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Comparative study of octane booster variations in pertalite on exhaust gas emissions of the K15B Engine

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Abstract

The increasing number of vehicles powered by internal combustion engines in Indonesia has led to a corresponding rise in air pollution. This growing pollution poses significant environmental challenges and directly impacts public health. This study aims to reduce emissions produced by combustion engines, particularly the Suzuki K15B engine, through the application of various octane booster types added to Pertalite fuel (octane rating 90) at concentrations of 0.3%, 0.4%, and 0.5%. Exhaust gas emissions were measured using an Engine Gas Analyzer during the use of both pure Pertalite and Pertalite blended with octane boosters. Each composition was tested three times to ensure data accuracy and reliability. The results revealed that the greatest reduction in carbon monoxide (CO) concentration occurred with a 0.4% addition of Octane Prime, where CO levels decreased from 0.5% to 0.013%. Meanwhile, the most significant reduction in hydrocarbon (HC) emissions was observed with a 0.3% Octane Prime addition, lowering HC levels from 265 ppm to 60.7 ppm. Based on these findings, it can be concluded that the appropriate use of octane boosters in Pertalite fuel effectively reduces exhaust gas emissions from combustion engine vehicles.

Keywords: Combustion Engine; Exhaust Gas Emission; Gas Analyzer; Pollution; Engine

1. Introduction

Indonesia is the largest country in Southeast Asia, with its population reaching approximately 281.6 million in 2024. In line with this demographic growth, air pollution levels in Indonesia have become increasingly alarming, with motor vehicle emissions identified as one of the major contributors to national pollution levels [1]. Air pollution refers to a condition in which pollutants—such as gases, smoke, dust, or odors are present in the atmosphere. The presence of these pollutants can cause harm and discomfort to living organisms, particularly humans [2]. Motor vehicles emit several hazardous pollutants, including carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbons (HC), sulfur dioxide (SO_2), lead (Pb), and carbon dioxide (CO_2). The impacts of air pollution extend beyond environmental degradation and significantly affect human health. Among these pollutants, CO and NOx are particularly concerning due to their prevalence in vehicular emissions and their detrimental physiological effects. Exposure to CO can lead to serious health consequences; when inhaled, CO binds to hemoglobin in the blood to form carboxyhemoglobin (COHb), thereby reducing the blood's capacity to transport oxygen throughout the body [3], [4].

As a consequence of the growing population, there is an increasing demand for transportation facilities to support human mobility and daily activities. According to data from the Central Bureau of Statistics (BPS), the number of motor vehicles in Indonesia has continued to rise each year. This upward trend in vehicle ownership is illustrated in Table 1.

Table 1. Increase in the number of vehicles in the last 5 years in Indonesia [5]

No.	Types of Motor Vehicles	Year				
		2020	2021	2022	2023	2024
1	Passenger Car	15,797,746	16,413,348	17,175,632	19,278,023	20,122,177
2	Buses	233,261	307,566	241,215	212,742	285,957
3	Goods Car	5,083,405	5,229,361	5,528,669	5,759,709	6,197,110
4	Motorcycle	115,023,039	120,042,298	125,267,349	127,082,370	137,350,299
5	Amount	136,137,451	141,992,573	148,212,865	152,332,844	163,955,543
6	Improvement (%)		4.30	4.38	2.77	7.62

Source: Vehicle Number Data from the Indonesian National Police Traffic Corps and Indonesia.id Data

Human mobility has increased in parallel with the rapid growth of urban populations, improved economic conditions, and the intensification of work-related activities. Rising economic prosperity in urban areas is one of the key factors driving the accelerated growth in motor vehicle ownership, further supported by the various purchasing conveniences offered by automotive dealers. Moreover, the high level of work activity in urban communities creates a strong dependence on transportation facilities, particularly motor vehicles. Long distances between residential areas and workplaces are no longer a major obstacle when adequate transportation modes are available [6].

