Fuel Additive Strategies for Enhancing the Performance of Engines and Engine Oils

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Presentation Outline

- Program Motivation
- Technical Challenges
- Program Milestones
  - Identification of Candidate Chemistry
  - Proof of Concept Data
- Conclusion

Program Motivation

Opportunity to Improve Performance

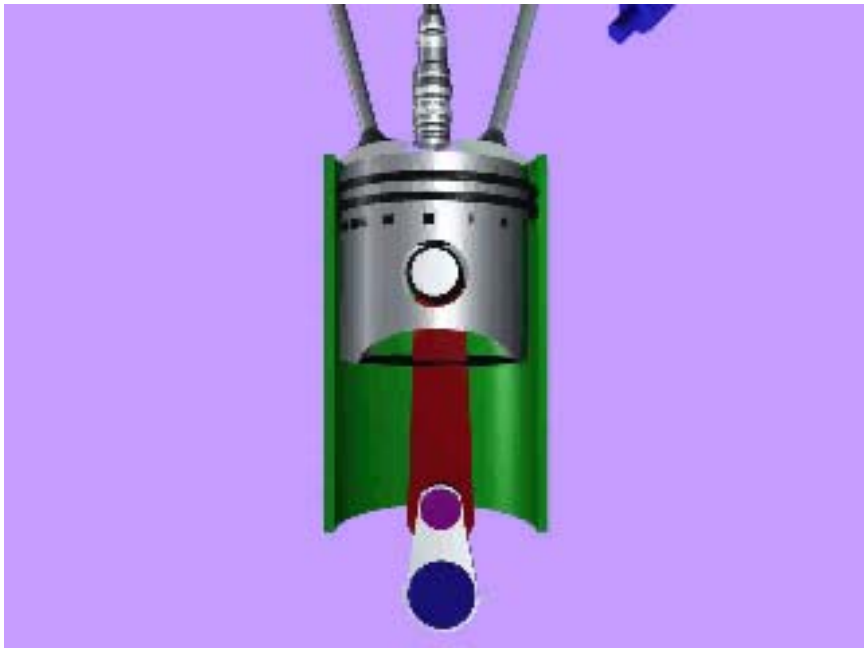
- **Deposit Control Additives**
  - Keep new engines clean
  - Clean up dirty engines
- **Novel Targets for Fuel Additives**
  - Performance not tied to deposits
  - Consumer will notice the benefit
  - Make vehicles perform better than new

Gasoline Friction Modifier

The Fuel/Lubricant Interface

Friction Modifier Delivery Mechanism

- Cylinder wall is the immediate target
- Long term gains are realized as the gasoline friction modifier collects in the crankcase



Friction Modifying Gasoline Additive

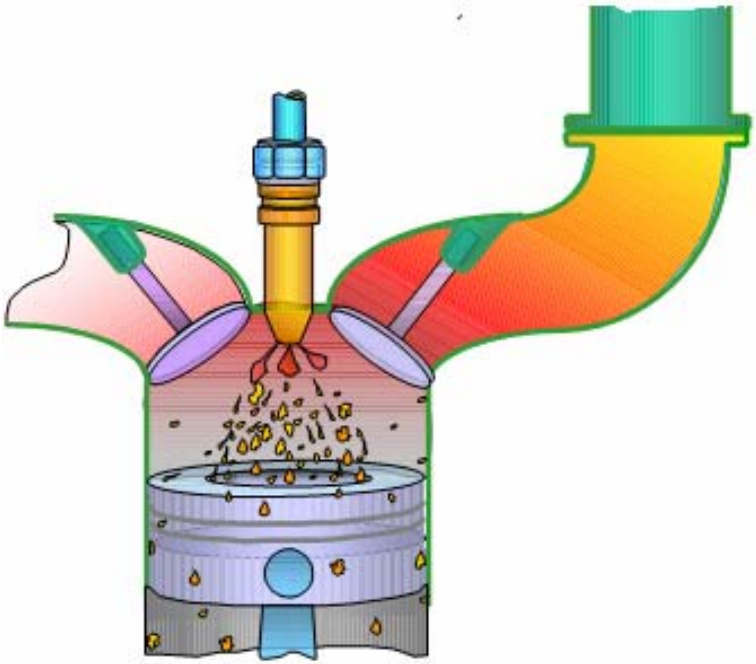
Vehicle Performance Testing with Fuel $aver

