

Advanced Three-way Catalysts

Optimisation by targeted zoning of precious metal

Three-way catalysts have been used to control gasoline-fuelled vehicle emissions for over twenty years, during which time significant advances have been made in performance. Nevertheless catalyst manufacturers strive for continual improvements, and further reduction of system costs remains a key target. This article summarises paper 2005-01-2158 given at the 2005 SAE Brazil Fuels and Lubricants Meeting.

Rhodium can be used exclusively in the rear of the catalyst for NO_x conversion with reduced precious metal loadings



One area of catalyst system design which has received relatively little attention is the method of application of precious metal, specifically with regard to its positioning in the catalyst. Recent advances in catalyst coating technology have enabled both washcoat and precious metals to be distributed inhomogeneously (zoned) along the length of a catalyst monolith. With the option of zone coating now available, it is important to assess what precious metal is appropriate in which position on the catalyst. It is also important to know how much or, from a cost point of view, how little needs to be applied in order to ensure regulatory compliance and cost-competitiveness. To evaluate the role of zoning in cost reduction, Johnson Matthey scientists have carried out detailed studies.

Background to testing

Two different state-of-the-art catalyst formulations were aged over a bench ageing cycle and then tested on vehicles. The first was 118.4 x 127 mm in size with a total platinum group metal (pgm) loading of 35 g/ft³, a platinum:palladium:rhodium (Pt:Pd:Rh) ratio of 0:6:1 (known as "35/0:6:1"), cell density of 400 cells per square inch (cps) and wall thickness of 6.5 mil. This was evaluated over the MVEG-B cycle in the close-coupled position on a 1996 Model Year 1.25L Euro 2 compliant vehicle. It was also evaluated after having been cut in half and only the front portion replaced on the vehicle. Further catalysts tested on this vehicle were zoned catalysts with a front half loading of 35/0:6:1 and rear half loadings of 25/0:4:1, 15/0:2:1 and 5/0:0:1 (Rh-only).

The second catalyst measured 101.6 x 152.4 mm Pt/Rh, with a cell density of 600 cps, wall thickness 4.3 mil and a loading of 15/2:0:1 g/ft³. This was also evaluated over the same cycle in the close-coupled position, this time on a 2001 Model Year Ford Focus 1.6L Euro 3 compliant vehicle. A length of 25.4 mm was then cut from the rear of the catalyst, and it was re-evaluated with a non-pgm (washcoat only) piece of catalyst replacing the portion removed, in order to ensure constant backpressure. The catalyst was further cut down in 25.4 mm stages and evaluated at each stage.

Vehicle testing

The results for the Pd/Rh catalyst, both full size and front half only are shown in Figure 1. Carbon monoxide (CO) emissions are barely affected by cutting it in half, hydrocarbon (HC) emissions have increased by only about 10% but emissions of oxides of nitrogen (NO_x) have nearly doubled, and are now outside the Euro 4 limit of 0.08 g/km. This suggests that the front half of the catalyst performs the vast majority of oxidation of HC and CO, but that the full volume is necessary for maximum reduction of NO_x.

To reduce the NO_x emissions whilst avoiding inclusion of the clearly unnecessary 30 g/ft³ of Pd in the rear half of the catalyst, further full size

Figure 1: Comparison of emissions from full size and half size catalysts

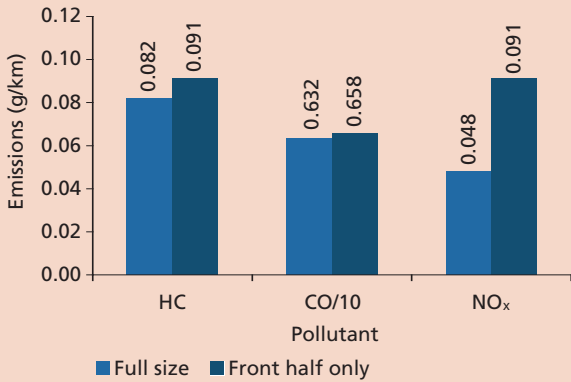
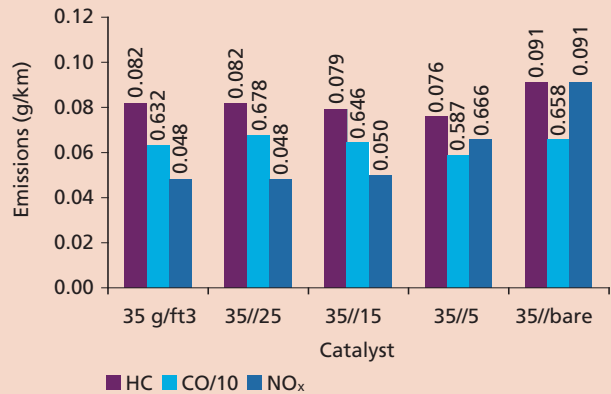


Figure 2: Comparison of emissions from homogeneous and zone coated catalysts



catalysts were tested with rear half loadings of 25/0:4:1, 15/0:2:1 and 5/0:0:1. The emissions results for these catalysts are shown in Figure 2.

than two smaller ones – a considerable cost saving over the possible alternative of using two differently loaded catalysts.

