Flex-Fuel engine: Influence of Ethanol Content on Efficiencies

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This study looked into the outcomes of ethanol concentration on the power and efficiency of a Flexi engine. It was found that a mixture of iso-octane, n-heptane, toluene, and ethanol performed equally well as Brazilian petrol with a high oxygen content. The Fiat Fire 1.4L Tetra fuel engine was chosen for testing and was powered by a combination of CNG, regular petrol, Brazilian petrol (18%-27% v/v anhydrous ethanol), and conventional petrol. The results showed a lambda value of 0.9, peak power at 5500 rpm, and peak torque at 2250 rpm. The spark timing was altered to maintain 900 C as the maximum exhaust gas temperature, and the ignition timing was altered to obtain maximum power at WOT.

Ethanol has a lower molar mass and stoichiometric air-fuel ratio than gasoline, leading to a reduction in engine volumetric efficiency. However, a higher ethanol content improves engine performance due to its higher efficiency. Future studies should track emissions and fuel economy data to evaluate the results of integrating engines with various designs and technological levels. Research on substitute fuels for high-octane oxygenated gasolines was done by Machado GB, Barros JEM, Braga SL, Braga CVM, Olivera EJ, Silva AHMFT, et al.

Keywords: - Flexi engine, Efficiency, Gasoline, Surrogates

ABOUTPROJECT

A number of variables can affect an engine's performance. Power and efficiency may be affected by a number of factors, such as engine size, design, operating temperature, and even the weather. Physical and chemical characteristics of the fuel are crucial. Most SI engines require gasoline to function. There may be hundreds of different ingredients, and most of them would only be present in minute quantities. Gasoline is difficult to simulate because of its adaptability. As a result, people are turning to nontraditional energy sources. But despite having a lot fewer chemical components, they still maintain many of the advantageous qualites of chemical fuels. Thanks to its diminished physical-chemical makeup, the surrogate fuel allows researchers to gain insight into the underlying mechanisms that determine ICE performance. Their physical and chemical properties can be easily obtained via databases and computations since they include fewer components.

Ethanol is widely used as a SI engine fuel in Brazil. Since the 1970s, ethanol has been added to gasoline to increase its octane rating. It also has the potential to be a renewable energy source for generating electricity.The percentage of anhydrous ethanol in Brazilian gas ranges from 18% to 27%. (E18 to E27). Flex fuel vehicles were first offered for sale in Brazil in 2003. These vehicles can also run on a mixture of petrol and hydrous ethanol (H100, with a maximum 7.5% m/m water content).

METHODOLOGY

Due to the proven performance of its "Partnerships for Impact"–inspired port fuel injection technology, the Fiat Fire 1.4L Tetra fuel engine was selected for evaluation (PFI). This engine can be powered by on CNG, conventional gasoline, Brazilian gasoline (18%-27% v/v anhydrous ethanol), or a mixture of these fuels (CNG). A programmable device known as a MoTeC M800 (ECU) has been installed in the place of the engine’s original ECU. Lambda readings were improved by switching to a linear, wide-band Bosch LSU 4.0 from the original narrow-band sensor. An AVL fuel mass flow metre model 735S, a Schenck W130 dynamometer, and an AVL PUMA OPEN automated system were utilised to assess and document the engine's performance. The pressures and temperatures of the engine's intake and exhaust gases may be measured in the test cell in addition to the oil and water. A piezoelectric pressure transducer (model AVL GU 1 3Z-24) and an angle encoder (model AVL 365) have been installed in the engine's cylinder 1 to measure pressure and crank angle, respectively.The fuel economy of an engine was tracked and analysed with the help of the AVL IndiModul 621. The results of the tests performed while under full load and at three different engine speeds are shown in the table below. Although peak power is reached at 5500 rpm, peak torque is reached at a lower engine speed of 2250 rpm.To arrive at a lambda value of 0.9, we used the wideband lambda sensor in closed-loop feedback mode. Due to the intake valves being shut down during the injection process, fuel was squandered. In order to prevent damage to the catalytic converter, the ignition timing was modified depending on the kind of fuel used and the operating conditions of the engine. As a rule, a lambda value between 0.88 and 0.92.21 is required to get maximum power at WOT. Similar to what is used by OEMs, this number for lambda is acceptable.In order to maintain a maximum exhaust gas temperature of 900 C and deliver the required break torque, the spark timing was modified so that the most severe banging would only occur during 5% of engine cycles (MBT). Finding out how much gasoline is saved and how much more effectively an engine performs is possible with the right measures and approaches.

