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Experiment Study on JS125-6A EFI Motorcycle for European Emission Regulation

Abstract: *Based on the JS125-6 A motorcycle, the electronic control fuel injection system and develop the electronic control system software was designed. The MAP figure of the electronic control fuel injection system advanced ignition angle is obtained through experiments. Based on the result, a series tests are conducted, including external characteristic of the motorcycle test, dynamic performance test, emission characteristics and durability test and other related test. Those results show that compared to the old system, the new system improves EFI system's engine performance.*

Streszczenie. *Przedstawiono projekt systemu kontroli wtrysku paliwa na przykładzie silnika JS125-6 A. System bazuje na rezultatach testów charakterystyki silnika, właściwości dynamicznych czy emisji spalin. (**Studia eksperymentalne silnika JS 125-6A EFI pod kątem europejskich wymagań emisji spalin**)*

Keywords: motorcycle; the electronic control fuel injection system; control strategy; emission control
Slowa kluczowe: elektroniczna kontrola wtrysku paliwa, kontrola emisji spalin.

Preface

Based on the escalating energy shortage and pollution, regulations on motor vehicle's exhaust emission are becoming more strictly worldwide, so is motorcycle. How to manage and control the motorcycle exhaust pollution to the atmosphere has become an urgent problem. The existing motorcycle engine's structure and technique lag behind; the motorcycle's exhaust emission is difficultly to achieve the standard of Europe three. So eliminate the old products, improve the emissions of motorcycle control technology, raise fuel economy, improve comfort is China's motorcycle industry's major problem of this moment. With the execution of EUOR-Ⅲ standards, motorcycle emissions will be the biggest technical problems faced by all motorcycle enterprise.

1 Technical proposal

1.1 Composition and function of EFI

This project's development used JS125-6A motorcycle as the test motorcycle, conducted a test on electronic fuel injection control system. In the process, according to motorcycle's character of wide engine speed range and cost relatively low, developed a special electronic control fuel injection system. The system consists of: air feed system, fuel feed system, ignition system and the electronic control system etc. One sensor including: throttle position sensor, intake air temperature-sensor, camshaft position sensor, engine coolant temperature sensor, etc. electronic control module (ECU) according to the information about the throttle valve provided by the sensor and rotary speed to determine the basic injection quantity and basic advanced ignition Angle, and then according to the information about cooling fluid temperature and the temperature of the injected air revised basic injection quantity and basic advanced ignition Angle. Obtain the best injection quantity and advanced ignition angle, and then actuators deliver these data to electronic control module (ECU) to control the engine. Executive components in the electronic control fuel injection system including: injector, electric purl pump, idle air control valve (IAC), ignition coil. At the same time in the intake manifold take the fuel injection method, which can make the system has higher performance-price ratio [1].

1.2 System software of EFI design includes

C language is chosen to be the development language, language ATMega168 microprocessor, this processor's corresponding development platform is perfect, can effectively support language C to conduct program design. The control system software has optimization design for fuel control, idling-speed control, ignition system and various kinds of control function [2]. Software control flow chart showed in figure 1.

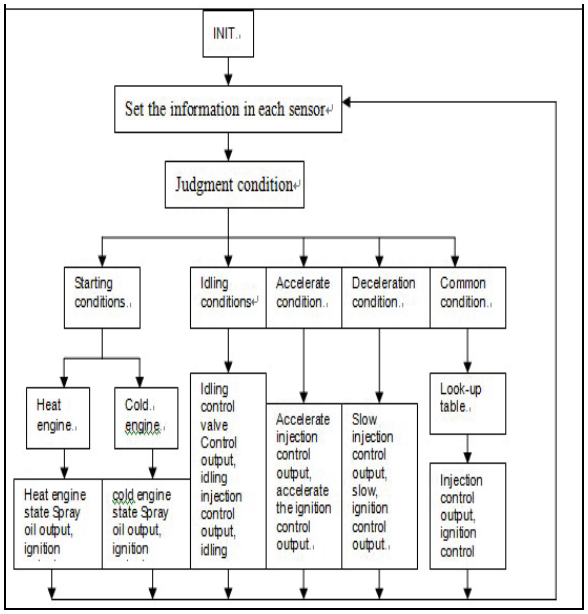

Fig.1. JS125-6A motorcycle EFI system software control diagram

1.2.1 Date flow analysis

The electronic control fuel injection system software involves large amount of parts which are too related to hardware. Considering the convenience of development, debugging and maintains of software, the main function modules are required to be independent from the hardware. As a result, the connection between hardware and upper algorithm should be designed correctly to guarantee the software will not despond on the hardware directly. So two intermediate procedures should be added in the software data process, state parameter storage areas and execution parameters storage area, to use public coupling way and add Hardware driver layer to isolate hardware.

