The Impacts of Water Injection Application on the Performance of Internal Combustion Engines

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Abstract. As the temperature of the air entering the combustion chamber rises, consequently the combustion temperature, resulting in complete combustion of air and fuel in the combustion chamber and a decrease in the performance of the internal combustion engine. It also influences increasing emissions while decreasing engine power and torque. The objective of this study is to describe the impact of water injection on the achievement of internal combustion engines. The torque, power, and specifies fuel consumption engine reveal the performance. Water injection was used to implement his research on various types of fuel, including RON 90, 92, and E10. According to the findings of his research, engine with water injection applications did not increase engine power (-1.74%), but there was an increase in torque of 1.30% on RON 90 and RON 92 fuel, an increase of 2.38%. Furthermore, the SFC of RON 92 fuel increased by 11.9%.

Keywords: water injection, combustion, engines

1 Introduction

The number of harmful substances contained in exhaust emissions is proportional to the number of vehicles that use fossil fuels. As a result, the number of motorized vehicles is increasing, causing gaseous hydrocarbons (HC) and nitrogen oxides (NOx) to agglomerate in the air, causing eye irritation and cancer. In general, exhaust emissions have a significant impact on health, causing symptoms such as throat itching, coughing, hypertension, and others. One of the reasons for the high levels of harmful substances in vehicle exhaust emissions is that many motorized vehicles still use conventional or carburetor fuel systems, where the level of ignition in the carburetor system is still imperfect, resulting in incomplete combustion in the combustion chamber and exhaust emissions containing reducing of CO_2 and increasing HC [1].

According to the findings of a study [2] titled exhaust gas analysis of engines with EFI technology using premium fuel, the carburetor has a CO content of 3.6% and an HC content of 545 ppm, whereas the EFI system has a CO content of 3.04% and an HC content of 63 ppm, implying that the use of a carburetor system has higher exhaust emissions. Then the results of research [3] with the title of study of engine performance

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analysis of the EFI combustion system and carburetor on gasoline engines, with the results of research for the same engine speed of 3500 rpm, the power produced by the EFI engine is 44.179 KW, while the power produced by the carburetor engine is 43.154 KW, with the conclusion that the power produced by carburetor engines is smaller than that of EFI engines.

Heat is one of the most common problems in motorcycle engines, and it is caused by the combustion process as well as heat generated by moving engine components such as piston motion, crankshaft, and bearings. To address the issue, the researchers installed water injection on injection-modified motorcycles. Water injection works by atomizing water and lowering the high temperature of the combustion chamber, thereby slowing down fuel combustion. A standard motor is tested against a motor that uses water injection. The addition of this water injection device necessitates an evaluation of the effects it has, both on the intake manifold and on the carburetor inlet. Water injection, which claims to increase torque, save fuel, and reduce toxins in exhaust emissions, will undoubtedly affect changes in the mass ratio of fuel to air, or Air Fuel Ratio (AFR), and levels of exhaust emissions produced by the combustion process [4]. Water injection works by injecting water mist into the engine to mix with the fuel and air. The water mist cools the air and fuel mixture, lowering the high temperature of the combustion chamber and thus slowing the burning of the fuel. This is comparable to using high-octane fuel. With water injection, the ignition timing can be advanced without causing knocking, and the engine's power output increases. At the hot temperature of the combustion chamber, fine water droplets should split into steam, generating extra power for the engine. The real benefit of using water injection is that it reduces fuel consumption while increasing torque and power due to a more efficient combustion process. Furthermore, because the combustion is more efficient, motorized vehicle exhaust emissions will be reduced.

