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Performance and Fuel Efficiency Evaluation of an Injection Converter Kit Retrofit on a 100cc Four-Stroke Engine

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Abstract

This study investigates the effectiveness of an injection converter kit as a small engine retrofit for improving torque and fuel efficiency in a 100cc four-stroke motorcycle engine. An experimental method was applied using two fuel systems: a conventional carburetor and a retrofit converter kit. Torque and fuel consumption were measured across engine speeds ranging from 3000 to 7000 rpm using a dynamometer and volumetric analysis. The injection system achieved a peak torque of 6.78 N·m at 3600 rpm, exceeding the carburetor's 5.90 N·m at 5300 rpm. It also demonstrated improved fuel economy at most RPM levels, with a spike at 6000 rpm due to overpressure. Statistical analysis via Two-Way ANOVA confirmed the significance of these differences. The results suggest that the injection converter kit is a viable small engine retrofit option for enhancing performance and efficiency in low-displacement motorcycles.

Keywords
Torque, Fuel Efficiency, Injection, Carburetor, Small Engine Retrofit

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INTRODUCTION

The increasing global demand for fuel-efficient and environmentally sustainable transportation is a significant catalyst for advancements in small-engine technologies. In emerging markets, motorcycles equipped with small displacement engines, especially those featuring 100cc configurations—continue to serve as a predominant means of personal and commercial mobility. Conventional carburetor-based fuel delivery systems frequently exhibit inefficiencies in combustion and fuel management, resulting in suboptimal performance and increased fuel consumption. It is essential to address these inefficiencies, particularly in light of increasing fuel costs and more stringent emissions regulations [1][2].

Two predominant fuel delivery technologies are prevalent in small engine systems: the conventional carburetor and Electronic Fuel Injection (EFI) [2]. Although carburetors exhibit mechanical simplicity and cost efficiency, they do not provide the level of precision and responsiveness that is characteristic of EFI systems [3]. EFI facilitates the real-time optimization of the air-fuel ratio by utilizing sensor-based feedback mechanisms, thereby enhancing the completeness of combustion and augmenting engine performance. Nevertheless, a significant number of motorcycles, particularly those that are older or of lower cost, lack the incorporation of Electronic Fuel Injection (EFI), resulting in a technological disparity regarding performance and efficiency enhancements for these engines.

In order to address this disparity, aftermarket solutions, including injection converter kit as depicted in Figure 1, has been developed. The kits function as an alternative to comprehensive EFI systems by emulating the role of an ECU, employing data from sensors such as the throttle position sensor and crankshaft pulser to regulate fuel injection timing and volume [4]. Despite the claims of these kits regarding enhanced fuel atomization and more accurate control over combustion parameters, there exists a scarcity of empirical studies that substantiate their effects on performance, specifically in relation to torque output and fuel consumption.

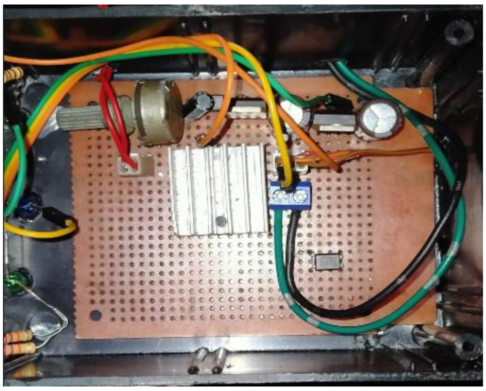

Figure 1. Converter Kit

The findings indicate that the injection converter kit markedly enhances engine torque, reaching a peak of 6.78 N·m at 3600 rpm, in contrast to 5.90 N·m at 5300 rpm with the carburetor system. Furthermore, the converter kit exhibits enhanced fuel efficiency throughout the majority of RPM ranges, with a significant deviation observed at 6000 rpm attributed to fuel overpressure [5][6][7]. The results indicate that the injection converter kit may function as a financially viable option for improving engine performance and fuel efficiency in small motorcycles, particularly in regions where the adoption of electronic fuel injection (EFI) is still constrained.

This study aims to conduct an experimental evaluation of the efficacy of an injection converter kit on a 100cc four-stroke engine, juxtaposing its performance against that of a traditional carburetor system. The present study employs a controlled experimental setup to assess engine torque and fuel consumption at different engine speeds (RPMs) through dynamometer testing [7][8]. The analysis of data was conducted utilizing Two-Way ANOVA to ascertain the statistical significance of the differences observed between the two systems.

