DIDACTIC BENCH WITH INTERNAL COMBUSTION ENGINE APPLYING AN OPEN ELETRONIC INJECTION

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Summary**: The purpose of this work is aimed at the implementation of a programmable electronic injection FT400 da FuelTech in a countertop with internal combustion engine, a Ford Zetec 1.6 Rocan year 2009. It was initially made the construction of a test bench that contains cooling system, ignition system, exhaust system, fuel tank, a fuel pump, and a stand where the electronic injection module was fixed. To the table ready to motor characterization, sensors and actuators have been checked and engine parameters were collected. Three electrical diagrams were created to target the correct connection of the module with the engine. With the module installed was the setting of the injection and ignition to the same fit to the engine parameters. The module also allows you to check the functioning of the sensors and actuators. The results show that the didactic built bench is able to control the main engine operating parameters, identifying your operating condition through sensors and commanding the actuators according to the maps and reference values, inserted through the human-machine Interface. The module also allows you to change the parameters of the job engine in order to find a better income, allowing also a significant reduction of greenhouse gas emissions.

Key Words: internal combustion engine, programmable system, electronics central, FT400.

1. INTRODUCTION

Nowadays the ease in acquiring a new car and the importance that many give the vehicle, motor vehicle fleet was growing every year, but in spite of its benefits, such as comfort and practicality, there are also cons, being one of the most worrisome the pollution generated. In the big cities of the country, the concentration of thousands of vehicles generates tons of pollutants a day, making it the major factor for the reduction of air quality. The major pollutants released into the atmosphere by motor vehicles come from incomplete combustion processes. The electronic injection aims to adjustment of combustion from a correct scale of this it is possible to get the lowest greenhouse gas emissions generated by the motor.

In this work, we built a test bench to fit an internal combustion engine and implement the same a programmable electronic injection module. Through the programmable FT400 injection module of FuelTech, you can vary the parameters to fit any engine. The electronic systems of automobiles in General, I keep the fuel/air mixture already predefined and cannot vary the parameters for analysis of variation in the emission of gases and getting a better yield of this, since this module programmable injection allows such variations.

2. BIBLIOGRAPHICAL REFERENCES

2.1 Power System

The power supply has the function of sending the required amount of engine air/fuel mixture to be burned, being transformed into chemical energy into mechanical energy.

Otto cycle engine feeding system consists primarily of fuel tank feeding pump, fuel filter, air filter and the carburetor. The air sucked by the engine enters by air filter carburetor, which carries out the air mixture more fuel. Enough fuel to carburetor feeding pump driven.

In general, the carburetor is one of the most important parts of the power system in the Otto cycle engines. Currently with the need for improvements of vehicles and reducing emissions of toxic gases, the carburetor was replaced by electronic injection.

2.2 Eletronic Injection

There are two types of fuel systems used in Otto-cycle engines: the carburetors, fuel suction-based and electronic injection systems, based on fuel injection. The electronic injection system comes as a replacement for the carburetor, taking advantage of the best fuel optimization, greater control of the fuel/air mixture, reduction of polluting gases such as CO, HC and NOx, idle control, possibility of greater fuel economy and engine thermal performance, second Albaladejo (2012).

Electronic fuel injection systems have the function of dose properly the fuel mass depending on the operating conditions of the engine.

Injection systems can be classified into three types:

- Point injection: injection System composed of only one injection valve positioned prior to the butterfly valve, irrespective of the number of engine cylinders.
- Multipoint injection: a fuel injection valve System for each engine cylinder, placed after the butterfly valve and previously at intake. The fuel is provided individually for each cylinder with the goal of letting the more homogeneous mixture and prevents condensation on the walls of the fuel intake manifold.
- Direct injection: Second Brunetti, 2012 this system the injectors require high fuel pressure, where this pressure is achieved by means of a mechanical secondary bomb, thrown by the vehicle's engine, which raises the pressure to about 4 bar from the electric pump installed in the fuel tank circuit for cercade40a 200 bar, depending on the system

