Design and Development of a Motorcycle Injector Cleaning Tool Using the Reverse Engineering Method to Improve Mechanical Performance

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Abstract. With the rapid advancement of technology, carburetor systems in motorcycles have been replaced by Electronic Fuel Injection (EFI) systems, which automatically regulate fuel delivery via an Electronic Control Unit (ECU). However, poor fuel quality often leads to injector clogging and increased carbon deposits in the combustion chamber, reducing engine performance. To address this, an injector cleaning device was developed using the reverse engineering method to restore injector functionality and improve combustion efficiency. Based on observations at several motorcycle workshops, including the Automotive Laboratory, it was found that injectors clogged with deposits are often difficult to clean using conventional methods. As a result, there is a tendency to replace them with new injectors, leading to higher maintenance and repair costs. With the custom-designed cleaning tool, the cleaning process for dirty injectors can be carried out effectively, achieving a significant result: 99.5% functionality, comparable to a new standard injector. This is expected to reduce maintenance and repair costs, thereby improving the mechanical performance of motorcycle workshops.

Keywords: Fuel-injected Motorcycles, Injector Cleaner, Mechanical Performance Improvement, Reverse Engineering

1 Introduction

Motorcycles traditionally use gasoline as fuel with a carburetor system that functions to mix fuel and air. In this era of globalization, the number of motorcycle users continues to increase, leading to a growing demand for fuel. To address these challenges, fuel injection systems have been developed to replace carburetors and improve fuel efficiency. Henkel et al. (2017) noted that fuel injection systems offer superior atomization and more precise fuel delivery, which significantly reduces emissions and improves overall engine performance.

Currently, carburetors are gradually being phased out and replaced by injection technology. This system works by automatically supplying fuel under the control of the ECU (Electronic Control Unit). However, with prolonged use and poor fuel quality,

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there is a high risk of injector clogging and excessive combustion residue forming on the combustion chamber walls. Jiang et al. (2019) reported that injector fouling alters spray characteristics, increasing droplet size and penetration length, which leads to higher particulate and unburnt hydrocarbon emissions. When such issues occur, cleaning becomes necessary, as failure to clean the injectors can lead to suboptimal engine performance.

Based on observations in several motorcycle repair shops, many damaged injectors are difficult to clean manually, and mechanics often tend to replace them with new ones right away. Reverse engineering approaches have proven effective in analyzing existing tools and developing more efficient, user-friendly designs for automotive maintenance (Freibergeret et al., 2011). Therefore, it is considered very important to design and build an injector cleaning infusion tool that can effectively clean injectors in fuel-injected motorcycles. Ideally, this cleaning process should be carried out every 3,000 km (Nurhadi & Ilhami, 2023).

The proposed injector cleaning tool is a specialized service tool designed to clean injectors, throttle bodies, and combustion chambers simultaneously. Reverse engineering workflows, such as those used to digitize and modify automotive components with 3D scanning and CAD modeling, have shown great potential in accelerating prototype development and improving accuracy (Stefan & Janette, 2022). According to the training module provided by PT Yamaha Indonesia Motor Manufacturing (2021), such tools are crucial for enhancing the workshop's operational efficiency. Traditional methods of cleaning involved manual cleaning of each component, a time-consuming and inefficient process. By automating this process, the new tool can significantly enhance the efficiency and performance of mechanics in the field, saving time and reducing labor costs. Furthermore, this tool could be integrated into automotive laboratories as a Special Service Tool (SST) during practical training sessions for students, as supported by findings that educational modules using diagnostic tools improve vocational students' competence in fuel injection system maintenance (Putra et al., 2020).

To ensure the tool's design is both practical and effective, the reverse engineering method has been employed. Reverse engineering involves analyzing existing injector cleaning tools to understand their working principles, components, and manufacturing processes. This analysis provides valuable insights that can be used to refine or improve the tool's design (Wibowo & Nugroho, 2019). By adopting this method, the development of a more efficient and user-friendly injector cleaning tool becomes possible, ultimately enhancing the performance and efficiency of motorcycle repair mechanics.

2 Methodology

The proposed research combines multiple methods, including design and experimental testing of a prototype tool for an injector cleaning infusion system on fuel-injected motorcycles. In this study, an installation system for spraying liquid injection cleaner will be designed under the assumption that a compressor unit is already installed in several motorcycle workshops or in the Automotive Laboratory where the research is conducted. The design of the injector cleaning assistive device is shown in Figure 1.