Figure 2 shows that there is no significant difference between the homogeneously coated 35/0:6:1 catalyst and those with 25 and 15 g/ft³ i.e. 35//25 and 35//15 rear loadings for any of the pollutants. In other words the removal of most or all of the palladium from the rear half has not had any adverse impact on HC or CO emissions. A small increase in NO_x is seen when the rear half contains only rhodium, but the emissions remain well within Euro 4 limits. Only when all the Pd and Rh is completely removed from the rear half do the emissions exceed the NO_x limits. Furthermore, the coating method used enables the different pgm loadings to be present on a single catalyst rather

In order to investigate this phenomenon further, a 101.6 mm diameter catalyst was aged and tested at lengths from 152.4 mm down to 25.4 mm, in 25.4 mm increments on a Euro 4 compliant 1.6 L vehicle. The results are shown in Figure 3.

The results show that emissions increase in a non-linear fashion, indicating differing contributions to the overall conversion from each separate 25.4 mm portion. NO_x emissions increase throughout the length of the catalyst, and far more than CO and HC as the catalyst is cut down in size.

Example of optimised zoned system

This work has led to several applications of the cost saving potential of the zoning strategy. One such is the case of a 40/0:7:1 catalyst, which had previously been used as a Euro 4 solution on a 1.6 L vehicle. Two possible cost saving strategies were tested, both based on zoning. The first was to reduce the pgm loading of the rear half of the system to 10/0:1:1, and the second was to replace the rear half with a single Rh-only formulation specifically developed for NO_x conversion, with a loading of 5 g/ft³.

Figure 4 shows that both of the aged catalyst systems are giving results well within the legal limits for all three pollutants. Furthermore the Rh-only system is showing equivalent performance to the 40//10 system.

The overall washcoat loading and backpressure of the catalyst with a Rh-only rear half have been significantly reduced as a result of the need only to apply multi-layer technology to the front half, and this can be achieved with no loss of performance. Both these solutions represent significant pgm cost saving (over \$5 per catalyst at average 2004 prices) over the original system.

Conclusions

Systematic studies of emissions as a function of catalyst length have shown that pollutant conversion efficiencies along the length of a three-way catalyst are non-uniform. NO_x emissions are reliant on having the largest catalyst volume available, whereas CO and HC are overwhelmingly converted on the front portion of a catalyst system.

It is possible to coat different quantities of pgm throughout a catalyst system; in particular to apply less Pt or Pd to the rear. This has been shown to have little or no adverse impact on overall emissions performance. In essence, pgm can be applied only where it is needed, whilst retaining virtually all the activity of a homogeneously coated catalyst. This simple yet effective approach can result in very significant cost savings.

Figure 3: Comparison of emissions from catalysts of different lengths

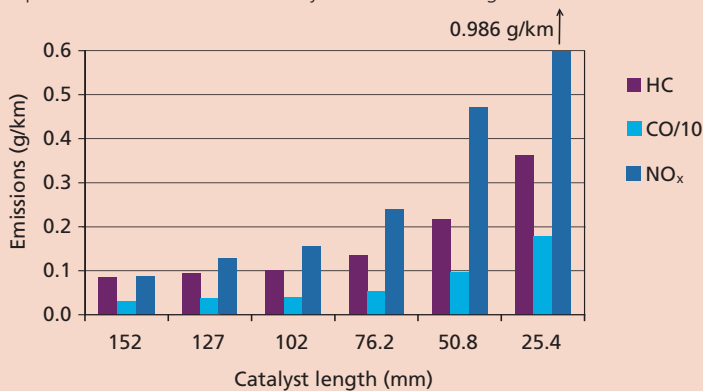
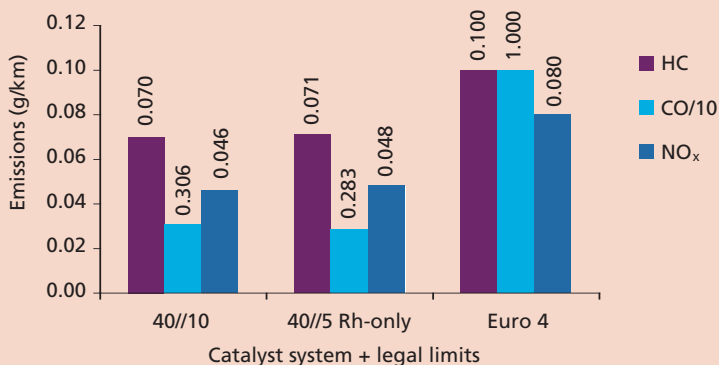


Figure 4: Comparison of Pd/Rh and Rh-only rear catalysts



The Diesel Engine and the Road Ahead

– a US Perspective



The diesel engine is subject to increasingly stringent emissions regulations, particularly for heavy duty applications. Magdi Khair (left), Institute Engineer at Southwest Research Institute, looks at the challenges facing diesel engines and the options available to engine and vehicle manufacturers to ensure their continued viability.

The diesel engine has become the workhorse of commercial transportation around the world and has had to adapt to different environments and various pressures throughout its history. It is now at the point where it has achieved excellent performance whilst maintaining its superior fuel economy and meeting ever-tightening emissions regulations.

