



VEHICLES EMISSION CONTROL SYSTEMS AND LEGISLATION

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Emissions Control and Technology

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1) Introduction

The concerning factors of air pollution gave rise to introducing such components throughout Europe. European regulation pushed for greater standards to be met since 1992 although regulations weren't as stringent as they are today but the first Euro 1 emissions legislation required the fitment of catalytic converters on any new cars at the time. Vehicle manufacturers since have been put to the task of reducing exhaust emission going out from engines. This gave rise to the employment of highly skilled engineers to design such components to reduce exhaust gasses and highly skilled technicians to have the knowledge of diagnosing, fitting and replacing such components.

This assignment is a study complete my research on the emissions systems that are in modern day cars and why they were invented. This assignment also delves into the chemical compounds of the fuel we burn and the outcome of its combustion with the backlash of trying to create a greener environment by making engines more efficient.



2) European governments earning power through the automotive industry.

A big debate nowadays to do with vehicles today having too many emission control systems on engines today. This gives rise to the creation of expensive components many of which don't have a long lifespan and need replacement after 40,000km which in turn costs more on the owner to keep the vehicle running and raises the price initially to buy the car. Components such as the EGR valve on diesel vehicles that will be discussed below have such problems.

Although factories and other such manufacturing sectors actually add a larger amount to air pollution than passenger vehicles, predominantly in Europe politicians of the commanding leading governments have been pushing largely towards reducing the emissions of the automotive industry. This is mainly due to the arguments that nearly everyone has a car or a van and many households have multiple cars per household like a Sunday car, work car, van, race car, motorcycles etc. This means that governments can easily get their revenue from the public through road tax of cars and special licensing of trailers and large and heavy goods vehicles rather than taxing large corporations that have found loopholes from paying corporation tax. An example of this is Apple Inc in Ireland where the corporation tax is one of the lowest in Europe at a yearly rate of 12.5% and Apple had found a way to pay less than 1% tax a year in Ireland up until 2018 where Apple had a tax bill of 13.5 billion unpaid. (Irish Examiner, Article 2018. Online)

The most common fuels used in the automotive industry are petrol and diesel, a small minority use electricity and another small minority use LPG liquid petroleum gas. The following assignment will cover gasses caused by petrol engines as they are the most used solid fuel type in the EU.

Fuel types of new cars, first quarter of 2018

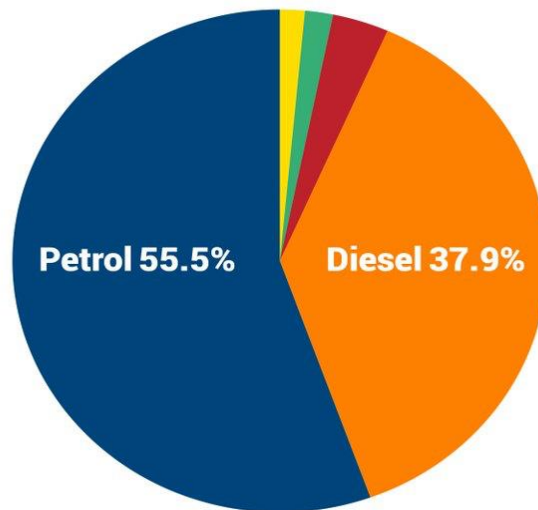
Market share (%)

