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Implementation of EFI System in 70cc Bike

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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.

Keywords:
Carbureted fuel engines; electronic fuel injection engines; emission analysis

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 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.

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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.

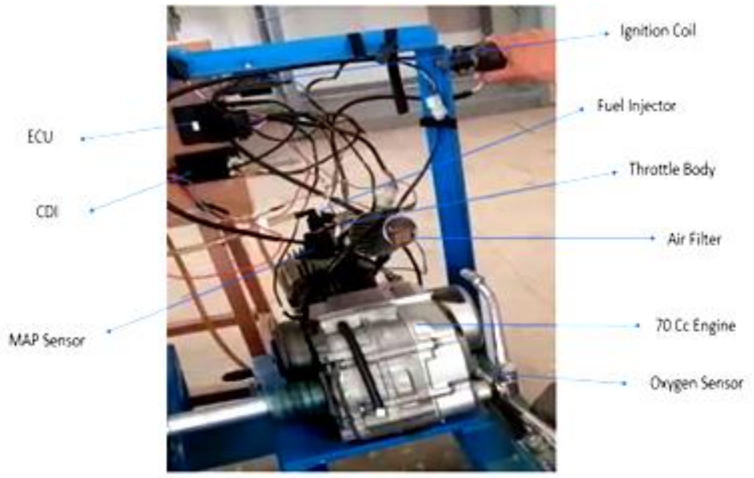


Fig. 1. EFI kit for 70cc engine

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 $M_f = ml/s$
		Initial	Final			
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 $\mathbf{M_f = ml/s}$
		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 $\mathbf{M_f = ml/s}$
		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 $\mathbf{M_f = ml/s}$
		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 $\mathbf{M_f = ml/s}$
		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 $\mathbf{M_f=ml/s}$
		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.

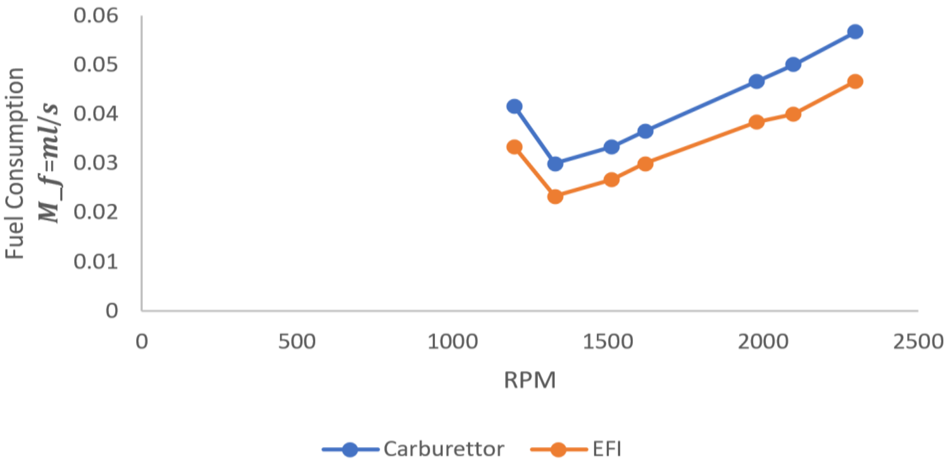


Fig. 2. Fuel consumption (idle condition or no load)

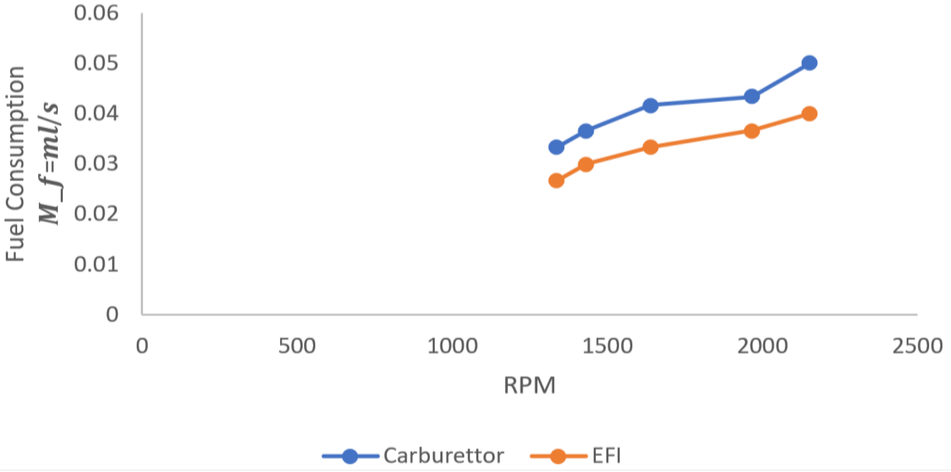


Fig. 3. Fuel consumption (at constant load)