Contrary to common belief, diesel engines emit extremely low levels of carbon monoxide (CO) and unburned hydrocarbon (HC) emissions, as shown in Figure 1. This fact is based mainly on their heterogeneous combustion that is characterised with high air-to-fuel (A/F) ratios. Their combustion efficiency is extremely high and consequently they convert their hydrocarbon fuel to mostly carbon dioxide (CO₂) and water. However, because they power vehicles that can travel almost twice as far as their gasoline-powered counterparts on a gallon of fuel, they have the ability to reduce the total man-made CO₂ contribution to the environment as seen in Figure 2. Diesel engines, however, have traditionally emitted higher levels of nitrogen oxides (NO_x) and particulate matter (PM) than their gasoline counterparts.

In the USA, regulatory limits imposed on the on-highway transportation segment in the 2007 to 2010 time frame seem to be technology-forcing and appear to favour using NO_x aftertreatment devices such as NO_x adsorber catalysts (NAC), and urea-based selective catalytic reduction (SCR). In addition to these two technologies, the diesel engine will undergo a high degree of change in its in-cylinder technologies aimed at reducing engine-out emissions. Most industry

observers realise however, that in-cylinder measures alone may not be sufficient to meet mandated emission limits, and that NO_x and PM aftertreatment will most likely be necessary.

Engine modifications

The diesel engine has continued to improve by adopting new technologies. For the on-highway heavy duty market segment in the United States, in-cylinder technologies were used to meet the Environmental Protection Agency's (EPA's) 2002/2004 emissions limits. Most of the technologies adopted so far have added tangible value to the end user. Figure 3 shows that using high injection pressure not only reduced the formation of PM, but also improved fuel economy and increased the specific power output of diesel engines. For 2007 the heavy duty diesel industry plans to introduce diesel particulate filters (DPF) to comply with the PM limit.

Exhaust gas recirculation (EGR) is not a new technology for diesel engines. It has been used in the light duty diesel segment for NO_x reduction, but the heavy duty diesel industry

adopted EGR as the technology to meet the 2.0 to 2.5 g/bhp-hr NO_x limit.

There are different designs of EGR systems. The most popular of these as far as the heavy duty industry is concerned is the high pressure loop

There are different designs of EGR systems. The most popular of these as far as the heavy duty industry is concerned is the high pressure loop EGR system.

EGR system shown in Figure 4. It has earned this designation because of the fact that EGR is taken from the high pressure side of the turbocharger turbine. In this configuration, exhaust is recirculated from the exhaust, upstream of the turbine stage, to the intake manifold by way of an EGR flow control valve and a heat exchanger. Naturally, the ability to flow EGR from the exhaust to the intake manifold depends on the pressure differential across the EGR flow control valve. To improve the effectiveness of EGR the stream of recirculated exhaust is cooled, thus increasing its density and reducing its volume.

One of the issues related to EGR is the small pressure differential that exists between the exhaust and intake manifolds in diesel engines. For 2002/2004, most heavy duty manufacturers were able to meet NO_x limits without any added measures to increase the natural pressure differential across the EGR control valve. However, as the industry approaches the 2007 model year, it is

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did not have to use EGR to meet mandated emissions standards until the 2002 model year in the United States. All but one of the engine manufacturers in the United States have



becoming more apparent that higher EGR rates will be more desirable in order to get closer to meeting the 1.2 g/bhp-hr NO_x limit.

Another EGR configuration that is currently receiving attention is the low pressure loop EGR system as shown in Figure 5. In this configuration, EGR is taken from the low pressure side of the turbocharger turbine, after its expansion through the turbine wheel, where the temperature is generally lower than in the exhaust manifold. Generally, it is thought that cooler and higher EGR rates can be delivered using the low pressure loop as opposed to the high pressure loop EGR configuration. The system is further favoured because of its ability to use filtered EGR if exhaust is taken from downstream of a DPF, as well as its superior EGR and charge air mixture quality. Even with some technical issues remaining as a challenge for this configuration, it is believed that competitive low pressure loop EGR designs will be developed.

Traditional in-cylinder measures for NO_x reduction in diesel engines were limited to injection timing retard, charge air cooling, and recently cooled EGR. More recent advances in fuel injection systems allowed the implementation of measures such as pilot injection as well as multiple injections per combustion cycle as seen in Figure 6. These new injection system capabilities are excellent tools allowing combustion engineers to shape the combustion pressure diagram including lowering peak combustion pressures and temperatures. Of course, the result of lower combustion temperatures is reduced NO_x

emission. For the heavy duty industry in the United States it is expected that all three measures (injection timing, EGR, and multiple injections) would be used to meet the 2007 NO_x limits. It is generally accepted that most heavy duty manufacturers will achieve an

engine-out NO_x level of about 1.00 g/bhp-hr. There are a number of new developments in the combustion field. These developments are generally titled Alternative Combustion Modes and include homogeneous charge compression ignition (HCCI), premixed-controlled

Emissions comparisons

Figure 1: HC and CO emissions typical of Heavy Duty Diesels relative to US EPA 2002/04 limits