Water injection (Wa-i) is defined as the injection of water into the engine combustion chamber by [4]. Furthermore, as explained [5], water injection is a system of adding water in the form of granules to the combustion chamber through the intake manifold. This viewpoint leads to the conclusion that water injection is a system that injects water in the form of granules into the combustion chamber via the intake manifold. Water has a very high evaporation rate, which means that it takes approximately 540 calories per gram to convert water into steam, as opposed to ordinary fuel, which only requires 135 calories to evaporate it. This explains why water is superior to providing more fuel oil for lowering the temperature in the intake manifold, allowing the engine's ignition timing to be advanced and the engine's power to be increased without symptoms of knocking (tingling) or the engine becoming too hot. At the hot temperature of the combustion chamber, fine water droplets split into steam, which breaks down into hydrogen and oxygen, generating additional power for the engine. The water discharge injected into the machine is extremely small, measured in units of water droplets. Water droplets will split into water vapor when it enters the high-temperature combustion chamber, so it is not in the form of whole water. Water injection, in other words, does not cause water hammer. Water hammer is a condition in which a large amount of water enters the cylinder, causing damage to the piston and cylinder. [6] Mentioned that the idea of using water to process engines had existed for a long time; in 1940, a mixture of water

and methanol was used in the Messerschmitt Bf109G-10 air fighter and this system increased engine power from 1,700 to 2,400 hp; and in 1983, Renault in F1 development was the first engine to use water injection in a racing engine to cool the compressed air, preventing engine knocking. Wa-i is not a new technique, but it was used on fighter aircraft during World War II to increase engine power during attacks.

2 Method

This study employs the experimental research method. Whereas the research starts with designing and manufacturing the equipment to be studied, testing is done with a dyno test using various treatments, such as standard testing and testing by injecting water into the combustion chamber. This measurement is used to determine how much influence it has on a motorcycle's power, torque, and SFC. The purpose of this study is to compare the effects of installing water injection on power, torque, and SFC on injection modified 4-stroke motorcycles. The test vehicle has a 4 stroke SOHC engine, a compression ratio of 9.3:1, a diameter x stroke of 50 x 57.9 mm, a maximum power of 6 KW/7,500 rpm, and a maximum torque of 8.3 Nm/4,500 rpm. While Fig. 1 depicts the research procedure. Fig. 2 depicts the schematic for water injection.

