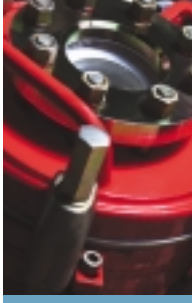


Platinum

Platinum

Autocatalyst

The use of platinum in autocatalysts grew by 17 per cent in 2002. Purchases of metal, however, increased by just 3.6 per cent to 2.61 million oz. The discrepancy was due to the use of significant volumes of stockpiled platinum by US auto manufacturers as they focussed on minimising costs. In Europe, where car companies tend not to hold stocks of pgm, sales of diesel cars climbed by 7 per cent and this led to strong growth in demand for platinum. Increased Japanese demand was primarily due to an export-driven rise in light vehicle production coupled with manufacturers working to meet lower emissions levels.

Europe

Sales of platinum to auto makers in Europe jumped by 17 per cent or 180,000 oz in 2002 to reach 1.24 million oz, the third consecutive year of double-digit growth. The strength of demand has been built on three key trends: growing sales of diesel powered cars (which only utilise platinum-based autocatalysts), tightening emissions standards, and the partial replacement of palladium-rich catalyst systems with those based on platinum on some gasoline models.

Sales of passenger cars in Western Europe were weak in 2002, dropping by 3.5 per cent overall to 14.3 million vehicles. Production was similarly sluggish, declining by around 2 per cent. The popularity of diesel powered cars, however, continued to soar and they took further market share from gasoline vehicles. The number of diesels sold rose by 7 per cent to reach 5.76 million cars – accounting for 40 per cent of total Western European sales.

European consumers have been very enthusiastic purchasers of the latest diesel models for a number of reasons: in many European countries diesel fuel is substantially cheaper than gasoline; diesel cars can be over 30 per cent more fuel efficient than the equivalent gasoline models; greater fuel efficiency means less carbon dioxide is emitted per kilometre (which is rewarded by lower taxation in some countries); and modern diesels offer good performance without the excessive noise or smoke that characterised many of their predecessors.

In contrast to diesels, both production and sales of gasoline powered cars declined by approximately 9 per cent in Western Europe in 2002. The sector lost out to diesels and sales suffered from the poor rate of economic growth in the major continental European economies. The impact on platinum demand, however, was mitigated by the move by some auto manufacturers to replace palladium-rich autocatalyst systems with platinum-based systems. These switching programmes were initiated in 2000 and 2001 when the palladium price soared to a substantial premium to platinum, but because lead times for the development of emissions control systems are lengthy *(see special feature on page 25)* the effect on platinum demand was not fully felt until 2002. The rapid and steep reversal in the palladium price and simultaneous rise in the price of platinum over the past 18 months, however, should preclude any further substitution and has encouraged auto manufacturers to re-examine their overall pgm mix.

Platinum demand also gained a boost in 2002 from tightening European emissions standards. Stringent new Euro IV standards for all light vehicles come into effect from 2005 and will cut permissible emission levels by around 50 per cent. Some manufacturers already offer Euro IV compliant vehicles and most new models currently under development will be certified to the new standards. Auto companies are likely to adopt a range of strategies to meet the new limits, and in some cases these will result in increased pgm use through higher loadings on catalysts or by increasing the number or volume of catalyst bricks.

Japan

Demand for platinum from Japanese auto makers surged by 25 per cent in 2002, reaching 425,000 oz. There were three primary reasons for the increase: rising car and light vehicle production, auto manufacturers working to tighter emissions standards and, in common with other regions, a degree of substitution of palladium with platinum.

Despite the continued weakness of the Japanese economy, domestic sales of cars climbed by 3.5 per cent to 4.44 million, supported by heavy promotion of new models. Production of cars grew even more strongly, rising by 6.2 per cent to 8.62 million units, as exports to North America and Europe remained robust.

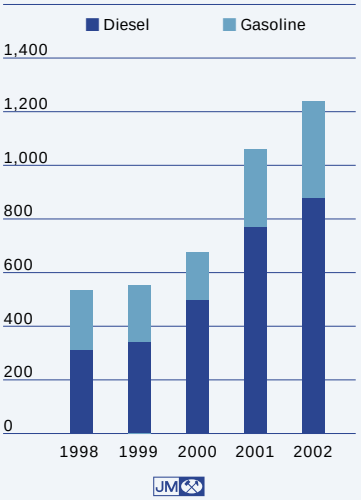
Japanese low emission vehicle (JLEV) and ultra low emission vehicle (J-ULEV) guidelines have been proposed that would require substantial reductions in NOx, HC and CO emissions from the current legal limits. Whilst these guidelines are not yet enforced by

Platinum Demand: Autocatalyst
'000 oz

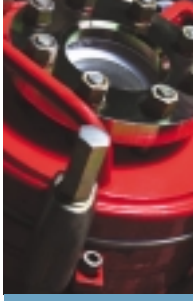
	2001	2002
Europe	1,060	1,240
Japan	340	425
North America	795	570
Rest of the World	325	375
Total	**2,520**	**2,610**

JM

European Demand for Platinum in Autocatalysts 1998-2002
'000 oz



JM



Platinum

Lambda or oxygen sensors, which contain platinum electrodes, are essential components of auto emissions control systems. By continuously monitoring the engine exhaust composition they enable catalytic converter efficiency to be maximised.

legislation, the majority of Japanese manufacturers now produce cars that meet the proposed JLEV standards and many have already launched models that would qualify for J-ULEV status. This voluntary improvement in emissions control has involved a rise in pgm catalyst loadings and an increase in the number of catalyst bricks used in some instances.

Given its strong export focus, the Japanese car industry has also had to respond to tightening emissions controls in the USA and Europe. These too have had the effect of increasing average pgm loadings for a number of models.