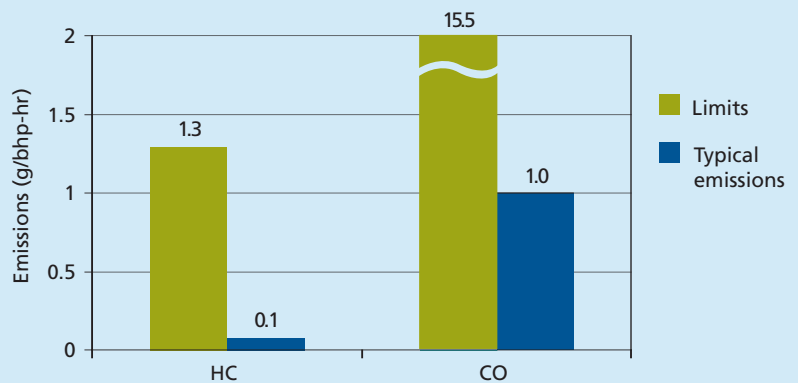


Figure 2: CO₂ emissions from Gasoline- and Diesel-powered cars

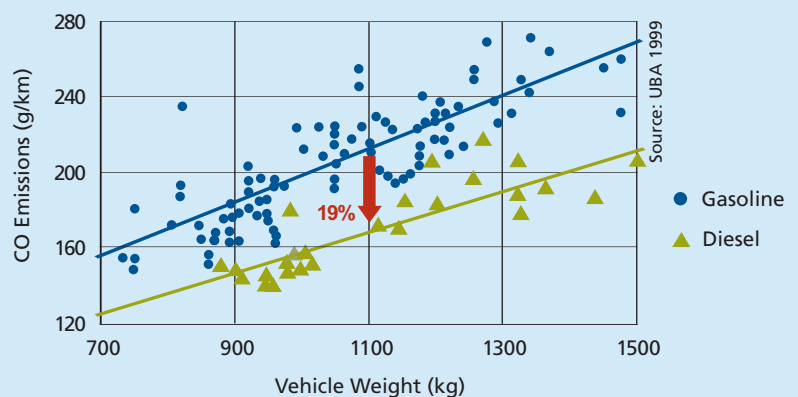
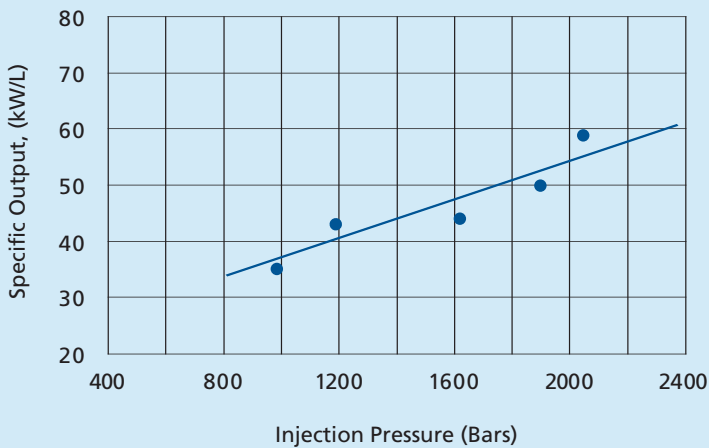


Figure 3: Effect of injection pressure on engine specific output



compression ignition (PCCI) and low temperature combustion (LTC), as shown in Figure 7. Research in these areas of combustion is intensifying, but is unlikely to be fully developed and commercialised by the 2010 time frame when the 2007 NO_x limit will be fully phased in at 0.20 g/bhp-hr.

NO_x aftertreatment systems

In the meantime, the catalyst industry has been hard at work developing auxiliary emissions control devices targeting significant NO_x reduction. The two leading candidates for NO_x aftertreatment (NO_x adsorbers and

urea SCR) have their advantages as well as their disadvantages.

Engine and vehicle manufacturers facing a decision as the deadline for 2010 approaches are dealing with a major challenge. On one hand they find urea SCR to be a more mature technology that faces infrastructure and end-user compliance issues, and on the other hand they see the promise of NO_x adsorbers. Considering the engine-out NO_x level anticipated for 2007 model year engines, it is easy to see that what is needed for 2010 is a system that would reduce NO_x by 80% or 90% from its 2007 level.

SCR has been extensively used in stationary engine applications since the 1960s. Anhydrous ammonia is the predominant reductant used in this application. However, the use of anhydrous ammonia in the mobile fleet is frowned upon due to the potential

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Schematic representations of high and low pressure loop EGR systems