FTP HWFET Results

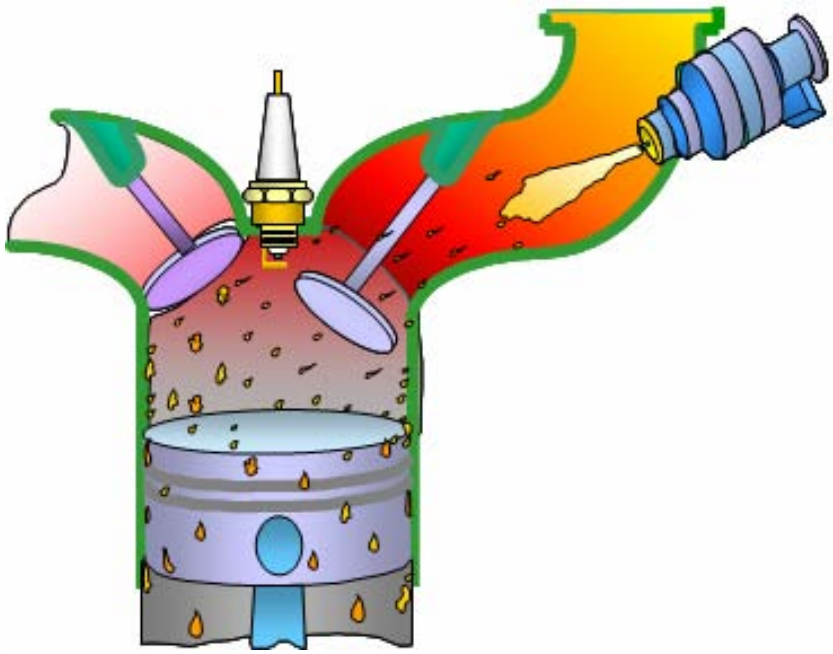
Make	Model	Immediate Benefit Base Fuel + F$	Long Term Benefit Base Fuel + F$ & F$ in Oil Sump
Jeep	2002 Cherokee	2.42%	4.40%
Dodge	1998 Caravan	0.92%	1.49%
Dodge	1997 Intrepid	2.08%	2.55%
Toyota	1997 Camry	2.45%	4.07%
Dodge	1994 Ram 1500	1.71%	2.84%
Average		1.92%	3.07%

