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MDPI

Varying Speed Test and Emission Performance of a Spark-Ignition Engine Fueled with Butanol–Ethanol–Propanol–Gasoline Blends

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INTRODUCTION & AIM

Air pollution in the Philippines remains a major concern as transportation still relies heavily on gasoline, which produces high CO, HC, and NO_x emissions due to its low oxygen content. Alcohol fuels offer cleaner combustion, yet n-propanol and its multi-alcohol blends are still underexplored. This study investigates the performance and emissions of a single-cylinder spark-ignition engine using gasoline blended with 15% total alcohol in varying ratios of ethanol, n-butanol, and n-propanol. Five fuels were tested following the PNS 396-397:2024 Varying Speed Test (2900 - 3800 RPM). Results were compared with pure gasoline to evaluate the potential of these blends as cleaner, more sustainable alternatives.

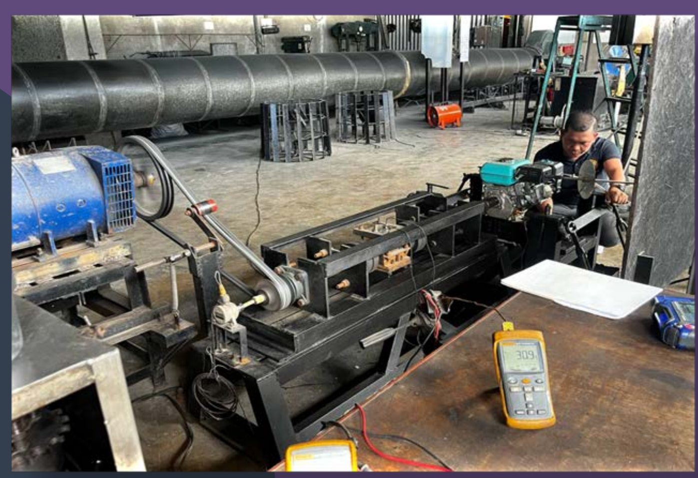


Figure 1 Setting Up the Engine Along with The Measuring Equipment

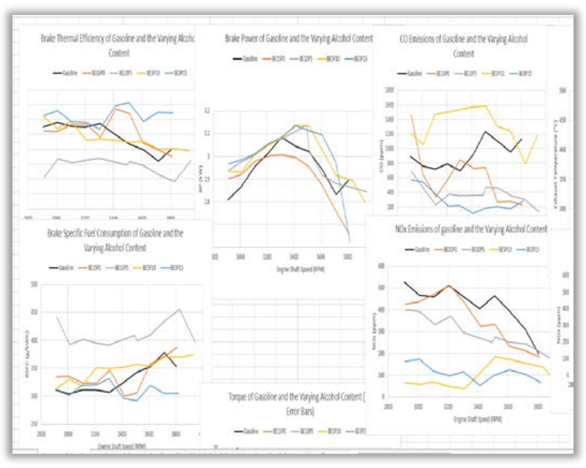
Figure 2. Single-Cylinder Spark Ignition Engine. Source: KHM Megatools Corp.

METHOD

Procurement of Equipment and Materials

Preparation and Mixing of Blends

Varying Speed Test (Load Simulation Setup)



$$LHV_{Mixture} = \frac{\sum \frac{V_{component}}{V_{total}} \rho_{component} LHV_{component}}{\sum \frac{V_{component}}{V_{total}} \rho_{component}}$$

