



Automotive Mechanical Engineering
Emission Control and Diagnosis

Emissions

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Module Code: M5X02202

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Abstract

Emissions

This is a major topic if start discussing it. This is because a lot of countries and governments are struggling to find solutions to this problem. If the sort of testing and analysis is examined with PEMS, this means a Portable Emissions Measurement Systems is being utilised, to evaluate and find ways to decrease the percentage of the Emission in the world, particularly at present and with regard to the future of the European vehicles Emissions rates and the legislation for that issue are needed.

General view on the expected benefits and underlying principles, many manufacturer are cared about that issue and want to resolve it.

Light-duty, heavy-duty, and all sorts of vehicles and mobile machinery in (EU) must comply with Euro 6 or 7 emission legislation and standards

This came into force from January 2014 onward, at the same time for first test procedures for standards of the emissions; it has been completed in the laboratory. To manage the fumes and exhaust gases. However, the sort of emission, over the wide range of our universal driving situations, there are two factors.

The first challenge is to answer the question - Is there any improved at current condition? This can be done by checking any mobile machinery randomly on the road by PEMS systems that is.

Secondly, in connection with the situation of the test, the design of affordable facilities and the method for creating the precise data will be evaluated.

It has been done, in relation to heavy-duty vehicles using PEMS and enforced in the EU since 2009.

In addition, the European Union requests (completed around 2014) place emphasis on the engine accordance testing of emissions under the actual driving situations. The probability of using checking throughout PEMS will create very important matter in future of EU legislation and standards of emissions.

PEMS application can easily manage cars emissions; all the targets are focused on technologies and ways to improve the quality of air throughout the EU

(SAE, 2014)

Acknowledgments

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Content

1.Abstract.....	(2)
2.Acknowledgments.....	(3)
3.Contents.....	(4)
4.Introduction.....	(5)
5.Literature review.....	(6)
6.Emission control Devices.....	(7)
7.Catalytic Converter.....	(8)
8.EVAP.....	(9)
9.EGR.....	(10)
10.SAIR.....	(12)
11.PCV.....	(14)
12.Air &Fuel ratio.....	(15)
13.Euro 6.....	(16)
14.Methodology.....	(17)
15.Discussion.....	(19)
16.Analysis.....	(21)
17.Conclusion.....	(26)
18.Bibliography.....	(28)

Introduction

It is much more interesting to talk about the Emissions, all the world now searching for how to reduce the emissions.

Some countries are making a great effort to doing natural greenhouses and forests also creating legislation and laws to manage that issue, one of the most important questions is how to reduce the contaminated emission of the greenhouse gases.

In Europe and UK start to dictating their requirements of engines specifications to reduce the emissions, using their legislation to manage that. The industry follows the governments and countries legislation and laws to make a better level of emissions in the vehicles to satisfying all the legislation.

There are most effective components in the engine will look at them like catalytic converter/ EVAP/EGR/SAIR/PCV/Air /Fuel Ratio.

In a assignment we will look precisely at each component for the three engines to be tested, those were Euro 2, 3, and 4. We will ask the question, what is the difference between each other around of modifications and different protocols, we will show also examine the global factors in this matter.

Industry is always looking at Euro legislations. They are asking themselves at the different stage of Euro 5 or 6 - How can we assess vehicle emissions and how can they be tested? That is, in traffic and in mountains different atmosphere. In addition, what are the global market needs and the government's markets asking to improve to satisfy their environment legislation? On the other hand, what are the implications for industry and the environment?

Actually if you look at Emission regulations Euro 4 and 5 applications of Emissions controls (EVAP, EGR), the question is how the industry add some modifications to another. For example, how to improve those to suit the legislation and global factors, how to reduce the NOx in the emissions by using chemical proses to send it back for recycling gases.

Literature review

According to the emissions subject, James D. Halderman, in Chapter 25, focused on the vehicle emission standards, and testing.

That is, some advancements and developments have successfully happened to reduce pollution from vehicles and commercial trucks about 90% since the 1970s, but sadly now many cars on the road are being used more miles for several years, slightly make up the environmental advantage of single car emissions reduction.

Showing that (SIP) which is state implementation plan for control the emission.

By using, these items

1. An advanced analyser for the emission.
2. Real testing of emission
3. A minimum limitation to achieve good results.
4. Remote on street to check 1% of the car population.
5. Yearly inspections.
6. OBD2 systems examined for models since 1996 and newest cars.

(Linder, 2009)

Emission control system

This means-employing sort of control to limit and manage the discharge of exhaust gases come from different components.

In the internal-combustion engine, the main source of this gases are three, fuel tank, engine exhaust and crankcase, the gases discharges in the exhaust pipe which is unburned hydrocarbons and fully burned hydrocarbons also some oxides of sulfur and nitrogen, carbon monoxide, different phenols and acids.

The second source for unburned hydrocarbons is crankcase, and another lesser rate of carbon monoxide in the third source, which is the fuel tank, or the carburettor, which was used in older vehicles, nowadays it has been massive modifications and developing on different systems to monitoring the emissions come from these sources.

(Encyclopaedia Britannica.Inc, 2018)

Emission Control Devices

Catalytic Converter

This is another sort of device treatment for emission used to reduce and limit exhaust gases away from the engine, also used as the catalyst which chemically assists to work chemical reaction just for start not going to join the chemical reaction.

Catalyst material which is on the surface of the inside structure of the converter is more beneficial for chemical reactions. The chemical reaction helps to reduce the impact of the exhaust emission gases into less harmful gases. The converter changes the harmful gases into (CO_2) carbon dioxide and (H_2O) water vapor. The location of this device is between the muffler and exhaust manifold underneath the passenger area. So as possible must be close to exhaust manifold.

(D.HALADERMAN, 2016)

