John Horangic
3/1/20

Abstract

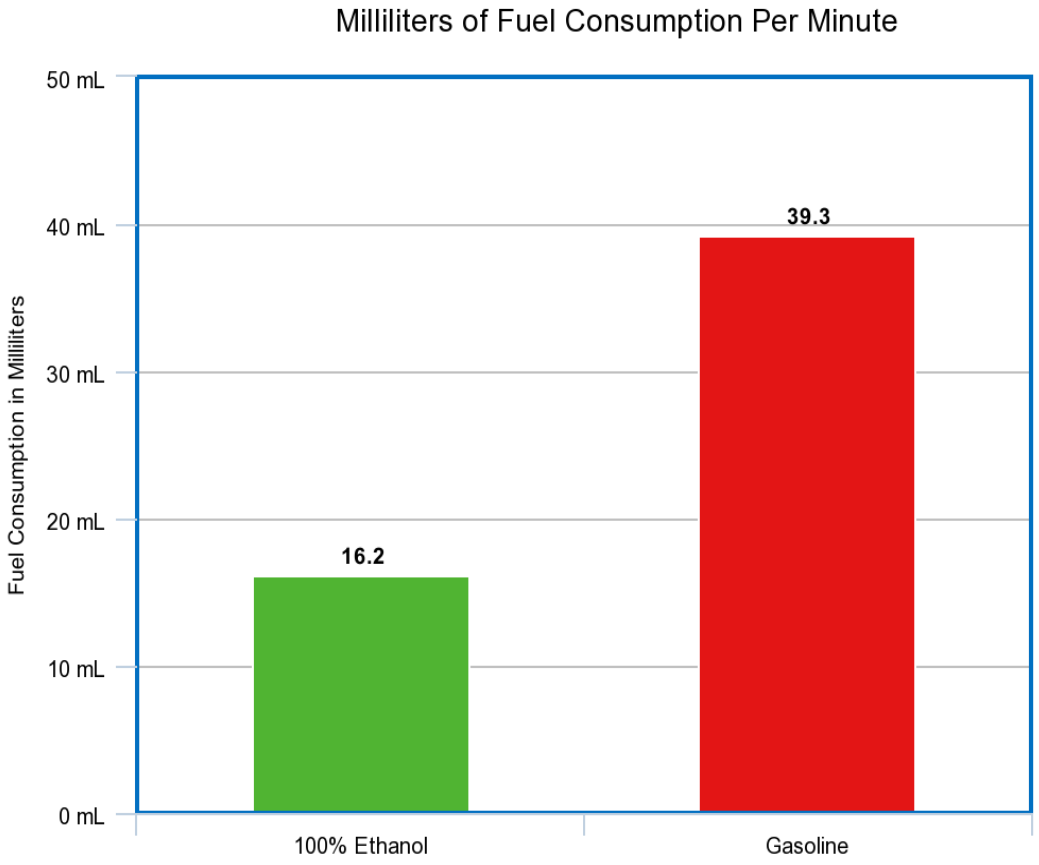
Gasoline-powered lawn equipment contributes significantly to air pollution by creating multiple nitrogen oxides. Nitrogen oxides emitted could be reduced by using 100% ethanol fuel instead of gasoline. This is so because ethanol burns at a lower temperature which creates fewer nitrogen oxides. Also, the EPA estimates gasoline-powered lawn equipment produce 11 times as much pollution as the average car for the same run time. This study uses a simple modification to allow, a standard gasoline lawn mower (22 inches wide 6.5 horsepower lawn mower) to run on 100% ethanol. A carburetor jet was modified and is responsible for aerosolizing fuel that enters the combustion chamber. A mathematical equation was used to determine the optimal carburetor jet size that is needed for both hot and cold weather combustion with ethanol fuel. The existing stock carburetor jet diameter was increased to the size that the mathematical equation indicated. The original gasoline-powered engine and ethanol modified engine were then tested on 500 square feet of a 5-inch high lawn using both gasoline and ethanol fuel respectively. It was observed that the engine operation, fuel consumption, and run times were similar for both fuels. This experiment proved that an existing standard 22 inches wide 6.5 horsepower lawn mower could be modified to run on 100% ethanol fuel and perform similarly to gasoline. Future studies will focus on determining how much of a reduction in harmful nitrogen oxides emitted can be achieved with this simple modification.