New Diesel Fuel Additives

Technical Challenges



Versus

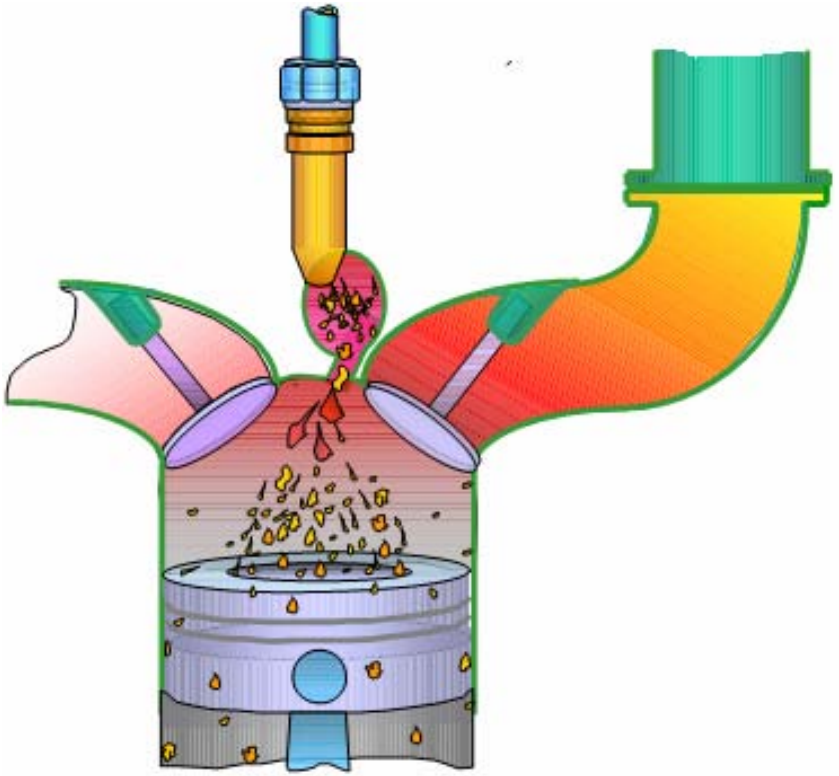


- **Diesel engine design has the injector spray fuel at the piston to minimize fuel hitting the combustion chamber wall**
- **The cylinder wall is exposed to fuel for far less time relative to that of gasoline engines**
- **Less surface area is exposed to the fuel relative to gasoline engines**

New Diesel Fuel Additives

Technical Challenges

- Various engine designs (DI and IDI)
- Range of injection pressures (250 to 3000 bar)
- The shear rate at the nozzle can impact the chemical integrity of the fuel additive



Engine hardware may demand different chemistries

It is far more difficult for the additive to preferentially reach the fuel/lube interface

New Diesel Fuel Additives

Development Program - Chemistry

- **Candidate Synthesis**
  - **Two distinct mechanisms are being pursued**
  - **Each mechanism requires the additive reaches the cylinder wall**
  - **Molecular weight and backbone type has been identified**
  - **Desired performance defines molecule's functionality**

