CONSTRUCTION OF A SIMULATION MODEL OF SENSORS AND ACTUATORS AUTOMOTIVE INJECTION SYSTEM OBD 1 GASOLINE ENGINE WIND CORSA 2001.

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***Abstract* 'In the present study the construction of a model simulation of automotive sensors and actuators of an injection system is presented. For the construction of the model, is considered all the right components to enable the proper functioning of the injection system, serve as educational material for students of Engineering in Automotive Maintenance. The construction of the model was performed according to the technical specifications provided by the manufacturer of the vehicle 2001 model Chevrolet Corsa Wind. Teaching tool for even more effective proceeded to the construction of ergonomic furniture where all components of the injection system were placed, minimizing the risks of ailments by an incorrect posture of students when working on the model.**

Finally we proceeded to check the operation of each of the sensors and actuators, making measurements of voltage, amperage; demonstrating the proper functioning of the model and effectiveness as a teaching tool for students studying engineering in automotive maintenance, since being interactive, students can manipulate the various components thereof and observe the operation of the different sensors and actuators.

***Index terms* -**

Actuating element responsible for carrying out the actions commanded by the ECU.

Engine Control Unit **ECU** *(Engine Control Unit).*

MPFI MULTI-POINT FUEL INJECTION (multipoint electronic fuel injection system).

Injector rail assembly that houses the injectors and fuel supplies.

SENSOR emitting element signals to the ECU.

For the construction of the model is not financial support received, all the work was done by self-sustaining project, it is thanks to the auto shop "GRAN PRIX" and the Engineer Andrés Enriquez, by providing technical support for the construction of the model.

I. Introduction

THE system that is responsible for delivering the fuel to the engine has evolved to improve performance and in turn comply with current environmental regulations that are stricter every day.

"All mobile source with gasoline engine during operation on condition of idling or idle and normal operating temperature, should not emit monoxide carbon air (CO) and hydrocarbons (HC) in excess of the indicated quantities (Table 1). "[1]

So that the first fuel delivery systems were well known carburetors, they delivered fuel to the engine according to the suction generated this is why this system was very inefficient and delivering high amounts of fuel generating more pollution.

TABLE 1

MAXIMUM PERMITTED EMISSIONS FOR MOBILE SOURCES

Año modelo	% CO*		ppm HC*	
	0 - 1 500 **	1 500 - 3 000 **	0 - 1 500 **	1 500 - 3 000 **
2000 y posteriores	1,0	1,0	200	200
1990 a 1999	3,5	4,5	650	750
1989 y anteriores	5,5	6,5	1 000	1 200

* Volumen
**Altitud = metros sobre el nivel del mar (msnm).

The next evolution to the delivery systems of fuel, were the first mechanical injection systems, where there was already injectors delivered fuel by the suction generated by the engine through a distributor, they remained inefficient because functioned much like a carburetor without monitoring engine performance. [2]

After mechanical injection systems, took a big step by introducing electronic systems without abandoning mechanical systems were still indispensable for the operation, it is here that begins to introduce sensors like TPS (Sensor Throttle Position) among others, was achieved better efficiency in delivering fuel but still producing a lot of greenhouse gases as the fuel delivered was still excessive.

It is here that engineers, introduced a fuel injection system, using information such as the regime of engine RPM (revolutions per minute), coolant temperature, crankshaft position, achieving greater efficiency in the delivery of fuel, these systems had a single nozzle , so the carburetor very similar but much more efficient to.

It is here that the auto industry a big step by introducing the MPFI system or system multipoint electronic injection, where you have one injector per cylinder, for the proper functioning of this many more operating parameters are needed because the mixture is regulated fuel according to the throttle valve, the coolant temperature and others; all this information is sent to a control unit or ECU (engine control unit) where the data is analyzed and a signal is sent to the actuators (injectors, valves, idle speed control, ignition coils) achieving better combustion, in if a better operation of the vehicle engine achieving high efficiency in fuel consumption and complying with environmental regulations.

The most modern injection systems, monitor the driving style of the driver and can modify certain parameters to achieve maximum efficiency in fuel consumption.