Mathematical Calculations

We found that for the lawn mower to run it needed about 63% more ethanol than gasoline per combustion event. The engine needs 63% more ethanol because there is too much air but not enough fuel in the cylinder for ethanol to combust. We can not decrease the amount of air easily but we could increase the amount of fuel. To calculate how much more ethanol the lawnmower needed we used the principle of stoichiometry. The stoichiometric ratio of Air to Ethanol is 9:1, i.e. 9 Kg of Air to 1 Kg of Ethanol for complete stoichiometric combustion. The stoichiometric ratio of Air to Gasoline is 14.7:1, i.e. 14.7 Kg of Air to 1 Kg of Gasoline. We then found that the cylinder displaced 190cc of air or 0.23275 grams. For every 0.23275 grams of air that enters the engine 0.01583 grams of gasoline needs to enter for optimal combustion. For the complete combustion of ethanol when mixed with the cylinder's 0.23275 grams of air, at the 9 to 1 ethanol/air stoichiometric ratio, there needs to be 0.02586 grams of ethanol in the cylinder with the air. To increase the amount of fuel that flows through the jet, we will need to increase the jet's cross-sectional area and enlarge it 63%. The original gasoline jet currently is 0.0014 square inches (0.024 inches current diameter / 2)^2 * Pi. 163 % of the current jet cross-sectional area is 0.002282 square inches. The current gasoline jet cross-sectional area of 0.0014 square inches has to be increased to the Ethanol required .002282 square inches by increasing the jet diameter from its current .024 inches to .031 inches or by 29%. We formulated all of these calculations into this equation. GD= Gas Diameter ED= Ethanol Diameter.

$$ED = \left(\sqrt{\left(1.63\left(GD \div 2\right)^{2}\right)}\right)2$$

[1]



This graph proves that ethanol is much more efficient. I hypothesize that the reason the engine is consuming less ethanol is that the engine is running slower because ethanol does not contain as much energy as gasoline. This means that the cylinder is traveling slower and not sucking in as much ethanol compared to gasoline where the engine consumes much more because the cylinder is moving much quicker. Although the engine may not be outputting as much power as gasoline when mowing I noticed no difference in the quality of the grass being cut. All fuel consumption data is from my lawn mower.

[1] Record of Ethanol and Gasoline Consumption. (19AD, November 30). Concord.

Can a Standard 4 Cycle Gasoline Lawn Mower be Converted to Start and Run on 100% Ethanol

Abstract

Gasoline-powered lawn equipment contributes significantly to air pollution by creating multiple nitrogen oxides. Nitrogen oxides emitted could be reduced by using 100% ethanol fuel instead of gasoline. This is so because ethanol burns at a lower temperature which creates fewer nitrogen oxides. Also, the EPA estimates gasoline-powered lawn equipment produce 11 times as much pollution as the average car for the same run time. This study uses a simple modification to allow, a standard gasoline lawn mower (22 inches wide 6.5 horsepower lawn mower) to run on 100% ethanol. A carburetor jet was modified and is responsible for aerosolizing fuel that enters the combustion chamber. A mathematical equation was used to determine the optimal carburetor jet size that is needed for both hot and cold weather combustion with ethanol fuel. The existing stock carburetor jet diameter was increased to the size that the mathematical equation indicated. The original gasoline-powered engine and ethanol modified engine were then tested on 500 square feet of a 5-inch high lawn using both gasoline and ethanol fuel respectively. It was observed that the engine operation, fuel consumption, and run times were similar for both fuels. This experiment proved that an existing standard 22 inches wide 6.5 horsepower lawn mower could be modified to run on 100% ethanol fuel and perform similarly to gasoline. Future studies will focus on determining how much of a reduction in harmful nitrogen oxides emitted can be achieved with this simple modification.