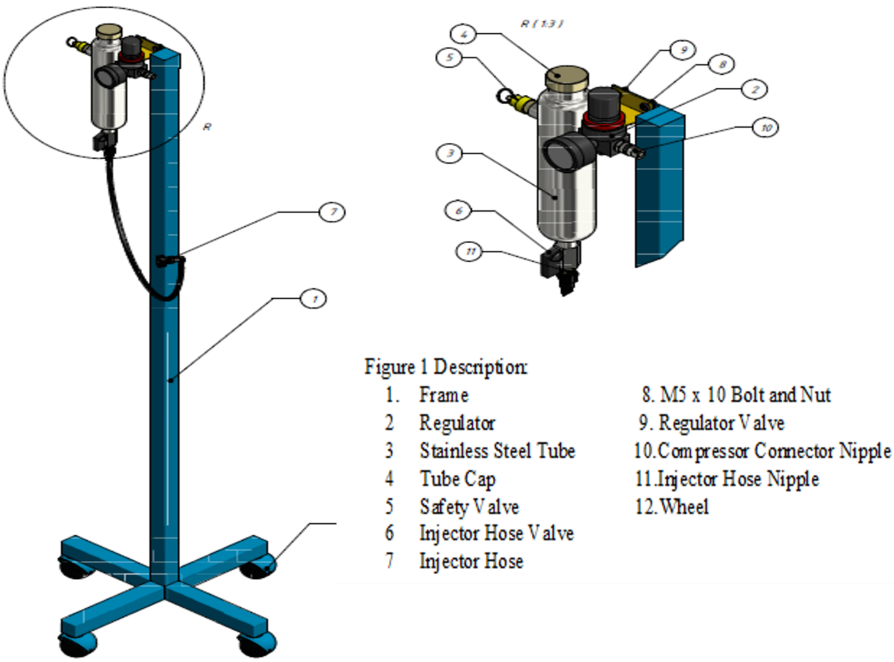


Figure 1. Design of the Injector Cleaning Assist Tool

Compressed air from the compressor pressurizes the injector cleaning fluid contained in the stainless steel tube through the compressor connector nipple, causing the fluid to flow under pressure through the injector hose and into the injector, allowing the injector to be cleaned. After passing through the injector, the fluid continues to flow directly into the throttle body and then into the combustion chamber, thereby cleaning carbon deposits in both the throttle body and the combustion chamber (Negara, 2020). This injector cleaning tool is designed for fuel-injected motorcycles with a single cylinder or single injector, and an engine capacity of 110–125 cc. It is compatible with all brands of fuel-injected motorcycles. As samples, three fuel-injected motorcycle models were taken: Scoopy, Beat, and X-Ride, and the injector hose socket must be adjusted to match the type or shape of the installed injector nipple.

3 Result and Discussion

3.1 Result

In this study, the notable achievement is the successful development of an injector cleaning tool, also referred to as a Special Service Tool. The injector cleaning tool is pneumatic-based, utilizing compressed air from a compressor to pressurize the injector cleaner fluid, which also functions as a fuel during the combustion process in the engine's combustion chamber. The design and development process of this pneumatic pressure-based injector cleaning tool began with design planning and material procurement.

The frame and tool components are constructed using materials such as 30 × 30 × 30 mm hollow iron, a set of 2-inch rubber wheels (4 pcs), a stainless steel tube because stainless steel material is more resistant to the corrosive properties of liquids injector cleaner or other substances with a height of 236.5 mm and a diameter of 51 mm, a BR 3000-TAC compressor pressure regulator valve, a ¼" pressure safety valve, a ¼" ball valve (air stop valve), 6 mm x 6 mm brass injector hose nipple, 6 mm injector connector nipple, double external-threaded nipple M1/4 x M1/4, and 600 mm long injector hoses compatible with Honda and Yamaha models. It also includes M10 × 30 mm bolts and nuts. The compressor unit itself is not included in the material list, as it was already installed at the test location. The final built design of the tool is shown in Figure 2.

Figure 2. Photo of the Developed Injector Cleaning Tool

The following Tables 1, 2, and 3 show the comparative data results of the time required for the combustion process of the same amount of fuel, namely 25 ml, for three types of motorcycles. This is based on five repeated tests conducted on dirty injectors after undergoing a cleaning process using both the prototype cleaning device and the conventional method, including tests using a new injector as the reference standard.