Figure 4. Schematic representation of high pressure loop EGR system

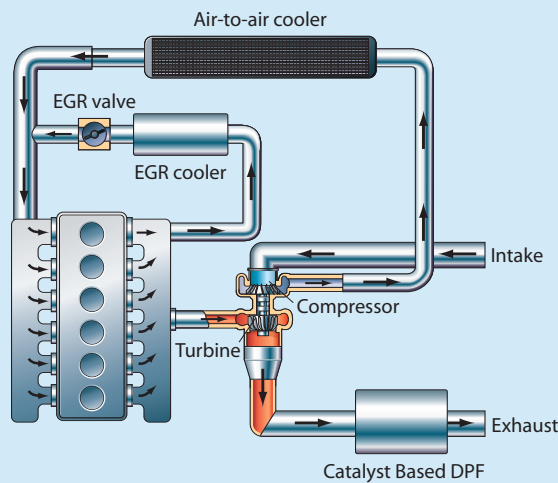
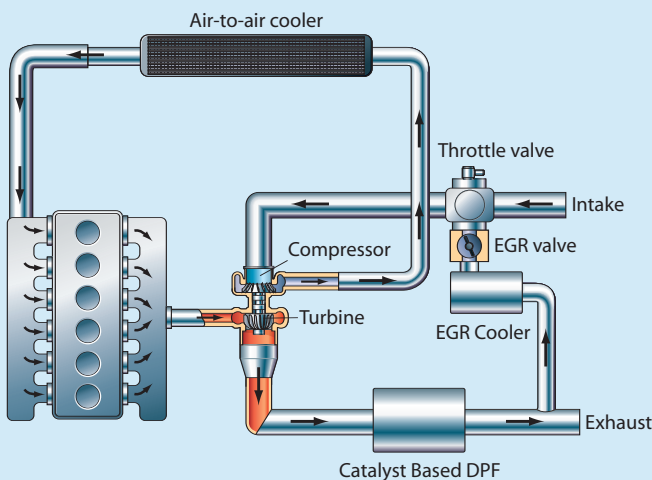


Figure 5. Schematic representation of low pressure loop EGR system



leak and/or slip while operating in densely populated areas. Therefore, urea solution has been the preferred ammonia-carrying medium for the transportation sector. The reductant solution used in SCR applications has a urea concentration of 32.5 percent with distilled water making up the balance.

Even though the SCR system has been proven to work in many demonstrations its introduction in the United States is still in doubt. The main reason for this situation is logistical in nature and largely dependent on the distribution network for urea. In addition, more work needs to be done to ensure the economic viability and long-term acceptance of this technology. In Japan, Nissan Diesel has already marketed a heavy duty urea SCR system. In Europe, urea SCR systems are slated for production in the near future. Some of the major heavy duty engine manufacturers in the United States have established ties with European companies that are leaning towards using urea SCR technology. It is possible that the future technological direction in the USA will be affected by the European influence.

Lean NO_x traps (LNT) are also known as NO_x adsorber catalysts (NAC) or NO_x storage reduction (NSR). These devices require the conversion of engine-out NO to NO₂ using oxidation catalysts. The NO_x storage catalyst is selective to NO₂ and stores this compound in the form of nitrate. As nitrates build up in the NO_x trap they need to be converted and

removed via a reduction process in rich exhaust if the NO_x trap is to continue to perform at high efficiency. This operation requires a preferred reductant, which may vary according to the exhaust temperature. At low exhaust temperature, hydrogen is generally preferred; at medium temperatures CO may be preferred while at elevated temperatures regular diesel fuel may be acceptable. Some have experimented with fuel reformers carried onboard the vehicle in order to produce the ideal reductant to match the exhaust temperature conditions.

One of the problems associated with the NAC system is its sensitivity to sulphur whether sourced in the fuel or in the lube oil additive package. Sulphur compounds are adsorbed on the NAC and thus compete with nitrates for catalytic sites. Another issue is the difficulty of ridding the catalyst from the sulphur compounds. While diesel engine engineers and calibrators have worked along with their colleagues in the catalyst industry to produce successful regeneration systems and controls, the challenge of developing consistent and safe desulphurisation controls still remains. The desulphurisation process requires high temperature (about 650°C) while operating under rich conditions. The process is relatively long (could last several minutes) and requires complex controls. Unless the temperature is tightly controlled and held below 700°C, the risk of destroying the catalyst increases.

A prediction for 2010

As outlined earlier, heavy duty engine manufacturers in the US have already stated that 2007 limits will be achieved using high EGR rates and DPF technology. Of course, these two technologies will be accompanied with improvements to the combustion process, which leads to lower NO_x formation. Many of the 2007 diesel engine calibrations will yield NO_x emissions of approximately 1.0 g/bhp-hr when tested in the EPA transient test. Further combustion system improvement, including high boost pressure ratios, high EGR rates, alternative combustion schemes such as low temperature combustion will continue their development and many aspects of such development will be adopted in production prior to 2010 heavy duty model year. These improvements may very well reduce engine-out NO_x to 0.60 to 0.80 g/bhp-hr thus requiring future aftertreatment systems with 75% to 80% NO_x conversion efficiency.

Urea SCR NO_x aftertreatment has already demonstrated over 90% NO_x conversion efficiency under ideal conditions, even with older vanadia/titania/tungsten catalyst formulations. These older SCR formulations have exhibited low NO_x conversion efficiencies

at temperatures below 250°C and have also shown deterioration in NO_x conversion efficiency when exposed to exhaust temperatures in excess of 540°C. Newer zeolite-based SCR formulations have demonstrated superior performance in low and high exhaust temperature conversion efficiency as well as high temperature

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durability. It was this superior characteristic that led Nissan Diesel to use zeolite-based formulations as the catalyst of choice in their SCR system. Advances in catalytic treatment of diesel exhaust gas will continue. NO_x reduction and conversion efficiencies in excess of 90% will eventually become the norm rather than the exception. Advances will also translate into more reasonable catalyst size which would reduce its cost and simplify its packaging.