■ ECV ■ HEV ■ APV other than electric

Alternative powertrains:
6.5%

Electric cars:
1.7%

Hybrids:
3.4%



The Pie chart above represents the % of market share that petrol has over other powertrains in 2018 throughout Europe. (ACEA Article, 2018. Online). In the past there has been examples of a huge influence that the British government has over European car legislation one of which was when David Camerons party were in power, the purchasing of Diesel cars sky rocketed because of his support of the diesel fuel being a greater benefit to the environment and economy over petrol. That's why you can see the % of market share above of diesel cars now being close to petrol cars. But now research has been done on the hydrocarbons and particulates that these modern engines create because of such innovation due to European regulation. An example of this is the increased combustion temperatures in diesel engines today. The emphasises on downsizing (reducing the capacity) of your engine to make cars burn less fuel to meet euro 6 regs gave rise to car manufacturers having to find different ways to create the same amount of power of a bigger cc engine with a smaller cc engine. The option most manufacturers went with was placing a turbo charger on their engines and BMW's twin power turbo technology and Toyotas twin entry turbo technology create a leaner burn which studies are now finding are rise in particulates in the atmosphere due to these higher combustion temperatures and lean burn. (R.Sindhu, G.Amba Prasad Rao, K.Madhu Murthy. 2018). The biggest restrictions for the cylinder heads designs on engines are because of legislation to improve emissions efficiency in recent years. The investing in downsizing and introduction of aluminium cylinder heads has improved efficiency vastly but has created problems such as Nox particles because of high combustion temperatures. (R.Sindhu, G.Amba Prasad Rao, K.Madhu Murthy. 2018). The benefit of aluminium cylinder heads in the case of high combustion temperatures is because these heads dissipate heat much faster than there iron counter parts but wont produce more power unless they flow better (Baechtel .2015)

3) Petrol combustion

The blend of petrol is complex as it has a branched and straight chain of hydrocarbons. The chemical formula is C_8H_{17} which means “one molecule of gasoline combines 8 carbon atoms and 17 hydrogen atoms bonded together” (Kevin S. Online). The combustion process with petrol is what creates the pollution not the air going into it but it's the mixture with petrol and air igniting is what emits hydrocarbons. The problem therefore is with its combustion as we can make it more efficient but in turn raise combustion temperatures and add to pollution by another volatile compound as stated above. Petrol's volatility is higher than diesels that's why petrol vaporizes fast so in a spark ignition engine less temperature is required for ignition (Burgess and Gollan. 1997). Also a petrol engine's most important qualities is its resistance to knock. Knock is pre-ignition or the fuel so the higher the octane the greater the resistance to knock. In economy vehicles we are supplied with in general 95 octane petrol from fuel pumps so manufacturers are building and calibrating their engines to run by fitting adequate internal components to ensure the engine will turn over during cold starts. The volatility of petrol is a measurement of how quickly or easily the fuel vaporizes, high pressure fuel pumps in race cars today with the help of high octane fuel means that engines can rev higher by raising compression with the help of a fuel that burns easier (Burgess and Gollan. 1997). For example in the race fraternity particularly in stage rallying Peugeot developed their 306 MAXI 2.0L 16valve NA (naturally aspirated) engine to rev to 11,000 rpm this was done by obvious hardware internal and software upgrades but to run the engine that fast, Peugeot had to raise the compression and in turn had to run their engine on 120 octane fuel.

In the combustion process an engine's ability to control how much an engine is polluting is done in many ways but in terms of overall emissions the Air/fuel ratio is the main factor that contributes to the release of Nitric Oxide, Hydrocarbons and Carbon monoxide from the exhaust. Honda brought out lean burn controls in the 90s which saw a reduction in carbon monoxide and hydrocarbons but results from studies such as (R.Sindhu, G.Amba Prasad Rao, K.Madhu Murthy .2018) showed that lean burn and turbocharging low cc engines aided to the production of Nox. Their paper stated that because of high combustion temperatures high levels of Nox particles are produced but with low levels of CO_2 . Also to note that research has found that aluminium cylinder heads in the case of high combustion temperatures, dissipate heat much faster than their iron counterparts but won't create more power unless they flow better (Baechtel .2015). Not only due to the machining benefits and lightness of aluminium over iron but this is another reason why aluminium heads are used on modern cars.

Air/fuel ratios of 14.5:1 are considered perfect combustion so this is the middle point where making a mixture richer or leaner starts. Enriching the mixture say for example 8.5/1 will increase the production of CO because the fuel will only partially burn and there is a lot of unburnt fuel exiting your engine. This is because the oxygen mixture in the combustion isn't enough so the carbon atoms as stated above will

create more CO₂. If the engine runs too rich the power output will therefore decrease. If the combustion process is a lot leaner than 14.5:1, hydrocarbon emissions rise and may rise due to a great rise in combustion temperatures as there is not enough fuel being injected to cool and now less than oxygen being ignited. This can lead to an engine misfire (Baechtel .2015).

