PLATINUM

AUTOCATALYST

Demand for platinum in autocatalysts increased by 9 per cent in 2005 to 3.82 million oz, a record high. Once again, much of the growth was generated in Europe, where diesels continued to increase their share of passenger vehicle sales. At the same time, the advent of Euro IV emissions limits plus the introduction of catalysed soot filters (CSF) led to an overall rise in platinum loadings. Platinum demand in China and the Rest of the World region rose on the back of higher vehicle output, and demand in North America increased marginally. Japanese purchases, however, fell following stock building the previous year.

Europe

European demand for platinum in autocatalysts increased by 17 per cent to 1.96 million oz in 2005 – the eighth successive year of growth.

The rising demand for platinum continued to be influenced by expanding production and sales of light duty diesel vehicles, although the rate of growth slowed significantly compared with the previous year. In 2005 diesels accounted for 49.5 per cent of new light duty vehicle registrations in Western Europe (up from 48.3 per cent in 2004) .

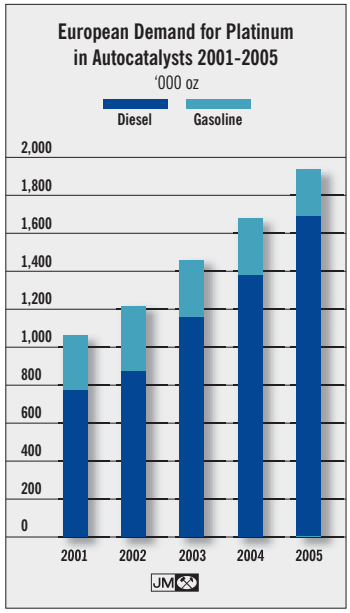
The slowing growth in the diesel sector was partly a reflection of a tough year for car sales in Europe overall, total new vehicle registrations edging lower. It was also a result of a relatively poor year for diesel sales in Germany, the largest market in the region. Uncertainty there over whether government subsidies or tax incentives for purchasers of cars fitted with CSF might be forthcoming in 2006, plus a lack of availability of particulate filters in the fourth quarter, dampened sales.

Platinum Demand: Autocatalyst
'000 oz

	2004	2005
Europe	1,680	1,960
Japan	615	595
North America	800	820
Rest of the World		
China	75	110
Other	320	335
Total	**3,490**	**3,820**

JM

However, average platinum loading levels for light duty diesels continued on an upward trend in 2005 as a greater proportion of vehicles were produced to Euro IV emissions standards. The Euro IV standard (which has applied to new models introduced after 1st January 2005) required a 50 per cent cut in oxides of nitrogen (NOx) emissions from light duty diesels compared with Euro III. One means of reducing NOx emissions from a diesel engine is to lower the temperature of combustion. This, however, results in greater emissions of carbon monoxide (CO) and a lower temperature exhaust flowing through the catalyst. In some instances catalyst platinum loadings have been increased to compensate.



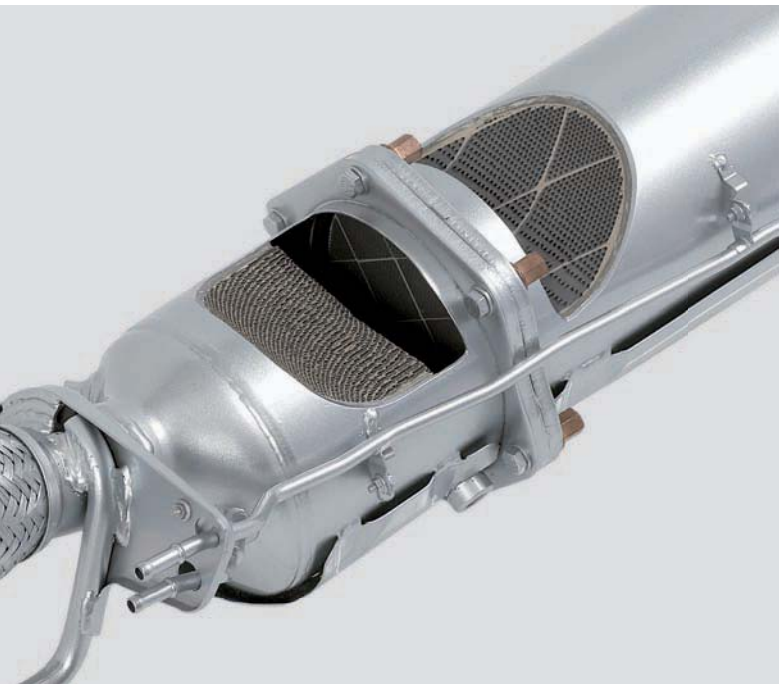
The Euro IV legislation also introduced stricter limits on emissions of particulate matter. Auto manufacturers have been able to meet these limits on the majority of new light vehicle models without using CSF. However, increased media attention and public concern about particulate emissions has helped drive sales of CSF as optional extras and has led manufacturers to increasingly fit them as standard equipment.

Japan

Purchases of platinum by auto makers in Japan dropped to 595,000 oz in 2005, down 3 per cent from the previous year. The year-on-year comparison of demand, however, is not representative of underlying use of the metal on catalysts as the 2004 figure was boosted by the purchase of metal for inventories.