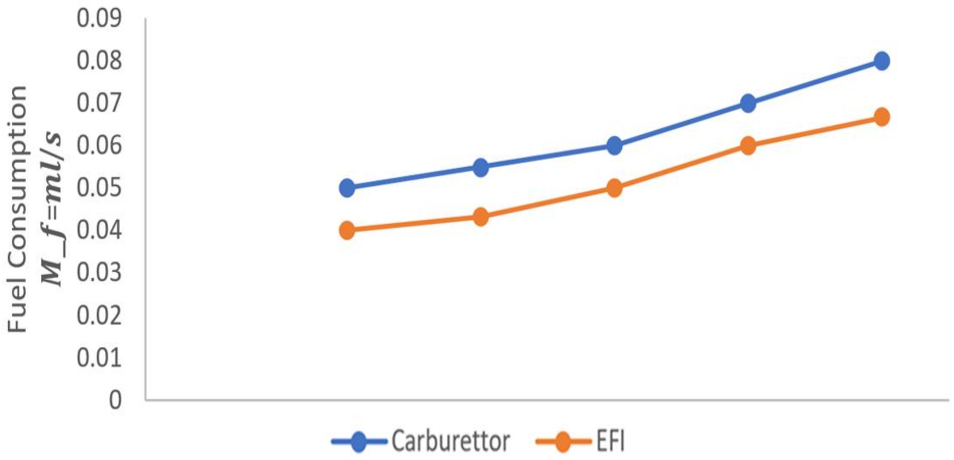
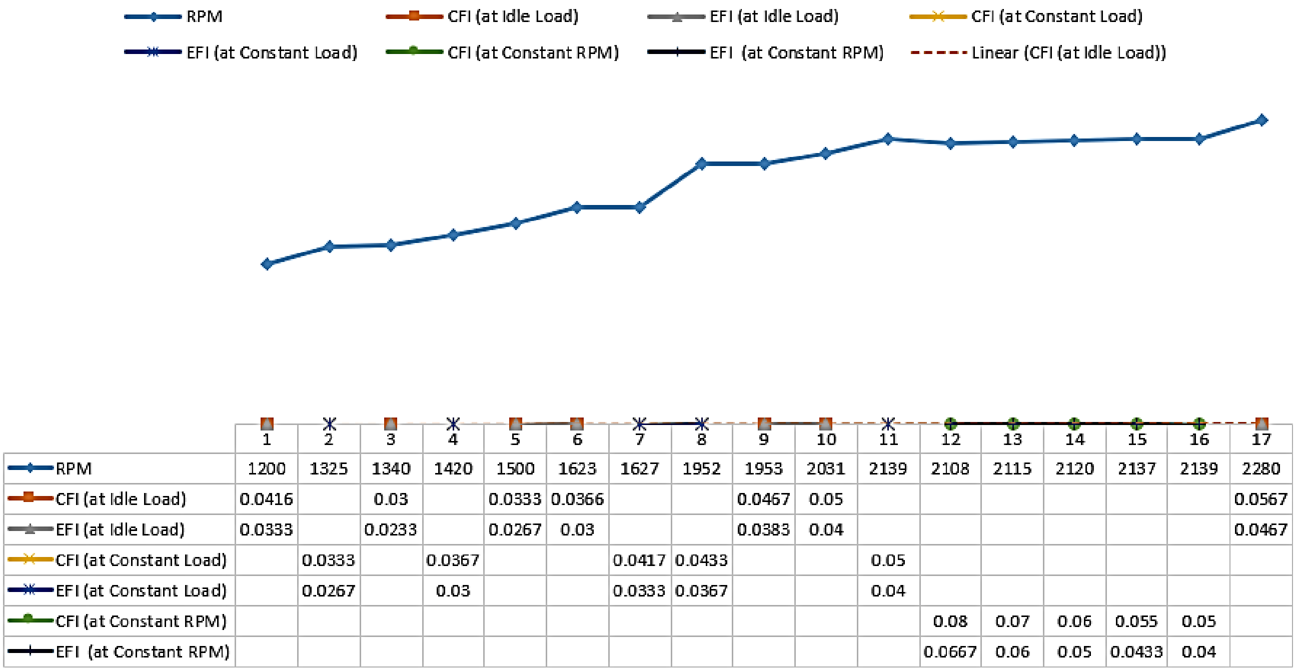


