Electronic Fuel Injection for Four Stroke Two - Wheeler Engines

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Abstract:

Modern four-stroke engines are equipped with carburetor, wiring harness, acceleration system, Ignition system and crank position indicator etc. In this work, a step towards electronic fuel injection system for four-stroke two-wheeler engines has been attempted. System components such as electronic control unit, harness with connectors, throttle body assembly, fuel pump assembly, MAP sensor, Engine temperature sensor, oxygen sensor have been used in the system. After installation the four-stroke engine performance test was conducted and the parameters like Total fuel consumption, brake power, frictional power, indicated power and specific fuel consumption were determined and the graphs were plotted.

Index Terms: **Four stroke engine, Electronic fuel injection, SFC, TFC, BP, FP, IP.**

Introduction

Electronic throttle control (ETC) is an automobile technology which electronically "connects" the accelerator pedal to the throttle, replacing a mechanical linkage. A typical ETC system consists of three major components:

(i) an accelerator pedal module (ideally with two or more independent sensors),
(ii) a throttle valve that can be opened and closed by an electric motor (sometimes referred to as an electric or electronic throttle body (ETB)), and
(iii) a powertrain or engine control module (PCM or ECM).

The benefits of electronic throttle control are largely unnoticed by most drivers because the aim is to make the vehicle power-train characteristics seamlessly consistent irrespective of prevailing conditions, such as engine temperature, altitude, and accessory loads. Electronic throttle control is also working 'behind the scenes' to dramatically improve the ease with which the driver can execute gear changes and deal with the dramatic torque changes associated with rapid accelerations and decelerations.

Electronic throttle control facilitates the integration of features such as cruise control, traction control, stability control, and before crash systems and others that require torque management, since the throttle can be moved irrespective of the position of the driver's accelerator pedal. ETC provides some benefit in areas such as air-fuel ratio control, exhaust emissions and fuel consumption reduction, and also works in concert with other technologies such as gasoline direct injection.

A crank sensor is an electronic device used in an internal combustion engine to monitor the position or rotational speed of the crankshaft. This information is used by engine management systems to control the fuel injection or the ignition system timing and other engine parameters. Before electronic crank sensors were available, the distributor would have to be manually adjusted to a timing mark on the engine.

Table 1 Engine Specification

Sl. No	Component	Description
1	Type	Air Cooled, 4 Stroke Single Cylinder OHC
2	Displacement	97.2 cc
3	Maximum power	6.15kW (8.36 Ps) @ 8000 rpm
4	Maximum Torque	0.82 kg-m (8.05 N-m) @ 5000 rpm
5	Bore × Stroke	50 mm × 49.5 mm
6	Carburetors	Side Draft, Variable Venturi Type with TCIS
7	Compression Ratio	9.9:1
8	Starting	Kick / Self Start

Figure 1 Air Cooled, 4 Stroke Single Cylinder OHC Engine.

The manifold absolute pressure sensor (MAP sensor) is one of the sensors used in an internal combustion engine's electronic control system. The manifold absolute pressure sensor provides instantaneous manifold pressure information to the engine's electronic control unit (ECU). The data is used to calculate air density and determine the engine's air mass flow rate, which in turn determines the required fuel metering for optimum combustion (see stoichiometry) and influence the advance or retard of ignition timing.

An oxygen sensor (or lambda sensor) is an electronic device that measures the proportion of oxygen (O2) in the gas or liquid being analyzed.

When signaled by the engine control unit the fuel injector opens and sprays the pressurized fuel into the engine. The duration that the injector is open (called the pulse width) is proportional to the amount of fuel delivered. Depending on the system design, the timing of when injector opens is either relative each individual cylinder (for a sequential fuel injection system), or injectors for multiple cylinders may be signaled to open at the same time (in a batch fire system). Standard electric fuel pumps operate in 50-200 PSI. pressure rate.

Table 2 Parts Details, to be removed and to be assembled.