The electronic injection vehicles is a system that monitors and controls the operation of the motor through the input and output of data, with the function of providing the ideal mixture of air and fuel the engine in any operating regime. All-important data are obtained by electronic sensors and sent to a central command unit (ECU) which is compared to the calibration data of the vehicle previously established. From these data, the same central unit commands the actuators that will fix the injection parameters, if necessary. (BOSCH, 2013)

2.3 Cooling System

The cooling system is an element that contributes a lot to the energy efficiency of the engine, as well as assists in the reduction of wear of parts, this is due to its main function, which is to reduce the temperature and do the heat exchange of the motor.

Its operation follows a cycle, where the liquid is pumped through the engine shirts carrying the heat fixed and mobile parts. This liquid circulates the shirts to the engine through a hose, where his fate is the radiator; at this point, the liquid is cooled due to the aid of a ventilator. Anyway, the cooling liquid circulates under pressure throughout the system. (Mte-Thomson, 2014).

The water pump is the component responsible for drive this movement, accelerating the passage of the liquid through a rotor. Already the thermostatic valve controls the entire system, where the same only allows the passage of liquid when it is the ideal operating temperature when this occurs the liquid can follow to the radiator, where the r and outer chain of air generated by the fan lower its temperature. (Mte-Thomson, 2014).

2.4 Sensors and actuators

The proper functioning of the sensors and actuators enables the proper functioning of the engine, ensuring performance, and lower fuel consumption and emission control of pollutants. The function of each sensor and the existing vehicle amount varies according to the specifications of each project. The description that follows in table 1 illustrates, generally, the main sensors currently used and their respective sizes.

Tabela 1- Sensors

Sensor	Sensor type	Description
Air temperature	**Term Resistance**	**Monitors the temperature of the air in the intake manifold. Tension varies with air temperature admitted**
Temperature of the cooling Liquid	**Term Resistance**	**Monitors the temperature of the coolant in the engine. As the temperature of the liquid increases the resistance decreases.**
Pressure on the collector	**Differential Pressure**	**Reports on the Centre to the pressure variation inside the intake manifold, as a function of engine speed and engine load.**
Rotation	**Inductive sensor or Hall**	**Determines, in addition to the engine rpm, the angular position of the crankshaft.**
Butterfly Valve position	**Digital Potentiometer**	**Reports on the central position of the butterfly for acceleration and deceleration. Also transmit important information for the control of marches and calculation of the Injection time**
Phase of the camshafts	**Inductive sensor or Hall**	**Is considered as a completion of the rotation sensor. Its function is to inform the central in that time is each cylinder**
Lambda Probe	**Platinum electrodes**	**Monitors the flow of air after the butterfly valve.**

So contrary to sensors, actuators, electronic control unit receive commands to act on the engine in order to adapt the same desired conditions of torque, power and consumption, according to Puajatti, 2007.

These commands are sent by the electronic control unit and the function of each actuator and the existing vehicle amount varies according to the specifications of each project (also, basically, depending on the final cost and the desired performance). The description that follows in table 2 illustrates, generally, the main actuators used and their respective functions.

Tabela 2 - Actuators

Actuator	Description
Injection Valves	**Dosing and spraying the exact amount of fuel, coming from the pressure line.**
Ignition coil	**Provides high voltage to the spark plug production**
Fuel pump	**Fuel tank offsets to the motor power supply system**
Stepper motor	**Controls the engine rpm at idle**

2.5 Exhaust System

The exhaust system is a set of pipes and silencers that function; Reduce noise generated by the motor, drive the harmful gases to the outside of the vehicle, control the compression in order to obtain the best performance, and assist in the reduction of fuel consumption. Its main components are:

- **Exhaust manifold:** Formed by a set made of cast iron, is attached to the motor. Responsible for collecting the gases resulting from the combustion of fuel, then forwards them to all primary discharge. (G1 .2014)
- **Muffler or silencer:** Reduces the motor noise. Is a House composed of internal divisions in passing the gases. The noise sound waves lose pressure resulting in the reduction of noise. (G1, 2014)
- **Catalyst:** It is found between the collector and the silencer. Transforms substances less harmful gases pollutants in the atmosphere.