The level of pollution produced by exhaust gas emissions is strongly influenced by the efficiency of the fuel combustion process. The more complete the combustion, the lower the resulting emissions. Achieving complete combustion is determined, among other factors, by the engine's compression ratio and the octane rating of the fuel used [7], [8]. Gasoline plays a crucial role in modern society, particularly for motor vehicle users, as the majority of vehicles worldwide rely on gasoline as their primary fuel source [9]. Commercial gasoline is a blend of various components derived from multiple refinery processes to meet specific quality requirements. Once the desired quality parameters are achieved, the gasoline is distributed to the market. This process results in the availability of different types and brands of gasoline, each possessing distinct characteristics and quality levels [10]. The quality of a fuel is generally indicated by its octane rating [11]. One approach to increasing the octane rating—thereby promoting more complete combustion—is the addition of an octane booster to the fuel [12].

2. Method

This study was conducted at the automotive workshop of SMK Swasta Mandiri Percut Sei Tuan. The study began with a comprehensive literature review, followed by the preparation of the required tools and materials, and subsequently the blending of fuel compositions with an octane booster to obtain samples ready for testing. After the literature review, the next step involves preparing all necessary tools and materials to ensure that the experimental procedures can be carried out systematically and accurately. Once the preparation is complete, the formulation of fuel mixtures is conducted by blending gasoline with octane booster additives in three specified volumes 4 ml, 8 ml, and 12 ml. These mixtures are then tested on a K3 engine under two conditions: without load and with load, allowing for a comprehensive evaluation of the additive's influence on engine behavior. Following the experimental testing phase, the recorded data are processed and interpreted during the data analysis stage. This analysis aims to identify performance patterns, variations among fuel compositions, and the overall effect of octane booster concentrations on engine outcomes. The results generated from the analysis are subsequently assessed to determine whether they meet the expected performance standards. If the findings are deemed unsatisfactory, the process cycles back to the earlier testing stage for refinement or additional trials. Conversely, if the results are acceptable, the procedure continues to the conclusion stage, where the final interpretations, key insights, and implications of the study are summarized. The research process formally ends with the "Finish" stage, indicating the completion of all activities outlined in the flowchart.

In this study, an octane booster was added to Pertalite fuel, which has an octane rating of 90. A dedicated tank was prepared specifically for blending the fuel with the octane booster. The resulting mixtures were then formulated in several composition variations, as presented in Table 2.

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Table 2. Composition of fuel mixture with octane booster

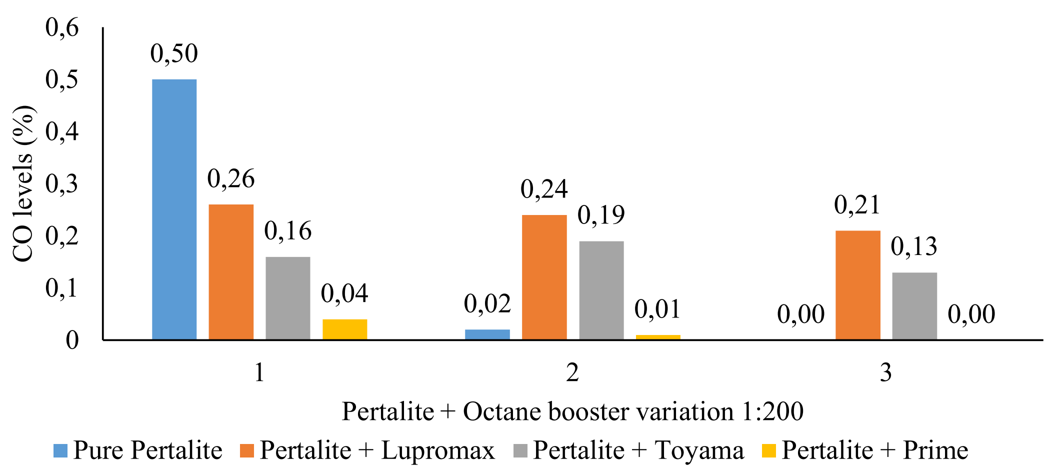
No	Octane Type	Composition		
		I	II	III
1	Toyama	1;200 ml	1;250 ml	1;300ml
2	Lupromax	1;200 ml	1;250 ml	1;300ml
3	Prime	1;200 ml	1;250 ml	1;300ml

The tools and materials used in this study, as shown in Figure 1, constitute the experimental setup for data collection. The primary equipment included a gas analyzer and a custom fuel tank. The engine was first operated for five minutes to reach its working temperature under a no-load idle condition, after which it was subjected to a load at 3000 rpm. The resulting data were recorded and subsequently processed using a computer.