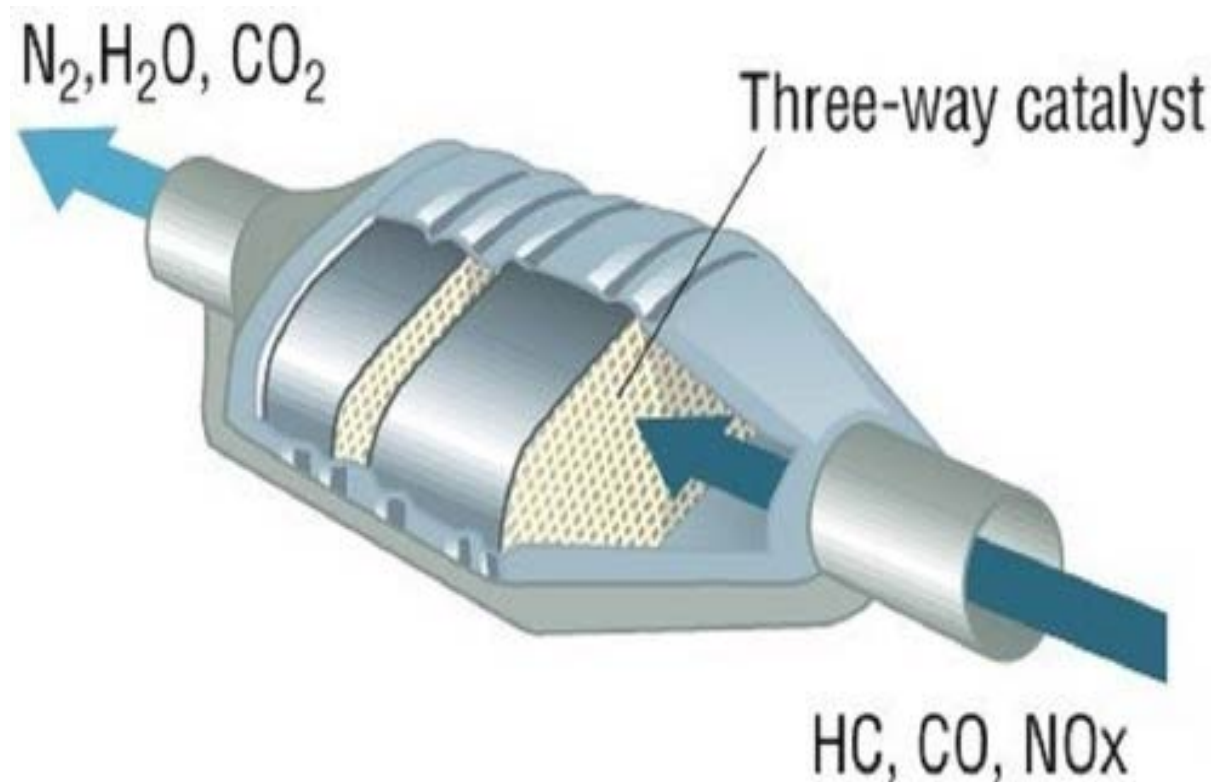


Figure (1)

(indiamart.com, 2018)

How to enhance the Catalytic converter

SCR which is Selective Catalytic Reduction, this the solution to meet and achieve new targets to reduce NOx, which is work throughout a catalyst by injecting liquid-reductant agent into the diesel engine exhaust, the impact of the chemical reaction changes the nitrogen oxide into nitrogen and harmless water, which are ejected through the pipes of the exhaust.

Another way to meet Euro 6 standards is EGR exhaust gas recirculation, here intake air is mixed with the percentage of the exhaust emissions to decrease the burning temperature. ECU controls the EGR according to the engine is speed and load.

Catalytic Converter in Modern cars

It's an important part has been added to modern vehicles. In fact, the air consists of some worse gases around any traffic area by using chemical reaction so infrequent metal on a surface inside the converter will break down the exhaust gases which is going out into their initial and basic components which are non-toxic gases. Oxygen sensor and catalytic converter are functioning together in modern cars at all times, the purpose is to monitor the fumes going out of the motor vehicle and remaining the car work efficiency.

The protocols between the catalytic converter and the oxygen sensor into the ECU is the function with catalytic warning light. When the catalytic is overheated or not working as intended, this light will warn the driver that there is a fault in the catalytic converter. Sensitive sensors pick this up, when the honeycomb is extended in the surface area with air contact.

By the time the metal will begin to plug up and deteriorate the sluts and that guide to increase the heat temperature problem and restricted the lanes of airflow.

Therefore, the malfunction will affect the oxygen sensor guiding the computer to say that converter not functioning nicely.

The big issue if the catalytic converter warning light faults are neglected will increase the amount of damage it might prevent to start the engine, such as any components in the car, actually to save the performance in the good level deal with warning light quickly.

(D.HALADERMAN, 2016)

EVAP

EVAP system functions on a modern system for that purpose as stores the fuel vapors, EVAP consist of vapor canister, canister vent valve, canister purge valve, hoses and lines, rollover valve to stop and prevent any sort of fuel leakage or infiltration, fuel tank, fuel cap.

EVAP function & purpose

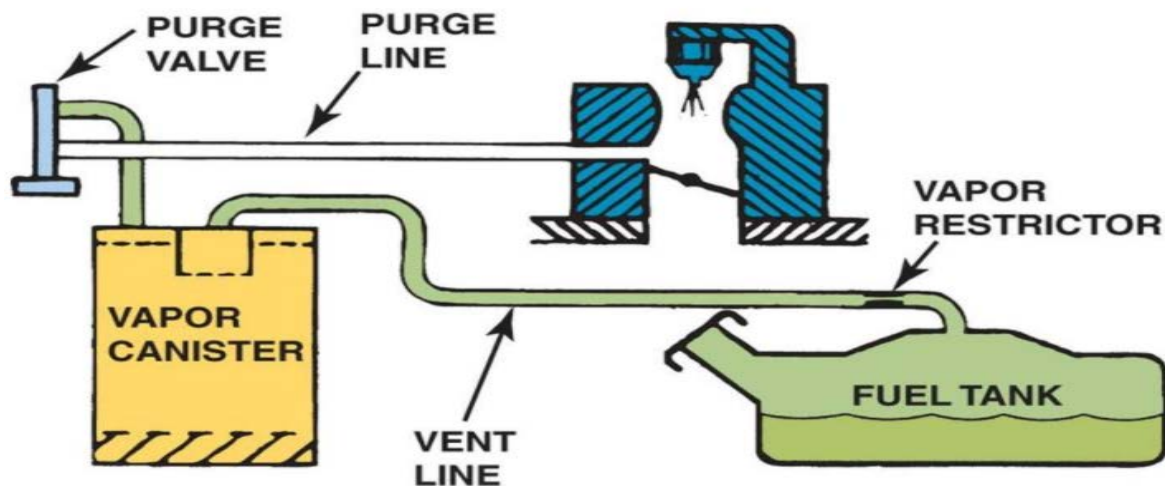


Figure (2)

(D.HALADERMAN, 2016)

The aim of EVAP emission system is to hold and trap gasoline vapors (VOCs) volatile organic compounds, EVAP totally with valves, charcoal canister, and pipes, the direction of vapors first going to charcoal canister after that into intake airflow, which the area burned in the motor vehicle instead of sending it to ambient atmosphere.

in the modern cars, the manufacturer's design the fuel tank filter covers used with EVAP system, a lot of (EVAP) fuel tank filter caps own fixed pressure-vacuum relief valve, that for if the vacuum or pressure pass appropriate value, the valve will open, exactly when the vacuum or pressure is calm down, then the valve will close.

That is why when fuelling operation while taking the fuel tank cap out, it is possible to hear the sound of sucking airflow into the fuel tank, from outside to inside the tank. The fuel tank might have experienced some damage if the fuel contraction or expansion.

EVAP Enhancement

To enhance EVAP system to avoid any sort of fault during it is operation, It is important to go through different test such as, pressure testing, vacuum testing, natural vacuum and leak detection.

(autofixworld.com, 2008)

Operation of EVAP system

The location of the canister is underneath the vehicle or under the hood. Charcoal granules inside the canister activate it and the charcoal can be filled and activated to catch and hold up of their own weight in fuel fumes and vapors.



Figure (3)

(D.HALADERMAN, 2016)

EGR

the Exhaust Gas Recirculation EGR manages and limits the amount of NO_x to form while the combustion process, which is the control emission system. It is used to control emissions at the lowest level of NO_x nitrogen oxides that been formed while the combustion operation.

EGR operation

When the EGR it is open, actually the emissions will flow through and around the valve into drawers, which is in the manifold intake, in modern cars EGR valve monitor and control the flow of emissions coming throughout the interconnecting passages.

EGR and NOx

“To handle the NO_x generated above 2,500F (1,370) the most efficient method to meet NO_x emission without significantly affecting engine performance, fuel economy, and other exhaust emissions is to use exhaust gas recirculation(EGR) the EGR system routes small quantities, usually between 6% and 10% of exhaust gas into the intake manifold.”

(D.HALADERMAN, 2016)

After this quote the exhaust gas will mix and will take some areas of intake charge, this process leaves small room is good for intake charge to throw it to combustion chamber.

EGR is inert means chemically inactive, refer that is not going through combustion operation, so it will produce low peak temperature of the combustion, final result is when the temperature of the combustion operation is in low that means the production of NO_x is reduced.

