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Application And Performance Of Arduino-Based Idle Stop System(ISS) On Carburetor Engine

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***Abstract* – Efforts to conserve fuel oil (BBM) promoted by the Indonesian government and many other countries are motivated by the fact that fossil fuel availability has decreased and environmental pollution continues to worsen. Strategies for utilizing fuel resources include conservation and the development of alternative fuels. Vehicle manufacturers have attempted to develop vehicles with IDSS (idling start-stop system) or SSS (start-stop system) technology, which are claimed to be more fuel-efficient. However, products with these features are only available in newer vehicles equipped with injection systems. To enable its application on conventional engines of which continues to utilize carburetors, an ISS (Idle Stop System) based on comparable IDSS and SSS systems was designed and tested in this study. Speed sensors, crankshaft sensors, and temperature sensors were used as inputs for the Arduino, which serves as the control for engine startup or shutdown. Test results indicate that the ISS (idle stop system) functions effectively, achieving fuel savings of 4.65–7.56% under test conditions on a 28-kilometer test track.**

Keywords: Idle stop, Idling start stop, Start stop, Carburetor Motor, Arduino.

I. Introduction

Fossil fuels are one of the main sources of energy that are essential in various sectors of life, ranging from transportation and industry to power generation. Limited oil reserves and dependence on imported supplies make Indonesia vulnerable to fluctuations in world oil prices [1], which have a direct impact on national economic stability [2]. In addition to affecting economic factors and supply availability, the use of petroleum products also has a significant impact on the environment. The combustion of petroleum products produces carbon dioxide (CO_2) emissions and other harmful gases that contribute to air pollution and global warming [3-5]. The current climate change is largely caused by human activities that are energy-intensive, particularly the use of fossil fuels [6]. Efforts to conserve fuel can be made individually by getting into the habit of using public transportation or through initiatives from vehicle manufacturers that offer IDSS features, such as Honda motorcycles, which claims fuel savings of up to 7% or more depending on road conditions [7]. Yamaha also offers a similar system called SSS, claiming fuel savings of up to 50% [8]. Although a number of academics have tried to create fuel-efficient systems through modeling methods [9] and motorcycle unit testing [10,11], none have tested them on real-world roads.

The fuel savings benefits of the IDSS and SSS features are nonetheless not available to owners of older models of motorcycles or cars that remain equipped with a carburetor fuel delivery system [12] because they are only available on motorcycles that already have fuel injection technology including an Electronic Control Unit (ECU) [13]. This study aims to develop an idle stop system (ISS) adapted from the IDSS system implemented by Honda and the SSS system by Yamaha. IDSS and SSS are practical efforts to support fuel efficiency initiatives, and their implementation is both effective and environmentally friendly [9,10,14,15].

II. Method

The basic idea behind IDSS and SSS is based on the factual condition that when vehicles stop at a red light intersection, most drivers keep their engines running. In such conditions, fuel continues to burn throughout the waiting period until the green light reappears. The fact that fuel continues to burn while the engine is running but the vehicle is not moving is clear evidence of waste. This unnecessary fuel consumption can be prevented by manually turning off the engine or through automatic control using digital systems, as developed in this study

A. Determining the wiring modification

The test unit in this study was a 2009 Honda Beat motorcycle. In terms of electrical specifications, the test vehicle still equipped by a carburetor supply system and therefore no ECU is installed. Figure 1 shows the standard wiring diagram of the vehicle.

The engine can be shut off by disconnecting the positive supply line from the CDI to the battery or by disconnecting the positive output line from the CDI to the spark plug coil. In this study, the method used was to disconnect the line from the CDI to the spark plug coil (indicated by the green line), as this carries a lower risk of affecting the CDI. In the standard wiring, the cable from the CDI is directly connected to the coil. In this study, the standard connection was disconnected (shown at point A) and routed through the relay contact, where the relay activation is controlled by the Arduino controller.