Parts	
To be Removed	**To be Assembled**
1. Carburettor	1.Engine Control Unit
2. Wiring Harness	2. Harness (including the connectors)
3. Acceleration System	3. Throttle Body
4. Ignition System (CDI)	Throttle body (including TPS sensor)
5. Crank Position indicator	Fuel injector
	4. Fuel pump assembly
	Fuel pump
	Fuel pressure regulator
	Fuel filter
	High pressure fuel line
	Fuel hoses, T-Pipes, Clamps
	5. MAP Sensor
	6. Engine temperature sensor
	7. Intake air temperature sensor
	8. Oxygen Sensor

Engine Control Unit (ECU):

ECU has to do the following work

1. Control of Air/Fuel Ratio

Most modern engines use fuel injection to deliver fuel to the cylinders. The ECU determines the amount of fuel to inject based on a number of sensor readings. Oxygen sensors tell the ECU whether the engine is running rich (too much fuel/too little oxygen) or running lean (too much oxygen/too little fuel) as compared to ideal conditions (known as stoichiometric).

2. Control of Idle Speed

Most engine systems have idle speed control built into the ECU. The engine RPM is monitored by the crankshaft position sensor which plays a primary role in the engine timing functions for fuel injection, spark events, and valve timing. Idle speed is controlled by a programmable throttle stop or an idle air bypass control stepper motor.

3. Control of variable valve timing

Some engines have Variable Valve Timing. In such an engine, the ECU controls the time in the engine cycle at which the valves open. The valves are usually opened sooner at higher speed than at lower speed.

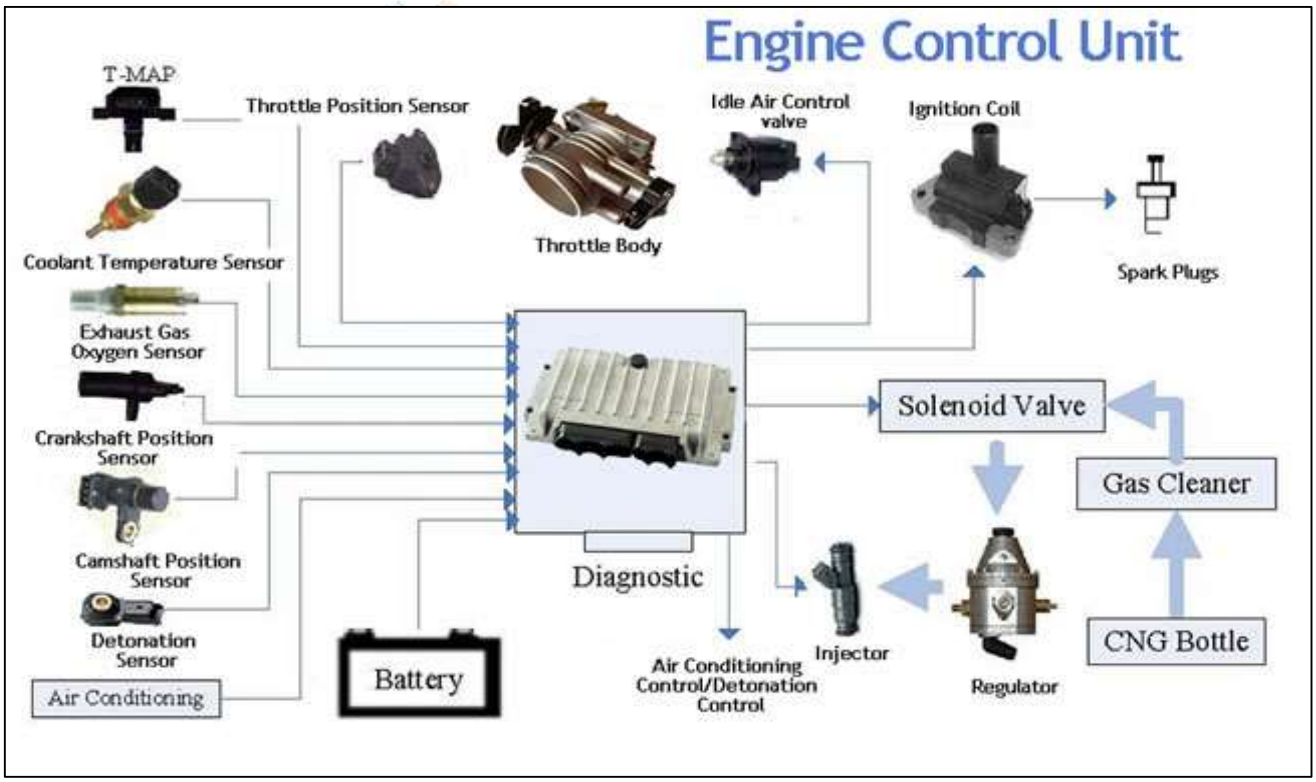


Figure 2 Engine Control unit (ECU)

