The Role of Fuel Additives in the Future of Liquid Fuels

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41st Automotive - Petroleum Industry Forum, April 12, 2022
Presentation Outline

- Today’s emission landscape
- The evolution of transportation technology
- Demonstrating the real-world benefits of fuel additives
  - GDI Gasoline
  - Diesel
- Summary
Aspiration is zero emissions for transport
- Regulators have goals of zero emission vehicles
  - CO₂ and criteria emissions
- Corporate sustainability goals are a significant driver
- Reduced carbon emissions/GHG are of particular interest

Requires significant shift in vehicle technology and energy sourcing
- OEMs are committed to zero emissions vehicles
- Fuel industry is reformulating fuel blends to reduce carbon intensity
  - Diesel leading with RD and BD
  - Difficult to decarbonize gasoline – 15% ethanol limit except in FFVs

Fuel additives can help achieve these aspirations by controlling deposits and reducing emissions degradation
The Evolution of Engine and Fuel Technology

Light Duty / Passenger Car
- Vehicle: PFI, GDI/Turbo, Hybrids, BEV
- Fuel: Conventional Gasoline, RFG, E15 +, Renewable Electricity, efuels

Medium / Heavy Duty Commercial
- Vehicle: HPCR, Hybrids, BEV
- Fuel: Conventional Diesel, Biomass Based diesel and blends, Blue/Green H2, Renewable Electricity, efuels
Vehicle manufacturers have delivered on lowering carbon emissions.

Fuel reformulations have also resulted in lower emissions and reduced carbon intensity.

Slow fleet turnover mitigates the immediate benefit of these advances:
- Leaves older technology in the car parc
- Necessitates a continued and significant liquid fuels market

The liquid fuel fleet benefits from engine deposit control to avoid emissions degradation and maximize fuel economy.

Source: US Energy Information Administration, Annual Energy Outlook 2022
How Fuel Additives Help Lower Carbon Emissions

- Liquid fuels will be a major energy source for transportation for many years
- There is a large vehicle parc that benefits from higher fuel quality
- Fuel additives can control deposit formation in internal combustion engines

- What is the role of fuel additives in lowering carbon emissions?
- Afton completed fleet trials to answer this question
  - Real world in-use light duty evaluations of a fleet of used cars
  - Real world fuel economy monitoring of a fleet of heavy-duty trucks

Can fuel additives deliver real world benefits in reducing carbon emissions?
Restoring Fuel Economy in GDI vehicles
Fuel Additives Provide Deposit Control in GDI Engines

- Afton has developed a vehicle-based testing protocol for GDI cleanliness
  - Accelerated injector fouling
- Used as a tool to develop fuel additive technology providing enhanced GDI deposit control

Does a fuel additive developed in an accelerated lab test deliver real world performance benefits?

Source: SAE 2017-01-2298, A General Method for Fouling Injectors in Gasoline Direct Injection Vehicles and the Effects of Deposits on Vehicle Performance

82% cleanup in 5 tanks
Real-World GDI Fleet Study

**Hypothesis**: Real-world GDI vehicles of lower mileage (30-50k) have dirty injectors, which result in lost fuel economy. Clean-up with a first-intent GDI additive can restore that lost fuel economy by cleaning up these harmful deposits.

- Vehicles bought as-is from a local dealership
- Newer model year GDI vehicles with 30 – 50K miles
- Fueled in the field with commercial pump fuel
- No pre-screening was conducted to determine if vehicles were “dirty”
Real-World GDI Fleet Results

Hypothesis: Real-world GDI vehicles of lower mileage (30-50k) have dirty injectors, which result in lost fuel economy. Clean-up with first-intent GDI additive can restore that lost fuel economy by cleaning up these harmful deposits.

A 1.5% Fleet Average Fuel Economy Improvement Was Measured
Do Fuel Additives Deliver Real-World Benefits?

Fleet study results:
- Average 1.5% Fuel Economy Restoration
- Fuel savings of 47 gallons per year
- 920 lbs. CO₂ avoided

Yes, there is a real-world benefit!