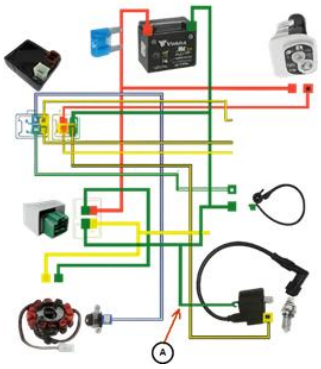

Figure 1. Honda Beat Wiring Diagram

B. Control system design

Figure 2 shows the circuit diagram for ISS control. A speed sensor is used to detect whether the vehicle is moving or stopping. The MAX6675 temperature sensor is used to measure engine temperature. The temperature sensor is important for starting the engine for warming up in the morning when the vehicle has been parked overnight, as well as for shutting off the engine when the motor has been running and the engine temperature becomes hot but the vehicle is not moving (zero speed). The crankshaft sensor is used to detect the engine status, whether the engine is running or off. The signal generated by the crankshaft sensor is a logic 0 and 1, which is read by the Arduino and processed along with signals from the temperature sensor and speed sensor.

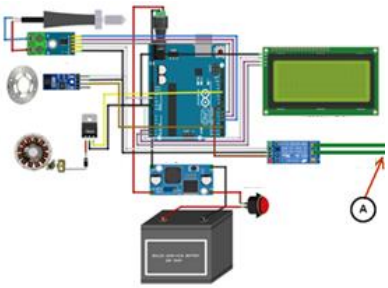

Figure 2. Wiring diagram of the ISS control system

C. Measurement of fuel consumption in stationary conditions

Fuel consumption testing in stationary conditions aims to determine the volume of fuel consumed per unit of time. Measurements are taken while the test unit is still in its standard condition or has not been modified. Measurements are taken by recording the time it takes for each 10 milliliters (and multiples thereof) of fuel to start the engine and allow it to run until it stops on its own. The type of fuel used in this study is Pertalite.

D. Determination of the route

The road route used to test the ISS system was determined by creating a route that represents the daily conditions of motorists. Under normal conditions in urban areas, traffic lights at intersections are common, with vehicles stopping 3 to 4 times at traffic lights during a single trip. The road route in this study is a highway in the city of Pekanbaru. Figure 3 shows the map of the road route used in the motor unit testing; the distance from the starting point to the destination and back to the starting point is estimated to be approximately 28 km based on Google Maps. The field testing was planned with two travel scenarios, as shown in Table 1.

Table 1 Number of stops on each trip

Scenario	Total Number of Traffic Light	Stopping Point
1	5 *traffic light*	1,2,4 – depart 3,1 – return
2	8 *traffic light*	1, 2, 3, 4 – depart 1, 2, 3, 4 - return

Scenario 1 involves a trip with a different number of stopping points between the outbound and return trips. The difference in the number of stopping points is due to the presence of traffic lights with traffic signs allowing left-turning drivers to continue without waiting for the green light from the traffic light. In scenario 2, the test is set up so that when the vehicle is at the traffic light position where it should turn left but can continue driving, the test unit is conditioned to stop as if waiting for the green light at the traffic light to turn on. This is done by stopping the vehicle about 40 meters away from the roadside before the traffic light so as not to disturb other drivers.

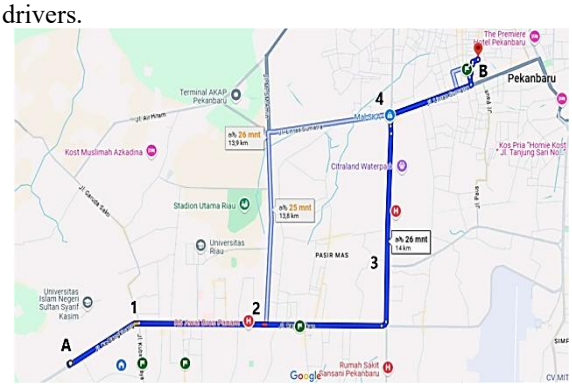

Figure 3. Road test route plan

III. Results and Discussion

A. Fuel consumption testing in stationary conditions

The results of fuel consumption testing in stationary conditions are shown in Figure 4. Fuel was added in increments of 10, 20, and 50 milliliters. Based on the data, a mathematical equation was derived to describe the relationship between volume and engine running time, as shown in equation (1), where y is time(duration) and x is volume.