In contrast, the use of platinum by the Japanese autocatalyst sector increased for the seventh year in succession in 2005, rising by around 7 per cent. In part this reflected greater production of cars and light trucks, vehicle output rising by almost 3 per cent to just under 10.5 million. Sales in Japan were lifted by the strengthening of the local economy, whilst the weakening of the yen over the course of the year contributed to an increase in vehicle exports. At the same time an increasing proportion of light vehicles for the domestic market was manufactured to tighter emissions limits. In 2005 the majority of cars and light trucks met Japanese Low Emissions Vehicle (J-LEV)

The construction of new furnaces in Asia for the manufacture of high-purity LCD glass generated substantial additional demand for platinum in 2005.



Increasing fitment of catalysed soot filters to light duty diesel vehicles contributed to strong growth in autocatalyst demand for platinum in Europe last year.

standards, with a growing number meeting the stricter J-ULEV rules.

Greater use of platinum in autocatalysts in Japan was also stimulated by the introduction of new national emissions regulations covering heavy duty diesel vehicles, which came into effect in October 2005. The legislation substantially reduced the permissible emissions of NOx, CO and PM from new trucks and buses, resulting in the fitment of oxidation catalysts and / or CSF to the majority of new models.

North America

Autocatalyst demand for platinum in North America rose by a modest 20,000 oz to 820,000 oz in 2005, despite the fact that light vehicle production in the region edged down to 15.7 million units.

Platinum use by the big three US-based auto companies slipped lower as several leading US light vehicle brands lost market share and recorded year-on-year declines in sales. Conversely, overseas manufacturers, notably some of the Japanese car companies, produced and sold greater numbers of vehicles within North America. The overall impact of these changes in the pattern of light vehicle production was a small rise in platinum demand. A slow but steady increase in retrofitting of after-treatment systems to heavy duty diesel vehicles contributed to the increase in North American platinum demand last year.

There was little change in total average loading levels in 2005 but switching from platinum to palladium will accelerate during 2006. The adverse effect of this on platinum demand, however, will be more than offset by the widespread introduction of diesel oxidation catalysts (DOC) and CSF on new heavy duty truck models to comply with new federal emissions regulations.

China

Demand for platinum from the autocatalyst sector in China climbed from 75,000 oz in 2004 to 110,000 oz in 2005, annual growth of 47 per cent. This was the result of a combination of higher vehicle production and ongoing tightening of vehicle emissions limits.

The rate of growth in Chinese vehicle production accelerated in 2005 compared with the previous year, when a deliberate tightening of the availability of consumer credit slowed growth in new car sales. Last year, production of light vehicles in China climbed by 14 per cent to more than 5 million units.

All new light vehicles produced in China have had to meet Euro II emissions standards since mid-2004, which necessitate the use of catalysts on gasoline cars and light trucks but not on diesels. Given that virtually all cars and a majority of light trucks in China are gasoline powered, more than three-quarters of new light vehicles sold are now catalysed.

Rest of the World

Autocatalyst demand for platinum in the Rest of the World region (excluding China) grew by just under 5 per cent to 335,000 oz in 2005. Demand increased on the back of much stronger light vehicle production in Asia and South America.

The South Korean auto industry in particular enjoyed a good year, with light vehicle output rising by 12 per cent to more than 3.8 million cars and light trucks. Vehicle production expanded in response to a rapid turn-around in the domestic market (sales of cars rising by 6 per cent after having fallen for the previous two years) and to meet strong demand from overseas markets in Europe and North America.

The impact on platinum demand, however, was dampened somewhat by an acceleration of switching from platinum-based catalysts to palladium after-treatment systems on both new and existing models.

Increased light vehicle production in India and much of South East Asia contributed to the overall rise in platinum demand last year, as did strong growth in sales in the major South American auto markets of Brazil and Argentina.

Autocatalyst Recovery

The total volume of platinum recovered from scrapped autocatalysts increased by 12 per cent in 2005, reaching 770,000 oz. Once again, substantial increases in recovery occurred in North America and Europe, but Japanese recovery fell as exports of used vehicles increased.

Platinum Demand: Autocatalyst Recovery
'000 oz

	2004	2005
Europe	(145)	(170)
Japan	(55)	(35)
North America	(435)	(505)
Rest of the World	(55)	(60)
Total	**(690)**	**(770)**

JM

Recovery of platinum from scrapped autocatalysts in North America surpassed half a million ounces for the first time in 2005, the total reaching 505,000 oz. Scrap yards and collectors continued to maximise the recovery of catalysts from vehicles, spurred by higher platinum prices. The increase in metal recovery, however, also reflected the changing mix of vehicles (and therefore catalyst systems) entering scrap yards.

In Europe, higher metal recovery from old catalysts reflected an increase in vehicle recycling rates, which in turn was driven by the introduction of new European legislation covering the disposal of end of life vehicles.

In Japan, however, recovery of platinum from autocatalysts fell. The adjustment to our 2005 number reflects in part a downwards revision in Japanese estimates of the number of end of life vehicles generated each year (a new vehicle disposal certification scheme introduced in 2005 allowed the collation of accurate data for the first time). In addition, the fall in platinum recovery last year was also a consequence of a growing export trade in second hand vehicles from Japan to markets in South East Asia, China and Russia.