In the late 1990s, Japanese auto makers were quick to respond to the rising price of palladium and growing concerns about possible supply disruptions. The increased use of platinum-based catalysts at the expense of palladium by Japanese manufacturers influenced their pgm demand as early as 2000, and boosted platinum purchases in 2001. By 2002, however, many of the switching programmes had already taken effect and so there was less impact on platinum demand.

North America

A substantial increase in light vehicle production, the impending introduction of tighter emissions standards, and the replacement of some palladium-based catalysts with platinum-based products led to a 14 per cent rise in the use of platinum in autocatalysts in North America in 2002. Purchases of the metal, however, fell by 28 per cent year-on-year to 570,000 oz as US-based car companies fulfilled a significant proportion of their requirements through the use of pgm inventories.

The US economy performed erratically in 2002 – strong GDP growth in both the first and third quarters led commentators to speculate that an enduring recovery might be underway. On each occasion, however, the optimism quickly evaporated and second and fourth quarter growth was poor. Against this background of economic uncertainty, a 1 per cent fall in light vehicle sales from the high levels of 2001 could be considered a good result. US-based manufacturers supported sales with a range of aggressive promotions and incentives, including interest-free financing packages and cash rebates.

On the production side, a need to rebuild car inventories at dealerships drove a strong increase in manufacturing rates in the first half of the year. This, together with the solid level of sales, resulted in light vehicle production rising by almost 6.9 per cent to over 12.3 million vehicles.

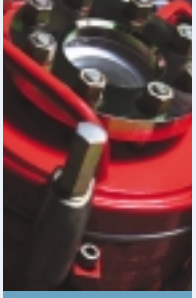
The swift fall in the palladium price plus the rise in the price of platinum during 2002 greatly reduced the justification for switching from heavy use of the former to greater use of the latter. Nevertheless, programmes to reduce dependence on palladium that were introduced in 2000 and 2001 by several auto makers continued to have a positive effect on platinum demand last year.

Counteracting these positive factors for platinum demand, however, was the depletion of the significant stocks of pgm held by US auto makers. The big US auto companies made large inroads into these inventories in 2002 as part of their intensive efforts to minimise costs and improve cash flows. Consequently, purchases of platinum fell even though the underlying use of the metal continued to rise.

Rest of the World

Autocatalyst demand for platinum in the Rest of the World expanded by 15 per cent (50,000 oz) to reach 375,000 oz. Rapidly rising light vehicle production in Asia – up by 17 per cent, excluding Japan – and the spread of tighter emissions limits were responsible for the growth.

Chinese light vehicle production grew phenomenally in 2002, surpassing all expectations by rising 35 per cent to 2.65 million vehicles. Production of cars, all of which are now fitted with catalytic converters, rose by a similar percentage, exceeding 1 million units for the first time. All Chinese



Autocatalyst development and the use of pgm

Significant changes in both the proportions of platinum, palladium and rhodium used in gasoline vehicle autocatalysts and in pgm loadings have occurred since the introduction of catalytic converters in the mid-1970s. This article dicusses the key influences on autocatalyst design and examines the process of catalyst development in the context of pgm use.

Emissions regulations and the pgm mix

The varying pattern of use of platinum, palladium and rhodium on autocatalysts over time has been intimately linked to the introduction and evolution of emissions regulations. Differences in these standards and how they are applied from country to country are instrumental in influencing pgm autocatalyst use.

Several other factors are also important, including:

- Fuel quality and the level of fuel impurities, which can reduce the effectiveness of autocatalysts.
- Wide variations in the types of vehicles and engine sizes produced (e.g. contrast the popularity of gasoline powered SUVs in the USA with diesel engined cars in Europe).
- Developments in engine design and electronic monitoring and control systems.
- Auto makers' strategies regarding pgm purchasing and use.

Catalytic converters were first fitted to cars in the USA and Japan in the mid-1970s in response to new emission standards, such as the US Clean Air Act Amendment of 1970. The first autocatalysts were oxidation catalysts, which convert carbon monoxide (CO) and hydrocarbons (HC) to carbon dioxide (CO_2) and water. These catalysts primarily used a mix of platinum and palladium.

The focus of regulation then turned to oxides of nitrogen (NOx) and new US regulations were phased in between 1981 and 1983. Because oxidation catalysts have little effect on NOx, the new standards resulted in the development and introduction of 'three-way catalysts' that simultaneously oxidise CO and HC while reducing NOx to nitrogen. The most common three-way catalysts fitted to cars in the 1980s contained platinum and rhodium in a 5:1 ratio, rhodium playing an important role in promoting the reduction of NOx.

Palladium came to the fore from 1989 onwards, as auto makers began using more durable palladium-based three-way catalysts to take advantage of the metal's price discount to platinum. In addition, the sudden spike in the price of rhodium to over $5,000 per oz in 1990 encouraged some manufacturers to utilise palladium-rich catalysts with lower rhodium loadings. Technological advances made by autocatalyst manufacturers enabled auto companies to be more responsive to the changing pgm price differentials.

The move to greater use of palladium gathered pace with the California Clean Air Act of 1990, the US Federal Tier 1 standards introduced in 1994, and the European Stage II regulations of 1996. These placed further limits on emissions levels, particularly for HC for which palladium is a highly-effective catalyst. The move into palladium was helped by reductions in the sulphur content of fuel in California, Europe and Japan.

Initially palladium loadings of two or three times that of platinum were required to maintain overall catalyst performance. However, as palladium was typically one-third to one-quarter of the price of platinum (averaging $88 versus $376 in 1991 for example) it was economical at much higher loadings.

The exceptionally rapid rise in auto company demand for palladium throughout the mid and late 1990s, coupled with disruptions to supplies from Russia, spurred the palladium price from around $200 at the start of 1998 to over $1,000 in January 2001. This triggered moves by some auto makers to shift a proportion of their autocatalyst pgm use back in favour of platinum. The subsequent reversal in platinum and palladium prices has created the financial incentive for the auto industry to re-examine greater use of palladium once again.