Table 1. Test Result Data

Motorcycle Type	New or Standard Injector (seconds)	Conventional Method (seconds)	Using Prototype Device (seconds)
Scoopy	186.9	311.3	187.2
	187	311.7	187.4
	187	312	187.5
	186	312	187
	186.5	311	187.5
Average	186.7	311.6	187.3

Table 2. Test Result Data

Motorcycle Type	New or Standard Injector (seconds)	Conventional Method (seconds)	Using Prototype Device (seconds)
Beat	183.2	328	184
	183.5	328.3	184.3
	183.5	328.5	184.5
	183	328.7	184.5
	182.7	329	185
Average	183.2	328.5	184.5

Table 3. Test Result Data

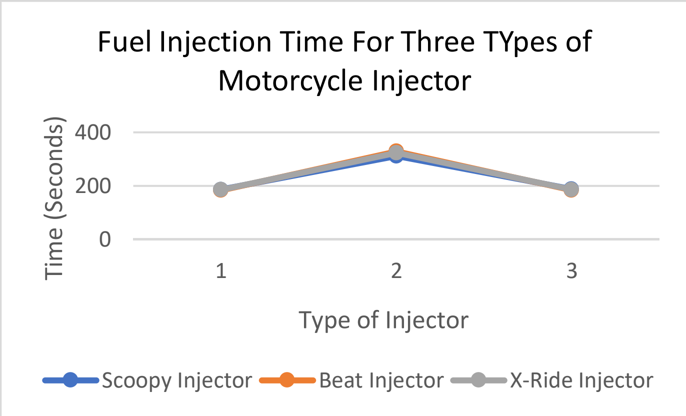
Motorcycle Type	New or Standard Injector (seconds)	Conventional Method (seconds)	Using Prototype Device (seconds)
X-Ride	185	323	186
	185.3	323.4	186.4
	185.5	323.9	185.7
	185	323.7	185.5
	184.7	324	186
Average	185.1	323.6	185.9

3.2 Discussion

The comparison of the average time required for burning the same amount of fuel, which is 25 ml, for the three types of fuel-injected motorcycles can be presented as shown in Table 4 below. Based on Table 4 and Figure 3, the average time required for the injectors of the three types of motorcycles, after being cleaned using conventional methods and capable of spraying the same amount of fuel (25 ml), is 321.2 seconds. This indicates that the injector is only functioning at 57.6% compared to a new injector. As a result, the engine is still unable to operate normally—in other words, engine performance remains unstable at idle, medium, and high speeds. This means the injector is no longer fit for use and must be replaced with a new one.

Table 4. Comparison of Average Test Result Data

No.	Motorcycle Type	New or Standard Injector (seconds)	Conventional Method (seconds)	Using Prototype Device (seconds)
1	Scoopy	186.7	311.6	187.3
2	Beat	183.2	328.5	184.5
3	X-Ride	185.1	323.6	185.9
	Average	185	321.2	185.9



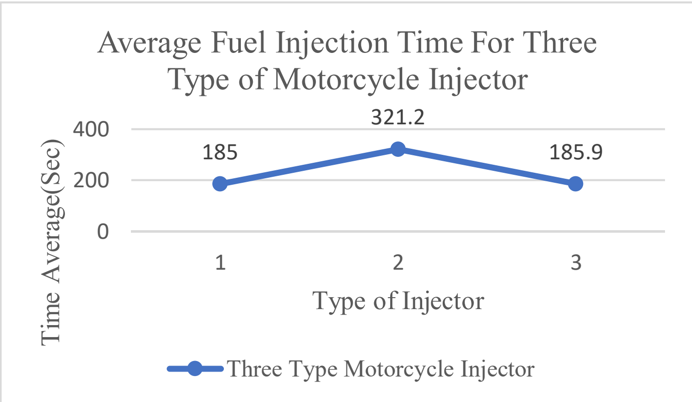


Figure 3. The Relationship Between the Average Time Required by the Injector to Spray Fuel and Each Type of Motorcycle

On the other hand, dirty injectors that were cleaned using the custom-designed cleaning tool were able to inject the same amount of fuel (25 ml) in an average time of 185.9 seconds. This shows that the injector can function at 99.5% efficiency, which is almost equivalent to the performance of a new injector. The improvement in injector function, nearly matching that of a new injector, as a result of the cleaning process using the custom-designed tool, is attributed to advancements in the tool's design and functionality. This innovation helps reduce maintenance and repair costs while also enhancing the mechanical performance of motorcycle workshops.

4 Conclusion

Based on the test results, the prototype of the motorcycle injector cleaning tool developed using the reverse engineering method proved to be effective. The average time required for the injector to spray fuel after being cleaned using the custom-designed tool was 185.9 seconds, showing a significant result of 99.5% efficiency compared to the standard average time of a new injector, which is 185 seconds. In contrast, injectors cleaned using conventional methods required an average of 321.2 seconds, indicating that the injector could only function at 57.6% compared to a new injector. This means that the injector is no longer suitable for use and should be replaced with a new one.

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