METHOD

This study employed a quantitative experimental approach to investigate the effect of fuel system configuration on torque and fuel consumption in a 100cc four-stroke engine. Specifically, the research compared the performance of a standard carburetor with that of an injection converter kit designed to simulate ECU functionality. The primary objective was to determine whether the converter kit could provide measurable improvements in engine output and efficiency across different engine speeds.

The research procedure followed a systematic sequence, beginning with a literature review and the determination of the research topic. This was followed by the preparation of tools and materials, configuration of the fuel delivery systems, experimental testing, data collection, statistical analysis, and conclusion drawing. This structured workflow is illustrated in Figure 2, which outlines the progression from initial planning to final evaluation, including stages for data gathering on torque and fuel consumption using both fuel systems.

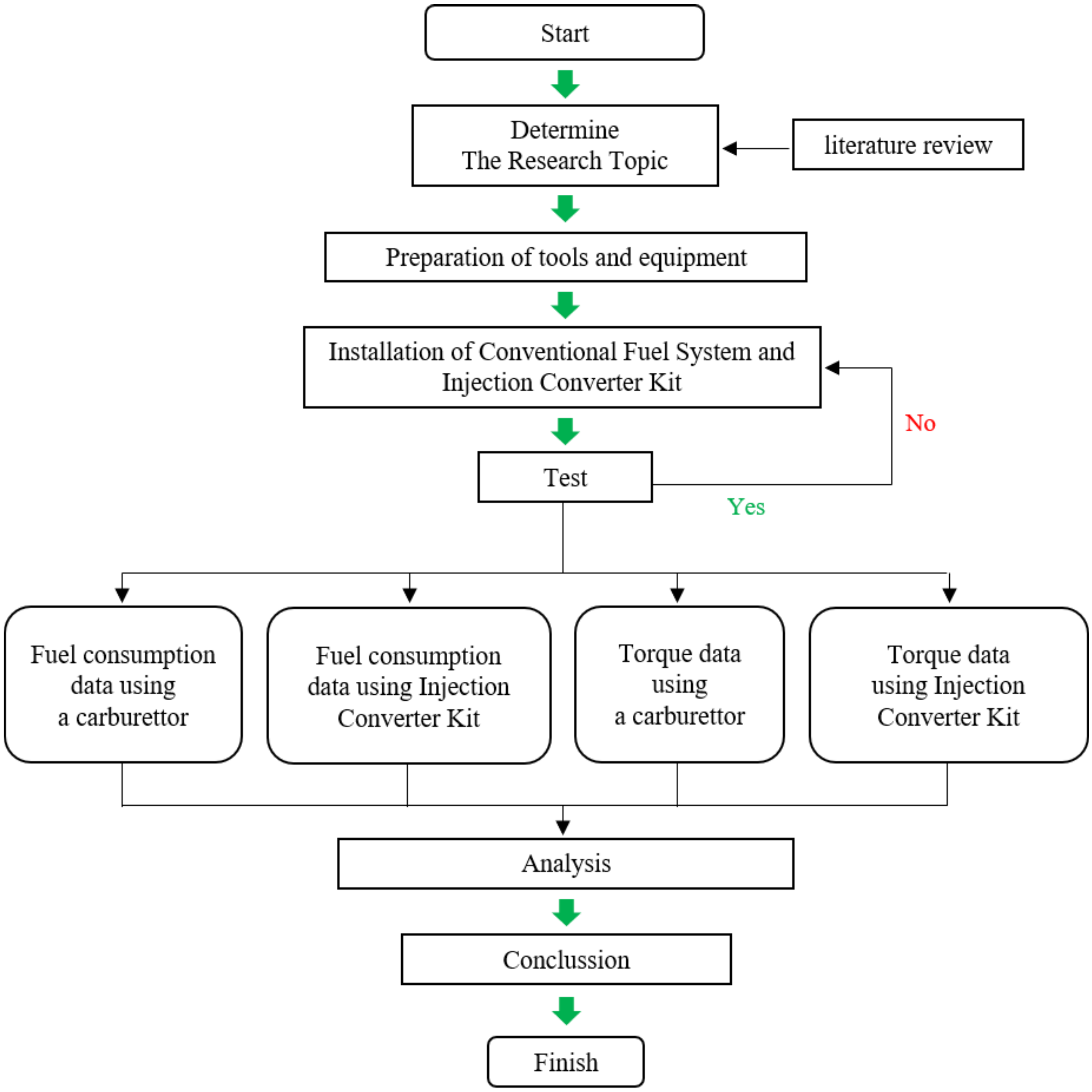

Figure 2. Research Process and Framework

The experimental setup involved a motorcycle engine that is commonly used in small-displacement commuter vehicles. The engine was tested under two separate configurations: one using the stock carburetor and the other using an injection converter kit. Each setup was tested using a dynamometer (BRT Super Dyno 50 LA) to measure engine torque, and a burette system to quantify fuel consumption. Tests were conducted at five RPM levels: 3000, 4000, 5000, 6000, and 7000, with each trial repeated three times for statistical robustness.

The engine specifications are shown in Table 1. With its 97-cc single-cylinder configuration, the engine represents a typical real-world application for users who may benefit from affordable fuel system upgrades.

Table 1. Engine Specifications

Parameter	Specification
Engine Type	4-Stroke, SOHC, 2 Valves, Air-Cooled
Bore × Stroke	50 mm × 49.5 mm
Displacement	97 cc
Cylinder Configuration	Single Cylinder
Compression Ratio	8.8 : 1
Fuel System	Carburetor
Transmission Type	4-Speed (N-1-2-3-4-N)

