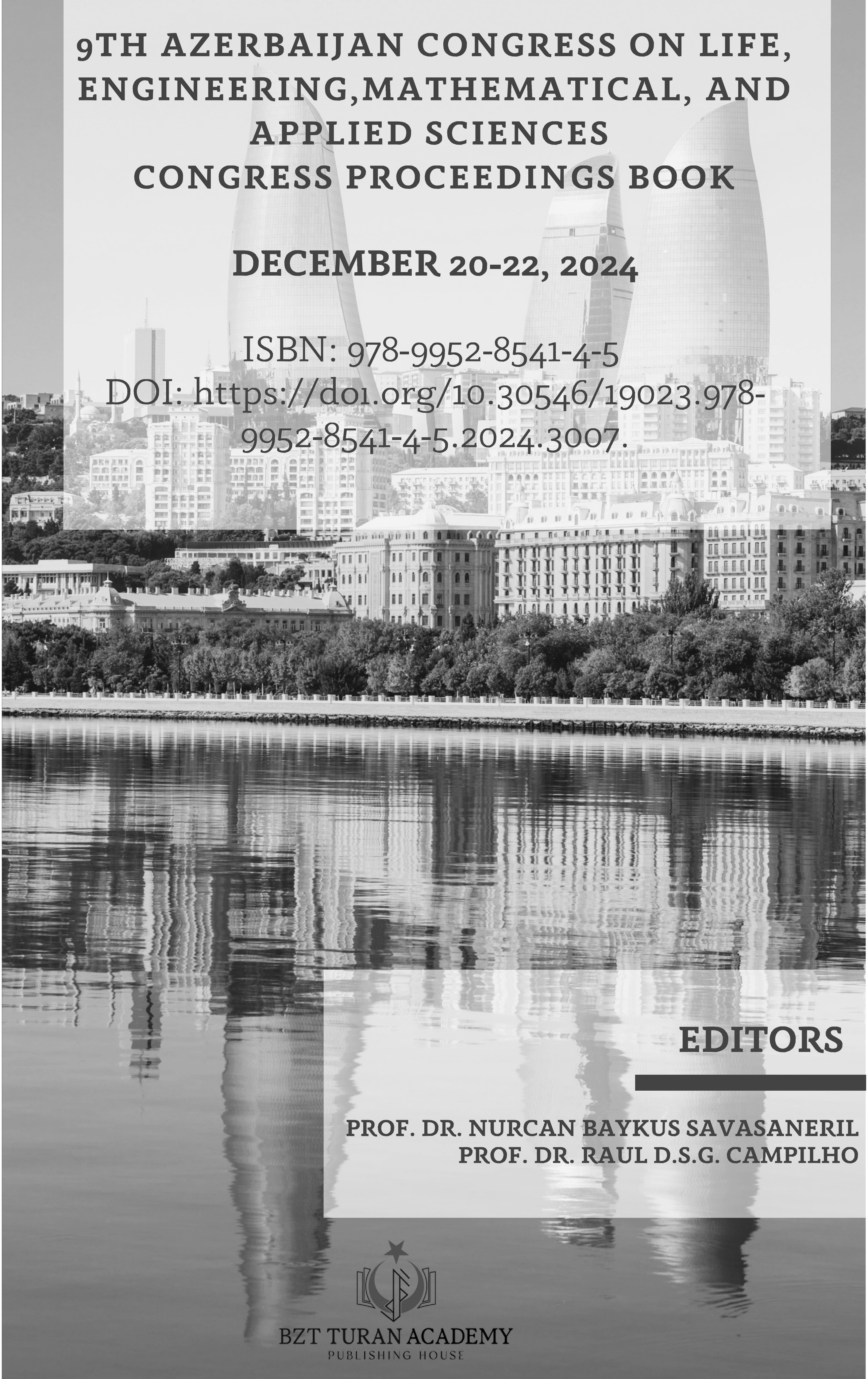

# 9TH AZERBAIJAN CONGRESS ON LIFE, ENGINEERING, MATHEMATICAL, AND APPLIED SCIENCES CONGRESS PROCEEDINGS BOOK

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DECEMBER 20-22, 2024

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| | 21.12.2024 | Time: 13⁰⁰-16¹⁵ (Turkiye Local time GMT+3) Time: 14⁰⁰-17¹⁵ (Azerbaijan Local time GMT+3) | MODERATOR / HEAD OF THE SESSION: *Furkan ATAKLI* COORDINATOR: *Ufuk EZGİN* |
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# INVESTIGATION OF PERFORMANCE AND EMISSIONS OF FUEL BLENDS FORMED BY MIXING JP8, JET A1, AND NITROMETHANE WITH GASOLINE USING A PISTON ENGINE

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**ABSTRACT**

This study investigates the impact of alternative fuel blends, including JP8, Jet-A1, and nitromethane, on the performance, combustion characteristics, and emissions of a single-cylinder gasoline engine at full load. A total of nine fuel blends were prepared, with gasoline (G100) serving as the baseline fuel. Engine performance was assessed in terms of thermal efficiency, brake-specific fuel consumption (BSFC), exhaust gas temperature (EGT), and emissions ($CO_2$, CO, HC, and $NO_x$). The results showed that G100 exhibited the highest thermal efficiency (16.667%) and the lowest BSFC (487.57 g/kWh), reflecting its superior combustion characteristics. Blends containing nitromethane demonstrated the highest thermal efficiencies, with 90G5NM5JetA1 achieving 18.457% due to nitromethane's oxygen-rich composition enhancing combustion. However, blends with JP8 and Jet-A1 exhibited slightly reduced thermal efficiency and increased BSFC due to their lower energy density. Exhaust gas temperatures were elevated for all alternative fuel blends, with nitromethane-containing blends recording the highest values (up to 740.8°C), indicating more intense combustion. Emissions analysis revealed that nitromethane and Jet-A1 blends significantly reduced CO and HC emissions due to improved combustion efficiency. Conversely, $CO_2$ and $NO_x$ emissions increased, particularly for nitromethane blends, due to higher combustion intensity and oxygenation. The findings highlight that while G100 remains the most efficient fuel, alternative fuel blends, especially those containing nitromethane, offer enhanced thermal efficiency and reduced incomplete combustion emissions, making them suitable for performance-focused applications. However, the associated $CO_2$ and $NO_x$ emissions increase underscores the need for advanced after-treatment systems and fuel optimization. This study provides valuable insights into the trade-offs between performance, fuel efficiency, and environmental impact when adopting alternative fuel blends in combustion engines.

