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The Impact of CO_2 Legislation on PGM Demand in Autocatalysts

It is estimated that emissions from road transport contribute 17% of total anthropogenic carbon dioxide (CO_2) emissions (1). Regulations coming into force in Europe and in the U.S.A. are seeking to change this. In December 2008, the European Parliament approved a directive to reduce the average CO_2 emissions of new passenger cars to 130 g km^{-1} by 2015, with a three-year phase-in period. Emissions will be reduced by a further 10 g km^{-1} through external measures including the increased use of biofuels, lower rolling resistance tyres and efficiency improvements to auxiliary devices such as air conditioning units. Overall, the 120 g km^{-1} target represents an improvement in fuel economy of about 25% from current levels (2). In the U.S.A., where vehicles have traditionally been much larger and less fuel efficient than in European markets, President Obama has unveiled an ambitious plan to improve the fuel economy of passenger cars and light trucks in the country to an average of 35.5 U.S. miles per gallon (mpg) by 2016, from the current 25 U.S. mpg average (3).

While there are longer-term clean transport options in development, such as electric and fuel cell vehicles, three different engine technologies are seen to be crucial in improving fuel consumption, and thus lowering CO_2 output to meet these 2015 and 2016 targets. These technologies are diesel engines, downsized turbocharged gasoline engines combined with direct injection, and hybrid gasoline- or diesel-electric vehicles. Each of these three technologies will have a different impact on platinum group metals (pgms) use.

Diesel vehicles already account for over half of new vehicles sold in Europe, and this high share is expected to be maintained over the next decade. However, with improvements in gasoline direct injection (GDi) engines and greater numbers of vehicle manufacturers offering this technology, it is likely that we will see more of these vehicles on European roads in future. Some estimates put penetration of GDi engines as high as 28% of the gasoline vehicle market in Europe by 2010 (4). In the U.S.A., increasing uptake of GDi vehicles is also expected. However, diesel sales are currently low, at around 5% of overall light vehicle sales. While there is potential for some growth in this market share, the main focus for automakers in the region is on gasoline-electric hybrid powertrain development.

Diesel Engines

Diesel engines are 20% to 30% more fuel efficient than similar sized conventional gasoline engines, and therefore produce less CO_2. On average, diesel vehicles use more pgm than their gasoline counterparts since they typically operate at lower temperatures, boosting the need for pgm use in the catalytic aftertreatment. Hydrocarbon (HC) and carbon monoxide (CO) emissions are managed through the use of a diesel oxidation catalyst (DOC), and many new diesel vehicles are fitted with a diesel particulate filter (DPF) to control PM emissions. Some vehicles use a catalysed soot filter (CSF) to control the CO, HC and PM emissions. Traditionally, platinum has been used as the main catalytic component in diesel aftertreatment due to its excellent oxidation activity at low temperature and resistance to 'poisons' in the exhaust stream, particularly sulfur. However, the greater availability of cleaner (lower sulfur) diesel fuel in Europe has resulted in the introduction of some palladium into diesel emission control systems (5).

Stricter legislation entering into force in Europe in 2014 will focus on reducing NOx emissions from diesel vehicles, thus requiring the use of additional catalytic aftertreatment, although some cars sold now already incorporate NOx aftertreatment. Two forms of aftertreatment can be used to reduce NOx emissions: a NOx trap (containing pgm), or selective catalytic reduction (SCR) using urea as the reductant where the SCR catalyst itself does not use pgm, although the aftertreatment system as a whole may still contain pgm. Both technologies are expected to be used to meet Euro 6 legislation, with vehicle size being a key consideration in the choice between the use of a NOx trap and an SCR catalyst.

Given the considerably higher amount of pgm used in diesel aftertreatment as compared with gasoline, any increase in the share of diesel engines will lead to greater demand for pgms.

Downsized Gasoline Engines

Downsized gasoline engines (such as turbo- and super-charged engines), particularly when combined with GDi, provide similar, or improved performance at reduced engine size and hence the potential for greater fuel economy. In recently developed GDi vehicles, the catalyst size tends to be smaller, but the pgm loading may be higher. While the net effect on pgm content is not yet clear, at present the catalyst loadings for GDi engines are broadly similar to naturally aspirated (conventional) gasoline engines.

Hybrid Powertrain

Hybrid vehicles offer fuel economy benefits over similar sized gasoline or diesel engines by combining the internal combustion engine with an electric motor. Because of the relatively small numbers of hybrid vehicles produced today, the comparison between similar sized hybrid and conventional gasoline or diesel vehicles in terms of pgm loading is not well defined and is complicated by two opposing factors. A hybrid vehicle generally has a smaller engine than its conventional gasoline or diesel counterpart, as the electric motor and battery assist during acceleration, and could therefore be expected to require less pgm for the catalyst. However, in the U.S.A., where the majority of hybrid vehicles are sold today, these vehicles are typically manufactured to meet more stringent Californian SULEV emissions standards (6), and therefore require higher pgm loadings. In the coming years, assuming that vehicles are manufactured to meet the same regional emissions standards, the current view is that a switch to hybrid vehicles from conventional gasoline or diesel vehicles will have little impact on overall uptake of pgm.

Vehicle Downsizing

Moving away from the subject of engine technoogies, a shift to smaller, lower-cost and more fuel efficient vehicles could reduce the average pgm loading per vehicle. Recently, there is evidence of a move to smaller vehicles in both the European and U.S. markets, but it is not yet clear whether this will be a long-term trend. In Europe, the growth in the small car segment is seen as a temporary effect caused by the scrappage incentives which are in place in key markets (7). These provide a one-off payment towards the cost of a new car to consumers scrapping an older vehicle. In the U.S.A., some consumers downsized from passenger trucks and sports utility vehicles (SUVs) to smaller vehicles in response to the higher fuel prices in 2008 and, despite falling gasoline prices this year, analysts are anticipating that the share of passenger trucks will continue to drop slowly over time.

Conclusion

Precise trends in regional uptake of pgms depend on both the extent to which each of the above strategies is pursued and consumer preferences, and remain difficult to predict. Overall, however, it is unlikely that tighter CO_2 emissions limits will strongly affect pgm demand from the automotive sector in either direction within the foreseeable future.

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