Sorting Data, Calculation of Parameters And Generating Curves

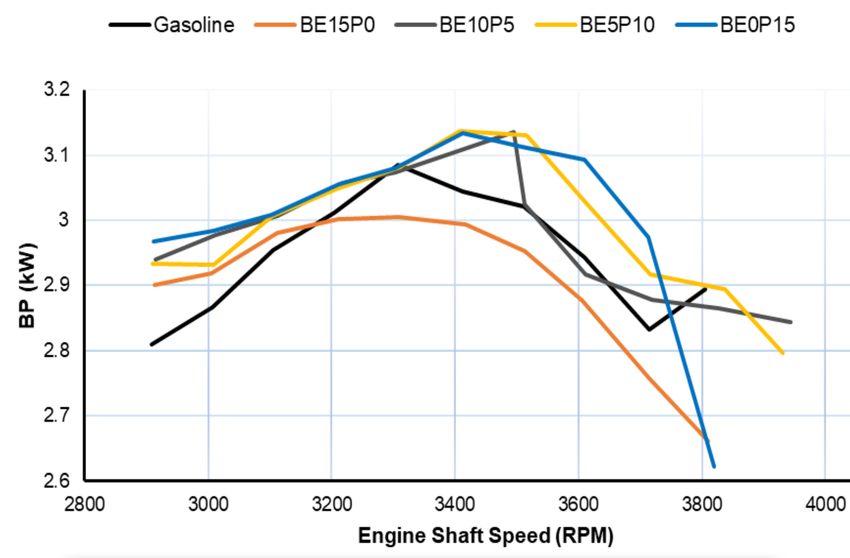
The study used a Fujistar FJ-200 gasoline engine (6.5 HP, 4-stroke, float-type carburetor). Blends were prepared using a magnetic stirrer at 1200 RPM, with equal amounts of n-butanol and ethanol. An alternating dynamometer and light bulbs simulated varying loads. Fuel consumption was measured by timing the flow of 10 mL from a burette to the carburetor using a stopwatch. Performance parameters were computed using theoretical equations.

RESULTS & DISCUSSION

Fuel and Temperatures Measured (℃)	Measured Density (kg/m^3)	Computed LHV (MJ/kg)	Computed RON	Computed AFR (kg_{air}/kg_{fuel})
Gasoline (32.7℃)	719.00	44.43	95.00	14.7:1
BE15P0 (33.8℃)	733.00	42.27	95.45	13.96:1
BE10P5 (32.9℃)	735.00	42.26	96.15	13.97:1
BE5P10 (32.7℃)	734.67	42.24	96.85	13.98:1
BE0P15 (32.2℃)	726.67	42.22	97.55	13.99:1

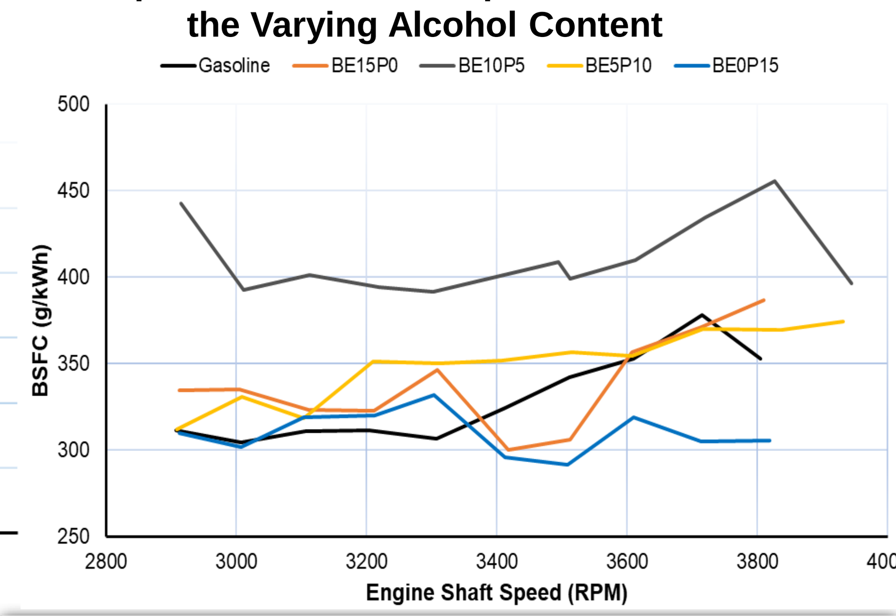
All alcohol–gasoline blends had lower heating values but higher octane numbers than pure gasoline, with BE0P15 showing the highest RON and closest AFR to stoichiometric among the mixes.

