Design and Applied Research of Corolla 1.6 AT Electronic Controlled Engine Experiment Bench

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Abstract: Experiment bench is based on Toyota Corolla 1.6 AT electronic controlled engine by use of the principle of virtuality and simulation, without mechanical system, but electrical control units are reserved. The bench has simple structure and low cost, and it is safe, environmental protection and economic when using; temperature sensor signals are simulated by variable resistance, and the working process of some actuators is shown using light bulbs, so that the whole bench is easy to operate, and the working process is visual and direct; the bench panel is equipped with measuring terminals to facilitate testing and practical teaching. The bench can also be independently developed, designed and produced by students under the guidance of teachers, which is beneficial to arousing the students' innovation consciousness.

At present, modern automobile has become a high-tech composite integrated with machine, electricity and liquid, of which the engine electronic control technology has been mature day by day, and its feature as the carrier of high and new technology is more and more obvious[1]. In order to strengthen practical teaching of automobile speciality in higher vocational colleges, and raise automobile students' professional skills, there is an urgent need to develop some teaching equipment suitable for the automobile development and conforming to the concept of modern vocational education, with low cost, no pollution, easy to use and safety. Nowadays, in terms of automobile speciality in vocational colleges, the "automobile engine electronic control technology" is deemed as a professional core course for teaching. To assist the theoretical and practical teaching of this course, it is necessary to develop an electronic controlled engine experiment bench, so that automobile students strengthen the awareness of electronic controlled engine, and master the detection and diagnosis ideas of common fault about electronic-controlled engine through repeated simulation experiment; teachers can improve their theoretical and practical level by developing and fabricating experimental equipment [2].

Overall Scheme And Composition Of The Experiment Bench

This experiment bench adopts Toyota Corolla 1.6 AT electronic controlled engine as a template, and has the system’s electronic control system, including sensor, ECU and actuators; only the mechanical parts accelerator pedal, crankshaft timing gear, crankshaft (timing) signal gear, timing chain, intake and exhaust camshaft timing gear, intake and exhaust camshaft (timing) signal gear are kept. All components of the electronic control system are connected with original wiring harness to form a set of systematic and complete automobile engine electronic control system with normal functions, and the system can simulate various operating conditions such as startup, idling, acceleration and deceleration. The whole system has the advantages such as simple structure, small size, low cost, economy, safety, no pollution and convenient detection.

As shown in Figure 1., this experiment bench consists of slide rheostat 1, storage battery 2, DC motor 3, ignition switch 4, normally open relay 5, oil atomizer relay 6, oil pump relay 7, water temperature sensor 8, oil pump indicator light 9, EFI main relay 10, crankshaft position sensor 11, exhaust camshaft timing oil control electromagnetic valve indicator light 12, intake camshaft timing oil control electromagnetic valve indicator light 13, air flow sensor with intake temperature sensor 14, oxygen sensor 15, exhaust mixing ratio sensor 16, charcoal canister electromagnetic valve

indicator light 17, knock sensor 18, intake camshaft position sensor 19, exhaust camshaft position sensor 20, throttle control unit with motor 21, accelerator pedal position sensor 22, capacitor 23, 1-cylinder fuel injector indicator light 24, 2-cylinder fuel injector indicator light 25, 3-cylinder fuel injector indicator light 26, 4-cylinder fuel injector indicator light 27, 1-cylinder ignition control module 28, 2-cylinder ignition control module 29, 3-cylinder ignition control module 30, 4-cylinder ignition control module 31, measuring terminal 32, fan DC motor 33, power control module ECM, and security control module (including key coil, transponder key amplifier and key transmission ECU) [3].

DC motor 3 is rotated by the homemade shaft driving the crankshaft timing gear and crankshaft signal gear, and the crankshaft signal gear provides the power control module ECM through the crankshaft position sensor 11 with the engine speed signal and crankshaft position signal [4]; at the same time, the crankshaft timing gear through the timing chain drives the intake and exhaust camshaft timing gear and the intake and exhaust camshaft signal gear to rotate, the intake camshaft signal gear through the intake camshaft position sensor 19 and the exhaust camshaft signal gear through the exhaust camshaft position sensor 20 provide the power control module ECM with intake and exhaust camshaft position signals [5]. The slide rheostat 1 is arranged below the accelerator pedal, and links with the accelerator pedal; when the accelerator pedal is stepped down, the resistance value is reduced, and on the contrary, its resistance value increases, which is used to control the speed of DC motor 3 (engine). The fan DC motor 33 connected in parallel with the DC motor 3 is arranged on the intake channel at the rear of the throttle body, to simulate the suction process when the piston runs downward in the intake stroke, and to provide the air flow sensor 14 with air intake flow; the air flow increases or decreases in synchronization with the accelerator pedal position and engine speed, and the lower accelerator pedal position, the higher air flow and engine speed.

