CHAPTER 1

INTRODUCTION

South Africa's reserve base of platinum-group metals (PGMs), with a metal content of 58 900t, is the largest in the world (van Graan and Fourie, 1992). It is 87,9 per cent of the world's total reserve base (TABLE 3.1).

Prior to 1990, it is estimated that local consumption of South Africa's PGMs amounted to less than 1 per cent of the total sales of unwrought metal (TABLE 3.2).

The PGMs are South Africa's second largest export earner in the minerals industry after gold. In 1993, the value of total PGM sales amounted to R5 18[illegible] million (98 per cent of this value is export sales) with gold exports at R23 239 million (Minerals Bureau, 1994). The PGMs are very important to the world in that they are used in many applications of modern day life.

The platinum-group elements are divided in the periodic table according to their relative densities into a heavier category, consisting of platinum, iridium and osmium, and a lighter group comprising palladium, rhodium and ruthenium. Their excellent catalytic qualities, resistance to corrosion and chemical inertness over a wide range of temperatures and high melting points, make them almost indispensable for a wide range of specialised applications. Replacement by other metals is not common, but one member of the group may be substituted for another when they are alloyed, which further enhances their properties.

One of the largest application for platinum is in autocatalysts which neutralise harmful emissions from motor vehicles. The local autocatalyst manufacturers are also the largest group of consumers beneficiating PGMs from primary production. There are two autocatalyst plants in South Africa, the first is situated in Germiston and the second in Port Elizabeth, neither of which consume significant amounts of primary PGM production. There is also a small chemical industry which produces PGM chemicals for commercial use for both the local and overseas markets.

LIST OF ABBREVIATIONS

Almaz	Almazjuvelirexport
ANC	African National Congress
CO	carbon monoxide
CSIR	Council of Scientific and Industrial Research
EU	European Union
Eskom	Electricity Supply Commission
FOB	free on board
GATT	General Agreement on Tariffs and Trade
GDP	gross domestic product
GNP	gross national product
HC	hydrocarbons
IMF	International Monetary Fund
IOU	intensity of use
Mintek	Council of Mineral Technology
MTBE	methyl tertiary butyl ether
NOx	oxides of nitrogen
PAFC	phosphoric acid fuel cell
PEM	proton exchange membrane
PGMs	platinum-group metals
R&D	research and development
RPM	Rustenburg Platinum Mines Limited
USA	United States of America

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ACKNOWLEDGMENTS

I am grateful for the comments, from a number of specialists in this field, which were used in the compilation of this report. I also appreciate the efforts of my brother Alan, Tony Harding and Janet Wilson for editing the manuscript.

I would like to express my sincere appreciation to the Minerals Bureau for facilitating the completion of this project report.

Thanks are also due to Dr Anton von Below for his supervision and guidance.

A special thanks to my wife Julie for her support.

ABSTRACT

South Africa is the largest primary producer of platinum-group metals (PGMs) in the world. It is estimated that only 2,1 per cent of the 153 711 kg of total sales for 1993 was beneficiated locally. Potential value added foreign exchange earnings and employment opportunities, therefore, are being forfeited.

This study identifies prospective areas of development in the major sectors of application of PGMs namely: autocataysts; chemical and allied industries; electrical and electronics sectors; jewellery and coinage fabricators.

The methodology of intensity of use (IOU) is first discussed. This is followed by an analysis of South Africa's production and sales of PGMs. The body of the report is an empirical study of the IOU of platinum and palladium to establish a world outlook for these metals in their applications. Finally, the more lucrative of these applications are discussed in the light of South Africa's participation and competitiveness in the world market.

The conclusions are firstly, that the established autocatalyst industry has the best prospect for growth and expansion. Secondly, the electrical application of platinum in fuel cells has potential depending on the level of government funding and support for a R&D programme. The third finding is that the electronics and jewellery industries have development potential on condition that resistance to market entry can be overcome by reduced public policy costs. Possible violation of GATT agreements may be avoided for these applications by world free trade co-operation.

DECLARATION

I declare that this project report is my own, unaided work. It is being submitted for the Degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

S.D. BARRY

10 day of June 1994

PROSPECTS OF A MANUFACTURING INDUSTRY FOR THE PLATINUM GROUP METALS IN SOUTH AFRICA

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A project report submitted to the faculty of Engineering, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Engineering.

Johannesburg, 1994

production of 720 000 units in 1993 utilising the same manufacturing process as Johnson Matthey will consume approximately 1 080 kg of platinum and 216 kg of rhodium, valued at approximately $20,88 million at 1993 average prices.

Of the total 1,22 million autocatalytic units which will be produced localy in 1993, Degussa will contribute 59 per cent of the South African sales. The country's total consumption of PGMs in this industry for 1993 will amount to approximately 1 830 kg of platinum and 366 kg of rhodium from local primary production. This is approximately 2 per cent and 5 per cent of South Africa's 1993 platinum and rhodium sales respectively or 1,4 per cent of the country's total PGM sales of 153 711 kg for the same year.

The entire production of catalytic converters in the RSA is exported. The reasons for this are:

(i) they cannot be used locally as the lead content of the petrol poisons the catalyst, rendering it useless,

(ii) and South Africa's environmental legislation does not require the use of autocatalysts.

Refineries, however, are set to market lead free petrol in 1995, and only then would the use of autocatalysts be justified in this country.

There is no actual cost benefit in producing autocatalysts in South Africa despite being close to the primary source of PGMs. Import costs of the ceramic monoliths from Europe and Japan outweighs the advantage of lower transport costs of PGMs to the autocatalyst plant. The PGMs are not even obtained at a discount to world market prices from the local primary producers.

The only incentive to manufacture these units locally is the Phase VI local content incentive for auto-manufactures, introduced in 1989, using value as a measure of local content. This replaced Phases I to V based on mass as a measure of local content. The higher value relative to mass of these units allows for more of a tax rebate.

the use of the ceramic monolith has become the dominant technology world wide. The monolith is a cylinder, normally of circular or elliptical cross-section. It is made from a porous ceramic called cordierite, extruded into a fine honeycomb with walls 0,15 mm thick and containing around 60 holes per cm^2. Both Johnson Matthey and Algorax import their monoliths from Belgium, Japan or Germany.

A washcoat (coating) of alumina is added to the substrate. Because of its high thermal stability, alumina withstands the harsh conditions present in the vehicle's exhaust system. A promoter, such as cerium, a rare earth element, is added to the washcoat creating an irregular surface. The washcoat increases the surface area of the monolith to approximately 30 000 m^2 after which it is fired in an oven. A coating of PGM solution is then applied, forming the active layer that converts the harmful exhaust gases. The substrate is then fired for a second time.

The production of platinum and rhodium solutions for coating the substrate is carried out in South Africa. Johnson Matthey obtains its PGMs from Rustenburg Platinum. The solution required for the autocatalyst is manufactured at its plant in Germiston. Degussa purchases its PGMs from Impala Platinum and produces the PGMs solution for its autocatalysts in Port Elizabeth.

The finished autocatalyst is sold either to exhaust manufacturers, or car manufacturers who contract exhaust manufacturers to produce the catalytic converter within Southern Africa. The autocatalyst is then mounted in a stainless steel canister, in which form it becomes more accurately described as a catalytic converter.

The Johnson Matthey plant, which opened on 26 March 1992, is expected to produce a total of 500 000 units in 1993. Each unit contains 1 to 2g of platinum and 0,2 to 0,4g of rhodium, an approximate precious metal content value of $29 per unit (total $14,50 million), using average 1993 prices. Total annual autocatalyst production will consume approximately 750kg of platinum and 150kg of rhodium from local primary PGM production, by the Johnson Matthey plant in South Africa.

Degussa South Africa (Pty) Ltd, a 100 per cent subsidiary of Degussa AG, markets autocatalysts on behalf of Algorax who established its plant in 1989. Algorax's expected

CHAPTER 4

AUTOCATALYST INDUSTRY

Motor vehicles are one of the world's largest sources of air pollution, emitting carbon monoxide (CO), hydrocarbons (HC) and oxides of nitrogen (NO_x) which cause smog, acid rain and contribute to the greenhouse effect in the earth's atmosphere. This chapter deals with the South African production of autocatalysts, which filter out these harmful emissions, and its future supply to the world market.

3.1 Local Production

There are two basic types of autocatalysts. The older design is the oxidation catalyst, which oxidises CO and HC to carbon dioxide and water. It is fitted to the exhaust stream and usually contains platinum or palladium, or more commonly, a mixture of both.

Conversion of NO_x by an oxidation catalyst, is limited, hence the introduction of a so-called three-way catalyst. The three-way catalyst converts all three major gaseous pollutants by stripping oxygen from the NO_x and using it to oxidise the CO and HC. Rhodium is the essential element which promotes the reduction of NO_x to harmless nitrogen. It is for this reason, therefore, that the majority of three-way catalysts contain platinum and rhodium. Palladium/rhodium autocatalysts are also produced, but are effective only for smaller engines, 1500 cm^3 capacity and less.

There are only two autocatalyst manufacturers in South Africa: Johnson Matthey (Pty) Ltd in Germiston and Algorax (Pty) Ltd in Port Elizabeth, which is 50 per cent owned by Degussa AG of Germany, and 50 per cent owned by the Industrial Development Corporation.

An autocatalyst consists of three parts, substrate, washcoat, and platinum-group elements coating. The substrate is a mechanical structure which supports the other materials. Early autocatalysts used alumina pellets for the substrate, but due to its higher geometric surface area

TABLE 3.2 - SOUTH AFRICA'S PLATINUM-GROUP METAL PRODUCTION, SALES AND EXPORTS. 1986 - 1993

YEAR	PRODUCTION	SALES		EXPORTS*
		Mass	Value (FOB)	
	kg	kg	R'000	kg
1986	120 542	120 433	2 964 108	120 100
1987	127 980	130 171	3 580 507	129 800
1988	131 722	130 854	3 813 431	130 500
1989	133 684	137 278	4 611 361	136 800
1990	141 913	135 581	5 164 216	134 200
1991	142 861	141 120	5 692 118	139 400
1992	152 891	137 063	4 677 841	134 700
1993	176 167	153 711	5 188 809	150 506

Source: Minerals Bureau of South Africa, 1994

Note: * Estimates excluding waste and scrap

Small quantities of platinum and palladium are recovered by Palabora Mining Company Ltd as by-products of copper mining. Minor amounts of osmiridium, a naturally occurring mineral of osmium and iridium, are produced mostly from the Kimberely reef in the Evander Goldfield of the Witwatersrand Basin.

Milling of ore and flotation are carried out on mine premises to obtain a concentrate. Smelting of the concentrate is carried out on most mines accept for Potgietersrust, Amandelbult and Lebowa Platinum. The final separation from the smelted matte of the constituent metals of the platinum-group, namely: platinum, palladium, rhodium, ruthenium, iridium and osmium, is undertaken at refineries in Springs, Brakpan and Rustenburg. Northam Platinum, however, has its precious metals matte toll refined by Heraeus in Germany. Impala Platinum also had part of its precious metals matte toll refined in Russia in the past.

The largest portion of South African PGM production is marketed on the basis of long-term principal-to-principal contracts. The principals are usually automobile companies. It is known that RPM supplies Toyota and Honda in Japan, Impala Platinum supplies General Motors in the USA and Western Platinum supplies Mitsubishi in Japan (Robinson, 1993: 19). Marketing agents such as Johnson Matthey (RPM), Ayrton Metals (Impala Platinum), Gerald Metals (Northam), Mitsubishi (Northam) and Western Metals Sales (Western Platinum) also play an important role in securing sales for their customers (Barry and Odendaal, 1993: 8 - 16).

Prior to 1990 nearly all PGM sales were directed to the export market (TABLE 3.2). Only from 1990 did local industries begin to consume more than 1,0 per cent of South African sales. Since 1990, local sales began to increase with the start of the autocatalyst industry.

As there are no offical figures of local consumption from total sales of PGMs, export figures in TABLE 3.2 have had to be estimated.

The largest producing group is Rustenburg Platinum Holdings Ltd, which has the controlling interest in Rustenburg Platinum Mines Ltd (RPM). RPM operates three mines in the western belt of the Bushveld Complex viz.: Amandelbult, Rustenburg and Union sections. Rustenburg Platinum Holdings Ltd is also the major share holder in Lebowa Platinum Mines Ltd and Potgietersrust Platinums Ltd. The latter commenced production in mid 1993.

Impala Platinum Ltd, the second largest producer in the Bushveld Complex, operates 3 mines viz.: Bafokeng North, and Wildebeestfontein North and South. These mines are all situated in the former Republic of Bophuthatswana, on the western belt of the Bushveld Complex. Impala Platinum Holdings Ltd also holds the controlling shares in Barplats Investments Ltd and Messina Ltd. The mines belonging to these companies, Crocodile River, Kennedy's Vale and Messina Platinum Mines Ltd, have been "mothballed" as they are uneconomical at present metal prices.

The other important primary producer is Lonrho with its Western Platinum, Karee and Eastern Platinum mines located east of the town of Rustenburg. Impala Platinum has a 27 per cent stake in each of these mines.

Eastern Platinum Ltd is situated within the border of the former Republic of Bophuthatswana. At RPM, underground operations take place on both sides of this former international boundary, and production and sales revenue were thus shared by both countries.

Northam Platinum Ltd, Gold Fields of South Africa's only platinum mine, delivered its first production in January 1993. It was expected to reach full production by late-1993, but this has been delayed due to mining difficulties experienced as a result of it being the deepest platinum mine in the Bushveld Complex and the introduction of new hydro-power technology.

Mining of the Merensky reef starts at 2 700 metres below surface with a temperature gradient twice that of Witwatersrand gold mines at Northam Platinum Ltd. Large quantities of chilled water are therefore required with a more efficient ventilation system than in Witwatersrand gold mines. Teething problems with the new hydro-power technology used for drills, winches and other equipment have also been experienced. However, full production should be reached during 1994 if metal prices improve and teething problems are sorted out.

CHAPTER 3

PRIMARY PLATINUM-GROUP METALS PRODUCTION AND SALES

South Africa's platinum mines and the Stillwater Mine in the USA are the only major primary producers of PGMs in the world. Most other large producers recover the metals as a by-product of nickel mining in igneous layered suites. The largest of these occur at Noril'sk in northern Siberia, Russia and at Sudbury in Ontario, Canada.

South Africa and Russia dominate the world production of PGMs (TABLE 3.1). With the present declining sales of PGMs from Russia and if this country's economic situation does not begin to improve, South Africa could become the only dominant producer of these metals in the world.

South African output is derived mainly from the Merensky Reef, with the remainder being mined from the underlying UG2 chromitite seam and Platreef in the Potgietersrust area. These reefs accounted for 54 per cent of the total world PGM production in 1992 (TABLE 3.1).

TABLE 3.1 - WORLD PLATINUM-GROUP METAL RESERVES AND PRODUCTION, 1992

COUNTRY	RESERVE BASE			PRODUCTION		
	t*	%	Rank	kg*	%	Rank
South Africa^x	58 900#	87,9	1	152 891	54,4	1
Russia	6 000	9,0	2	105 000	37,4	2
Canada	280	0,4	4	10 505	3,7	3
USA	780	1,2	3	7 780	2,8	4
Australia	na	-	-	700	0,2	5
Other	1 031	1,5	-	4 124	1.5	-
TOTAL	66 991	100		281 000	100	

Sources: British Geological Survey, 1994
United States Bureau of Mines, 1994
Minerals Bureau of South Africa, 1994

Notes:
Includes PGMs and gold
* Metal content
x Republics of South Africa and Bophuthatswana
na not available

It is the concept of life cycle phases and transmaterialisation that this study uses to establish an outlook for the PGMs in the major sectors of consumption. Life cycle phases are identified in these sectors from the IOU curves of platinum and palladium. Potential growth areas can then be found and discussed in the South African context as to what can be done to promote manufacturing of PGM consuming products.

