

# Research on Electronically Regulated Air-to-Fuel and Ignition Timing for Light-Duty Gasoline Engines

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**Abstract**— Right now, commercially available ignition systems include both electronic ignition and carburetor setups. The method would optimise the performance of the engine by adjusting the ratio of air to fuel and the timing of the ignition according to the conditions at the time. Based on our analysis of the available experimental data, we came to the conclusion that the use of electronic control of the engine led to a 10% rise in the specific fuel consumption while simultaneously leading to a 90% improvement in the exhaust emission performance.

**Keywords**— Ignition system, carburetor, exhaust.

## I. INTRODUCTION

Motorcycle performance, fuel economy, and exhaust quality can all benefit from electronic management of the air-to-fuel ratio and ignition timing. [1] People in various East Asian countries have seen a rise in the popularity of small motorbikes in recent years. The high ongoing and up-front costs of electronic controlled fuel injection technology make it difficult to implement in smaller petrol engines. Carburetors have proven to be an essential component of the regulatory infrastructure in this kind of society and environment. Almost every aspect of modern life is regulated electronically.

## II. ELECTRONIC CONTROL PRINCIPLES

Maximum performance, fuel efficiency, exhaust emissions, optimum combustion, and a fast cold start all depend on the air-fuel ratio, which must be electronically controlled. A low-cost air-to-fuel ratio control system relied heavily on the solenoid valve. A Simplified version of the setup is shown in Fig.1. The carburetor's air bleed tube now has a solenoid valve placed in it for more precise control. Adjusting the duty ratio of the valve enables one to have control over volume of air that is passing through the pipe. Changing the air bleed flow rate will vary the air-fuel, which is one system defining characteristics. By altering the frequency of the control signal from 10 to 90 Hz, As can be seen in Fig. 2, the open time of the valve was adjustable from 10 ms to 90 ms..

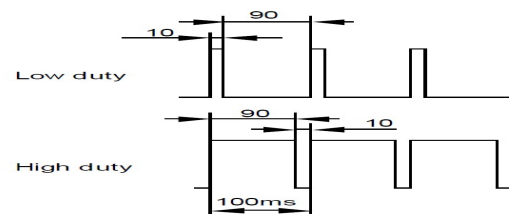
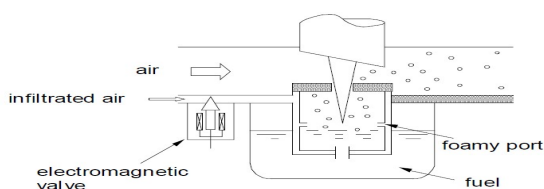


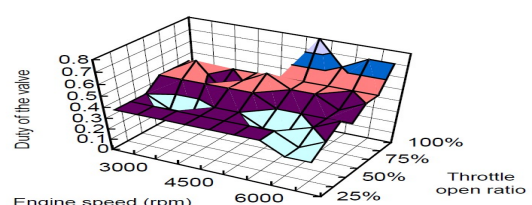
Fig.1. A model of a carburetor that is operated electronically.

Fig.2. Control signal for the electromagnetic valve; the operating frequency was ten hertz.

The "duty" (the fraction of a cycle during which the electromagnetic valve is open) may be changed to fine-tune the air-fuel ratio. Careful management of the air-to-fuel ratio, which theoretically should be about 50:1, maximises production while slashing fuel usage by as much as 70 percent. Based on the results of the tests, it was also found that the electromagnetic valve has a scalar response to variations in throttle ratio and engine speed. The ROM was utilized to keep track of trial data. Figure 3 shows a three-dimensional representation of the electromagnetic valve's verified functionality. The electronic system may keep the air-to-fuel ratio stable by real-time adjustments to the duty signal for the electromagnetic valve.