In order to guarantee the precision of measurements, a burette was affixed to the fuel line for the purpose of quantifying consumption volume. The carburetor system was installed at the inlet of the carburetor, whereas the converter kit system was connected to the inlet of the external fuel pump. Both configurations facilitated precise real-time observation of fuel flow.

Figure 3 presents the comprehensive experimental setup, detailing the testing configuration and the flow of components involved in the study. The identified components consist of (1) combustion engine, (2) intake manifold, (3) burette, (4) carburetor, (5) throttle body, and (6) external fuel pump. This configuration enabled effective transitions between fuel systems without modifying engine components, thereby maintaining uniform testing conditions.

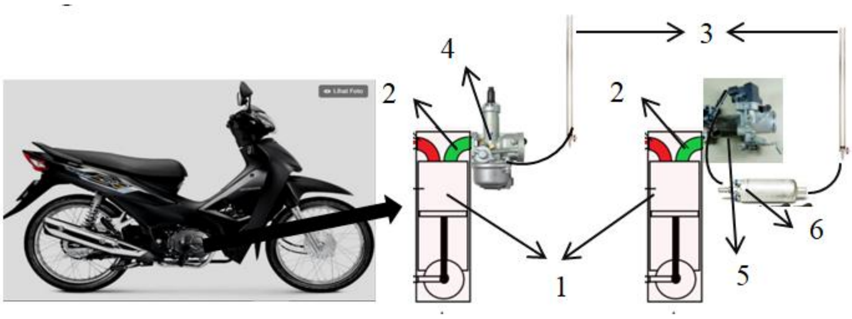

Figure 3. Experimental Setup

Subsequent to the data collection process, torque and fuel consumption values were systematically tabulated, averaged, and subsequently transformed into graphical representations to facilitate the visualization of comparative performance. The statistical analysis was conducted utilizing Two-Way ANOVA via Minitab 21 to assess the significance of differences between the systems and their interactions with engine RPM. This method established a robust quantitative foundation for assessing the efficacy of the injection converter kit in improving performance and efficiency.

RESULT AND DISCUSSION

The experimental results presented in this study compare the performance of two fuel systems—standard carburetor and injection converter kit—on a 100cc four-stroke engine. The evaluation focused on two main parameters: torque output and fuel consumption, tested across a range of engine speeds (RPM). Each test was conducted in three repeated trials to ensure consistency, with the results averaged for analysis.

The torque test results are shown in Table 2. At nearly all RPM levels, the injection converter kit produced higher torque than the carburetor system. The most significant improvements were observed at 4000 and 5000 rpm.