FIG. 2.1 - THEORETICAL LIFE CYCLE PATTERN: FIVE-PHASE MODEL

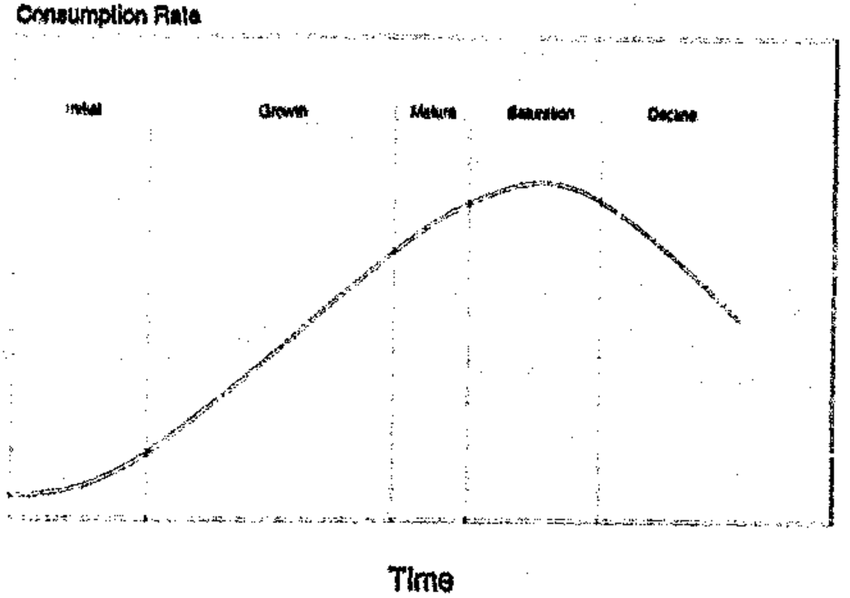
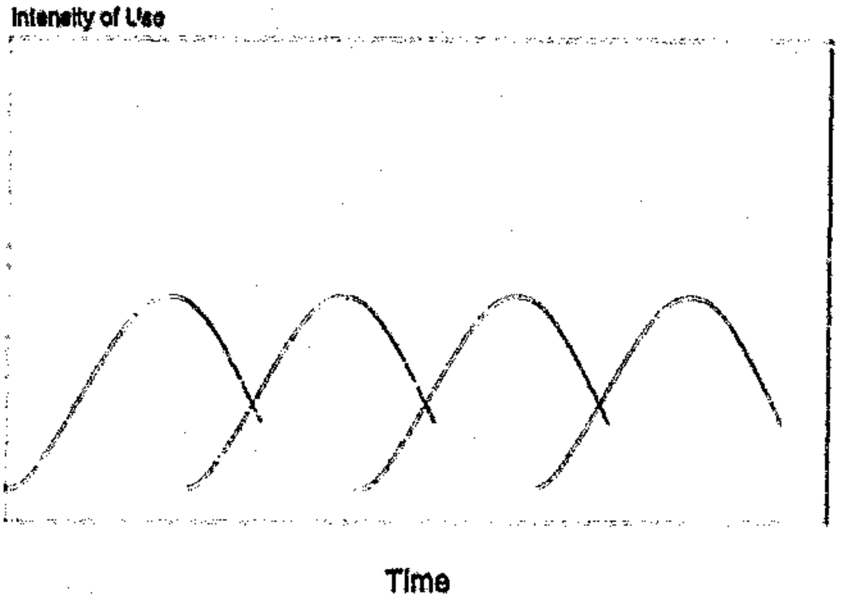


FIG. 2.2 - THEORETICAL TRANSMATERIALISATION PATTERN



CHAPTER 2

THEORY OF INTENSITY OF USE

The basis of this study uses the IOU of metals to establish areas of growth in the PGM manufacturing industry of South Africa. It is, therefore, pertinent to discuss the theory and background of IOU before using this methodology to analyse demand of PGMs.

Malenbaum (1975) was the first to introduce the concept of IOU for materials. He suggested that a minerals IOU (consumption of a mineral per GNP of a nation) is related to per capita GNP of a nation showing an inverted "U" shaped curve.

Subsequent studies, by Malenbaum and other academics in this field, stressed the issue of dematerialisation where minerals experience a once off change never gone through before (Waddell and Labys, 1988). All these studies support an inverted "U" shaped IOU curve as a function of GDP per capita. However, the perspective remains one of declining material trends rather than cyclical waves of innovations with technological change and discoveries of new materials such as ceramics and plastics. An assumption was made that declining IOU was because of a shift in demand from manufacturing to the less materials intensive service sector in the industrialised countries.

As opposed to dematerialisation, transmaterialisation suggests that demand for minerals experiences phases in which older, lower quality materials linked to mature industries undergo replacement periodically by higher quality or technologically more appropriate materials. Throughout time a series of natural replacement cycles in industrial development occurs (Waddell and Labys, 1988).

Humphreys (1982) identified 5 phases of growth and development in one cycle listed as follows; Introductory, growth, mature, saturation, and declining phases, representing a product life cycle (FIG. 2.1). Waddell and Labys (1988) proposed regular product life cycles for a number of minerals over extended periods of time (FIG. 2.2). The timing and phases of these cycles vary with the nature of the products or minerals selected bring about transmaterialisation.

manufacturing industry, and research and development of new products for the domestic PGM industry.

Problems arose in the study due to the lack of historical data. Demand statistics for platinum and palladium by various applications were obtained dating back to when statistics were first published in 1975 and 1980 respectively by Johnson Matthey. Other PGMs demand statistics are not available as far back as 1980. Consumption statistics of PGMs by the South African industries are strictly controlled so as not to divulge information to competing firms. The study is, therefore, restricted only to platinum and palladium.

This report is divided into 9 sections. The theory and background of IOU is discussed in Chapter 2. Chapter 3 discusses primary production of PGMs and sales strategies by the South African producers. Chapters 4 through to 7 investigate the four major sectors of application for platinum and palladium. In these chapters, local manufacturing in applications for PGMs are discussed followed by world demand in 1992 and IOU from 1975 in order to establish outlooks for these metals in specific sectors. Future prospects for each application are then addressed pertaining to South Africa. Chapter 8 discusses the findings of the study in detail with emphasis on the IOU of the metals followed by the competitiveness of the more prospective applications. A short political comment is also added at the end of this chapter. The final chapter concludes the findings of the report in the light of the best prospects for development of local beneficiation sectors for the country's primary PGM production.

Statistics of demand for the PGMs, by sector, were obtained from Johnson Matthey. The IMF and the Commodity Research Unit provided statistics of GDP and world motor-car production. Background information on the extensive topic of applications for PGMs was extracted from Johnson Matthey, Mintek and Platinum Guild International publications. Personal communications with members of the industry both locally and in the United Kingdom were also conducted.

Mintek has also attempted to promote platinum jewellery manufacturing in the country by developing platinum alloys and organising seminars and workshops for the local jewellery industry with technical advisers from Platinum Guild International. The Government abolished the *ad valorem* excise duty on jewellery in 1990 to boost jewellery fabrication.

The local PGM manufacturing industry has consumed very little of total primary production and has only begun to increase since 1990 with the manufacture of autocatalysts in South Africa (TABLE 3.1).

The purpose of this study, therefore, is to identify the most obvious areas where value may be added to primary PGM production in South Africa for both local and export markets. This is accomplished by investigating the four major areas of application (autocatalysts, chemical and allied industries, electrical and electronics, and jewellery and coinage). A study of the intensity of use (consumption in kg per USA dollar GDP of the developed countries) of the metals in these applications over the last 17 years was used to identify areas of potential growth.

The time series of the intensity of use (IOU) for these metals, as investigated by Waddell and Labys (1988) in a number of different materials, are used to determine a future outlook for each application. In the calculation of these IOU curves, the GDP of the developed countries, as defined by the IMF in constant 1985 prices, is used to establish real growth or decline.

There have been limited attempts to promote a local manufacturing industry in the PGM sector. No studies, to the author's knowledge, have ever been attempted to identify the problems that have prevented growth in this specific sector. This project is, therefore, justified in attempting to determine potential growth areas in South Africa's PGM beneficiation industry. The country's economy is presently struggling to come out of a recession and political change has brought about demand for affirmative action. Both employment opportunities and additional foreign exchange earnings could be achieved by the development of an industry that beneficiates this country's scarce, though unique endowment of these metals.

From the IOU curves, potential growth in applications for PGMs are identified and discussed to establish whether the future "New South Africa" government, should play a role in promoting a

These concerns consume very little of South Africa's primary PGM production and some 50 per cent of their production is estimated to be exported as the local market for their products is small.

Locally, the chemical and allied applications industry is known to be the second largest consumer of PGMs after the autocatalyst manufacturers. To obtain an idea of the size of demand for PGMs by this local beneficiating industry, a number of assumptions have to be made. It is estimated, however, that local consumption of total sales of primary production remained static below 1 per cent prior to autocatalyst manufacturing in 1989 (TABLE 3.2). The chemical and allied industry is estimated to have consumed 1 000 kg of PGMs in 1993. Minerals Bureau (1994) figures indicate that total South African sales of PGMs reached 153 711 kg in 1993 showing that this local industry only consumed approximately 0,7 per cent of this total.

Some of the major applications for these beneficiated products are discussed below.

5.2.1 Chemical applications

Petroleum refining

Platinum is primarily used as a catalyst in the reforming and isomerization production of high-octane, unleaded petrol and aromatic chemicals. Palladium and rhodium are used in the catalysis of fat and polymer hydrogenation reactions, rhodium being prominent in hydroformulation reactions. Ruthenium and its complexes are used in the reforming of natural gas, the production of diesel fuel and the synthesis of ammonia. Osmium is used in the conversion of olefins and the synthesis of ammonia.

Legislation on vehicle exhaust emissions, which became compulsory in the European Union from the beginning of 1993 and is under discussion in Southeast Asia, will increase the demand for unleaded petrol. Belgium constructed a large reformer in 1990 and further increased demand is expected in Europe and Southeast Asia as refiners ensure adequate supplies of unleaded fuel for catalyst-equiped cars.

CHAPTER 5

CHEMICAL AND ALLIED APPLICATIONS

5.1 Introduction

Platinum-group metals are used in a vast number of applications in chemical and related industries due mainly to their catalytic properties and extremely high resistance to chemical attack. These applications are divided into two broad categories.

(i) Chemical, which includes petroleum refining, nitric acid production and medical uses. Platinum-group metals are used in these categories because of their catalytic and therapeutic chemical properties.

(ii) Allied, which covers analytic laboratory apparatus, glass production, pigments and electroplating. Their application for these purposes is due to the physical properties of the PGMs such as their extreme high resistance to chemical attack and very high melting points.

In this chapter, discussion is confined to petroleum, chemical, glass and dental applications, as comprehensive statistics are available only for these industries.

5.2 Local Production and Major Applications

There are two companies, situated in South Africa, suppling beneficiated PGM products to end user industries. They are as follows: Johnson Matthey South Africa (Pty) Ltd and PGM Chemicals (Pty) Ltd. Johnson Matthey South Africa obtains their primary PGMs from Rustenburg Platinum mines while PGM Chemicals source their primary metals from Impala Platinum mines.

(ii) Production can be increased reducing unit costs from established capital investments. (Economies of scale).

(iii) Producers in this country already have an established source of PGMs close to their place of manufacture. (Security of supply).

(v) Fixed costs are already covered by their present market share. (Competitive).

The estimated 2 196 kg of PGMs consumed by the South African manufactures amounts to only 2,5 per cent of the total Western World consumption of 87 401 kg (Coombes, 1994). Figures from the Minerals Bureau (1994) show that total South African PGM sales amount to 153 711 kg. The autocatalyst industry alone, therefore, consumed only 1,4 per cent of the countries total sales.

South Africa, therefore, holds only a small market share by world standards. However, expansion in the export market for local autocatalyst manufacturers could result from two main factors.

(i) Export drive by local motor manufacturers to countries where autocatalysts are required.

(ii) A spread of environmental legislation, to other countries in the world, requiring autocatalysts for motor vehicles.

Alternatively, South Africa needs to attract other autocatalyst manufacturers in the world to set-up plants in this country, in order to expand this PGM beneficiating industry. This is only possible if the cost of production is much lower than elsewhere and a favourable tax policy improves competitiveness. This point is discussed further in Chapter 8.1.

industry in the long term as import tariffs on motor cars are lowered from their present 115 per cent to 45 per cent by 2003.

Present investigations into the Phase VI incentive scheme are under way, initiated by the Minister of Trade and Industry, Mr Derek Keys. This incentive scheme will not be scrapped until 1997 (Smith, 1994: *Pers Comm*). Suggestions have been made, however, to cap the value of platinum and rhodium at \$360/ozt and \$1000/ozt respectively for the rebateable excise duty on the export earnings from autocatalysts. This will possibly reduce tax rebates, increasing costs (tax), and could effectively raise the price of motor-cars in South Africa.

Economies of scale are also important for the future of the industry. Specifications of an autocatalyst are different for each model of car. Small production runs of autocatalysts for one local model of car will have a high unit cost. A large production run of autocatalysts for an overseas motor manufactures with a bigger market for a different model of car, will have a lower unit cost. Therefore, the small South African motor industry, by world standards, will be less profitable than the export market for the local autocatalyst manufacturers.

From an export point of view, South Africa has a promising future in suppling autocatalysts to Southeast Asia and Latin America where legislation already requires their use in some of the countries in these regions. South Korea, Mexico and Brazil are some of the biggest producers of motor vehicles at more than a million units produced in each country during 1992 (Automotive News, 1993). These are growing markets which already produce nearly 4 million vehicles in total at present. The demand for autocatalysts in these regions should be targeted by South African supplies.

A number of factors give local producers an advantage.

(i) Autocatalytic manufacturing is not a labour intensive process and, therefore, will not gain from a cheap labour force available in third world countries. This makes it unlikely that developing countries will have a competitive advantage. (Capital intensive).

Palladium consumption in autocatalysts is presently entering a growth phase. It will be used more in conjunction with the 3 way platinum/rhodium autocatalyst as emission regulations become more stringent and efforts are made to reduce vehicle emissions even further.

4.3 Future for South African Production

The in[illegible] g[illegible] use of autocatalysts has been introduced in South Africa through the availab[illegible] unleaded petrol by 1995. Legislation, not yet implemented, restricting motor vehicle emissions would be the next step taken by government, following world trends.

Future priorities for government in South Africa will be more orientated towards providing for the social needs of the underprivileged as the country enters a new era in its politics. Keeping pace with world environmental protection trends will possibly fall into a new social policy since at present the low income suburbs have high levels of air pollution. Vehicle emission legislation, therefore, could well become a reality in South Africa before the turn of the century, helping to improve living conditions amongst the poorer communities of the country.

When this legislation does come about, present local production capacity of 2,1 million autocatalytic units will be adequate to supply both the domestic and export markets. Facilities, at the two producers in the country, can supply an estimated local production of over 200 000 new passenger car by 1995 and export the surplus of 1,9 million autocatalytic units at full production levels. Further increases in output could be attained if production shifts were doubled thus obviating the necessity for any capital expenditure by the autocatalyst manufacturers.

The South African autocatalyst industry is presently geared for the export market as a result of the Phase VI local content incentive scheme for the motor manufacturers. This could be affected, however, by trade agreements with the world trade body, General Agreement on Tariffs and Trade (GATT). GATT has recently applied pressure on South Africa to reduce tariffs and incentive schemes to promote trade amongst countries in the world. Smith (*Pers Comm*) of Johnson Matthey, South Africa, noted that this will effect the motor manufacturing

The consumption of platinum from autocatalysts in the Western World will increase from 40,6 t in 1992 to 60 t by the year 2000. Palladium demand from this industry will overtake platinum, increasing from 12,6 t in 1992 to 75 t in the year 2000.

The IOU of platinum and palladium will then enter a mature phase as their growth rates slow, ending in 2010. The only growth will come from the developing world, while new technology in the industrial world enters the transport industry. Emission control legislation in the industrial countries becomes too severe for the internal combustion engine to meet.

The IOU of these metals enters a saturated life cycle phase after 2010 and a decline begins as soon as new transport technology, without the use of autocatalysts, becomes prevalant.

This time series will occur assuming cheaper, more effective substitutes for platinum are not found for autocatalysts.

Motor companies have often suggested the use of palladium as a substitute for platinum. It is more likely that palladium will be increasingly use along with platinum in autocatalysts. The following factors rule out total substitution of platinum by palladium.

(i) Platinum is far more resistant to poisoning by petrol contaminates, such as lead, than palladium.

(ii) Cost savings, if any, achieved by using palladium rather than platinum will be outweighed by larger amounts of palladium required in the autocatalyst to compensate for the loss of platinum.

(iii) Should palladium demand rise significantly, South African producers could demand a higher price for palladium when supply becomes restricted (palladium is a by-product of platinum mining).

(iv) Although Russia is the world's largest supplier of palladium, it is expected that production will decline in the short to medium term due primarily to declining nickel output (the palladium is a by-product of nickel mining in Russia).

FIG. 4.5 - INTENSITY OF USE FOR PLATINUM AND PALLADIUM: AUTOCATALYSTS

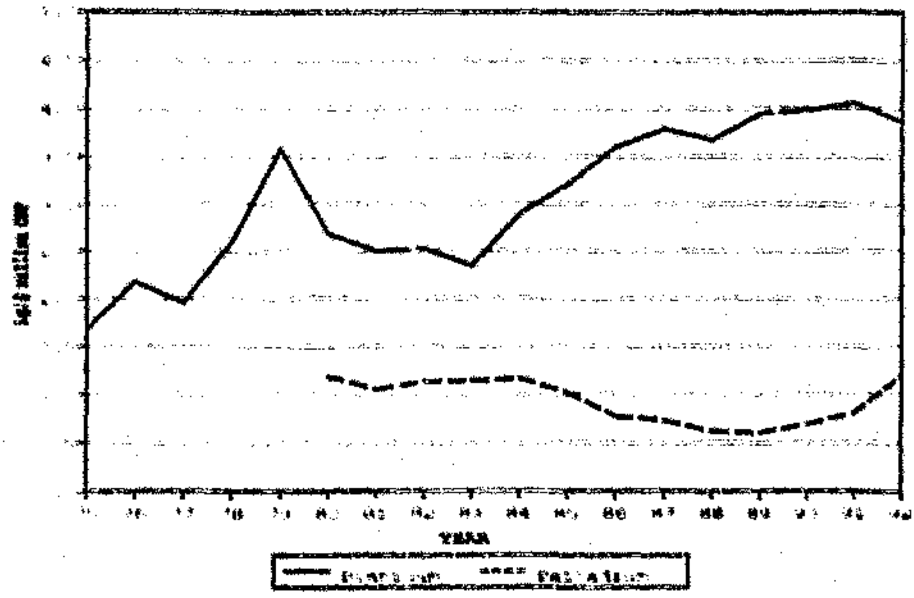
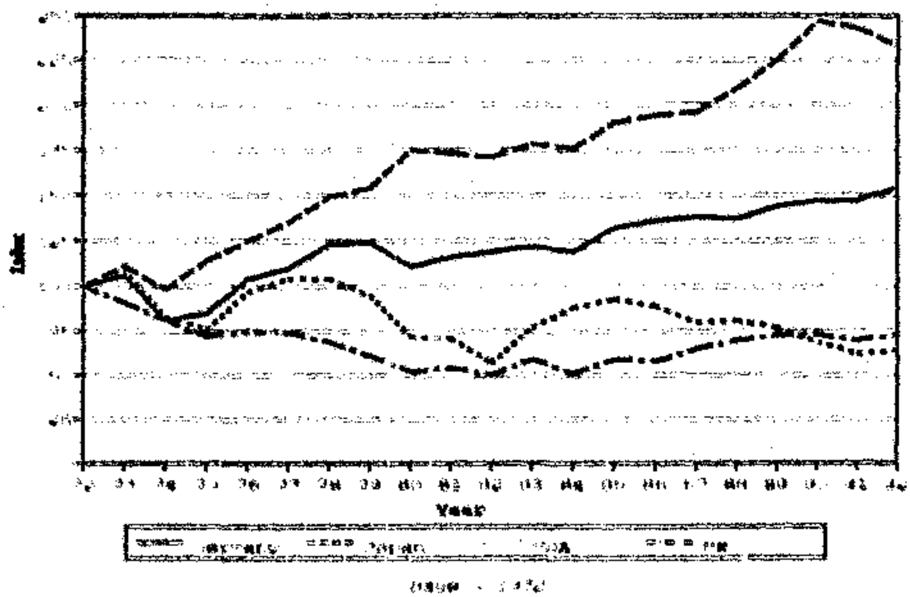


FIG. 4.6 - PASSENGER CAR PRODUCTION INDICES, 1972 - 1992



Source: Commodity Research Unit data files, 1993.