JEWELLERY

In 2005 jewellery demand slipped below 2 million oz for the first time since 1996, dropping by 9 per cent year-on-year to 1.96 million oz. Purchases of metal by jewellery manufacturers fell in the three largest markets, China, Japan and North America, as the rising price of platinum encouraged destocking and recycling of old jewellery. Platinum jewellery also faced increased competition from alternative precious metal alloys. Jewellery demand for platinum in Europe was static.

Europe

Total European demand for platinum in jewellery was unchanged at 195,000 oz in 2005. Throughout the region sales of platinum bridal jewellery and luxury pieces continued to fare better than fashion products, which faced tough competition from white gold in lower price brackets.

The UK bridal market for platinum jewellery continued to develop positively at the retail level but concern about the rising price led some jewellers to stock fewer platinum pieces. This was reflected in hallmarking statistics, the number of platinum pieces hallmarked during the year falling by 11 per cent. However, the total weight of pieces marked actually increased marginally to almost 94,000 oz, reflecting a consumer preference for heavier rings.

Platinum Demand: Jewellery
'000 oz

	2004	2005
Europe	195	195
Japan	560	510
North America	290	275
Rest of the World		
China	1,010	875
Other	105	105
Total	**2,160**	**1,960**

JM

In Germany the rising price of the metal added to the pressure on sales of platinum jewellery from alternative white metals. Some manufacturers, however, reported improved sales of large luxury pieces in the domestic market, and German exports of bridal products to the UK increased. The net result was little change in purchases of metal by German manufacturers. The picture was similar in Italy, with manufacturers facing a difficult domestic market but managing to make modest gains in exports.

Platinum demand from the Swiss jewellery sector was also fairly stable in 2005. The number of platinum

watchcases manufactured slipped lower, following strong production the previous year, but this was compensated for by higher output of Swiss-made bridal jewellery and products for the upper end of the fashion market.

Japan

Jewellery manufacturers in Japan purchased 510,000 oz of platinum in 2005, a fall of 9 per cent compared with the previous year. The continuing rise in the platinum price had a number of adverse effects on manufacturers' purchases of metal. In particular, scrap collection increased, with greater volumes of metal being recycled from trade inventories and from consumers selling back old jewellery. Some smaller manufacturers and wholesalers, facing rising metal financing costs, reduced the proportion of platinum produced and stocked, whilst an increase in the number and type of retail outlets that purchase old jewellery for cash contributed to a rise in returns from the public.

In addition, the average weight per piece of platinum jewellery continued to decline as manufacturers sought to meet key price points by producing lighter designs. In the bridal sector, total sales of platinum rings edged downwards once again, reflecting the long-term decline in marriages, a trend of fewer couples purchasing engagement rings, and increasing competition from white gold for wedding rings.

In the fashion sector, platinum did well at the upper end of the market, although overseas brands rather than Japanese manufacturers were the main beneficiaries. At the lower end, the pressure on platinum sales from white gold remained high.

North America

Demand for platinum from the North American jewellery sector slipped by 5 per cent to 275,000 oz in 2005 – a smaller decline than we had forecast at the time of our Interim Review last November. In particular, luxury jewellery marketed under international brand-names continued to sell well, both domestically and abroad. Several of the leading manufacturers of products for the upper end of the market experienced a very good level of orders leading up to Christmas, regardless of the strength of the platinum price.

In contrast, however, the rise in the platinum price made it increasingly difficult for the metal to compete in lower-priced segments of the market, with sales of both fashion and bridal products suffering from increased competition from white gold. At the same time, the high price led to an increase in scrap returns and recycling of out-dated platinum jewellery throughout the trade, reducing demand for new metal.

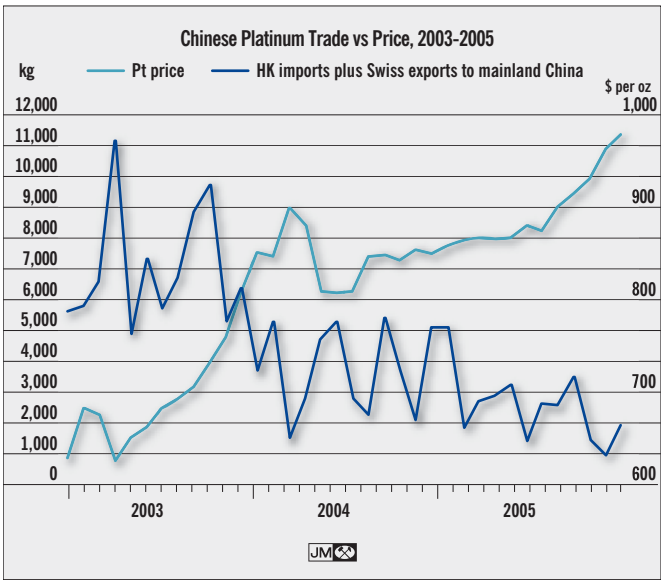
China

Purchases of platinum by jewellery manufacturers in China fell by 13 per cent to 875,000 oz in 2005, the lowest level of demand for new metal since 1998. In our Interim Review, published last November, we forecast Chinese demand for the year at 920,000 oz. However, the rate of fabrication and metal purchasing by Chinese manufacturers fell to very low levels during November and early December when the platinum price soared from $930 to over $1,000. Activity did pick up during the second half of December when the price fell back, but not by enough to offset the poor performance of the preceding few weeks.