3. PROJECT DEVELOPMENT

3.1 Countertop

The project proposal is to set up an electronic injection engine in open Workbench, but before implementing to implementing the injection, the engine and the construction of a countertop was necessary.

The engine available for the Zetec Rocam 1.6 model work of the manufacturer Ford year 2009. The engine has part of the transmission, but the same has not been used since there was no installation of wheels on the counter. A semi countertop ready was reused, this countertop possessed structural conditions to support the engine, however some modifications were necessary.

The table already had a small cooling system with the radiator and electro fan in operation, such important to maintain the correct temperature. The structure had a small panel with lever (used as an accelerant), tachometer and speedometer, an ignition key to start the engine, two brackets to engage the motor, and an oil storage tank. Figure 1 illustrates the description

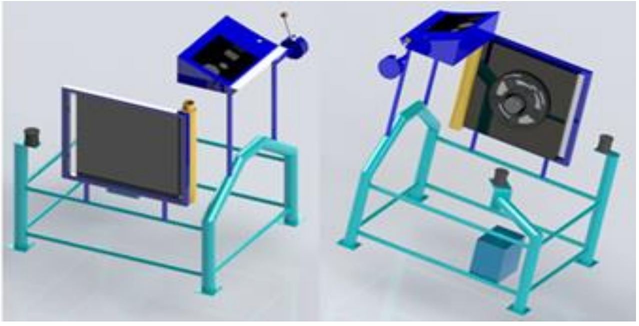

Figure 1 – Semi Countertop ready

The first modification made was the removal of the brackets, as the same were not in a position suitable for the engine. Therefore, they have been relocated; a central position of the front of the countertop, to support the front top of the engine, the other on the side later left that was attached to the left side of the engine. There was the need to make one more support in central position at the back of the countertop, so the engine had more stability and was properly set, this support has been docked and attached to part of the transmission. Exhaust pipe coming out of the engine was secured to countertop structure.

With the fixed engine was adapted the existing Panel, replacing the tachometer and speedometer for a stand to put the module programmable injection and an inductive ignition module, which will be described later. For the pumping of oil was used an external pump connected to the mini tank, noting that between the pump and the engine was placed a filter for the fluid.

Finally was added to the support structure for a 12 V battery, for motor and power injection module, a small panel of circuit protection fuses and relay compound, and a tank for fuel storage.

3.2 Programmable injection module (FT400)

Programmable electronic injection used was the FT400, a *touch screen* module with a human machine interface/simple and objective, the screens are easily accessible and allows it to be made a variation of the parameters being accepted by several engines. It is relatively easy to move, since the user has a prior knowledge of the operation and engine components.

Before installing the module a brief study of the engine was done, where were identified the sensors and actuators that it owns and which were needed for the proposed project. Were used seven sensors and four actuators. The following will be described as FT400 interprets the information passed to it:

- *Temperature Sensor of the intake air* - By reading made by the sensor module can program automatic fixes of the mixture depending on the air temperature, even if that change is climate or not.
- *Engine temperature Sensor* -The module receives information of the motor temperature monitoring and through that work together with the cooling system.
- *Pressure Sensor* -Automatically detected by injecting to be installed, the information obtained by this sensor allows program warnings of high and low pressure and differential pressure.
- *Throttle position Sensor (TPS)* – This is the main injection sensor in an engine sucked without vacuum stable. It reports to the amount of ingested air. With this information, the FT400 knows the amount of fuel to be injected.
- *Rotation and position Sensor* – Through them the FT400 causes the control of injection and ignition. In this case you use the Phonics wheel which tells the exact position of the crankshaft, so it is possible to determine the point of ignition to be applied also on the reading Phonics wheel teeth informing the engine position module for the injection.
- *Command phase Sensor* -Informs the management the exact moment that the first cylinder is at TDC. On this basis the module recognizes the position of the cylinder and on the fuel injection.
- *Lambda Probe* -Is made for concentrations of oxygen, and that information is displayed on the dashboard and in the diagnostic screen, such as the lambda probe was the engine itself, the module is configured to with narrow band (narrowband).
- *Stepper Motor or idle (IAC)* – This is always calibrated when the module is connected, so the FT400 can control the idle with the aid of this actuator.

- *Injection Nozzles* - The only information that needs this FT400 actuator is to know what kind of gun, whether it's high or low impedance, knowing this you can controls nozzles correctly.
- *Fuel pump* -There is no information that the bomb should pass the FT400, but was important to connect this actuator in a PIN, so that the module switches the pump as needed.

3.3 Installation of the module

To finish the Assembly, for the electrical part, where three wiring diagrams were developed to assist in the link between module and motor. Figure 2, 3 e 4 shows the diagram used. In the first diagram are represented the sensors; coolant temperature, air density meter set for admission, position of the throttle butterfly, tree position of crank and camshaft position the left and right main harness FuelTech. In the second and third charts are represented the connection of peripherals and actuators. For circuit protection made necessary the use of Fuses and relays, A 12 V battery as power supply of the entire system.