In order to establish a long term outlook for the consumption of platinum and palladium in the autocatalyst industry, a time series for the IOU of these metals is investigated (FIG. 4.5).

The following must also be noted.

(i) Approximately 80 per cent of the world's annual car production and sales are in the developed countries, as defined by the IMF (TABLE A1), and so the GDP in US dollars of these countries is used to calculate the IOU of platinum in the autocatalyst sector.

(ii) Nearly all the cars fitted with autocatalysts are sold in the developed countries where present legislation requires their use.

Platinum has shown an annual average growth of 5,1 per cent since 1975 in its IOU curve (FIG. 4.5). Palladium on the other hand has shown a decline of 7,2 per cent per annum from 1980 to 1989 after which an annual average growth rate of 25,3 per c nt is calaulated from 1989 to 1992.

This renewed growth in palladium began in 1989 when the platinum price tra d above \$500/ozt, up from the previous years from 1981 to 1986 when the price was below \$500/ozt. Palladium has increasingly been used with platinum since 1989. The first announcement of intentions to substitute platinum with palladium came from the Ford Motor Company in the USA in 1988.

Of the 4 largest passenger car manufacturing countries in the world, only Japan and Germany have shown growth in production since 1974 at 4,9 and 3,6 per cent respectively (FIG. 4.6). However, the production of passenger cars in Japan fell in 1991 and 1992 at 2,9 per cent each year on average.

Platinum consumption is presently in the growth phase of Humphreys (1982) proposed 5-phase model for the autocatalyst industry. It is estimated to have commenced in 1975 and is expected to end in the year 2000 as "Zero Emissi n Vehicles" appear on the market starting in California, USA. Platinum consumption in the autocatalyst industry will grow at an annual average rate of 5 per cent until the year 2000.

FIG. 4.1 - WESTERN WORLD PLATINUM DEMAND, 1992: AUTOCATALYSTS

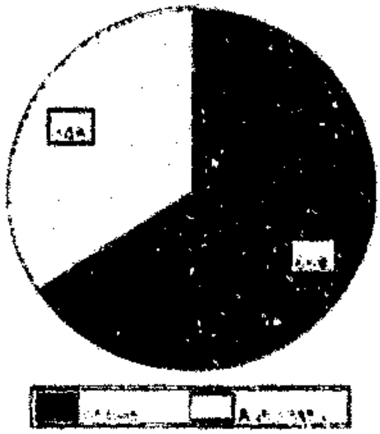


FIG. 4.2 - PLATINUM DEMAND BY : REGION, 1992: AUTOCATALYSTS

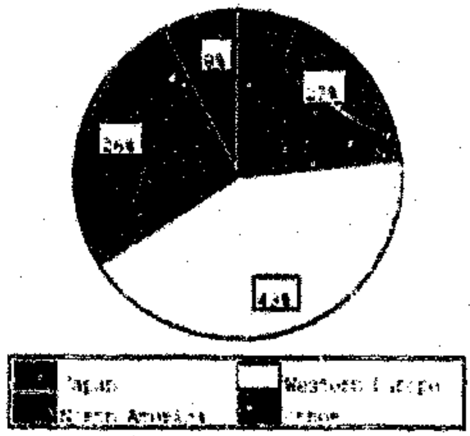


FIG. 4.3 - WESTERN WORLD PALLADIUM DEMAND, 1992: AUTOCATALYSTS

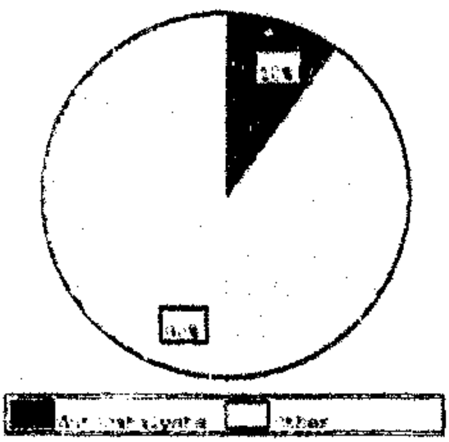
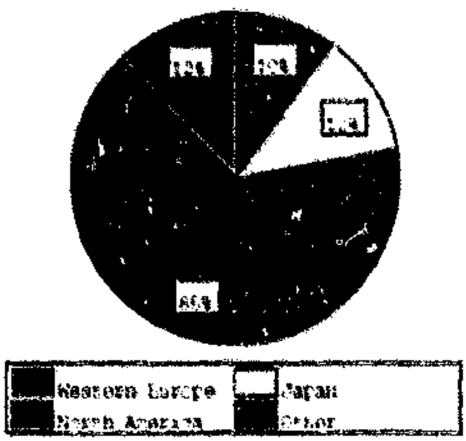


FIG. 4.4 - PALLADIUM DEMAND BY REGION, 1992: AUTOCATALYSTS



California has the world's most stringent vehicle emission controls where a time table of increasing controls has been established. By the year 1998, two per cent of motor vehicle sales in California are to be "Zero Emission Vehicles", building up to 10 per cent by the year 2003 (Coombes, 1992: 40).

The "Zero Emission Vehicles" could take the form of electric cars, possibly powered by fuel cells. If this be the case, then a fall in platinum consumption is not expected in this transfer of transportation mode, as fuel cells also use platinum as a catalysts in the generation of electricity. This is discussed further, however, in Chapter 6.2.1.

Tighter emission controls are expected to be enforced in the EU countries by 1996 and will probably be equivalent to the USA 1990 Clean Air Act standards (Coombes, 1992: 41).

The present economic recession in the world's developed economies has not had a significant effect on the rise in demand for autocatalysts, since at this stage, the demand is induced primarily by government legislation. As legislation becomes more stringent and spreads to more countries, so demand for platinum, rhodium and palladium to manufacture an increasing number of autocatalysts with larger loadings of the metals will increase. However, when an acceptable standard of anti-pollution regulations is reached, the demand for these PGMs will depend on world car sales and concomitant global economic cycles.

A total of 34 per cent of Western World demand for platinum in 1992 was generated by the autocatalyst industry (FIG. 4.1). Of this, the largest consumer was Western Europe at 43 per cent followed by North America, 26 per cent and Japan, 23 per cent (FIG. 4.2).

Palladium is used to a much lesser extent than platinum, only 10 per cent (12,6t) of total Western World demand in 1992 (FIG. 4.3). North America consumed the largest proportion of this demand at 65 per cent (FIG. 4.4).

3.2 World Demand

Mandatory stringent auto-pollution controls are spreading throughout the world. All new cars produced in the European Union (EU) as from 1 January 1993 had to be fitted with autocatalysts. Outside the 12-nation EU, Austria and Switzerland introduced anti-pollution standards in 1987. Norway and Sweden followed suit in 1989. Other nations, including Japan, Canada, Australia, Brazil, Hong Kong, Singapore, South Korea, Taiwan, Chile and Mexico have also passed a. -pollution regulations which require the fitting of autocatalysts.

The leader in anti-pollution legislation is the USA where it was initiated by the 1970 Clean Air Act. By 1975, the limits imposed on emissions of CO and HC became too severe for mechanical techniques alone and oxidation catalysts were fitted to over 80 per cent of all new cars. This set the stage for the use of PGMs to control air pollution from motor vehicles. Increasing amounts of platinum, rhodium and palladium will be utilized by the automoblie industry to meet the goals of a cleaner world.

The world autocatalyst industry is presently expanding to meet future government environmental legislation. Heraeus, a precious metals refining company in Germany, signed a joint venture agreement with Russian precious metal supplier Almaz in June 1991 for the production of autocatalysts at a new plant in Karlskoga, Sweden (Penson, 1993: 27). Almaz will supply the PGMs for the pla which will have a production capacity of 2 million units per year by 1994. The plant will then consume approximately 3 000 kg of platinum and 600 kg of rhodium.

There are plans, by this joint venture, to build a second facility in Germany and a third one in Russia in the near future (Penson, 1993; 27).

The USA's Clean Air Act of 1990, based on laws put into effect in California in 1989, requires NOx to be reduced by 60 per cent and HC by 35 per cent of present standards between 1994 and 1996. The autocatalyst is also required to last 100 000 miles, or ten years, twice the current limits. In 2004, if the Environmental Protection Agency decide it is necessary, the limits may be cut by a further 50 per cent (Coombes, 1992: 39).

The objectives of Phase VI are as follows:

(i) to increase local content by value from 55 per cent to 75 per cent by 1997,

(ii) to reduce imports of automotive components,

(iii) to save on foreign exchange,

(iv) to promote local growth and attractive economies of scale for component manufactures,

(v) and to encourage exports.

Phase VI works by levying the car manufacturer with a 40 per cent rebateable excise duty based on the wholesale price of the motor vehicle. Of this, 2,5 per cent is a non-refundable fiscal duty retained by the Receiver of Revenue. The remaining 37,5 per cent excise duty is rebated at 50 cents of every 1 rand of local content (including exports) above 55 per cent by value of the motor-car. At 75 per cent local content by value, the entire 37,5 per cent excise duty is rebated.

There are 3 catagories which qualify as local content.

(i) Locally sourced components.

(ii) Marketing, advertising and overhead costs.

(iii) Export earnings.

Autocatalysts fall into the third catagory where the higher the export earnings a local car manufacturer attains, the larger the return on its rebateably excise duty.

The export market is hindered by two major factors (French, 1993: *Pers Comm*).

(i) Duties of 3 to 4 per cent are levied on these products by the importing countries of Europe, Japan and the USA.

(ii) Competition from international companies, Johnson Matthey PLC, Englehard and Degussa AG is very strong, making entry to these markets by local producers very difficult.

The IOU of platinum in the glass industry, fluctuating in tandem with world economic cycles, is in a saturated phase of its life cycle. Growth for this application is not expected in the future. As more efficient uses of platinum/rhodium alloys occur, a decline in the IOU for these metals is expected.

Free and subsidised health schemes in Europe and Japan have resulted in recent increases in demand for palladium in the dental sector. Even though base metals can be used as cheap substitutes, dentists are becoming increasingly cautious about the effects of base metal dental alloys on the health of their patients. Precious metal alloys are, therefore, preferred and the gold-palladium alternative to the expensive high-gold alloys have become more popular during the present recession in Japan.

The prospect of South African companies manufacturing PGM dental alloys for export is, therefore, a viable possibility.

5.4.2 Allied applications

The local market for laboratory apparatus is not expected to expand and is presently very small. It is, therefore, not viable to manufacture this equipment only for the domestic market.

Established international companies, such as Johnson Matthey, already supply the world market. A local manufacturer of PGM laboratory equipment will have to compete with these firms.

Nitrogen fertilizer sales in South Africa have fallen since 1980 at an average annual rate of 2,1 per cent (FIG. 5.6). This decline occurred as a result of 3 main factors.

(i) The removal of subsidies to the fertilizer manufacturers has increased the costs of producing fertilizers.

(ii) Frequent droughts during the decade of the 80s has negatively affected agricultural production.

(iii) Farming has become more scientific and as a result the utilisation of fertilizers has become more efficient.

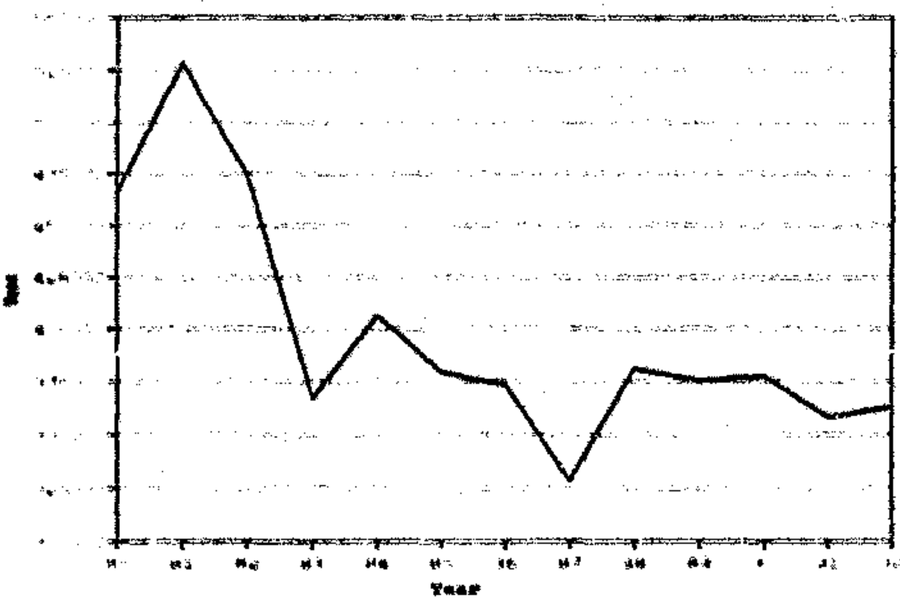
Since 1987, declining world mineral commodity prices and rising inflation in the South African mining industry have reduced profit margins. This has resulted in the more efficient use of mining explosives in order to control escalating costs.

However, an expansion of the mining and, possibly, the agricultural industries in the developing world, could see increased demand for explosives and fertilizers with changing political ideologies supporting free market economics. The supply of catalytic gauzes to these industries for developing countries could, therefore, expand. Neighbouring African countries are the first choice for this expansion but political stability and economic change in the region is necessary before the increase in demand for catalytic gauzes can occur.

The prospects of growth occurring in the local manufacture of PGM chemicals for various applications at present, is considered to be weak. The local market is very small and some 95 per cent of production is exported.

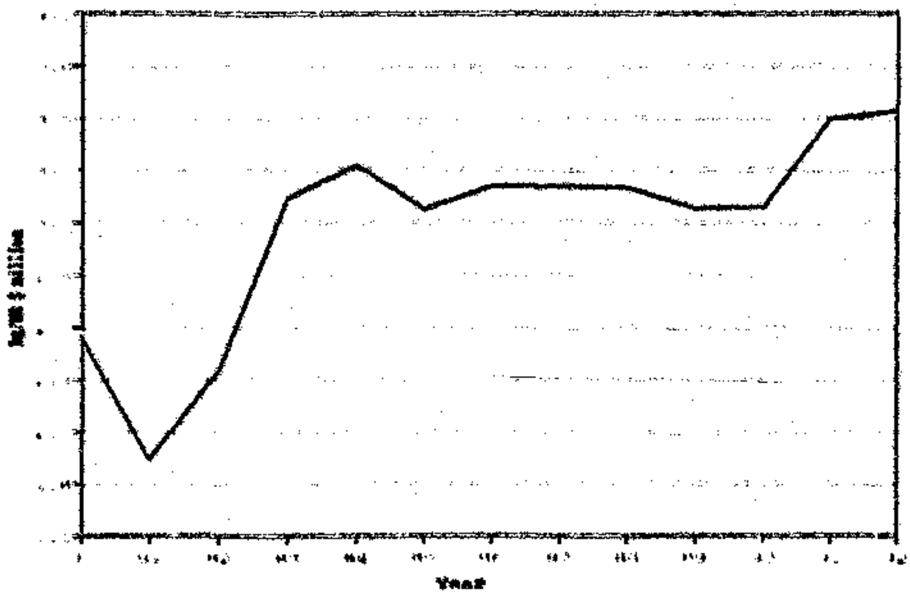
Growth in demand for catalytic gauzes for the production of nitric acid, is not expected over the short term in the South African market. Nitric acid is used to manufacture nitrate, which is a feedstock for fertilizers in the agricultural industry and explosives in the mining industry.

FIG. 5.6 - NITROGEN FERTILIZER SALES IN THE REPUBLIC OF SOUTH AFRICA, NAMBIA AND THE INDEPENDENT NATIONAL STATES



Source: The Registrar, Act 36/1947, Dept of Agricultural Economics and Marketing, 1983 - 1992.

FIG. 5.5 - INTENSITY OF USE OF PALLADIUM: DENTAL



Source: Table A4, pp. 87.