Between state parameter and execution parameters are upper algorithm modules, which is unrelated to hardware. It including oil amount calculation, ignition calculation, communication management, alarm management, the rest of the elliptic expressed hardware driver modules and the parts closely related to hardware. State parameter and execution parameters of two rectangles are the data interface mentioned before.

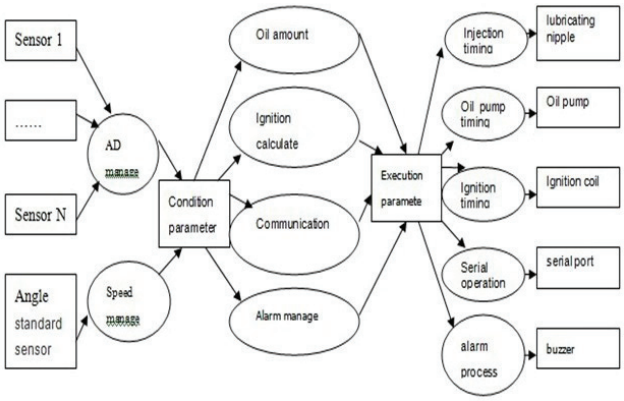

Fig.2. MPO EFI data flow chart

1.2.2 Management scheduling process

Motorcycle electronic control fuel injection system management software has high real-time requirements and timing order requirement, combined with the interruption work mode of the microprocessor peripherals, took the "front desk program/background program" structure. Front desk program is responsible for handling high real-time requirement parts, such as: data collection and oil spraying, ignition timing [3]. Use micro processor's interruption model to achieve; the background processing parameters handling low real-time part, main function in the cycle of the Lord come true. Plus, because of the engine is cyclic running , and each part is orderly working, so software control process is cyclic conduct, and each cycle's each module in orderly calculated. Considering the above situation, basic scheduling as follows: Subscript TDC signal starts the cycle , in which the client service function to run immediately start collecting module , and call management module speed and stroke . Since the time of the demand is high. Can call computer module start calculating the main parameters; slowly change parameters such as temperature can use last work cycle's values.

2 Determine the angle of ignition MAP

After JS125-6A motorcycle of electronic control fuel injection system research development comes out, conduct the MAP of the system optimized matching tests. This experiment used the 75 kWDCD dc power dynamometer and PEMOTOR45 communication power dynamometer to acquire and calibrate the data of the angle of ignition MAP. The angle of ignition calibration scope is:

The throttle opening range is from 10% to 100%.

The inlet pressure is from 30 kPa to 100 kPa.

The calibration of the control data basically covered all conditions of this type of motorcycle's normal work can appear. Calibration results showed in figure 2.

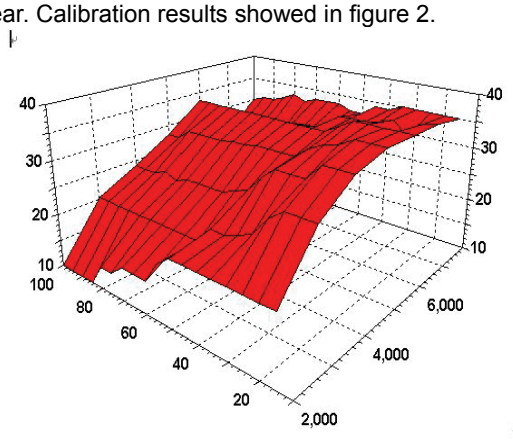

Fig.3. JS125-6A angle of ignition advance MAP

3 JS125-6A motorcycle electronic control vehicle fuel injection system tests

This project conduct a lot of validation, contrast test on JS125-6A vehicle and the original carburetor motorcycle equipped with electronic control of the fuel injection system, test items include: the engine external characteristics test, vehicle emission ageing test, starting performance (top speed and acceleration performance, Climbing performance[4], fuel economy performance and emission performance. The test motorcycle equipped with electronic control fuel injection system's test results meet the EUOR-III standards. Furthermore, tests about comfort evaluation show that: the electronic control fuel injection system's test motorcycle's comfort is superior to that of the carburetor motorcycle.

3.1 The engine characteristic test

JS125-6A motorcycle engine outside characteristics data see table 1.

