

Emissions



Benjamin Coney

1703189

Emissions Control & Diagnosis

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Introduction

Within this assignment, a definition of how a modern catalytic converter system monitors its function, the protocols needed will also be discussed, a discussion of how a technician would evaluate the efficiency of the catalytic converter will also be made. From here, the functions of an evaporative emissions system on a modern system will be discussed whilst stating its importance in the emissions control of a vehicle. The exhaust gas recirculation system will then be discussed, along with the effects of having the EGR on and EGR off. The Secondary air injection system will then be discussed and how it varies in its mode of operations between a cold and hot engine, along with the effects it has on the pre and post-cat emissions. The positive crankcase valve will then be discussed and its use within an internal combustion engine and how to diagnose a faulty PCV system. The air/fuel ratios will then be discussed along with how the ratios effect how the engine runs, and the damages that can be caused if the air/fuel ratios are incorrect. Finally, the Euro 6 standards will be discussed with a comparison to the Euro 5 standards and how they differ, the changes needed for a vehicle to comply with the Euro 6 standards will then be discussed, followed by a conclusion of the findings.

Research

Catalytic Converters

The catalytic converter is an 'after treatment device' (Gibson) located within the exhaust, it is usually located as close to the exhaust manifold as possible, this is to ensure that exhaust gases are still hot when they reach the cat. The optimal temperature for the catalytic converter to be fully effective is between 480°C and 870°C. The internals of the catalytic converter comprise of a ceramic material which is coated with catalytic materials such as platinum and rhodium, this is made into a honeycomb shape. The efficiency of a catalytic converter can be evaluated by measuring the NO_x, CO and HC that is produced by the test vehicle after the cat using an emissions probe inserted into the end of the exhaust, a probe can also be inserted into the pre and post-cat lambda sensor positions. The emissions probe measures the levels of hydrocarbons, NO_x and CO's that are still present after the cat, if there are high levels of these emissions then it would suggest that the catalytic converter isn't working effectively, this could be due to the catalytic converter being either damaged or faulty. The catalytic converter can become damaged due to contamination or excessive temperature, the cat may become contaminated by excess oil or antifreeze in the exhaust. Excessive temperatures within the cat can be caused due to improper air/fuel ratios, for instance, if the engine was running rich the excess fuel would burn in the exhaust, causing the honeycombing within the cat to melt, thus restricting the flow in the cat and the possible blocking of the catalytic converter (Automotive handbook, 2007). A modern vehicle can monitor the catalytic converter using lambda sensors, the ecu can measure the waveforms produced by the sensors, when the cat is working effectively, the post-cat lambda is less active than the pre-cat lambda. The lambda sensors monitor the oxygen levels in the exhaust gases. The ecu would usually undergo these tests when the engine load is less than 65% and steady and the engine speed is lower than 4000 rpm, also the engine coolant temperature must be over 18°C (Gibson).

EVAP

The Evaporative emissions control system, EVAP for short, is a system used to trap and hold gasoline vapours, these vapours are also known as Volatile Organic Compounds, VOCs for short. These VOCs are then routed to a charcoal canister and then on to the intake manifold before being burned in the engine (Gibson). The EVAP system also comprises of a pressure vacuum valve on the fuel filler cap, this is in place to protect the fuel tank from overexpansion or over contraction, it is also there to avoid vacuum lock within the fuel system. The charcoal canister is filled with active charcoal granules, the granules absorb the fuel vapour, the vapour is then drawn out of the charcoal canister and into the inlet manifold by vacuum when the purge valve is opened (Hillier, Hillier and Smith, 2012). The ecu controls the purge valve by sending a duty cycle to open and close the valve, this is usually done when the engine is under minimal load when on light throttle. The EVAP system is an important aspect in the control of emissions as it stopped the gasoline vapours from being vented into the atmosphere as they are in vehicles produced before 1970, thus meaning that the overall emissions produced by the vehicle on a whole can be reduced.

EGR

The EGR or exhaust gas recirculation system is an emission control system that lowers the combustion temperature, thus lowering the amount of NO_x production and reduces exhaust emissions (Hillier, Hillier and Smith, 2012). The ecu opens the EGR valve when the engine is under a light or medium load, the valve opening allows for exhaust gases to be conducted back to the combustion chamber, reducing the peak combustion temperatures, thus effectively controlling NO_x emissions (Automotive handbook, 2007). When the EGR valve is open, the intake manifold pressure is increased, reducing the charge cycle work, thus lowering the fuel consumption. The EGR valve is closed when the engine is at idle and when the engine is cold as it causes the engine to have an erratic idle, the EGR valve is also closed at high RPM, this is due to a loss of power when the EGR is open at high RPM this is due to oxygen starvation. The EGR is controlled by an EGR position sensors, a linear potentiometer located on top of the valve and an exhaust back pressure sensor.

SAIR

The secondary air injection system or SAIR for short is a system used to inject air into the exhaust manifold when the engine is cold, the air then combusts with the HC and CO to help heat the catalytic converter up to operating temperature (Hillier, Hillier and Smith, 2012). When the engine is up to operating temperature, the ecu controls the solenoids so that the air is sent to the cat and when there is an increase in vacuum the ecu diverts the air to the air filter to avoid backfire (Gibson). On modern vehicles, an electronic air pump is used, this is supplied by a timer relay when the engine is cold until the catalyst is at operating temperature, this can also be controlled by the ecu. Older vehicles used belt driven air pumps, which were also known as smog or thermactor pumps. If the SAIR system fails it would cause for the engine to run poorly as it would have an excessive amount of exhaust gases in the inlet manifold (Gibson).