**Keywords:** Exhaust emissions, Engine Performance, JP8, Jet-A1, Nitromethane, Gasoline

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## 1. Introduction

The growing demand for energy and increasing environmental concerns have driven extensive research into alternative fuels for internal combustion engines. Gasoline, the primary fuel for spark-ignition engines, provides high energy density and reliable performance. However, its use contributes significantly to greenhouse gas (GHG) emissions and air pollutants such as carbon monoxide (CO), unburned hydrocarbons (HC), and nitrogen oxides ($NO_x$)[1]. To mitigate these environmental impacts while maintaining engine performance, researchers have explored blending gasoline with alternative fuels, including aviation fuels like JP8 and Jet-A1, as well as oxygenated additives like nitromethane[2][3]. JP8 and Jet-A1 are kerosene-based aviation fuels with lower volatility and energy density than gasoline[4]. These fuels have been considered viable alternatives due to their widespread availability, high thermal stability, and ability to improve combustion stability in specific engine conditions[5]. However, their use in spark-ignition engines introduces challenges, such as reduced efficiency and increased emissions due to differences in chemical composition and combustion characteristics[6][7]. Blending JP8 or Jet-A1 with gasoline offers a potential solution, enabling partial substitution of gasoline while maintaining acceptable performance and emission levels. Nitromethane, an oxygen-rich compound widely used in high-performance engines, enhances combustion by introducing additional oxygen into the fuel-air mixture[8,9]. This promotes more complete oxidation of hydrocarbons, potentially reducing CO and HC emissions. However, the intense combustion associated with nitromethane can result in higher exhaust gas temperatures (EGT) and elevated $NO_x$ emissions[10]. Despite these drawbacks, nitromethane's ability to boost thermal efficiency and combustion intensity makes it an attractive additive for performance-focused applications[11].

This study investigates how blending gasoline with JP8, Jet-A1, and nitromethane affects engine performance and emissions. The experimental approach involved testing nine fuel blends, with gasoline (G100) serving as the baseline fuel. Blends with JP8 and Jet-A1 were prepared at 5% and 10% concentrations, while nitromethane was added at 2.5% and 5% concentrations to combinations of JP8 and Jet-A1. The engine was operated under full-load conditions to evaluate key performance parameters, including thermal efficiency, brake-specific fuel consumption (BSFC), and exhaust gas temperature (EGT). $CO_2$, CO, HC, and $NO_x$ emissions were also measured to assess the environmental impact of each blend. Evaluate the impact of JP8 and Jet-A1 blends on thermal efficiency, fuel consumption, and emissions. Determine the potential of nitromethane as an additive for improving combustion efficiency and reducing incomplete combustion emissions. Analyze the trade-offs between performance improvements and increased emissions associated with alternative fuel blends. This research provides valuable insights into the use of alternative fuels in spark-ignition engines. This study identifies the benefits and challenges associated with their adoption by comparing the performance and emissions of JP8, Jet-A1, and nitromethane blends with those of conventional gasoline. The findings contribute to the ongoing effort to develop cleaner and more efficient fuel solutions for internal combustion engines, balancing performance requirements with environmental sustainability.

## 2. Material and Methods

This section details the experimental procedures employed to investigate the effects of JP8, Jet-A1, and nitromethane blended with gasoline on engine performance and exhaust emissions. The study was conducted using a single-cylinder, air-cooled, four-stroke gasoline engine. The experimental setup, fuel mixtures, engine testing procedure, and measurement methods are described below.

A single-cylinder, air-cooled, four-stroke Honda GX200 engine was used (Table 1). The engine operated at 2500 RPM under full load controlled using a dynamometer.

Table 1 Engine Specifications

| **Features** | **Statement** |
|---|---|
| Brand&Model | Honda GX200 |
| Bore x stroke (mm x mm) | 68 x 54 |
| Cylinder volume ($cm^3$) | 196 |
| Number of cylinders | 1 |
| Cooling type | Air cooled |
| Max. power (Hp, @3600 d/dk) | 6.5 |
| Max. torque (Nm, @2500 d/dk) | 13.24 |
| Compression ratio | 8.5:1 |