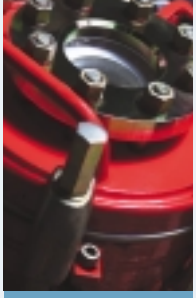
Influences on catalyst development

Car companies are already working with catalyst suppliers on vehicle models that will be launched in three to four years time and beyond, to meet the emissions regulations that will be in effect during these cars' lifetimes. The regulations stipulate what needs to be achieved in terms of emissions control and consequently influence many of the catalyst system parameters.

In addition to emissions legislation, other factors that will affect catalyst system designs include engine size, fuel type (gasoline or diesel), engine performance characteristics, and technical considerations such as the level of engine-out emissions, operating temperatures and exhaust system back pressure. Catalyst system design and layout (the number, size, shape and location of bricks, for example) will also be influenced by fundamental parameters such as the available space.

Although common components will be used as far as possible across a number of engine sizes, types, and even vehicle platforms, catalyst formulations and configurations and the calibration of engine control systems are tailored to individual models. Throughout the entire process the auto company, therefore, works very closely with the catalyst supplier in the design and formulation of an overall emissions control system that will meet the relevant emission standards at an acceptable cost.

Once a catalyst has been designed and the associated engine management controls have been calibrated, the system then has to be tested and approved by official certification bodies. After certification, changes to a catalyst system on a specific car model



cannot usually be made without it being re-certified.

In order to benefit from changes in pgm prices, auto manufacturers may re-examine the pgm loadings or ratios on an autocatalyst system after the vehicle model it is fitted to has entered production. However, catalyst design, testing and certification in association with calibration of the engine and on-board diagnostic systems typically takes many months and requires the input of highly qualified technical staff from both the auto manufacturer and catalyst supplier. It is complex, time consuming, and carries a significant cost to the car company.

Auto manufacturers, therefore, are reluctant to make major changes to pgm loadings once a specific model has entered production. By this stage the engine management and catalyst engineering teams will have long moved on to work on future models. Of course, knowledge gained and advances made in the development of a particular vehicle's catalyst system may be adapted and applied to subsequent models, and in this regard the process is evolutionary.

Advances in catalyst design

Substantial advances have been made in autocatalyst design and technology over the last 10 years and some have influenced pgm loadings. The most important trends can be summarised as:

Inspecting autocatalyst bricks on the production line at a plant in Shanghai.

- Improved thermal and chemical characteristics of the catalyst

A number of advances in pgm salts and washcoat formulations have enabled substantial improvements to be obtained in the efficiency of pollution conversion and in the thermal durability of catalysts. A key enhancement was the addition of ceria (cerium oxide) to the washcoat. This helped to stabilise the surface area of the washcoat and greatly improved oxygen storage capacity. The latter is crucial in maximising the ability of three-way catalysts to both oxidise HC and CO and reduce NOx, and also enables on-board diagnostic systems to evaluate the 'health' of the catalyst. Subsequently, catalyst manufacturers developed sophisticated catalytic formulations that contain all the active components in a single washcoat.

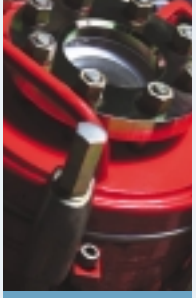
The production of catalytic materials with greater thermal durability and stability at high temperatures has also been achieved. High thermal durability is particularly important as a more thermally durable catalyst can be fitted much closer to the engine, where exhaust temperatures are higher and where it will reach light off (the temperature at which it becomes active and starts converting pollutants) more rapidly. This is critical as the pollutants emitted before the catalyst reaches light off account for the great majority of total emissions. The previous generation of catalysts with lower thermal durability had to be loaded with more pgm to counteract the possibility of degradation in performance over time.

- Closely tailoring catalysts to individual vehicle models

By optimising engine operating parameters (fuel combustion, the air:fuel ratio, exhaust temperature, etc.) in concert with close calibration of engine management systems and catalyst development, pgm loadings can be reduced compared to a one-catalyst-fits-all approach. Of course, improvements in engine design to reduce engine-out emissions will intrinsically lower the demands on the catalyst system and may also enable lower loadings of pgm to be utilised.

- Substrates with higher cell density and thinner walls

Five years ago a standard ceramic catalyst substrate contained 400 cells per square inch (cpsi) and the cells walls would have been around 0.125 millimetres thick. Today, substrates with 600 cpsi are common and some of 900 cpsi with walls less than 0.06 millimetres thick are in use. Similar advances have also been made in increasing the cell density of metallic substrates. This has an indirect effect on pgm loadings as a larger catalyst surface area can be incorporated into a given converter volume and this allows better conversion efficiency and durability. Alternatively, smaller converters with the same performance can be produced, making the catalyst easier to fit close to the engine where space is usually limited. This close-



coupling allows light off to be achieved more rapidly, enabling emissions limits to be achieved with lower pgm loadings. Substrates with thinner walls also heat up more rapidly, again reducing the time to light off.

Changes in pgm loadings

Thrifting in the context of precious metals and autocatalysts is generally understood to refer to the reduction of pgm loadings on a vehicle's catalyst system without compromising its ability to meet the relevant emissions legislation.

The rationale for thrifting is primarily economic: the goal is the most cost-effective catalyst system possible. Given their relatively high cost, efforts to thrift precious metals are a consequence of this drive, although strategic considerations – the security and reliability of pgm supply – are also relevant. In addition, thrifting of pgm can only be taken so far without impairing catalyst performance. For all auto companies the need to maintain 100 per cent compliance with emissions regulations is paramount. The development of sophisticated new autocatalysts by catalyst manufacturers has enabled the use of lower pgm loadings while still comfortably meeting the relevant emissions legislation.