Table 2. Torque Test Results (N·m)

RPM	Torque (N.m)							
	Carburetor Trial				Converter Kit Trial			
	Trial 1	Trial 2	Trial 3	Average	Trial 1	Trial 2	Trial 3	Average
3000	3.30	3.30	3.30	3.30	3.50	3.60	3.70	3.60
4000	4.40	4.60	4.90	4.63	6.70	6.60	6.60	6.63
5000	5.70	6.10	6.10	5.97	6.30	6.20	6.30	6.27
6000	5.60	5.60	5.65	5.62	5.45	5.50	5.50	5.48
7000	4.70	4.90	4.90	4.83	5.45	5.00	4.95	5.13

The findings indicate a persistent pattern of enhanced torque performance attributable to the injection system. The converter kit demonstrated an average torque of 6.63 N·m at 4000 rpm, in contrast to the 4.63 N·m produced by the carburetor, resulting in an increase exceeding 43%. Furthermore, the dynamometer measurements obtained from the BRT Super Dyno 50 LA indicated a peak torque of 6.78 N·m at 3600 rpm for the injection system, surpassing the carburetor's maximum torque of 5.90 N·m at 5300 rpm. The results suggest that the converter kit enhances power delivery, especially within the mid-range RPMs, presumably attributable to more accurate and consistent fuel atomization.

On the other hand, fuel efficiency results are summarized in Table 3, showing the volume of fuel consumed at different RPMs for both systems. The injection converter kit generally demonstrated lower consumption—except at 6000 rpm.

Table 3. Fuel Consumption Test Results (mL)

RPM	Fuel Consumption (mL)							
	Carburetor Trial				Converter Kit Trial			
	Trial 1	Trial 2	Trial 3	Average	Trial 1	Trial 2	Trial 3	Average
3000	8.4	7.0	8.0	7.8	5.8	5.9	6.0	5.9
4000	10.2	9.0	10.0	9.7	8.0	8.2	7.8	8.0
5000	12.5	11.0	11.5	11.7	8.9	9.0	9.3	9.1
6000	12.0	13.2	12.0	12.4	15.1	15.1	15.6	15.3
7000	16.0	15.6	16.8	16.1	11.4	11.6	12.0	11.7

Based on Table 3, it can be seen that within the range of 3000 to 5000 rpm, the injection system demonstrated a substantial reduction in fuel consumption. At an engine speed of 5000 rpm, the average fuel consumption decreased from 11.7 mL with the carburetor to 9.1 mL with the converter kit, indicating a reduction of approximately 22%. Comparable efficiency was noted at 3000 rpm (5.9 mL compared to 7.8 mL) and at 4000 rpm (8.0 mL in contrast to 9.7 mL). At an engine speed of 6000 rpm, the injection system demonstrated a significant rise in fuel consumption, measuring 15.3 mL, which surpassed the carburetor's consumption of 12.4 mL. The observed anomaly can be ascribed to a potential overpressure condition within the fuel pump, which is likely a result of electrical overcharging or a miscalibration of the sensor during periods of elevated engine load.

Furthermore, Figure 4 presents the interaction plot illustrating the relationship between engine speed (RPM) and torque output for two different fuel delivery systems: a conventional carburetor and an injection converter kit. The graph is designed to examine the interaction effect between the independent variable (fuel delivery system) and the controlled variable (RPM) on the dependent variable (engine torque).