Brake Power of Gasoline and the Varying Alcohol Content



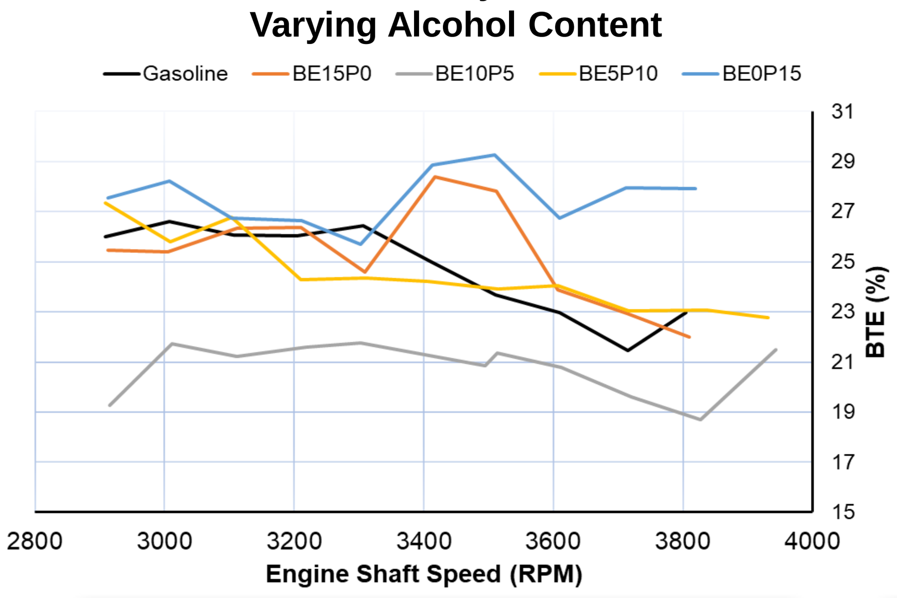
BE10P5, BE5P10, and BE0P15 showed higher peak brake power than gasoline.

Brake Specific Fuel Consumption of Gasoline and the Varying Alcohol Content



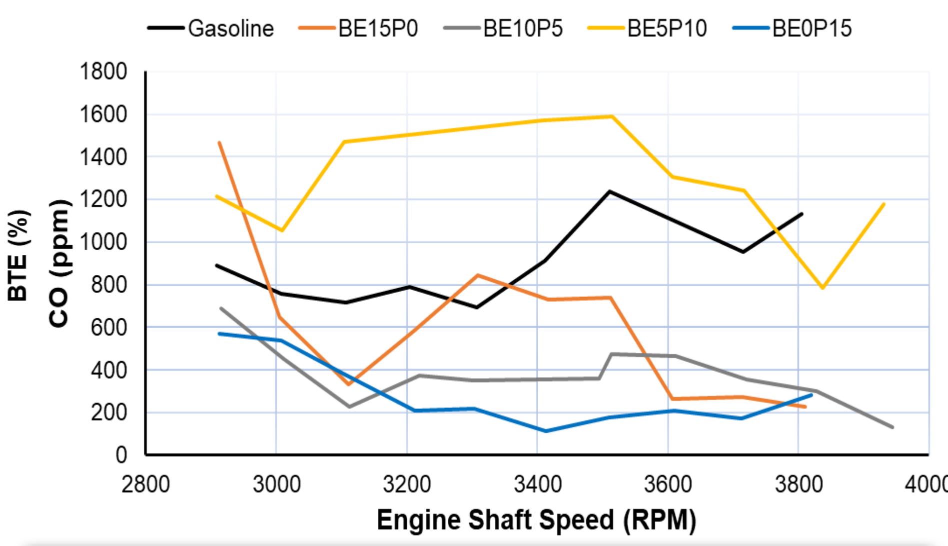
BE10P5 had the highest BSFC due to a lean mixture caused by higher density and poor vaporization.