Procedure

To modify the 4.5 horsepower lawn mower to run on 100% ethanol we developed an equation that took into account the current diameter of the carburetor jet. To find the diameter we inserted several different needles into the carburetor jet. By doing this we were able to determine the size of the jet down to the thousandth of an inch. The original size was 0.028 of an inch. We plugged that value into the equation and found we needed to increase the diameter of the carburetor jet to .039 of an inch**.** To do this

we used fine modeling drill bits readily available at harbor freight. Once the jet had been widened we installed it back onto the carburetor and began the testing procedure. The procedure that was used for testing the modified lawn mower was as follows. Fill the lawn mower's fuel tank with a ½ gallon of ethanol or gasoline depending on the fuel we were testing. Before testing the lawn mower we took measurements of the temperature, humidity, and grass height. After this, we started the lawn mower on 500 square feet of grass and timed how long it took for the lawn mower to finish mowing the 500 square feet of grass. Once the mower had finished we measured how much fuel the mower had consumed. To test a different fuel we ran the lawn mower till it was empty and installed either the modified carburetor jet or the unmodified. After this, we repeated the procedure from the beginning.

Potential Impact Explain how alcohol does not output as much carbon, hydrocarbon, nitrous oxide

Ethanol as an alternative fuel has the potential to reduce carbon monoxide, nitrous oxides, and hydrocarbon emissions by half and in some cases by 99%. Carbon monoxide emission could be cut back by 100% because ethanol does not produce any carbon monoxide when combusted. Nitrous oxide emissions also have the potential to be reduced greatly. Nitrous Oxide is produced when nitrogen and oxygen combine at high temperatures. Ethanol, however, does not burn at high enough temperatures and would create little if any nitrous oxide. Hydrocarbon emissions also stand to be cut buy greatly as a blend with 15% ethanol and 85% gasoline found a reduction of 16% compared to 99% gasoline.

$$ED = \sqrt{(1.63(GD \div 2)^2)} \times 2$$

date	fuel	Fuel used	temp	Grass height	humidity	Run time	Grass area
11/30/19	Denatured Ethanol	34.5ML	34F	5in	32%	2 minutes 7 seconds	500 square feet
11/30/19	Gasoline	44ML	34F	5in	32%	1 minute 7 seconds	500 Square feet

Example of Brazil as a country who has implemented alcohol as a gas

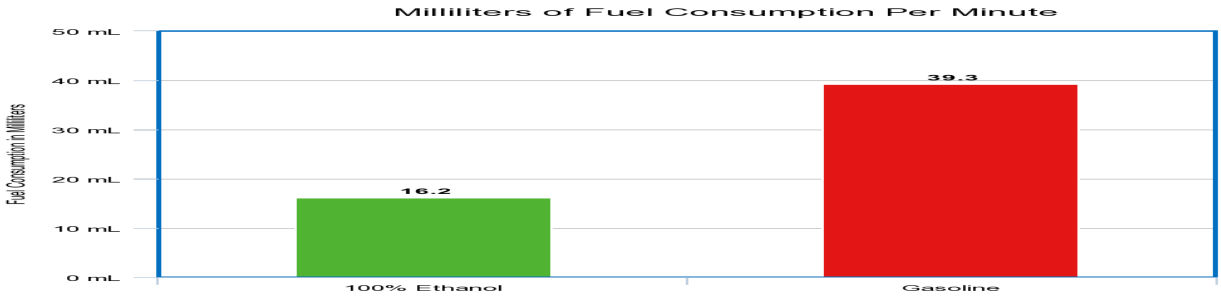
100% ethanol has been implemented on a national scale before one such example is Brazil. Brazil is a good comparison as it has a population of 209 million compared to the United States 327 million. Brazil introduced a mandate that fuel must contain at least 20% ethanol in 1978 and in 2017 produced and consumed 7.06 billion gallons of ethanol and consumed 15.26 billion gallons of gasoline. Whereas the United States consumed 142.97 billion gallons of gasoline. The use of ethanol by Brazil is not only good for the environment but great for their economy as it provides a very large amount of jobs in agriculture and refining the ethanol. Another byproduct is that Brazil imports very little oil which keeps money inside the country and boosts the local economy. All of these benefits could be brought to the United States and us to could create jobs and reduce air pollution. To introduce ethanol to the United States the lawn mower is a good place to start as it pollutes 11 times as much as a car and is inexpensive and easy to modify.