The effects of the rising platinum price on the jewellery trade in China were similar in many respects to those seen in Japan and North America; specifically, a reduction of inventories and greater recycling throughout the business.

The increasing and unpredictable costs of financing metal resulted in manufacturers cutting back on production and stocks of platinum products, with the majority only producing new items to fill firm orders from retailers. To overcome the reluctance of manufacturers to take on metal price risk some leading retail chains purchased metal themselves from the Shanghai Gold Exchange and provided it to their suppliers on consignment.

Wholesalers reduced their holdings of platinum, being able to stock considerably more white gold or palladium jewellery for the same level of investment. Outside of Shanghai and Beijing the mix of jewellery stocked by retailers followed a similar pattern, with the proportion of counter space devoted to platinum declining. The volume of old platinum jewellery traded-in for new pieces by consumers also increased. These factors all contributed to a marked rise in the volume



The relationship between the platinum price and Chinese jewellery demand for the metal is apparent from trade data.

of metal returned to manufacturers for recycling into new platinum products.

At the same time, retailers tended to re-order platinum less frequently and in smaller quantities. Many recorded lower sales of platinum jewellery, which was partly a consequence of stocking fewer products, but 2005 was widely considered to be an inauspicious year to get married and sales of bridal jewellery suffered as a result. Despite all of the above, in the largest cities, where development of the platinum brand has been focussed, consumer demand remained relatively robust. In Beijing and Shanghai in particular, buyers of platinum jewellery were largely undeterred by higher prices, which for many reinforced the metal's exclusive image and attractiveness as an investment.

Trade statistics are not an accurate guide to the actual level of platinum demand in China, but the trend in Chinese imports clearly reflects the underlying fall in purchases of metal by the jewellery sector.

Rest of the World

Demand for platinum from jewellery manufacturers in the Rest of the World was unchanged at 105,000 oz in 2005. Some markets in Asia, notably Taiwan, India and South Korea, continued to show promise but gains within these countries were offset by lower exports to North America and Japan. The nascent South African platinum jewellery manufacturing sector consumed increasing volumes of metal but remained small.

CHEMICAL

Consumption of platinum by the chemicals sector grew by 3 per cent to 335,000 oz in 2005. Thrifting affected demand from the nitric acid industry but this was outweighed by increased purchases of platinum for process catalysts.

Platinum's single largest application in the chemicals sector is as a catalyst for the manufacture of silicones, which are widely used by the construction and automotive industries.

Strong economic growth in parts of Asia, particularly China, continued to support investment in new capacity for silicones production in 2005. However, the recent rise in the platinum price has encouraged a certain degree of thrifting, with manufacturers reducing the amount of platinum catalyst used in the process. Since the platinum from the catalyst ends up in the final product and (unlike most process catalysts) cannot subsequently be recovered, this represents a direct and substantial cost saving for the manufacturer. Overall, usage of platinum in silicones was up moderately in 2005.

The most significant other chemical catalyst application for platinum is in the production of paraxylene. Investment in the latter has been stimulated by rising demand from the purified terephthalic acid (PTA) sector, for which paraxylene is a precursor. PTA is in turn a feedstock for the production of the plastic polyethylene terephthalate. Purchases of platinum for new paraxylene plants softened slightly in 2005, reflecting a slightly lower rate of expansion in the sector than in 2004, but demand was still relatively strong by historical standards.

Platinum Demand: Chemical
'000 oz

	2004	2005
Europe	115	110
Japan	40	55
North America	90	100
Rest of the World	80	70
Total	**325**	**335**

JM

The declining trend in demand for platinum from the nitric acid industry continued in 2005. Thrifting is having a negative impact on consumption, especially in Europe; nitric acid manufacturers are now using fewer catalyst gauzes per burner and the metal content of individual gauzes is also decreasing. At the same time, the rate of expansion of the nitric acid industry in Asia slowed compared with the previous year, and there were fewer additions to existing capacity.

ELECTRICAL

Soaring demand for personal computers and consumer products containing hard disks was the driving force behind a 20 per cent increase in platinum demand from the electrical industry in 2005. Use of the metal in fuel cells also increased. Total worldwide consumption in electrical products reached 360,000 oz, up from 300,000 oz in 2004.

The hard disk industry enjoyed another year of rapid expansion in 2005, with worldwide disk output estimated to have risen by more than 30 per cent and platinum consumption increasing at a similar rate. Both private consumers and businesses appear to be replacing personal computers (PCs) more rapidly than in the past, due to lower prices and a shift in consumer preferences towards less durable notebook computers. This helped to drive PC sales upward by around 16 per cent last year. In addition, there has been strong growth in the use of hard drives in a range of consumer electronic devices, particularly personal video recorders and MP3 music players.

Platinum Demand: Electrical
'000 oz

	2004	2005
Europe	40	40
Japan	50	65
North America	90	95
Rest of the World	120	160
Total	**300**	**360**

JM

In recent years, the average number of disks required in each hard drive has fallen, as increases in data storage capacity have been offset by improvements in the quantity of data that can be stored on a given area of disk (the areal density). However, improvements in areal density have now slowed, while data storage requirements are still growing rapidly; as a result, the disk per drive ratio has begun to increase again, further boosting overall demand for hard disks.