The water temperature sensor 8 is replaced by a variable resistor with appropriate range of resistance value, and a different resistance value can simulate the corresponding signals; the 1-cylinder fuel injector indicator light 24, 2-cylinder fuel injector indicator light 25, 3-cylinder fuel injector indicator light 26, and 4-cylinder fuel injector indicator light simulate the working process of fuel injector, and the fuel injector indicator light is intermittently when the engine is working [6], but it is in the injection status when the indicator light is on; the charcoal canister electromagnetic valve indicator light 17 simulates the working state of the charcoal canister electromagnetic valve, and the charcoal canister electromagnetic valve is open when the light is on; the oil pump indicator light 9 simulates the working state of the electric oil pump, and the oil pump works when the light is on; the exhaust camshaft timing oil control electromagnetic valve indicator light 12, and intake camshaft timing oil control electromagnetic valve indicator light 13 simulate the working state of the corresponding timing oil control electromagnetic valve, and the corresponding electromagnetic valve is open when the light is on.

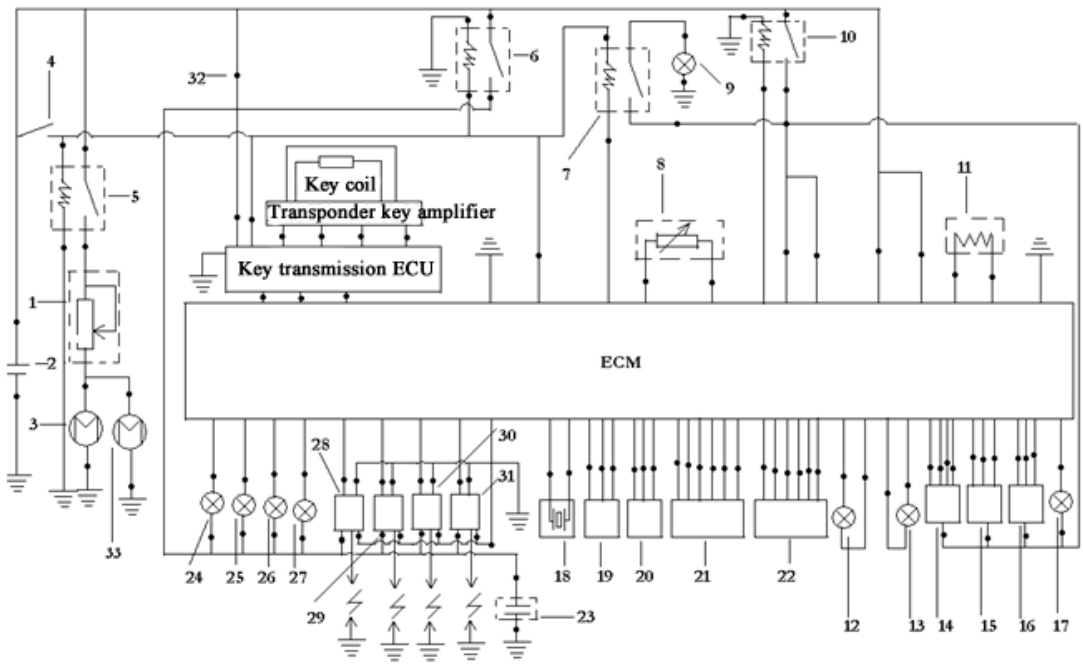

Fig. 1 Control schematic diagram

1-slide rheostat 2-storage battery 3-DC motor 4-ignition switch 5-normally open relay 6-injector control relay 7- oil pump relay 8- water temperature sensor 9- oil pump indicator light 10- EFI main relay 11-crankshaft position sensor 12-exhaust camshaft timing oil control electromagnetic valve indicator light 13-intake camshaft timing oil control electromagnetic valve indicator light 14-air flow sensor with intake temperature sensor 15-oxygen sensor 16-exhaust mixing ratio sensor 17-charcoal canister electromagnetic valve indicator light 18-knock sensor 19-intake camshaft position sensor 20-exhaust camshaft position sensor 21-throttle control unit with motor 22-accelerator pedal position sensor 23–capacitor 24-1-cylinder fuel injector indicator light 25-2-cylinder fuel injector indicator light 26-3-cylinder fuel injector indicator light 27-4-cylinder fuel injector indicator light 28-1-cylinder ignition control module 29-2-cylinder ignition control module 30-3-cylinder ignition control module 31-4-cylinder ignition control module 32-measuring terminal 33 - fan DC motor

Control Function And Working Process Of The Experiment Bench

This experiment bench can intuitively and strikingly show the working process of the automobile engine electronic control system. When the ignition switch 4 is closed, the storage battery provides each control unit with working power supply, and its main control functions are as follows.