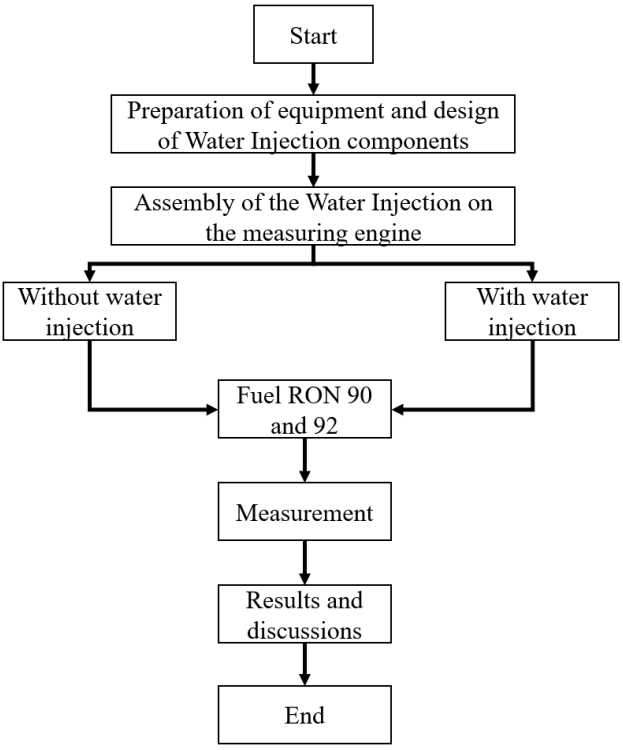

Fig. 1. Experimental procedures

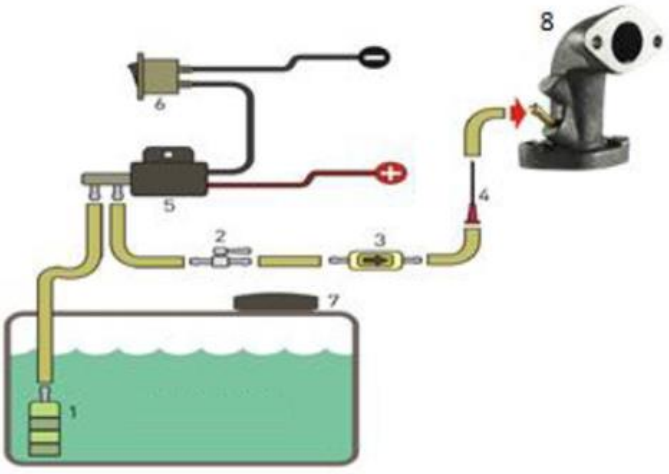

Fig. 2. Schematic of water injection implementation, 1) water filter, 2) one way valve, 3) one way filter, 4) orifice, 5) vacuum solenoid, 6) on/off switch, 7) water tank, 8) intake manifold

3 Result and Discussion

Table 1 displays the data from the power and torque tests performed on the test vehicle without the use of water injection and RON90 fuel. The results of the power test using RON 90 at a maximum rotation of 7100 RPM with three tests obtained an average power of 5.25 Kw and the torque test using RON 90 at a maximum rotation of 5863 RPM with three tests obtained an average torque of 7.32 Nm. Whereas for testing with RON 92 torque without water injection, data obtained from testing results for power at a maximum rotation of 7200 RPM with three times of testing yielded an average power of 5.11 KW and torque testing at a maximum rotation of 5890 RPM yielded an average torque of 7.75 N.m. The data obtained from the SFC test results using RON 90 fuel at 4000 RPM rotation with a result of 249 g/kWh is then followed by a 5000 RPM round with a result of 225 g/kWh, a 6000 RPM round with a result of 218 g/kWh, and the 7000 spin gives a yield of 228 g/kWh, and the 8000 RPM spin gives a yield of 262 g/kWh. While using RON 92 fuel, at 4000 RPM, the result is 619 g/kWh, followed by a 5000 RPM round with a result of 219 g/kWh, followed by a 6000 RPM round with a result of 209 g/kWh at 7000 rounds, giving a result of 295 g/kWh at 8000 rpm. The discussion and Table 1 show that the use of water injection influences the power and torque generated by the test vehicle. The difference in the results before and after using water injection can be seen in the power test; before using RON90 fuel water injection, the maximum power produced is 5.25 KW, while the power after using water injection is 5.16 KW, and on RON92 fuel before using water injection, the maximum power produced is 5.11 KW, while the power after using water injection is 5.11 KW. When the maximum torque of the RON 90 fuel is tested before implementation of water injection, the resulting torque is 6.66 Nm while the torque increases to 7.66 Nm after applied water injection. The torque obtained in the RON 92 fuel torque test before using

water injection is 7.75 Nm, while the torque obtained after using water injection is 7.56 Nm.

Table 1. Experimental results

Engine speeds (rpm)	RON 90 Power (KW)	RON 90 Torque (Nm)	RON 90 SFC (g/kWh)	RON 92 Power (KW)	RON 92 Torque (Nm)	RON 92 SFC (g/KWh)
Without Water Injection						
4000	2.71	7.89	249	1.09	7.8	619
5000	3.75	7.56	225	3.84	7.8	219
6000	4.65	7.54	218	4.87	7.65	209
7000	5.2	7.39	228	5.11	7.75	240
8000	4.51	6.2	262	3.89	6.5	295
With water injection						
4000	2.71	7.89	381	1.8	7.56	374
5000	3.75	7.56	218	3.72	7.6	227
6000	4.65	7.54	248	4.55	7.52	223
7000	5.2	7.39	234	4.84	7.56	245
8000	4.51	6.2	262	3.88	6.3	295