$$y = 14.14x + 5.8 \quad (1)$$

Based on equation (1), it can be roughly estimated that every 1 milliliter of fuel can power the engine for 19.9 seconds. In real-road conditions, vehicles stop at red lights for between 1 and 2 minutes at each traffic light which equals to 10 mililiter fuel consumption for motorcycle, but the number of stops per trip will also determine the total volume of wasted fuel during waiting time for green light to lit.

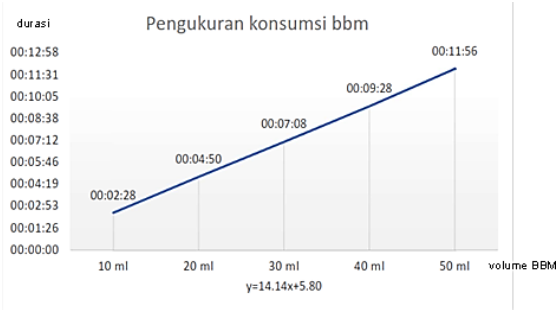

Figure 4. Duration vs volume graphic during idling condition test

B. Red light duration

Table 2 shows the measurements of the duration of red lights at several traffic light points in Pekanbaru City. The measurements were taken from the moment the red light turned on until the green light turned on. If a vehicle passes through the four intersections listed in Table 1, the total duration of the vehicle's stop is approximately 418 seconds, or 6.96 minutes, assuming that the vehicle stops precisely when the red light turns on. The estimated potential fuel savings for a duration of 6.96 minutes is approximately ~30 mL based on the linear regression pattern in Figure 4. The traffic light durations recorded from the measurements in Table 2 are values that are relatively in common with those of traffic lights in Indonesia [16].

Table 2 Traffic light duration in Pekanbaru

Traffic Light Position	Red Light Duration
Simpang Empat Panam	2:15
Simpang Tabek Gadang	1:47
Simpang Tiga Datuk Basilo	1:34
Simpang Empat SKA	1:22

C. Physical circuit

Figure 5 shows the physical circuit of the ISS. The circuit is packaged in a plastic box to prevent the risk of short circuits caused by individual cable strands inside the prototype. Circuit function testing is carried out in two ways, namely offline and online. Offline testing is conducted when the ISS circuit is not yet installed on the motor unit. Offline testing is performed by simulating the sensor with heat stimulation from a lighter and manual fan rotation. Once the circuit functions according to the program, it is then installed on the motor unit and undergoes online testing or direct integration with the wiring of the vehicle.

Figure 5. Physical circuit of the ISS

D. Records of fuel use

The measurement of fuel consumption on the test route was carried out using the full-to-full method, where the fuel tank was filled to capacity at the start of the trip and then refilled at the same fuel station after the trip. The trip was carried out by following the same route, with the same travel time and the same driving style [17], and at a safe driving speed [18]. The trip was conducted according to the scenario as shown in Table 1. The difference between Scenario 1 and Scenario 2 aims to test the effect of the number of vehicle stops at traffic lights on fuel consumption. Table 3 shows the test results under the test conditions conducted between 8:00 AM and 10:00 AM WIB, during which time the risk of travel is minimized due to less dense traffic.