Given that at present, systems carburetor, mechanical injection and electromechanical injection are completely obsolete, it seeks to keep students career Maintenance Engineering Automotive, properly trained in MPFI systems found in most vehicles , so that the object of this study is the construction of a model simulation of sensors and actuators where , students will be able to observe and make certain measurements that allow a proper understanding of the functioning of MPFI injection system.

II. Materials used in the construction of the interactive model on the system of electronic injection methods obd 1 vehicle 2001 model Chevrolet corsa wind.

For correct assembly of the different component parts of the injection system of a vehicle Chevrolet Corsa Wind 2001 model, a piece of furniture as ergonomically designed

was manufactured, for students Career Maintenance Engineering Automotive have adequate tool learning on the various sensors and actuators that can be found therein; and, that all components are available for analysis in a quick way, because most of these components are difficult to locate in a vehicle running.

A. SENSORS OPERATING IN THE MPFI SYSTEM OF A VEHICLE 2001 CHEVROLET CORSA USED FOR THE CONSTRUCTION OF THE MODEL

It is then that can be defined as a sensor to "the devices that monitor the operating conditions of the vehicle, and send your information to the computer for this order to the actuators to operate on certain parameters, according to changing conditions motor operation "[[3]]. In this thesis the following sensors were used:

MAP sensor.

Its acronym MAP (Manifold Absolute Pressure), translated into Spanish it is known as absolute pressure sensor intake manifold, which expresses the variation of atmospheric pressure and vacuum generated in the intake manifold and the engine; then, produce signals that are send to the ECU so that it can regulate the time of ignition and set the air / fuel according to the characteristics and conditions of the engine under different environmental regimes.

MAP		
pin sensor	Colour	It issig-
A	Marr ng	5v
B	Green	It issig-
C	black White	dough

TABLE 1

TPS sensor.

Its acronym TPS (Throttle Position Sensor Position Sensor Acceleration Butterfly, which tells the ECU the opening angle of the flap throttle body. This allows you to adjust the injection pulse enriching or impoverishing the mixture as the position of the accelerator pedal. To generate this signal has a position potentiometer which indicates the engine load according to voltage variation.

TPS		
Sensor Pines	Colour	It issig-
A	Marr ng	5v
B	black White	dough
C	Blue	It issig-

TABLE 2

ECT sensor.

Its acronym (Engine Coolant Temperature) Temperature Sensor Coolant, indicating the actual temperature of the coolant as the engine; to enrich or impoverish the air / fuel mixture and obtain adequate regime of engine operation.

This works with a type NTC thermistor, this means that by increasing the coolant temperature resistance decreases, your body is coated to resist corrosion bronze producing the refrigerant so that does not affect the operation.

ECT		
Sensor Pines	Colour	It is sig-
1	marr ng	5v
2	blue	It is sig-

TABLE 3

IAT sensor.

Its acronym (Intake Air Temperature) Temperature Sensor Air Intake indicates the temperature at which air enters the intake manifold; This sensor helps us measure the temperature and mass of air entering the engine, "Depending on the mass measurement air, the computer will decide the exact amount of fuel to be injected to mix ideal in all conditions acceleration . "[[4]]; In order to know the actual amount of air entering the combustion chamber so that the ECU processes this data and inject a precise amount of fuel.

IAT		
Pines sensor	Colour	It issig-
1	Marr ng	5v
2	marr ng / celeste	It issig-

TABLE 4

CKP sensor.

Its acronym (Crankshaft Position Sensor) Sensor Crankshaft Position "that receives the force of the pistons through the connecting rod and transforms it into rotary motion" (Martinez, 2003), it helps to know the state of rotation crankshaft at any time and the engine speed RPM; This sensor allows the ECU to know the angle of rotation of the crankshaft to regulate the injection timing and synchronizing the ignition of the mixture; in the sensor body has a permanent magnet, iron core and a coil, these are about the toothed pulley, each tooth meets the tip of the sensor produces a voltage which induces the internal sensor coil, the variation voltage depends on the speed of rotation of the toothed pulley, the faster turn, the sensor voltage increase.

