The VW scandal exposes the high tech control of engine emissions

October 9 2015, by Ben Mullins, Richard Brown, And Zoran Ristovski

As the fallout continues from the emissions scandal engulfing Volkswagen, the car maker has said it will make its vehicles meet the United States emissions standards.

The company has also revealed it will fix more than 77,000 VW and Skoda vehicles sold in Australia, plus a number of Audi vehicles, to add to the already 11-million vehicles affected worldwide.

But why did the German car maker try to cheat the emissions testing in the first place?

Diesel engines as a whole are very thermally efficient, and consequently fuel efficient, compared to gasoline engines.

But they have the downside of generating a large quantity of ultrafine particulates, classified by the International Agency for Research on Cancer as a Group 1 carcinogen.

They also produce NO_x – which includes nitric oxide NO and nitrogen dioxide NO_2 which are both highly reactive atmospheric pollutants and highly toxic to humans.

For these reasons NO_x (as well as other gases) emitted by vehicle engines are heavily regulated by legislation.

The software is in control

Most operations of modern engines are controlled by quite sophisticated software. The engine is managed by an Engine Management System, a specialised computer that receives input from the driver through the brake and accelerator pedals.

It also receives data from many sensors on the engine and at other important points in the vehicle. The software then makes decisions regarding the operation of the engine including the fuel volume injected, timing of injection and operation of emission aftertreatment systems.

Since engines can be used in many different applications – from automobiles to ships, boats or electric generators – the emission standards for these various applications may vary significantly. The Engine Management System is therefore able to vary the operation of the engine under a wide range of requirements to meet these different applications. These different settings are generally termed "maps" in the automotive world.

There is actually negligible nitrogen in diesel fuel. All the NO_x is generated through a reaction between nitrogen in the air and oxygen at the high temperatures reached during combustion. The problem is that low NO_x combustion conditions are at odds with combustion conditions to generate maximum power and maximum fuel efficiency.

To reduce the emissions

Modern diesels use Exhaust Gas Recirculation (EGR) to combat NO_x production and catalysts to (chemically) reduce NO_x already generated. The use of Selective Catalytic Reduction (SCR) has become increasingly widespread.

SCR basically injects aqueous ammonia into the exhaust to reduce NO to N_2 and O_2. Many of the low emission diesel vehicles on the market have found it necessary to fit SCR to meet the most stringent emissions targets (not yet in place in Australia).

There is public perception (which has some foundation) that EGR is unhealthy for engines, as a result there are many aftermarket "kits" available for sale to remove or block EGR systems. Likewise SCR adds additional cost, as diesel exhaust fluid (Adblue) must be purchased.

The computer also controls the EGR and SCR in modern engines including the amount of exhaust gas which is recycled or ammonia injected.