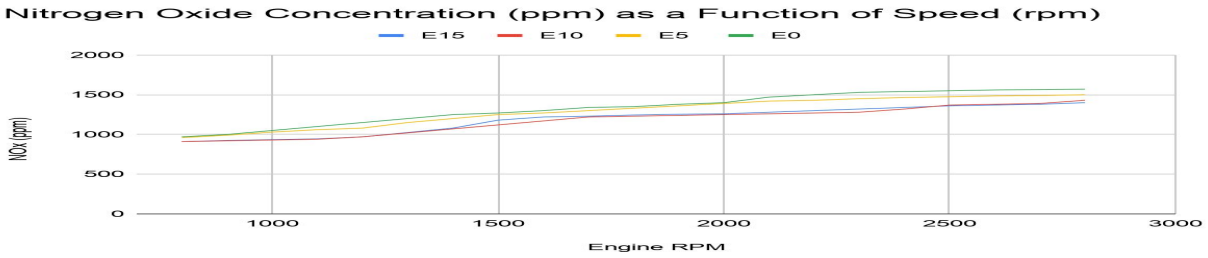
Sources

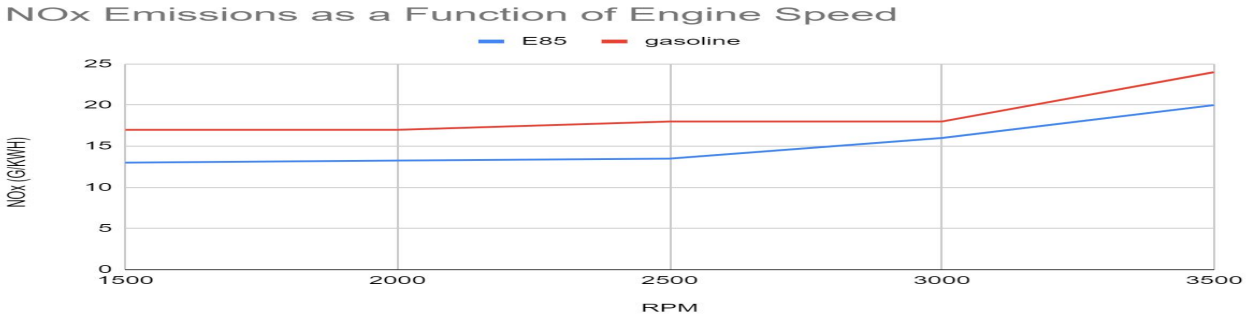
Gasoline price per a gallon
Ethanol price per a gallon
https://www.ijser.org/researchpaper/Exhaust-Emissions-of-Ethanol-Unleaded-Gasoline-blends-in-Spark-Ignition-Engine.pdf
Alcohol can be gas
Modifying Brigs and Straton to run on E85 article from collage
Price of ethanol
Census of Brazil
Census of USA
https://afdc.energy.gov/data/10331
1978 ethanol thing Rico, JAP (2007) . *Biofuels Program in Brazil and Colombia: an analysis of implementation, results and perspectives* .Master's Dissertation, Energy, University of São Paulo, São Paulo. doi: 10.11606 / D.86.2007.tde-07052008-115336. Retrieved in 2020-03-20, from www.tese.usp.br

Turner, James WG, et al. “Alcohol Fuels for Spark-Ignition Engines: Performance, Efficiency and Emission Effects at Mid to High Blend Rates for Binary Mixtures and Pure Components.” Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, vol. 232, no. 1, Jan. 2018, pp. 36–56, doi:10.1177/0954407017752832.

https://www.theglobaleconomy.com/rankings/gasoline_consumption/https://www.theglobaleconomy.com/rankings/gasoline_consumption/ 15,266,840400 gallons of gas consumed by Brazil
Us consumed 142.97billion


Milliliters of Fuel Consumption Per Minute
50 mL
40 mL
30 mL
20 mL
10 mL
0 mL
Fuel Consumption in Milliters
16.2
39.3
100% Ethanol
Gasoline


Nitrogen Oxide Concentration (ppm) as a Function of Speed (rpm)
E15
E10
E5
E0
2000
1500
1000
500
0
NOx (ppm)
1000
1500
2000
2500
3000
Engine RPM


NOx Emissions as a Function of Engine Speed
E85
gasoline
25
20
15
10
5
0
NOx (G/KWH)
1500
2000
2500
3000
3500
RPM