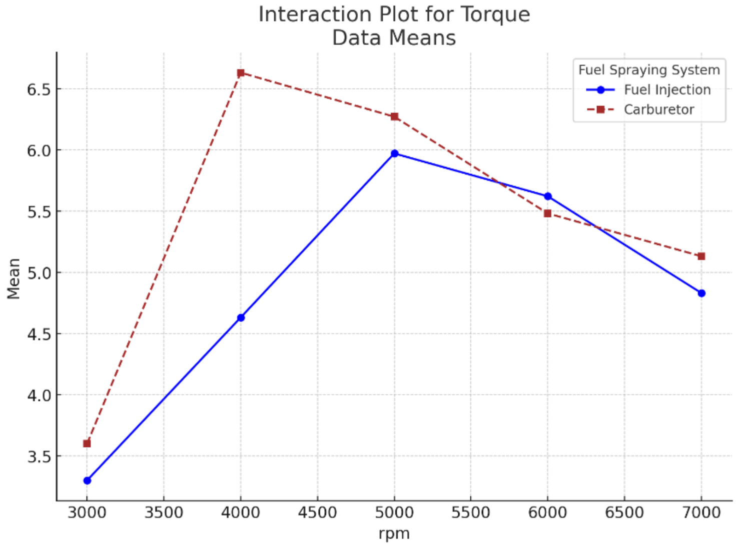

Figure 4. Interaction Plot between Fuel Delivery System and RPM on Torque Output

Two distinct lines represent the systems: the blue line corresponds to the carburetor-based system, while the orange line represents the injection converter kit. The horizontal axis indicates variations in engine speed, while the vertical axis represents the average torque output in Newton-meters (N·m). The blue line shows that the carburetor system achieved torque values of 3.30 N·m at 3000 rpm, increasing to a peak of 5.97 N·m at 5000 rpm before gradually declining to 4.83 N·m at 7000 rpm. In contrast, the injection system (orange line) shows a sharper increase, peaking earlier at 6.63 N·m at 4000 rpm, followed by a decline to 5.13 N·m at 7000 rpm. These results indicate that the injection converter kit delivers a higher and earlier peak torque compared to the carburetor, suggesting improved combustion efficiency and throttle responsiveness at mid-range RPMs.

On the other hand, Figure 5 illustrates the interaction effect between engine speed (RPM) and fuel consumption for the same two fuel delivery systems. As with the previous figure, the horizontal axis represents engine speed (RPM), while the vertical axis indicates the average volume of fuel consumed (in milliliters).

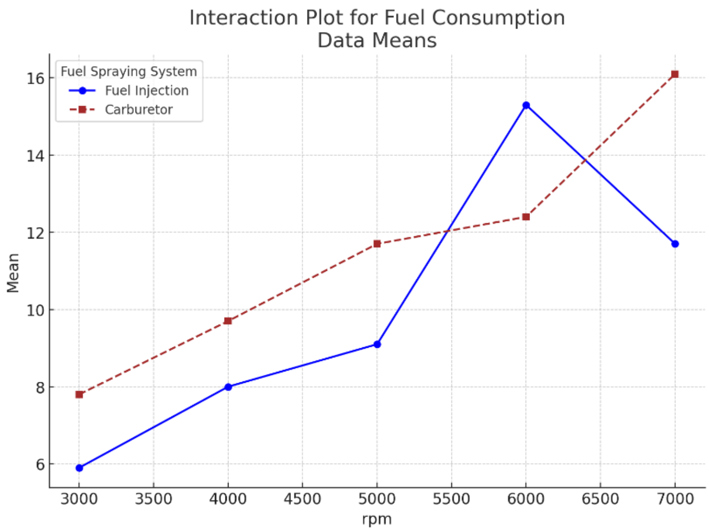

Figure 5. Interaction Plot between Fuel Delivery System and RPM on Fuel Consumption

The blue line highlights the standard carburetor system, illustrating a progressive an increase in fuel consumption, starting at 7.8 mL at 3000 rpm and resulting at a maximum of 16.1 mL at 7000 rpm. The injection system, depicted in orange, exhibits a consistently reduced fuel consumption across all RPM levels, with the exception of 6000 rpm. The converter kit documented fuel consumption levels of 5.9 mL at an engine speed of 3000 rpm, 8.0 mL at 4000 rpm, 9.1 mL at 5000 rpm, and 11.7 mL at 7000 rpm. Nonetheless, a significant increase was observed at 6000 rpm, where consumption rose to 15.3 mL, exceeding the carburetor's performance at that juncture. This anomaly is presumably attributable to fuel overpressure resulting from excessive electrical charging within the vehicle's system, which impacts the regulation of the external fuel pump. At rotational speeds of 3000, 4000, 5000, and 7000 rpm, the injection system demonstrated a consistent superiority over the carburetor regarding fuel efficiency, thereby underscoring its viability as a more economical and effective option for fuel delivery.

Discussion

This study aimed to investigate the influence of two different fuel delivery systems—standard carburetor and injection converter kit—on the performance of a 100cc four-stroke engine, specifically focusing on torque output and fuel consumption. The independent variables consisted of the fuel systems used, while the dependent variables were torque and fuel consumption across five engine speed levels. Statistical analysis confirmed that the interaction between fuel system type and engine speed had a significant impact on both performance metrics, with p-values lower than the established alpha level ($\alpha = 0.05$), thus rejecting the null hypothesis and supporting the research hypothesis.

The torque results showed that the injection converter kit consistently outperformed the carburetor system, particularly in the low to mid-range RPMs. The converter kit achieved its peak torque of 6.63 N·m at 4000 rpm, while the carburetor reached a lower peak of 5.97 N·m at 5000 rpm. This earlier peak torque observed in the injection system indicates that it enabled more efficient combustion and improved engine responsiveness at lower speeds. These advantages are likely due to the more accurate and responsive fuel metering enabled by the converter kit, which allows the engine to produce higher torque with less delay. This observation aligns with the theoretical expectation that EFI-like systems provide better atomization and combustion control compared to mechanical carburetors. Furthermore, the torque curves suggest that while both systems experienced a decline in torque at higher RPMs (6000–7000), the injection system maintained a higher average torque than the carburetor throughout the test range. The ability to deliver torque consistently across a broader RPM band implies better drivability and performance flexibility, making the injection kit particularly valuable for urban and stop-and-go traffic conditions.

