Steel — the Best Material for Alternative Fuels

As gasoline (petrol) prices continue their upward spiral and geopolitical issues threaten stability of oil supplies, automakers are increasing the number of models with the capability of handling alternative fuels such as blends of gasoline and ethanol (flex fuels) and biofuels. Alternative fuels can lessen North America's dependence on imported oil and the global use of oil. And that can be good for the car business.

"As the use of alternative fuels grows, most fuel system engineers begin to 'discover' steel once again in preference over the uncertainties of plastics," says SASFT[1] Program Manager, Peter Mould. "They wonder if plastic tanks can stand up to the different situations presented by flex-fuels or biofuels. Their primary concerns are increased evaporative emissions through plastic tank walls for alcohol-containing fuels and adequate strength of plastic at elevated temperatures. In addition, there are always the underlying environmental issues associated with end-of-life disposal of plastic tanks. Virtually all plastic tanks are sent to landfills in North America."

Alternative fuels are derived from resources other than petroleum. In North America the alternatives are **flexible fuels**, which are blends of gasoline and ethanol made from renewable sources such as corn, and **bio-diesel or bio-diesel blends** manufactured from vegetable oils, animal fats, and recycled cooking oils.

"The effectiveness of steels in alternative fuel environments is already established while the performance of plastic fuel systems remains in question," says Mould. It has been well established that steel is impermeable to hydrocarbon fuels. Also, with diesel and bio-diesel fuels operating temperatures can reach 90º C, which can lead to softening of plastic tanks; but not steel tanks.

"The plastic fuel tank industry has done a good job in creating new materials and developing new multiwall tank designs," says Mould. "The results, however, are tanks that are more expensive than earlier plastic tanks. This has served to diminish the cost competitiveness of plastic over steel, thus elevating steel to the 'preferred material' for PZEV and alternative fuel vehicles."

Flex Fuels

Ethanol is an alcohol-based fuel made by fermenting and distilling starch crops, corn mostly. Only a relative handful of renewable energy companies produce it, but virtually all the ethanol they generate comes from renewable crops grown on American farms. One acre of corn, for example, can be processed into about 330 gallons of combustible ethanol. In 2007 some 40 new ethanol production facilities are expected to come on line, bringing the total number of facilities to slightly over 100.

About one-third of all gasoline sold in the United States contains some ethanol, typically in a ratio of 90 percent gasoline and 10 percent ethanol. E85, on the other hand, is 85 percent ethanol and 15 percent gasoline. The problem with flex-fuel is the fact that there can be many different blends in between, each with a different combination of ethanol and gasoline and each with a different level of aggressiveness.

[1] SASFT stands for the Strategic Alliance for Steel Fuel Tanks, which is an international alliance of companies specializing in the various areas of fuel tank production, possessing a common interest in the development, optimization and application of steel fuel tanks for automobiles.

The full story of how plastics behave in gas/alcohol environments is not fully understood, but generally it is accepted that plastics have problems with evaporative emissions where there is a range of alcohol. The emission problem starts with 10 percent alcohol and gas and increases in severity up to 40 percent alcohol before decreasing again at E85. Additionally, there is evidence that small amounts of water in ethanol-containing fuels, actually a common contamination in all fuels, increase the rate of permeation of hydrocarbons through plastic tank walls.

For 2007, 29 different vehicle models for sale in the U.S. are E85 ethanol flex-fuel capable. That's up from 20 for the 2006 model year. For 2007, GM will offer 17 E85 ethanol flex-fueled models totaling abut 400,000, compared to nine models in 2006. Ford was expected to sell 250,000 E85 ethanol flex-fuel models in 2006.

Bio-Diesel

Bio-diesel is a diesel replacement fuel that is manufactured from vegetable oils, recycled cooking greases or oils, or animal fats. Because plants produce oils from sunlight and air, and can do so year after year on cropland, these oils are renewable. Animal fats are also renewable. They are produced when the animal consumes plant oils and other fats. Used cooking oils are mostly made from vegetable oils, but may also contain animal fats. Used cooking oils are both recycled and renewable.