Machado provides a thorough breakdown of the equipment and procedures used to track combustion and engine performance. Three readings were obtained with each fuel type to assess torque, fuel consumption, speed, and other critical parameters after allowing the engine settle into each operational condition for 1 minute. We give three examples demonstrating how each independent variable is useful. The average combustion data from 300 engine cycles was derived using pressure curves inside the cylinders. Regardless of the fuel type or the operating conditions, the maximum projected degree of inaccuracy was 0.6%.

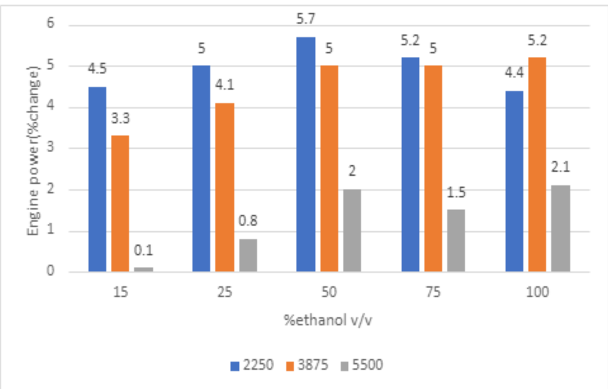

Figure a

RESULT

$$\eta_m = 1 - \frac{FMEP}{IMEP_n} \qquad \text{(A)}$$

Formula A was used to determine the engine's mechanical efficiency (hm). Frictional mean effective pressure is a term that describes this idea.

Fuel quality was evaluated using the FMEP, as shown in Figure 1. (in comparison to B_E0 fuel). Figure 1 displays the results of tests done on engines using E100 instead of B_E0, which reveal a 20.9% increase in FMEP value.

Both the combustion pressure and the IMEPn increase in tandem with increasing ethanol content. Since higher concentrations of ethanol lead to more powerful combustion processes, this is the case. As the ethanol concentration in the gasoline grows, so does the load on the bearings that hold the pistons, cylinders, and connecting rods. This is shown by the higher FMEP readings. Figure 1 shows the outcomes of integrating FMEP into IMEPn. Unlike IMEPn, FMEP does not grow linearly with frequency. E100's overall effectiveness is 1.2% lower than that of B_E0. E100 increases IMEPn, FMEP, and mechanical efficiency on average, whereas B_E0 decreases.

Parameter	**E100/B_E0**
IMEPn	5.1%
FMEP	20.9%
η_m	-1.2%

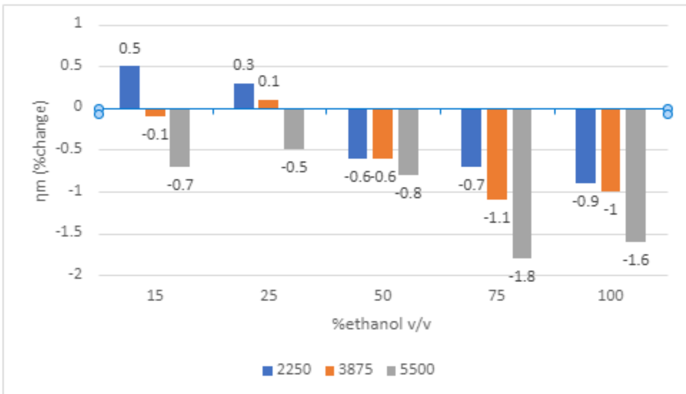

Figure 1

Figure 2 displays data on the overall efficiency of the engine. A system's overall efficiency is equal to the product of its thermal efficiency and mechanical efficiency. The increased ethanol content improved heat transfer efficiency in the engine. While mechanical efficiency did decrease by 1.2% from B E0 to E100, the increase in thermal efficiency (6.7%) more than made up for the loss. Figure 3 demonstrates the little but observable impact that the factors in LHV=AFRstoic: have on engine power and provides some context for understanding these effects. Ethanol is commonly used to increase productivity and efficiency in terms of both energy production and volume. With the engine's overall efficiency and thermal efficiency improved by ethanol's use, the vehicle's output was raised. However, while utilising ethanol, the engine's volumetric efficiency dropped. Analyzing experimental data from engines and data on fuel qualities might provide light on the effect of ethanol on engine performance.