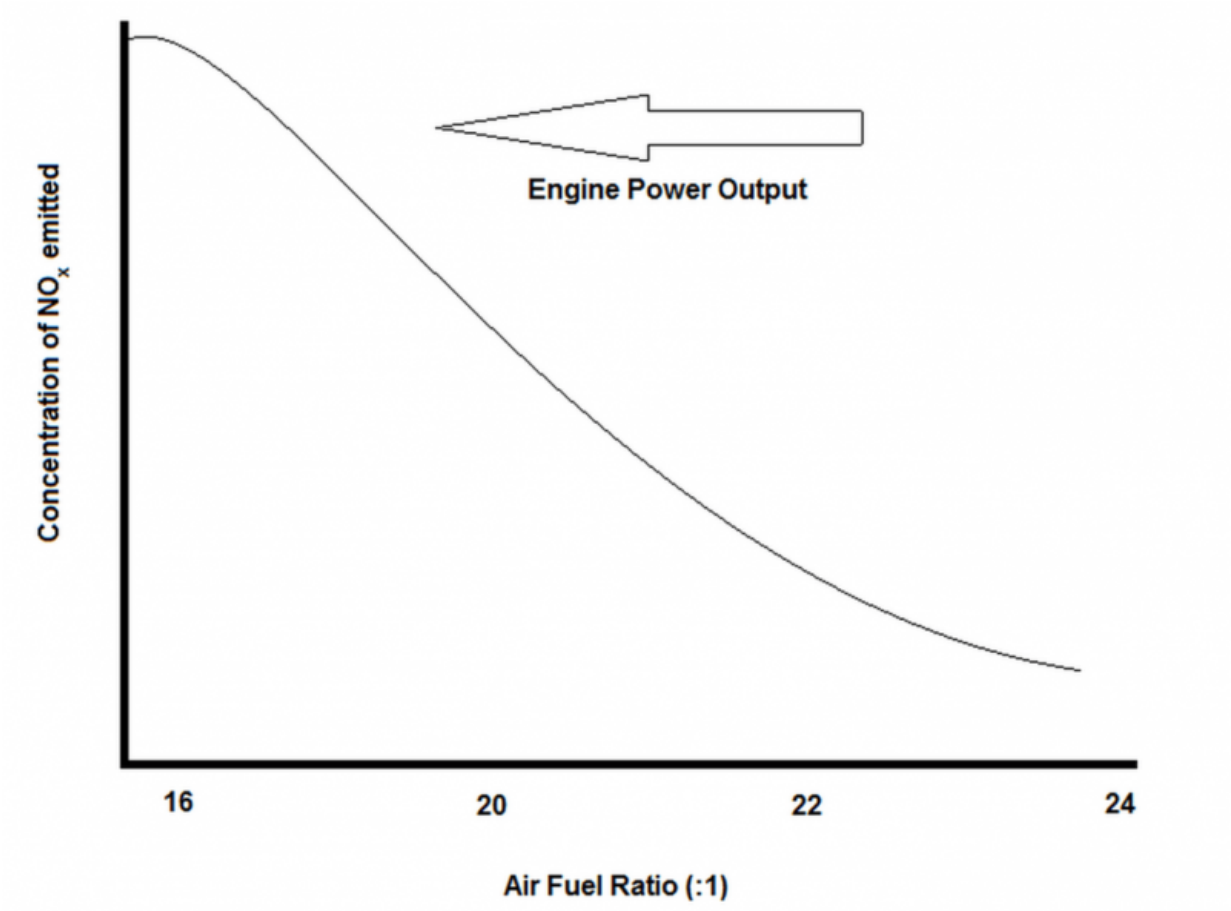
Secrets in the system

Engine manufacturers are generally very protective of their engine management software as they do not wish their competitors to know their engine management or emission control strategies.

When regulators test the emissions from a vehicle they have no direct knowledge of the software operating in the Engine Management System. They can only operate the engine at various loads and engine speeds, then measure the emissions under these conditions.

If the software detected the engine was in a vehicle undergoing an emissions test there is little to stop the software switching to a different "map" which conforms to emissions standards.

But why would a vehicle manufacturer do this. The figure below gives the best answer to the question: power and performance.



NOx emitted as a function of air fuel ratio in a diesel. Credit: Credit: BenMullins, Author provided

We can see that higher air to fuel ratios reduce NOx generation, but this also results in lower power generation and possibly lower fuel efficiency.

The VW fix may lead to other problems

VW has announced a recall on more than 11-million vehicles but it is likely the affected owners will notice reduced power after the fix. This may then lead to many owners seeking third party options to restore lost

engine power.

Many aftermarket engine tuning companies already exist and they can modify the Engine Management Systems by altering, adding or rewriting "map" settings. Other companies provide electronic devices that alter sensor settings before they reach the computer, to fool the manufacturer's Engine Management System. Many of these such devices reduce EGR and SCR or turn it off entirely, as well as reducing air fuel ratios.

Note that this amounts to modification or removal of pollution control equipment, which carries heavy penalties for individuals and even heavier penalties for companies in Australia. Retailers of such systems generally avoid this legality issue by branding their products as for racing or offroad use only.

The problem in Australia, and indeed much of the world, is that emissions tests during safety or roadworthy inspections are generally conducted at idle (if at all) for vehicles in use. Vehicle roadworthy inspections cannot (easily) determine if a software alteration has been conducted to render pollution controls inoperable.

Since the inspectors cannot access the software, they can only check if manufacturer pollution control devices appear to be present and appear to be in working order.

The VW recalls won't alter the fact that emissions tests are not representative of normal driving conditions, and aftermarket modification of engine management computers is widespread. Just one modified vehicle could emit enough NO_x for a thousand unmodified vehicles.

Without access to the source code, we don't know what the difference is

between the "map" for normal driving and the "map" for emissions testing in affected vehicles.

One solution would be to allow open access to the source code. If the US testing authorities had had access to that code in the VW case then any "defeat device" would likely have been obvious.

This story is published courtesy of The Conversation *(under Creative Commons-Attribution/No derivatives).*

Source: The Conversation