Sales of platinum for use in fuel cells increased in 2005 but demand in terms of ounces was still not significant. Most of the metal was destined for the manufacture of proton exchange membrane (PEMFC) and direct methanol (DMFC) fuel cells, used in prototypes for automotive, electronic and stationary power applications.

Work on commercialising PEMFC and DMFC technology in portable electronic devices has accelerated recently, with the first products expected to be on sale within the next two years.

Demand for platinum wire for use in thermocouples remained strong in 2005, supported by increased production capacity and output in the glass and semiconductor industries. Both sectors are important users of high-temperature platinum-wire thermocouples.

GLASS

Sales of platinum to the glass industry rose by over 20 per cent in 2005, reaching a new record of 355,000 oz. Demand was driven by substantial investment in the production of glass for liquid crystal displays (LCDs) in Japan and other Asian countries, while the North American fibre glass industry recorded positive demand for the first time in three years.

Industry estimates suggest that production of LCD glass substrates rose by around 60 per cent in 2005. This reflects rapid expansion in consumer demand for flat screen computer monitors and LCD televisions. The latter accounted for an estimated 15 per cent of the total world market for televisions by the end of last year, up from 6 per cent at the end of 2004. With further strong growth expected, glass manufacturers continue to invest heavily in new facilities for the production of large-size glass substrates used in LCD screens.

In 2004 and 2005, capacity increases were concentrated in Japan and the Rest of the World region, with large new LCD glass plants being developed in Japan, South Korea and Taiwan. Since a single new LCD glass furnace requires several thousand ounces of platinum, recent investment activity in this sector has driven world-wide demand from the glass industry to all-time record levels.

Platinum Demand: Glass
'000 oz

	2004	2005
Europe	5	10
Japan	90	95
North America	(10)	5
Rest of the World	205	245
Total	**290**	**355**

JM

In North America, glass companies made substantial sales of pgm back to the market in 2003 and 2004, following the closure of the remaining US plants producing cathode ray tubes used in conventional television screens. There is no longer any production of traditional television glass in the USA. In 2005 demand was positive, with the North American fibre glass industry needing to procure small amounts of platinum for capacity additions and to replace metal lost in the manufacturing process.

There was also a modest increase in platinum consumption in China, reflecting strong demand for glass fibre from the booming construction industry.

PETROLEUM REFINING

The petroleum refining industry consumed 155,000 oz of platinum in 2005, an increase of 5,000 oz compared with the previous year. Demand was once again supported by investment in new reforming and isomerisation capacity in the Rest of the World region; elsewhere, only small additions to capacity are being made, and growth in platinum demand is being limited by thrifting.

Given the tightness in the global petroleum markets in 2005, the majority of refineries were run at very high operating rates throughout the year. In this environment, plant operators aim to minimise downtime and maximise output, delaying full catalyst change-outs for as long as possible. Conversely, however, higher operating rates tend to lead to greater losses during service and so increased volumes of top-up catalyst are required. The net result last year was a modest increase in demand for platinum.

Platinum Demand: Petroleum Refining
'000 oz

	2004	2005
Europe	15	15
Japan	5	5
North America	35	35
Rest of the World	95	100
Total	**150**	**155**

JM

Average loadings on platinum reforming catalysts are trending slowly downwards over the long term. In the Rest of the World region, however, thrifting has been more than offset by the construction of new reforming and isomerisation units. In 2005, metal was purchased in advance of planned increases in capacity which will occur this year and next in the Middle East and Asia.

OTHER

Demand for platinum in other applications was stable at 470,000 oz in 2005. Lower offtake from the dental sector was offset by greater consumption of the metal in biomedical devices and turbine blades for aircraft engines.

The use of platinum in its four principal other applications – dental alloys; automotive (spark plugs and oxygen sensors); biomedical components and drugs; and turbine blades – is discussed in detail in a special feature on pages 28 to 31. Most of platinum's remaining applications consume only small amounts of metal; the exception to this is pollution control for off-road vehicles (such as mining equipment) and stationary sources, which accounts for approximately 20,000 oz of platinum demand annually.

Platinum Demand: Other
'000 oz

	2004	2005
Europe	190	180
Japan	40	40
North America	205	210
Rest of the World	35	40
Total	**470**	**470**

JM

INVESTMENT

Net demand for large platinum bars was negative in 2005, in line with lower purchases by Japanese private investors and a price-driven increase in sales of old bars back to the market at the year end. In contrast, interest in platinum among US investors surged in late 2005, and this compensated for weak sales of bullion coins earlier in the year.

Sales of US Mint's Platinum Eagle bullion coins totalled 20,000 oz in 2005, almost unchanged compared with the previous year. In addition, the US Mint also produces proof-quality platinum Eagle coins for collectors. Demand for bullion coins was weak in the first 11 months of the year, with sales down 26 per cent on 2004. However, December was an exceptionally good month with 6,900 oz of coins being shipped, the upturn clearly linked to a resurgence of investor interest in precious metals as the gold price moved above $500.