Table 1. the engine performance date

Rotate speed(rpm)	Torque（N·M）		Power（kW）		Fuel consumption g/(kW·h)	
	EFI	Carburetion	EFI	Carburetion	EFI	Carburetion
3 512	8.76	8.13	3.27	2.87	305	315
4 026	9.16	8.24	3.75	3.48	287	312
4 528	9.21	8.58	4.33	4.03	294	309
5 037	9.15	8.53	4.79	4.47	307	320
5 529	8.95	8.46	5.14	4.86	318	334
5 982	8.56	8.14	5.37	5.1	327	341
6 110	8.19	7.83	5.57	5.3	336	355
6 987	7.74	7.43	5.67	5.44	346	370
7 496	7.21	6.83	5.65	5.36	359	389
8 013	6.74	6.19	5.66	5.19	369	428

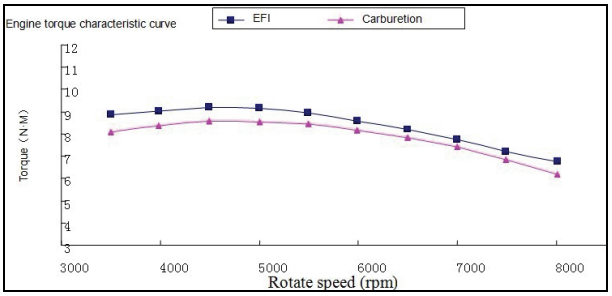

Fig.4. The torque of engine characteristic curve

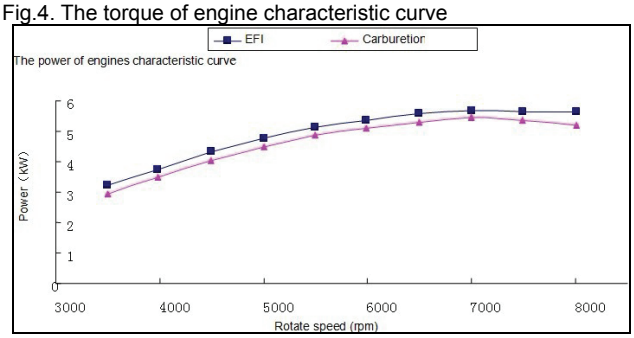

Fig.5.The power of engines characteristic curve

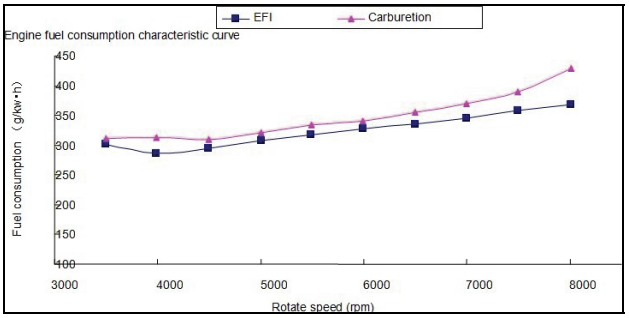

Fig.6. Engine fuel consumption characteristic curve

The torque of engine characteristic curve was shown in figure 4

After data processing the conclusion shows: the engine's max torque is 4 512 RPM, 9.26 N·M, more than the original engine increased about 7.5%; the maximum power point now is 7 260 RPM, 5.67 KW, improved about 4%; the minimum fuel consumption appeared in 4 000 RPM, reaching 287 g/ (kW·h), down about 8%. clearly, equipped with electronic control fuel injection system of motorcycle engine's torque and power, fuel economy improved significantly compare to carburetor engine.

3.2 Vehicle emission characteristic experimentation

According to the EUOR-Ⅲ cyclic test's requirement, use electronic fuel injection system's motorcycle conduct an emission control test.

3.2.1 Working condition

Test require engine's size is less than 150 ml of the two rounds of the motorcycle, conduct six consecutive cycle around downtown , last 1 200 s. The experimental results are shown in figure 7.

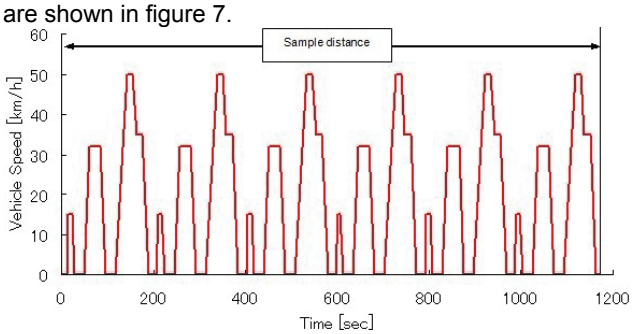

Fig.6. Engine size of less than 150 ml of the two rounds of the motorcycle operation cycle

The working condition's emission test is based on the durability test, measurement results in comparison to EUOR-Ⅲ standard, and the results as shown in table 2.