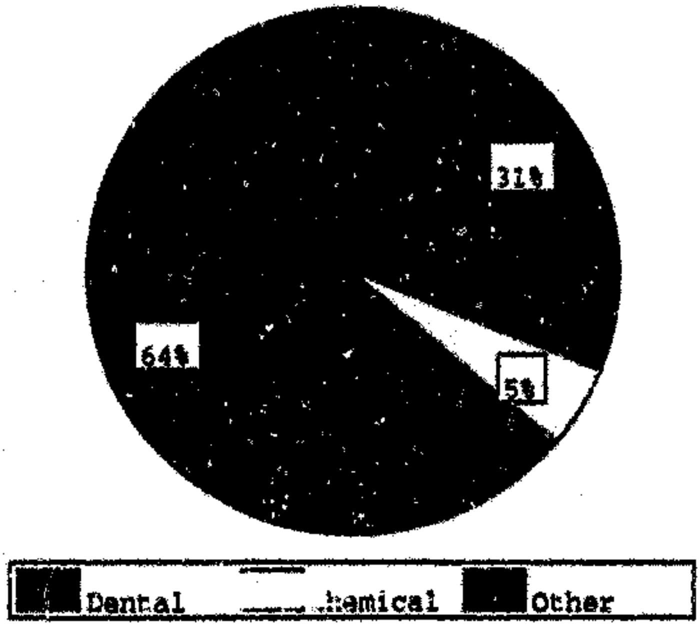
5.4 Future for South African Production

Coombes (1994) estimated that during 1994 the Western World consumed approximately 49 081 kg of platinum, palladium and rhodium in the chemical, petroleum, glass and dental sectors. The total South African share of 1 000 kg in this world market will, therefore, only amount to 2 per cent.

5.4.1 Chemical applications

Once the world has completed its refinery expansion projects to meet the world's unleaded petrol demands, future growth prospects for the supply of PGM catalysts to the petroleum industry is limited. The next century will see the decline of the petrol driven motor vehicle and a rise in "zero emission vehicles" which will likely be in the form of electric vehicles.

FIG. 5.4 - WESTERN WORLD PALLADIUM DEMAND, 1992



Cheaper base metal alloys can be used as alternatives and, therefore, a slow down in demand could be expected if palladium becomes too expensive even though some of these alloys are suspected of having adverse health implications.

The Japanese government's health care scheme does allow for the use of a standard gold-palladium-silver alloy for crowns and bridges. This will, therefore, sustain growth in this sector for the short to medium term.

The consumption of platinum in the glass industry will decline if a suitable substitute is found or else if more efficient use of the metal takes place. For example, this could occur if ceramic bushings were used, plated with a platinum/rhodium alloy instead of solid metal alloy bushings in the extrusion of glass fibre.

The IOU of platinum in the chemical industry declined by an annual average of 5,3 per cent from 1975 to 1992 (FIG. 5.2).

In 1990 and 1991, a sharp increase in demand for iso-butylene occured in North America which is a feedstock for methyl tertiary butyl ether (MTBE). Since the 1990 Clean Air Act in the USA, MTBE production increased, replacing lead as an octane improver in petrol. During 1990 and 1991, two new dehydrogenation processes for producing iso-butylene from butane, based on platinum catalysts, were introduced.

The decline in the IOU of platinum in the chemical industry of 5,3 per cent per annum over the last 17 years, indicates that this phase will continue unless new applications are found.

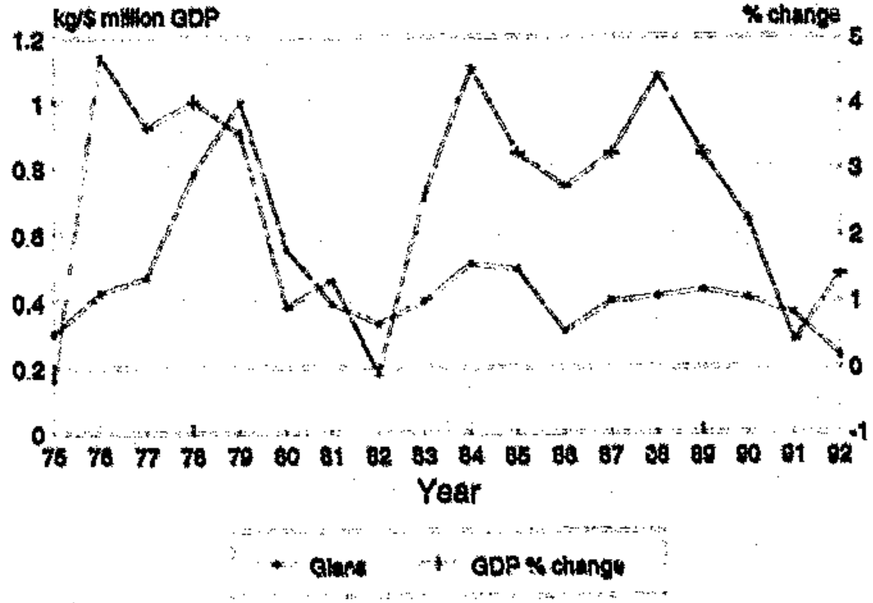
The dental sector, at 37 169 kg or 31 per cent of total consumption in 1992 (FIG. 5.4), is second only to the electronics industry in the Western World demand for palladium. The chemical industry only consumed 6 065 kg or 5 per cent of 1992's total palladium demand. These two sectors' combined offtake amounted to 36 per cent of total Western World demand.

There has been an average annual growth of 3,1 per cent in the IOU of palladium in the dental sector since 1980 (FIG. 5.5). Silver-palladium-gold alloys, containing 20 per cent palladium, are widely used in Japan, thus creating a steady demand. However a surge in demand occured in Germany in 1991, due to a provision in the national insurance scheme which grants free dental treatment to the unemployed. M[illegible] Germans in the east who lost their jobs after unification and the introduction of a market economy in the eastern territories, were given free treatment under these terms.

industries has fluctuated to some extent with the economic growth of the developed world since 1975 (FIG. 5.3).

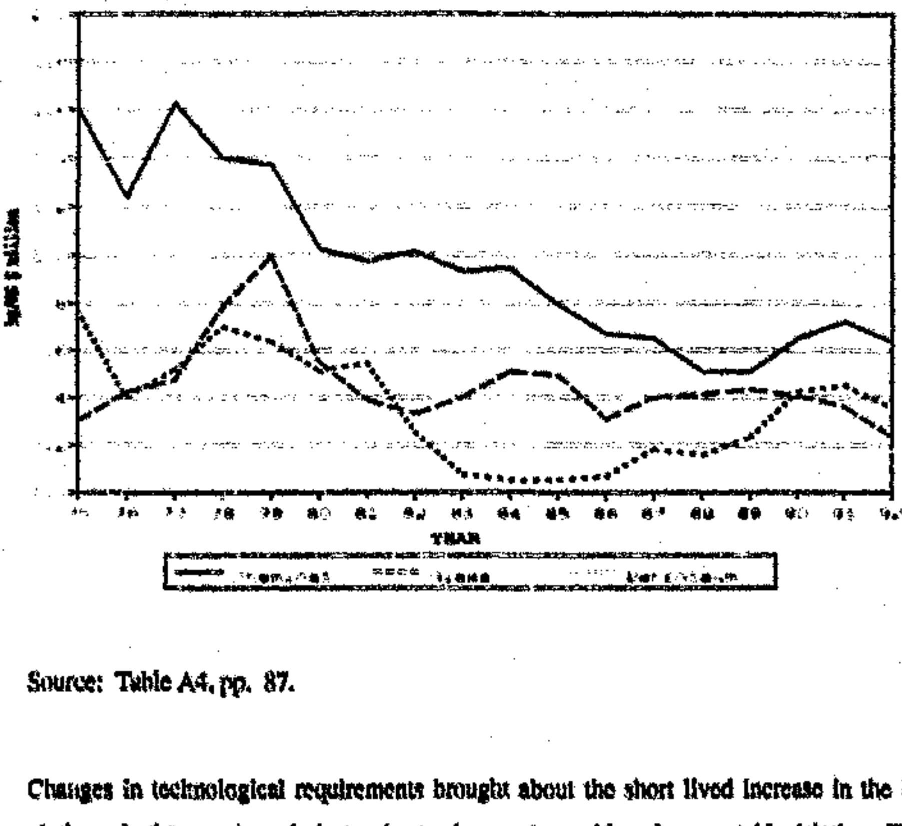
A correlation coefficient of 0,4 was calculated between the IOU of platinum in the glass industry and the percentage change of GDP for the developed countries in constant 1985 prices (FIG. 5.3). As their is a correlation between these variables, the IOU of platinum in this industry can be consided to be in a satur··ed stage, dependant to some extent on world economic growth cycles.

FIG. 5.3 - INTENSITY OF USE FOR GLASS INDUSTRY VS DEVELOPED COUNTRIES ECONOMIC GROWTH



Source: International Monetary Fund, 1993 platinum demand in this industry will begin to slow and then decline as the last conversion projects reach completion.

FIG. 5.2 - INTENSITY OF USE OF PLATINUM: CHEMICAL, GLASS AND PETROLEUM

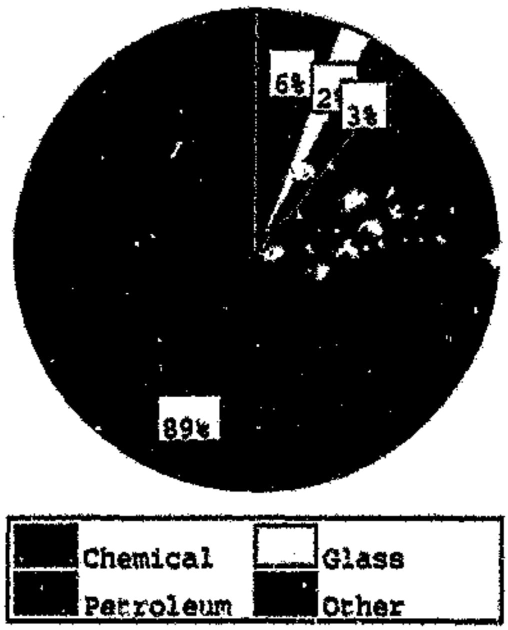


Source: Table A4, pp. 87.

Changes in technological requirements brought about the short lived increase in the IOU of platinum in the petroleum industry due to changes in world environmental legislation. The IOU will resume its average ,4 per cent annual decline once refinery requirements are met in the next 1 to 2 years. This decline will accelerate in the next century as the environmentally conscious world moves away from petrol and diesel driven vehicles.

The IOU of platinum in the glass industry had a negative 1,4 per cent annual growth rate from 1975 to 1992. Since 1989, the consumption of platinum in the production of glass fibre has fallen a significant 18,1 per cent due to the economic downturn in the developed countries (FIG. 5.2). Demand for glass fibre used mainly in the construction, recreational and electronics

FIG. 5.1 - WESTERN WORLD PLATINUM DEMAND, 1992



Over a 17 year period from 1975 to 1992, the IOU of platinum in the petroleum industry declined on average by 4,4 per cent each year (FIG. 5.2). However, from 1985 to 1991, a growth rate of 42,9 per cent per annum in the IOU of platinum occured before the decline resumed in 1992.

During periods of low investment in new refining capacity, platinum demand falls since the losses of metal in use during refining are very small. The increase in the IOU of platinum from 1985 resulted from world increases in new investment for refining capacity. In the developed world, it was prompted by the conversion of refineries to produce unleaded petrol, however, the expansion in these countries has virtually been completed and a fall of 21,1 per cent was recorded in 1992.

At present, the demand for refineries to convert to the production of unleaded petrol is taking place in Southeast Asia, Latin America and even in South Africa. It is, therefore, expected that

Johnson Matthey supplies this equipment to the South African glass industry. The equipment is manufactured overseas and is imported into the country.

Pigments

A minor application of platinum is in the use of pigments and lustres mostly for pottery, tiles and glass. They are generally used for decorative colouring purposes and also form a constituent of paint used for motor-cars.

Johnson Matthey manufactures these products for the local and overseas markets at its Germiston plant.

Electroplating

Palladium chloride and rhodium "syrup" are used for electroplating in decorative, industrial and electronic applications. These are produced by Johnson Matthey and PGM Chemicals and marketed both locally and abroad.

5.3 World Demand

Western world demand in the chemical industry for 1992 accounted for 5,6 per cent of total platinum demand (FIG. 5.1). The glass and petroleum industry accounted for 2,1 and 3,1 per cent respectively. These applications combined consumed 12 908 kg or 10,8 per cent of total Western World platinum demand in 1992 (Coombes, 1993).

The market for unleaded petrol is expected to increase with legislation on vehicle exhaust emissions coming into play in many parts of the world. New plant construction is expected to continue in Latin America and Southeast Asia.

Cisplatin is manufacture by PGM Chemicals, mostly for the export market.

For diagnostic purposes, osmium tetroxide is used to stain tissue samples allowing detailed examination with the use of an electron microscope. It can then be determined whether tumours are malignant or benign. This substance is produced in fluid and crystalline form by both of th previously mentioned manufacturers for the local and overseas markets.

Osmium is also used in the manufacture of drugs for the treatment of arthritis.

In dentistry, PGMs confer hardness, strength and corrosion resistance in dental alloys. Palladium, as a result of its relatively low price compared with that of gold or platinum, is now the most favoured metal. Base-metal alloys, however, are used as cheaper substitutes.

5.2.2 Allied applications

Laboratory apparatus

Platinum and platinum alloys are used for laboratory apparatus due to their extremely high resistance to chemical corrosion.

Johnson Matthey South Africa is the only supplier of laboratory ware which is imported from the parent company in the United Kingdom.

Glass production

A platinum/rhodium alloy is used to make bushings for the extrusion of molten glass in the production of glass fibre and optical fibres. No other metal is known to be able to withstand the high temperatures and severity of continuous operation.

Platinum alloys are also used for glass-melting tanks and as stirrers and crucibles to make high quality optical and speciality lenses.

Local demand for PGMs will increase due to South African oil companies' plans to produce lead free petrol in 1995. At present there is R2 billion worth of refinery projects in progress to meet the increasing demand of fuel in the South African petroleum industry (Engineering News, 1993). The present expansion of SASOL's ammonia plant which will feed the fertiliser and explosives industries will also increase platinum demand.

Both Johnson Matthey and PGM Chemicals manufacture petrochemical and other chemical catalysts for the local industry.

Nitric acid production

A mixture of air and ammonia, passed over pre-heated platinum/rhodium catalyst gauzes, is oxidised to produce nitric acid which forms the basis for the bulk of agricultural inorganic nitrogenous fertilizer production as well as mining explosives. During the oxidation process, the platinum/rhodium gauze looses some 10 per cent of its weight through volatilisation, however, recovery through the use of a catchment system of palladium gauzes retrieves up to 80 per cent of that which is vapourised.

These platinum/rhodium and palladium gauzes are recycled and so approximately 500 kg of primary PGMs are consumed each year by the local industry. This industry is second only to the autocatalyst manufacturers in the consumption of platinum and rhodium in South Africa.

Johnson Matthey is the only producer of these gauzes in South Africa and, therefore, has a monopoly for the supply of these products.

Medical uses

Platinum, in the form of Cisplatin, is the most successful chemotherapeutic agent yet developed for the treatment of certain types of cancer and in particular that of the testes and ovaries. Carboplatin is one of the several second generation platinum compounds investigated for use in cancer chemotherapy for the treatment of ovarian cancers and small-cell lung cancers. Carboplatin has the advantage of causing fewer toxic side effects.

South Africa does not have the technology or skills at present to manufacture fuel cells. Technology and consumer demand is presently situated in Japan, the USA and Europe. Skills and technology can be imported in order to start a local R&D programme and ultimately manufacturing facilities. There is a sub-Saharan market waiting to be exploited. Many rural settlements in this region are currently without electricity, and should be ready to be exploited early next century, once present excess electricity capacity has been utilised.

Fuel cells not only generate electricity but also heat and water. These by-products can be utilised in many applications such as heating homes in cold climatic regions and providing limited clean drinking water.

The potential for the country in this field of platinum application is large, even though large capital outlays are required. A local fuel cell project would require the co-operation between a platinum producer, to supply the metal and Eskom's co-operation to develop a fuel cell. The risk of failure should be low since the technology has already been developed, mostly by Japan and the USA. This technology could be imported by the local joint venture. The platinum could be supplied on a loan basis by the platinum producer.

Both parties will benefit if the project proves successful. The platinum supplier will have developed a new market for their metal. Eskom will have a pollution free means of generating electricity for the next century keeping pace with world environmental trends.

6.4.1 Electronics

South Africa's electronics industry is insignificant in size relative to Japan, the USA and Germany. It is geared to produce only specialised components. The country will have to compete with these countries in the mass manufacture of electronic components if it is going to add any value to the country's primary PGM production.

The current market share reflects the inability of the local electronics industry to compete with the rest of the world. It is, therefore, apparent that present economic conditions do not allow for the expansion in the manufacture of electronic components. Factors such as fiscal policies, natural costs and the ability to attract investment will have to improve to provide for growth in

Two large independent electricity generating systems exist in the southern African sub-continent. Firstly, there is the predominantly coal-fired system to the south encompassing South Africa, Namibia, Lesotho, Swaziland, Botswana and southern Mozambique. Secondly, there is the predominantly hydropowered system to the north including Zimbabwe, Zambia, Ziare, Angola, central Mozambique and Malawi.

Since coal-fired electricity is more expensive but more reliable than hydro electricity as it is not susceptible to low rainfall periods, plans to interconnect the two systems are presently in progress.

