

Performance Additives Update

Direct Injection Gasoline – Performance and Efficiency For Vehicles of Today and Tomorrow

Q. Why are engines changing?

Transportation accounts for more than half of global oil consumption and a third of all U.S. greenhouse gas emissions. Regulations have been passed that require the OEMs and Oil Companies to reduce these harmful emissions:

- + 2011: California Air Resources Board (CARB) Low Carbon Emissions Standard
- + 2016: Cars and trucks in the U.S. must meet a mandated 35.5 MPG CAFÉ standard (an increase of 8 MPG per vehicle)

Introducing vehicles with improved fuel efficiency is one of the most direct routes to meeting these regulations. Therefore vehicle manufacturers in all global regions are rapidly moving to Direct Injection Gasoline (DIG) engines as a next generation technology platform.

Q. What does DIG engine technology offer?

The DIG engine delivers reduced CO₂ emissions, superior fuel economy and enhanced performance by:

- + Improving engine thermal efficiency
- + Generating more power across the entire speed range
- + Enabling higher gearing and lower engine speeds
- + Reducing frictional and throttling losses

The DIG engine operates by injecting fuel directly into the combustion chamber, where the air and fuel are mixed prior to ignition. In Port Fuel Injected (PFI) engines, the fuel is injected into the intake manifold and mixed with the air prior to entering the combustion chamber.

The DIG gains in fuel efficiency and performance are achieved through the higher compression ratio associated with charge cooling and the precise control over the amount and timing of the fuel injected. The injection is varied according to the engine load conditions.

Q. Where do you find DIG?

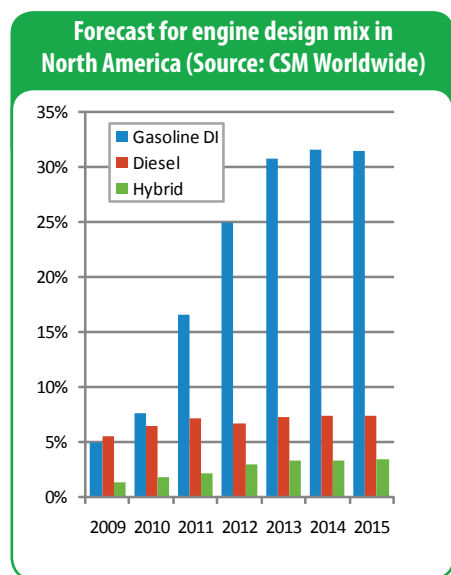


Courtesy of Ford Motor Company

Direct Injection Gasoline was developed for use in aircrafts during World War II with the first automotive direct injection system being introduced in 1952. However, it wasn't until the late 1990's that the engine technology became commercially available, when Mitsubishi led the drive with what they called GDI (Gasoline Direct Injection).

Since then, the increasing need to offer vehicles with improved fuel economy and lower emissions has made DIG one of the engine technologies of choice for the leading OEM's. It is estimated that over 45% of gasoline vehicles in North America and Europe will utilize DIG by 2015.

Various acronyms are used such as DISI (Direct Injection Spark Ignition), FSI (Fuel Stratified Injection) and others, but all mean the same as DIG.



Q. What impact does injector fouling have on DIG engine performance?

As DIG penetrates the market the fuel retailer needs to ensure that their fuel quality matches the needs of the engine. It is essential that the critical engine parts are protected against performance degradation.

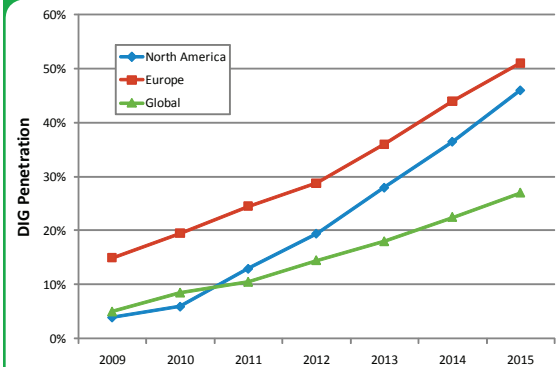
The correct distribution of the fuel/air mixture in the cylinder is essential for optimal performance of the engine across all operating conditions.

Engine designers utilize wall guided and, more recently, spray guided systems to ensure proper formation of a combustible fuel/air mixture. The guided spray systems rely on the correct functioning of the fuel injection system.

Formation of deposits in the fuel injection system can adversely impact the fuel spray pattern and reduce the levels of fuel being injected into the engine, leading to:

- + Power loss
- + Increased greenhouse gas emissions
- + Increased fuel consumption

DIG Penetration Projection (Source: Delphi)

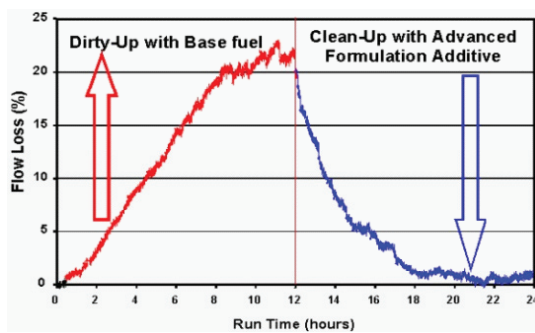


Q. How does Afton's gasoline additive technology keep DIG engines performing as designed?

DIG injectors are more prone to deposit formation than conventional Port Fuel Injectors (PFI) due to their positioning in the cylinder, where they are directly exposed to a thermally harsh environment and combustion by-products.

Since the launch of DIG, Afton has been working with OEM's, FIE Manufacturers and Oil Companies to develop additive solutions which deliver optimal performance to DIG engines.

Afton's DIG Clean-Up Performance



Afton has specifically developed additives that ensure performance in both DIG and PFI operating conditions. These unique solutions are supported by Afton's U.S. Patent # 7,491,248 and European Patent # 1250404. The additives clean up harmful deposits that form on the injectors and deliver sustained power, increased fuel economy and reduced harmful emissions.

Continuous use of gasoline containing Afton fuel additives will prevent the formation of injector deposits that can alter the fuel delivery and rob your vehicle of optimal fuel efficiency and performance.

Summary

The global push to reduce greenhouse gas emissions and improve fuel consumption has led OEM's to rapidly accelerate their launch of DIG technology which has demonstrated improvements in both of these areas.

Afton has worked in cooperation with OEM's, FIE Manufacturers and Oil Companies to develop advanced fuel additives which are effective in controlling the unique deposit control requirements of DIG engine technology and to ensure that these engines run at their optimal efficiency.

For more information please contact your local Afton representative or visit www.aftonchemical.com