CKP		
Sensor Pines	Colour	It is sig-
1	gray / black	Output sig-
2	gray / red	output sig-
3	marr ng	Dough

TABLE 5

KS sensor.

Its acronym in English (Knock Sensor), knocking sensor, this regulates the time if there are auto detonations due to pre-ignitions in the chamber; This sensor allows the ECU to control ignition timing adjustment or ignition due to auto detonations that may occur in the combustion chamber, a phenomenon known as "jingle".

KS		
Sensor Pines	Colour	It is sig-
1	yellow / black	Voltage

TABLE 6

Oxygen sensor.

This sensor is known as O2 sensor or lambda sensor, the ECU helps determine the correct percentage of air / fuel entering the engine; It is located in the center of the exhaust manifold in the front of the engine, its body is made of material zirconium, this generates a signal that compares the amount of oxygen in the atmosphere and the exhaust gas has a connector black and green color, and a single pin communication, cable color is purple.

ACTUATORS B. MPFI SYSTEM OF A VEHICLE CHEVROLET CORSA 2001UTILIZADOS FOR THE CONSTRUCTION OF THE MODEL

Electronic injectors.

The vehicle Chevrolet Corsa Wind 2001 with 4 - cylinder engine has a set of 4 injectors, MPFI (Multi Point Fuel Injection) Fuel Injection Multi-Point, one for each cylinder; These injectors are responsible for supplying fuel to the combustion chamber by spraying method, these are mounted on the rail charge of delivering the fuel to each of them, also referred to as flute or rail injectors; It has a pressure regulator located at the end of the rail where the surplus fuel returns to the reservoir. This regulator maintains a pressure in the rail 3 Bar, the injector opening is regulated by the ECU, which is responsible for opening the same for a period of time; this opening is open approximately 1.6 milliseconds at idle and up to 10.1 milliseconds at high RPM.

injectors				
	injector 1	injector 2	injector 3	injector 4
pin	2	2	2	2
Colour	Black	Black	black	black
voltage	9	9	9	9
ohms	2. 3	2. 3	2. 3	2. 3

TABLE 8

Ignition coil.

Ignition coil transforms the voltage delivered by the battery to produce a greater than adequate spark to combustion work is done; This system is called for on DIS (Direct Ignition System), Direct Ignition system, completely eliminating the distributor, setting the spark timing by the signal sent by the ECU using the signal from the sensors.

Chevrolet Corsa in the Wind 2001, the coil sends the spark ignition in the 1-4, 2-3 order; which means that the spark plug cylinder 1 and the cylinder 4 will receive at the same time the spark gap, the same is repeated for cylinders 2 and 3. It is located on the right side of the headstock or cylinder head.

Ignition coil		
acuador pins	Colour	signal
1	Brown	dough
2	Black	Positive
3	Black / Red	Signal
4	Black / Yellow	Signal

TABLE 9

Air control valve.

Its acronym in English IAC (Inlet Air Control), Air Control Valve Flow, is responsible for providing the necessary for proper vehicle operation at idle air; It is located in a separate air conduit adjacent to the throttle valve, since its operation allows the passage of additional air into the engine without operating the same.

This valve is regulated to keep the engine at a rate of 700 to 1000 RPM, according to information sent by the ECU and the various sensors.

Fuel pump.

It is responsible for providing the fuel needed for the proper functioning through pipes from the reservoir, through the fuel filter to the rail, where it is delivered to each injector to be sprayed into the intake manifold for subsequent combustion; It is located inside the fuel tank and generates a pressure of 3 bar.

III C. OTHER COMPONENTS NECESSARY FOR THE CORRECT OPERATION OF THE BOARD

Given that is a model simulation for proper operation extra components was acquired to be as similar to the vehicle 2001 model Chevrolet Corsa Wind, listed below.

Engine control unit ECU.

The ECU is an essential for the proper functioning of the board component, since it is responsible for processing all the information sent by the sensors, process it and send the appropriate commands to the various actuators.

Connection systems.

For connecting the various system components harness original connection of the vehicle was purchased, as these have special connectors for each sensor and actuator; and these are joined to the ECU.