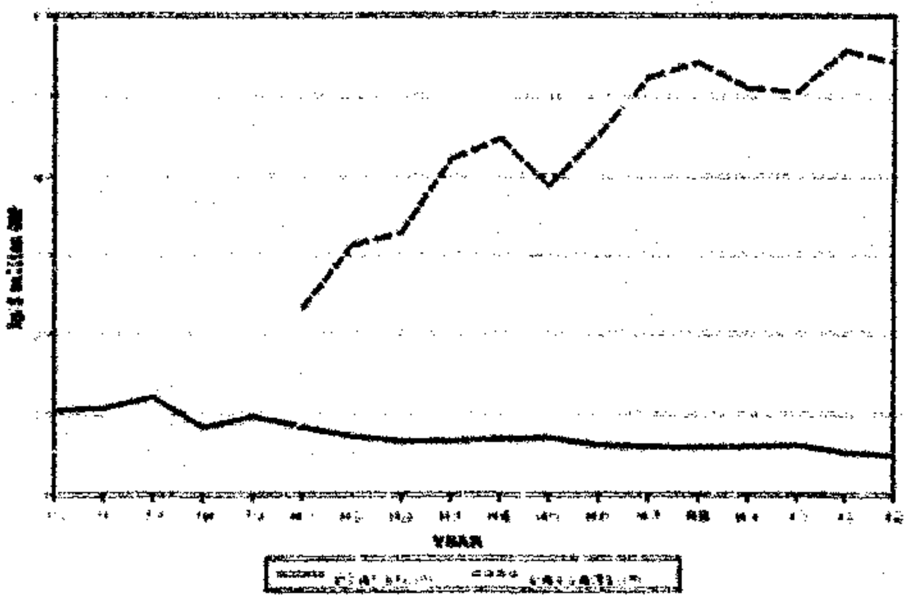
South Africa's peak consumption of electricity is just over 23 000 megawatts and, even taking into account a reserve margin of about 25 per cent to cover maintenance and breakdowns, Eskom still has an excess capacity of 8 000 megawatts. Africa, south of the equator, has a combined excess capacity of 11 000 megawatts (Engineering News, 1993).

Eskom itself, has planned to provide electricity to 1 million homes before the year 2000. At the same time, local authorities are expected to supply electricity to a further 2 million dwellings. But even with this major expansion in electrification, many rural areas will remain without grid electricity. The costs of suppling electricity to small remote rural communities by a regional grid of coal-fired power stations is prohibitive, as well as causing pollution to the atmosphere. Other forms of clean, cost effective energy are, therefore, required and the answer to this problem is the fuel cell's safe chemical means of generating electricity.

However, the present 11 000 megawatt excess electricity generation capacity will have to be utilised to warrant further capital expenditure in electricity generation in the form of fuel cells.

If the pre-commercialisation phase of the development of fuel cells in Japan and the USA proves successful, large commercialisation should begin in the second half of this decade in the developed countries. If this event occurs, South Africa, which holds 88 per cent of the world's PGM reserves (van Graan and Fourie 1992), and presently has no R&D programme for fuel cells, will forfeit an opportunity which could be exploited adding much value to the countries platinum resources.

FIG. 6.5 - INTENSITY OF USE FOR PLATINUM AND PALLADIUM: ELECTRICAL SECTOR



6.4 Future For South Africa in Fuel Cells and Electronics

6.4.1 Fuel cells

The Electricity Supply Commission of South Africa (Eskom) presently holds a monopoly in the generation and transmission of electricity with a 98 per cent share of the market. The distribution side of Eskom's business, however, only holds 55 per cent of the market share. The other 45 per cent of the distribution market is held by 452 different distributors (municipalities, homeland author' s, and local governments).

Eskom presently plans to reduce the number of distributors to between 4 and 25 regional entities. The reason for this is to make the provision of electricity more efficient by improving the economies of scale. Having a large number of distributors has resulted in 3.5 million urban households still without electricity and 75 per cent of the population without power (Financial Mail, 1993).

FIG. 6.1 - WESTERN WORLD PLATINUM DEMAND,1992: ELECTRICAL

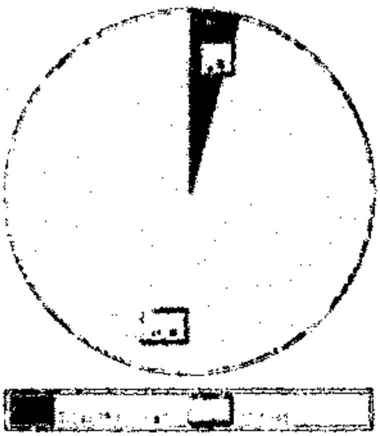


FIG 6.2 - PLATINUM DEMAND BY REGION, 1992: ELECTRICAL

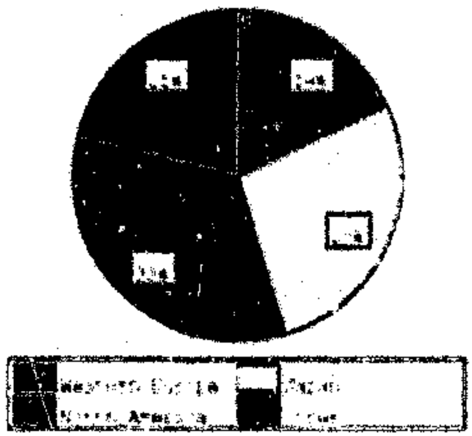


FIG. 6.3 - WESTERN WORLD PALLADIUM DEMAND, 1992: ELECTRICAL

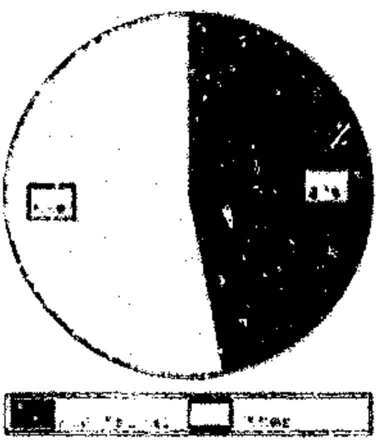
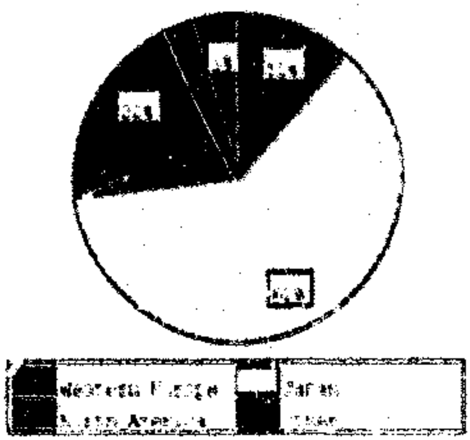


FIG 6.4 - PALLADIUM DEMAND BY REGION, 1992: ELECTRICAL



annum. This will amount to approximately 16.4 tonnes of platinum per annum. In addition, the state of California requires 2 per cent of its vehicles in 1998 and 10 per cent by 2003 to have zero emissions. Vehicles powered by fuel cells and fuelled with hydrogen would qualify for this catagory.

Current PAFC systems require 4 grams of platinum per kilowatt, with the PEM fuel cell requiring much more. It is expected, however, that 350 milligrams per kilowatt might eventually be achieved for the more likely PEM technology for transport.

A fuel cell car would need 20 kilowatts of power and consume 7 grams of platinum. If all the Californian "Zero Emission Vehicles" required in 2003 where to use PEM fuel cells, then the platinum demand in that year would be 878 kilograms.

A total of 17 tonnes of platinum could, therefore, be consumed by fuel cell applications at the turn of the century. This is an annual average 16 per cent increase in consumption of platinum from 1993 to the year 2000.

The IOU of palladium has grown at 7.3 per cent each year on average since 1980 (FIG. 6.5). This was brought about by the rapid growth in the Japanese electronics industry. As of yet, the substitution of palladium by base metals and silver has not yet impacted on the growth of its IOU.

It is expected that this growth will continue into the next century as new areas of application in electronic equipment are found in our daily lives.

Investments Ltd. Funds are are being suppled for a R&D programme which [illegible] onducted overseas.

6.3 World Demand

Western World offtake for the electronics and electrical industry during 1992 accounted for 4,3 per cent of platinum and 46,9 per cent of total palladium demand in 1992 (FIG. 6.1 and 6.2). Fifty seven tons of palladium was used in the electronics industry during 1992. Platinum consumption amounted to 5,1 t for the same period of which approximately 6 per cent was used for a new emerging application of electrical generation in fuel cells.

North America and Japan are the largest consumers of platinum and palladium in the elec rical and electronics industries (FIG. 6.2 and 6.4). North America is the largest consumer of platinum (33 per cent) while Japan consumed the largest share of palladium (62 per cent) in this sector for 1992.

The IOU of platinum in the electrical and electronics industries declined by 4,4 per cent on average each year since 1975 (FIG. 6.5. [illegible] recent world recession in the developed world has contributed to the decline since 1990 and has reduced the offtake of platinum and rhodium/platinum thermocouples used in the glass, steel and semiconductor industries. The steel industries of the developed world in particular began a slow-down in growth of metal consumption since the mid-1970's (Lohani and Tilton, 1993) and this has generally contributed to the gradual decline in the use of thermocouples.

The biggest potential growth area for the IOU of platinum is in the application of fuel cells. Present consumption has until now remained below 310 kg but is expected to increase in the second half of the 1990s once commercialisation of the PAFC is established. Japan will become the largest consumer of platinum in this sector, since this country is in the most advanced stage of production in fuel cells for commercial use.

Aurther D Little (Bennetts, 1994: 34) has suggested that by the year 2000 fuel cells could account for 5 per c[illegible]t of the annual world-wide generation capacity or 4 100 megawatts per

Projects are underway to develop fuel cell-powered vehicles or fuel cell-battery hybrids in which the fuel cell is used to recharge the battery and provide unlimited range and clean motive power. General Motors, Ballard Power Systems, Los Alamos National Laboratories and Dow Chemical are being sponsored by the US Department of Energy to research a proton exchange membrane (PEM) fuel cell/battery hybrid power source for a vehicle by 1997 (Platinum Guild International, 1993).

The PEM fuel cell uses platinum as a catalyst, coated on carbon electrodes. The unit is small, robust and suitable for mobile applications. Units of up to 10 kW have so far been manufactured for use in military underwater vehicles and for aerospace applications. A hydrogen-fuelled car which incorporated a PEM fuel cell, was demonstrated in the USA in 1991. Mazda in Japan has also developed a vehicle using a platinum-based PEM fuel cell for a vehicle, while extensive research programs are underway in Europe, Canada, Russia and Brazil.

Fuji Electric in Japan, tested a PAFC in the US Department of Energy's project for a bus powered by a fuel cell. The PAFC has reached commercialisation in Japan and the USA for on-site generation of electricity. It also uses platinum as a catalyst, coated on carbon electrodes.

Platinum, therefore, can be seen to have a positive future as an essential component in the development of fuel cells for electric vehicles. The use of fuel cells will reduce harmful emissions and thus help to protect the earth's environment. However, costs are still prohibitive in the use of fuel cells for propulsion but these will fall as commercialisation takes place, and economies of scale come into play. Auther D Little (Bennetts, 1994: 35) suggests that costs should be reduced to $300 per kilowatt for mobile applications to be competitive.

An increase in the efficience of these fuel cells, with lower loading of platinum per kilowatt, will also have to be achieved before full commercialisation occurs. However, with commercialisation, the higher volumes of production should offset lower loading of platinum per fuel cell and generate significant demand for platinum.

The PEM fuel cell is foreseen to be the most promising for transport purposes. It is presently being promoted by a joint venture from Johnson Matthey PLC and Johannesburg Consolidated

South Africa has no local R&D programme for fuel cells. Currently research work is being conducted on these electrochemical power generators only in the developed countries and so local consumption of PGMs in this sector is zero.

Electric vehicles

Motor vehicles, one of the world's largest sources of air pollution, emit carbon monoxide, hydrocarbons and nitrous oxides which cause smog, acid rain and add to the greenhouse effect on the earth's atmosphere.

The Dutch government has recently announced that it is to allow local businesses accelerated depreciation on electric powered company cars. This new scheme was devised to promote the use of electric cars (The Star Motoring, 28 January 1993: 5).

In 1990, the Californian Air Resources Board set regulations that, by 1998, 2 per cent of vehicles in the state will have to meet the "zero emissions" classification. By the year 2003, 10 per cent of all vehicles will have to comply with the "zero emissions" classification (Coombes, 1992: 40).

The Japanese Ministry of International Trade and Industry (MITI) has set a target of having about 200 000 domestic electric cars in use by the year 2000. Toyota and Nissan have, therefore, joined forces to develop an electric car (The Star Motoring, 28 January 1993: 5).

There are, however, three problems with electric cars using conventional batteries.

(i) The time taken to recharge batteries is impractical.

(ii) The electricity used to recharge the car would be generated from fossil fuel power stations which are not "environmentally-friendly".

(iii) These vehicles have a limited range before having to be recharged.

Exhaust emissions from fuel cells of particulates and oxides of sulphur and nitrogen are below 200 grams per megawatt hour. These emissions from gas, oil and coal fired power stations are well above this level. Oil and coal fired powered stations alone emit greater than 3 kilograms of oxides of sulphur per megawatt hour (Coombes, 1991: 44).

Production facilities have been established in Japan and the USA to manufacture Phosphoric Acid Fuel Cells (PAFC) so that trials may be carried out. Most of these units in production at present, provide an output of between 25 kw and 200 kw. They are designed to generate power and heat for buildings and small communities, and are the closest to being fully commercialised out of approximately five different types of fuel cells. Three of these five use platinum of which the PAFC is one. A total of 157 PAFCs have been scheduled to come into operation by 1994: 14 in Western Europe, 19 in North America and 124 in Japan (Coombes 1993).

Costs, however, are still very high and need to be reduced considerable. These will fall as research improves the efficiency of fuel cells, and with commercialisation, economies of scale are achieved. According to Arther D Little of International Technology Consultants (Bennetts, 1994: 35) power unit costs of \$1 500 per kilowatt in current terms are needed to be competitive. At present, costs are in excess of \$5 000 per kilowatt for PAFC technology and considerable more for PEM fuel cells.

The high cost per kilowatt is not a result of platinum. Only 4 grams of platinum is needed for each kilowatt of the total generating capacity of a fuel cell system. If the price of platinum was \$390/ozt then the cost would only be \$50/ozt per kilowatt. This is only 1 per cent of the total cost of \$5 000 per kilowatt.

It appears the reason for the high price of fuel cells is economies of scale. Insufficient demand means high unit costs and this will only be reduced if demand increases.

The main reason for fuel cells not achieving full commercialisation is that they have not yet proved reliability over extended periods of time. This could be solved, however, with research and development (R&D).

A rhodium/platinum alloy is used for thermocouples which are vital to the glass and foundry industry, notably steel production, where accurate high temperature measurement is critical.

Johnson Matthey South Africa (Pty) Ltd offers a full service on thermocouples including supply and recycling scrap. The local market, however, is very small by world standards and so this company has a monopoly for this service in the domestic market.

Both Johnson Matthey and PGM Chemicals provide chemicals for electroplating in electronic devices and platinise anodes for electrochemical proccesses.

The consumption of PGMs by local manufacturers of electronic devices are insignificant by world standards. The two local firms who provide PGMs for the electronics industry are not at liberty to divulge actual figures, as it could give away their competitive advantage. It can be said though, that the amount of consumption of PGMs by the electronics industry in South Africa is included in the 1 000 kg mentioned in Chapter 4.2.

6.2.1 Electrical applications

The fuel cell

The fuel cell is a power plant which generates electricity by chemically combining hydrogen and oxygen to form an electric current, heat and water. Fuel cells require a catalyst, and whilst a variety of catalytic materials can be used, nearly all fuel cells built so far have used platinum because of its efficiency and resistance to decay. These generators of electricity are one of the most efficient and "environmentally-friendly" forms of power generation known to man, and are presently in a research and development (R&D) stage.

Present fuel cells operate at greater than 40 per cent efficiency in converting chemical energy into electrical energy. Advanced fuel cell designs are expected to reach 60 per cent efficiency, reducing the amount of fuel consumed per unit of electricity produced. Conventional generators offer between 25 and 40 per cent efficiency (Coombes, 1991: 41).

CHAPTER 6

ELECTRONICS AND ELECTRICAL INDUSTRY

6.1 Introduction

Demand figures published by Johnson Matthey do not distinguish between electrical and electronics sectors and are all placed under the one heading of electrical. In this chapter, however, the various applications of platinum and palladium in each sector will be discussed separately.

The electronics industry is the single largest consumer of palladium and is still a growing industry. Demand for platinum in electronic applications is very much less. However, an emerging electrical application for platinum is in fuel cells which promises to be a potentially large consumer of platinum in the near future.

6.2 Major .. plications and Local Production

6.2.1 Electronic applications

The world's largest single use of palladium or palladium-silver pastes is in the manufacture of multi-layer ceramic capacitors and, to a lesser extent, hybrid integrated circuits. These electronic components are not manufactured in South Africa to any large extent, and the local consumption of palladium in this application is estimated to amount to only a few grams.

South African Micro-Electronic Systems (Pty) Limited (Sames) is the only producer of integrated circuits in the country. The Industrial Development Corporation of South Africa Limited has a 50 per cent shareholding in Sames. The remainder of the shares are held by the major electronics companies of South Africa, who are also major consumers of the company's products. Sames, therefore, provides for a selected niche market and only 8,4 per cent of turnover is exported (Industrial Development Corporation, 1992).

As in the case of laboratory apparatus, it is not cost effective to manufacture glass fibre bushings for a small domestic market. The international market is presently serviced by established companies, such as Johnson Matthey, overseas

The local pigment industry is dependent on the health of the motor and building indusuries for growth. There is no expansion in the manufacturing of these pigments in South Africa at present, suggesting that the market is well supplied.

An extensive market research will have to be conducted to establish a viable overseas market for locally produced pigments before an export drive can be established. This will, however, require financial resources and initiative from local companies and could well be a viable proposition with world economic growth.

(iii) the primary platinum producer would benefit from profit sharing in the value added product offsetting the discount allowed for the supply of platinum to the jeweller.

(iv) increased demand for platinum from primary producers will be created by the local jeweller.

(v) and the country as a whole will benefit from value added foreign exchange.

The local platinum jewellery market shows little sign of growth at present, since platinum jewellery is not well known to the public, and so very few local jewellers manufacture platinum jewellery. This, however, can easily be overcome through local advertising campaigns by the proposed joint venture.