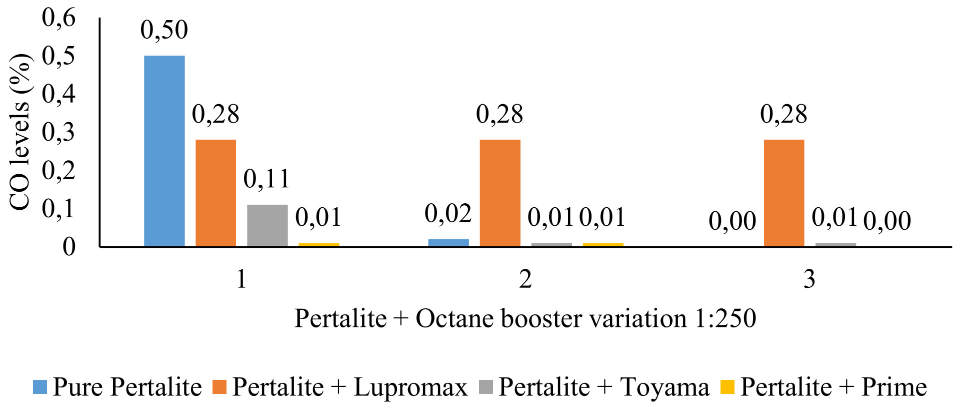
Figure 1. Experimental setup on test vehicle

3. Result and Discussion

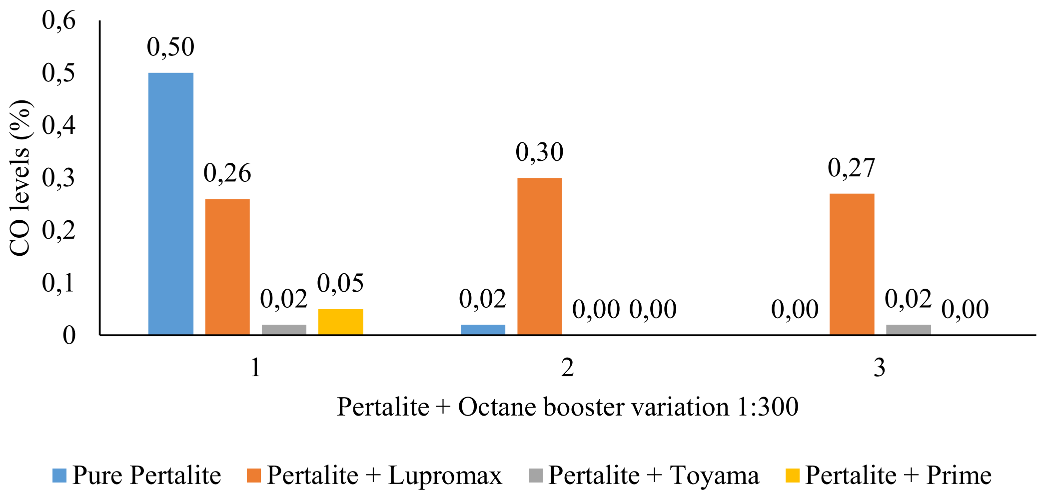
The results of the study regarding the use of an octane booster for Composition I at idle engine speed are presented in Figure 2(a). The CO emission measurements for Composition II can be observed in Figure 2(b), while the CO emission results for Composition III are shown in Figure 2(c).