Tab.2. Durability test data in-use light-duty gasoline-fuelled vehicles emissions

Test project	Experimental basis for			Test results				
				Test mileage (km)				
	Standard	Limits	Unit	0	1 000	3 000	6 000	12 000
CO	EUOR-Ⅲ	≤2.0	g/km	0.96	0.86	0.92	0.94	1.40
HC		≤0.8		0.20	0.18	0.18	0.19	0.22
NO_x		≤0.15		0.05	0.04	0.07	0.09	0.09

Table 2 shows, equipped with electronic control injection system of motorcycle with the increase of the test mileage, the measured results slightly increased, but can completely meet the requirement of EUOR-Ⅲ emission regulations.

3.2.2 Idling condition

According to the requirements, measure the idling condition's pollutants. Idling process's requirement: the vehicle driving wheel dormant, the engine runs normally, throttle position at least, choke full open, the rotating speed meet vehicle operating instruction's regulations. The test data statistics are shown in table 3.

Table 3. The idle exhausts pollutants of test data

Category	Test project	Unit	Limits	Test results
Before durable	CO	%	≤3.8	1.2
	HC	10^{-6}	≤800	140
After durable	CO	%	≤4.0	1.5
	HC	10^{-6}	≤1 000	150

Data shows, the idle method exhaust emission's results are better than the EUOR-Ⅲ standards.

3.3 Dynamic performance tests

Motorcycle dynamic performance mainly include: the highest speed, and accelerating performance and climbing ability. This test conducts at change a university's car testing ground, test results shown in table 4.

Table 4 Vehicle performance test results

Test project		Limits	Unit	Measurement and value
Top speed		80	km/h	81.8
Acceleration performance	Started	≤17.0	s	14.7
	Over taking	≤16.0	s	14.7
Climbing ability		≥18	°	18

3.4 Other tests items

Other related tests results shown in table 3.5.

Table 5. Other project test results

Test project		Experimental basis for	Limits	Unit	Test result
Accelerating noise		EUOR-Ⅲ	≤77	dB(A)	73
Economic fuel consumption		EUOR-Ⅲ	≤2.1	L/100km	1.2
Starting performance	Feet	EUOR-Ⅲ	≤15	s	3.8
	Electric start	EUOR-Ⅲ	≤15	s	3.3

3.5 Analysis of experiment results

Through above test and verify, the JS125-6A motorcycle with EFI, which overall performance than carburetor engine has improved. And also satisfy the EUOR-Ⅲ.

The conclusions are as following:

(1) External characteristics of the equipped with electronic control injection system of engine is better than the carburetor engine. The engine's max torque is 4 512 RPM, 9.26 N·M, more than the original engine increased about 7.5%; the maximum power point now is 7 260 RPM, 5.67 KW, improved about 4%; the minimum fuel consumption appeared in 4 000 RPM, reaching 287 g/ (kW·h), down about 8%.

(2) The motorcycle with EFI which exhaust pollutants has achieve to the EUOR-Ⅲ,but carburetor motorcycle only can get EUOR-Ⅱ.

(3) The power of the engine performance can completely meet the EUOR-Ⅲ.

(4) In the tests, top speed, acceleration performance, Climbing performance in the motorcycle with EFI which are better than carburetor engine, and they are meet EUOR-Ⅲ of motorcycle of performance requirements.

(5) The speed of kilometers to fuel consumption of the economy is only 1.2 L, is below carburetor engine.

4 Conclusions

This work is about the invention and development of the type JS125-6A electronic control fuel jet system motorcycle, cooperating with a motorcycle verification institute. In the case of guaranteeing the basic driving properties, the sample motorcycle could meet the EUOR-Ⅲ standard. The economy and power of the motorcycle are improved, and the convenience of driving the motorcycle is also improved.

The conclusions are as following:

(1) Electronic control fuel jet system which could be used in motorcycle is developed successfully. Through the match test of part work situation of the developed electronic control fuel jet system, the fire advance angle MAP figure is acquired.

(2) The out property of the electronic control fuel jet system performances better than the vaporizer engine. The maximum torque is 4512 rmp, and reaches 9.26 N·M; the maximum power appears at 7260 rpm, and reaches 5.67 KW, increases about 4%; improves about 7.5% more than previous engine. the minimum fuel consuming power appears at 4000 rmp, reaches 287 g/（kW·h), decreases about 8%.

(3) The pollution emitted by the motorcycle which is

installed with the electronic control fuel jet system could meet the EUOR-III standard. However, the vaporizer engine could only meet the EUOR-II standard.

(4) The power property of the engine could meet the EUOR-III standard totally.

(5) The oil consumption of one hundred kilometers is only 1.2 L at the economic speed, much lower than the vaporizer motorcycle.

Although the electronic control fuel jet system has already been invented successfully, the system still has some defects, for example, the calibration is not perfect, the closed cycle control is not used and the signal of measurement is not accurate because parts of sensors has drifted. The questions stated above should be studied further.

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