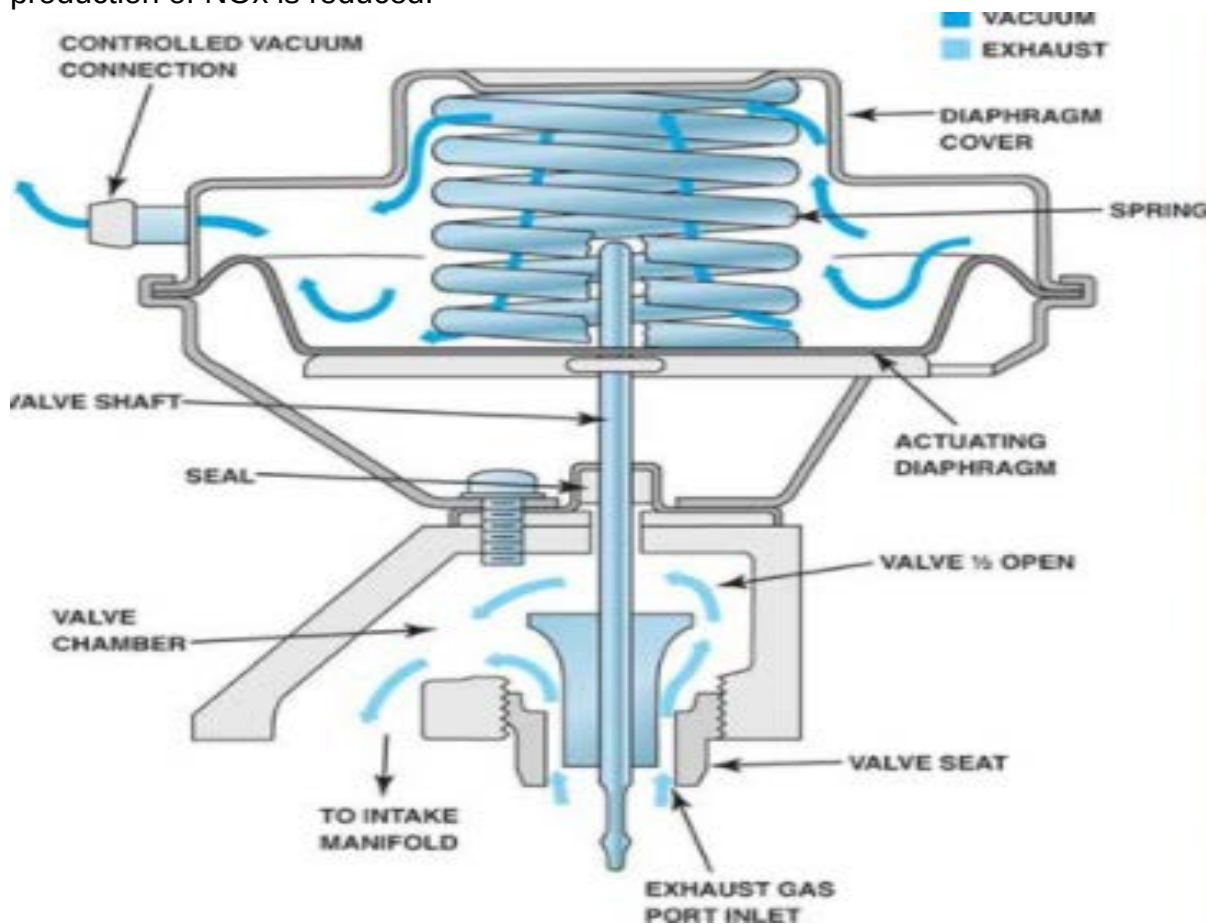


Figure (4) EGR

(D.HALADERMAN, 2016)

Notice

Low combustion temperatures will occur under the following conditions:

1. While idle speed
2. When starting the engine and it is cold
3. WOT means at Wide Open Throttle. This prevents EGR to let the motor to produce more power when it is required. During the NO_x built up high in this period that not use EGR while WOT cases is not essential.

(D.HALADERMAN, 2016)

SAIR

This system is famously called as AIR pump or thermactor, the purpose and function of the Secondary Air Injection Reaction system are to provide the required air important for the oxidizing operation in both inside the catalytic converter or the exhaust manifold.

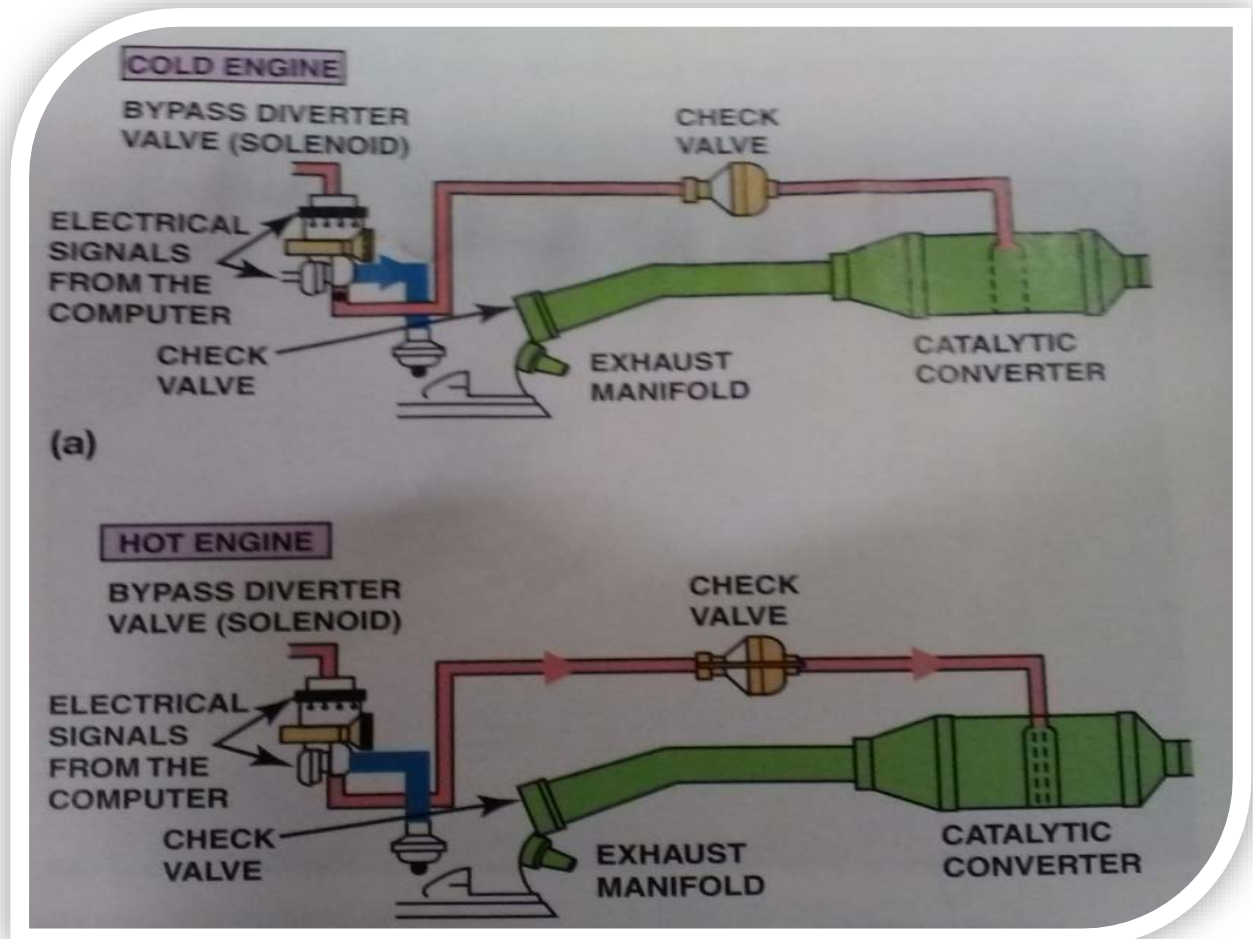


Figure (6)

(D.HALADERMAN, 2016)

Location of SAI

It is located at the front of engine pool and functioning by a belt with crankshaft pulley, the first job for pulls the air from external filter and pumps this fresh air with specific pressure to all exhaust ports throughout the manifold or connecting pipes and hoses. This consist of the electric pump, nozzles or distribution manifold, exhaust check valves, for air distribution need connecting hoses, solenoids, and air management valves, particularly in newer apps.

