# Implementation of EFI System in 70cc Bike

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| ARTICLE INFO | ABSTRACT |
|---|---|
| | In Carburetted Fuel Engines (CFI), the air-fuel ratio is being controlled conventionally whereas in Electronic Fuel Injection Engines (EFI) the air-fuel ratio is being controlled electronically by ECU. In this research, a rope brake dynamo test bench has been designed to check the comparative analysis between CFI and EFI of 70cc engines with and without loading conditions, in addition, flue emission analysis has been carried out on both CFI and EFI engines. The main purpose of this research is to introduce the 70cc bike in Pakistan for better fuel economy and lower fuel emission. On the basis of comparative analysis between CFI and EFI engines, it has been observed that the EFI engine gives a better fuel average in 1 litre i.e. 55.26 km, reduces exhaust emission, saving PKR 4,141 per year for a normal user and PKR 16,556 per year for a commercial user. Thereby, profitable than that of carburetted bikes used in Pakistan. |

## 1. Introduction

Carburated engine mix air and fuel for Internal Combustion Engines (ICE) and thereby responsible for the control of vehicle speed. In the carburetor, there were the following components like storage tank, idling jet, choke, main jet, venturi-shaped air flow restriction and pump. In the EFI engine; the air fuel ratio was being controlled electronically with two devices (air flow meter and ECU) to measure the intake air volume and injection of fuel. Intake air volume is measured by an air flow meter and a corresponding signal is sent to the electronic control unit (ECU). The ECU then transmits the signals to the fuel injectors, which inject a proper amount of pressurized fuel into the cylinder in the intake stroke. EFI systems can be divided into two types, according to the method used for sensing the intake volume of air.

D-EFI (Manifold Pressure Control Type) measures the vacuum in the intake manifold and senses the air-volume by its density. The D-EFI type was used in some TCCS engines L-EFI (Air-Flow Control

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Type) that directly senses the fuel-amount flowing into the intake manifold using an air flow meter. This L-EFI system was used on Toyota's analog circuit type EFI engines and some TCCS engines.

## 2. Literature Review

Schock *et al.,* [1] in 2018 observed the ICE pressure inside the pre-equator chamber was equal to or greater than the pressure inside the primary fire chamber by using control software ICEs. Shiraishi *et al.,* [2] in 2000 regulated the control unit of ICEs by receiving sensors with the objective to enhance the controlling of fuel injection and valve timing to achieve better fuel economy. Sadakane and Yonezawa [3] in 2006 examined the ignition of ICEs to make them more reliable as compared to classic ignition and injection systems. Thereby, achieving/ensuring favorable engine start ability and suppressing the emission of unburned components in the engine starting state. Deshmukh and Atpadkar [4] in 2009 tested a 4-cylinder gasoline engine that adjusted the cracks in the cylinder head and analyzed low fuel consumption by adding grooves on the cylinder head. Duncan *et al.,* [5] in 2017 optimized the four-valve ICEs w.r.t cam design parameters in single cylinder engines to identify the high performance of ICEs. Kunjam *et al.,* [6] in 2015 examined an advanced and improved fuel injection system for small vehicles that was recently available commercially. This EFI system uses an electronic device consisting of an ECU that receives electrical signals from various sensors to monitor and control the engine operation. Grau *et al.,* [7] in 2019 developed a numerical model for an injection control system of an ECU for single-cylinder 4-stroke motorcycle engines with different displacements. Mon Su Su Yi [8] in 2014 reviewed the port fuel injection cycle; the body injection and the direct injection system for optimized fuel injection and emissions. Roman *et al.,* [9] Harmful pollutants (CO, NO, and unburnt hydrocarbons) coming out from the exhaust manifold of an engine must be converted into harmless gases by using cheap metals in the catalytic converter. Kim *et al.,* [10] explained the effective plasma of Capacitive Discharge Ignition (CDI) compared with conventional ignition discharge. Ilham *et al.,* [11] identified suitable potential renewable energy resources by analyzing the outcomes of Focus Group Discussions (FGD) using the Analytic Hierarchy Process (AHP) as an analytical technique. Mohd Khairi *et al.,* [12] reviewed advanced modelling, and emissions software that could play a vital role in sustainable road transit. Ismail *et al.,* [13] analyzed renewable energy resources economically to overcome the energy crisis, thus reducing global $CO_2$ emissions.

