

Cutting NOx Emissions with Innovative SCR Technologies

The coming Tier 4 and EURO VI emissions standards for diesel-powered vehicles are right around the corner, and that has vehicle manufacturers scrambling to implement some new technologies that should meet these higher expectations for diesel engine emissions, with a race to see who can do it best without compromising work output or efficiency. The emissions that are capturing the vast majority of the attention are nitrogen oxide (NOx) given their relative potency as a greenhouse gas, and selective catalytic reduction (SCR) technologies are emerging as the predominant solution for cutting emissions of nitrogen oxides. Given that these emissions standards for gases such as NOx will effectively require nearly all vehicles worldwide to toughen their handling of emissions such as nitrogen oxide and carbon dioxide (CO₂), the new diesel vehicles that emerge in the battle to see who will be the most compliant will provide not only significant climate savings, but also fuel efficiency improvements as well.

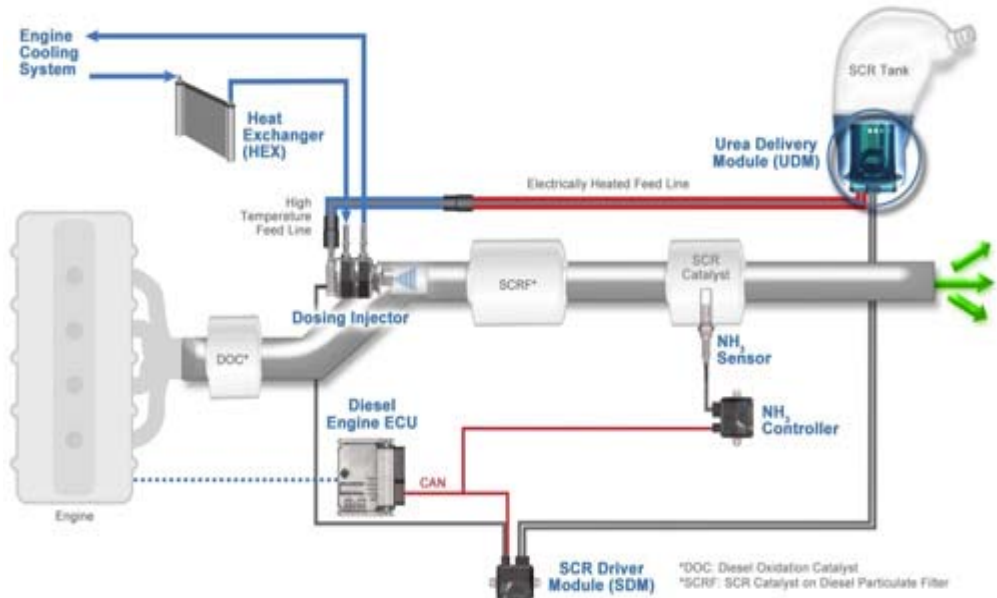
Approaches by vehicle manufacturers to implementing SCR technology range from integrating the technology into new engine designs to creating add-ons or modular components that can be used to modify engine layout or retrofit existing vehicles. Tweaks in the design cover a wide range of components to boost efficiency and cut tailpipe emissions, with innovative solutions ranging from carefully-calibrated dosing systems hooked up to sensitive monitoring components; adding insulation or heating to ensure temperatures are optimal for the NOx reaction; optimizing flow and droplet size to aid in mixing efficiency; and so on. Some of the more exciting solutions in development are surveyed here.

Fine-Tuned Dosing of Reductant Using Injector Control for Greater NOx Emissions Reductions with SCR

When, how much, and in what manner the reductant is introduced to the exhaust gases is one of the keys to achieving high emission reductions in diesel engines. As such, one of the leading technologies being employed for the reduction of NOx emissions in SCR systems is a more finely-tuned injector control system. The Delphi Selective Catalytic Reduction Dosing System is an example of this type of technology at work in light duty diesel vehicles.