Table 3 Fuel consumption in real road experiments

Scenario	Number of Traffic Light	Setting	Fuel Consumption
1	5 traffic light (3 depart, 2 return)	ISS OFF	860 mL
		ISS ON	820 mL
2	8 traffic light (4 depart, 4 return)	ISS ON	900 mL
		ISS OFF	832 mL

The percentage value of the fuel volume difference is calculated using equation (2).

$$\text{Fuel saving } \% = \frac{Volume\ ISS\ OFF - Volume\ ISS\ ON}{Volume\ ISS\ OFF} x100\% \quad (2)$$

In scenario 1, The motorcycle was driven without activating ISS, the engine remained running during

the waiting time at the red traffic light, and 860 mL of fuel was consumed. With the same route, the vehicle was driven with the ISS activated, the machine immediately turned off 3 seconds after the motorcycle stopped, and it remained turning off during the waiting time at the red lamp on traffic light intersection. The fuel consumed was 840 mL when ISS activated. Using equation (2), it was calculated that :

$$\text{Fuel saving } \% = \frac{860-840}{860} x100\% \quad (1)$$

$$\text{Fuel saving } \% = \frac{40}{860} x100\% = 4.65\ \%$$

In scenario 2, the vehicle passes through more red lights. Fuel consumption without activating ISS is 900 mL, while the same route with ISS activated requires only 832 mL of fuel.

$$\text{Fuel saving } \% = \frac{900-832}{900} x100\%$$

$$\text{Fuel saving } \% = \frac{68}{900} x100\% = 7.55\ \%$$

When ISS mode is ON, it has been proven to save fuel consumption within a relatively dependent range based on the number of vehicle stops. The more frequently a vehicle stops at traffic lights, the less fuel is consumed. The difference in fuel consumption saved by ISS in this study is consistent with study [11], where the difference lies in the vehicle model used, which is a newer model. In study [11], no idle stop system design was conducted; instead, only the standard factory idle stop feature was tested. Fuel savings ranged from 40 mL to 60 mL, similar to the results of this study. Table 4 shows a comparison of the results of this study with those of other existing studies. Study [9] involved circuit design and was only tested via simulation, making it difficult to compare the results achieved in real-world testing.

Table 4 Comparison of this study with other researchers

Author	Method – Test		Parameter	Result
[9]	Simulation	software	-	Time compara tive
[10]	Design and Experiment Eco Idle System(EIS)	Install EIS on test unit (parking lot)	-	-
[11]	Existing unit test	1 unit IDSS off 1 unit IDSS on(existing)	• Volume	Fuel saving 40 mL (13.3 Km) ; 45 mL (23.3 Km) ; 60 mL (30 Km)
			• Exhaust gas	Less 11.7% ; 11 % ; 10.8%
This study	Design and Experiment Idle Stop System	modification ISS	Fuel Volume	Fuel saving 4 – 7 %

In study [10], design and testing were conducted on a limited track within the parking lot of the building where the researchers were based, and no measurements on the fuel saving ever recorded. Fuel savings occur because when the vehicle stops at a red light, the ISS system automatically shuts down the engine after 3 seconds. ISS shuts down the engine based on signals from a temperature sensor that measures the engine's heat condition and a crankshaft sensor that detects the rotation of the piston shaft. When the engine is off, the piston stops and does not create negative pressure to draw fuel from the vacuum valve on the fuel tank outlet line, as if the fuel line leading to the engine were closed. If there is any remaining fuel in the combustion chamber, combustion will not occur because the spark plugs in the vehicle will not produce a spark, as the circuit from the coil to the spark plugs is interrupted by the relay controlled by the Arduino. The fuel savings recorded in this study align with the reduction in vehicle emissions, no combustion occur means no exhaust gas is produced [19]. This fuel efficiency not only reduces fuel consumption but also contributes to reducing exhaust emissions, making it a more environmentally friendly option.

IV. CONCLUSION

The idle stop system (ISS) developed in this study has performed admirably and generated results that are comparable to those of the Honda and Yamaha IDSS and SSS systems. Based on test conditions in Pekanbaru city traffic over a test distance of 28 km, the ISS produced savings of 4.65 to 7.56%. In contrast to IDSS or SSS, which automatically restart the engine when the driver turns the throttle after the engine stops and idles for a brief period of time, the ISS in this study has the drawback of requiring manual engine restarting after the engine stops due to ISS control. An automatic engine restart procedure could be added by installing sensors on the throttle handle and/or brake lever; however, adding sensors would affect the vehicle's aesthetic appearance, making it less neat.

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