In terms of fuel consumption, the injection converter kit exhibited lower fuel usage than the carburetor at four out of five RPM levels, with improvements ranging from modest to significant. For instance, at 5000 rpm, the injection system consumed an average of 9.1 mL, compared to 11.7 mL with the carburetor—indicating a fuel saving of approximately 22%. Similar savings were observed at 3000 rpm (5.9 mL vs. 7.8 mL) and 4000 rpm (8.0 mL vs. 9.7 mL).

However, the test revealed an anomalous spike at 6000 rpm, where the injection system's consumption rose to 15.3 mL, exceeding that of the carburetor (12.4 mL). This deviation is likely attributed to fuel overpressure in the external pump, potentially caused by overcharging or a feedback imbalance within the electrical or sensor system. This suggests that while the injection kit improves efficiency overall, its performance may be sensitive to high-RPM operating conditions unless further calibration is applied. Notably, fuel consumption for the carburetor followed a linear upward trend, directly proportional to the increase in RPM—suggesting inefficient fuel control under load. Meanwhile, the injection kit displayed a more regulated and efficient profile, with consumption peaking only under the aforementioned irregular condition at 6000 rpm, then correcting itself at 7000 rpm.

The results obtained from the torque and fuel consumption assessments indicate that the injection converter kit constitutes a notable enhancement in both performance and efficiency for small-displacement motorcycle engines. The capacity to produce increased torque at reduced RPMs indicates an enhancement in throttle response and the effective utilization of engine power. Concurrently, the prevailing trend of reduced fuel consumption reinforces its contribution to improved fuel efficiency—an indispensable characteristic for cost-sensitive and high-usage contexts. The findings presented herein possess significant implications for both practical applications and academic discourse. The implementation of injection converter kits has the potential to enhance the functionality and performance of older motorcycles that continue to utilize carburetor systems, especially in regions where the complete integration of electronic fuel injection is financially unfeasible. The data provides substantial support for the continued advancement of hybrid or modular fuel management systems that integrate the straightforwardness of carburetors with the regulatory advantages offered by EFI systems. The findings underscore the necessity for additional refinement in the designs of converter kits, especially with regard to the regulation of fuel pressure and the provision of sensor feedback under elevated engine loads.

CONCLUSION AND RECOMENDATION

Conclusion

In considering the experimental findings and analysis conducted in this study, it is concluded that the implementation of an injection converter kit markedly enhances the torque performance of a 100cc four-stroke engine. The system demonstrated a maximum torque output of 6.78 N·m at an engine speed of 3600 rpm, exceeding the 5.90 N·m produced by the traditional carburetor at 5300 rpm. The observed increase in torque output indicates the efficacy of the converter kit in not only restoring but potentially augmenting engine performance, particularly within the mid-range speed spectrum. The injection system demonstrated superior fuel efficiency compared to the carburetor at various RPM levels, thereby substantiating its effectiveness in minimizing operational fuel expenses. With the exception of a singular anomaly observed at 6000 rpm, which can be attributed to a transient overpressure condition in the fuel pump, the converter kit exhibited a consistent and efficient fuel delivery profile. The converter kit has demonstrated its effectiveness as a retrofit solution, providing measurable advantages in terms of power output and fuel efficiency.

Recommendation

It is advisable to pursue additional optimization of the injection converter kit for future research and product enhancement. The kit presently seems to inject fuel twice during each engine cycle, perhaps leading to inefficiencies or unexpected fuel delivery traits. Enhancing the synchronization of input signals—especially from sensors like the throttle position sensor and crankshaft pulser—could improve control precision. This study also assessed fuel use with a rudimentary burette measurement technique, which just yields volumetric fuel usage. Future research should incorporate the measurement of Specific Fuel Consumption (SFC) to more accurately evaluate the correlation between fuel input and engine output power, hence enhancing understanding of the system's fuel efficiency. This would offer a more thorough assessment of the converter kit's efficacy under diverse load levels and enhance its prospects for broader commercial utilization.

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