(D.HALADERMAN, 2016)

SAIR varying operation modes

The airflow going directly from the air pump to exhaust manifold when the engine is not hot means cold and the oxygen sensor is not hot to approach the closed loop through check valve one-way. which his job to keep all exhaust gases to go to inside the pump itself and switching solenoids, so actually when the engine on the closed loop automatically the air is going to enter the catalytic converter.

SAI ON duty

When the engine is cold, the exhaust manifold helps HC unburned hydrocarbons and CO oxidize carbon monoxide into H₂O water vapour and CO₂ carbon dioxide. In contrast, when the engine is warm in different models the catalytic converter increase the amount of oxygen required for efficient conversion of HC and CO into H₂ O and CO₂. In addition, the air pump work while WOT wide-open throttle or deceleration as air cleaner during engine operation.

Engine function	SAI on Normal Operation
Warm engine (closed-loop operation)	The direction of the air is changed to catalytic converter
Cold engine (open-loop operation)	The direction of the air is been diverted by ECU controls solenoid valve to cylinder head or exhaust manifold.
Wide open throttle	Air is change its direction ECU by to the air cleaner assembly.
Deceleration	When the vacuum is increased over the normal limit the airflow is been diverted by ECU to the air filter cleaner to avoid any sort of backfire.

Figure (7)

(D.HALADERMAN, 2016)

SAI off function

If the SAI is not functioning means off that may make poor running because the excessive amount of exhaust is going to inlet.

PCV

Positive crankcase ventilation system. There are two ways to work of PCV for heated and un heated system, it is use normally a fixed orifice or valve to manage and limit crankcase vapors, which is in the back of the crankcase and diverted to intake system.

PCV valve

The job of this valve is to regulate the vapors of crankcase flow which is rely on the seals crankcase vent in the backfire if its occurs and engine vacuum.

Regular types of faults

Because this ventilation system it might happen in the PCV valve is clogged up, some sort of flow problems such as plugging or blocking in PCV system, this happened by accumulations of oil varnish and fuel inside the valve, that can block and restrict the vapours flow current in the valve.

PCV impact faults

- 1.unstable idle and sounds rough.
2. The oil consumption is excessive.
3. Some oil inside the air filter housing.
4. Excessive crankcase pressure makes oil leak.

(D.HALADERMAN, 2016)

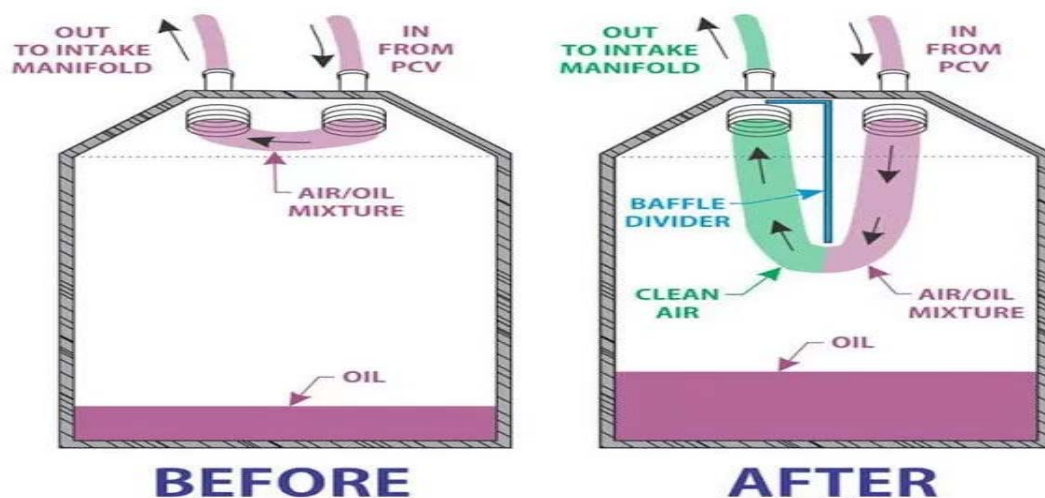


Figure (9)

(Naijacarrovers.com, 2018)

Air fuel ratio

Just as water and oxygen are vital to humans, it is important for an engine to functioning properly, if the percentage of air and fuel ratio is not adapting properly will create a major impact on the engine performance, if it increase with increase NOx gases. Air and fuel ratio are very important matter because they are changeable in different variable ratios and that affect hydrocarbons exhaust emission.

Some investigators saying that fact is as the air and fuel ratio have decreased the concentration of the hydrocarbon will be increased, this fact has been founded by combustion Orsat method, which found the percentage of the hydrocarbon concentration is very low.

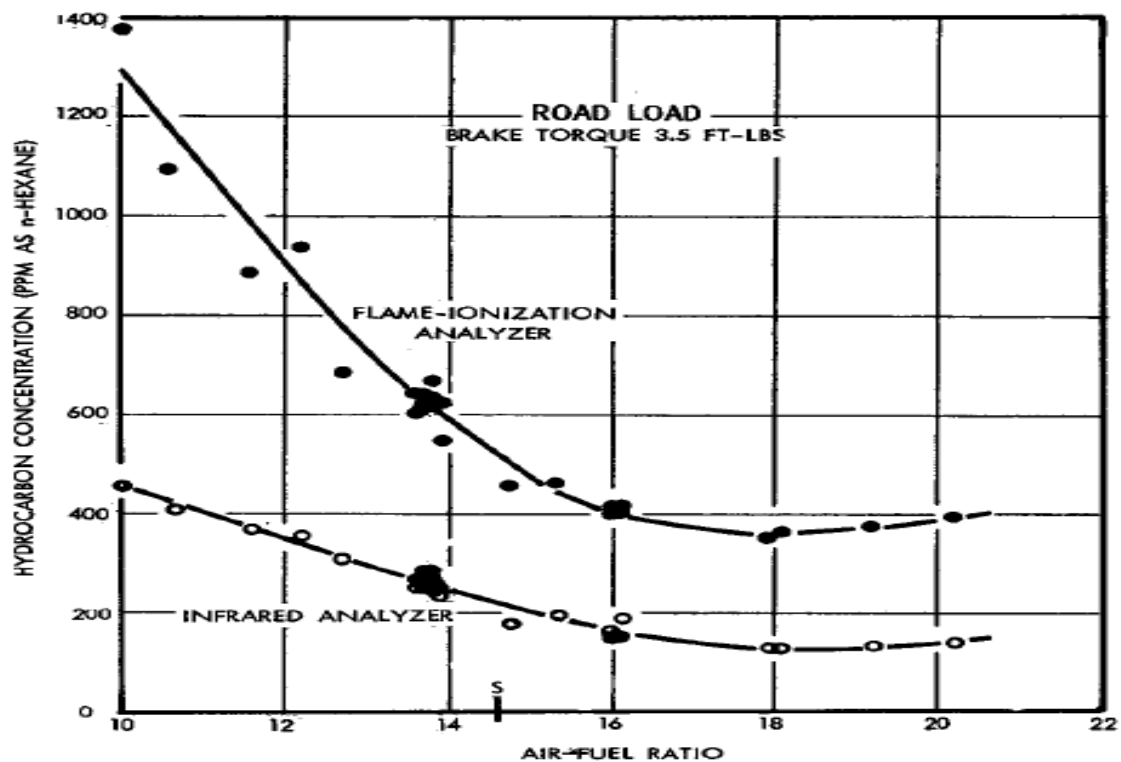


Figure 1 - Effect of Air-Fuel Ratio on Exhaust Hydrocarbon Concentration at a Simulated Road Load Condition (Single-Cylinder Engine A, 1200 rpm, Manifold Vacuum 13.7 to 18.2 in. Hg, Spark Timing 30° BTC)

Figure (10)

(SAE, 1962)

As a result, there is a real relationship between a load of air and fuel ratio to the concentration of the hydrocarbon in the emission.