4) Modern emissions control systems

Catalytic converters:

The catalytic converter reduces three main harmful chemicals created by combustion of air/fuel, they are CO, HC and lower Nox. Carbon monoxide (a poisonous gas), Hydrocarbons (cause smog) and Nitrogen oxide (also causes smog and acid rain). In modern vehicles catalytic converters. The reduction of Nox by the catalytic converter relies on the oxygen level in the exhaust to be very low. A catalyst cannot oxidise carbon monoxide or hydrocarbons unless oxygen is sufficient in the exhaust. The need for oxygen in the exhaust to oxidise CO and HC and the need for little oxygen in the exhaust for the cat to reduce Nox meant that the cat had to be redesigned for greater efficiency. These are called dual bed catalytic converters, they work by allowing air to be injected in one part of the cat which that part receives more oxygen to help oxidise HC and CO but for the other half does not receive an extra supply of oxygen.

In the modern vehicle the use of Lambda sensors is how the vehicle monitors and reacts the oxygen levels in the exhaust by altering fuel mixtures for example enriching and leaning. Nowadays cars have two O₂ sensors one before the cat and one after so that the ecu can increase or decrease the oxygen levels based on the transmitted by the sensors. "This ensures that enough oxygen is being supplied to burn those unburnt hydrocarbons" and CO within the cat (Hillier, .2014). The cat's O₂ sensors work from heat, the old design with only one O₂ sensors had some drawbacks to measure accurately and they had to be close to the manifold as that where it is hottest. The main drawback was due to any untreated gas from the sensor to the cat weren't measured so you couldn't tell if your cat was clogged or failing until your car goes into limp mode and won't run correctly. With both sensors the ecu monitors levels the enter and leave the cat.

EGR:

This was another emissions reduction technique that is used in petrol and diesel engines today. The EGR valve works by recirculating a portion of the engines exhaust gas that has gone through the combustion process back to the engines cylinders to burn again hence the name exhaust gas recirculation. This valve helps reduce Nox in diesels by remixing exhaust gases with fresh air which decreases velocity of combustion (Bosch .2014). In race engines like in formula 1 and rallying the main aim isn't to reduce the level of Nox but its to protect the engine from harm like the turbochargers in modern f1 cars and rallying where temperatures is always an issue. This is done once again by "slowing down combustion velocity" (Bosch .2014)

PCV:

Positive crank ventilation is what this invention stands for. It is simply venting the crankcase from any combustible mixtures that get into the crankcase from miniscule gaps in piston rings and from pressure build up from the cycle of the combustion process (Hillier .2014). From the moisture in the air that enters an engine can corrode internals, venting is used to release this build up that can happen. Venting the crankcase mixture out to the atmosphere so the engine doesn't blow up as seen on all race engine for reasons like when they are used they are run at max rpm and they are left unused for a time until the next event. The PCV system on a road car has emissions benefits by exiting the crankcase mixture made of engine oil and gas back to into the inlet manifold to be burnt again and in tiny amounts and replace the crank mixture with fresh air.

EVAP:

The evaporative emission control system is used to prevent petrol vapours from escaping into the atmosphere from the fuel tank and fuel system. Like venting the crankcase the fuel tank is full of molecules with vapour that are deemed bad for the atmosphere even though they are not burnt yet. EVAP charcoal canisters are used to prevent fuel vapours from entering the environment. The charcoal canister is linked to the inlet manifold of the engine that is where the fresh air is drawn into the canister by a Purge valve. The fuel tank must have some type of venting so the air can enter to replace fuel as fuel is sucked up the engine pump to the engine. If the tank were sealed the fuel would create enough pressure to break the tank.

SAIR:

The secondary air injection system is a modern technique of reducing hydrocarbons by supporting the catalytic converter to function efficiently. For example once the catalyst is warm, fresh air is injected into the exhaust manifold by an electric pump and a fan to add a fuller combustion. The systems benefits by helping with reducing the hydrocarbon output due to the fresh air but it helps aid the catalyst heating phase (SAE int, S.Yasoshina and R.Salto .2014). The SAE study confirmed that hydrocarbon emissions were reduced by 32% on a test vehicle fitted with a 3 way catalyst along with a reduction 50degree Celsius with increased oxygen concentration. Hydrocarbons emissions dropped little more than 50% than what they were without the SAIR system. Vehicles such as the Toyota corolla T-sport 1.8vvti can be seen with this setup.

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