## 3. Engine Specification

The engine chosen for EFI implementation is a 70 cc carbureted engine, its specifications are given in Table 1.

**Table 1**
Engine specification

| Model | 70 cc |
|---|---|
| Type | Four stroke, Single cylinder, Petrol engine |
| Max. horsepower | 5.0 PS (3.7 KW;5.0 HP) at 8000 RPM |
| Max. torque (crank PTO) | 4.5 Nm (0.46 kg.); at 6000 RPM |
| Clutch method | Manual wet multi plate |
| Gears | 4 |
| Cooling system | Forced air |
| Ignition system | Capacitive Discharge Ignition CDI |
| Starting system | Electric or kick |
| Fuel consumption | 45 Km/L |
| Oil capacity | 7.0L |

| | |
|---|---|
| Engine cylinder bore | 47.0 mm (1.85 in) |
| Piston stroke length | 41.4 mm (1.63 in) |

## 4. EFI Kit

After implanting the EFI System on a 70cc bike-engine, the labelled figure is shown as Figure 1.
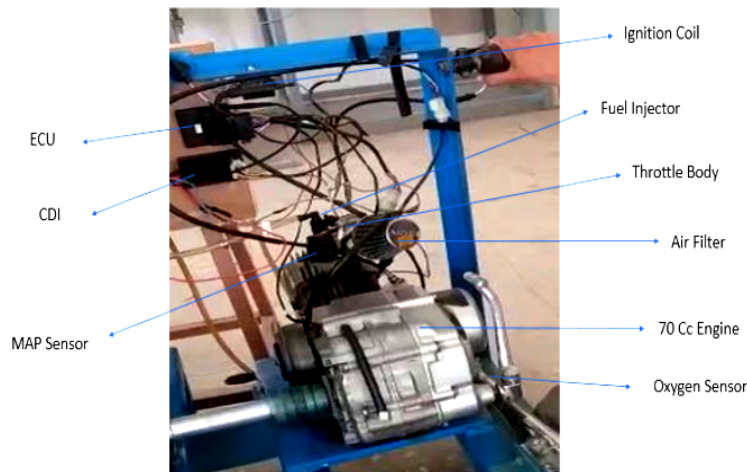


**Fig. 1.** EFI kit for 70cc engine

ECU and harness control the fuel-injection and spark timing to ignite the fuel in petrol engines. The throttle body mechanism enables to control of the air-fuel mixture or fluid flow by changing the angle of the throttle valve. Integrated sensor (MAP Sensor) provides information to ECU to measure air density and the engine's (air) mass flow rate which determines the required amount of fuel injection for complete combustion. Fuel pressure was generated using the pump to regulate fuel pressure against air pressure. A diaphragm regulator was used to control the bypass valve whereas the injector acted as a spray nozzle to distribute the fuel-spray. CDI stores the charge to supply it to the spark plug. The purpose of the oxygen sensor was to communicate to the ECU if the air fuel mixture was correct or not by means of leftover oxygen in the exhaust to determine rich or lean air fuel mixture. TPS sensor was used to monitor the air intake of an engine whereas MAT sensor was used to measure the temperature of air intake then the data was sent to ECU for further processing to control air fuel ratio according to the temperature of air intake.

## 5. Results Experimental Results and Fuel Emission Analysis

Specific fuel consumption readings were taken under three different conditions: (a) at no load with varying RPM (b) at constant load with different RPM (c) at varying load with approximately equal RPM; when the carburetor is attached to the engine are shown in Table 2, 3 and 4 respectively.

**Table 2**
Fuel consumption for carburetor (idle condition or no load)

| Sr. No. | RPM | Meter reading (ml) | | Difference (ml) | Time (s) | Fuel consumption |
| | | Initial | Final | | | $M_f$=ml/s |
|---|---|---|---|---|---|---|
| 1 | 1200 | 200 | 187.5 | 12.5 | 300 | 0.0416 |
| 2 | 1330 | 180 | 171 | 9 | 300 | 0.0300 |
| 3 | 1512 | 165 | 155 | 10 | 300 | 0.0333 |
| 4 | 1620 | 150 | 139 | 11 | 300 | 0.0366 |
| 5 | 1980 | 135 | 121 | 14 | 300 | 0.0467 |

| 6 | 2098 | 115 | 100 | 15 | 300 | 0.0500 |
| 7 | 2298 | 95 | 78 | 17 | 300 | 0.0567 |