1 hr lawn mower use

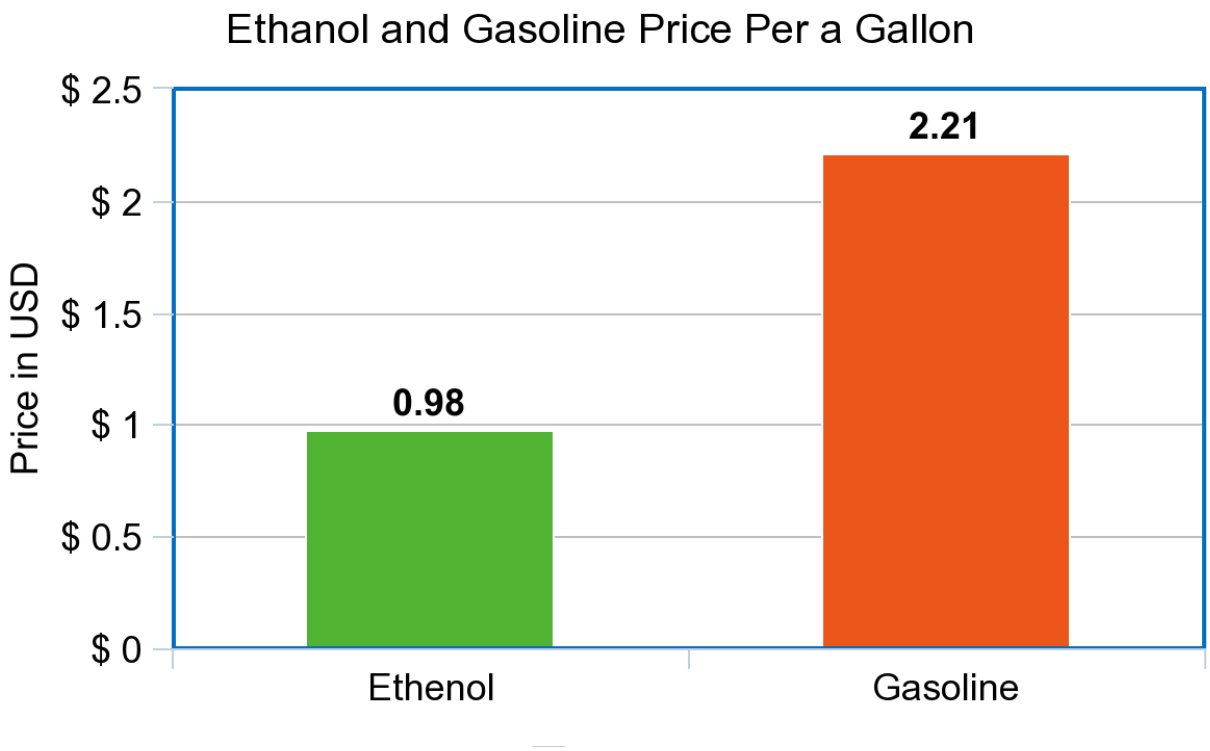
=

driving 300 miles
from LA to Vegas

1 hr leaf blower use

=

driving 1100 miles
from LA to Denver


Ethanol and Gasoline Price Per a Gallon
Price in USD
$ 2.5
$ 2
$ 1.5
$ 1
$ 0.5
$ 0
0.98
2.21
Ethenol
Gasoline

The three main emissions that ethanol decreases are nitrous oxides, carbon monoxide, and unburnt hydrocarbons. It is very important to decrease these emissions on lawn mowers as they are 11 times dirtier than a car[1]. Nitrous oxides are dangerous as it is responsible for causing respiratory issues, it is the main component of smog, and causes acid rain. Nitrous oxides are know for inflaming the lungs and causing lung and brain cancer. Carbon Monoxide is an unnaturally occurring form of carbon that is not consumed by plants and is a main component of smog. Carbon monoxide also has the potential to kill a person in a matter of minutes. Ethanol does not produce any carbon monoxide which dramatically reduces smog formation. Data has shown that higher percentages of ethanol lead to less unburnt hydrocarbons[2]. Which intern leads to a healthier ozone layer. These are just a couple of the environmental benefits that ethanol would provide

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[1] Steele, Dylan. "Cleaner Air : Gas Mower Pollution Facts." *Gas Mower Pollution Facts*, People Powered Machines, www.peoplepoweredmachines.com/faq-environment.htm#environment.