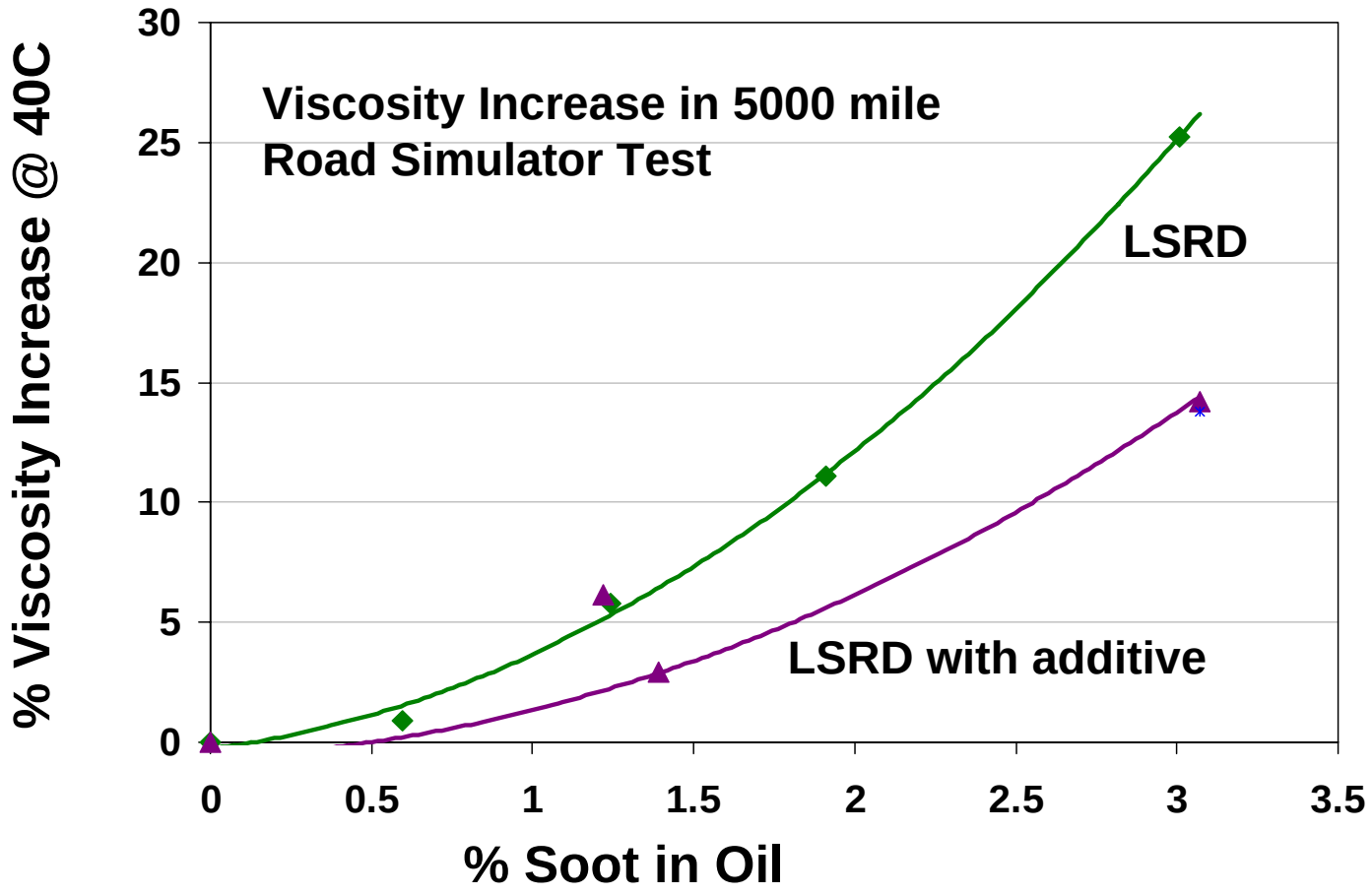
Molecule Design Strategy

Backbone	--Hook-->	Backbone-H
Backbone-H	--Performance--> Additive	Backbone-H-P

Soot Dispersing Diesel Fuel Additive

Passenger DI Vehicle Performance Data

- **Soot Dispersant Delivered to Lubricant via Fuel**



Soot Dispersing Diesel Fuel Additive

Status

- A soot dispersing additive was successfully delivered to the oil sump via the fuel in a small diesel engine test
- The additive remains chemically intact according to IR spectra
- The lubricant's viscosity increase control is continuously supplemented during the drain interval
- Retaining the viscometric characteristics of the oil during use yields a fuel economy benefit

Soot Dispersing Diesel Fuel Additive

Performance Data

- **Passenger Vehicle 1 on Base Fuel**
  - Accumulated Mileage = 7379
  - Weight % Soot in Oil = 3.7
- **Passenger Vehicle 1 on Base Fuel and Additive**
  - Accumulated Mileage =6952
  - Weight % Soot in Oil = 3.4

Fuel Economy Improvement of 7.6%

- **Passenger Vehicle 2 with Base Fuel**
  - Accumulated Mileage = 9659
  - Weight % Soot in Oil = 0.5
- **Passenger Vehicle 2 with Base Fuel and Additive**
  - Accumulated Mileage = 9651
  - Weight % Soot in Oil = 0.6

No Fuel Economy Improvement Seen

Friction Modifying Diesel Fuel Additive

Performance Data

DI Passenger Vehicle Test

Time	16 hrs conditioning followed by 12 hr hot/cool cycles
Speed	2200 rpm in all stages
Load	75 lb-ft during conditioning, 25 lb-ft during all other stages

Fuel Order:

1. **Non-FM base fuel**
2. **Non-FM base fuel**
3. **FM treated fuel**

FEI measurement: 3.- 2.

RESULTS:

Additive A = 1.9% FEI

Additive B = 2.0% FEI

Friction Modifying Diesel Fuel Additive

Performance Data

Additional DI Passenger Car Vehicle Test Sets

- Non-FM treated fuel
- FM treated fuel
- FM treated fuel + treated oil

RESULTS:

Passenger vehicle 1 - No improvement
Passenger vehicle 2 - 1.04%FEI immediate benefit
- No appreciable predicted long term benefit

Conclusions

- Performance additives other than deposit control have been identified for both gasoline and diesel engine applications
- Fuel/lubricant interactions in diesel engines are intrinsically more difficult to develop than for gasoline applications
- Additive chemistries successful in one application is not necessarily transferable to another application
- Soot dispersant and friction modifying additives added to the fuel can provide benefits in some diesel engines
- The chemistry needs to be optimized to perform across the breadth diesel engine designs