Working Principle of the Security System. Transponder key amplifier is connected with the key transmission ECU by a total of four wires: 5V voltage reference provided by the key transmission ECU, signal transmission output of key transmission ECU, signal transmission input of key transmission ECU and bonding; the key transmission ECU is connected with ECM by a total of three wires: bonding, ECM signal input and ECM signal output [(7)].

A pulse transponder is installed in the car key, and it is a kind of induction and emission element not driven by battery.

When the car key is inserted into the lock hole and the ignition switch is opened (that is, the ignition switch 4 is closed), the transponder key amplifier transfers energy to the key coil. The energy is transmitted by the key coil to the pulse transponder by means of induction, to activate the pulse transponder. At this point, the pulse transponder sends "program code" immediately after receiving induction energy, the program code through the key coil is transferred to the transponder key amplifier, and then it is sent to the key transmission ECU via the transponder key amplifier for its verification, to identify the legitimacy. If the key is legal, the key transmission ECU sends an key legal signal to ECM, and the engine can start smoothly; otherwise, the ECM controls the engine not

to inject or ignite, and the engine can't start smoothly. The car key to every car, that is, pulse transponder has a different program code [8].

Working Process of the Experiment Bench. When the ignition switch 4 is closed, the switch contacts of the normally open relay 5, injector control relay 6 and EFI main relay 10 are all closed, and the fuel injector, ignition control module, and ECM power control module are provided with a working power supply; at the same time, the DC motor 3 and fan DC motor 33 rotate at a certain speed according to the accelerator pedal position, the crankshaft signal gear through the crankshaft position sensor 11 provides the power control module ECM with crankshaft position signal and engine speed signals, and the intake and exhaust camshaft signal gear through the intake camshaft position sensor 19 and exhaust camshaft position sensor 20 provides the power control module ECM with intake and exhaust camshaft position signal (9); after the power control module ECM receives the engine speed signal, the switch contact of the oil pump relay 7 will be controlled, and the oil pump works when the oil pump indicator light 9 is on, also to provide the air flow sensor 14, oxygen sensor 15, exhaust mixing ratio sensor 16, and charcoal canister electromagnetic valve indicator light 17 with working power supply; the fan DC motor 33 provides the air flow sensor 14 with air flow, and the air flow sensor 14 changes the air intake flow signal into electrical signal, which is then output to the power control module ECM; the water temperature sensor 8 according to the adjusted resistance value provides the power control module ECM with water temperature signal (10); the accelerator pedal position sensor 22 provides the power control module ECM with accelerator pedal position signal; the air intake temperature sensor on the air flow sensor with intake temperature sensor 14 provides intake temperature signal (11). After the security control unit tests that the ignition key is legal, the engine ECU according to each sensor’s signal determines an optimal fuel injection quantity, injection time, ignition moment, and throttle opening through calculation, analysis and processing (12), to control the working state of each cylinder injector indicator light, each cylinder ignition control module and spark plug, throttle control unit, charcoal canister electromagnetic valve indicator light 17, oil pump indicator light 9, exhaust camshaft timing oil control electromagnetic valve indicator light 12, intake camshaft timing oil control electromagnetic valve indicator light 13 and other actuators, while the fuel injection and ignition frequency synchronize with the engine speed.

Each measuring terminal is used for detection of various parameters, convenient for judgment and detection of fault and for teaching needs.

Conclusion

This experiment bench is designed as a practical system by selecting the representative Toyota Corolla 1.6 AT electronic-controlled engine. Traditional experiment bench is generally made of real components; on one hand, the production and operation cost is high, and the size is big, and on the other hand, it is also easy to cause safety accidents and environmental pollution. This experiment bench has a simple structure and low costs using the principle of virtuality and simulation, and is safe, environmental protection and economic in use; the temperature sensor can be simulated by using variable resistance, so that the signal changes become more direct and convenient; light bulbs as actuators enable the whole process to be more visual and direct, convenient for teachers' teaching and students' learning, thus improving the teaching effect. The bench can also be independently developed, designed and produced by students under the guidance of teachers, which is beneficial to arousing the students' innovation consciousness.

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