The air and fuel ratio is dependent on the engine load, fan and air condition and many devices work at the engine load will burn a lot of fuel, it increases the combustion operation finally increase the emission, which is relative to the air/fuel ratio as well.

Euro 6

Euro 6 emissions standards are founded to reduce and limit harmful exhaust gases and make it to a low level as possible, the main gases are HC hydrocarbons, NOx nitrogen oxides, CO carbon monoxide, PM particulate matter.

Emission gas	Petrol down to	Diesel down to	Year since
CO	63%	82%	1993
HC	50%	No change	2001
NOx	84%	No change	2001
PM	No change	96%	1993

Figure (12)

(rac.co.uk, 2018)

Euro 6 standards for petrol and diesel engines

Exhaust gas type	Petrol Engine rate	Diesel Engine rate
CO	1.0 g/km	0.50 g/km
THC	0.10 g/km	HC+NOx 0.17 g/km
NMHC	0.08 g/km	
NOx	0.068 g/km	0.08 g/km
PM	0.005 g/km only direct injection	0.005 g/km
PN	6.0x10 ⁶ l/km only direct injection	6.0x10 ⁶ l/km

Figure (13)

(rac.co.uk, 2018)

Important changes to meet Euro 6

The important changes and modifications to bring the engine to meet Euro standards are many, for example, fit modern sorts of devices to limit and reduce the NOx or total gas emissions such as EGR, EVAP, SAIR, PCV, in addition balance air and fuel ratio.

Therefore, the way of injection fuel systems such as port injection, direct Injection, simultaneous injection and sequential injection will make difference at the gas percentages. The implementation timing to function this standard it was in 1st Sep 2015, for diesel engines the allowances and permitted the range of NOx it been reduced from 0.18 g/km in Euro5 until achieved to 0.08 g/km.

All car manufacturers focus on diesel engine NOx percentage. This is because it makes a huge impact on the increase of respiratory diseases in society.

(rac.co.uk, 2018)

Methodology

what the industry doing to contribute Euro 6 emission standard.

Carmakers or industry dealing with every new engine model that is sells in Europe, must go through New European Driving Cycle procedures (NEDC).

Before it going to displaying in market by the show rooms, this procedures to measures and test emissions of every engines.

The applications of this procedure it will be functioning in a managed environment, and checked by witnessed from different agencies and governments, the procedures consist of check the fluid levels, ambient temperature and tyre pressure, all this sort of balances and measured will be between different models to keep the accuracy of the test as possible.

So refer that the car is tested and the emissions percentage recorded for all, therefore that gives the possibility of comparing directly between each other .the way to choose the car for test it will be randomly chosen from the manufacture production lines by legislative team, that shows the manufacturer hasn't any authority to supply specific model that gives positive results for emissions tests.

(Autoexpress.co.uk, 2018)

Euro emissions standards for diesel cars

Euro standard	Date	CO	NO _x	PM
Euro 1	July 1992	2.72	-	0.14
Euro 2	January 1996	1.0	-	0.08
Euro 3	January 2000	0.64	0.50	0.05
Euro 4	January 2005	0.50	0.25	0.025
Euro 5a	September 2009	0.50	0.180	0.005
Euro 6	September 2014	0.50	0.080	0.005

Figure (14)

(Autoexpress.co.uk, 2018)

Euro emissions standards for petrol cars

Euro standard	Date	CO	NO _x	PM
Euro 1	July 1992	2.72	-	-
Euro 2	January 1996	2.2	-	-
Euro 3	January 2000	2.3	0.15	-
Euro 4	January 2005	1.0	0.08	-
Euro 5	September 2009	1.0	0.060	0.005
Euro 6	September 2014	1.0	0.060	0.005

Figure (15)

(Autoexpress.co.uk, 2018)

Discussion

NO_x forms at temperatures exceeding 2000K during combustion. Bonds between Nitrogen are broken by Oxygen radicals (lone Oxygen atoms) to form NO oxides of Nitrogen. Typical strategies to minimise formation include water injection as well as EGR, to increase the mass of intake charge.

Direct Injection

Difficulty in making Homogenous mixture – this is why fuel rail pressures are higher, to make very fine spray quickly. As fuel and air is not always a good mix, we get patches of rich mixture and lean mixture together, resulting in higher NO_x and particulate emissions. However, due to only pumping air there is more air in the same space as the fuel is added later, this means the volumetric efficiency is improved and compression can be higher as there is no risk of pre-detonation until after the fuel is added. The engine has to pump less hard for same power output and because it is working less hard, does not require so much for acceleration. As the fuel is delivered directly to a cylinder, there is no condensation loss to inlet port walls and acceleration is more instantaneous. EGR can also be increased as no space in the inlet charge is occupied by fuel at induction and compression. Some negative influences on emissions include more particulate matter and hydrocarbons being produced in cold-starting and warm-up. This is caused directly by the mixture not being completely homogenous, being made up of fuel droplets in air, which don't burn well. These are carcinogenic.

(Dimou, 2011)

Port Injection

Good mixing of fuel and air is possible by spraying fuel on back of inlet valve, this also helps to keep it cool. It allows for the manifold to be a shape which optimises air flow to the engine by the fuel being added to the flow of air near the port. There is less opportunity for fuel to condense on cold intake walls than with a carburettor delivery system and provides an even distribution of fuel to cylinders due to each cylinder having its own injector.

Some environmental influences of the port injection are increased volatile organic compounds (VOCs), when compared to a direct injection engine. Emissions of benzene and toluene are higher. Betrol is carcinogenic, and long-term exposure can cause a range of adverse health effects including damage to bone marrow, a reduction in red blood cells and a weakened immune system.

(sourceable.net, 2018)

Sequential Firing (SFI)

The style of fuel burning in sequential Firing injection manor is preferable way of regulating the port fuel injection, also when the injectors firing by sequential that it dependent on the engine is order accurately. As known the sequential manor is 1243

The expenses of manufacturing sequential injection is high that why the carmakers spend a lot of money to design and manufacture this system.

(HALDERMAN, 2009)

Why Sequential better than Simultaneous

The reason that all the industry looking at this type of injection is producing very low emissions and very economical for injecting the fuel. because the fuel rate is changeable for every cylinder, that probably can get the high performance out of the motor vehicle in reality, immediate response for the throttle, which permit for many changes in the air to fuel mixture, because consumption of the fuel is very economy, so the emissions will be released to lower level, the governments looking for how the carmakers producing the vehicles to meet hard emissions standards.

Another of high performance of the sequential system is total system has a very good reaction and response time while the driver speeds up the engine or makes the fast change. However less or more fuel easy to be released during the intake valve is opened.