The fact that auto manufacturers place different emphasis on the importance of pgm thrifting also has to be taken into consideration. Those for whom environmental 'leadership' is a key element of their marketing strategy may attach greater weight to meeting new emissions legislation ahead of the required deadlines than they do to pgm thrifting.

It is also useful to draw a distinction between pgm loading levels on individual catalyst bricks and the loading of pgm across the whole catalyst system of any one vehicle. Two brick systems are common, and it is not unusual for larger, high-performance passenger cars to be fitted with four to six catalyst bricks. The loading, choice of precious metals, and ratio of pgm used can vary substantially from brick to brick. It is the use of pgm across the system as a whole that is important.

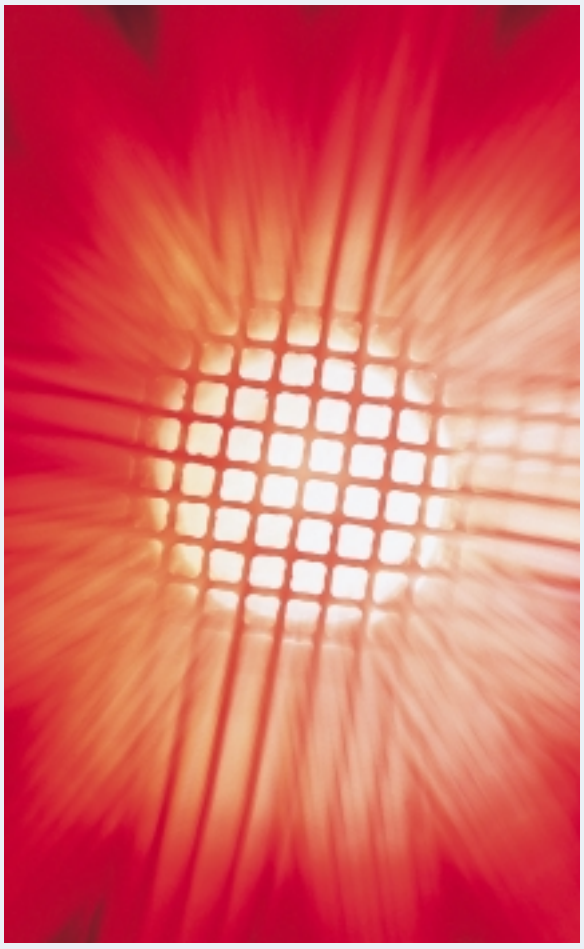
Dual certification – hard to justify

In light of the historical volatility in platinum and palladium prices, some auto companies have investigated the certification of both platinum and palladium-rich catalyst systems for the same vehicle model. Catalyst designers have responded by developing both palladium-rich and platinum-rich systems that meet existing emissions legislation, to enable car companies to adopt a more flexible approach towards pgm use. Dual certification would, in theory, allow a car manufacturer to have greater control over its pgm costs by switching from a platinum-rich catalyst system to a palladium-rich variant, or vice versa, when metal prices changed significantly (though this is only relevant to gasoline vehicles as diesels are dependent upon platinum-based catalysts).

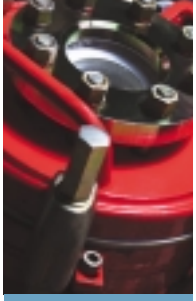
However, the characteristics of the two metals such as reactivity, pollutant conversion efficiency and durability are not identical and a recalibration of the engine management systems and on-board diagnostics will normally be required. This, in turn, usually means that the entire system has to be recertified.

Auto manufacturers, therefore, have to assess whether the cost of developing and certifying two separate catalyst systems for the same car model will be offset by the potential benefits that may be gained through being able to switch from one to the other. This cost-benefit analysis requires car companies to take a view on how pgm prices will move over the coming 3 to 4 years or more – a tough proposition given their recent unpredictability.

Dual certification also has to be seen in the context of the strong desire by most auto companies to minimise costs. In this environment it is hard to justify the capital expenditure and the redeployment of resources required for additional catalyst engineering, testing, calibration and certification when there is no guaranteed financial benefit. Although attempts are being made to speed up and simplify the cost of the catalyst certification process, it will still have an associated cost that the auto maker is not guaranteed to recoup.



Close-up through an autocatalyst substrate. The development of substrates with thinner walls and a greater number of cells per inch has had a number of benefits for catalyst performance.



Platinum Demand: Autocatalyst Recovery
'000 oz

	2001	2002
Europe	(70)	(90)
Japan	(55)	(60)
North America	(370)	(380)
Rest of the World	(35)	(40)
Total	**(530)**	**(570)**

JM

manufactured cars have to be certified to Euro I equivalent emissions limits and the introduction of Euro II standards has been accelerated. Vehicles sold in Beijing have had to meet Euro II limits from January 2003 and the regulations will be introduced nationwide in July 2003.

Elsewhere in Asia, South Korean light vehicle production exceeded 3 million vehicles, an increase of 4.5 per cent, with larger cars and SUVs gaining in popularity. Double-digit growth in production and sales were also seen in India, Thailand, Malaysia and across much of the rest of Asia. This growth far outweighed a worsening of the economic situation in South America, where Brazilian light vehicle production dropped by 9 per cent to around 1.43 million vehicles and Argentinean output slumped to less than 160,000 units.

Autocatalyst Recovery

Recovery and recycling of autocatalysts continues to provide a growing secondary source of pgm. An estimated 570,000 oz of platinum were recovered from recycled autocatalysts in 2002, an increase of 40,000 oz from 2001.