Other platinum coins struck in 2005 included 30,000 one tenth ounce Panda coins issued by the People's Bank of China.

Demand for large platinum bars from Japanese private investors was negative in 2005, with a net 15,000 oz being returned to the market. Gross sales of large bars were down about 15 per cent as higher prices deterred investors, while returns of old bars to the market were up by a similar percentage. Most returns to the market occurred in June, as the yen-denominated platinum price moved decisively over ¥3,000, and December, when the price surged towards ¥4,000.

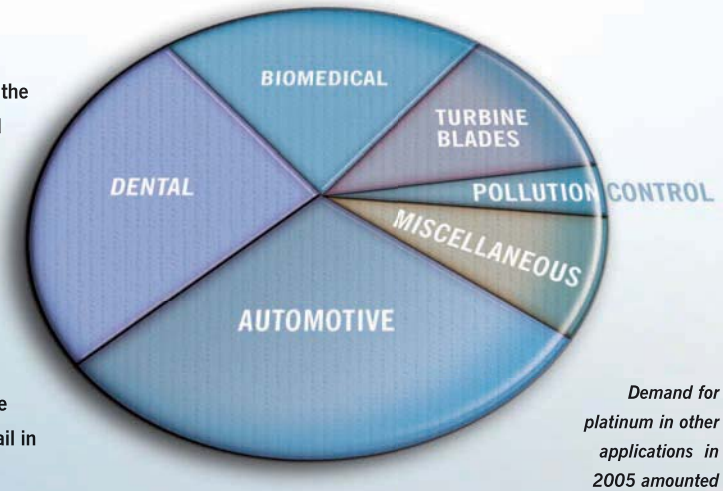
Platinum Demand: Investment
'000 oz

	2004	2005
Coins and small bars		
Europe	0	0
Japan	0	0
North America	25	25
Rest of the World	5	5
Large bars in Japan	**15**	**(15)**
Total	**45**	**15**

JM

Other Applications for Platinum

In addition to its well known applications in the autocatalyst, jewellery, chemical, electrical and glass sectors, platinum has a wide variety of other uses. These vary from automotive and medical applications for platinum consuming over 100,000 oz of metal annually, to many small end uses such as stationary source pollution control, catalytic heaters, gas safety sensors and cathodic protection which individually require just a few thousand ounces. The largest sectors of the market (tabulated below) are discussed in more detail in the following sections.



Demand for platinum in other applications in 2005 amounted to 470,000 oz

Main sectors of demand for other applications for platinum in 2005	
non-catalytic automotive	>130,000 oz
dental alloys	>120,000 oz
biomedical	>100,000 oz
turbine blades	> 50,000 oz

Combined demand for these four sectors in 2005 amounted to almost 90 per cent of the total demand of 470,000 oz

Dental Alloys

Platinum has a long and varied history of use in the dental industry, dating back to at least the early 19th century. In modern dentistry, however, platinum's use is confined to alloys used in bridges and crowns (prosthetic teeth). The latter can either be made entirely of precious metal alloy or from a porcelain crown bonded to an alloy core.

There are two principal types of precious metal alloy used in dental restorations: low gold and high gold alloys. The latter have been used in restorative dentistry for many decades, and are typically at least 75 per cent gold (as high as 99 per cent in some cases). Most contain platinum as an alloying element: the platinum content can vary from 1 per cent to as much as 20 per cent. These alloys may also contain small amounts of silver, palladium and base metals.

The use of platinum in high gold alloys is principally to improve the strength and stiffness of the alloy, enabling the crown or bridge to withstand the forces generated during biting and chewing. Its high melting point is advantageous as this helps to minimise the risk of deformation when firing porcelain bonded crowns, while its resistance to corrosion and tarnishing are also beneficial.

The low gold category encompasses a much wider range of alloy types. These generally contain gold, palladium and silver in varying quantities, but do not incorporate platinum. Palladium is usually a significant component, accounting for up to 80 per cent of the alloy by weight.

The choice of alloy is partly based on its technical characteristics such as melting point, strength and ductility, ability to retain fine details when cast, bonding performance with porcelain, and resistance to corrosion and tarnishing. However, the preferences of dentists and their patients also play an important role, resulting in great variations between patterns of alloy consumption in different parts of the world.

Finally, cost is an important factor; in recent years demand for dental alloys has been heavily influenced by fluctuations in the prices of gold, platinum and palladium.

Europe is currently the world's principal market for high gold alloys, accounting for around two-thirds of platinum demand in the global dental industry. Most of this demand occurs in Germany, where dental practitioners and consumers have tended to be rather less price-sensitive than in other European countries.

The North American dental

Platinum has a long history of use in dentistry but demand has diminished in recent years as use of lower cost alloys and ceramic alternatives has risen.

sector uses only modest amounts of platinum in high gold alloys; products with a high palladium content have a dominant share of this market.

In both regions, the trend of platinum demand is downwards. Full ceramic crown and bridge systems (which do not have a metal core) are now starting to encroach upon the market for high gold alloys. At the same time, the price differentials between gold, platinum and palladium are encouraging a shift towards low gold alloys, which do not normally contain platinum.

Outside Germany and North America, consumption of platinum-containing dental alloys is minimal. The Japanese market is dominated by the Kinpala alloy, which contains 20 per cent palladium but no platinum, while in China and the Rest of the World region, the relatively high cost of restorative dental treatment means that the use of precious metal dental alloys remains small.