(a)



(b)



(c)

Figure 2. Results of testing CO levels in several octane booster mixtures: (a) 1:200, (b) 1:250, and (c) 1:300

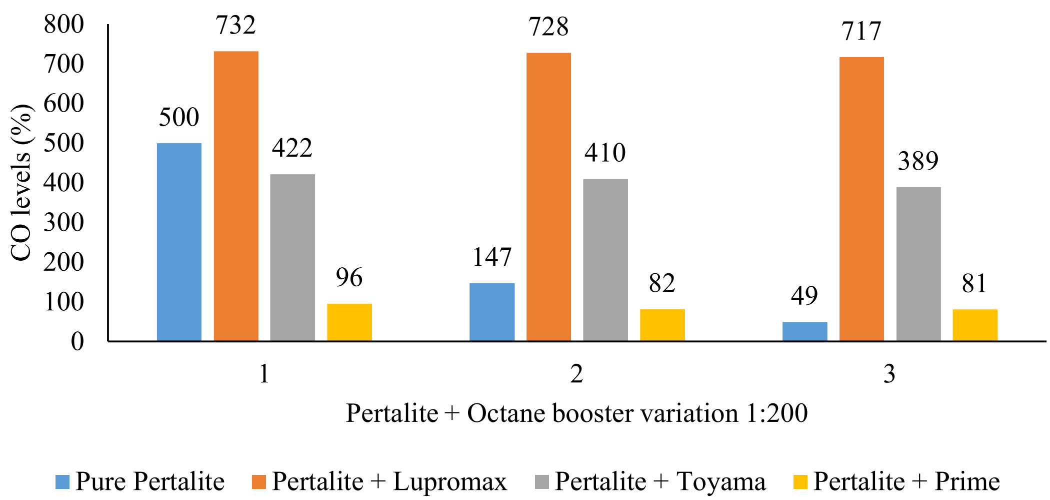
Based on the graph in Figure 2(a), the addition of 0.5% octane booster (Composition I) significantly reduced the CO concentration emitted by the K15B engine. Under pure Pertalite conditions, the CO emission level reached 0.5%. The lowest reduction was observed with the use of the Prime octane booster, which produced an average CO concentration of only 0.013%. In comparison, the CO emission for Composition II (0.4% octane booster) was shown in Figure 2(b). CO levels continued to decline with the use of the Prime variant, achieving an emission level of 0.003%. Meanwhile, the addition of a 0.3% octane booster (Composition III), presented Figure 2(c), resulted in a CO concentration of 0.017%.

These findings align with previous research demonstrating that octane boosters and fuel additives can enhance combustion efficiency and reduce exhaust emissions, particularly carbon monoxide (CO). Reported that adding a 2.5% liquid octane booster significantly reduced CO levels in a four-cylinder gasoline engine [13]. Found that the application of an octane booster in Pertalite fuel increased engine power and reduced fuel consumption by up to 15%, indicating more complete combustion and lower CO emissions [12]. Demonstrated that adding octane-enhancing agents to gasoline produced combustion characteristics comparable to Pertamax, with notably lower CO emissions [14].

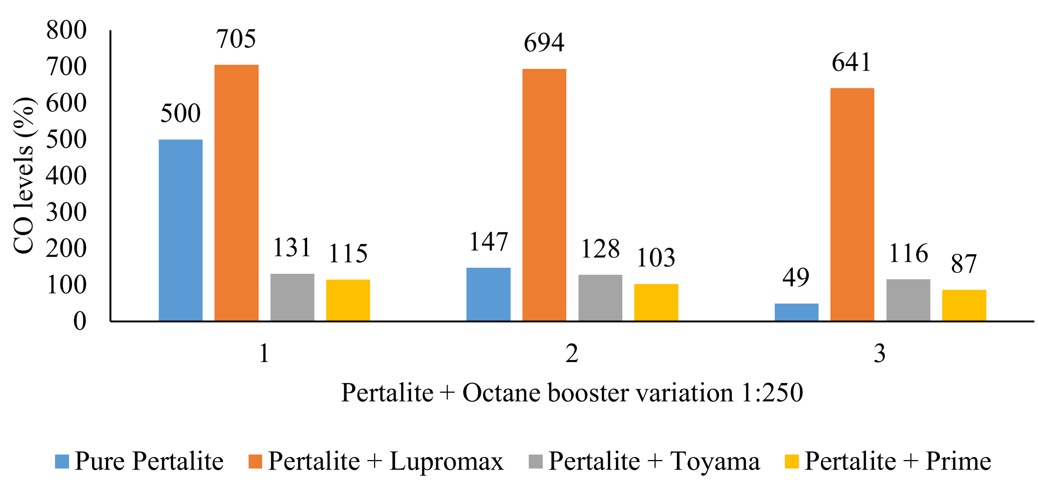
The hydrocarbon (HC) emission test results for the use of an octane booster in Composition I at idle engine speed are presented in Figure 3(a). The HC emission levels for Composition II are shown in Figure 3(b), while the HC emission results for Composition III can be observed in Figure 3(c). Figure 3(a) illustrates the hydrocarbon (HC) emission levels resulting from the addition of 0.5% octane booster