Meanwhile, the use of fuel specifically for water injection is better than it was previously. This demonstrates that the use of water injection, which atomizes water into the cylinder, will be more resistant to temperatures caused by pressure in the combustion chamber, preventing spontaneous or self-ignition before being exposed to sparks and allowing complete combustion to occur so that the gas pressure from the combustion products can maximally suppress the piston, resulting in increased power generation [7]. As a result of SFC being inversely proportional to power, SFC will decrease. Based on the t test statistical data, the calculated t_{test} is 0.735, while the t_{table} is 2.776. This means $t_{table} < t_{count}$. The power data show that there is no significant difference between using water injection and RON 90 fuel. Meanwhile, the statistical data for the t test using RON 92 show that t_{count} of 3.449 and t_{table} of 2.776. It denotes that t arithmetic bigger than t_{table}. The torque data show that there is a significant difference between using water injection and RON 92 fuel.

Even for the same type of motorcycle, each machine has a distinct personality. The engine specifications are the most important factor in determining torque power and SFC, and using standard components is the best option for applying to the vehicle. However, do not rule out the possibility of using water injection as a driver requirement. According to the research results to be obtained, which are to reveal how much influence the use of water injection on the test vehicle has on power, torque, and SFC using a dyno test tool. For this study, testing was done at full speed with three times the power and torque on a variety of fuels. Based on a dyno test comparison of motorcycle power, torque, and SFC, it can be concluded that motorcycles with water injection applications do not increase engine power, engine power decreases by -1.74%, but there is an increase in torque of 1.30% on fuel RON90 fuel, and the use of RON92 fuel increased by 2.38% at lower engine rpm rotation than in standard conditions. Furthermore, the SFC of RON90 fuel increased by 11.9%, and the use of RON92 fuel increased by 18.1%,

decreased and increased torque, power, and SFC, but testing revealed that there was an insignificant increase in power and torque due to changes in the temperature of the combustion chamber caused by spraying water droplets on the intake manifold after the hole injector, because after percentage analysis and the t test showed a significant level did not reach 5 According to research [8] the torque in this study increased due to decreasing SFC, while the power decreased due to the quality of the combustion, resulting in increased torque and decreased power.

The faster the engine spins, the higher the rpm generated, and thus the power generated, as well as the rotating moment of the motor, the greater the number of teeth on the gears, and the greater the torque that occurs [9]. Thus, the number of revolutions per minute (rpm) and the magnitude of the torque or torque affect the motor power output [10]. The useful power in an internal combustion engine is shaft power because the shaft moves the load. In this study, the SFC is decreasing due to the influence of installing water injection on motorcycles with injection system modifications so that fuel is sprayed according to the needs of the engine as detected by the sensor. So that the fuel condensation is more homogeneous and perfect. As seen in the SFC graph, if the fogging of the fuel is more homogeneous and perfect, the combustion that occurs will also be more perfect, enabling fuel savings. The produced exhaust gas will be cleaner, and the levels of harmful substances in exhaust emissions will be lower.

4 Conclusion

Based on the findings of the research, the following conclusions can be drawn:

1. The use of water injection with RON90 fuel produces power results on the test motorcycle with an average power reduction of -1.74% or a decrease of 0.9 Kw from the average power, and there is no change in power produced by engine using water injection with RON92 fuel.
2. The use of water injection with RON90 fuel increased the torque on the tested engine by an average of 1.30% or 1 Nm from the average torque, and a torque decrease of -0, 25% or a torque reduction of 0.19 Nm using RON92 fuel produced by the engine without water injection.
3. The use of water injection against SFC using RON90 fuel on the test motorcycle increased by 11.9%, or 32.2 g/kWh more than the average, while the use of RON92 fuel decreased by -16%, or 43.6 g/kWh less than the average.
4. Based on the data obtained, it can be concluded that using water injection can increase torque when using RON90 fuel but not when using RON92 fuel. The torque increase is 1.30%. While SFC increased by 11.9% or 32.2 g/kWh when RON92 fuel was used, it can be concluded that engine efficiency is inversely proportional, meaning that the lower the specific fuel consumption, the greater the engine efficiency, allowing torque to increase and achieve maximum power at low rpm.

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