[2]Kumar, Deepak, and Ajay Trehan. "Exhaust Emissions of Ethanol-Unleaded Gasoline Blends in Spark Ignition Engine." *International Journal of Scientific & Engineering Research* 7.12 (2016): 1–3. Print.

John Horangic
OP-RZW
NoteBook SRC

9/9/19

Received the Gasoline Carburetor

Today we received a new carburetor in the mail this carburetor will be used for gasoline.

9/10/19

Measuring the Diameter of the Carburetor Jet

Today we received the second new carburetor this carburetor will only be used for ethanol. We found the diameter of the gasoline carburetor jet. The gasoline jet measured .023 inches. First, we removed the jet from a carburetor with a ⅜ inch socket wrench. We then used 22 and 25 gauge needles and thousandth-inch gradation calipers to estimate the diameter of the carburetor jet.

10/12/19

Meeting with Qualified Scientist and Designated Supervisor

I met with my qualified scientist and my designated supervisor we reviewed the safety precautions and made improvements to them. While also discussing what needed to be achieved to modify the lawnmower to run on ethanol. After reviewing the safety precautions and procedures put in place the qualified scientist and designated supervisor signed the forms needed.

10/20/19

Science Fair Project Mathematical Calculations

My mentor and I read through resources and other references to create an equation. Below is the process we went through to create the equation.

The stoichiometric ratio of Air to Ethanol is 9:1, i.e. 9 Kg of Air to 1 Kg of Ethanol.
The stoichiometric ratio of Air to Gasoline is 14.7:1, i.e. 14.7 Kg of Air to 1 Kg of Gasoline.

The main jet diameter of approximately 0.024 inches is currently set for Air to Gasoline hstoichiometry of 14.7 to 1 by the manufacturer.
The cylinder has a volume of 190 cc which equals .23275 g of Air as Air weighs 1.225 grams per Liter at sea level.
For the Gasoline stoichiometric ratio of 14.7:1 currently the cylinder gets .01583 g of Gasoline per combustion event.
For Ethanol stoichiometric ratio of 9:1, would need .02586 g of Ethanol per combustion cycle.

To maintain stoichiometry we will need the jet to provide .02586 g of Ethanol instead of the current .01583 g of Gasoline as Air will be constant at 190 cc or .23275 g per combustion event. The jet needs to provide 163 % (.02586 g Ethanol / .01583 g Gasoline) of the gasoline fuel it currently supplies.
The amount of fuel that flows through jet will be roughly controlled by jet cross-sectional area which currently is 0.0014 square inches (0.024 inches current diameter / 2)^2 * Pi.
163 % of the current jet cross-sectional area is 0.002282 square inches.
Current Gasoline jet cross-sectional area of .0014 square inches can be increased to Ethanol presents the original diameter of the jet. This formula can be simplified by eliminating Pi, so the Ethanol jet diameter will = √(1.63 * (x/2)^2) * 2.

The assumption for all this is that there is a linear relation of jet cross-sectional diameter to flow rate and density of fuel saturated air is the same.

11/30/19

Performing and Testing Carburater Jet Modifications

Today we modified the jet and tested it by mowing 500sq of a 5-inch high lawn. We used the equation root((1.63 * (x/2)^2*Pi))/Pi) * 2 to indicate how much wider we would need to make the carburetor jet. The jet was made bigger by using very fine modeling drill bits. The bits were hand-turned into the carburetor jet to widen the hole a drill was not used. All of the measurements were taken with calipers accurate to the thousandth of an inch. After making this modification we installed the jet back onto the lawnmower. We then hand started the lawn mower after 5-10 pulls. The weather was 34 degrees Fahrenheit at 32% humidity. Once we started the lawnmower on 100% ethanol we began mowing 500sq feet of 5-inch lawn immediately. After finishing this we recorded time and fuel consumption. Those results were 34.5ML of denatured alcohol consumed and it took 2 minutes 7 seconds to mow 500sq of the lawn. After the lawn mower had cooled sufficiently we swapped the carburetor jet with an unmodified jet and filled the fuel tank with 87% octane gasoline. The tests were performed in the same weather conditions and the same variables were measured as well. The amount of fuel consumed was 44ML and the run time was 1 minute and 47 seconds.