Fig. 4. Fuel Consumption (at variable load by keeping RPM constant)

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 - Global warming
Carbon Monoxide (CO)	- Reduce ability of blood to holds oxygen - Headaches - Respiratory problems - Death
Nitrogen Oxides (NO_x)	- Acid rain - Asthma
Sulphur Dioxide (SO_2) (from lubrication oil)	- Acid rain - Engine corrosion - 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.

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References

[1] Schock, H., Zhu, G., Toulson, E., & Stuecken, T. R. U.S. Patent No. 10,161,296. WASHINGTON, DC: U.S. PATENT AND TRADEMARK OFFICE. (2018)

[2] Shiraishi, T., Ohsuga, M., & Fujieda, M. U.S. Patent No. 6,055,948. WASHINGTON, DC: U.S. PATENT AND TRADEMARK OFFICE. (2000).

[3] Sadakane, S., & Yonezawa, K.. U.S. Patent No. 7,082,926. WASHINGTON, DC: U.S. PATENT AND TRADEMARK OFFICE. (2006)

[4] Deshmukh, V. R., and A. B. Atpadkar. "Analysis of IC Engine to Improve Performance due to Grooves on Engine Cylinder Head." (2019).

[5] Duncan, Bill, Brian Remsen, I. I. David Pick, and Dylan Johann. "Single Cylinder Four Stroke Four Valve Engine Optimization."

[6] Kunjam, Ram Kumar, Prakash Kumar Sen, and Gopal Sahu. "A Study on advance electronic fuel injection system." *Int. J. Sci. Research and Mgmt* 3, no. 10 (2015): 1-6.

[7] Grau, José Hernández, Ragusa Simone, and Stefano D'ambrosio. "Development of a numerical model for injection control system of an ECU for single-cylinder 4-stroke motorcycle engines with different displacements." (2019).

[8] Mon, Su Su Yi. "Capacitive Discharge Ignition CDI System for Spark Ignition SI Engine Pulse Control Circuit." *Int. J. Trend Sci. Res. Dev. Int. J. Trend Sci. Res. Dev* 3, no. 5 (2019): 1925-1929.

[9] Kalvin, Roman, Juntakan Taweekun, Kittinan Maliwan, and Hafiz Muhammad Ali. "Fabrication of catalytic converter with different materials and comparison with existing materials in addition to analysis of turbine installed at the exhaust of 4 stroke SI engine." *Sustainability* 13, no. 18 (2021): 10470. https://doi.org/10.3390/su131810470

[10] Kim, Kwon Se, Mun Seok Choe, and Doo Seuk Choi. "Effect of combustion reaction based on capacitive discharge ignition in air-propane equivalence ratio." *International Journal of Automotive Technology* 20 (2019): 855-866. https://doi.org/10.1007/s12239-019-0080-1

[11] Ilham, Zul. "Multi-criteria decision analysis for evaluation of potential renewable energy resources in Malaysia." *Progress in Energy and Environment* 21 (2022): 8-18. https://doi.org/10.37934/progee.21.1.818

[12] Khairi, Danial Mohd, Mohd Azman Abas, Mohd Farid Muhamad Said, and Wan Saiful-Islam Wan Salim. "Fuel consumption mathematical models for road vehicle–A review." *Progress in Energy and Environment* (2021): 59-71.

[13] Ismail, Ainaa Maya Munira, Zurriati Mohd Ali, Kamariah Md Isa, Mohammad Abdullah, and Fazila Mohd Zawawi. "Study On the Potentiality of Power Generation from Exhaust Air Energy Recovery Wind Turbine: A Review." *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* 87, no. 3 (2021): 148-171. https://doi.org/10.37934/arfmts.87.3.148171