## III. ELECTRONIC CONTROL PRINCIPLES

The timing at which the engine is ignited is another important control parameter. Since it has such a dramatic effect on both fuel efficiency and air pollution, it must be strictly regulated. As it turned out, the 2-D ratio of open throttle to load to engine speed. The optimal ignition timing database, as established empirically [1], is stored in ROM. An ignition timing value of 60 degrees BTDC was entered into the database using the crank angle reference signal, as used on the test engine. In Fig. 4, we see a three-dimensional representation of the ideal delay angle for the ignition signal



in relation to the reference signal for ignition.[3]

Fig.3. Databases in three dimensions for the function of the

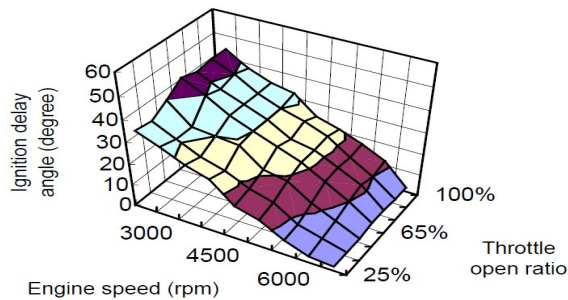


Fig.4. The angular offset between the ignition and the starting position.

The electronic control system of the vehicle takes into account a number of variables, such as the speed of the vehicle's engine and the amount of throttle that is open, in order to calculate the best timing of the spark in the vehicle's engine. Fig.5 depicts a signal that is sent to the electronic ignition system from the control system. This schematic depicts a transfer switch that links the ignition circuit to the regular power control infrastructure.

#### IV. CONTENTS OF ELECTRONIC CONTROL SYSTEM

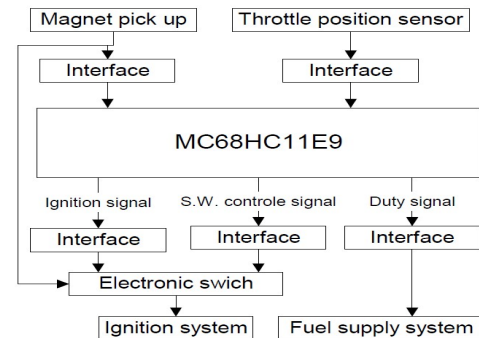
##### A. Multiple analogue and digital parts work together to form the electronic control system.

The following is an explanation of the software and hardware components that together make up the electronic control system.

The brain, the sensor and forward interface circuits, and the control nodes all had significant roles. In addition to an 8-bit ADC, ROM, and a watchdog timer, the Motorola MC68HC11E9 includes these features. Even pulses are not lost on it. An analog-to-digital (A/D) port took in the throttle position signal, pulse-catching devices picked up the crank angle and rotation signals, and output compare units took care of the executive units.

A line voltage sensor, throttle position sensor, crank angle sensor, and speed sensor were all installed. Before delivering the signal from each sensor to the ECU's input wire, the voltage adjustment circuit calibrated the signal. For

this evaluation, a standard motorcycle spark plug was used. As a result, the magnet inside the igniter could be used to keep track of how many times the crank had been turned. Pulse-forming was performed on the final reading before it was sent to the ECU. The analog-to-digital (A/D) link between the throttle position sensor and the ECU reduced



noise and amplified the signal intensity.

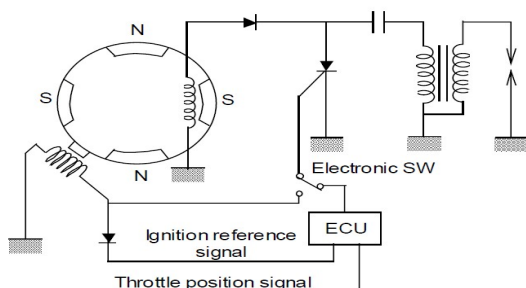
Fig.5. System of electronic control for the ignition tested.

Fig.6. System of electronic control for the ignition tested.

##### B. The software's major:

The tested ignition system a) was designed to use the ECU's signal for the optimal ignition time under normal circumstances, but to return to the original igniter unit in the event of a malfunction. A computer-operated electrical switch was used to accomplish this. An electromagnetic valve installed in the intrinsic carburetor's air output served as the primary switching duty control component. When everything were running well, the ECU oversaw the valve's operation, but when problems arose, the subsystem took control.

The control software included a main program, an I/O program, an interrupt subprogram, an analogue-to-digital converter subprogram, and a number of additional calculating subprograms. then look it up in the data base. Fig. 7 depicted the flowchart. The system's main software automatically compiled and tested the system. Then, based on the ratio of open throttle to engine speed, it made a determination as to the health of the engine. I/O program and database reference program were also streamlined.