**Table 3**
Fuel consumption for carburetor (at constant load)

| Sr. No. | RPM | Load (kg) | | | Meter reading (ml) | | Difference (ml) | Time (s) | Fuel consumption $M_f$=ml/s |
| | | $M_1$ | $M_2$ | $M = M_1 - M_2$ | Initial | Final | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1338 | 3.5 | 2 | 1.5 | 150 | 140 | 10 | 300 | 0.0333 |
| 2 | 1433 | 3.5 | 2 | 1.5 | 135 | 124 | 11 | 300 | 0.0367 |
| 3 | 1640 | 3.5 | 2 | 1.5 | 120 | 107.5 | 12.5 | 300 | 0.0417 |
| 4 | 1965 | 3.5 | 2 | 1.5 | 100 | 87 | 13 | 300 | 0.0433 |
| 5 | 2152 | 3.5 | 2 | 1.5 | 80 | 65 | 15 | 300 | 0.0500 |

**Table 4**
Fuel consumption for carburetor (at variable load by keeping RPM constant)

| Sr. No. | RPM | Load (kg) | | | Meter reading (ml) | | Difference (ml) | Time (s) | Fuel consumption $M_f$=ml/s |
| | | $M_1$ | $M_2$ | $M = M_1 - M_2$ | Initial | Final | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2131 | 3.5 | 2 | 1.5 | 150 | 135 | 15 | 300 | 0.0500 |
| 2 | 2129 | 4.5 | 2 | 2.5 | 130 | 113.5 | 16.5 | 300 | 0.0550 |
| 3 | 2112 | 5.5 | 2 | 3.5 | 105 | 87 | 18 | 300 | 0.0600 |
| 4 | 2107 | 6.5 | 2 | 4.5 | 80 | 59 | 21 | 300 | 0.0700 |
| 5 | 2100 | 7.5 | 2 | 5.5 | 100 | 76 | 24 | 300 | 0.0800 |

Readings of specific fuel consumption were taken under three different conditions: (a) at no load with varying RPM (b) at constant load with different RPM (c) at varying load with approximately equal RPM; when the EFI System is attached with the engine are shown in Table 5, 6 and 7 respectively.

**Table 5**
Fuel consumption for EFI (idle condition or no load)

| Sr. No. | RPM | Meter reading (ml) | | Difference (ml) | Time (s) | Fuel consumption $M_f$=ml/s |
| | | Initial | Final | | | |
|---|---|---|---|---|---|---|
| 1 | 1200 | 185 | 175 | 10 | 300 | 0.0333 |
| 2 | 1340 | 70 | 63 | 7 | 300 | 0.0233 |
| 3 | 1500 | 83 | 75 | 8 | 300 | 0.0267 |
| 4 | 1623 | 157 | 148 | 9 | 300 | 0.0300 |
| 5 | 1953 | 105 | 93.5 | 11.5 | 300 | 0.0383 |
| 6 | 2031 | 140 | 128 | 12 | 300 | 0.0400 |
| 7 | 2280 | 122 | 108 | 14 | 300 | 0.0467 |

**Table 6**
Fuel consumption for EFI (at constant load)

| Sr. No. | RPM | Load (kg) | | | Meter Reading (ml) | | Difference (ml) | Time (s) | Fuel consumption $M_f$=ml/s |
| | | $M_1$ | $M_2$ | $M = M_1 - M_2$ | Initial | Final | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1325 | 3.5 | 2 | 1.5 | 187 | 179 | 8 | 300 | 0.0267 |
| 2 | 1420 | 3.5 | 2 | 1.5 | 175 | 166 | 9 | 300 | 0.0300 |
| 3 | 1627 | 3.5 | 2 | 1.5 | 165 | 155 | 10 | 300 | 0.0333 |
| 4 | 1952 | 3.5 | 2 | 1.5 | 154 | 143 | 11 | 300 | 0.0367 |
| 5 | 2139 | 3.5 | 2 | 1.5 | 137 | 125 | 12 | 300 | 0.0400 |