7.4.2 Coins

Before sanctions were imposed on South Africa in the 1980s, the Krugerrand gold coin, marketed by the Chamber of Mines subsidiary, International Gold Corporation, proved to be a major success. World sanctions curtailed these sales and inhibited further initiatives from this organisation.

The time is now right for the return of South African investment coins to international markets. The world precious metals market came out of its bear run in April 1993 and a persistent bull market is expected for at least the medium term.

There are a number of factors to consider in the minting of platinum and palladium coins.

(i) A guarantee on the physical delivery of platinum and palladium.

(ii) "Fly-wheel" borrowing costs must be kept low. The fly-wheel refers to the amount of metal which will end up as scrap and is equal to the amount used in the coins. It is not bought outright but borrowed and later returned after the coins are struck.

Further marketing campaigns by PGI in Europe and North America will also bring about growth as these markets have not yet been exploited to the full. The IOU of platinum in the jewellery sector has, therefore, experienced a renewed growth phase since 1980, which can be expected to continue into the next century.

South African producers could do well if a joint venture was set up with Mintek and its newly developed technology to produce platinum jewellery for the growing Asian market. Security and ease of supply from local primary platinum producers are the first stumbling blocks that need to be overcome before any progress can be made.

The other barrier preventing entry into the export market include the following.

(i) Import duties imposed on jewellery by importing countries.

(ii) Each region in the world has its specific fashions and designs with which South African jewellery manufacturers have not kept pace.

(iii) Specific platinum jewellery equipment is required, raising the cost of fabrication if only small quantities are produced.

(iv) Local jewellers are far from the export markets and so transport costs are high.

Most of these barriers can be overcome by a joint venture between a primary platinum producer, Mintek and a jewellery manufacturer. The platinum used to manufacture the jewellery could be supplied by a primary producer at a slight discount to the market price, so as to offset the import duties which would be imposed on the finished product. This would benefit all parties in the joint venture as:

(i) the jeweller would be able to export jewellery more competitively.

(ii) Mintek technology would be utilised.

7.4 South Africa's Future Prospects

7.4.1 Jewellery

Mintek, based in Randburg, has strived for many years to promote added value in the mineral industry and consistently campaigned for the expansion of the local jewellery industry. Further incentives have also been provided by the Government's abolition of the *ad valorem* excise duty of 20 per cent on both locally produced and imported jewellery in 1990.

Although South Africa is the world's major producer of platinum, only 9 kg of imported platinum is estimated to have been used locally for jewellery fabrication in 1993. Mintek has, therefore, set about developing new alloys that will give the metal a wider appeal, not only in wider ranges of colours but also in the field of physical workability.

The project was sponsored by Western Platinum Ltd, who are joint patent-holders with Mintek of the new materials. The first is a coloured platinum intermetallic compound known as Platigem and the second is a powder-metallurgy product known as Goldina.

Platigem has a melting point between 1200°C and 1400°C, considerably lower than that of pure platinum (1700°C) but must be melted in an inert atmosphere to avoid oxidation. It is extremely hard and takes a high polish. The material is based on an intermetallic compound of platinum and ranges in colour from yellow to shades of orange and pink.

The coloured platinum was introduced at a meeting of the International Platinum Association in Johannesburg in December 1991 and was favourable received.

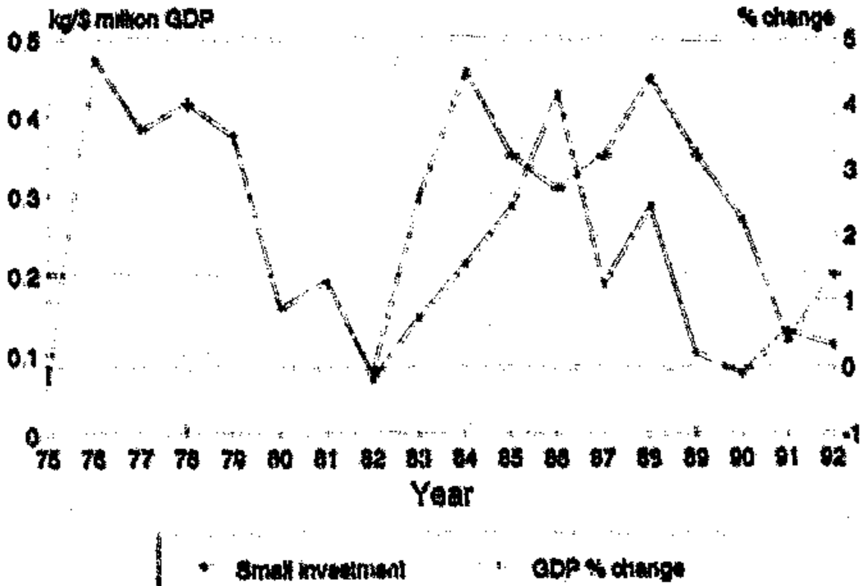
Asian people are said to have an affinity to platinum jewellery as it suits their complexion. Sustained growth in the IOU can, therefore, be achieved if marketing was expanded to other Asian countries, especially since this part of the world is presently enjoying the highest economic growth rate. People in this region are becoming wealthier and, therefore, disposable income is increasing, which will result in increased demand for luxury goods such as jewellery.

Demand statistics for the calculation of the IOU of platinum in the small investment sector first appeared in 1982 giving only a 10 year period for analysis (FIG. 7.8). This is too short a period to establish a definite life cycle phase in the IOU curve.

However, a positive correlation of 0.5 is calculated between the percentage change in industrial countries GDP and the IOU of platinum in small investment. This is not a perfect correlation but it does indicate that with economic growth the increased earnings of people allow for more savings which to some extent is taken up as investments in platinum coins and small bars. The reverse occurs with declining economic growth and the concomitant earnings of individuals.

This correlation suggests that platinum coins are in a saturated life cycle phase of its IOU curve and are dependant on world economic cycles. The pattern, however, should be tested over a longer period to confirm the relationship between GDP growth and IOU.

FIG. 7.8 - INTENSITY OF USE OF PLATINUM FOR SMALL INVESTMENT VS DEVELOPED COUNTRIES ECONOMIC GROWTH



Demand for small platinum investment bars and coins amounted to 4,5t in 1992 which is only 4 per cent of the total Western World platinum offtake for the year (FIG. 7.6). This is 20 times smaller than the gold coin market.

Palladium coins consume an insignificant amount of total Western World palladium offtake. No statistics are available for empirical analysis in this specialised application.

North America is the largest consumer of small investment platinum demand at 45 per cent of total 1992 Western World offtake followed by Japan at 28 per cent (FIG. 7.7).

FIG. 7.6 - WESTERN WORLD PLATINUM DEMAND, 1992: SMALL INVESTMENT

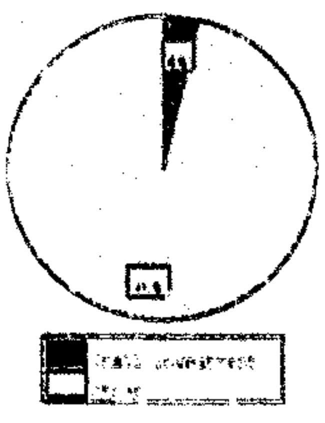


FIG. 7.7 - PLATINUM DEMAND BY REGION, 1992: SMALL INVESTMENT

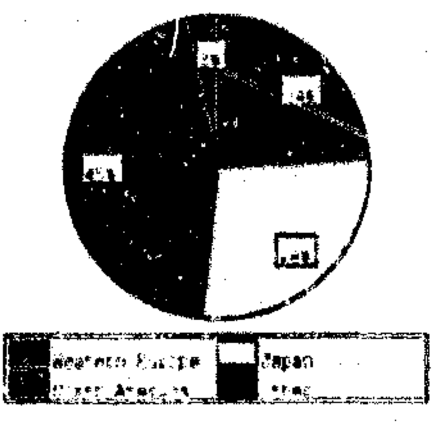


FIG. 7.3 - WESTERN WORLD PALLADIUM DEMAND, 1992: JEWELLERY

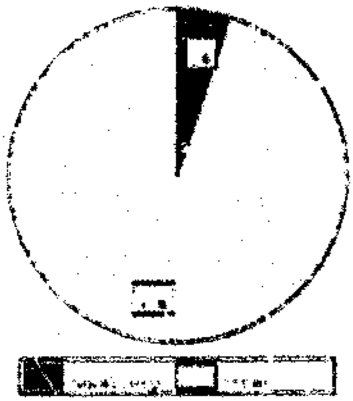


FIG. 7.4 - PALLADIUM DEMAND BY REGION, 1992: JEWELLERY

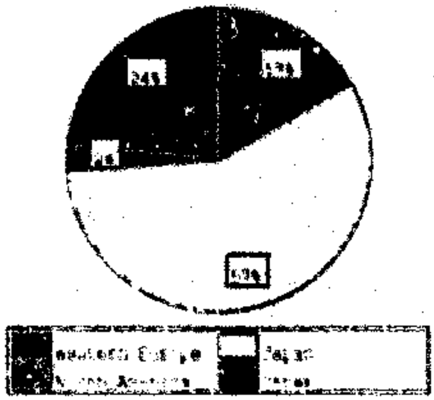
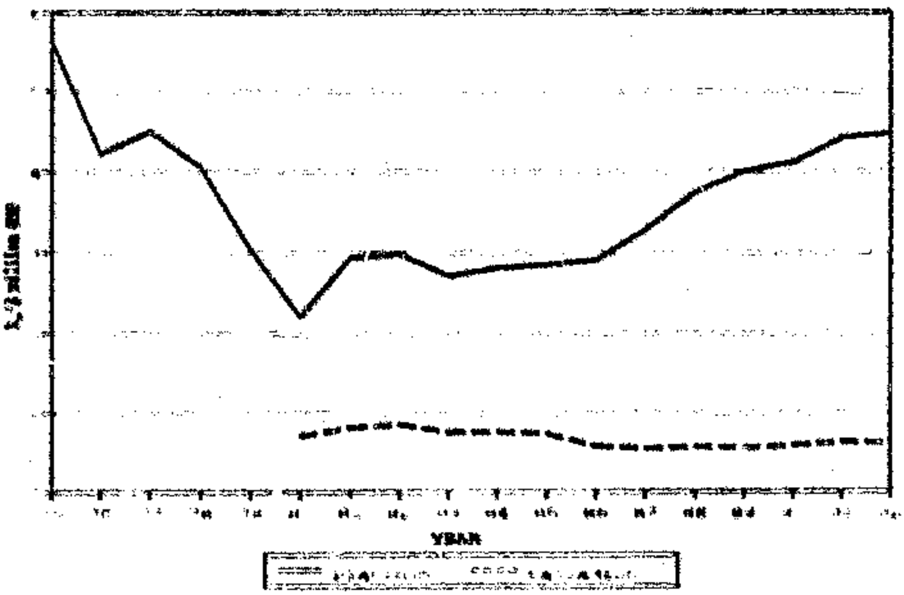


FIG. 7.5 - INTENSITY OF USE OF PLATINUM AND PALLADIUM: JEWELLERY



Palladium, in its pure form has not been promoted in jewellery and has therefore has never shown any growth. The IOU of palladium in jewellery has declined by 1,1 per cent annually and is regarded as being in a saturated life cycle phase (FIG. 7.5).

Growth in world consumption of palladium in jewellery fabrication can only be changed if it could be promoted in its pure form or in some alloy resulting in positive growth. If a substitute was to be found for its principal use as white gold, it would cause a more rapid decline in its IOU than at present. Both prospects, however, seem unlikely in the short term.

FIG. 7.1 - WESTERN WORLD PLATINUM DEMAND, 1992: JEWELLERY

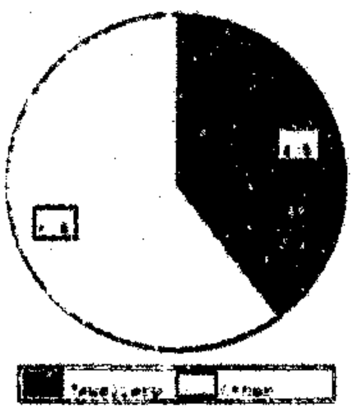
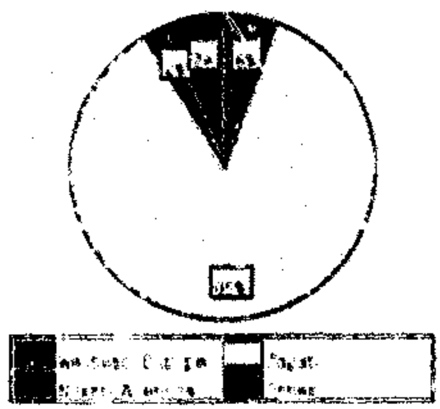


FIG. 7.2 - PLATINUM DEMAND BY REGION, 1992: JEWELLERY



Other palladium coins have come form Bermuda - The Sea Venture, and from the USSR - ten series of commemorative palladium, gold, silver and platinum coins in 1988. This was followed by the Chinese Palladium Panda coin in 1989.

Palladium's hardness makes it a very difficult metal to mint. Excessive damages occur during minting while difficulty also occurs during the blanking process (Diaz, 1989).

Up to now, palladium coinage production has been very limited, and restricted to collectors. The Soviet Union decided to mint the world's first legal tender palladium bullion coin in 1989. It honours the Russian ballet and has given investors the opportunity to invest in this rare metal with its guaranteed industrial demand and accessible price range (Diaz, 1989).

7.3 World Demand

The world's largest consumer of platinum is the jewellery sector at 40 per cent of total 1992 Western World demand (FIG. 7.1) amounting to 47t. Eigthy five per cent of this total was absorbed by Japanese jewellery manufacturers (FIG. 7.2).

The IOU of platinum in jewellery declined at an average rate of 17 per cent each year from 1975 to 1980 (FIG. 7.5). However, this rapid decline reversed after 1980 and the IOU of platinum in the jeweller sector increased at 6,1 per cent per year to 1992.

This renewed growth was the result of successful marketing campaigns by Platinum Guild International (PGI) which concentrated its initial efforts in Japan. The PGI is financed by the 3 platinum producers in South Africa: Rustenburg, Impala and Western Platinum. It is a non-profit organisation based in Switzerland and has recently expanded its promotion of platinum jewellery to the USA, Germany and Italy.

Palladium consumption in the jewellery industry is, however, much smaller at only 5 per cent of the total Western World palladium demand (FIG. 7.3). Once again Japan consumed the largest share at 57 per cent of the total 6,5t used in the jewellery sector during 1992 (FIG. 7.4).

Palladium is used to a much lesser extent than platinum mainly as an alloying component with nickel to manufacture white gold, as well as with platinum in platinum jewellery as mentioned previously in the last 2 categories.

7.2.2 Coins

In an attempt to strengthen the Russian national economy with much-needed funds, legal tender platinum coins were first introduced in 1828. They were issued in three, six and twelve-rouble denominations. These coins weighed 10,55 g, 20,7 g and 41,4 g respectively. Between 1828 and 1846, after which the coins were withdrawn, the mint coined almost 500 000 ozt of platinum (Nathan, 1993).

Only in 1983 did platinum bullion coins re-emerge on the investment market. The first legal tender investment coin to be issued in the 1980s to the public was the Isle of Man Noble followed soon after by the Australian Koala and the Canadian Maple Leaf.

Some other popular platinum coins or medallions include:

(i) Japan, Swan from Tanaka;

(ii) Switzerland, Swiss Shooting Thaler and Hevetia;

(iii) USA, American Prospector from Englehard, Liberty from MTB Banking;

(iv) Hong Kong, Dragon From Johnson Matthey;

(v) Singapore, Dragon, Rabbit and Tiger from the Singapore Mint.

The Kingdom of Tonga produced the world's first palladium coins in 1967. During 1987, two palladium coins entered the market. The first was the French Lafayette issued in conjunction with the second, a Liberty Trade Palladium one ozt piece minted by Engelhard Corporation for MTB Banking.

The reason cited for the primary platinum producers in the country not suppling jewellers directly is that primary producers are committed to large long term contracts and do not find it viable to supply small insignificant and erratic quantities to the local market.

Miltos Voyiatzis Jewellers in Johannesburg is estimated to consume approximately 90 per cent of the local jewellery demand for platinum. What is more, this manufacturer imports the metal from Johnson Matthey PLC in the United Kingdom in the form of bars (Voyiatzis, 1993: *Pers Comm*). The remaining 10 per cent of metal consumed by platinum jewellery manufacturers is obtained from scrap coins and jewellery.

Platinum is harder than gold but relatively easily worked in its pure form. The high purity of platinum jewellery makes it very expensive, limiting the market share to only the wealthy.

Platinum is highly malleable and possess properties of toughness and strength. Platinum alloyed with other metals acquire properties that make it more suitable for use in jewellery. The final processing work of platinum alloys still takes between two and two-and-a-half times longer than that for silver and gold alloys. However, after high-gloss polishing, the particular beauty of platinum jewellery becomes obvious.

There are three broad categories of platinum alloys used in the fabrication of jewellery.

(i) The first are alloys that have good all-round properties. These materials can be used for casting applications, have good mechanical properties and range from soft to hard. In this category are the 950 parts per thousand and higher purity platinum alloys containing copper and cobalt.

(ii) Secondly, there are platinum alloys that have been developed specifically for their excellent casting properties and these include alloys containing palladium and ruthenium.

(iii) Finally, the demand for alloys with good spring properties resulted in the development of slightly more complex alloys, such as those containing gallium and copper, or palladium and gallium.

CHAPTER 7

JEWELLERY AND COINS

7.1 Introduction

The establishment of a significant world jewellery manufacturing industry in South Africa has never been achieved even though the country has the world's largest endowment of precious metals. This chapter investigates, specifically, the prospects of local platinum and palladium jewellery fabrication.