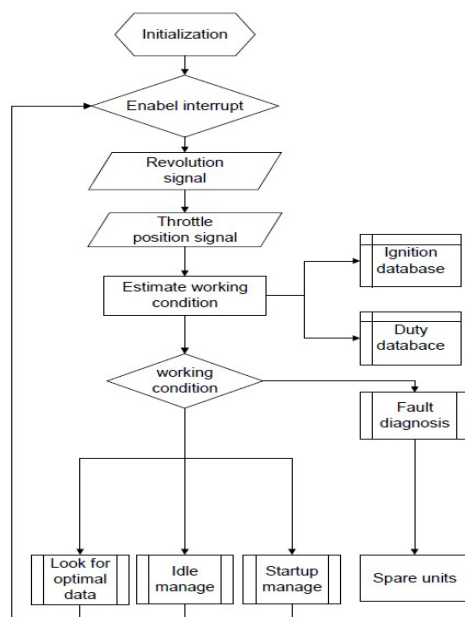


Fig.7. Flow chart of main program.

to work together with the right data processing to send out the command signal. The ignition reference signal was used for interrupt management to improve control accuracy. The duty and ignition output subroutines were also kicked off by an interrupt function. Ignition's interference made for an unstable working environment; hence, the software often crashed. The system's internal watchdog was put to use to keep tabs on the app's health and ensure its dependability. [2] proposed a system, this fully automatic vehicle is equipped by micro controller, motor driving mechanism and battery. The power stored in the battery is used to drive the DC motor that causes the movement to AGV. The speed of rotation of DC motor i.e., velocity of AGV is controlled by the microprocessor controller. This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased. [4] proposed a system, in which a predicate is defined for measuring the evidence for a boundary between two regions using Geodesic Graph-based representation of the image. The algorithm is applied to image segmentation using two different kinds of local neighborhoods in constructing the graph. Liver and hepatic tumor segmentation can be automatically processed by the Geodesic graph-cut based method. This system has concentrated on finding a fast and interactive segmentation method for liver and tumor segmentation. In the preprocessing stage, the CT image process is carried over with mean shift filter and statistical thresholding method for reducing processing area with improving detections rate. Second stage is liver segmentation; the liver region has been segmented using the algorithm of the proposed method. The next stage

tumor segmentation also followed the same steps. Finally the liver and tumor regions are separately segmented from the computer tomography image.

## V. CONTROL SYSTEM EXPERIMENTAL VERIFICATION

Apparatus and state for experimental use most of the relevant data may be found in Table I. the air-cooled, one-cylinder petrol engine of the yamaha dx100 was put through its paces. The experimental conditions are listed in Table II. Of the 63 different combinations tested, nine involved the throttle open ratio and nine dealt with engine speed.[5]

## VI. EXPERIMENTAL RESULT

As can be seen in Fig.8-10, the engine speed and stopping power both shift in tandem with the change from 50% to a 100% throttle open ratio. The round icons represent electronically controlled braking systems, whereas the square ones represent mechanically controlled systems. Based on these numbers, the following assumptions may be made about the braking pressures applied to the electronic control system.

TABLE I. TESTED ENGINE SPECIFICATION.

Bore (mm)		50
Stroke (mm)		45.6
Compression ratio		6.5
Displacement volume (cm <sup>3</sup> )		97
Port timing (mm)	Exhaust	27.0
	Scavenging	36.8
Type of carburetor		VM20SC ϕ 20

TABLE II. EXPERIMENTAL CONDITION.

Engine speed (rpm)	3000,3500,4000,4500,5000,5500,6000,6500,7000
Throttle opened ratio (%)	25,30,35,50,65,75,85,100

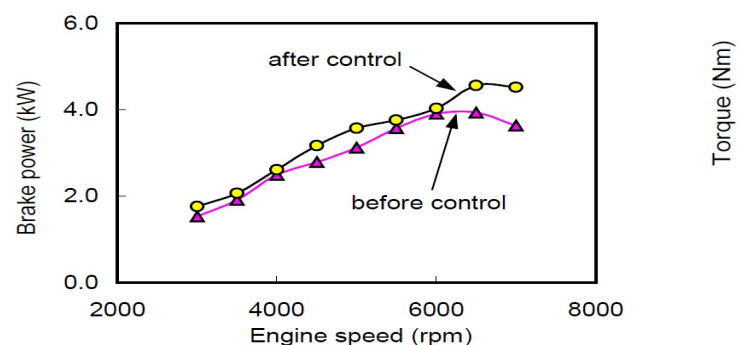


Fig.8. Control results of brake power when the throttle position was set at 50%.