Installation

1. Carburetor was removed from the Engine and in the same position new throttle body was installed, with the same intake manifold is connected.
2. Map sensor to the manifold or the throttle body (downstream of the throttle pate) was connected. MAP sensor was meant to measure the pressure between the throttle plate and the intake valve.
3. In-between fuel tank and the throttle body, fuel pump was fixed, so that both the fuel feed line and the fuel return lines can be short;
4. Cylinder Head Temperature sensor was fixed at the backside of the engine to measure the engine temperature.
5. Air temperature sensor was fixed in between the air filter and the throttle body.

6. Crank Position Sensor is the most important for EFI system. It gives the feedback to ECU the engine timing, or TDC position. The ECU uses it to calculate the RPM; and it also uses it to trigger the fuel injection once per cycle, and to command the spark at the specific crankshaft angle.
7. O_2 sensor was installed with a tilt angle the sensor head can be fully exposed to the exhaust gas; yet NOT to block the exhaust pipe and Otherwise the condensation could damage the sensor.
8. All the sensor were connected to the ECU unit in order to provide the correct data, to control the correct mixture of fuel flow into the engine.

Figure 3 a. Existing fuel & air mixing and b. Modified Fuel & Air mixing

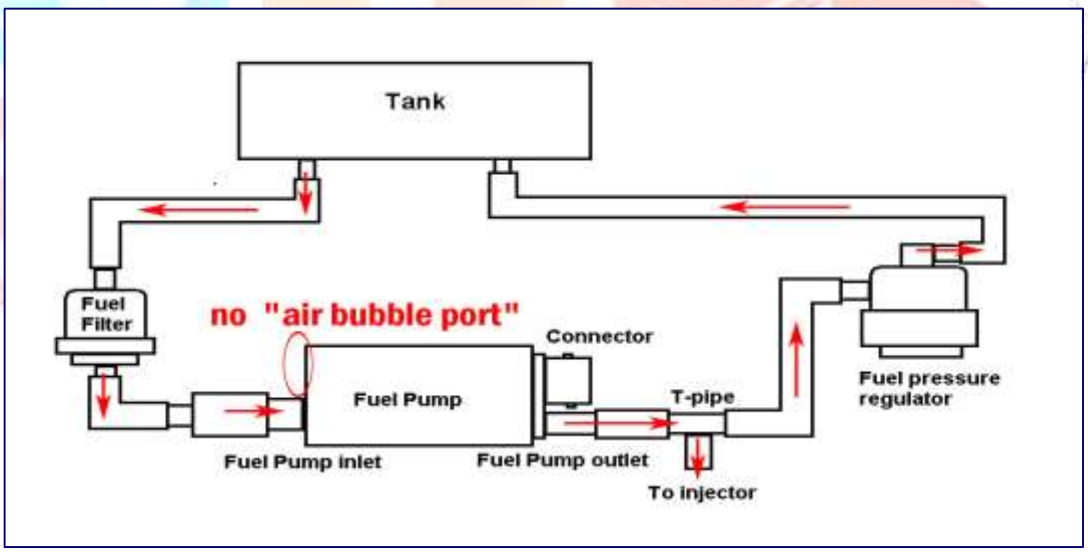


Figure 4 Fuel Circuit

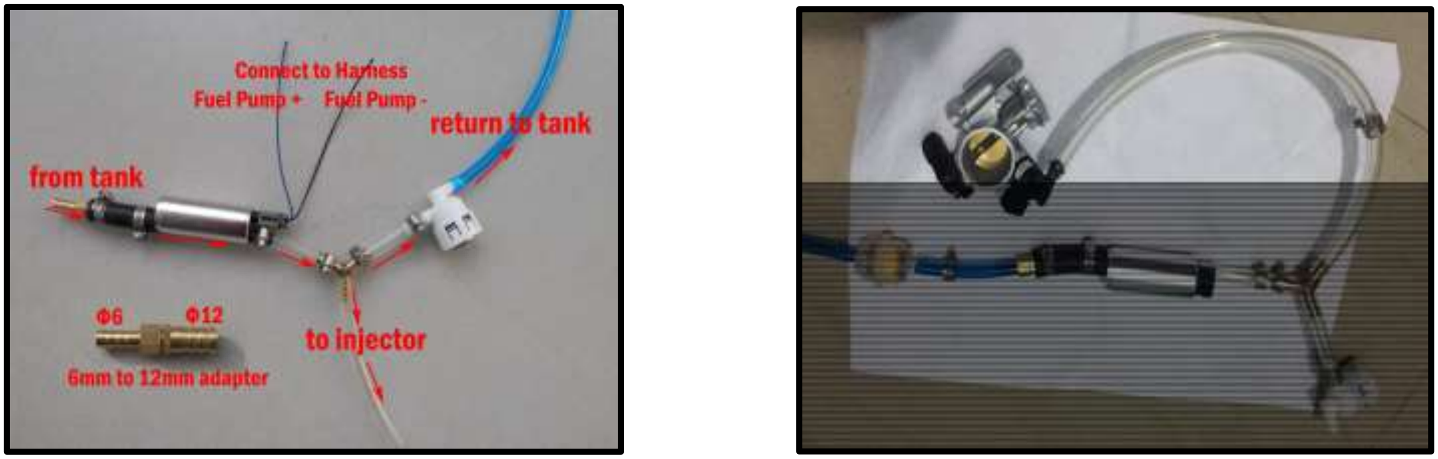


Figure 5 Fuel Circuit Assembly

Figure 6 Engine Temperature Sensor & Intake Air Temperature Sensor Assembly

Table 3 ECU Harness Details

Label	Descriptions	Notes
ECU	Electronic Control Unit	
RS232	Serial communication cable to a PC computer	
O2S	Oxygen sensor	
Fuel Pump	Fuel pump power and ground	
12V-	Battery 12V-	
12V+	Battery 12V+	
IAT	Intake Air Temperature sensor	
ECT	Engine (Coolant) Temperature sensor	
Performance switch	Manual switch to select fuel tables: ECO mode vs. Rich mode	
TPS	Throttle position sensor	
MAP	Manifold absolute pressure	

INJ	Injector	
CKP	**Crank Position Sensor Connect to Ignition pickup wire** (also called **VRS before**)	**Orange**
CDI-Ctrl	CDI control output from ECU (also called CDI-PG before)	**Gray**
GND	Ground (previously called Analog Ground)	**Green**
KEYSW	Key On switch (previously called IGNSW)	**Pink**