With the above mentioned advances in in-cylinder technologies, and improved urea SCR technology offering the higher NO_x conversions required in heavy duty vehicles, it is predicted that more heavy duty diesel engine manufacturers will commit to the SCR technology. Thus, establishing a urea infrastructure will be more economically viable and even more likely to happen.

NAC technology is more suited to light and medium duty applications, as less fuel is required to regenerate the catalyst, and less catalyst is required. The technology will continue to be developed and eventually reach a level where its viability for the light and medium duty diesel applications will improve. A bold example of such technology may very well be the diesel particulate and NO_x reduction system (DPNR) by Toyota. Its prototype/pilot fleet of Avensis passenger cars offered in Europe has shown that areas of this technology need a lot of improvements. It is almost certain that these will be made and will be associated with system cost reductions to extend the economic viability of the diesel engine.

Figure 6: Multiple injections from a modern diesel injection system

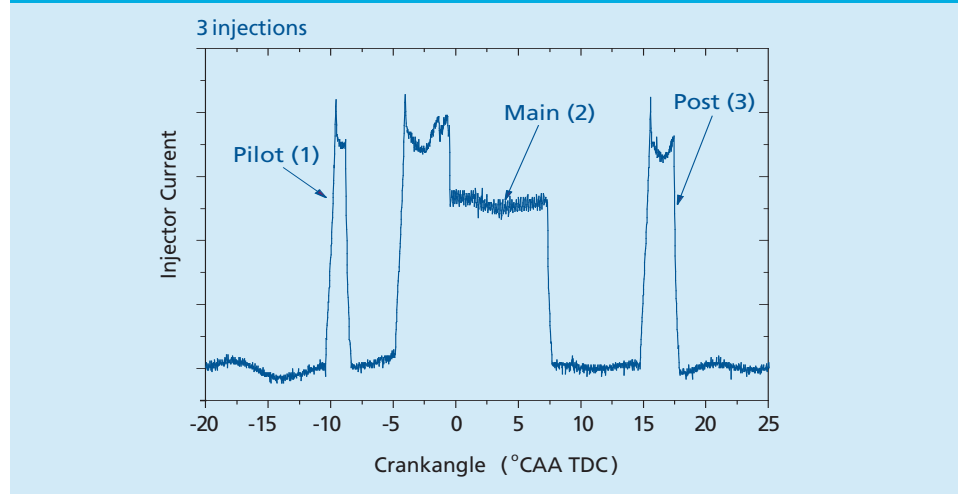
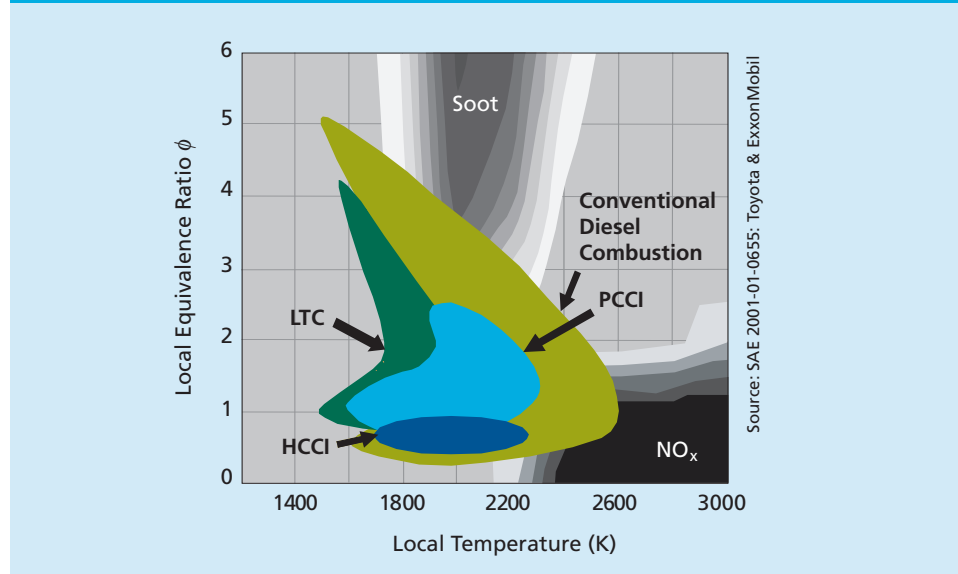


Figure 7: Alternative combustion modes



Developments in Auxiliary Power for Vehicles

Fuel cells are widely recognised as a technology of the future and as a potential replacement for the internal combustion engine in cars and other vehicles. This article looks at the potential for fuel cells to provide auxiliary power to vehicles, rather than primary motive power.

Today, hydrogen-fuelled proton exchange membrane (PEM) type fuel cells, as illustrated in Figure 1, are being showcased in the demonstration fleets of some major carmakers and in government supported programmes such as CUTE (Clean Urban Transport for Europe) which has fuel cell buses operating in a number of European cities. Although these demonstrations are said to be progressing well, current fuel cell technology still has a huge challenge to match the cost, performance and reliability of the internal combustion engine (ICE).