Significant fuel savings and CO₂ avoidance is available without hardware or fuel modification by using a first-intent GDI additive
- There are about 62 million GDI vehicles on the road

Calculations:
- Assuming annual mileage of 11,500 for these seven vehicles only
- One gallon of gasoline when combusted creates 19.6 lbs. CO₂

If this fleet study is representative of the overall GDI car parc, the potential CO₂ reduction is a very big number!
Restoring Fuel Economy in a HD Diesel Fleet
Fuel Additives for Deposit Control in Diesel Engines

The DW10 B test is commonly used to test for injector deposit control in HPCR injectors.

This is an accelerated test:
- Severe cycle
- Duration: 32 hours
- Uses Zn in the fuel as an accelerant

Clean Up in Peugeot DW-10 Direct Injection Engine (Premium treat rate; RF79 reference fuel + 1ppm Zn)

Does a fuel additive developed in an accelerated lab test deliver real world performance benefits?
Real-World Diesel Fleet Study

**Hypothesis:** Real-world diesel vehicles of lower mileage (150K) have dirty injectors, which result in lost fuel economy. Clean-up with first-intent HPCR diesel additive can restore that lost fuel economy by cleaning up these harmful deposits.

- No prior additive use by this fleet
- Vehicles operated under normal daily business routines
  - Real-world variability in daily operation
- Criteria were developed to parse and normalize the data
  - Engine at or very near operating temperature
  - Vehicle is at or very near “rated speed”
  - Vehicle is not coasting or idling
  - The final models are fit using linear regression

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**Vehicle Selection**
- Four matched pairs
- Similar mileages

**Fuel Dosage**
- Separate yard tanks
- QC for additive dosing
- Checks for consistent fuel properties

**Data Acquisition**
- Data loggers
- Real-time upload to cloud

**Statistical Analysis**
- Download and parse data
- Fit to statistical model
### Real-World Diesel Fleet Study

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<th>Miles</th>
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<tr>
<td>129</td>
<td>2019 Mack/Tractor</td>
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</tbody>
</table>

- **Baseline**
  - Unadditized baseline data
  - Statistical analysis

- **Develop Model**
  - Good statistical model with small standard error

- **Additive Clean-Up**
  - One of each pair is treated, common fuel batch, normal routes

- **POST Testing Analysis**
  - Compare base vehicle to treated vehicle
Hypothesis: Real-world diesel vehicles of lower mileage (150K) have dirty injectors, which result in lost fuel economy. Clean-up with first-intent HPCR diesel additive can restore that lost fuel economy by cleaning up these harmful deposits.
Afton Chemical.com

Confirmation of Fuel Injector Cleanliness
Mack Injector Tip Deposits - New, Base, and Additized SEM/EDX

**New**

**Base (unadditized)**

**Additized**

A truck with relatively low mileage can have injector deposits and benefit from additized fuel

Significant build up of carbonaceous deposits around and inside injector fuel flow holes

Significant clean-up of deposits around and inside additized injector fuel flow holes
Do Fuel Additives Deliver Real-World Benefits?

Fleet study results:

- Average 3.6% Fuel Economy Restoration
- 1470 gallons of diesel fuel
- 15 MT CO₂ avoided

Yes, there is a real-world benefit!

Significant fuel savings and CO₂ avoidance is available without hardware or fuel modification by using a **first-intent diesel HPCR additive**

Assumptions:

- Benefits for this eight-vehicle fleet only over the duration of this test
- One gallon of diesel fuel when combusted creates 22.4 lbs. CO₂

If this fleet study is representative of the overall HD vehicle parc, the potential CO₂ reduction is a very big number!
Summary

леп The aspiration is zero emissions for transport. All stakeholders are working toward this goal.

Liquid fuels will remain in the market for years

 Deposits are causing a loss of fuel economy over time

Afton fleet studies show that the use of properly-formulated fuel additives can restore fuel economy, resulting in a significant reduction of CO2 emissions

Source: clipground.com
Thanks for your attention