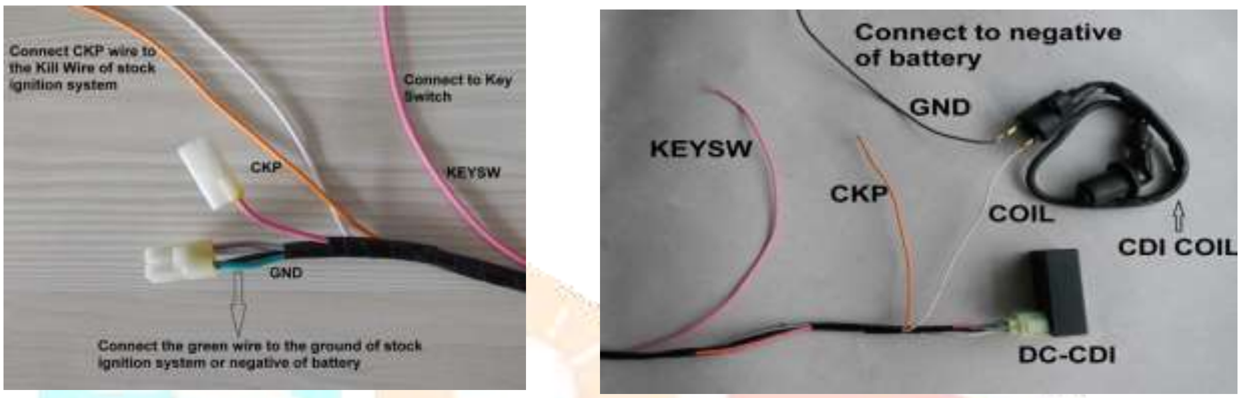


Figure 7 CDI Unit Assembly

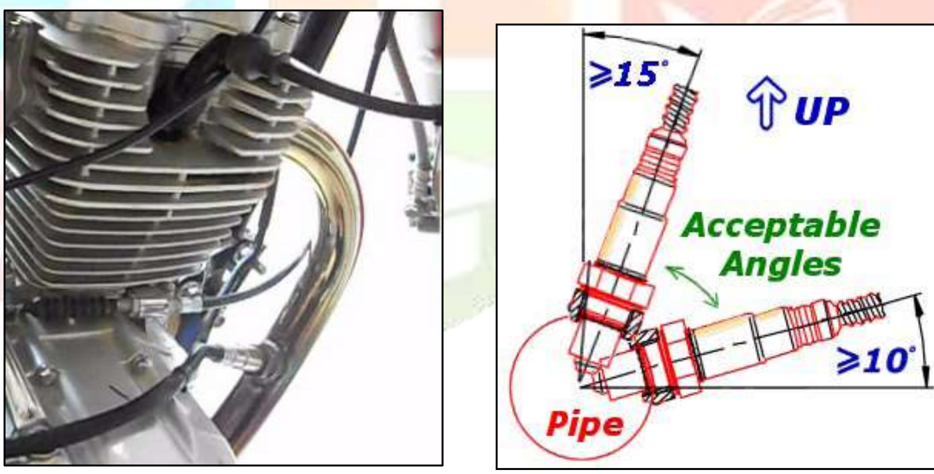


Figure 8 O_2 Sensor Assembly

Table 4 Performance of the Engine, Before Installation

Sl. No	Load (W) in kg	Speed (N) rpm	Time for 10cc fuel consumption (sec)	TFC kg/hr.	BP kW	FP kW	IP kW	SFC=TFC/BP kg/kW-hr
1	1.5	2080	78	0.36	0.016	0.0024	0.0184	0.044
2	3	1904	70	0.4	0.0155	0.0022	0.0177	0.0387
3	4.5	1810	61	0.46	0.0147	0.0021	0.0168	0.037

4	6.0	1695	50	0.56	0.0138	0.002	0.0158	0.0246

Table 4 Performance of the Engine, After Installation

Sl. No	Load (W) in kg	Speed (N) rpm	Time for 10cc fuel consumption (sec)	TFC kg/hr.	BP kW	FP kW	IP kW	SFC=TFC/BP kg/kW-hr
1	1.5	2100	87	0.32	0.016	0.0024	0.0184	0.0382
2	3	1900	79	0.36	0.0155	0.0022	0.0177	0.0344
3	4.5	1800	69	0.41	0.0147	0.0021	0.0168	0.0325
4	6.0	1700	57	0.5	0.0138	0.002	0.0158	0.0221

Formula Used :

1. Brake Power:

B. P = 2πNT/60*100

T = W * Re

Re = R + r

2.Indicated Power:

IP = FP + BP

3.Specific Fuel Consumption = TFC / BP

TFC=Total Volume of fuel Consumed X Density of Fuel / Time in Hour

4.Friction Power = 10 to 20 % of the BP

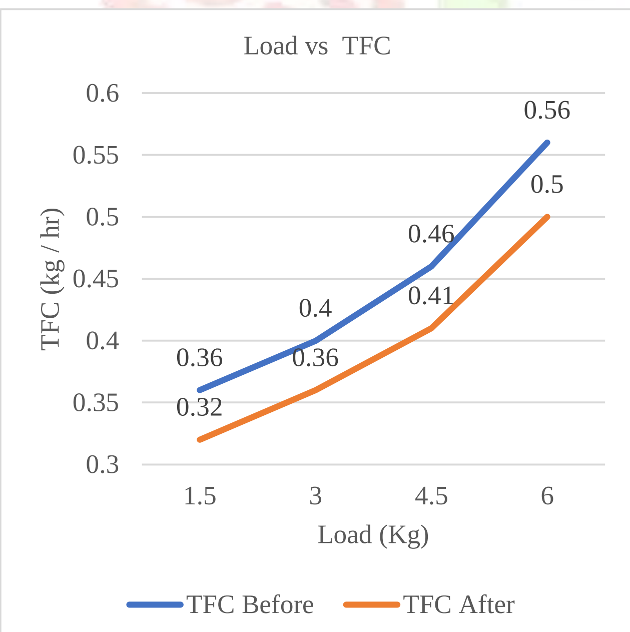
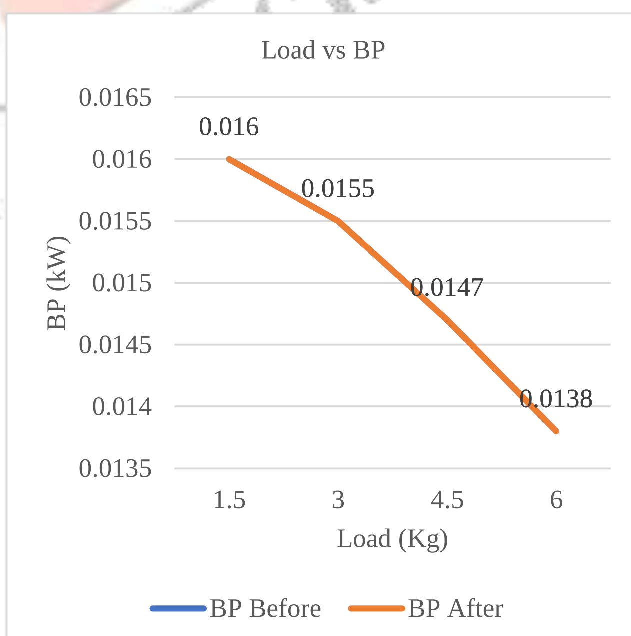


Figure 9a & 9b



Performance Analysis Curve (Load vs Total fuel consumption & Brake Power)

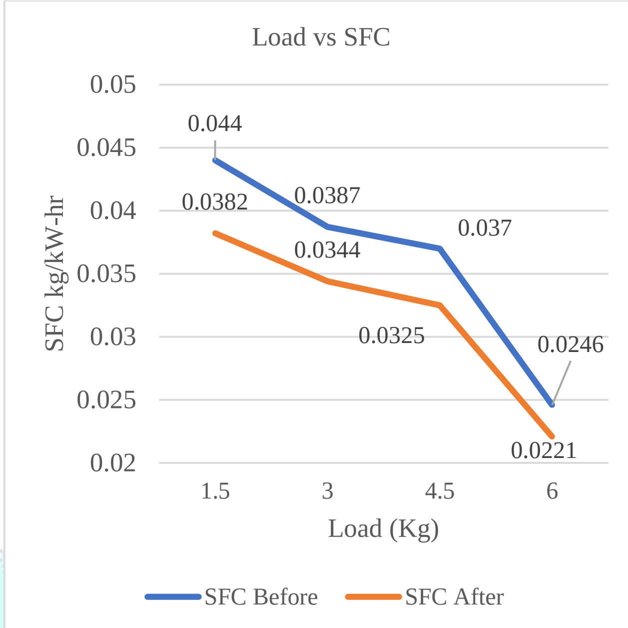


Figure 10 Performance Analysis Curve (load vs Specific fuel consumption)

RESULT and DISCUSSION

1. Fuel consumption timing was increased after installation of ECU by 10 %.
2. Friction power, Brake power and Indicated power were same as in the conventional system.
3. Specific fuel consumption was decreased by 10 % because of Total fuel consumption was less compared to conventional method, thus increases the engine performance.
4. The project setup cost was is in higher side while compare to the conventional method of fueling, when moving with mass production the manufacturing cost will be very cheaper than the conventional method.

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