**Table 7**
Fuel consumption for EFI (at variable load by keeping rpm constant)

| Sr. No. | RPM | Load (kg) | | | Meter reading (ml) | | Difference (ml) | Time (s) | Fuel consumption $M_f$=ml/s |
|---|---|---|---|---|---|---|---|---|---|
| | | $M_1$ | $M_2$ | $M = M_1 - M_2$ | Initial | Final | | | |
| 1 | 2139 | 3.5 | 2 | 1.5 | 137 | 125 | 12 | 300 | 0.0400 |
| 2 | 2137 | 4.5 | 2 | 2.5 | 114 | 101 | 13 | 300 | 0.0433 |
| 3 | 2120 | 5.5 | 2 | 3.5 | 100 | 85 | 15 | 300 | 0.0500 |
| 4 | 2115 | 6.5 | 2 | 4.5 | 83 | 65 | 18 | 300 | 0.0600 |
| 5 | 2108 | 7.5 | 2 | 5.5 | 61 | 41 | 20 | 300 | 0.0667 |

A comparative graphical illustration of specific fuel consumption under different conditions is shown below: (a) fuel consumption (at no load with varying RPM) for both EFI and CFI is shown in Figure 2, which illustrates that as RPM increased, fuel consumption decreased up to an optimum point but beyond this point, fuel consumption also increased. (b) fuel consumption (at constant load with different RPM) for both EFI and CFI is shown in Figure 3, which illustrates that there is an approximately inclined straight-line behavior at constant load which means that as RPM was increased fuel consumption also increased and vice versa. (c) fuel consumption (at varying loads with approximately equal RPM) for both EFI and CFI is shown in Figure 4, which illustrates that if RPM were maintained to keep it approximately constant with an increase in load, fuel consumption also increased to produce the same torque as produced prior to the increase in load.
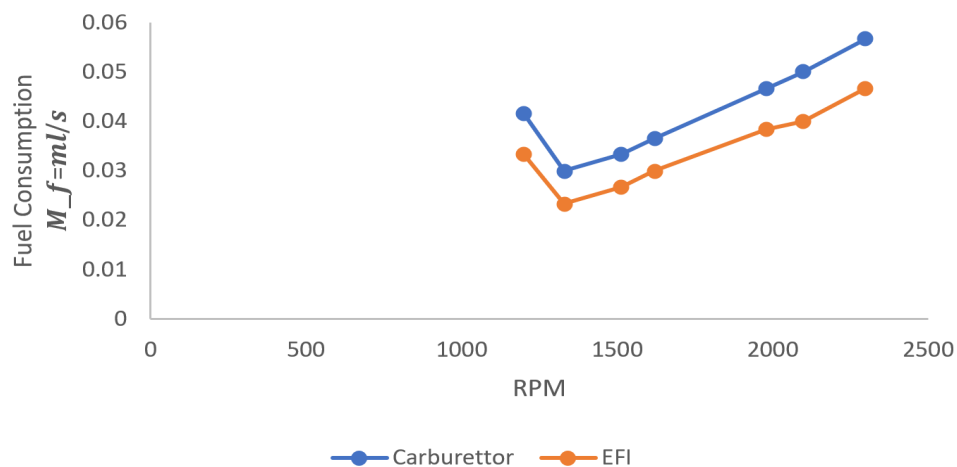