The increase was most marked in Western Europe, where greater collection and processing of spent autocatalysts resulted in a 20,000 oz rise in platinum recovery. The sector has for several years been attracting greater attention on the back of relatively high pgm prices and through the development of legislation to increase scrap vehicle recycling. The European End of Life Vehicle (ELV) recycling directive will apply from 2005 and aims to increase the rate of re-use and recovery of materials to 85 per cent by weight per vehicle by 2006.

Furthermore, as catalytic converters were only required on all new gasoline cars in Europe from 1993, the proportion of cars currently being scrapped that are fitted with catalysts is increasing as greater numbers of these vehicles reach the end of their lives.

Recovery has also increased in the USA, although to a lesser extent, as collection rates were already high relative to Europe. The strength of the platinum price in 2002, which averaged almost $540 over the year, helped to support the profitability of recovery and recycling businesses, despite the fall in the price of palladium. North American-based collection companies also sought to widen their sources of scrapped catalysts and imported increased volumes of material from Mexico and South America.

Platinum Demand: Jewellery
'000 oz

	2001	2002
Europe	170	165
Japan	750	780
North America	280	310
Rest of the World	1,390	1,575
Total	**2,590**	**2,830**

JM

Jewellery

Demand for platinum from the global jewellery industry expanded by 240,000 oz (9 per cent) in 2002 to total 2.83 million oz. Strong sales of platinum to the Chinese jewellery industry again provided much of the growth, demand climbing 14 per cent to 1.48 million oz. Purchases of platinum by Japanese jewellery manufacturers also increased but here the growth was due to less metal being available from inventories, stock levels throughout the industry having been run down to low levels during 2001. Total European demand was marginally down, although the UK market again performed well. In North America purchases increased due to restocking by fabricators at the start of the year and to moderately improved retail sales.

Europe

European demand for platinum in jewellery declined marginally to 165,000 oz in 2002, reflecting soft conditions in most continental European markets. The UK and export markets, however, provided growth opportunities for some manufacturers.

The UK cemented its position as the largest European jewellery market for platinum in 2002 as the popularity of platinum bridal jewellery continued to grow robustly. Bridal jewellery accounts for approximately 90 per cent of the UK's total platinum jewellery market. The number of platinum items hallmarked by UK assay offices increased by almost one-third, and with the average weight per piece of jewellery rising, the total weight of platinum jewellery hallmarked jumped by 43 per cent to over 63,000 oz. The buoyant UK market provided a degree of relief for continental fabricators whose domestic markets were subdued, particularly those in Germany. Imports accounted for one-fifth of the total UK market, almost doubling year-on-year and exceeding 10,000 oz.

In contrast to the UK, the German jewellery market was depressed in 2002; the country's deepening economic problems dulled consumer spending on non-essential goods across the board. The fashion sector of the German platinum jewellery market suffered as non-precious white metals such as titanium and stainless steel made further inroads. German fabricators looked to export markets in the UK and North America to bolster sales but these did not wholly offset the weakness in the domestic market.

In Italy, sales of platinum jewellery to the bridal market were steady but in other sectors platinum came under price pressure from white gold as the year progressed. Italian platinum jewellery fabricators, however, have a large and well-established presence in international markets and gained a degree of success in increasing exports to North America and Japan. Sales of Italian jewellery also increased to stores in China, where modern European-style jewellery is distinctive and popular.

Demand for platinum from the Swiss jewellery industry softened somewhat in 2002 after performing particularly strongly in 2001. The weakness of demand for luxury goods in late 2001 resulted in lower numbers of platinum watches being manufactured in the first half of 2002 – a lead time of several months is common in this sector due to the complexity of the products and the labour intensive nature of the business.

Chinese stores reported strong sales of platinum jewellery during the New Year holiday period in 2002. Chinese demand for platinum in jewellery increased by 14 per cent to 1.48 million oz.

Japan

Demand for platinum from the Japanese jewellery industry increased by 30,000 oz to 780,000 oz in 2002. Although retail sales of platinum jewellery slipped lower, purchases of platinum by fabricators increased. Metal held throughout the manufacturing and retail pipeline had been run down to relatively low levels during the previous year and so there was less opportunity to recycle metal from stocks.

The stagnant Japanese economy and the rising price of platinum combined to produce a 15 per cent fall in platinum jewellery retail sales in 2002. However, this has to be put in the context of a 10 per cent fall in sales of all precious metal jewellery in Japan, and platinum still accounted for one-quarter of this market. Sales of platinum products to the core bridal segment of the market were broadly stable. Sales of platinum wedding bands in the over ¥50,000 price bracket actually increased by 4 per cent year-on-year, and platinum retained a very strong hold on the bridal jewellery market as a whole.

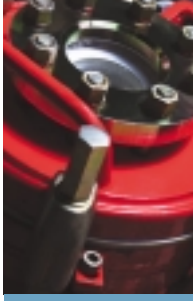
Sales of other platinum jewellery generally lost ground, with competition from white gold increasing in the lower-priced fashion sectors. Sales of platinum products such as women's rings, necklaces and earrings all lost ground. As the price of platinum rose from close to ¥2,000 per gram at the start of the year to over ¥2,300 per gram briefly in April, and then again in October, wholesalers and retailers were better able to market white gold jewellery to price-conscious consumers. The growth of white gold, in part at the expense of yellow gold, was evidence of the continued strong consumer preference for white precious metal jewellery in Japan.

North America

North American jewellery demand for platinum grew by 30,000 oz (close to 11 per cent) in 2002 to 310,000 oz. Retail sales held up reasonably well even though consumer confidence became more fragile as the widely predicted economic recovery failed to materialise. However, the growth in metal purchases by fabricators was primarily due to restocking of the manufacturing and retail pipeline during the first quarter of the year following a sustained run-down in inventories during 2001.

Reports from retailers about the level of sales of platinum jewellery were mixed in 2002, reflecting the increasingly unpredictable purchasing behaviour of consumers. The uncertainty about prospects for the market meant that retailers in turn were cautious in placing orders with fabricators.