It is apparent that the widespread use of fuel cells to provide the motive power for cars and buses is some way off but, according to companies such as Volvo and General Motors, there is a fuel cell application for vehicles that could be commercialised in the near future. This is the use of fuel cells as auxiliary power units (APUs) to provide electrical power to a vehicle when the main engine is not operating. The typical output required is 5-20kWe, compared with hundreds of kiloWatts for a primary power source.

The need for trucks to run at idle in order to provide a continuous electrical power supply for air-conditioning, heating and other onboard equipment is obvious, but brings with it a number of undesirable side-effects. The noise is a nuisance factor and also contributes to driver fatigue. The cost of idling is a particular concern to operators of heavy duty vehicles. According to the US Department of Energy, the cost is over \$2 billion per year, split between fuel and engine wear. There is also a considerable environmental impact. Running at idle burns a lot of diesel compared to the small amount of electrical power that is needed. It has been estimated that this results in the production of up to 15 million tonnes of carbon dioxide each year in North America alone, in addition to nitrogen oxides (NO_x) and particulate matter (PM), both regulated pollutants. For this reason, in Europe and in a number of US states, legislation will be tightened over the next five years to limit the amount of time that the engine can be left idling.

Diesel powered ICE APUs have been available for many years. These better match the fuel consumed to the electrical power demand but still produce noise and pollutants. They are

Fuel cell technology still has a huge challenge to match the cost, performance and reliability of the internal combustion engine.



The US Department of Energy estimates the cost of idling is over \$2 billion a year

therefore subject to legislation requiring exhaust aftertreatment systems to be fitted. As trucks typically idle for up to eight hours, a battery, although releasing no emissions, would not have sufficient capacity to provide all the auxiliary power needed.

PEM fuel cell APUs powered by hydrogen have been developed. Fuel cells are very quiet and because they operate at low temperature and no combustion is involved, do not produce any NO_x or PM. Their power output varies in direct response to the electrical load from the vehicle accessories and therefore they only consume the amount of fuel necessary to meet the demand. When combined with their inherently high efficiency, the result is excellent fuel consumption and minimal environmental impact.

So, a PEM fuel cell can provide the electrical power for a parked truck, but where does the hydrogen come from? The answer to this comes from the ability of 'reforming' technology to extract the hydrogen from diesel fuel shown in Figure 2. The reforming process takes place on board the vehicle and produces hydrogen when it is needed by the fuel cell. This technology is an adaptation of the reforming technology that is used on a large scale to produce hydrogen from hydrocarbons in an oil refinery.

The reforming process for converting diesel into hydrogen is not as simple as it is for some fuels. Diesel is a difficult material to reform and arguably presents a harder technical challenge than the fuel cell itself. The reforming process requires diesel fuel to be vaporised, needing a relatively high vaporisation temperature (300°C), which makes rapid start-up difficult. High temperatures in the reformer can also result in carbon deposition problems that can reduce operating efficiency. A further issue is

Diesel is a difficult material to reform and arguably presents a harder technical challenge than the fuel cell itself.

the impurities found in commercial diesel, including sulphur, and a number of chemical additives. These can poison the catalysts in the reformer and require the use of precious metals that are more tolerant to poisoning than base metal catalysts.

Diesel reforming also tends to produce some carbon monoxide (CO), which is a poison for the catalysts in the fuel cell. Acceptable performance can be achieved with good fuel processor design and a treatment step to reduce the amount of CO produced. Special CO tolerant fuel cell catalysts have also been developed, to ensure continued operation of the fuel cell in applications where CO levels are relatively high.