Marketing of Krugerrand gold coins were marred by world sanctions against South Africa in the 1980s. These have fallen away with political change and renewed marketing efforts are in progress. Prospects for platinum and palladium coin sales are investigated in this chapter, in the light of the present unrestricted trade for South African investment coins.

7.2 Applications of Platinum and Palladium in Jewellery and Coins

7.2.1 Jewellery

Although interest in platinum jewellery is starting to grow in Europe and the USA, Japan is still the dominant market. In this Asian country, platinum in its pure form, is used mostly in jewellery fabrication.

South Africa has an insignificant platinum jewellery fabrication industry. It is estimated to have consumed approximately 9 kg of platinum in 1993. This is less than 0.1 per cent of the total 50 077 kg (Coombes, 1994) offtake for the Western World jewellery industry in 1993.

the South African electronics manufacturing industry. Import tariffs also hinder the possibility of export by this country's electronics manufacturers. Until such time these factors change for the better, prospects for the local beneficiation of PGMs in this sector do not look promising.

In summary, the tax will merely burden the primary producers and not directly stimulate the PGM beneficiation industry. The stimulation of a PGM beneficiating industry, therefore, can only be achieved by joint co-operation between the government of the day and the PGM primary producers in a free as possible market economy.

Policy suggestions made by the ANC to provide for the social needs of their voters, by creating and ensuring jobs, have been as follows.

(i) A tax on the export of unprocessed ores as a possible measure to promote domestic beneficiation (Metals Bulletin Monthly, 1993).

(ii) A centralised marketing system for the sale of the country's minerals (Davison, 1993).

(iii) A move towards a system of state ownership of mineral rights which is regarded as the international norm (Metals Bulletin Monthly, 1993).

The last two policy suggestions do not effect the PGM beneficiation industry directly and have only been included to give the reader insight to ANC policy direction. This political player, however, has not yet made any commitment on these suggestions.

The first suggestion concerns the prospects of the PGM beneficiation industry the most and does not seem a practical solution to the problem of providing for the social needs of the under privileged.

Let us assume a tax is imposed on exported refined PGMs and concentrates. This would raise the price of the primary metals above the market related prices resulting in two major repercussions.

Firstly, with higher prices, substitution of PGMs will become more viable. This will result in the eventual decline in demand for PGMs. For the demand/supply balance to re-establish, reduction in supply will follow. A loss of jobs will then occur in the South African PGM mining industry.

Secondly, foreign capital investment for platinum mines will be diverted to countries with lower tax jurisdictions. Platinum deposits on the Zimbabwe Great Dyke will possibly become more favourable investments for international mining companies. South Africa will lose world market share with declining foreign and domestic investment.

It must, therefore, be concluded that to improve the PGM manufacturing industry's competitiveness, a reduction in public costs is required. These could take many different forms such as tax incentives, protection tariffs, regulatory requirements, subsidies, etc, which could contravene GATT. However, venture capital from the Industrial Development Corporation, and funds for R&D through the CSIR may not pose a problem in improving competitiveness. The fuel cell, for example, could benefit from such R&D funds and venture capital.

A problem not mentioned by Tilton (1992) in natural competitiveness is security and ease of supply of raw materials. This applies specifically to the South African PGM manufacturing industry and needs to be overcome for growth in PGM beneficiation to occur.

This problem is specifically prevalent in the chemical and jewellery sectors. It could be solved, however, by a precious metals exchange. Platinum-group metal producers could sell some of their production on the exchange in South Africa to local consumers and even overseas procurement agencies

The South African Precious Metals Exchange could be run on the lines of other commodity exchanges in the world. There is no reason why local PGM producers should pay transport costs to reach commodity markets overseas when their production could be sold on a local market.

This will improve the access to PGMs by the local PGM manufacturing industry and, in turn, their competitiveness.

8.2 Emerging Policy Issues in South Africa

From a political point of view, as South Africa moves into a new era of dispensation, a number of changes in the minerals industry have been mooted by the African National Congress (ANC). The country's minerals industry is not expected to be nationalised under an ANC government, but increased control will definitely be the order of the day.

TABLE #2 - TOTAL SALES AND ESTIMATED LOCAL CONSUMPTION OF PLATINUM GROUP METALS FOR SOUTH AFRICA, 1993

SECTORS	SOURCE	PGMs (kg)
Autocatalysts	primary	2 196
Chemicals and other	primary	1 000
Electrical and electronic	primary	Included in chemicals and other
Jewellery and coinage	imported	9
Total local consumption		3 205
Total sales by primary producers		153 711

This lack of local PGM manufacturing industry competitiveness resulted from non-existent demand for these products at the time of the first primary metal production in South Africa. The primary producers, therefore, had to sell there metals overseas where the demand for their metals existed. The local PGM manufacturing industry has since been neglected as there has been no free market need to develop such an industry in South Africa.

The first sign of large scale sustainable development in the beneficiation of PGMs was in autocatalyst manufacturing. This was brought about indirectly by the Governments' Phase VI incentive scheme for the motor industry. Government intervention has, therefore, played an indirect role in a PGM manufacturing industry. The less significant local consumers of PGM, for example jewellery and chemicals, have managed to establish production through free market forces of demand and supply. They have not succeeded, however, as growing suppliers to the local and export markets.

(ii) Low capital costs.

(iii) Skilled labour force.

(iv) Well developed infrastructure.

(v) Geographical location to major markets and concomitant lower transport costs.

(vi) Down stream in the production process from mining to beneficiated goods, the link between mineral endowment and output becomes weaker.

(vii) Mineral endowment changes over time with exploration and technological change.

(viii) A multitude of public policies affect costs of production.

The South African PGM industry is a prime example of this point made by Tilton (1992). The country's large PGM endowment has not improved the competitiveness of its PGM beneficiation industry which is significantly small by world standards (TABLE 3.2). The platinum mines and refineries, however, have the largest market share and, therefore, are most competitive. This illustrates two main points that endowment is important in competitiveness but downstream from mining to beneficiated goods, the link becomes weaker. Table 8.2 high lights this point with figures from the Minerals Bureau (1994) and in chapters 4 to 7, by means of total sales and local consumption of PGMs for South Africa in 1993.

The South African electronics manufacturing industry caters for a small specialised clientele and has a very small world market share. For it to increase its apparent competitiveness it will either have to reduce its natural costs or public costs or both. Wages, which are usually the largest part of any manufacturing cost, have generally more than kept up with inflation in South Africa. Inflation in South Africa has been far higher than the industrial countries and so reduction in the natural costs of local firms are limited. The only way for these firms to gain apparent competitiveness would be through a fall in public costs.

For the South African jewellery sector, high labour and transport costs due to long distances to markets have been cited as the main lack of natural competitiveness. Public costs were reduced in 1990 by the abolition of the *ad valorem* excise duty of 20 per cent imposed on the sale of both locally produced and imported jewellery (Axsel, Bulmer and Schreuder, 1992). To improve apparent competitiveness, public costs will have to be lowered even further in the form of incentives from the government.

It must, however, be noted that the General Agreement on Tariffs and Trade (GATT) will have to be adhered to if trade with member countries is to be on a sound footing. Protection tariffs and government subsidies could contravene this agreement.

A final factor in considering the prospects of a domestic PGM manufacturing industry, which is related to competitiveness, is mineral endowment.

The traditional view stresses the importance of natural costs and in particular high quality, low cost mineral deposits (large endowment), in the determination of competitiveness. From this point of view, South Africa would be the most competitive in products manufactured containing PGMs in the world since it has the largest natural endowment (TABLE 3.1) of these metals.

Tilton (1992), however, is quick to point out that abundant, high quality mineral resources and deposits are important but are over emphasised and is not the only significant determinant of competitiveness. Numerous factors also influence competitiveness.

(i) Low energy costs.

8.2 South Africa's Competitive Position

Competitiveness is a measure of market share and is largely based on cost of production (Tilton, 1992). A firm with low unit production costs would likely have a large share of the market and, therefore, be more competitive than a firm with higher unit production costs and a smaller share of the market.

Two types of production costs can be distinguished (Tilton, 1992: 238).

(i) Natural costs which cover expenses associated with labour, capital and other essential factors of production.

(ii) Public policies costs includes the costs of royalties, income taxes, tariffs, regulatory requirements and other government policies.

Natural costs and public costs allows for further division of competitiveness into apparent and natural competitiveness. Apparent competitiveness reflects both natural competitiveness, which is based solely on natural costs, and the effects of public policy (Tilton, 1992: 238 - 239)

Taking competitiveness into account, the prospective applications of PGMs, viz.: autocatalysts, electrical, electronic and jewellery are now discussed in a South African context.

The reason for the establishment of the two autocatalytic plants in South Africa have been due to the Phase VI incentive scheme. This scheme applies to the motor-car manufacturers, as explained in Chapter 3, and does not reduce the autocatalytic manufacturers' public costs resulting in improved apparent competitiveness. Natural costs are low enough for these firms to enjoy a natural competitiveness and gain a world market share.

In the electrical industry, fuel cell commercialisation in the industrial countries presently enjoys apparent competitiveness due to government subsidies for R&D. A similar arrangement will be needed for a South Africa fuel cell project to be competitive. A willing local private enterprise will, therefore, need government funding to succeed.

External factors such as advertising, new applications, substitution and more efficient use of metals must all be taken into account in determining a metals outlook for world demand. Table 8.1 summarises current IOU life cycle phases for the application of platinum and palladium in the various sectors as previously discussed.

TABLE 8.1 - SUMMARY OF IOU LIFE CYCLE PHASES BY SECTOR

SECTOR	METAL	LIFE CYCLE PHASE	GROWTH RATE
Jewellery	Platinum	growth	+6,1
	Palladium	saturated	-1,1
Petroleum	Platinum	decline	-4,4
Chemical	Platinum	decline	-5,3
Glass	Platinum	saturated	r = 0,4
Dental	Palladium	mature	+3,1
Electronic	Palladium	growth	+7,3
Electrical	Platinum	initial	-4,4
Coinage	Platinum	saturated	r = 0,5
Autocatalyst	Platinum	growth	+5,1
	Palladium	initial	+25,3

Note: r is the correlation coefficient with economic growth of developed countries.

From the point of view of the domestic PGM manufacturing industries, not only is outlook for world demand as determined by IOU important, but competitiveness becomes an important point to consider as well.

expected to grow with ever increasing new applications for electronics being found. The possibility of South Africa taking part in this growth does exist, skills and costs of production permitting.

The potential for South Africa in generating electricity with fuel cells, which uses platinum as a catalyst, is limited in the short term due to the 8 000 megawatt surplus generation capacity of Eskom. This will change in the medium term (20 to 50 years) once the excess capacity has been utilised.

The IOU curve of platinum in the electrical industry (FIG. 6.5) is in the initial life cycle phase. Once commercialisation of the fuel cell gets underway in the beginning of the next century the IOU curve will enter a growth phase. It is the author's opinion that South Africa must begin R&D as soon as possible, in order to establish a manufacturing facility by early next century if it wishes to be in a position to take advantage of this expected growth.

There are large companies and government institutions, such as the mining houses and Eskom, which could raise the capital to foster a fuel cell project with a potential domestic and overseas market by the year 2000. Expertise, however, will have to be imported form Japan, North America or Europe. A project like this can benefit both the primary platinum producers in terms of developing a demand for platinum from local sources and the country as a whole, as far as employment and foreign exchange earnings are concerned.

The autocatalyst industry shows the biggest potential for the local beneficiation of PGMs. The IOU curve of platinum is in the growth phase, while for palladium, it is still in the initial phase (FIG. 4.5). This situation has been created by world environmental concerns over the pollution of the global atmosphere.

Whatever new technology is developed for autocatalysts, it is expected that platinum, palladium and rhodium will still be used, either individually or in some combination. The growth in the use of these metals for autocatalysts will continue into the next century as environmental legislation on vehicle emissions in the world proliferates and becomes more stringent. Although substitution may occur, this appears at present to be only a medium term possibility, as it should have occurred by now if any other material was readily available.

The IOU of platinum in the chemicals industry is harder to forecast. It has seen a long term declining phase (FIG. 5.2) which could be reversed by some not yet utilised new application. In the sort term though, use of platinum in the chemicals industry is expected to continue to decline leaving little hope for South African prospects of increased involvement.

In the glass fibre manufacturing industry, world economic cycles are found to influence the use of platinum. This relationship suggests that platinum is in a saturated life cycle phase of its IOU (FIG. 5.3). External factors such as substitution or more efficient use of the metal can change the IOU to a declining phase and renewed growth, therefore, is not expected in the near future.

South African industrialists, however, could gain a share of the market in manufacturing equipment for the production of glass fibre that uses platinum and rhodium more efficiently. This would benefit glass fibre manufactures by reducing their production costs while allowing local industrialists to gain a share of the market in beneficiating PGMs into equipment used for glass fibre manufacturing.

A second example showing the IOU of platinum in a saturated life cycle phase is in coinage (FIG. 7.8). The correlation between economic growth and IOU of platinum in coins is not perfect but its positive nature indicates that these coins are traded according to world economic perceptions. A renewed and sustained growth phase could only be achieved by successful advertising to inform the public and create demand and increased participation in a new investment medium.

The IOU curve for palladium in the dental sector (FIG. 7.5) shows that it is in a mature phase approaching saturation. Long term (greater than 50 years) growth is not expected in the future and substitution by cheaper base metals is more likely to result in a decline in the use of the precious metal. Fears of health problems from base metal substitutes should not play a major role as research should establish suitable base metals for dental use.

The IOU of palladium in the electronics industry has been in a growth phase (FIG. 6.5) over the last 12 years. Future growth is set to continue as the world's electronics industry itself is

CHAPTER 8

DISCUSSION

8.1 Intensity of Use

During this investigation it was found that a specific mineral could go from a declining phase in its life cycle back into a new growth phase. The use of platinum in jewellery manufacture is one such example (FIG. 7.5). Through advertising campaigns by Platinum Guild International, the IOU of platinum in the jewellery sector increased from 1980 to 1992 from a previous declining phase. This observation, therefore, indicates that in the short term (1 to 20 years) external factors can reverse a metals life cycle phase.

The increase in the use of platinum in jewellery fabrication is expected to continue for at least the short term into the next century as advertising by the Platinum Guild International shifts its efforts to Europe and North America. The prospects of South African involvement in world platinum jewellery manufacture is very positive from this point of view.

The use of palladium in jewellery is not expected to show any growth and will remain in its saturated phase of IOU (FIG. 7.5) as no new alloys or substitution is foreseen in the near future.

A second example of renewed growth occurred in the petroleum and chemical industries where the sudden increase in demand for MTBE resulted in an increase in the use of platinum for catalysis from 1986 (FIG. 5.2). The increase in demand for MTBE was brought about by the change in peoples' needs from leaded to unleaded petrol. Once new refining capacities have been established, declines in the IOU of platinum in these industries will resume.

The renewed growth phase in the IOU of platinum in the petroleum industry was very short term and the long term declining phase is expected to continue. The next century will see a need for "zero emission vehicles" reducing the demand for petrol, and so the room for growth for South African companies to produce PGM catalyst products for the petroleum industry is weak.

(iii) Doubts about the marketability of platinum and palladium coins as they are not well known to the general public.

(iv) Return on precious metal coins have not always been attractive.

(v) Premiums per coin fall during periods of low precious metal price levels.

The gold coin market is more than 20 times larger than the platinum bullion coin market. Palladium is even smaller and consumes an insignificant amount of total Western World palladium demand.

Extensive market research and advertising campaigns are needed by institutions such as the Chamber of Mines, to inform the public both locally and abroad in the potential of platinum and palladium investment coins. Taking the success of the Krugerrand in the early 1980s into account, prospects for increased sales of platinum and palladium coins appear to be good.

