Ethanol Efficiency

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Chemistry I H, 1^{st} Period

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Problem

Does the addition of ethanol to gasoline affect mileage and spark plug wear?

Hypothesis

E10 Fuel will reduce the mileage of the vehicle by as much as 10%, and spark plugs will indicate undue deposits and wear with the use of E10.

Variables and Controls

Independent variable—type of fuel, either straight gasoline or E10

Dependent variables—amount of fuel used, wear on spark plugs

Controls—vehicle, driver, pace of vehicle, distance traveled

Materials

1997 Mazda Miata

Driver

3 gallons gasoline—93 octane…*English units are used to communicate in vernacular language*

3 gallons gasoline with 10% ethanol(E10)—93 octane

2.9 miles of track on which to run the vehicle

4 NGK Iridium spark plugs

Spark plug socket and wrench

17 mm socket and wrench

Calculator

Camera

Experimental Procedures

1. Using the 17 mm socket and wrench, the fuel tank of the 1997 Miata will be drained.
2. 3 gallons of 93 octane fuel will be added to the empty tank of the vehicle. The odometer reading will be recorded.
3. The 4 NGK Iridium spark plugs will be photographed and documented as to which cylinder will house each of them. They will then be placed in the proper cylinders within the vehicle.
4. The vehicle will be driven around the 2.9 mi track ten laps.
5. Steps 1-4 will be repeated, noting any fuel that was not used and subtracting it from the original 3 gallons of fuel.
6. The spark plugs will be removed, photographed, and analyzed for deposits and wear. The odometer reading will be recorded.
7. Steps 1-6 will be repeated using the E10—93 octane fuel.
8. Calculations for miles/gallon will be made and comparisons of spark plug deposits and wear will be prepared.
9. Graphs will be constructed and photographs will be used to communicate results effectively.

The addition of ethanol, or grain alcohol, to gasoline remains contentiously debated even into the 21st century. While it is known that the combustion of ethanol reduces the emissions of carbon dioxide and carbon monoxide gases, the effects upon fuel consumption and wear on engine components are not as well understood. It is prudent to investigate whether the addition of ethanol to gasoline has deleterious results that could overshadow the benefits of reduction in greenhouse gas emissions.

Ethanol is a combustible fuel that is renewable, as it is harvested from such crops as corn. Grain alcohol, as it is commonly known, has the chemical formula C_2H_5OH, and is the second simplest alcohol, with methanol being the simplest. Due to its make-up, ethanol may be reacted with oxygen to produce carbon dioxide and steam (Brady and Humiston 1982).

The use of alcohols as fuel in internal combustion engines is not novel to present day scientists. Ethanol was used in engines as early as the 19th century, and only when lead additives were introduced in the mid-20th century did ethanol take a hiatus from internal combustion engines (Jeuland 2004). Within the last several years, renewed interest in ethanol as a fuel has arisen due to desires to reduce emissions and ultimately to comply with the Kyoto Protocol's mandate to reduce greenhouse gases to at least 1990 levels (Kyoto Protocol: Status of Ratification 2009).

Jeuland and colleagues state, "According to the raw material (sugar beet, corn, wheat, etc.), to the agricultural yield and to the transformation process efficiency, the energy balance (energy used/energy produced) has been shown to vary from 0.3 to 1.6" (Jeuland 2004). Thus the positive argument for ethanol use is that for every 30 units of energy used to make ethanol, 100 units of energy can be produced by the ethanol. Conversely, that ratio can become such that for every 160 units of energy used to make ethanol, only 100 units of energy can be produced by the ethanol. Further investigation is needed to discern the most efficient crop to yield ethanol.

A University of California—Berkeley scientist writes, "One farm for the local village probably makes sense. But if you have a 100,000 acre plantation exporting biomass on contract to Europe , that's a completely different story. From one square meter of land, you can get roughly one watt of energy. The price you pay is that in Brazil alone you annually damage a jungle the size of Greece" (Patzek 2005). Patzek published a study that indicates that the ratio of ethanol usage to output capability actually lies closer to 600 units of energy used to produce the ethanol for every 100 units of energy that can be produced by the ethanol (Patzek 2005).

Some studies indicate that the majority of engines in use today show signs of fatigue when ethanol is used in the fuel. Ethanol does not allow proper cooling of exhaust valves, and such resultant high temperatures can lead to failure of both exhaust valves and spark plugs (Jeuland 2004). The ease of checking spark plug wear facilitates its being used as a gauge of ill effects upon engine performance. Spark plugs may be inspected for what is known as fouling, or abnormal wear. Normal wear on a spark plug is indicated by a tan or gray appearance on the ground electrode, center electrode, and insulator nose. A plug fouled by improper cooling conditions has a sooty, black appearance to the aforementioned components of the spark plug (Caradonna 2008).

While many manufacturers have engineered changes to existent engines to accommodate flex fuel (85% ethanol and 15% gasoline—E85), most manufacturers have not made changes to handle a solution made of 10-15% ethanol that is added to gasoline—E10 or E15. Engines that have not been modified to be compatible with ethanol also fall victim to the hygroscopic nature of the alcohol. A hygroscopic substance absorbs water from its environment. Thus, when ethanol is present in fuel in a humid environment, the absorbed moisture in the fuel can result in decreased efficiency, decreased power, and possibly mechanical failure. According to PowerTech! Marine Propellers Marketing Manager, Marcus Clements, “Some major outboard manufacturers report greatly increased warranty issues related to ethanol issues in their products” (Clements 2010).

E10 has caused such a stir in the marine industry due to it hygroscopic nature, but more importantly due to its solvent nature. A solvent dissolves other substances. E10 cleans resins and gums off of the walls of a fuel tank, proves to be incompatible with some fuel hoses, and reacts with fiberglass fuel tanks to produce a black sludge that causes engine failure. The boating industry warns boat owners of the dangers inherent with E10 use on marine engines (Boat Owners Association of The United States 2008).

AAA Oregon Approved Auto Repair Coordinator Earl Baker stated, "Ethanol is a solvent. It can help clean combustion chambers, and scour your fuel delivery systems, fuel tanks, fuel lines and fuel injectors. Over time, E10 will break loose any deposits of dirt or water currently suspended in your fuel tank” (Salem News Business Report 2008). Baker’s comments stem from the enactment of a Northwest Oregon law mandating that fuel stations pump E10 effective January 15, 2008. Currently ten states demand that stations pump only E10 and no so-called straight gasoline, and by 2022 over five times the current amount of ethanol will be blended with gasoline. Many drivers are searching for fuel stations that offer ethanol-free fuel, and these drivers seem to be willing to pay the higher cost of the straight gasoline for their perceived improved mileage (Galbraith 2008).

As with any change, it will take time to assess the benefits and detriments of ethanol blended fuels. Lead was added to gasoline for decades until it was proven to be harmful to the environment, and ethanol has potential to be just as long-standing until another more appealing option is made readily available.

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