Platinum has gained a substantial share of the bridal jewellery market in North America and white precious metal jewellery remains very popular, particularly amongst younger consumers. Although this sector remains more price resistant than the market for fashion jewellery, there was a degree of erosion of platinum's bridal market share by white gold in the lower-priced product ranges. That said, platinum still



Platinum Demand: Chemical
'000 oz

	2001	2002
Europe	105	115
Japan	25	30
North America	100	100
Rest of the World	60	80
Total	**290**	**325**

JM

Platinum Demand: Electrical
'000 oz

	2001	2002
Europe	65	65
Japan	80	80
North America	120	115
Rest of the World	120	120
Total	**385**	**380**

JM

accounted for more than one-third of total US sales of engagement rings and wedding bands in 2002.

The strength of platinum prices held back any growth in sales of fashion jewellery. In this sector, white gold offered higher margins and greater flexibility in terms of meeting key price points for both wholesalers and retailers.

Rest of the World

Demand for platinum from the Chinese jewellery market continued to grow rapidly in 2002, expanding by almost 14 per cent to reach 1.48 million oz (over 46 tonnes). This represented more than one-fifth of total global platinum demand.

Retail sales of platinum jewellery were strong throughout the year, but were particularly buoyant during the Chinese New Year and Labour Day holidays in February and May respectively. The Chinese New Year celebrations coincided with Valentine's Day, giving an extra promotional push to platinum jewellery sales.

In contrast to Japan, the Chinese platinum jewellery industry is not dominated by bridal rings, although they do account for a substantial proportion of sales. The largest sector of demand is for plain (not gem set) fashion rings, with diamond rings and other fashion items such as necklaces and pendants becoming increasingly popular.

The level of consumer enthusiasm for platinum jewellery appeared to be uninhibited by the metal's rising price in 2002. Platinum remained highly desirable, particularly among younger, affluent middle-class consumers for whom platinum jewellery is often regarded as a status symbol.

The successive rallies in the platinum price to around $560 in April, June and August also did little to discourage purchases by manufacturers, although the level of offers for metal tended to fall off at the peaks.

In October, however, buying by fabricators slowed noticeably as the price climbed quickly towards $600. A problem for manufacturers is that Chinese retail prices of platinum jewellery do not move in step with international bullion prices. The Chinese market is very competitive and is characterised by a high degree of price transparency as the majority of platinum jewellery is still sold by weight. In this environment retailers are very reluctant to increase their prices for fear of either driving consumers to competitors or away from platinum. Therefore, as the platinum spot price climbed fabricators were largely unable to pass on higher metal costs to retailers, and by the fourth quarter their profit margins had been heavily eroded.

Demand picked up again in November and December as it became evident that the platinum price was well supported around $580 and major retailers were persuaded of the need to push up their prices. However, the end-of-year increase in demand was not as great as might have been expected. Some stores, still unwilling to accept that firmer spot prices would persist, appeared to hold back from ordering stock for the Chinese New Year sales. There were also indications that some fabricators had accumulated inventories of metal and were able to satisfy orders without making further purchases. As 2002 drew to a close, many fabricators were awaiting either a further increase in retail prices or a significant softening in the platinum spot price.

Other Asian centres of platinum jewellery manufacturing primarily supply the export markets of North America, Japan and Europe. Demand for platinum from fabricators in South Korea and Thailand increased moderately in line with sales to the USA.

Chemical

Consumption of platinum in the chemical industry climbed to 325,000 oz in 2002, an increase of 35,000 oz from the year before. The construction of new paraxylene manufacturing plants and growth in demand for silicones, particularly in China, were the key components of higher demand for platinum-based catalysts.

New plants for the manufacture of paraxylene were constructed in the Middle East and Asia during 2002 and the installation of catalysts in these facilities boosted platinum demand. Paraxylene is an intermediate chemical in the manufacture of purified terephthalic acid (PTA), which in turn is the source of polyesters and polyethylene terephthalate (PET). Use of the latter continues to grow rapidly in plastic film and packaging applications and is expected to stimulate further investment in paraxylene capacity in Asia in the short to medium term.

Catalyst metal losses during the production of paraxylene are low and therefore replacement demand for platinum-based catalysts in this application is stable and relatively small.

The manufacture of silicone compounds is a major application for platinum catalysts. As the level of metal consumed during production is significant, the rate of

silicones output has a direct effect on catalyst demand. Silicone-based coatings, sealants and adhesives are used in a wide range of industrial and consumer applications but markets in North America and much of Europe were subdued in 2002 in line with weak levels of economic activity. Firm demand from Asia, however, provided a counterbalance with China leading the growth. Overall, sales volumes gained ground slightly and this was reflected in platinum catalyst demand.

Demand for platinum catalyst gauze for the production of nitric acid increased slightly in 2002. Activity in the global nitric acid industry depends largely on the level of nitrogen fertiliser output. Large fertiliser inventories carried over from 2001 depressed demand during the first quarter but as the year progressed the market improved, particularly in South America and Asia. Profitability throughout the industry, however, remained under pressure and investment in new capacity was restricted to a handful of plants in Eastern Europe and Asia.

Electrical

Demand for platinum used in electrical applications fell slightly in 2002 to 380,000 oz, 16 per cent below the peak of 455,000 oz purchased in 2000. Weak global economic conditions were responsible for a slight decrease in demand from both the hard disk and thermocouple sectors, but this was offset by an increase in the volume of platinum used in fuel cells and other applications.

Demand for platinum in computer hard disks grew rapidly throughout the late 1990s and 2000, as manufacturers rapidly adopted the use of platinum-cobalt alloys to improve data storage performance. Demand faltered in 2001, however, as sales of personal computers fell and softened further in 2002 as both consumer and business spending on new information technology equipment remained weak. The penetration of hard disks containing platinum now exceeds 90 per cent.