Brake Thermal Efficiency of Gasoline and the Varying Alcohol Content



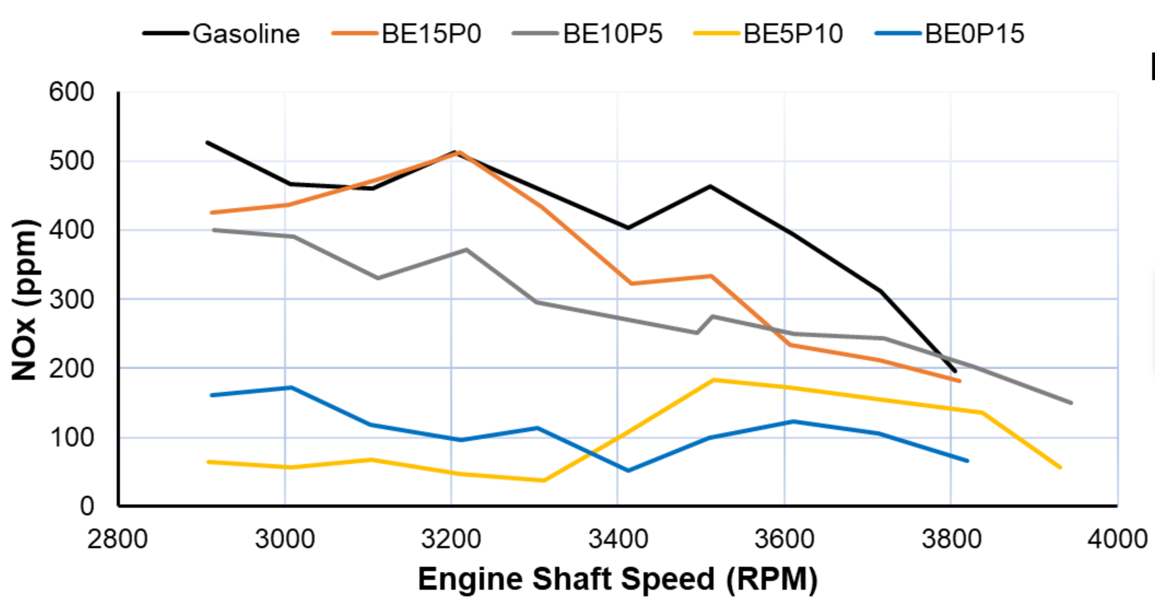
BE0P15 recorded the highest BTE across most engine speeds

CO Emissions of Gasoline and the Varying Alcohol Content



CO emissions were lowest for **BE0P15**, reflecting improved vaporization and more complete combustion.

NOx Emissions of Gasoline and the Varying Alcohol Content



NOx emissions were highest for **BE15P0 and gasoline.**

CONCLUSION

- BE0P15 blend performed the best, showing higher power, better fuel economy, and lower emissions, with results at 3300 RPM closely matching gasoline.
- BE5P10 exhibited high CO emissions due to rich conditions, while BE10P5 showed lean operation that reduced CO but lowered efficiency.
- The results highlight that fuel properties, vaporization, and engine–blend compatibility, rather than just AFR, critically influence performance and emissions, emphasizing the need for careful blend optimization.
- N-propanol demonstrated strong potential as a clean-burning, high-octane additive in multi-alcohol fuel systems.
- Results confirm that proper blend formulation can improve combustion efficiency without requiring engine modifications.

FUTURE WORK / REFERENCES

- Future studies should use automated fuel and emissions sensors to improve the accuracy and reliability of data.
- Experiments should cover a wider range of engine speeds and loads, including cold-start conditions, to better understand blend performance.
- Future work should explore different alcohol ratios and implement electronic or adjustable fuel delivery systems to enhance combustion efficiency.

Reference: Reference: Ahmed, H. A. (2017). The effect of the heavy alcohol additive to base fuel of spark ignition engine.