Automotive

The automotive industry is the single largest consumer of platinum, accounting for nearly half of all demand in 2005. Although most of this metal was used in autocatalysts, two other automotive applications, spark plugs and oxygen sensors, together consumed more than 130,000 oz of platinum in 2005.

SPARK PLUGS

In a gasoline engine, power is generated by mixing air and fuel inside a combustion chamber (cylinder) and igniting this mixture with a spark generated by a spark plug. The plug also has an important secondary function - that of removing excess heat from the combustion chamber. A correctly functioning plug helps to ensure clean and efficient combustion, thereby playing a significant role in meeting emissions limits.

Traditionally, most spark plugs had base metal electrodes. However, these electrodes are gradually eroded by the repeated cycles of firing, which widens the gap between them. Ultimately, this can lead to misfires, which increase pollution and can damage the catalytic converter.

The use of platinum-tipped electrodes largely eliminates this problem because platinum resists chemical and electrical erosion much better than base metal alloys. As a result, a platinum-tipped plug generally has an effective life of 100,000 miles or more, compared with around 30,000 miles for a typical base metal plug. This in turn allows for longer intervals between servicing and reduces costs: on many modern engines, replacing plugs is a difficult and time-consuming job.

Platinum plugs are now fitted as original equipment on all new vehicles in North America, where strict on-board diagnostic (OBD) and catalyst durability requirements have caused manufacturers to abandon the use of base metal plugs.

In Europe and Japan the use of platinum plugs is increasing: we estimate that currently around 25 per cent of new gasoline cars in Europe and around half of Japanese vehicles are fitted with platinum plugs. Diesel vehicles, which currently account for more than half of the European market, utilise glow plugs, which do not use platinum. The aftermarket has tended to lag behind, such that only around a third of all replacement plugs are platinum-tipped, but here too sales are increasing.

Platinum-tipped spark plugs are increasingly fitted as original equipment as they last several times longer than their base metal predecessors.

OXYGEN SENSORS

Oxygen sensors are less familiar to motorists than spark plugs, but the role they play in ensuring optimal engine performance and reducing emissions is no less vital. An oxygen sensor is an indispensable part of a modern vehicle's closed-loop engine management system, which controls the air-fuel mixture that is fed to the combustion chambers.

In the majority of oxygen sensors the sensing element consists of a ceramic bulb coated on both sides with a thin layer of platinum, the outside of which is exposed to the exhaust gases. The voltage generated by the sensor is determined by the

amount of oxygen in the exhaust: a high voltage indicates that the air-fuel mixture is too rich (there is too much fuel and not enough air), a low one that the engine is running too lean. This voltage is monitored by the onboard engine management computer, which adjusts the proportion of air to fuel to ensure that the average is close to the optimal ratio of 14.7:1. The sensor ensures that the autocatalyst works efficiently and that emissions leaving the engine are minimised.

All catalyst-equipped cars have at least one sensor mounted in the exhaust system upstream of the catalytic converter; in countries where strict OBD legislation is in place (such as the USA), vehicles are also fitted with one or more sensors downstream of the autocatalyst in order to monitor emissions. A large vehicle may therefore have as many as four sensors. The average number of sensors per car has grown steadily in recent years as a result of tightening OBD legislation, and this has generated proportionate increases in platinum demand.

Biomedical Uses

Biomedical, the third largest of platinum's other application categories, encompasses uses varying from anti-cancer drugs to devices used in cutting-edge treatments for heart and brain disease. We estimate that a little over 100,000 oz of platinum was consumed by this sector in 2005.

ANTI-CANCER DRUGS

The first platinum-based anti-cancer drug, cisplatin, has been in use for nearly three decades and has revolutionised the treatment of certain diseases, particularly testicular cancer. The chemical compound itself had been known since the mid-nineteenth century but its ability to inhibit cell division (and thus its potential utility in the fight against cancer) was discovered by chance in 1965; the development and approval of the drug took over 10 years, and cisplatin was first approved in 1978. Despite the subsequent development of other platinum compounds with less severe side-effects, the drug is still in widespread use, especially in the treatment of testicular, ovarian, bladder and lung cancers.

More recently, two other platinum-based drugs have come onto the market. The first, carboplatin, was approved in the late 1980s and is currently the most widely used of all the platinum anti-cancer compounds. It indicated for the treatment of a similar range of cancers to cisplatin but is considerably less toxic. A second drug, oxaliplatin, was first approved in Europe in 1996 and in the USA in 2004 and is principally used to treat advanced colorectal cancer. In the last two years oxaliplatin has been rapidly adopted by oncologists and its use has now overtaken that of cisplatin.

Other platinum compounds with anti-cancer activity have been discovered, but most are still in the very early stages of development. However one potential new drug, satraplatin, is currently in Phase 3 trials (the final stage of clinical evaluation which, if successful, may lead to the approval of the drug). It is thought that an application for European approval could be made as early as 2007.