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Nine fuel blends were prepared using gasoline as the base fuel and varying concentrations of JP8, Jet-A1, and nitromethane. The baseline fuel, referred to as G100, consisted of 100% gasoline. Two blends were created by mixing gasoline with JP8: 95G5JP8 (95% gasoline + 5% JP8) and 90G10JP8 (90% gasoline + 10% JP8). Similarly, two blends with Jet-A1 were prepared: 95G5JetA1 (95% gasoline + 5% Jet-A1) and 90G10JetA1 (90% gasoline + 10% Jet-A1). Blends incorporating nitromethane were also tested. These included mixtures of gasoline, JP8, and nitromethane: 95G2.5NM2.5JP8 (95% gasoline + 2.5% JP8 + 2.5% nitromethane) and 90G5NM5JP8 (90% gasoline + 5% JP8 + 5% nitromethane). Similarly, Jet-A1 was combined with nitromethane to produce 95G2.5NM2.5JetA1 (95% gasoline + 2.5% Jet-A1 + 2.5% nitromethane) and 90G5NM5JetA1 (90% gasoline + 5% Jet-A1 + 5% nitromethane). Each blend was carefully prepared in the laboratory by precisely measuring the required volumes of fuel components using a calibrated scale to ensure accurate ratios and thorough mixing for uniformity. The engine testing procedure was conducted under controlled conditions to evaluate the effects of various fuel blends on performance and emissions. Before the test, the engine was warmed up for 10 minutes using the baseline fuel (G100) to stabilize its operating conditions. The engine speed was fixed at 2500 RPM, while the load was steadily at full load. A dynamometer was used to apply and measure the engine load precisely. All measurements were taken for each fuel blend. Fuel consumption was measured using a digital precision scale with an accuracy of 0.1 grams, ensuring accurate fuel usage readings. Exhaust emissions (CO, $CO_2$, HC, and $NO_x$) were monitored using a Bilsa exhaust gas analyzer, capturing data at each load condition. Vibration data were recorded along three axes (X, Y, and Z) using a UNI-T UT315A vibration meter mounted on the engine block. The recorded values were averaged to assess engine stability. Noise levels were measured in decibels (dBA) using a PCE 322A sound level meter placed 1 meter away from the engine. Noise data were collected every second and averaged over a 2-minute period for each load condition. To ensure consistency, the engine was purged with G100 fuel between tests to prevent cross-contamination of fuel blends. After switching to a new fuel mixture, the engine was allowed to stabilize for 2 minutes before measurements were taken. Each test was repeated three times for reliability, and the average values were recorded. The collected data included fuel consumption, exhaust emissions, vibration, and noise levels at each load condition. The results were analyzed to determine the impact of JP8, Jet-A1, and nitromethane blends on key engine performance parameters, including brake-specific fuel consumption (BSFC), thermal efficiency, exhaust gas temperature, and emissions.

## 3. Results

The thermal efficiency data shown in Figure 1 highlights the impact of fuel blends on engine performance at full load. The baseline fuel, G100 (100% gasoline), exhibited a thermal efficiency of 16.667%, which is the highest among the pure fuel blends, indicating its superior combustion characteristics and energy conversion efficiency. Blends with JP8 (95G5JP8 and 90G10JP8) demonstrated slightly lower thermal efficiencies of 15.860% and 16.854%, respectively. The reduction is attributed to JP8's lower energy density, which results in less efficient energy extraction from the fuel. Notably, the blend with a higher JP8 concentration (90G10JP8) showed marginally better efficiency than 95G5JP8, potentially due to improved combustion stability at this concentration. Jet-A1 blends (95G5JetA1 and 90G10JetA1) exhibited 15.673% and 18.239% thermal efficiencies, respectively. Interestingly, the higher concentration Jet-A1 blend (90G10JetA1) achieved better efficiency than the lower concentration blend, which might be due to enhanced atomization or combustion dynamics  Blends containing nitromethane (95G2.5NM2.5JP8, 90G5NM5JP8, 95G2.5NM2.5JetA1, and 90G5NM5JetA1) yielded the highest efficiencies among all blends, with values ranging from 17.482% to 18.457%. The oxygen-rich composition of nitromethane enhances combustion, increasing thermal efficiency despite its lower energy density. Among these, the 90G5NM5JetA1 blend achieved the highest thermal efficiency of 18.457%, showcasing the synergistic effect of nitromethane and Jet-A1. The results highlight that while the baseline fuel (G100) remains the most efficient conventional option, blends with nitromethane significantly improve thermal efficiency, making them promising for performance-focused applications. However, the moderate efficiency reductions seen with JP8 and Jet-A1 blends underscore the need for optimization to maximize their practical applicability.