Figure 1: Power generation in a PEM fuel cell

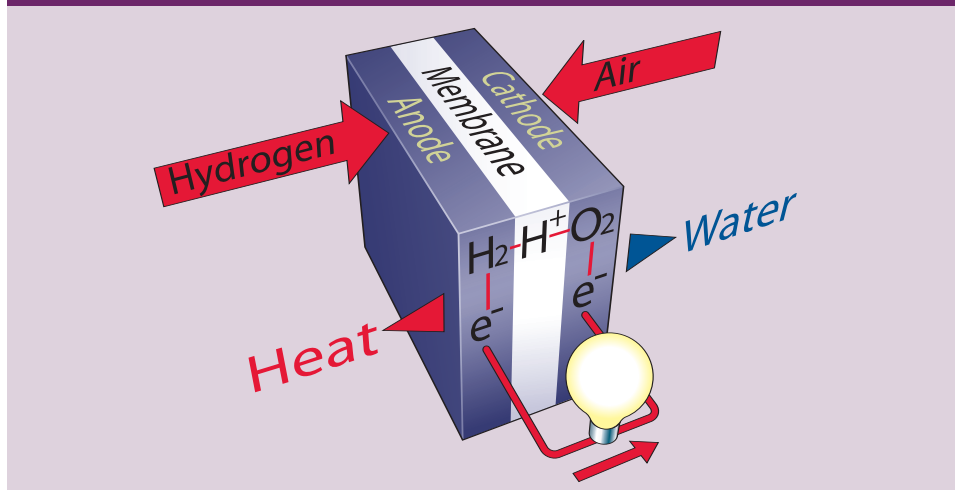
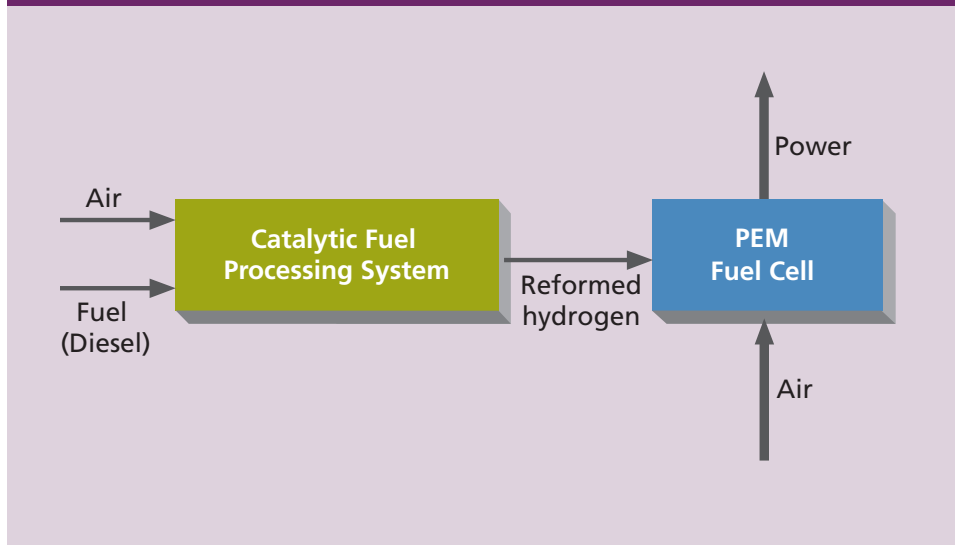


Figure 2: Hydrogen generation via reforming technology



Combined fuel cell and reformer systems that give acceptable performance in the APU application are close to commercialisation, but some work to demonstrate acceptable reliability and cost is still required. The first prototype was developed by Freightliner in 2000 shown below, and more recently, in June 2005, Volvo Technology (VTEC) and Statoil demonstrated their intent to commercialise the technology by the formation of a new joint venture, PowerCell, to develop and produce PEM fuel cell APUs.



Prototype APU developed by Freightliner

Other companies such as Delphi and General Motors have also announced that they are developing fuel cell APUs and reformers for commercial and military vehicles. In the case of Delphi, solid oxide fuel cell (SOFC) technology will be used instead of PEM. Both technologies have their own merits and challenges. SOFCs operate at high temperature and are not prone to catalyst poisoning but they have longer start-up times and require careful thermal management. This means that they are better suited to continuous operation. However, ongoing research and development is focussed on materials improvements to deal with thermal stresses associated with frequent start-ups and load variations. SOFCs do have a major potential benefit in that they could operate on diesel fuel directly without a separate reformer and if this is achieved, it could simplify the system considerably.

In conclusion, this is an interesting and important area of fuel cell development that could lead to a commercial fuel cell product being introduced sooner than those fuel cell engines being designed as complete replacements for the internal combustion engine.



Shinjuku district, Tokyo

Johnson Matthey Sponsors Urban Air Quality Seminar

At the beginning of August, Johnson Matthey sponsored a seminar session at *The 16th Regional Conference of Clean Air and Environment in Asian Pacific Area*, held at the Kogakuin University Shinjuku in Tokyo.

The seminar, entitled *Managing the Impact of Vehicles on Urban Air Quality*, heard from experts in the fields of technology, planning and demand management. This was followed by a review of developments in various cities around the world. Although Asia was a key focus of the event, experiences from cities in Europe, America and Australasia were heard.

Richard Mills, Director General of the International Union of Air Pollution Prevention and Environmental Protection Associations (IUAPPA), summed up the seminar, emphasising the importance of having a policy framework in place locally and nationally, in order to facilitate improvements in air quality through technology. He also stressed the capability of planning systems around the world to help provide the benefits of sustainable air quality improvements.

New President for ECT North America



Following the announcement of John Fowler's move to Johnson Matthey's Pharmaceutical Materials Division, Alan Myers has been appointed President of Environmental Catalysts and Technologies North America. Alan joins from Johnson Matthey Noble Metals where he was Director of the global business unit. Prior to joining Noble Metals, Alan had been Finance Director of Johnson Matthey's Chemicals and Refining business in West Deptford, New Jersey.

Johnson Matthey ECT Launches New Website



Johnson Matthey ECT has updated its website, which is now to be found at www.jmcatalysts.com/ect. It was launched at the start of the summer, and is designed to make navigation around the site as easy as possible. There are sections specifically for diesel retrofit, truck and bus, non road mobile machinery, light vehicles, two- and three-wheelers and stationary source. Information within these applications is complemented by detail on technologies available from Johnson Matthey, such as three-way catalysts, diesel particulate filters, selective catalytic reduction and four-way diesel emissions control.

Alongside product literature, the library area of the site contains back issues of *Global Emissions Management*, with individual articles available to download in pdf format. The front cover of the latest issue is displayed on the left-hand side of the home page, making it extremely easy to access.