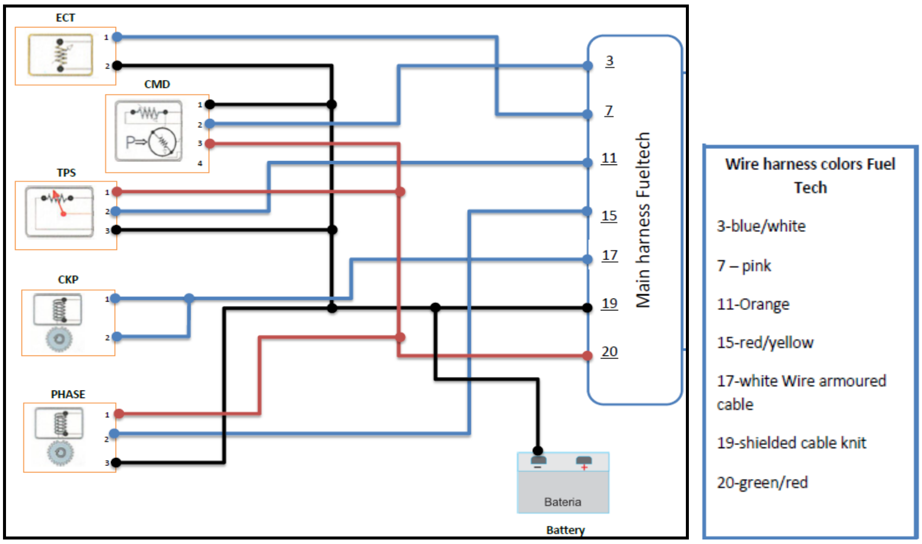

Figura 2 - Diagram 1

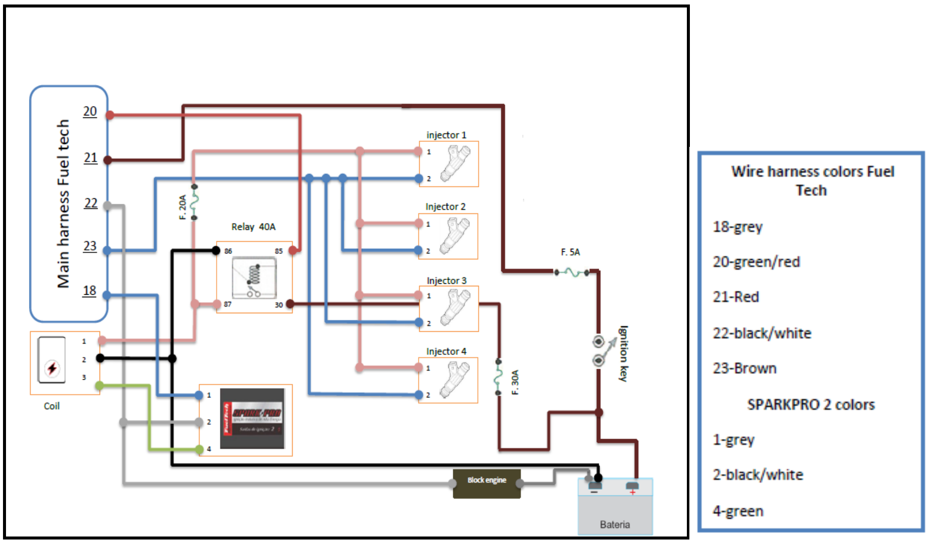

Figura 3 - Diagram 2

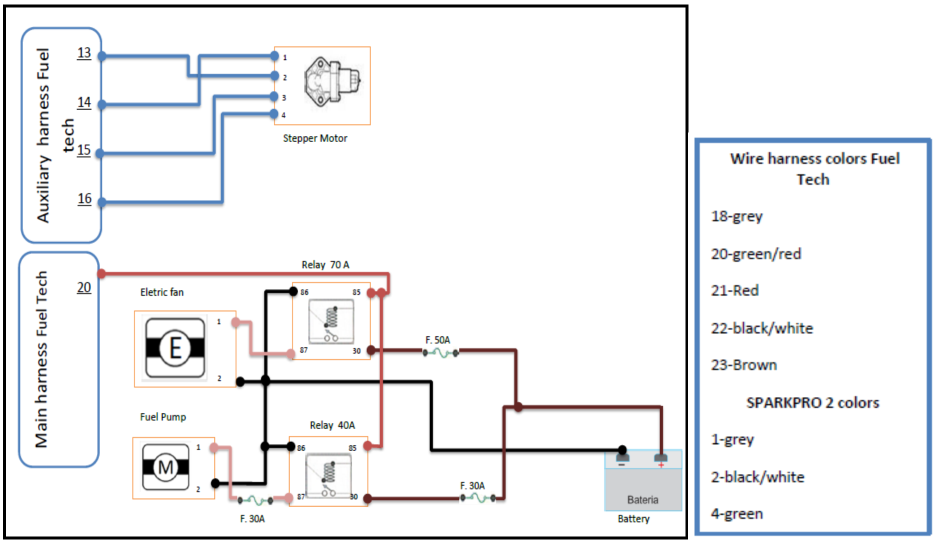

Figura 4 – Diagram 3

With the engine installed FT400, followed for the injection and ignition settings on the programmable module. Was passed to the module information maximum rotation where the same plays as a limit to create the map for injection rotation. This parameter is also required for the calculation of the percentage of opening of the injector nozzles, then was informed about the type of engine used, to this work the conventional type engine with aspirated piston for TPS/MAP, or aspirated by TPS and corrected by MAP. In addition, more details are entered in the configuration phase of injection such as the number of engine cylinders and delay of the injectors.

Already in the ignition settings configured or Phonics, wheel sprocket as 60-2 inductive type and the edge as standard. The Zetec engine works with Phonics wheel and double coils making ignition control like lost spark. The coil of the motor does not have integrated ignition, so it was necessary to use an inductive ignition module of high energy, SparkPro2, this module allows electrical arcs in high voltages.

4. RESULTS

After all properly connected and configured Ft400, were made the first tests to ensure the operation of the motor bench with programmable electronic injection.