Parameter	**E100/B_E0**
η_G	5.5%
η_v	-2.2%
ρ_{atm}	0.3%
LHV/AFR$_{stoic.}$	0.4%
P	3.9%

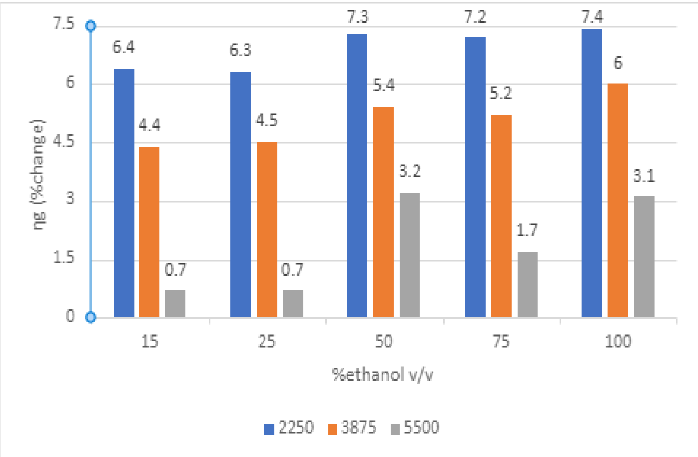

Figure 2

Conclusion

Using a commercial SI Flex-fuel engine, this study aimed to determine the best calibration for each fuel type by evaluating several combinations of a gasoline substitute fuel with different ethanol content. Increasing the ethanol concentration in the gas increased the engine's output and efficiency (relative to B_E0). Our findings disprove the theory that adding more ethanol to the fuel will increase the engine's volumetric efficiency. This essay investigates the background of the current trend toward better gasoline quality and increased volumetric efficiency. This research gives a more in-depth investigation into the effects of various engine settings and fuel quality on engine power and efficiency, making use of fundamental thermodynamic theories, in order to more fully explain the results that were discovered when the ethanol content of the gasoline was changed. There were numerous important takeaways from our testing of the engines and fuels.

Ethanol increases the boiling point of water, making evaporation of water a more laborious processfuel, which leads to less oxygen being breathed in at that temperature.

The molar mass of the fuel is decreased, and the stoichiometric air-fuel ratio is also decreased, when ethanol is added.

It now takes the same amount of time to take in less air as before, due to lower volumetric efficiency.As the percentage of ethanol in the fuel increases, the LHV=AFRstoic: characteristic rises somewhat, but reducing the intake air mass while maintaining lambda results in a loss of chemical energy in the fuel-air combination.

Engine performance was enhanced by a higher concentration of ethanol. Thus, when running on ethanol, the engine was better able to transform the chemical energy of the fuel into useful mechanical work.

At greater ethanol percentages, the fuel's increased efficiency more than made up for the fuel's lower energy density, resulting in increased engine power.

When the efficiency pattern is broken down into its component parts, we see that the engine thermal efficiency increased as ethanol concentrations did. This was due in large part to the increased IMEPn. This graph shows that, for a certain spark timing (MBT), with the exception of B_E0, where knock was limited by lower AKI, a higher ethanol content led to a more effective conversion of the fuel's chemical energy into heat and indicated work.

In recent studies, a faster-moving ethanol laminar flame has been seen, which has led to speculation that this is the cause of the improved thermal efficiency and IMEPn.

Greater FMEP readings are also brought on by IMEPn increases brought on by increased in-cylinder pressures.

Reduced mechanical efficiency resulted from the addition of ethanol to the fuel because the FMEP rose more than the IMEPn.

When the fuel's ethanol content was raised, the engine's overall efficiency significantly increased because the increase in thermal efficiency more than offset the decline in mechanical efficiency.

In-depth discussion of the effects of varying ethanol concentrations on the efficiency of Flex-fuel vehicles' internal combustion engines. This information will be useful for improving future engine designs. Due to cost considerations, commercial Flex-fuel engines rarely address the requirement for appropriate engine calibration for each fuel to extract the engine's full capability and efficiency. Future research should monitor emissions and fuel efficiency measurements to assess the effects of combining engines with different designs and degrees of technology with real-world driving conditions.

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