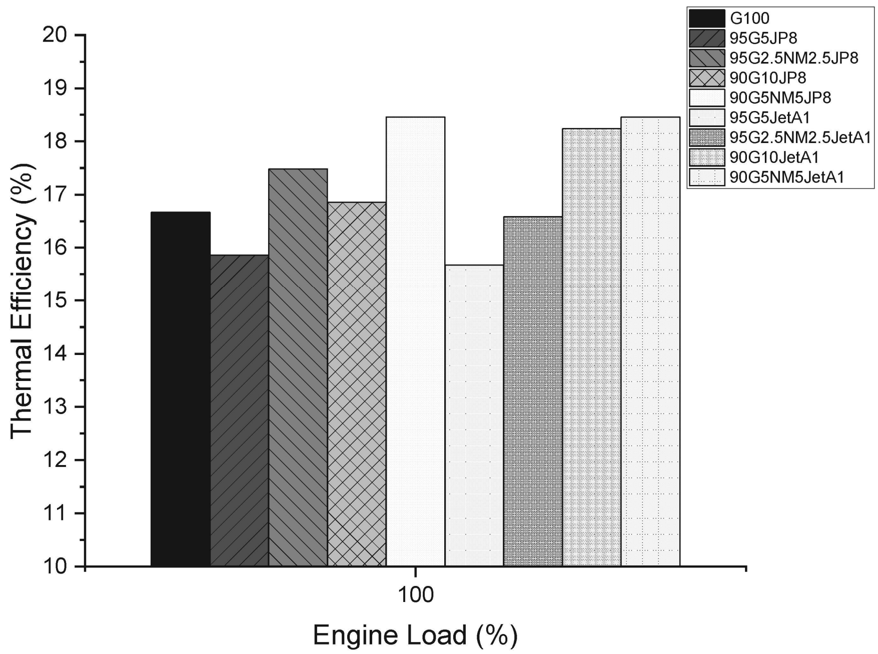


Figure 1. Thermal Efficiency of Fuel Blends at full load

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The brake-specific fuel consumption (BSFC) data in Figure 2 illustrates the impact of different fuel blends on engine fuel efficiency at full load. The baseline fuel, G100 (100% gasoline), achieved the lowest BSFC of 487.57 g/kWh, reflecting its high energy density and optimal combustion characteristics. The JP8 blends, 95G5JP8 and 90G10JP8, demonstrated BSFC values of 513.30 g/kWh and 483.90 g/kWh, respectively. The higher BSFC for 95G5JP8 indicates a slight loss of efficiency due to the lower energy density of JP8 compared to gasoline. Interestingly, 90G10JP8 showed a reduction in BSFC, likely due to improved combustion stability at higher JP8 concentrations, partially offsetting the fuel's lower energy content. Jet-A1 blends, 95G5JetA1 and 90G10JetA1, displayed BSFC values of 519.42 g/kWh and 447.14 g/kWh, respectively. The higher BSFC for 95G5JetA1 reflects the effect of Jet-A1's lower energy density, while the lower BSFC for 90G10JetA1 suggests improved combustion efficiency at higher concentrations. Blends with nitromethane, such as 95G2.5NM2.5JP8, 90G5NM5JP8, 95G2.5NM2.5JetA1, and 90G5NM5JetA1, recorded BSFC values between 447.14 g/kWh and 499.82 g/kWh. Nitromethane's oxygen-rich structure enhances combustion, allowing for more efficient fuel usage. The 90G5NM5JP8 and 90G5NM5JetA1 blends exhibited some of the lowest BSFC values among all fuel blends, at 458.17 g/kWh, highlighting their potential for improved energy utilization. The results indicate that G100 remains the most fuel-efficient option, while JP8 and Jet-A1 blends show moderate increases in BSFC due to their lower energy content. The inclusion of nitromethane improves combustion, reducing BSFC for nitromethane-containing blends. This suggests that nitromethane may be a valuable additive for performance applications where fuel efficiency is critical.

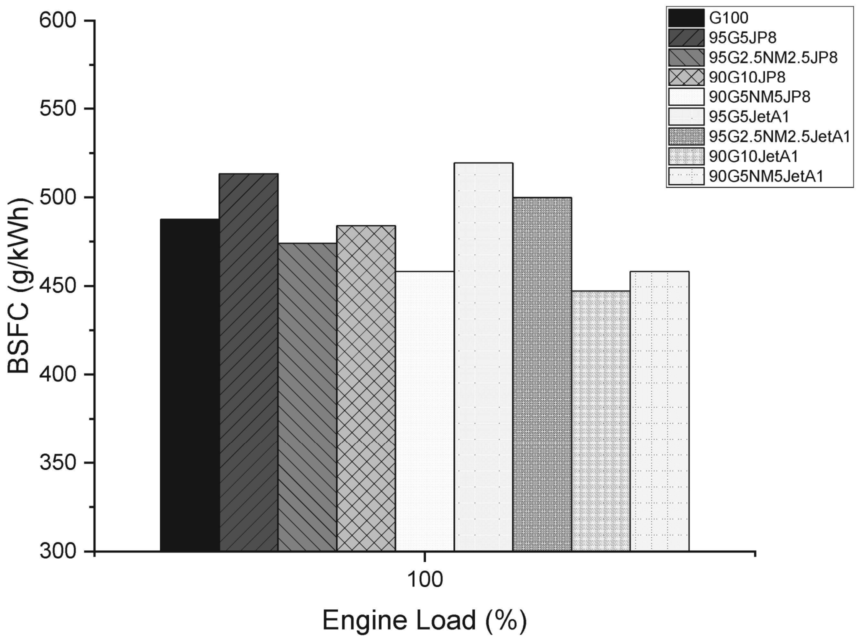


Figure 2. Brake-Specific Fuel Consumption (BSFC) of Fuel Blends at full load

The exhaust gas temperature (EGT) data in Figure 3 demonstrates the effect of various fuel blends on combustion temperature at full load. The baseline fuel, G100 (100% gasoline), recorded the lowest EGT at 706°C, reflecting efficient combustion with minimal heat transfer to the exhaust. JP8 blends, 95G5JP8 and 90G10JP8, exhibited EGTs of 719.2°C and 721.9°C, respectively. The higher EGT values compared to G100 can be attributed to JP8's lower volatility and energy density, which result in slower combustion and extended heat release into the exhaust gases. The small increase in EGT with higher JP8 content (90G10JP8) indicates that a greater proportion of JP8 marginally increases post-combustion heat. Jet-A1 blends, 95G5JetA1 and 90G10JetA1, showed EGTs of 732.9°C and 723.6°C, respectively. Both blends recorded higher temperatures than their JP8 counterparts, likely due to differences in chemical composition that influence combustion dynamics. The higher EGT for 95G5JetA1 may reflect a more prolonged combustion phase. Blends containing nitromethane (95G2.5NM2.5JP8, 90G5NM5JP8, 95G2.5NM2.5JetA1, and 90G5NM5JetA1) showed the highest EGT values, ranging from 734.8°C to 740.8°C. Nitromethane's oxygen-rich composition enhances combustion intensity, leading to higher heat release. The highest EGT was observed for 90G5NM5JetA1 (740.8°C), suggesting a synergistic effect of Jet-A1 and nitromethane in increasing combustion temperature. The increasing EGT values with alternative fuel blends indicate more intense combustion, which can improve exhaust after-treatment efficiency but may impose higher thermal

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stresses on engine components. While nitromethane blends produce the highest EGT, care must be taken to manage thermal loads to avoid durability issues. Future research should focus on optimizing fuel blends to balance thermal performance and engine reliability.