(Linder, 2009)

Analysis

Three engines Ford Ecotec, Vauxhall and Ford Zetec, all of them they struggling to how the limit and managing three gases which is CO, CO₂, Oxygen so those four gases have work a real challenge for the industry and manufacturers.

Ford Pin21

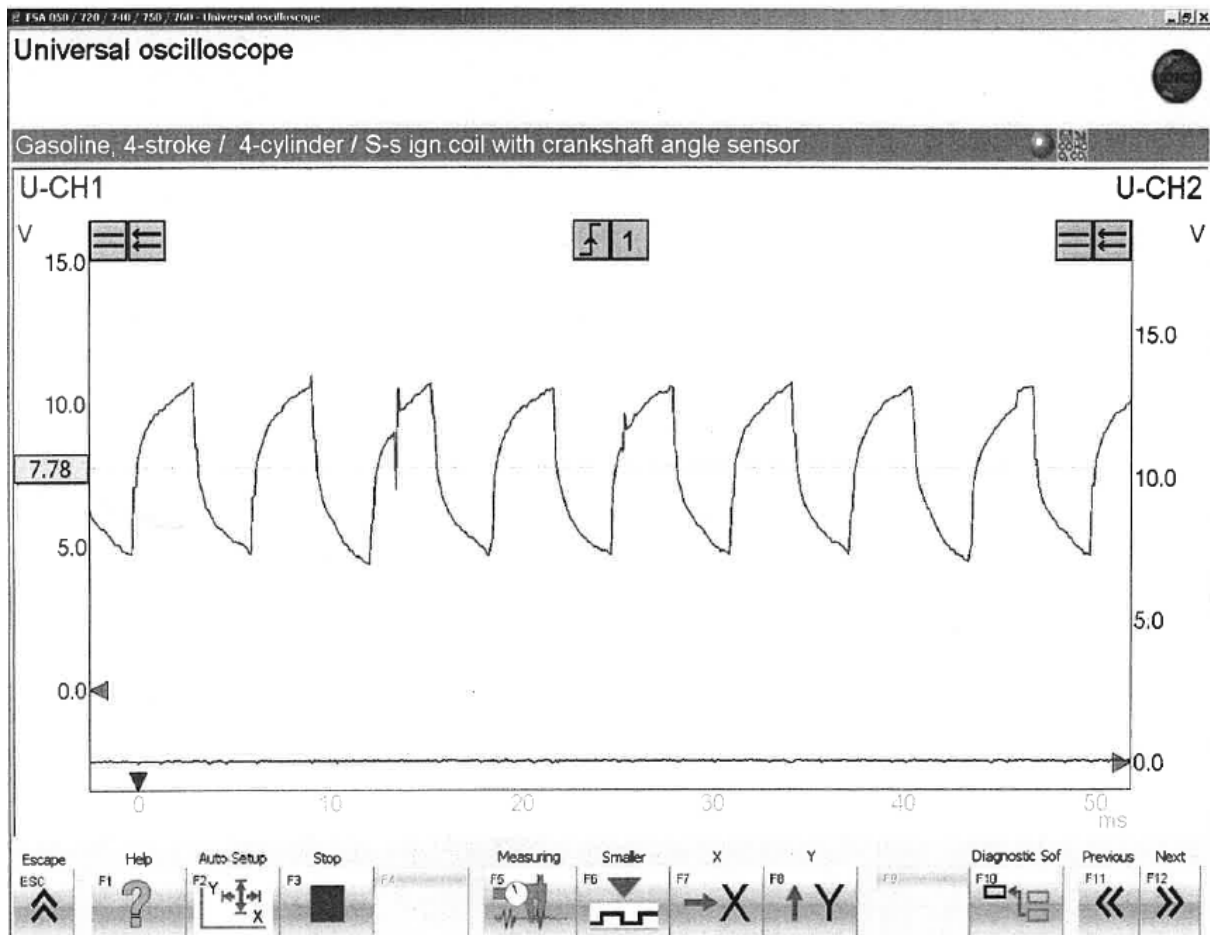


Figure (1) shows pin 21 pulsed sides of the idle control valve, this camshaft phase sensor recognize when number one on the system, so valve solenoid plunger and phasing to control if it low load will give high voltage results will be low current, if it is high load will be low voltage and result will be high current.

Ford Pin24

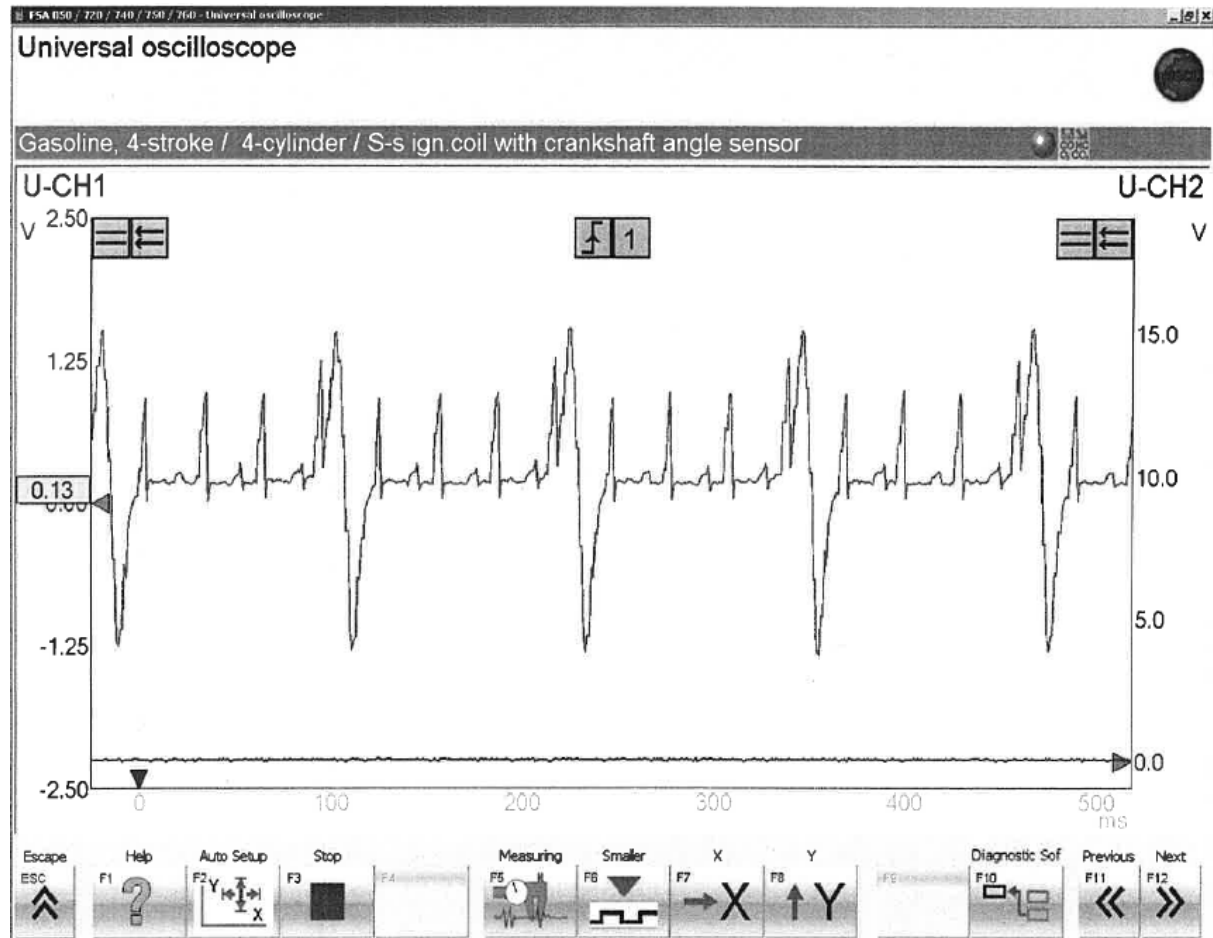


Figure (2) displaying AC input from camshaft phase sensor, the waveform showing that the camshaft is been deployed and produced to the system, the reference of this sensor is ECU so can presenting number one cylinder of Top Dead Centre (TDC) it could be down, this is dependent on the phase where it is, so this type is reluctant pulls generating.