By providing a highly atomized dose of liquid urea (particle size of SMD <math>< 50 \mu\text{m}</math>) and combining that with the ability to situate the system close to the engine for minimal mixing length and better thermally-aided NOx conversion, this system requires little need for catalyst heating technologies.

This helps reduce CO2 emissions further and makes it simpler for manufacturers to meet both the EU's EURO VI standards and Tier 4 standards in the US for diesel vehicles.



Delphi Selective Catalytic Reduction Dosing System

This Delphi SCR Dosing System is modular, and includes the urea delivery module (UDM) which combines the urea sensor, filter, and heater in one single component that can be fitted into the bottom of a manufactured tank. This allows for retrofits of existing engines, with Delphi support for the electronic set-up as well as diagnosing assistance for dosing system components. Additionally, because of the dosing pump injector configuration, the system can be installed at a variety of mounting angles on the exhaust either axially or radially.

The Delphi system promises resistance to repeated freeze and thaw cycles without complication for the urea solution. It can also withstand temperatures below -11C. Additionally, because the dosing injector is cooled by water, it can be mounted in engine compartments where the ambient temperatures can exceed 200C.¹

Another player in selective catalytic reduction systems is Bosch with their Denoxtronic reduction-agent metering system. By injecting AdBlue into the exhaust gas stream in precisely-metered doses, the Denoxtronic ensures the exact amount of AdBlue is added when needed. This dosing control system is wired into the engine electronics of the vehicle, adjusting the metered AdBlue based on information about operating temperature, engine speed, and so forth.

Using a modular design, this system can be used in both heavy commercial vehicles (where it has been in use successfully since 2004 in Europe) and passenger vehicles. When combined with an SCR-catalytic converter, the Denoxtronic system helps to reduce nitrous oxide emissions by up to 85%. This dosing system has been used in the BlueTEC diesel system being marketed in the US by Daimler.ⁱⁱ

SCR Technology Without Exhaust Recirculation

Iveco and FPT (Fiat Powertrain Technologies) Industrial recently announced a new high-efficiency SCR system that will meet EURO VI requirements using SCR technology which they hope to provide substantial operating costs as well as emissions reductions. Their system is unique in that it provides significant NOx emissions reductions through SCR without the need for exhaust recirculation.ⁱⁱⁱ

In conventional SCR systems, exhaust gas is recirculated to reduce the NOx emissions in the combustion chamber, which results in an increase in the particulate matter as well as a corresponding reduction in combustion efficiency. Additionally, because of the increased particulate emissions, these systems usually require a forced regeneration of the diesel particulate filters.

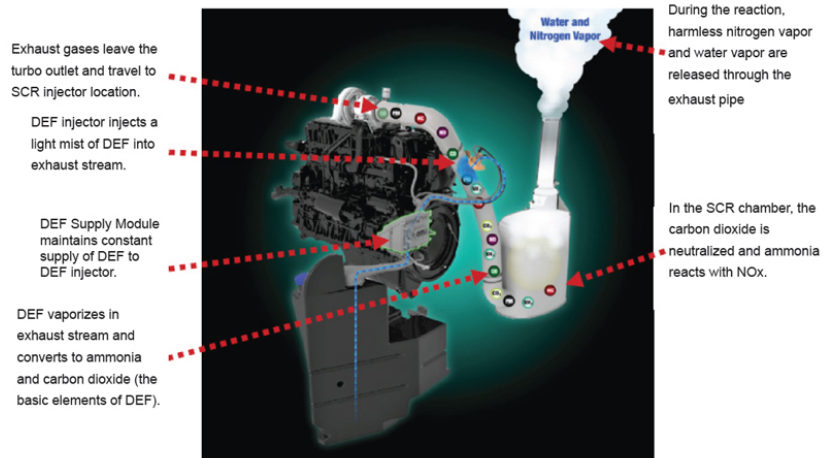
But the new FPT Industrial system both reduces particulate emissions and increases combustion efficiency by skipping the exhaust gas recirculation process. This is accomplished by using control technology based on sensors for NOx and ammonia emissions which allows for adaptive AdBlue dosing. Their closed control provides precise dosing of AdBlue to reduce the NOx emissions entering the SCR catalyst.