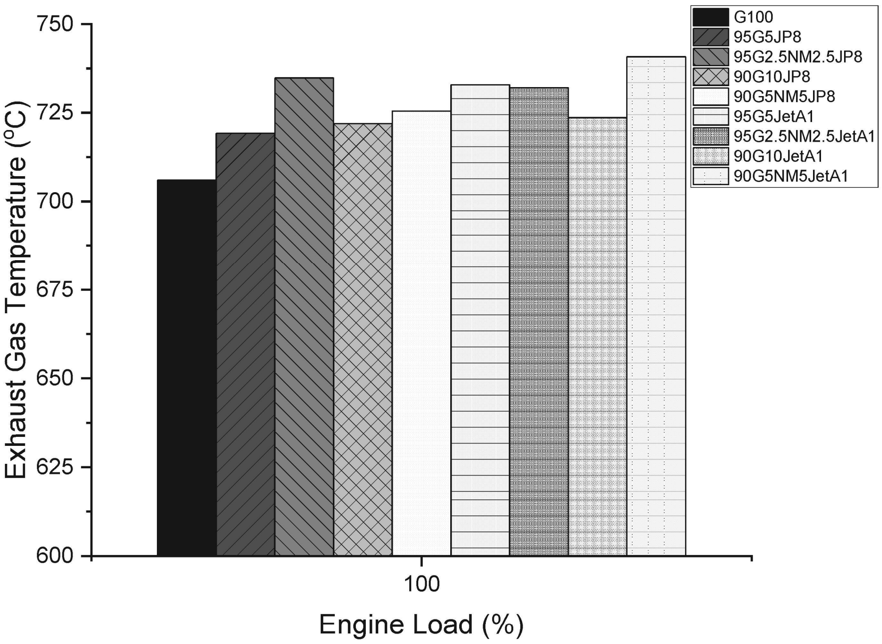


Figure 3. Exhaust Gas Temperature (EGT) of Fuel Blends at full load

Figure 4 shows the carbon dioxide ($CO_2$) emissions for different fuel blends at full load. The results highlight the impact of alternative fuels, such as JP8, Jet-A1, and nitromethane, on combustion efficiency and emission characteristics. The baseline fuel, G100 (100% gasoline), exhibited moderate $CO_2$ emissions, reflecting its optimal combustion efficiency. Gasoline's high carbon content and energy density result in relatively balanced $CO_2$ emissions during complete combustion. Blends with JP8 (95G5JP8 and 90G10JP8) showed slightly increased $CO_2$ emissions compared to G100. The values were higher for 90G10JP8 than 95G5JP8, suggesting that higher JP8 concentrations contribute to more complete combustion due to enhanced oxygenation, thereby increasing $CO_2$ levels. However, JP8's lower energy density may also lead to increased fuel consumption, contributing to the elevated $CO_2$ emissions. Jet-A1 blends (95G5JetA1 and 90G10JetA1) exhibited similar trends, with higher $CO_2$ emissions than G100. The emissions were slightly higher for 90G10JetA1, indicating a potential improvement in combustion at higher Jet-A1 concentrations. The chemical composition of Jet-A1, with a high hydrogen-to-carbon ratio, may favor slightly more complete combustion, but the increased fuel usage offsets this benefit. Nitromethane-containing blends (95G2.5NM2.5JP8, 90G5NM5JP8, 95G2.5NM2.5JetA1, and 90G5NM5JetA1) exhibited the highest $CO_2$ emissions. Nitromethane's oxygen-rich structure improves combustion efficiency, leading to higher $CO_2$ formation. The highest emissions were observed for 90G5NM5JetA1, which combines nitromethane and Jet-A1, promoting complete combustion but at the cost of increased $CO_2$ output. The results suggest that alternative fuel blends enhance combustion completeness and increase $CO_2$ emissions due to higher fuel consumption and oxygenation effects. G100 remains a balanced option for minimizing $CO_2$ emissions, while nitromethane blends, though efficient, lead to significantly higher emissions. Optimization of fuel blends is essential to reduce environmental impacts while maintaining performance.