MEDICAL COMPONENTS

Platinum components are a critical element of many biomedical devices, particularly those which are implanted permanently into the body or used in minimally-invasive surgical procedures. The metal has many qualities which make it an ideal choice for medical applications: it is among the most biocompatible of all metals; it conducts electricity well; it is hard and resistant to corrosion, yet workable enough to permit the machining of tiny, complex components; and it is radiopaque (visible under x-ray).

The two largest uses for platinum components are in angioplasty, a treatment for blocked arteries, and

Micro-machined platinum components have numerous surgical applications, whilst platinum-based drugs are widely used in the treatment of cancers.

in devices such as pacemakers and implantable cardioverter defibrillators (ICD) that are used in the treatment of cardiac arrhythmias (irregularities in the beating of the heart). Platinum marker bands enable surgeons to track the position of guidewires and catheters within the body, whilst pacemakers and ICD are usually connected to the heart by platinum-tipped electrodes.

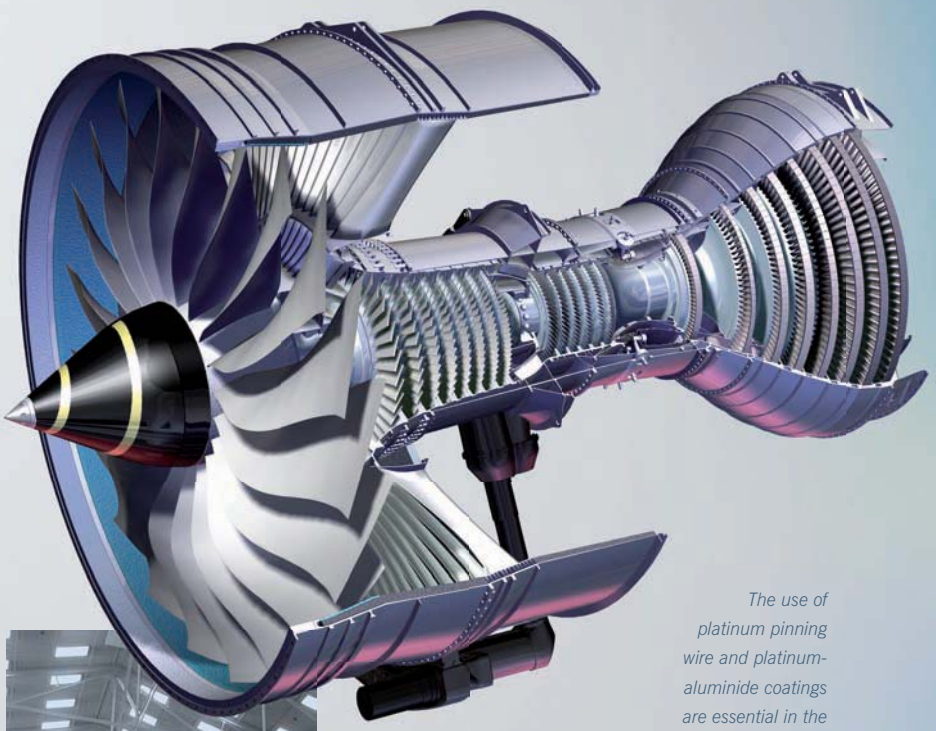
Recent medical trials have improved doctors' ability to identify people at risk of fatal arrhythmias. As a result, there has been rapid growth in the number of patients implanted with an ICD – up by around 20 per cent in 2005. This application has consequently been the largest single contributor to recent growth in biomedical demand for platinum.

Turbine Blades

In 2005, more than 50,000 oz of platinum were used in the manufacture of turbine blades, making this the fourth largest of the metal's other applications. Platinum is used both in the casting of blades and in coatings required to increase their longevity in the very harsh operating conditions of a modern gas turbine engine.

Turbine blades are manufactured via investment casting, which enables the production of very complex cast shapes with, in some cases, hollow cores. The process involves the creation of a disposable wax mould or form that is subsequently coated with a ceramic material. The wax is then removed by melting and the ceramic shell is fired. Molten metal (often a titanium-based superalloy) is then cast into the shell.

Blades destined for use in the hottest part of a turbine engine often have a hollow core, which functions as an internal cooling vent. This is formed by fixing a ceramic core inside the ceramic shell using platinum "pinning wire". The pinning wire holds the core in place while the blade is cast, before melting into the alloy and thus remaining permanently within the blade.



The use of platinum pinning wire and platinum-aluminide coatings are essential in the production of blades used in modern high-temperature turbines.

Platinum is universally used for pinning wire as its high strength and rigidity ensures that cores are held securely during casting, and it does not adversely affect the structure and integrity of the blade.

The efficiency of a gas turbine is related to its running temperature. In the quest for ever greater fuel efficiency, turbines are becoming hotter: the gases from the combustion chamber in a modern aero-engine may enter the high pressure section of the turbine at temperatures of over 1,500ºC. In order to extend the life of the blades used in the high pressure section of the engine, a platinum aluminide coating is usually applied. This provides protection from oxidation and allows the blade to operate continuously for as long as 20,000 hours before it requires repair or replacement. It is usually possible to strip and reapply the platinum coating once, after which the blade must be changed.

Demand for platinum in turbine blades is expected to rise steadily over the next few years as increasing demand for air travel stimulates sales of new aircraft. Not only will additional platinum be required for new engines, but the expansion of the world air fleet will also boost the recoating and replacement blade markets.