Additionally, their system is thermally insulated with high turbulence mixing, which permits homogenous hydrolysis of urea and correct distribution of exhaust gas flow. This further improves the system by speeding the SCR light-off process in the cold part of an emission cycle.

The advantages of this system is that it is able to reduce particulate matter in a passive diesel particulate filter and reduce NOx emissions in the exhaust system, all while improving fuel consumption and vehicle performance. They estimate that their system will reduce operating costs due to low engine wear and high maintenance intervals of up to 150,000 km, depending on the mission. The complete system is composed of a diesel oxidation catalyst (DOC), passive diesel particulate filter (DPF), AdBlue dosing module and mixer, selective catalytic reduction system, and clean up catalyst (CUC). The entire system is wired with a network of integrated sensors that provide expert control of NOx and ammonia emissions. Their system provides a 95% reduction in NOx levels.

Improved Fuel Efficiency with SCR Technology in the Agriculture Sector

Innovations in ammonia-based SCR technology are being developed to address the needs for better efficiency in the agricultural vehicle industry. Take the New Holland Agriculture EcoBlue technology recently released for their high-horsepower agriculture equipment. The system works by sending exhaust gases through the turbo outlet into the SCR injector where DEF injector adds DEF mist to vaporize and convert ammonia and carbon dioxide. The result is nitrogen vapor and water that released through the exhaust pipe.



The New Holland EcoBlue Technology for Agriculture Vehicles

This technology has been developed with US Environmental Protection Agency

Tier 4 and the European Union Stage 3B and 4 emissions regulations. The technology will be released by New Holland in two phases, with the final tweaks to the technology introduced by the beginning of 2014. In all, the system is said to reduce particulate matter and nitrogen oxides by 90% compared to Tier 3 levels.^{iv}

AGCO has also developed its own brand for its SCR engines called e3, which are built by their European subsidiary AGCO Sisu Power. They have touted this new engine technology, which is in its Massey Ferguson 8600 Series tractors, as setting a new fuel efficiency record at the University of Nebraska Tractor Test Laboratory. In fact, they boast a 10% improvement in fuel economy by using their e3 SCR technology.^v

Their system, which uses AdBlue DEF aqueous urea solution at a 2% to 6% of the vehicle's fuel consumption, improves fuel efficiency and reduces input costs. This e3 technology has already been in use in Europe, where emissions standards were already ahead of those in the US, for seven years.^{vi}

All Sectors Seeing SCR Technology Implementation

From public buses to tractors to passenger vehicles, selective catalytic reduction technologies are having a positive impact on the emission production of diesel fuel vehicles. DaimlerChrysler Mercedes Benz, Volkswagen, and Audi have been using their BlueTEC solution for several years now with great success, and will be adding it to their newest vehicles in the near future including the Mercedes E300 and the Volkswagen CC BlueTDI. Porsche has introduced a new Cayenne Diesel that will integrate SCR technology for luxurious, but low-emissions ride. And component manufacturers like Cummins and Dinex are all developing solutions to add-on or integrate into the newest engine designs.

Looking forward we anticipate further tweaks in engine design will add even greater efficiencies as manufactures look to meet future standards that are even tougher.

Sources:

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A student of all things green, Maryruth has a special interest in cleantech and green buildings. In recent years, Maryruth has worked as the senior editor of The Green Economy magazine, is a regular blogger for several green business ventures, and has contributed to the editorial content of not one, but two eco-living websites: www.ecolife.com and www.GreenYour.com. You can learn

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Sources:

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