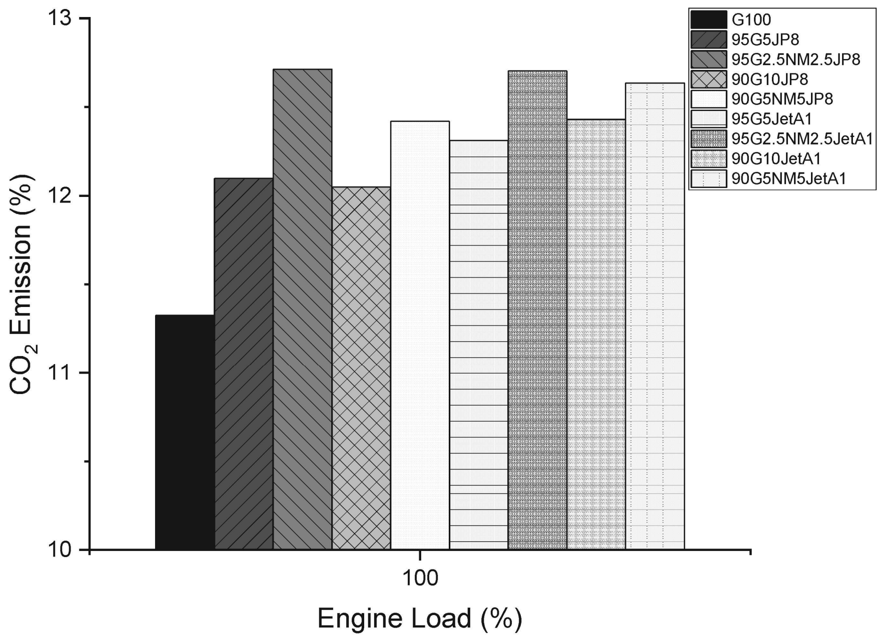


Figure 4: $CO_2$ Emissions of Fuel Blends at full load

Figure 5 presents carbon monoxide (CO) emission data for fuel blends at full load. CO emissions indicate incomplete combustion and are influenced by fuel composition, oxygen content, and combustion efficiency. The baseline fuel, G100 (100% gasoline), recorded the highest CO emissions at 4.785%, reflecting incomplete combustion despite its high energy density. Gasoline's lack of inherent oxygen contributes to less complete oxidation of carbon, resulting in elevated CO levels. JP8 blends, 95G5JP8 and 90G10JP8, exhibited CO emissions of 3.357% and 3.411%, respectively. These emissions were lower than those of G100, likely due to oxygen in JP8, which enhances combustion completeness. However, the slight increase in CO for 90G10JP8 compared to 95G5JP8 may indicate diminishing oxygenation benefits at higher JP8 concentrations, potentially due to less efficient mixing

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or combustion dynamics. Jet-A1 blends, 95G5JetA1 and 90G10JetA1, recorded further reductions in CO emissions, with values of 2.73% and 2.832%, respectively. These reductions reflect improved combustion associated with Jet-A1's chemical composition, including a higher hydrogen-to-carbon ratio, promoting more efficient carbon molecule oxidation. Nitromethane-containing blends (95G2.5NM2.5JP8, 90G5NM5JP8, 95G2.5NM2.5JetA1, and 90G5NM5JetA1) exhibited the lowest CO emissions, ranging from 1.886% to 3.026%. The oxygen-rich structure of nitromethane significantly enhances combustion completeness, reducing CO formation. Among these, the 90G5NM5JetA1 blend achieved the lowest CO emissions (1.886%), reflecting the synergistic effects of nitromethane and Jet-A1. The results show that alternative fuel blends, particularly those containing nitromethane, significantly reduce CO emissions by improving combustion completeness. While G100 produces the highest CO levels, Jet-A1 and nitromethane blends demonstrate a clear advantage in minimizing incomplete combustion. However, further optimization is necessary to balance combustion efficiency with performance and emissions.

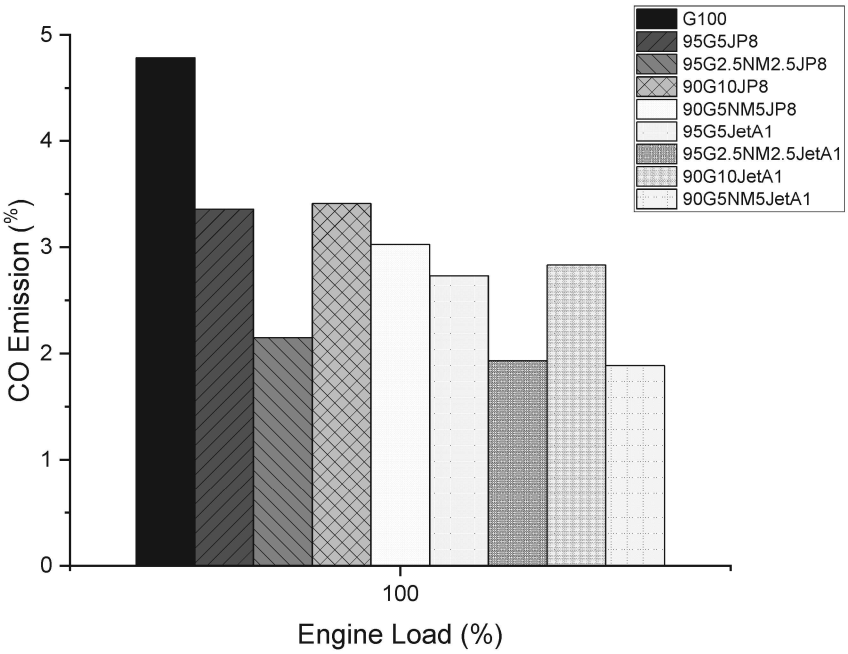


Figure 5: CO Emissions of Fuel Blends at full load

Figure 6 shows the hydrocarbon (HC) emissions for different fuel blends at full load. HC emissions result from incomplete fuel combustion, and their levels depend on fuel composition, volatility, and combustion efficiency. The baseline fuel, G100 (100% gasoline), exhibited the highest HC emissions at 125 ppm. This reflects incomplete combustion due to gasoline's lack of inherent oxygen, which limits the oxidation of hydrocarbons during combustion. Blends with JP8, 95G5JP8, and 90G10JP8 recorded HC emissions of 92 ppm and 81 ppm, respectively. The reduced emissions compared to G100 can be attributed to JP8's slightly higher oxygen content, which enhances combustion efficiency. The further decrease in HC emissions for 90G10JP8 suggests that higher JP8 concentrations promote more complete combustion under the tested conditions. Jet-A1 blends, 95G5JetA1 and 90G10JetA1, produced HC emissions of 84 ppm and 72 ppm, respectively. The lower emissions compared to JP8 blends reflect the better combustion characteristics of Jet-A1, possibly due to its higher hydrogen-to-carbon ratio. The significant reduction for 90G10JetA1 indicates improved oxidation of hydrocarbons at higher Jet-A1 concentrations. Nitromethane-containing blends (95G2.5NM2.5JP8, 90G5NM5JP8, 95G2.5NM2.5JetA1, and 90G5NM5JetA1) exhibited the lowest HC emissions, ranging from 76 ppm to 61 ppm. The oxygen-rich composition of nitromethane significantly improves combustion efficiency, minimizing unburnt hydrocarbons. The lowest HC emissions were observed for 90G5NM5JetA1 (61 ppm), demonstrating the combined benefits of nitromethane and Jet-A1 in achieving near-complete combustion. The results show that alternative fuels, particularly those containing nitromethane, substantially reduce HC emissions by enhancing combustion completeness. While G100 produces the highest HC levels, blends with Jet-A1 and nitromethane provide notable reductions, suggesting their suitability for applications where low hydrocarbon emissions are critical. Further optimization of these blends can enhance their environmental performance.