**Fig. 2.** Fuel consumption (idle condition or no load)
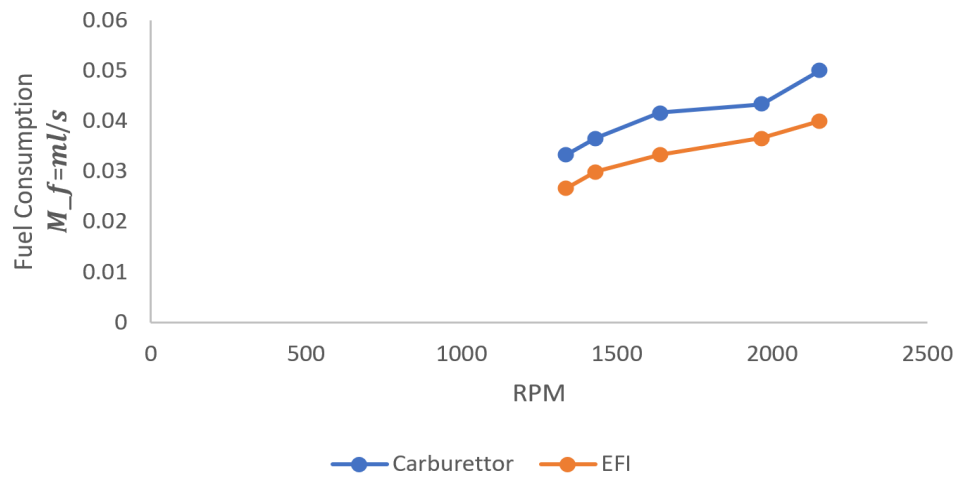
**Fig. 3.** Fuel consumption (at constant load)
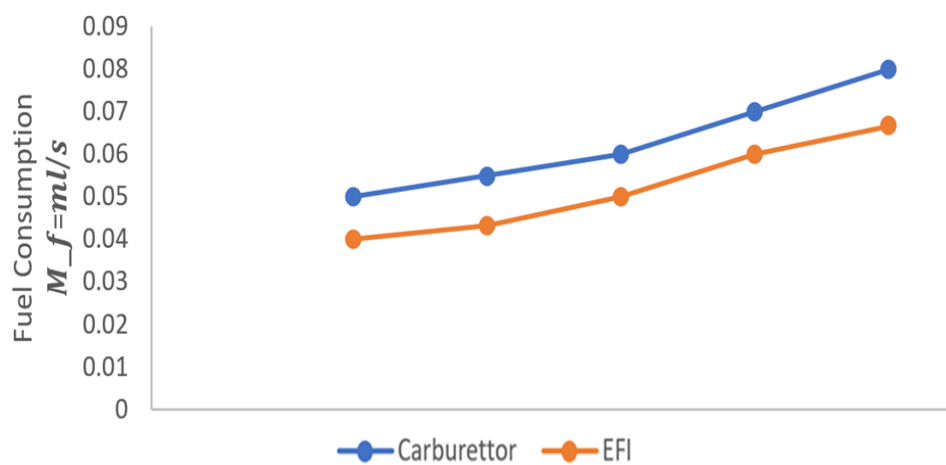


