AN ASSESSMENT OF HIGHER ALCOHOL BIOFUEL BLENDS

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Due to concerns over fossil fuel scarcity and environmental pollution, biofuels, especially alcohol-based ones, are gaining traction as viable gasoline substitutes. While ethanol has been a primary focus, recent attention has shifted to higher alcohols (C4-C7) due to their superior energy content and compatibility with gasoline (Ashok et al., 2019, p. 266). This thesis aims to evaluate higher alcohols and their blends to determine the optimal alternatives for spark-ignition (SI) engines.

This research evaluated 18 high-alcohol gasoline blends for SI engines, covering C4-C7 alcohols. Specifically, were studied n-Butanol blends like NB10-NB30 (Ashok et al., 2019 pp. 265-289), iso-Butanol blends IB10-IB30, n-Pentanol blends Pt5-Pt20 (Yaman & Yesilyurt, 2021), and 1-Hexanol and 1-Heptanol blends HEX5-HEX20 and HP5-HP20 (Yaman et al., 2021).

To evaluate SI engine performance with various fuel mixtures, two factors are commonly used: Brake Thermal Efficiency (BTE) and Brake-specific Fuel Consumption (BSFC) (Ashok et al., 2019, p. 267). Additionally, the alcohol content in blends also is an important criterion, as increasing the content can decrease carbon emissions, given that many alcohols can be biosynthesized by capturing CO2 from the air (Yunus & Jones, 2018, p. 59).

The referenced studies tested blends on single-cylinder, 4-stroke SI engines with varying modifications, like different compression ratios and engine power. These variations can greatly influence BTE and BSFC, rendering direct data comparisons impractical. In this study, blends were assessed based on their change rates relative to a benchmark fuel (pure gasoline) for each test. This approach allows for dynamic comparisons across different engine modifications. However, (Yaman & Yesilyurt, 2021) did not provide BSFC data for n-Pentanol, so comparisons were made with the other blends.

Two figures were constructed and analyzed in this study, emphasizing the comparison of BTE and BSFC values for different blends.

BTE line graphs (see Figure 1) are segmented into three experimental setups, showcasing net maximum power and CR. Other modifications are excluded for clarity. At a 40% engine load, there's a notable BTE reduction in each test. As engine load increases, most blends' BTE aligns with the 20% load, except for n-Pentanol blends which exhibit a moderate decline.

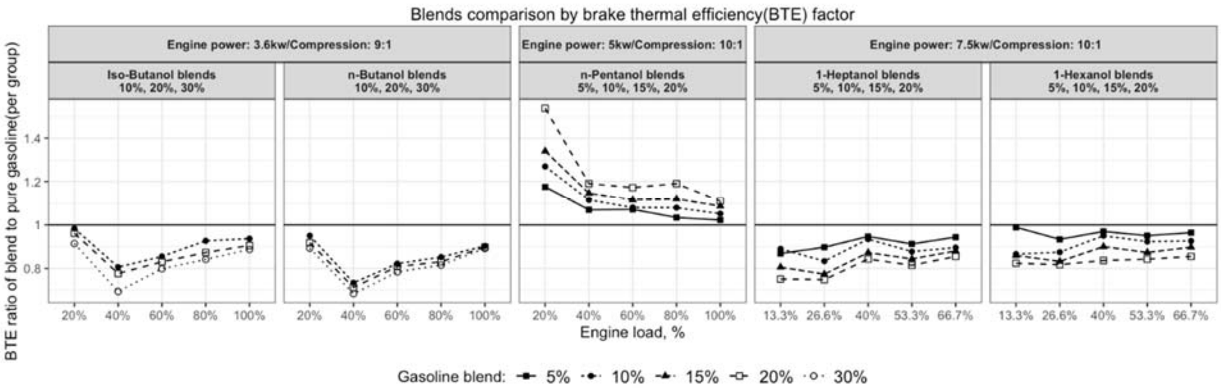

Figure 1. Brake thermal efficiency of alcohol blends under varying engine loads (This work).

Surprisingly, n-Pentanol consistently outperformed pure gasoline in BTE throughout the tests. As for the influence of alcohol content, a rise in content generally led to a BTE drop, most pronounced with 1-Heptanol and 1-Hexanol blends. Contrarily, n-Pentanol demonstrated the highest BTE with a 20% n-Pentanol and 80% gasoline blend.

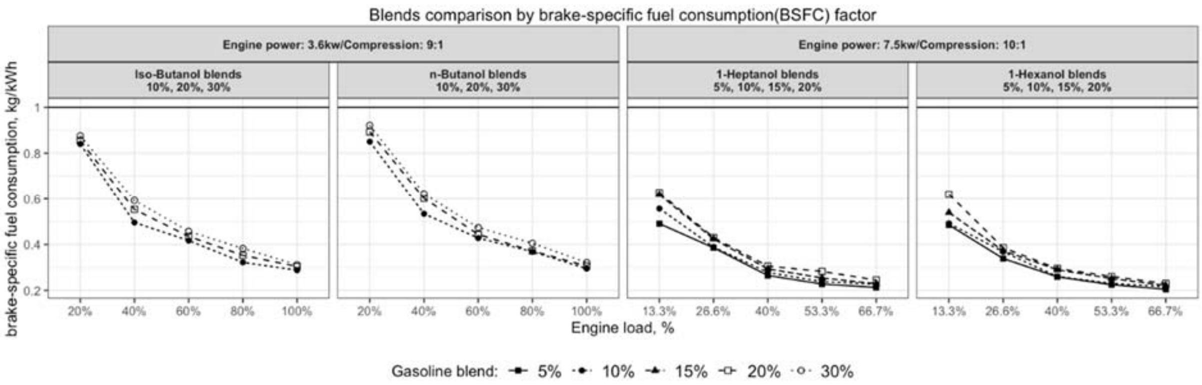

Figure 2. Brake-specific fuel consumption of alcohol blends under varying engine loads (This work).

Subsequent graphs (see Figure 2) present BSFC data for blends, excluding n-Pentanol. A trend can be seen: as engine load increases, BSFC decreases, indicating potential fuel savings under high engine loads. While different alcohol contents had a minimal impact, higher alcohol content generally resulted in increased BSFC.

Comparing BTE and BSFC data, 1-Hexanol and 1-Heptanol blends exhibited superior performance over Iso-Butanol and n-Butanol blends. Only n-Pentanol blends surpassed pure gasoline in BTE, underscoring its potential as an efficient gasoline substitute. However, the lack of BSFC data requires further exploration to fully understand n-Pentanol's capabilities.

This research introduced a comparative algorithm for analyzing blends across different experimental setups, streamlining blend evaluations. The C4-C7 alcohol blends were thoroughly assessed. Notably, n-Pentanol showcased superior Brake Thermal Efficiency, surpassing the benchmark fuel. While C6-C7 blends demonstrated moderate BTE and reduced fuel consumption, C4 blends lagged in performance. Given these findings, n-Pentanol emerges as a promising gasoline alternative, warranting further investigation.

References:

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