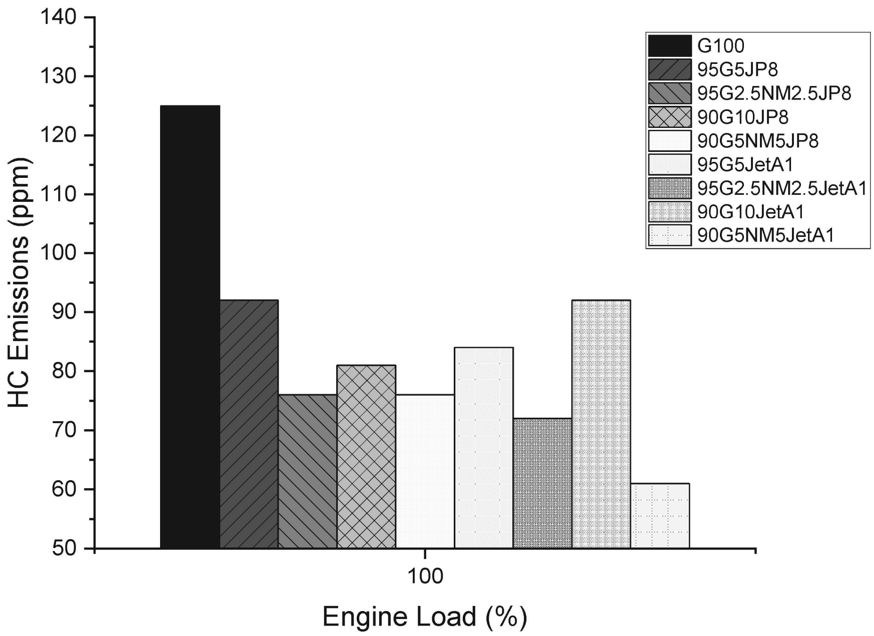


Figure 6. HC Emissions of Fuel Blends at full load

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Figure 7 presents the nitrogen oxide ($NO_x$) emissions for various fuel blends at full load. $NO_x$ emissions are a direct result of high combustion temperatures and oxygen availability, which facilitate the formation of nitrogen oxides during combustion. The baseline fuel, G100 (100% gasoline), recorded the lowest $NO_x$ emissions at 987 ppm. This result reflects gasoline's combustion characteristics, which, while efficient, produce relatively lower peak combustion temperatures and oxygen availability for NOx formation. Blends with JP8 (95G5JP8 and 90G10JP8) showed $NO_x$ emissions of 1319 ppm and 1293 ppm, respectively. The increase in $NO_x$ compared to G100 is attributed to the higher combustion temperatures resulting from JP8's lower volatility and slower burn rate. However, the slightly lower $NO_x$ for 90G10JP8 compared to 95G5JP8 suggests improved combustion efficiency at higher JP8 concentrations, reducing oxygen excess and peak temperatures. Jet-A1 blends, 95G5JetA1 and 90G10JetA1, exhibited $NO_x$ emissions of 1426 ppm and 1298 ppm, respectively. The results indicate a trend similar to the JP8 blends, with higher Jet-A1 concentrations reducing $NO_x$ formation due to improved combustion dynamics. The slightly higher NOx for 95G5JetA1 reflects increased peak temperatures during combustion. Nitromethane-containing blends (95G2.5NM2.5JP8, 90G5NM5JP8, 95G2.5NM2.5JetA1, and 90G5NM5JetA1) exhibited the highest $NO_x$ emissions, with values ranging from 2000 ppm to 2011 ppm. Nitromethane's oxygen-rich composition increases combustion intensity and peak temperatures, significantly enhancing $NO_x$ formation. The highest emissions were observed for 95G2.5NM2.5JP8 (2011 ppm) and 90G5NM5JP8 (2000 ppm). The results highlight the trade-off between combustion efficiency and $NO_x$ emissions. While nitromethane improves combustion completeness, it substantially increases $NO_x$ emissions due to higher temperatures. G100 remains the best option for minimizing $NO_x$ emissions, while JP8 and Jet-A1 blend provide moderate increases. Optimization of these blends and advanced after-treatment technologies are essential to mitigate $NO_x$ while maintaining performance.

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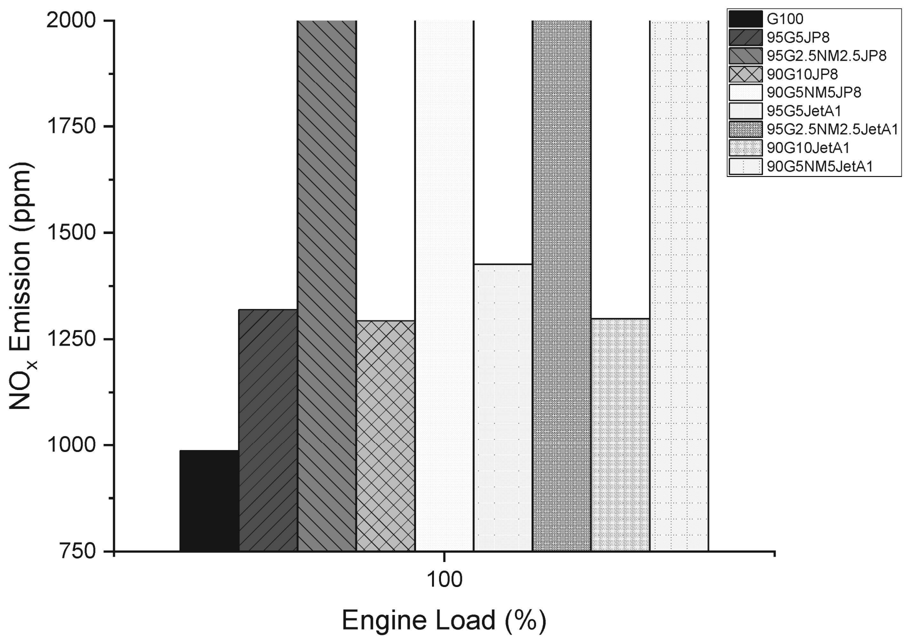