PCV

Positive crank case ventilation, PCV for short, is a system designed to reduce both CO and HC emissions, this is done by venting the blow-by vapours from within the crankcase to the inlet manifold, the vapours then get burned within the combustion chamber along with the fresh air fuel mixture (Gibson). The PCV is controlled by a spring-operated plunger, the air flow through the crankcase is regulated through all conditions, the air flow is restricted when the manifold vacuum is high, this is when the engine is at idle or when under light loads. When the engine is under heavy loads the valve is opened fully to allow for maximum airflow through the crankcase. A faulty PCV could cause the blow-by gases to condense and combine with oil vapour present within the crankcase, forming a sludge or cause the oil to become diluted with unburnt fuel. Also, if the vapours are not vented, they could cause excessive pressure within the crankcase, resulting in oil leaks from the crankshaft seals and the head gasket (Hillier et al., 2004). A fault within the system could be diagnosed by testing the vacuum produced by the engine at the valve cover, this can be done by placing a bank note over the oil filler cap, if the PCV is working correctly, there should be a small vacuum on the oil cap.

Air/Fuel ratio

The air/fuel ratio or AFR of an engine is a vital part of the combustion, this is due to the air/fuel mixture having a direct affect to how the engine runs and the emissions that are produced after combustion. If the air fuel ratios are too low, the engine will be running lean, thus causing the combustion temperatures to increase, resulting in the increase of NO_x (Haynes Publishing, 2019), the increase in temperature could also result in the damage of vital engine components such as the pistons and spark plugs. If the air fuel ratios are too high, the engine will run rich, thus meaning that the fuel consumption will increase, as there will be excess fuel in the combustion chamber, the excess fuel would then go into the exhaust where it can combust, resulting in damage to the catalytic converter. When the engine is running rich, there is also an increase in CO emissions (Gibson). Having the perfect air/fuel ratio is important as it reduces the emissions produced and improves the fuel economy. The pre-cat lambda is the point where the air fuel mixture is considered as being perfect, this is due to the air/fuel mixture having already been through the combustion chamber and what remains is the exhaust gases, which would have minimum emissions, the gases would then go through the catalytic converter to undergo oxidation. The pre-cat lambda also has a vital part in the controlling of the air/fuel ratio as it communicates with the ecu and tells it whether the air/fuel ratio is lean or rich, the ecu then controls the rest of the engines sensors to adjust the air/fuel ratio accordingly.

Euro 6

Euro 6 was introduced in September 2014 for new approvals and September 2015 for most new registrations. Euro 6 was introduced to combat the NO_x levels produced by diesel vehicles, the levels where reduced from 0.18g/km in Euro 5 to 0.08g/km, the reason for this is because studies showed that NO_x was related to respiratory problems (Rac.co.uk, 2019). Below are the Euro emissions standards for Euro 5 and 6;

Euro 5 emissions standards (petrol)

CO: 1.0g/km

THC: 0.10g/km

NMHC: 0.068g/km

NO_x: 0.06g/km

PM: 0.005g/km (direct injection only)

Euro 5 emissions standards (diesel)

CO: 0.50g/km

HC + NO_x: 0.23g/km

NO_x: 0.18g/km

PM: 0.005g/km

PN [# /km]: 6.0×10^{11} /km

Euro 6 emissions standards (petrol)

CO: 1.0g/km

THC: 0.10g/km

NMHC: 0.068g/km

NO_x: 0.06g/km

PM: 0.005g/km (direct injection only)

PN [# /km]: 6.0×10^{11} /km (direct injection only)

Euro 6 emissions standards (diesel)

CO: 0.50g/km

HC + NO_x: 0.17g/km

NO_x: 0.08g/km

PM: 0.005g/km

PN [# /km]: 6.0×10^{11} /km

From the Euro 5 and 6 standards for petrol (Rac.co.uk, 2019) it is evident that the standards haven't changed for petrol cars, however, there has been an introduction of PN, which is particulate number, this only affects direct injection engines though. When making a comparison between the diesel standards however, there have been some changes to the standards between Euro 5 and Euro 6, the main difference is the level of NO_x, which as stated previously has been decreased from 0.18g/km to 0.08g/km. In order to achieve these levels the air/fuel ratios would have been adjusted to get the perfect air/fuel ratio, to ensure that the wasn't running lean as the increased temperature in the combustion chamber would result in an increase in NO_x, due to this the air/fuel ratio would have been increased so that it is running slightly richer, however if the ratio was too high there would be an increase in CO, to avoid this the PCV would open sooner to reduce both HC and CO. The EGR would also have a part to play in the reduction of NO_x, this is due to the EGR having a direct affect to the temperatures within the combustion chamber. Having a higher compression ratio would also help with reducing the NO_x levels as it would allow for a higher inlet pressure, thus allowing for a lower combustion temperature and a better air/fuel ratio. The reduction in NO_x would have a positive effect on society as a whole as it will reduce the emissions produced by diesel vehicles and will benefit society as it will reduce the respiratory issues that occur from a high level of NO_x.

Conclusion

To conclude, from the findings discussed within this report it is evident that the emissions produced by internal combustion engines are being controlled to a good standard, however, in the future with Euro 7 and so on, the standards will only get stricter, in order to hit the targets set, there will have to be improvements as a whole to the systems used. To improve the emissions further for Euro 7 ensuring the air/fuel ratios were at the perfect point would be important, introducing a secondary catalyst may be another way to reduce the emissions produced. This could be done using a secondary catalytic converter.

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