These connection systems are mounted on the back of the board and are not the views of students, to avoid damaging it.

For ease data collection for future practical work in a bypass it was performed on each of the wires of the lords and actuators, and special pins that facilitate data collection was placed.

Acrylic bases.

To assemble some components were sent to manufacture acrylic bases, which facilitated the assembly and in turn improved the presentation of the model.

Test tubes.

Since the system causes the operation of the injectors, it is necessary to collect the liquid specimen used in replacement fuel.

Dashboard.

The dashboard is essential in the model as reported by MIL lamp or better known as LIGHT CHECK ENGINE, if the ECU has recorded fault codes.

The dashboard also indicates coolant temperature, very important to know if the ECT sensor works properly.

it was also used to simulate the movement on the speedometer, as the ECU needs this information to work properly.

C. Process

For proper assembly and handling of the different components of the board as a cabinet was manufactured.

The cabinet has the following dimensions; from the floor to a height of 90 cm, a width of 110 cm and 60 cm deep with finishes in black and wood; this closet that is the basis for sustaining the central board, inside contains the central control board. It was designed that way in order to protect and provide for the improper handling. It also has 2 hinged doors with corresponding security.

On the closet, which is based, it is located the central board whose dimensions are 110 cm x 120 cm, made of wood and which are located sensors and actuators that make up the vehicle system model 2001 Chevrolet Corsa Wind.

Above the board described above is located the lighting panel horizontally, with 110 cm wide, 20 cm high and wide, 50 cm deep, which are embedded 2 "portholes" with spotlights technology LED 100 watts.

Getting the different materials for the construction of the interactive whiteboard as sensors, actuators, dashboard, diagnostic connector, toothed pulley, electro-fan throttle body ECU, spark plugs, spark plug wires, specimens measuring, I base precipitation, drills, among other things complementary.

To obtain the least common elements, several trips to other cities where it was feasible to acquire as in the cities of Ibarra and Otavalo was impossible acquisition were made. This happened with the dashboard of the vehicle Chevrolet Corsa Wind 2001 model, diagnostic connector rail injectors, pulley, the throttle body, among others.

The other constituent parts of the board were found in the city of Otavalo.

For the location of components in the interactive model, it took into account the position of the components in the vehicle Chevrolet Corsa Wind, with this placed them as close to the vehicle to help students identify more interactively sensors and actuators, thus they can be placed in a vehicle running.

Then the location of the harness connecting the back of the board without being in sight was performed; since the connection harness that was originally acquired a vehicle, only it proceeded to place on the board and make the respective passage of the connectors of each of the sensors and actuators to the front of the board.

Some connectors were not the right distance to get to their respective sensor or actuator, so cable was increased to reach the desired distance.

With all correctly located and connected components, we proceeded to perform a reconnection back in different connecting cables to place the pins for data collection, enabling students when working on the board.

Because it needs to generate a circular to simulate the movement of the motor movement 1 drill with adjustable speed to simulate this movement was set, and I connect with a shaft constructed as the pulley with the CKP sensor. To perform the tests in this sensor, specialized scanner was used, getting to have readings ranging from 0 to 2700 RPM, being a purely didactic model, a higher number of RPM is not necessary

Very similarly another drill was used to generate movement on the speedometer, as this sends a signal to the ECU very necessary for proper operation. This was achieved speedometers rotating at a speed of 140 km / h, very similar to a vehicle speed reaches and the limits permitted by law.

The oxygen sensor was located under the toothed pulley with a coating asbestos to prevent the heat away from the heat source does not affect the operation of CKP sensor, the tests performed in this sensor, subjecting gave direct contact with a heat source, achieving simulate the same with the exhaust gases.

Because the position sensor TPS throttle flap actuator and the IAC (intake air control), are mounted on the throttle body for didactic reasons mounted one on the board. To observe the operation carried out by the IAC

valve, a cut was made in the throttle body, so it was possible to observe the opening and closing thereof.