Ford Pin35&39

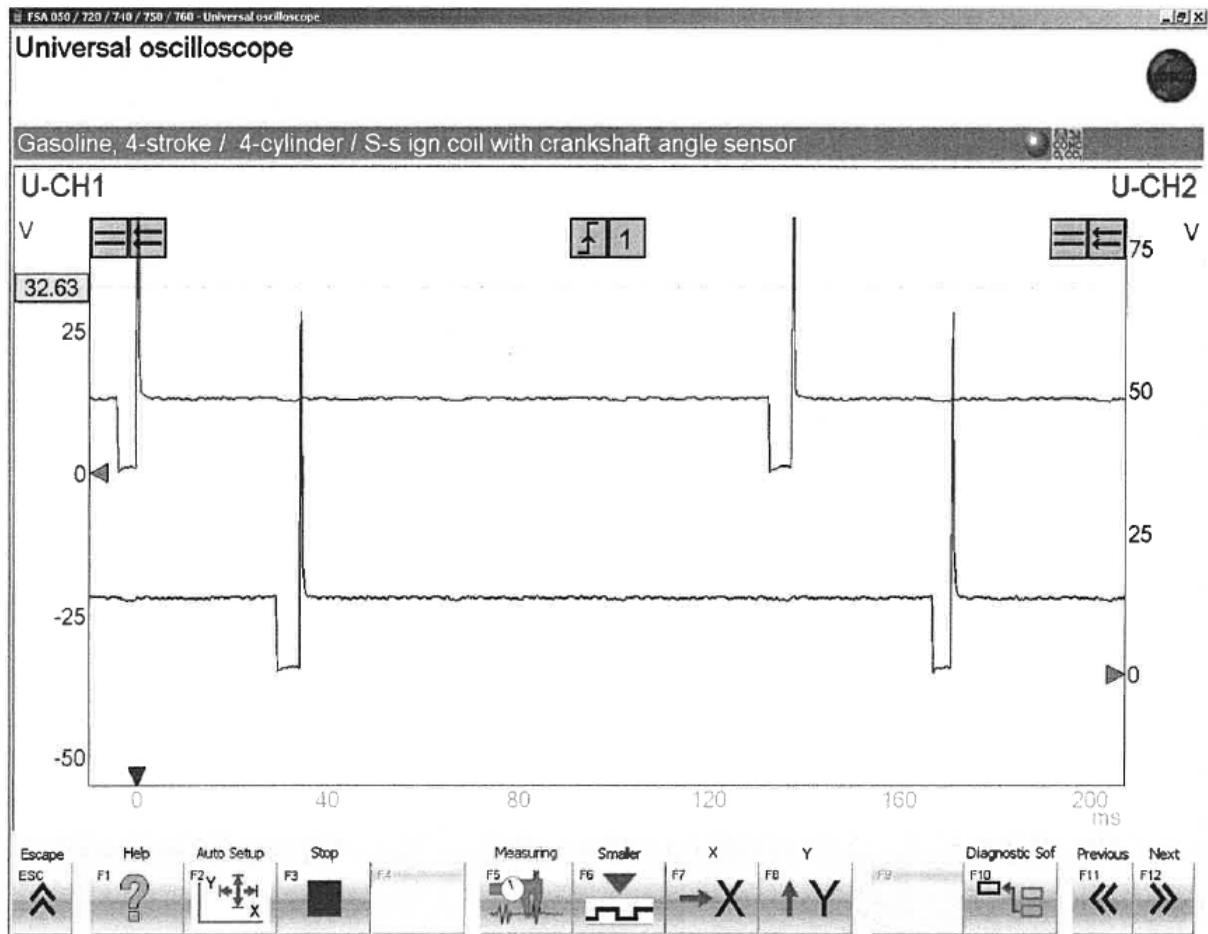


Figure (3) displaying two injectors which is number4 earth via ECU and number 3 earth via ECU, the waveforms shows sequential injection from the engine change from another one, which is simultaneous into sequential injection, Idle control be more solenoid control and side of things, actually got pulls air system such as hot air mass meter and fan, when speed up revs and warm-up phase of the catalytic converter and more.al this things to make environment-friendly.