The specification for bio-diesel (B100) is ASTM D6751-03. This specification is intended to insure the quality of bio-diesel to be used as a blend stock at 20 percent and lower blend levels. Any bio-diesel used in the United States for blending should meet ASTM D6751 standards.

The definition of bio-diesel within ASTM D6751 describes long chain fatty acid esters from vegetable or animal fats that contain only one alcohol molecule on one ester linkage. Raw or refined vegetable oils contain three ester linkages and are therefore not legally bio-diesel. Bio-diesel can be made from methyl, ethyl, isopropyl, and other alcohols, but most bio-diesel research focuses on methyl esters and virtually all commercial-production in the United States today uses methyl esters.

Bio-diesel is a recognized alternative fuel under the Energy Policy Act of 1992 (EPAct) as amended in 1996. The EPAct required more than 75 percent of new vehicle purchases by certain federal, state, and alternative fuel provider fleets be alternative fueled vehicles. As a recognized alternative fuel, any vehicle certified to run on B100 could qualify under the alternative fuel vehicle purchase provisions of EPAct, but it does not appear that any vehicles meeting this requirement are available today. B100 is more expensive than other alternative fuel options, and the original equipment manufacturer (OEM) community has had little interest in certifying vehicles on B100, so this vehicle credit has not created a market for B100.

EPAct was amended in 1998 by the Energy Conservation and Reauthorization Act (ECRA). The amendment allowed qualified fleets to use B20 in existing vehicles to generate alternative fuel vehicle purchase credits, with some limitations. This has created significant B20 use by government and alternative fuel provider fleets. As bio-diesel grows in popularity, some states are beginning to develop bio-diesel incentive policies to promote bio-diesel use and production.

The New Steel

In recent years, various new steel "systems" have been developed by the worldwide steel community for automobile fuel tanks (The term "system" denotes a unique approach for resisting corrosion, such as special coatings, and/ or special steel alloys) .

A recent Corrosion study by SASFT showed that ten special steel systems which are available throughout the world for automotive fuel tanks, will resist perforation corrosion in severe external environments for 20 years. Additionally, the study shows that all of the steel systems tested will resist internal corrosion from an aggressive fuel such as CEI0A (alcohol-containing fuel) for at least 15 years.

Thus, it is fully anticipated that all of the systems will meet the 15-year durability requirements of California's Air Resources Board. All of the steel systems tested in this work are commercially available from the worldwide steel industry.

New Internal Testing is Now Underway

To broaden the scope of earlier corrosion resistance tests in CE10A fuel, SASFT has initiated new tests of 10 steel systems in flex and bio-diesel fuels having different compositions or blends as follows:

Flex-Fuels (alcohol containing fuels) – test at 60º C
- CE10A (10 percent aggressive ethanol*)
- E22A (22 percent aggressive ethanol*)
- E85A (85 percent aggressive ethanol*)

*Contains water, sodium chloride acetic acid and sulphuric acid, as specified in SAE J1681.

Bio-diesel fuels – test at 90º C
- Euro B5 (non-aggressive) – 5 percent RME and 5 percent deionized water
- B20A (aggressive) – 20 percent Soybean diesel and 5 percent acetate water
- B95A (aggressive) – 90 percent Soybean diesel and 5 percent acetate water

Results from the above testing are expected to be available in the first quarter of 2008.

To provide quantitative information on the elevated-temperature performance of HDPE plastic in alternative fuels and at typical operating temperatures, SASFT is conducting the following tests:

- Permeation testing of multilayer HDPE in each of the three flex fuels described above and at a typical flex-fuel operating temperature of 60º C.
- Structural testing on mono-layer HDPE in each of the three bio-diesel fuels described above and at a high diesel operating temperature of 90º C.

The results of the above tests on plastics should be available in early 2008.