**Fig. 4.** Fuel Consumption (at variable load by keeping RPM constant)

The combined graph of fuel consumption of CFI and EFI setup under the aforementioned three conditions is given in the table below in Figure 5.
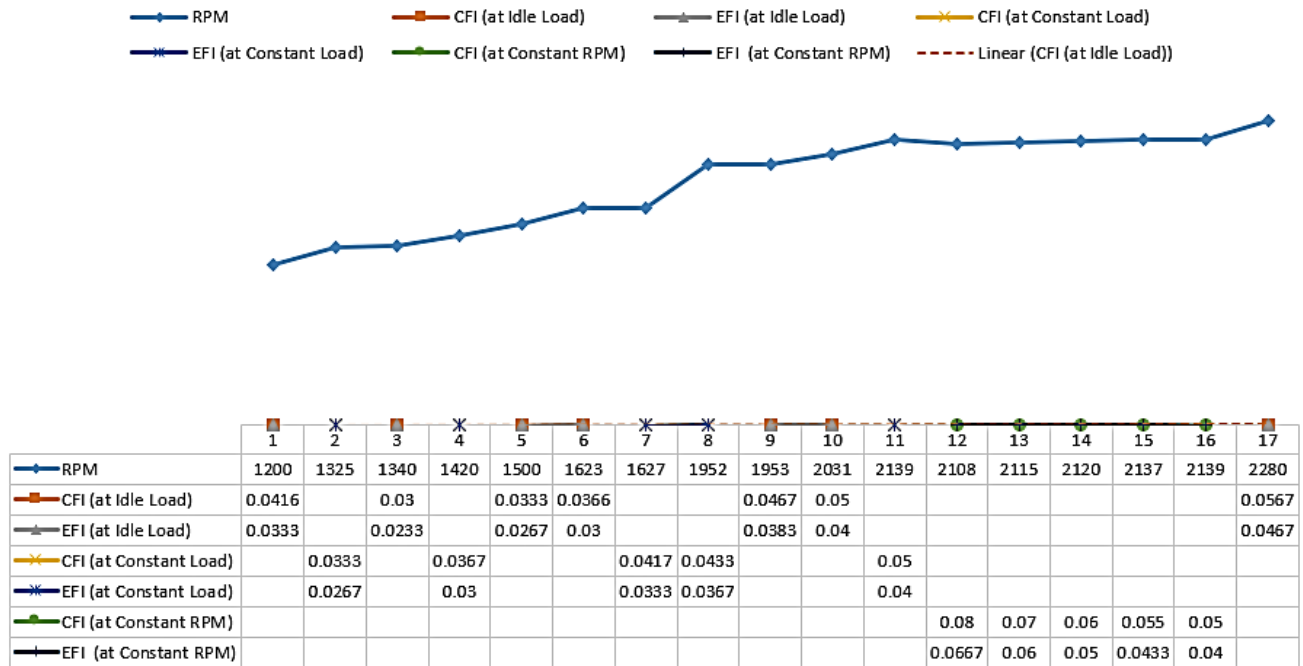
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RPM | 1200 | 1325 | 1340 | 1420 | 1500 | 1623 | 1627 | 1952 | 1953 | 2031 | 2139 | 2108 | 2115 | 2120 | 2137 | 2139 | 2280 |
| CFI (at Idle Load) | 0.0416 | | 0.03 | | 0.0333 | 0.0366 | | | 0.0467 | 0.05 | | | | | | | 0.0567 |
| EFI (at Idle Load) | 0.0333 | | 0.0233 | | 0.0267 | 0.03 | | | 0.0383 | 0.04 | | | | | | | 0.0467 |
| CFI (at Constant Load) | | 0.0333 | | 0.0367 | | | 0.0417 | 0.0433 | | | 0.05 | | | | | | |
| EFI (at Constant Load) | | 0.0267 | | 0.03 | | | 0.0333 | 0.0367 | | | 0.04 | | | | | | |
| CFI (at Constant RPM) | | | | | | | | | | | | 0.08 | 0.07 | 0.06 | 0.055 | 0.05 | |
| EFI (at Constant RPM) | | | | | | | | | | | | 0.0667 | 0.06 | 0.05 | 0.0433 | 0.04 | |

**Fig. 5.** Combined graph of fuel consumption and RPM, under a. idle load, b. constant load, c. constant RPM

A comparison of specific fuel consumption had been made for CFI and EFI systems. There was an 18.57 percent reduction in fuel consumption in EFI engines as compared to carbureted engines. Furthermore, averages of specific fuel consumption under three different conditions: (a) at no load with varying RPM (b) at constant load with different RPM (c) at varying load with approximately equal RPM are shown in Tables 8, 9 and 10 respectively.

**Table 8**
Fuel consumption (idle condition or no load)

| Carburetor (ml) / 300s | EFI (ml) / 300s | Percentage decrement (%) |
|---|---|---|
| 12.5 | 10 | 20 |
| 9 | 7 | 22.22 |
| 10 | 8 | 20 |
| 11 | 9 | 18.18 |
| 14 | 11.5 | 17.86 |
| 15 | 12 | 20 |
| 17 | 14 | 17.64 |
| Average fuel consumption in decrement in percentage | | 19.13 |

**Table 9**
Fuel consumption (at constant load)

| Carburetor (ml) / 300s | EFI (ml) / 300s | Percentage decrement (%) |
|---|---|---|
| 10 | 8 | 20 |
| 11 | 9 | 18.18 |

| 12.5 | 10 | 20 |
| 13 | 11 | 15.38 |
| 15 | 12 | 20 |
| Average fuel consumption in decrement in percentage | | 18.14 |

**Table 10**
Fuel consumption (at variable load by keeping RPM constant)

| Carburetor (ml) / 300s | EFI (ml) / 300s | Percentage decrement (%) |
| --- | --- | --- |
| 15 | 12 | 20 |
| 16.5 | 13 | 21.21 |
| 18 | 15 | 16.67 |
| 21 | 18 | 14.28 |
| 24 | 20 | 16.67 |
| Average fuel consumption in decrement in percentage | | 17.76 |

Exhaust products and their effects on the environment were also analyzed. During complete combustion Nitrogen ($N_2$), Oxygen ($O_2$) and water ($H_2O$) were the exhaust gases while exhaust gases during incomplete combustion are given in Table 11.