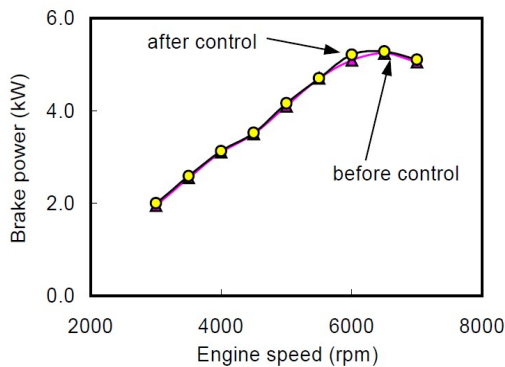


Fig.9. Control results of brake power when the throttle position was set at 75%.

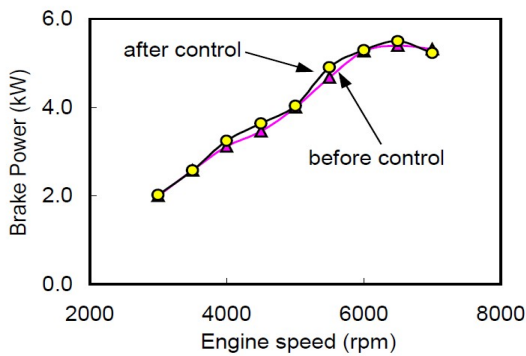


Fig.10. The results of a test of the brakes at full throttle.

At any particular throttle open ratio, the forces generated without the aid of the ECU may be nearly equal to or slightly more than the brake powers. Average returns were 5.6%, with gains ranging from +0.6% to +24.5%. Adjusting the air-to-fuel ratio reduced stopping power, but this was offset by fine-tuning the ignition timing. Figs. 11-13 display the torque output by the engine as a function of engine speed, which can be used to calculate the throttle open ratio. Results-based modifications at low loads, changes in air-to-fuel ratio and ignition duration had the largest impact, but at medium and high speeds, their significance waned. The electronic control system boosted torque by an average of 5.6%, from a range of 12% to 24

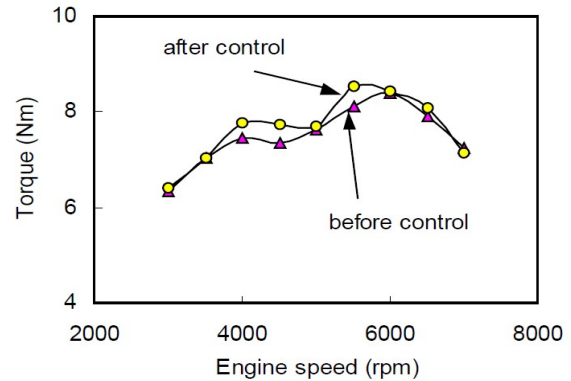
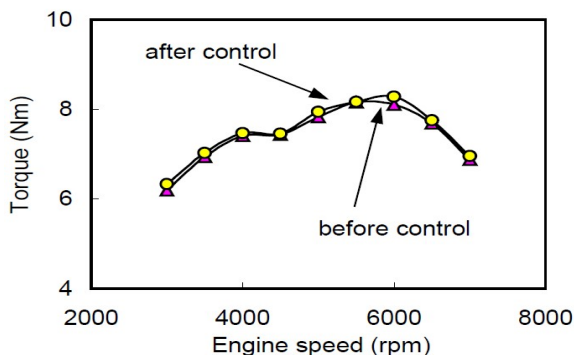


Fig.12 Control results of torque when throttle Position was set 75%.