(Composition I). The graph shows that the use of Lupromax octane booster in the K15B engine increased HC emissions to an average of 622 ppm, compared to only 265 ppm when using pure Pertalite fuel. In contrast, the use of the Prime octane booster resulted in a substantial reduction, with average HC emissions of just 86.3 ppm. For Composition II (0.4% octane booster), shown in Figure 3(b), HC levels decreased to 103.3 ppm when using Prime, whereas the use of Toyoma octane booster led to an increase in HC emissions, reaching 680 ppm.

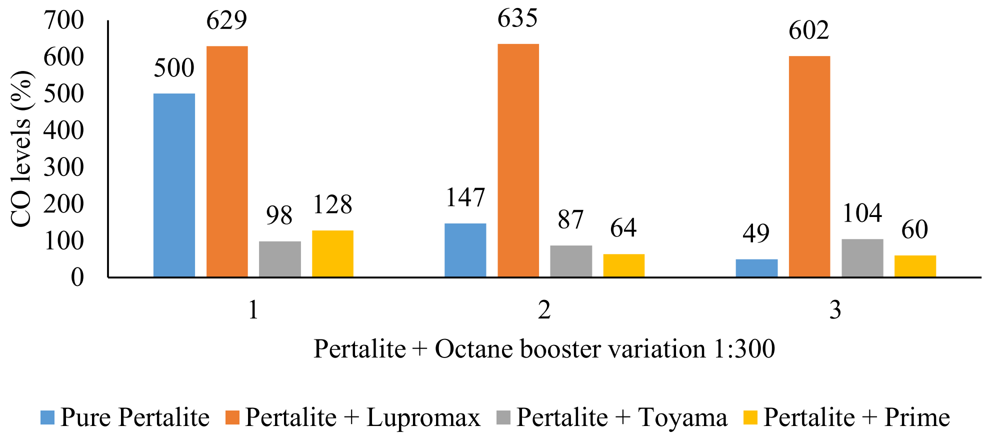
Similarly, for Composition III (0.3% octane booster), presented in Figure 3(c), the lowest HC emissions were again achieved with the Prime variant at 60.7 ppm, while Lupromax produced a significant increase, reaching 622 ppm. The observed fluctuations—both decreases and increases in HC emissions—are consistent with findings reported in previous studies. Octaviani et al. (2020) reported that increasing the octane number through bioethanol blending can enhance combustion quality; however, at certain concentrations, HC emissions may rise due to incomplete combustion associated with shifts in the air–fuel ratio [15]. A similar trend was highlighted who found that oxygenated additives in gasoline–bioethanol blends significantly reduced HC emissions only at optimal mixtures (E10), whereas excessive concentrations led to unstable combustion and increased HC levels [16]. Additionally, demonstrated that octane-enhancing additives can indeed reduce HC emissions when the resulting octane number approaches that of Pertamax; however, inappropriate blending ratios may increase unburned fuel residues and consequently elevate HC emissions [14], [17].



(a)



(b)



(c)

Figure 3. Results of testing HC levels in several octane booster mixtures: (a) 1:200, (b) 1:250, and (c) 1:300

4. Conclusion

The use of Prime octane booster significantly reduced both CO and HC emission levels in the K15B engine compared with pure Pertalite. This improvement is attributed to the appropriate addition of the octane booster, which increases the fuel's octane rating and promotes more complete combustion. In the tests conducted, the greatest reduction in CO emissions occurred with the addition of 0.4% Prime octane booster, which produced a CO concentration of only 0.013%, compared with 0.5% when using pure Pertalite. Furthermore, the most substantial decrease in HC emissions was observed at a Prime concentration of 0.3%, yielding an HC level of 60.7 ppm, in contrast to 265 ppm recorded for pure Pertalite.

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