Vauxhall Ecotec Pin 42

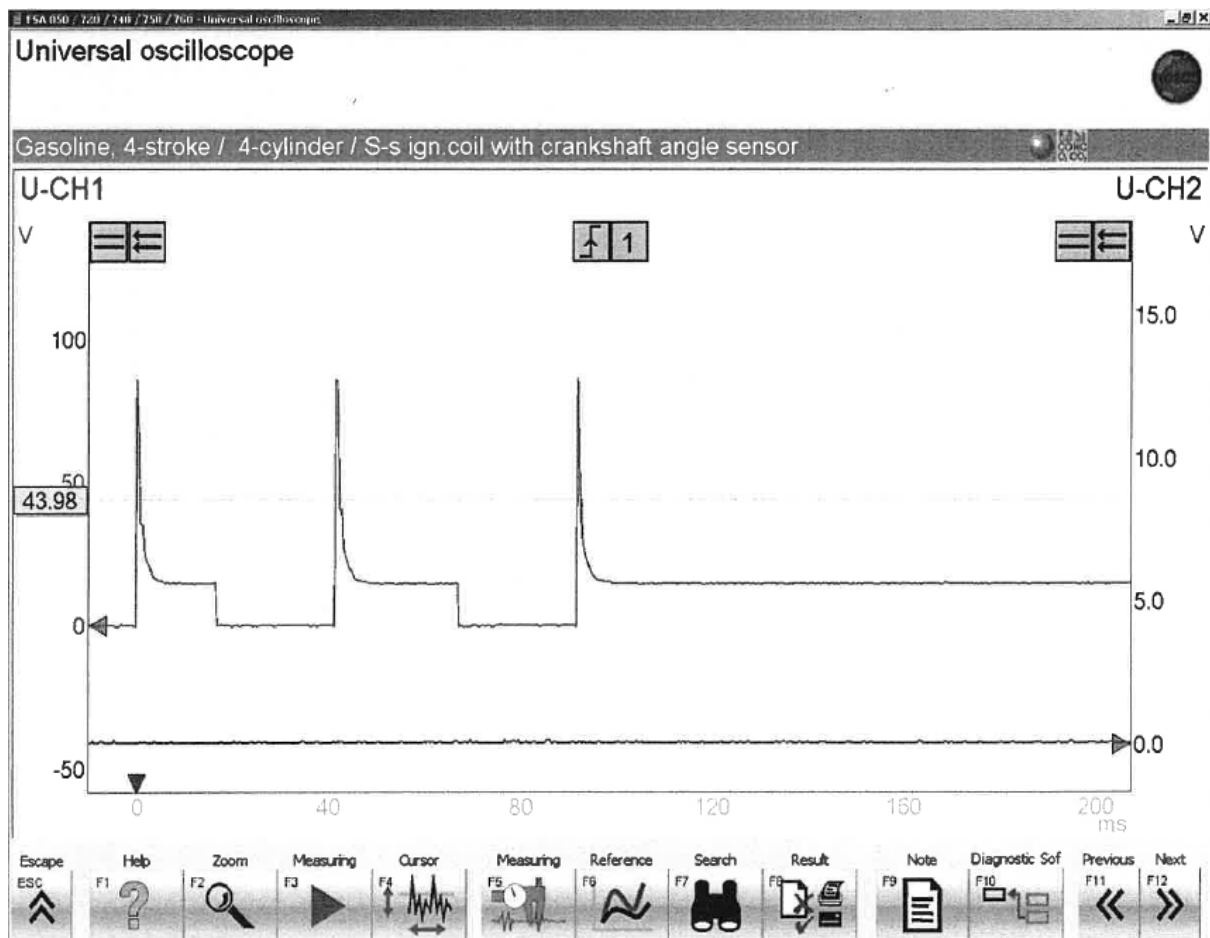


Figure (4) shows negative side of EGR solenoid valve

So EGR now is deployed is going slightly high voltage scale, if ECU order throttle open EGR be deploy ,so the solenoid open to EGR ,that happened again to send exhaust gases back to EGR. The topic is different EGR have different opens so much or less some of them have 8 sequences to open it. The amount of deployment and length of time is adjustable, also it dependent on the revs range and frequencies coming.

Vauxhall Ecotec Pin 52

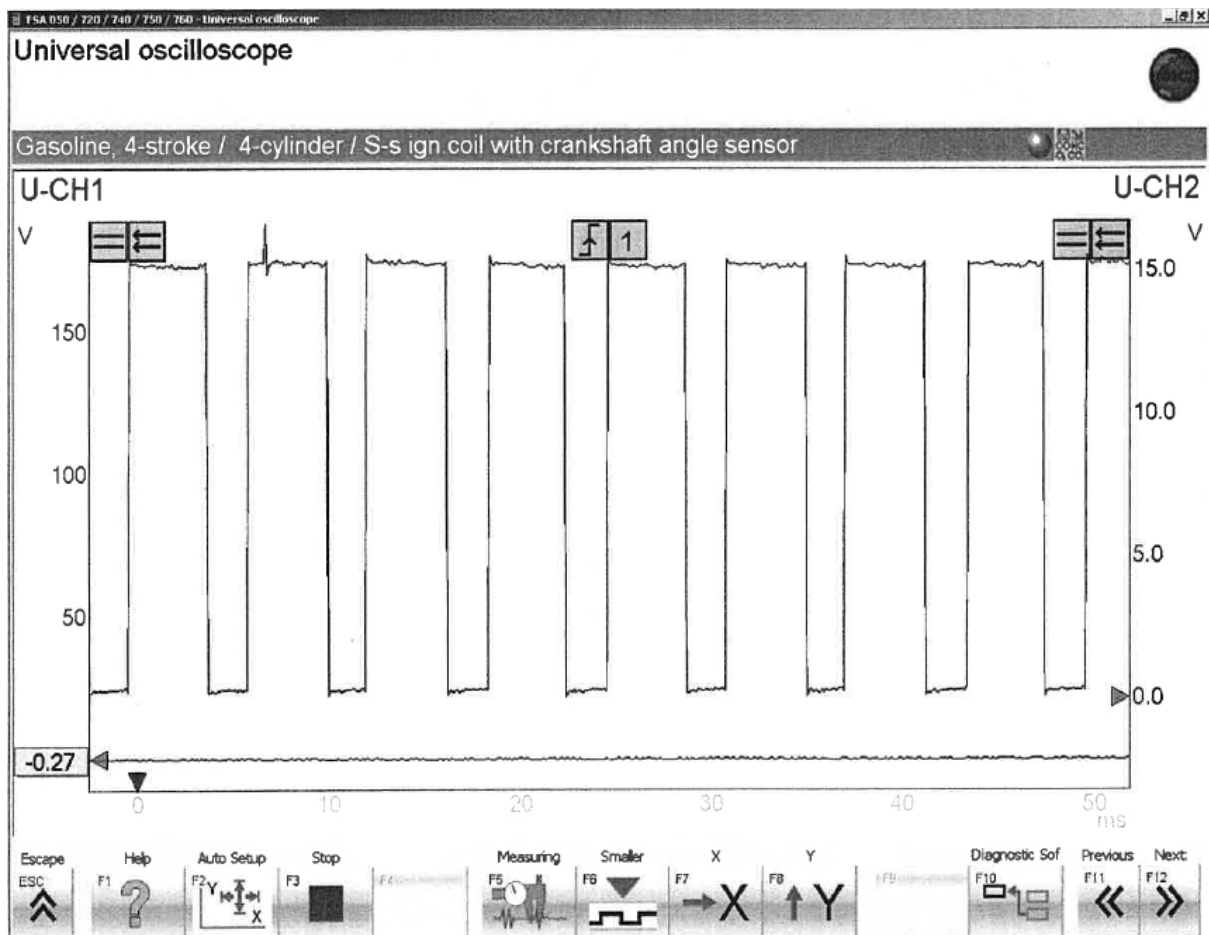


Figure (5)

Pin 52 showing the negative side of the idle valve which is the complete sequence and the current drawn on it, not focusing at the time, and not exactly on and off sides but looking at the load, this phasing is expected to be going fast and wide, because of it plunger type accurate and delivery. Finally if we need to have a great opening or less opening the current going to it is going to be exchange, if we would have employed more current for it to draw open it, and on opposite side for less current to not draw so much, the impotency is looking at the load.

Test Example

If looked at Vauxhall 2.L, this engine is consist of camshaft face sensor this run sequential injection as the last explanation of sequential manner to 1342.

Got hotwire mass meter for load phase and for accuracy, got the crank sensor, Knock sensor, also got EGR valve because this engine is higher compression.

EGR solenoid controls his job to left the valve to allow the exhaust gases to travel along back to induction stroke.

In this engine there is coal canister worked through the solenoid, so the same factor hydrocarbons can be rejected to the atmosphere so we have a lot of components.

Defiantly this system now has become fully adapted, because we got lambda sensor, EGR, knock sensor and idle control valve, idle control valve is solenoid type plunger type.

This just shows the manufacturers looking at influences of these systems on the emissions in the modern cars.

why they put the lambda sensor before and after the catalytic converter because the lambda can recognize the gases and the chemical materials is coming out from the engine to catalytic, why after to monitor the catalytic functioning properly or not.

Conclusion

As Newton's "To every action there is always opposed an equal reaction.", the same in vehicles emissions, the action is combustion the fuel to gain torque which is the speed of rotation converted to speed movement, the reaction is emissions.

How to manage that by setting the standards, from Euro1 to Euro 6 is to show the total amount and percentage of exhaust gases which is coming out from the vehicle.

The main four gas is hydrocarbons, carbon monoxide, PM particulate matter and nitrous oxide.

There are six times to reduce the gas emissions happened from 1993 to Euro 1 standard, Euro2 (1996), Euro 3 (2000), Euro4(2005), Euro5 &6(2014).

Realization of the challenges to limit and reduce PM particulate Matter in diesel vehicles, that the reason for Euro 5 is were organized for a diesel engine.

Each standard from Euro 1 to 6 is allowed for maximum hydrocarbons and carbon monoxide for many vehicles, the manufacturer and experts looking to monitoring the component to manage the emissions gases.

Finally for both vehicle diesel and petrol must exhale less than 0.005 g/km for PM Particulate Matter, therefore DPFs which is Diesel Particulate Filters is been produced this time to fit to help to pass Euro 7 emissions standards.

(carkeys.co.uk, 2018)

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