Overview: Octane number, efficient engines, ethanol, and infrastructure

Robert L. McCormick

Washington DC
June 12, 2015
What is Engine Knock?

• Fuel with adequate octane number is required to prevent engine knock
• Knock occurs when unburned fuel/air mixture auto-ignites — essentially a small explosion in the engine
  — Higher octane fuel is more resistant to auto-ignition

• Knock can cause engine damage
• Modern cars have knock sensors
  — Reduce engine power and efficiency at knock onset
  — Drivers rarely experience knock
What is Octane Number?

- Pump octane is the average of research octane (RON) and motor octane (MON) – also known as (R + M)/2
  - Two tests to cover the full range of engine operating conditions 80 years ago when this was introduced

- For modern technology engines, RON is the better measure of performance (knock prevention)

- There is no nationwide (ASTM) standard for minimum octane number in the United States
Why do we care?

**Strategies to Increase Engine Efficiency (and Lower GHG Emissions):**

- **Increased compression ratio**
  - Greater thermodynamic efficiency
- **Engine downsizing/downspeeding**
  - Smaller engines operating at low-speed/higher load are more efficient
  - Optimized with 6 to 9 speed transmission
- **Turbocharging**
  - Recovering energy from the engine exhaust
  - Increase specific power allowing smaller engine
- **Direct injection**
  - Fuel evaporates in the combustion cylinder, cooling the air-fuel mixture

All of these strategies can take advantage of higher octane (more highly knock resistant) fuels
Ethanol and Octane Number

- Ethanol has high RON
  - RON = 109
  - Relatively low cost source of octane

- What about charge cooling?
  - Ethanol almost 3x higher than gasoline
  - MIT study suggests 1 RON unit increase for every 3°C additional cooling

- Optimum blend likely 20-40% ethanol
  - Non-linear benefit of higher octane vs. linear decrease in energy density
Large Challenges to New Fuel Introduction

• EPA Requirements – Clean Air Act
  – Emission Control Equipment Compatibility
  – Toxic Emissions and Health Effects
  – Registration
  – Misfueling Mitigation

• Safety and Infrastructure Compatibility
  – Prevention of Leaks
  – Fire Safety
  – Ground Water Protection

• Engine Compatibility – Quality Standards
  – New Vehicle Development/Deployment
  – Consumer Protection and State Fuel Quality Regulation

• Coordinated investments in vehicles, biorefineries, and refueling infrastructure
Joint National Lab Study

• The potential benefits of high octane fuels (HOF) and optimized vehicles appear to be large – pump-to-wheels

• HOF may also create additional demand for ethanol with significant well-to-pump GHG benefits

Three national laboratories have jointly been conducting a scoping study directed at:
• Understanding hurdles
• Proposing resolutions
• Quantifying potential benefits
• Determining if additional R&D is warranted
E20 to E40 Blends in Refueling Infrastructure

- Most underground tanks are compatible with any ethanol blend
- Potential issue: refueling stations are not required to keep equipment records - a challenge to determine compatibility
  - But can be determined by an experienced inspector
- Fuel dispensers would have to be upgraded:
  - Current E10 dispensers can be retrofitted to E25
  - For higher blends an E85 dispenser is required (more expensive)

Most retail stations are small businesses

Estimate that ~ 20% of stations have to carry new fuel for it to be considered convenient