The average number of hard disks used per computer continued to trend lower in 2002 as growth in data storage density was maintained – the greater the data storage density, the fewer disks are required for a set level of performance. Balancing this, however, was the further spread of hard disks to non-computing applications such as video game consoles.

High temperature thermocouples utilising platinum wire are widely used in the steel, glass and semiconductor manufacturing industries and demand is related to both the level of production and investment in new capacity. Steel output was stable in Western Europe and increased by 2.5 per cent in North America; again, however, low profitability and excess capacity constrained capital spending. Although Chinese steel output surged by 20 per cent, most Chinese steelmaking plants do not generally utilise platinum wire thermocouples.

Semiconductor sales fell in Europe, North America and Japan in 2002 but increased in China and South East Asia. Overcapacity remained substantial and profit margins were under pressure from low product prices, holding back investment in new equipment. With production closely related to GDP, the global glass industry also faced tough conditions in many markets in 2002, particularly for float glass. The combined overall impact was a 10 per cent reduction in thermocouple demand for platinum.

There were numerous announcements of advances in fuel cell technology during 2002 (*see panel*). Of long-term significance was the increased commitment of some leading petroleum companies to the

Fuel Cell Developments

Several notable advances in fuel cell technology were made during 2002, not least within the automotive industry.

In late 2002, Honda and Toyota delivered the first 'commercial' fuel cell cars to government agencies and universities in Japan and in the USA. Although the cost of these test vehicles is still far higher than would be needed to make them a realistic alternative for consumers, the fact that they will be operated under normal driving conditions represents significant progress.

Other data from real-life operating environments will be obtained from the Japan Hydrogen and Fuel Cell Demonstration Project. Under this partnership Federal Express will operate a General Motors HydroGen3 fuel cell powered van on its regular delivery routes in Tokyo. Test programmes like these will allow car manufacturers to refine their present designs and reduce costs.

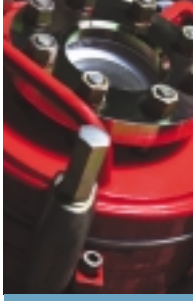
The attraction of fuel cells in powering cars was also evidenced by the increasing level of governmental involvement. In Japan, the government announced new initiatives to move the adoption of fuel cells forward, assisted by industry. The European Commission established a new high-level advisory group for hydrogen and fuel cell issues, and in January 2003, US President Bush proposed additional funding for fuel cell development.

Fuel cell cars are regarded as a long-term prospect, whereas other applications promise to come to the market sooner. Companies such as Smart Fuel Cell and Toshiba are working on fuel cell powered laptop computers. The primary advantage is extended operating times, and such products could be on sale in the first half of this decade.

Residential or small-scale fuel cells are also still on track to make their debut from 2005 onwards, and field trials of precious metal containing units (and some competing precious metal-free technology) continued. Again, the products first introduced into the sector are unlikely to have been optimised in terms of cost and performance but should find a market for low emission, low noise, electricity generation, for example in providing high quality back-up power.

For updates on fuel cell developments, visit ***www.fuelcelltoday.com***.

A General Motors HydroGen3 van (left) will be the first fuel cell vehicle fuelled with liquid hydrogen to be commercially tested in Japan. Federal Express will use one of these vehicles on its normal delivery schedules in Tokyo for one year from June 2003.



Platinum Demand: Glass
'000 oz

	2001	2002
Europe	10	10
Japan	85	80
North America	35	30
Rest of the World	160	135
Total	**290**	**255**

JM

Platinum Demand: Petroleum Refining
'000 oz

	2001	2002
Europe	15	15
Japan	5	5
North America	40	45
Rest of the World	70	75
Total	**130**	**140**

JM

development of hydrogen storage, transportation and refuelling systems that will be necessary to supply fuel cell powered vehicles. Demand for platinum used in catalysts for both proton exchange membrane (PEM) and phosphoric acid types of fuel cells grew but with commercialisation still some years away was still less than 20,000 oz.

Glass

The glass industry consumes substantial volumes of equipment either manufactured from or coated with platinum. Heavy investment in additional LCD glass and fibreglass manufacturing capacity in Asia in 2001 boosted platinum demand substantially but as the rate of new capacity construction slowed in 2002, metal consumption fell back to 255,000 oz.

Platinum purchases for glass production applications eased in 2002 from the high level of consumption seen in 2001. Nevertheless, total platinum demand of 255,000 oz was relatively firm by recent historical standards. Fewer new furnaces were brought on stream in China in 2002 than in the previous year but investment continued, particularly for LCD glass and fibreglass manufacturing capacity. The booming Chinese production of automobiles has boosted demand for textile (reinforcing) glass fibre, and growing consumer purchases of electronic goods such as televisions and computers are driving demand for TV and LCD glass.

In Western Europe and North America, weak domestic markets and competition from lower-priced imported glass products from Asia led to the closure of several glass furnaces between 2001 and the end of 2002. With demand from these markets relatively mature and fixed costs high compared to elsewhere, little investment in new capacity is expected in these regions. Eastern Europe and South East Asia offer greater potential for expansion going forward but these markets were largely stable in 2002.

Petroleum Refining

Demand for platinum in catalysts for the petroleum refining industry increased modestly to 140,000 oz in 2002. One significant addition to reforming capacity was made in North America and investment was also seen in the Middle East and Asia. This, however, was partly offset by the suspension or closure of other reforming and isomerisation units. In broad terms, the weak global economy in 2002 kept demand for petroleum products subdued and prices relatively low for much of the year. This, is turn, deterred capital investment.