The TPS has been calibrated as follows, first energized the system without triggering the departure, then measure voltage with the butterfly closed, namely, idling, and then with the butterfly fully open, fully loaded. Figure 5 below shows the calibration values.

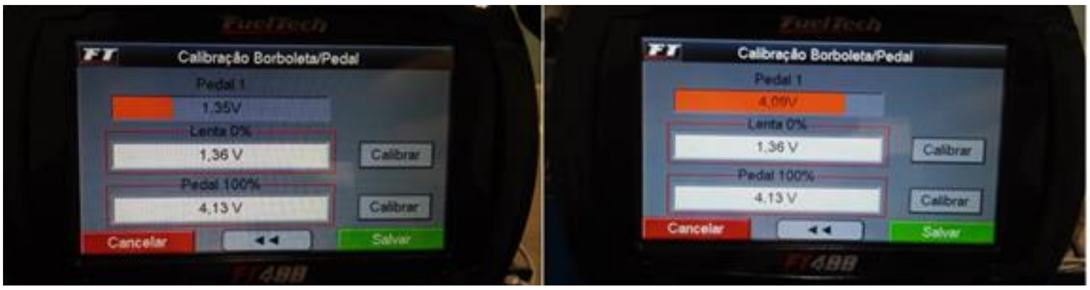

Figure 5 – TPS Calibration

FT400 injection module has a diagnostic Panel, i.e. a screen that allows it to be verified the functioning and as some sensors, such as for example, on this screen was possible to see the air temperature sensor is working and which to read he reported. If a sensor has not been connected correctly or do not operate the panel reports the problem. In this test, the system was just powered up. To better visualize the figure 6 below shows how the diagnostic panel.

Figure 6 – Diagnostic panel

Continuing the tests, was given to start the engine and the first thing done was to verify the heating time of the coil, in this work the coil heated up quickly, showing that the time the same was above the required. Immediately the engine has been turned off and the load time decreased. So the coil chilled a new start can be made, where this match showed the rotation shown by injecting and, if the throttle variations coincide with the value shown for the TPS.

With the engine, still running was calibrated ignition, so it was possible to make sure the point applied by injection was coming to the engine properly. With the help of a dial, indicator gauge was made a mark on the wheel and the engine block, where this mark indicates the PMS of the first cylinder. In sequence with a point was read the point of ignition. By definition manufacturer, FT400 marks the point as 20th or 40th (lost spark) to any rotation. The point read the gun was 43; this small difference of 3 is passed to the module so that it can understand what is the point of ignition of the engine in use.

Finally, the engine was ready for use in the laboratory, getting available for student and faculty community. Completing the initial project proposal. Figure 8 shows the bench ready to use.

Figura 7 – Countertop terminated (right)

5. CONCLUSION

The didactic built bench is able to control the main engine operating parameters, identifying your operating condition through sensors and commanding the actuators according to the maps and reference values inserted. FUELTECH FT400 system is capable of performing control of air/fuel mixture and idle in closed loop, with the possibility of adjustment of the controllers implemented for different types of engine.

Within the proposal of work, was built the bench test teaching, with the Zetec Rocam engine and the module FT400 da FUELTECH, with all the necessary peripherals for your operation as mentioned above. The instrumentation of the sensors and actuators, building three wiring diagrams for these were properly linked to FUELTECH module. Configure the module FUELTECH according to the specifications of the engine, since the input data are extremely important for the correct functioning of the module to the motor.

Tests were carried out to validate the operation of the bench and fix potential failures throughout the system. The module is not just stuck in a didactic environment since it can be adapted to a vehicle.

The work is a tool that makes the development of researches and studies in the area of thermal machines, since with this countertop can vary in the module parameters to analyze the fuel/air mixture and the engine gas emission, another branch that the work can be used and improved it's like study for students of graduation in mechanical engineering Since this can show the full operation of the engine, having easy access to the user. Besides the possibility of using a dynamometer and check, situations at full load and can improve the performance of the engine to be used.

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