**Table 11**
Flue emissions and their effects during incomplete combustion

| Gases | Effects |
| --- | --- |
| Carbon Dioxide ($CO_2$) | • Greenhouse gases<br>• Global warming |
| Carbon Monoxide (CO) | • Reduce ability of blood to holds oxygen<br>• Headaches<br>• Respiratory problems<br>• Death |
| Nitrogen Oxides ($NO_x$) | • Acid rain<br>• Asthma |
| Sulphur Dioxide ($SO_2$) (from lubrication oil) | • Acid rain<br>• Engine corrosion<br>• Ozone formation |
| Hydrocarbons (HC) | • Asthma |

After analyzing specific fuel consumption, exhaust flue gases were also checked and analyzed and it was observed that there was a reduction in parts per million (ppm) of flue gases i.e., CO by 400

ppm, NO by 5 ppm and SO$_2$ by 63 ppm in EFI system as compared to CFI as shown in Table 12. Flue Gas Analyzer E4400 (e-instrument) was used to measure emissions.

**Table 12**
Flue emissions results

| 1 | Carburetor (ppm) | EFI (ppm) | Difference (ppm) |
|---|---|---|---|
| CO | 9800 | 9400 | 400 |
| NO | 7 | 2 | 5 |
| SO$_2$ | 131 | 68 | 63 |

## 6. Cost Recovery Analysis

In this section cost analysis and recovery of bike-cost after implanting EFI kit on bikes for normal and commercial users was taken into consideration, where normal users are mainly students and regular office-job persons on the other hand commercial users are mainly couriers and delivery boys. Cost analyses for normal and commercial users are shown in Tables 13 and 14. Furthermore, the recovery period of the EFI kit is also given in Table 15.

**Table 13**
Cost analysis for normal user

| For normal user | Carbureted bike | EFI bike |
|---|---|---|
| Fuel average in 1 liter | 45 km | 55.26 km |
| Distance travelled by bike in 1 day | 25 km | 25 km |
| Price of 1-liter petrol | PKR 110 | PKR 110 |
| User spent on petrol in 1 day | PKR 61.11 | PKR 49.76 |
| User spent on petrol in 1 year | PKR 22,305 | PKR 18,164 |
| Price difference (1 Year) | PKR 22,305 – 18,164 = PKR 4,141 | |

**Table 14**
Cost analysis for commercial user

| For commercial user | Carbureted bike | EFI bike |
|---|---|---|
| Fuel average in 1 liter | 45 km | 55.26 km |
| Distance travelled by bike in 1 day | 100 km | 100 km |
| Price of 1-liter petrol | PKR 110 | PKR 110 |
| User spent on petrol in 1 day | PKR 244.44 | PKR 199.05 |
| User spent on petrol in 1 year | PKR 89,222 | PKR 72.656 |
| Price difference (1 Year) | PKR 89,222 – 72,656 = PKR 16,566 | |

**Table 15**
Recovery period of EFI kit

| Price of EFI kit PKR 15,000 | For normal user | For commercial user |
|---|---|---|
| Per year saving | PKR 4,141 | PKR 16,566 |
| EFI kit price recovery period | 4 years | Less than 1 year |

## 7. Conclusion

From the results based on specific fuel consumption, flue gas emission analysis and cost analysis of carburetor vs electronic fuel injection engines in 70cc bikes, the following comments were deduced:

i. 18.57 percent reduction in fuel consumption in EFI engines as compared to carbureted engines.
ii. EFI engines are more eco-friendly as compared to the carbureted engine having a reduction of 400 ppm in carbon monoxide, 7 ppm in nitrogen oxide and 63 ppm in sulphur dioxide.
iii. EFI in 70cc engines are more profitable than carbureted engines for normal users as well as for commercial user.
iv. Normal user saves PKR 4,141 per year and commercial users save PKR 16,556 per year in 70cc EFI engines.

It was evident from the above case study that CFI conversion to EFI results in reduced fuel consumption and emissions thereby improving the economy of the engine/vehicle. Moreover, it cost difference of PKR 15,000 for an EFI Kit could easily be recovered in a year by the commercial user thereby sustainable for overall reduced fuel consumption as the majority of the people in a country like Pakistan use motorbikes, and rickshaws. So, in short by implementing this idea, country reserves and the environment could be saved.

## Acknowledgement

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