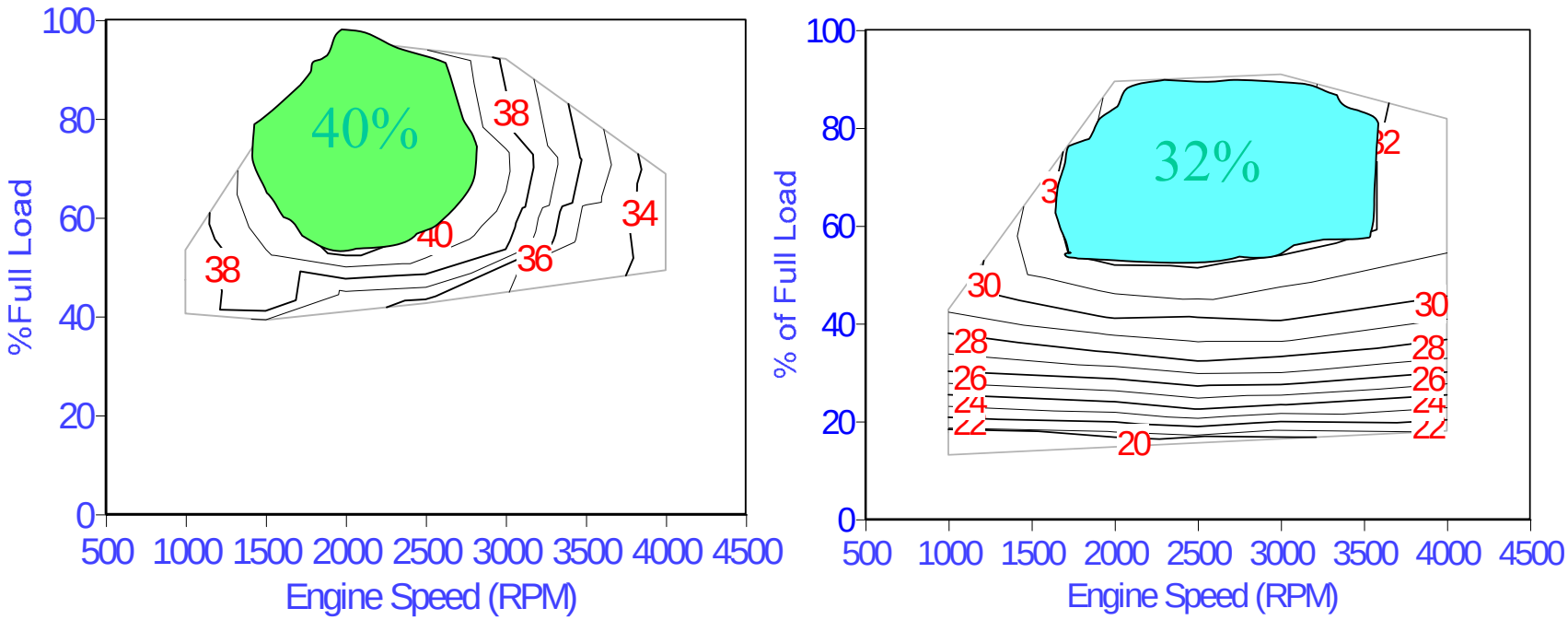
Methanol



Gasoline

33% higher efficiency with methanol
Broad region of high efficiency

Efficiency: Ethanol



25% higher efficiency with ethanol
Further optimization ongoing

Economic Impact

- **Estimated Fleet Vehicle Annual Fuel Costs*:**
  - **Gasoline: $1400/yr**
  - **E85 FFV: $1867/yr**
  - **EPA Engine: $1400/yr**

(*-based on sedan fleet vehicle, 20k miles/year, $1.40/gal fuel price)

- **Engine costs:**
  - **Comparable to FFV engine**
  - **1/4 cheaper than a diesel**
- **Clean, renewable alternative**
  - **potential market pull-through**

Criteria Pollutant Emissions

Pollutant	*Output (g/kW-hr)*	*Tier II/Bin 5 Equivalent* (g/kW-hr)*
NOx	< 0.2	0.25
CO	< 0.2	11.6
NMOG	< 0.2	0.32

*-For an "aerodynamic" 3000 lb vehicle

Low emissions with conventional exhaust aftertreatment

Enables attainment of Tier II-level emissions

Technical Challenges

- **Cold starting**
  - **Ongoing work with single cylinder engines**
  - **Earlier work at EPA down to -29 ^{o}C**
- **Engine component durability**
  - **Ignition system**
  - **Fuel system**
    - **Not yet addressed in our research**
    - **Addressed by FFV manufacturers**

Summary

- **Economic benefits of engines optimized for alcohols**
  - **Annual vehicle fuel costs similar to gasoline vehicles**
    - **High engine efficiency: 1/3 better than gasoline**
  - **Engine manufacturing costs expected to be similar to gasoline engines**
- **Low Criteria Emissions**
  - **Enables attainment of emissions on level of Tier II**