To operate the throttle valve, a lot like the original cable, with the difference that this extended from the top of the dashboard, one end is linked to the butterfly and the other with a handle that facilitates placed the drive, when testing was found that with a 0% drive voltage was 0.4 volts and be driven 99% is has a voltage of 4.8 volts, which corresponds to normal operation in a vehicle.

The ignition coil, which is responsible for providing a high voltage to the spark plugs to produce the required spark for combustion, this vehicle has a body coil 2, ie the spark generated for cylinders 1-4 and 2 -3 simultaneously; since this is joined by special cables coil to the spark plug, which is responsible for producing the necessary spark for combustion.

It was found that the coil installed on the board, correct voltage generates a spark in split producing the spark plug as well as accurate time synchronized with the fuel injection. You should take care not to bump the spark plugs when the board is running, since being a high voltage can cause injury.

Fuel injectors, which are responsible for delivering the right amount at the right time, are mounted on a specially designed track, with a pressure regulator.

The board allowed us to observe how the fuel injection is carried out and in what order, the board can also be used as an injector tester because it allows us to observe the quality of fuel atomization and consequently the state of the injectors.

The MAP sensor is responsible for informing the ECU on depression formed in the intake manifold, this works by a diaphragm that generates a resistance force depending on the vacuum acting on it.

On the board not having the vacuum generated by the engine, it proceeded to simulate using a syringe, connected by pipes to the MAP sensor, managing to correctly simulate the sensor in a vehicle in operation.

The IAT sensor is responsible for temperature survey the air entering the intake manifold, this is mounted before the throttle valve after the air filter.

In the model would amount to an acrylic base custom built, measuring the temperature of the air entering the manifold, this would be taken as the ambient air temperature, so I leave it to the environment, achieving a correct measurement compared to a vehicle running. This sensor may present variations in voltage when ambient temperature varies several degrees Celsius.

To simulate the temperature reaches the coolant, a specimen of 1000 ml is used, with controlled from the main board niquelina in this are submerged both the ECT sensor and the spin temperature, which allows it to work the temperature gauge present in the dashboard.

To perform the tests in this sensor, coolant was used, it presented the disadvantage that reached the boiling point at 89 ° C, without activating the electric fan installed in the model; another test was attempted with ordinary water, achieving a boiling temperature of 93 ° C, without achieving activation electro fan. Finally we used brake fluid, and having a melting point higher boiling, activating the niquelina, brake fluid did not reach the boiling point, which allowed us to observe that the electric fan comes on at 103 ° C. To get an accurate reading of the temperature of the coolant, a specialized scanner that allow us to read correctly using the same sensor ECT was used.

The dashboard, in addition to indicate the speed and coolant temperature, helps us identify fault codes by MIL (mal function indicator lamp), this is a focus of yellow color, with a figure of an engine or It turns often find the words CHECK ENGINE. When this is switched it is because it has stored fault codes in the ECU.

The lamp MIL instrument panel placed in the model always remains on and records fault codes, this because it is an interactive board and several of the sensors are programmed to work together, and having no matching a sensor with another, fault codes are generated.

Finally the fuse box and relays are installed, since in this diagnostic connector, very important for the board is since this allows to establish a communication between the ECU and scanner, to monitor the work of the different sensors and actuators and in turn read fault codes.

Being an OBD-1 connector has a particular figure, because patents vehicle 2001 model Chevrolet Corsa Wind correspond to the Opel brand, use a special adapter for reading fault codes.

Figure 1 Model of complete simulation.

D. Discussion.

Injection systems have not changed much since the MPFI system, the most important improvement is the approval of diagnostic systems OBD-2 system, where the connectors are universal and fault codes, providing the time of maintenance and diagnostics.

Whether the sensors and actuators have not changed, only the way to interpret the fault codes have been approved for all brands, because in the OBD-1 systems, each manufacturer had its fault code and its own connector communication. [5]

So that the model provides an interactive way to observe the operation of each of the sensors and actuators, and learn to properly measure the values thereof.

E. References.

For the construction of the model is not financial support received, all the work was done by self-sustaining project, it is thanks to the auto shop "GRAN PRIX" and the Engineer Andrés Enriquez, by providing technical support for the construction of the model.

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