Fig.13 When the throttle was opened all the way, the results of the torque control were at 100 %

Figs. 14 and 16 show the effects on test engine speed and specific fuel consumption of varying the throttle open ratio from 50% to 100%. Permission to Disclose

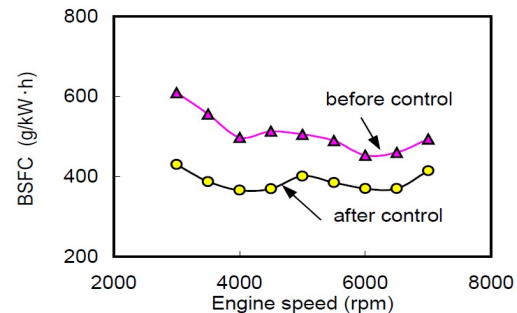


Fig.14 Control results of BSFC when throttle position was set at 50%.

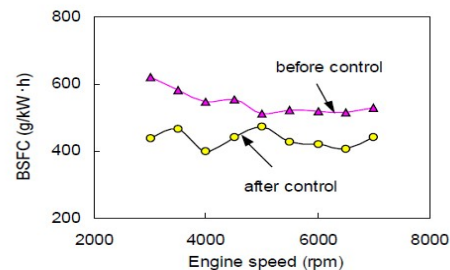


Fig.15 Control results of torque when throttle Position was set 75%.



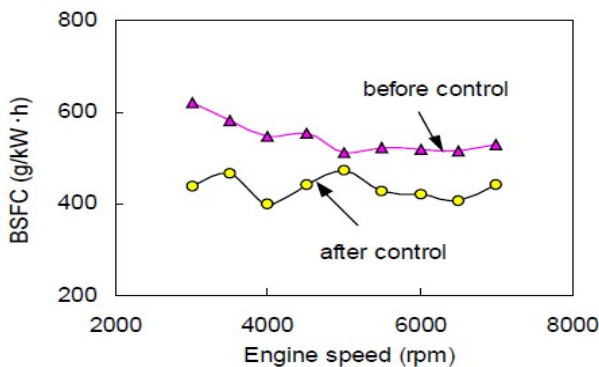


Fig.16 The regulated BSFC performance at full speed.

Demonstrated that by carefully adjusting the air-to-fuel ratio and ignition time, BSFC may be increased by 7.4%-30.3% (mean = 23.0%). These findings demonstrate the effectiveness of the electronic control system in maintaining a constant air-to-fuel ratio and spark timing. It was demonstrated that using the technique reduced both operating costs and energy consumption.

Exhaust manifold samples were analyzed for CO and hydrocarbon emissions, and the findings are shown in Table III.

Table IV shows the revised ratio from Table 3's calculations. A 97% decrease in CO emissions and a 10% reduction in HC emissions are possible with electronic control compared to a conventional carburetor, as shown in the graph.

TABLE III. EMISSIONS TESTING (USING A HORIBA MEXA-324F EXHAUST GAS ANALYZER).

Throttle position (%)	Engine speed (rpm)	Before control		After control	
		CO (%)	HC (ppm)	CO (%)	HC (ppm)
50	3000	5.5	2800	0.10	2700
	5000	5.5	2600	0.15	2800
75	3000	6.5	4000	0.20	3200
	5000	5.0	4200	0.25	3400
100	3000	4.8	4200	0.10	3600
	5000	3.4	4600	0.10	3800

TABLE IV. IMPROVED RATIO OF EXHAUST EMISSION.

Throttle position (%)	Engine speed (rpm)	Improved ratio	
		CO (%)	HC (%)
50	3000	-98.2	-3.6
	5000	-97.3	7.7
75	3000	-96.9	-20.0
	5000	-95.0	-19.0
100	3000	-97.9	-14.3
	5000	-97.1	-17.4
Average		-97.1	-11.1

## VII. CONCLUSION

- The standard carburetor's air bleed electromagnetic valve and spark plug allowed engineers to design a system with minimal moving parts. With the use of an electronic carburetor, HC and CO emissions were cut by 97%, while BSFC was boosted by 8-10%.
- The system architecture was simplified by using a single-chip CPU designed by Motorola and software developed by Motorola. The device's low cost and consistent performance are important selling features. Third, the electronic control system's hardware and software would need updating so that it could be utilised in a closed-loop control model to manage the air-to-fuel ratio and ignition timing of the four-stroke petrol engine.
- The electronic control system would be employed in a closed loop control model to optimise the hardware and software components of a four-stroke petrol engine, hence controlling the air-to-fuel ratio and ignition timing.

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