The addition of a new petroleum reforming unit at a refinery in the south-eastern USA was partly responsible for an increase in demand for platinum-based petroleum catalysts in North America in 2002. This, however, was an exception in the region and demand for platinum was largely restricted to top-up catalyst orders for existing plants. The same was also true for the mature Western European market.

In Asia there was also some investment in new reforming and isomerisation capacity. However, this was offset to a certain degree by other plants being taken out of commission and there was little net change in platinum catalyst demand. Demand in the Middle East increased with the installation of new refinery capacity in Qatar.

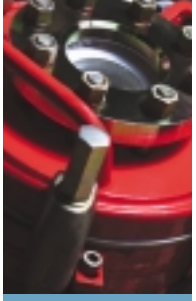
Other

Demand for platinum from other industrial end uses advanced in 2002, growing by 5 per cent to 490,000 oz. Use of the metal in dental alloys increased marginally as the effects of moves to substitute palladium following its price spike in 2001 drew to a close. Platinum demand for use in spark plugs, sensors and biomedical applications grew significantly but consumption in turbine blade manufacture decreased.

The consumption of platinum in dental alloys in Europe rose slightly in 2002 as programmes to replace palladium-based products with high-gold alloys (which typically contain 8 to 15 per cent platinum) were concluded in Germany. In the Italian market, however, palladium alloys began to regain market share as the price of the metal fell.

In North America, dental demand for platinum declined marginally in 2002. There were indications that a move back towards palladium-based alloys had started, although many users remained wary of a repeat of the previous price volatility. The impact on platinum demand, however, was limited as palladium took market share from a range of alloy types, not only from high-gold alloys containing platinum.

Platinum-tipped spark plugs continued to gain market share in 2002, leading to a noticeable rise in platinum demand. Spark plugs with platinum



electrodes have improved durability compared to conventional products, and this is important in maintaining engine performance and emissions control. The high durability and thermal stability of platinum also allows manufacturers to decrease the diameter of the electrode, which in turn means that a lower voltage is required. Platinum spark plugs are fitted as standard to most cars manufactured for the North American market and are increasingly specified in Europe, despite their higher cost.

Platinum electrodes are the key component of many gas sensors, including oxygen or lambda sensors that are essential to automobile engine management and emissions control systems. Demand for oxygen sensors in Europe increased substantially in 2000 and 2001 as auto companies increased the number used per car to enable engine control systems to meet tighter European emissions limits. In 2002, demand stabilised and more closely reflected the level of vehicle production. Demand from auto manufacturers in North America increased somewhat as light vehicle production rose but was largely flat in other regions.

Biomedical applications for platinum continued their recent strong growth in 2002, led by greater use of platinum equipment in surgery. Platinum electrodes are utilised in pacemakers, and platinum stents, coils, guide-wires and springs are becoming more widely used in a variety of surgical procedures.

Platinum is also used to manufacture radio-opaque marker bands fitted to plastic catheters for intravenous treatments. These marker bands allow surgeons to follow and control the progress of catheters using medical imaging techniques as they progress through the patient. The advantages of platinum include its chemical inertness, electrical conductivity, strength and radio-opacity.

Drugs used to combat cancer are a growing biomedical use for platinum. In August 2002 the US Food and Drug Administration (FDA) approved the drug Oxaliplatin, which was already in use in Europe and Asia, for the treatment of colon cancers. Oxaliplatin and related platinum-based anti-cancer pharmaceuticals consume a fairly limited volume of platinum per year but demand is growing.

The high melting point, corrosion resistance, and thermal durability of platinum lead to its use in the coating of turbine blades in jet engines. Demand for platinum from this industrial sector decreased in 2002 as a significant number of commercial aircraft orders were deferred or cancelled. In the longer term, growth in the international aerospace industry is expected to resume, and demand for higher performance aero-engines should rise. This would lead to renewed growth in demand for platinum-coated turbine blades in the most demanding applications.

Investment

Net demand for platinum investment products fell by an estimated 10,000 oz in 2002 to 80,000 oz. During the first half of the year sales of both Japanese bars and US platinum bullion coins continued at similar levels to 2001. However, as the price of platinum climbed above $550 the volume of metal sold back to the market by investors increased and sales of new products slowed.

Purchases of the US Mint's platinum American Eagle bullion coins during the first half of 2002 totalled just over 18,000 oz. The drop in the platinum spot price in January towards $450 stimulated buying, together with promotion of the new year's series of coins. Demand fell back through the following three months as the price climbed past $500 and then breached $550.

Greater purchasing was seen again in May and June but then dropped away during the second half of the year as the platinum price strengthened to average $565, and neared $600 on several occasions. Demand for US platinum American Eagle proof coins from specialist collectors declined by 7 per cent.

Japanese investors also took advantage of the relative price weakness of platinum during January and February by purchasing significant quantities of 500 g and 1 kg bars, both directly and through investment plans. As the platinum price then started to climb the volume of platinum sold back to the market increased, peaking in April as the price passed ¥2,300 per gram.

The level of disinvestment slowed as the price dropped back under ¥2,200, and as the yen strengthened versus the US dollar the level of new purchases rose again. The fall in the local price of platinum to under ¥2,000 spurred strong buying in July.

Conversely, August through to October saw sales of platinum bars back to dealers accelerate once more as the spot price of platinum climbed towards $600 and the price in yen again exceeded ¥2,300. Overall, Japanese investors purchased a net 35,000 oz of physical platinum during 2002.

Platinum Demand: Other
'000 oz

	2001	2002
Europe	155	170
Japan	35	40
North America	250	255
Rest of the World	25	25
Total	**465**	**490**

Platinum Demand: Investment
'000 oz

	2001	2002
Coins and small bars		
Europe	0	0
Japan	5	5
North America	45	40
Rest of the World	0	0
	50	**45**
Large bars in Japan	**40**	**35**
Total	**90**	**80**