Figure 7: $NO_x$ Emissions of Fuel Blends at full load

## 4. Conclusions

This study evaluated the effects of various fuel blends on engine performance, combustion characteristics, and emissions at full load. The findings demonstrate that the baseline fuel, G100 (100% gasoline), achieved the highest thermal efficiency and lowest BSFC among pure fuels, confirming its superior energy density and combustion characteristics. However, alternative fuel blends with JP8, Jet-A1, and nitromethane showed notable performance and emission trends:

- Nitromethane-containing blends significantly enhanced thermal efficiency due to their oxygen-rich composition, with the 90G5NM5JetA1 blend achieving the highest efficiency (18.457%). JP8 and Jet-A1 blends exhibited moderate reductions in efficiency, highlighting the need for optimization to improve their practical applicability.

- G100 remained the most fuel-efficient option, while nitromethane-containing blends, particularly 90G5NM5JP8 and 90G5NM5JetA1, demonstrated improved fuel utilization despite their lower energy density.

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- Exhaust gas temperature increased for all alternative fuel blends, with nitromethane blends recording the highest values. While higher EGT improves after-treatment efficiency, it imposes greater thermal stress on engine components.

- Due to improved combustion, JP8 and Jet-A1 blends reduced CO and HC emissions compared to G100. Nitromethane further minimized these emissions due to enhanced combustion efficiency. $NO_x$ and $CO_2$ emissions were higher for nitromethane and Jet-A1 blends, attributed to increased combustion intensity and oxygenation effects.

While G100 remains the most efficient and balanced fuel option, blends with nitromethane and Jet-A1 offer performance enhancements, particularly in applications requiring higher thermal efficiency and reduced incomplete combustion emissions. However, the NOx and $CO_2$ emissions increase highlights the need for optimized fuel compositions and advanced after-treatment technologies to mitigate environmental impacts. Future research should focus on refining these blends to balance performance, fuel efficiency, and emissions control.

## References

[1] Citaristi I. International Energy Agency—IEA. Eur Dir Int Organ 2022 2022:701–2. https://doi.org/10.4324/9781003292548-126.

[2] Caranton ARG, Silva V, Galindo M, Pava J, López M, Cerón A, et al. Enhancing performance and emission characteristics of palm based biodiesel blends with aeronautical Additives: A comprehensive analysis in a J69 aviation engine. Energy Convers Manag 2024;313:118600. https://doi.org/10.1016/J.ENCONMAN.2024.118600.

[3] Kurban M, Kurban H, Dalkılıç M. Effects of Using JP8-Diesel Fuel Mixtures in a Pump Injector Engine on Engine Performance. Bilge Int J Sci Technol Res 2019;3:106–11. https://doi.org/10.30516/BILGESCI.652473.

[4] Jia T, Zhang X, Liu Y, Gong S, Deng C, Pan L, et al. A comprehensive review of the thermal oxidation stability of jet fuels. Chem Eng Sci 2021;229:116157. https://doi.org/10.1016/J.CES.2020.116157.

[5] Lee J, Bae C. Application of JP-8 in a heavy duty diesel engine. Fuel 2011;90:1762–70. https://doi.org/10.1016/J.FUEL.2011.01.032.

[6] Lee J, Lee J, Chu S, Choi H, Min K. Emission reduction potential in a light-duty diesel engine fueled by JP-8. Energy 2015;89:92–9. https://doi.org/10.1016/J.ENERGY.2015.07.060.

[7] Fernandes G, Fuschetto J, Filipi Z, Assanis D, McKee H. Impact of military JP-8 fuel on heavy-duty diesel engine performance and emissions. Http://DxDoiOrg/101243/09544070JAUTO211 2007;221:957–70. https://doi.org/10.1243/09544070JAUTO211.

[8] Çelebi S, Demir Ü, Ergen G. Experimental Investigation of the Effect of Nitromethane Addition to Gasoline Fuel on A Single-Cylinder Spark-Ignition Engine Performance and Emissions. Int J Automot Sci Technol 2022;6:226–32. https://doi.org/10.30939/IJASTECH..1109370.

[9] Zhuang Y, Li Y, Zhai R, Huang Y, Wang X, Tang L, et al. Research on the impact of nitromethane on the combustion mechanism of ammonia/methanol blends. J Energy Inst 2024;117:101867. https://doi.org/10.1016/J.JOEI.2024.101867.

[10] Raviteja S, Ramakrishna PA, Ramesh A. Laminar burning speeds of nitromethane-gasoline blends at elevated temperatures and pressures. J Energy Resour Technol Trans ASME 2019;141. https://doi.org/10.1115/1.4041725/368147.

[11] Nayyar A, Sharma D, Soni SL, Bhardwaj B, Augustine M. Modeling and experimental investigation for performance and emissions on a diesel engine using bio-oxygenated ternary fuel blends. Energy 2019;168:136–50. https://doi.org/10.1016/J.ENERGY.2018.11.098.