TABLE A3 - PLATINUM AND PALLADIUM DEMAND BY SECTOR, 1975 - 1992

Year	Autocatalyst		Electrical		Jewellery		Chemical	Glass	Petroleum	Dental	Small Investment
	Pt(kg)	Pd(kg)	Pt(kg)	Pd(kg)	Pt(kg)	Pd(kg)	Pt(kg)	Pt(kg)	Pt(kg)	Pd(kg)	Pt(kg)
1975	11 197,2		6 998,3		37 645,3		10 730,7	2 021,2	5 132,1		
1976	15 240,7		7 464,8		29 548,3		8 709,0	2 954,8	2 799,3		
1977	14 152,1		8 709,0		32 658,7		11 819,3	3 421,4	3 732,4		
1978	19 595,2		6 220,7		30 637,0		10 575,2	5 909,7	5 287,6		
1979	27 993,2		7 464,8		23 794,2		10 730,7	7 775,9	4 976,6		
1980	21 150,4	9 331,1	6 531,7	18 351,1	17 418,0	5 598,6	8 086,9	4 354,5	4 043,5	19 284,2	
1981	19 906,3	8 397,9	5 754,2	24 882,8	23 483,2	6 531,7	7 775,9	3 110,4	4 354,5	14 929,7	
1982	20 061,8	9 020,0	5 287,6	26 127,0	23 794,2	6 842,8	8 086,9	2 643,8	2 021,7	18 351,1	1 399,7
1983	19 122,7	9 331,1	5 443,1	34 524,9	22 239,0	6 220,7	7 620,4	3 265,9	622,1	25 504,9	2 799,3
1984	24 727,3	9 953,1	5 909,7	38 257,3	24 105,2	6 531,7	8 086,9	4 354,5	466,6	27 993,2	5 287,6
1985	28 304,2	9 020,0	6 220,7	34 213,9	25 193,9	6 531,7	6 998,3	4 354,5	466,6	27 060,1	8 086,5
1986	32 658,7	6 998,3	5 598,6	41 056,6	26 438,0	5 287,6	6 065,2	2 799,3	622,1	28 770,8	13 996,6
1987	35 458,0	6 842,8	5 598,6	48 988,0	30 792,5	5 132,1	6 065,2	3 732,	1 710,7	29 703,9	6 687,3
1988	35 924,6	6 065,2	5 754,2	53 031,5	36 702,2	5 598,6	4 976,6	4 043,5	1 555,2	30 948,0	19 264,2
1989	39 812,5	6 065,2	6 065,2	51 476,3	40 434,6	5 598,6	5 132,1	4 354,5	2 332,8	30 948,0	4 043,5
1990	41 056,6	7 153,8	6 376,2	52 098,4	42 456,3	6 065,2	6 687,3	4 199,0	4 354,5	31 725,6	3 110,4
1991	41 989,8	8 398,0	5 443,1	57 697,0	45 722,2	6 531,7	7 464,8	3 732,4	4 665,5	36 235,6	5 443,1
1992	40 590,1	12 596,9	5 132,1	56 919,4	46 966,3	6 531,7	6 687,3	2 488,3	3 732,4	37 168,7	4 510,0

Source: Johnson Matthey, 1986 - 1993

TABLE A2 - INDUSTRIAL COUNTRIES GDP, INDEXED AND IN USA DOLLARS, 1970 - 1992

Year	Index	$ billion	% change
1970	65,6	5 797,15	
1971	67,8	5 991,56	
1972	71,2	6 292,02	
1973	75,3	6 654,35	
1974	76,0	6 716,21	
1975	75,8	6 698,53	-0,2
1976	79,3	7 007,83	4,7
1977	82,2	7 264,11	3,6
1978	85,5	7 555,73	4,0
1979	88,5	7 820,84	3,5
1980	89,3	7 891,54	0,9
1981	90,4	7 988,75	1,3
1982	90,3	7 979,91	-0,1
1983	92,7	8 192,00	2,6
1984	[illegible]6,9	8 563,16	4,5
1985	100,0	8 837,11	3,2
1986	102,7	9 075,71	2,7
1987	106,0	9 367,34	3,7
1988	110,7	9 782,68	4,4
1989	114,2	10 091,98	3,2
1990	116,8	10 321,75	2,3
1991	117,2	10 357,10	0,4
1992	118,9	10 507,33	1,4

Source: International Monetary Fund, 1993

APPENDIX A

TABLE A1 - INDUSTRIAL COUNTRIES GDP, 1985

	Country	GDP in domestic currency (bil.)	Exchange rate Domes. cur./$	GDP in $ billion
1	Australia	229,63	1,4269	160,93
2	Austria	1 348,40	20,6900	65,17
3	Belgium	4 795,00	59,3780	80,75
4	Canada	477,99	1,3655	350,05
5	Denmark	615,10	10,5960	58,05
6	Finland	334,99	6,1979	54,05
7	France	4 700,10	8,9852	523,09
8	Germany	1 834,50	2,9440	623,13
9	Greece	4 617,80	138,1200	33,43
10	Iceland	114,41	41,5080	2,76
11	Ireland	17,79	0,9384	18,96
12	Italy	810 580,00	1 909,4000	424,52
13	Japan	321 556,00	238,5400	1 348,02
14	Luxembourg	205,30	59,3780	3,46
15	New Zealand	45,43	2,0064	22,64
16	Netherlands	418,20	3,3214	125,91
17	Norway	500,20	8,5972	58,18
18	Portugal	3 523,90	170,3900	20,68
19	Spain	28 201,00	170,0400	165,85
20	Sweden	864,99	8,6039	102,44
21	Switzerland	228,00	2,4571	92,79
22	UK	357,27	0,7714	463,14
23	USA	4 038,70	1,0000	4 038,70
	Total			8 837,11*

Source: International Monetary Fund, 1993

Note: * This total is used to convert the indexed GDP figures in table A2 to US dollar figures. Where GDP was not available the GNP was used for that country.

other commodity exchanges in the world. It would not only promote local beneficiation in these applications indirectly, but also attract foreign commodity traders to this country.

The millions of dollars allocated to promotion institutes overseas such as Platinum Guild International in the USA should rather be channelled to these projects which will certainly benefit the country's PGM industry more.

The philosophy behind these three recommendations is to ensure the importance of the country's PGM industry and to develop it to its full potential. There is no plausible reason not to develop it and be only the miners of the raw metals in the world. The country's mines should not need to sell their production on commodity exchanges overseas. Procurement agents should come do there business in South Africa.

CHAPTER 10

RECOMMENDATIONS

Three recommendations can be made from this study to improve the beneficiation of the country's PGMs. The first is a fuel cell programme.

The use of platinum in fuel cells is regarded as entering the initial phase of its IOU life cycle. Fu[illegible] [illegible] pre-commercialisation stage. It is, therefore, recommended that a local fuel c[illegible] [illegible] government intervention to start a R&D programme as in Japan and the U[illegible] South Africa can import already developed technology and capital can be obtained from government research grants and private enterprise. A project of this nature should involve the platinum mines, Eskom and the CSIR.

South Africa needs to take advantage of this burgeoning application for platinum to add value to the metal, create further demand and develop an alternative environmentally clean source of electricity.

Secondly, it is recommended that joint ventures be negotiated between platinum producers, Mintek and jewellery manufacturers. Resources such as capital funds, already developed platinum alloy technology and jewellery fabrication skills can be pooled. All the members of such a joint venture would benefit as further platinum demand is created and money spent on developing alloys is repaid with returns.

Reasons for the lack of growth in the local platinum jewellery industry are import duties, keeping pace with fashion trends in diverse markets, special manufacturing equipment costs and distance to export markets. Most of these problems can be overcome by such a joint venture project.

Thirdly, the lack of competitiveness in the local jewellery and chemical industries is partly due to poor security and ease of supply of relatively small quantities of PGMs. A recommendation to solve this problem is the creation of a South African precious metals exchange operating like

Lastly, in the South Africa's jewellery industry, competitiveness also needs to be improved by reducing public policy costs subject to GATT regulations.

In 1993, it was estimated that the South African PGM manufacturing industry consumed a total of 3 205 kg of these metals. This is only 2,1 per cent of the total sales of PGMs by the country's primary producers illustrating the need to increase competitiveness for the PGM manufacturing industry.

Competitiveness will change, however, as policy issues come to light with the new South African government. The ANC has indicated a policy of promoting beneficiation in the form of a tax on the export of unprocessed ores. This would increase the price of these exports. Substitution might then occur reducing the demand for PGMs, resulting in a cutback in mine production. Job losses will become a problem in the country's platinum mines if this had to occur, contrary to what the ANC ultimately intends achieving.

Platinum deposits in other parts of the world will become more attractive for mining investment if South Africa's tax policy becomes unfavourable. A loss of market share in PGM production for the country's platinum mines will then arise.

In closing, this project has succeeded in identifying areas of growth in South Africa's PGM manufacturing industry, viz.: autocatalysts, fuel cells, jewellery and electronics, with consideration to world growth and local competitiveness. Due to the scope of the topic, this project was unable to conduct extensive research on these four individual applications for PGMs. Such studies should be considered, therefore, for the future of the industry.

Platinum is entering an initial phase of its life cycle in the use of fuel cells for the generation of electricity. Palladium, however, is well established in an initial phase of its IOU in the autocatalyst industry and will soon enter a growth phase.

These sectors of PGM applications should be concentrated on by the PGM manufacturing industry of South Africa in order to increase local beneficiation. The other applications such as palladium jewellery, petroleum, chemical, glass, dental and even coins are either in a mature, saturated or declining life cycle phase of their IOU.

Some PGM applications, however, could be revived into a new growth phase either by technological change or through awareness campaigns. In the latter case, coins or palladium jewellery could be promoted through advertising. Technological change would be required for the other sectors to create renewed growth in the IOU of PGMs. An example of this was the new demand for unleaded petrol which caused the petroleum industry to change refinery processes creating a surge in demand for platinum from 1988 to 1991.

Turning to the application of PGMs with the highest potential of growth, viz.: autocatalysts, fuel cells, electronics and jewellery, an examination was undertaken of South Africa's competitive position in the world market.

In the first case, the country's autocatalyst manufacturers have a small world market share but are ready to expand to full production and are able, therefore, to compete in this growing world market. This is the only local PGM manufacturing industry where growth is occurring and is competitive with the world market.

Secondly, a fuel cell project requires government subsidies to initiate a R&D programme and technology needs to be imported for South Africa to be competitive with Japan, the USA and other developed countries.

Thirdly, the local electronics industry has an insignificant world market share. It requires reduced public policy costs to improve international competitiveness. This could take the form of tax incentives, protection tariffs and regulatory requirements all of which could contravene GATT.

Several reasons have been cited for the lack of growth in the local platinum jewellery manufacturing industry. These are import duties, keeping pace with fashion trends in diverse markets, special manufacturing equipment costs and distance to export markets.

The world's largest consumer of platinum is the jewellery sector at 40 per cent of the total Western World offtake in 1992. The IOU of platinum averaged an annual growth rate of 6,1 per cent since 1980. Jewellery represents a definate growth area, especially in Japan which consumed 85 per cent of total platinum demand in the fabrication of jewellery for the Western World in 1992.

Only 5 per cent of total Western World demand for palladium was used in jewellery fabrication during 1992. It is regarded as being in the saturated phase of its IOU life cycle with an annual average decline of 1,1 per cent.

In the investment sector, South Africa has not been known to have minted platinum or palladium coins and so no attempt has been made to enter this market as yet.

A market analysis would be required before South Africa considers minting platinum and palladium coins. Factors such as supply of metal, fly-wheel borrowing costs, marketability, returns on investment in precious metal coins and the premium on such coins will have to be considered.

Small investment in the form of coins and bullion bars consumed only 4 per cent of Western World platinum demand in 1992. The IOU of this sector is related to the world economic cycles and growth can only be expected with world economic growth.

After having discussed the major uses of PGMs, it can be deduced using the IOU methodology, world growth industries for the application of platinum are jewellery and autocatalysts. In the application of palladium, the electronic industry is also in a growth phase of its IOU life cycle.

The electronics industry consumed 47 per cent of Western World palladium supply in 1992. The IOU of palladium in this sector is in a growth phase with a rate of 7,3 per cent on average per year since 1980. This trend is expected to continue into the next century.

The ability of the local electronics industry to compete with severe international competition depends on fiscal policies, natural costs and foreign investment. World trade policies on tariffs and duties also need to be addressed before this local PGM manufacturing industry can expand.

A potential growth area for platinum in the generation of electricity is in fuel cells. This is one of the cleanest forms of energy. If its reliability, cost effectiveness and competitiveness with other forms of energy is proved, rapid commercialisation will take place in the second half of the 1990s.

The consumption of platinum in the electrical and electronics industries amounted to only 4 per cent of the total Western World demand in 1992. The IOU of platinum in these industries collectively declined by 4,4 per cent on average per year since 1975. However, with the likely commercialisation of fuel cells in the second half of this decade, it is predicted that platinum will enter the initial growth phase in its IOU life cycle for electrical applications.

The future of fuel cells in South Africa in the medium term is not prosperous for two main reasons. Firstly, there is a 11 000 megawatt surplus electricity generation capacity in Southern Africa and secondly, there is no present R&D programme for fuel cell in the country. The technology and R&D programmes are in the developed countries, with Japan and the USA being the most advanced. South Africa needs to start its own programme to take advantage of this burgeoning application for platinum.

The final application of PGMs discussed was the jewellery and coinage sectors. Potential for growth does exist but requires entrepreneurial initiative.

It is estimated that only 9 kg of platinum was used in the fabrication of jewellery in South Africa during 1993, virtually all of which was imported from Johnson Matthey in the United Kingdom. This is not even 0,1 per cent of the total Western World demand for platinum in the jewellery sector.

The petroleum and chemical industries of the world are in a declining life cycle phase of their IOU curves. A negative annual average growth rate of 4,4 per cent was calculated for the petroleum industry. The chemical industry showed a negative growth rate of 5,3 per cent per annum. The glass industry is in a saturated phase of its IOU with a negative 1,4 per cent annual average growth rate.

The dental industry, however, showed a 3,1 per cent annual growth rate in the IOU of palladium. Thirty one per cent of the total Western World palladium demand was consumed by the dental industry in 1992 and is considered to be in the mature phase of its IOU life cycle.

Growth in the demand for platinum/rhodium and palladium gauzes for the production of nitric acid in South Africa is not expected in the near future. Nitric acid is used as a feedstock for fertilizers and mining explosives. The production of both these products has fallen due to frequent droughts during the 1980s and an effort by the mines to reduce costs due to falling world metal prices in recent years. Import duties and severe international competition hinders the export potential for local manufacturers of gauzes and PGM chemicals.

The local glass industry is too small to manufacture PGM alloy equipment. Export potential is also limited as this is not a world growth industry and is dependent on global economic trends.

Palladium dental alloys are a mature industry and show no real potential for growth. Export potential does exist, however, for South African manufacturers to countries where these alloys are used by their national health schemes such as in Japan and Germany.

Electronic and electrical applications for PGMs was the third sector discussed and showed growth for the former application and burgeoning growth for the latter.

The only manufacturer of electronic components in South Africa is Sames (Pty) Limited. They use a negligible amount of PGMs. Since its establishment it has not competed with the large, mass producing international electronics companies and has not shown any significant signs of expansion into the world market. It caters only for a small local niche market.

much higher rate of 25,3 per cent per annum since 1989. As the need to control air pollution in the world increases, so the IOU for both these metals will increase until the year 2000, after which maturity in this industry is reached.

At present, the local autocatalyst plants are producing under their full capacity of 2,1 million units. They are, therefore, ready to meet the increase in demand of both the local and overseas markets. South Africa will begin to use autocatalysts only from 1995 when lead free petrol becomes available.

For 1993, it was estimated that 2 196 kg of platinum and rhodium was consumed by the country's autocatalyst manufacturers. This is only 1,4 per cent of the 153 711 kg of total sales of PGMs from the primary producers in 1993 and is in contrast to zero consumption of PGMs from this industry before 1989.

It is quite clear that this local PGM manufacturing industry is established and will continue to grow with no further need for government incentives.

Chemical and other related uses of PGMs was the second application discussed and showed no promise for world growth. This chapter subdivided the applications into petroleum, chemical, glass and dental sectors.

In this local industry, there is very little consumption of PGMs. It is estimated that only 1 000 kg was consumed in 1993 and very little growth is foreseen in present world economic conditions. There are only two players in the local market, Johnson Matthey (Pty) Ltd and PGM Chemicals (Pty) Ltd.

The local market for PGM products such as chemicals, platinum/rhodium catalytic gauzes, cancer drugs, pigment and rhodium "syrups", for electroplating, is very small. Most of South Africa's production of these products is exported

The three industries which consume these PGM products namely, chemical, glass and petroleum, amounted to only 6, 2 and 3 per cent of total Western World platinum demand respectively, in 1992.

CHAPTER 9

CONCLUSION

The PGMs account for the second highest foreign exchange earned (R4 821 million in 1992) by the minerals industry of South Africa. In 1993, exports accounted for 98 per cent of the total sales of PGMs of which the largest portion is committed to long-term export contracts of undisclosed quantities. An estimated 3 205 kg of PGMs was consumed by the local PGM manufacturing industry of the total 153 711 kg sold in 1993. Beneficiation, therefore, is at a very low level considering the country's dominance in world production of PGMs.

South Africa and Russia produce by far the majority of the world PGMs at 54 and 37 per cent respectively (TABLE 3.1). If Russian sales of PGMs continue to decline and if the country's economic situation does not improve, South Africa will increase its advantage as a world PGM producer.

This project identifies areas of improvement in beneficiating PGMs. The concept of IOU was used to study the four main sectors of application to establish areas of growth. These sectors included autocatalysts, chemical and allied, electronics and electrical, and jewellery and coinage.

The first sector investigated in this study was the autocatalyst industry. Two manufacturing plants were established in South Africa since 1989 due to the incentive of the Phase VI local content scheme for the motor industry. Exported autocatalysts qualify under the category of "export earnings" for a rebate on the 40 per cent rebateable excise duty based on the wholesale price of a locally manufactured vehicle.

In the Western World, offtake for platinum in the autocatalyst industry amounted to 34 per cent in 1992. For palladium, however, only 10 per cent of total Western World demand was consumed by this industry.

The IOU of platinum in the Western World is in a growth phase for autocatalysts at an annual average rate of 5,1 per cent. Palladium, on the other hand, is in an initial growth phase with a

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TABLE A4 - INTENSITY OF USE FOR PLATINUM AND PALLADIUM, 1975 - 1992

Year	Autocat comm.		Electrical		Jewellery		Chemical	Glass	Petroleum	Dental	Small investment
	IOU Pt	IOU Pd	IOU Pt	IOU Pd	IOU Pt	IOU Pd	IOU Pt	IOU Pt	IOU Pt	IOU Pd	IOU Pt
1975	1,6722		1,0451		5,6203		1,6025	0,3019	0,7664		
1976	2,1755		1,0656		4,2179		1,2432	0,4218	0,3996		
1977	1,9489		1,1993		4,4974		1,6276	0,4712	0,5140		
1978	2,5943		0,8236		4,0561		1,4001	0,7824	0,7880		
1979	3,5805		0,9548		3,0434		1,3725	0,9946	0,6365		
1980	2,6810	1,1828	0,8280	2,3262	2,2079	0,7097	1,0251	0,5520	0,6125	2,4445	
1981	2,4926	1,0516	0,7205	3,1158	2,9405	0,8179	0,9737	0,3895	0,5453	1,8695	
1982	2,5149	1,1307	0,6628	3,2752	2,9827	0,8578	1,0137	0,3314	0,2534	2,3004	0,0698
1983	2,3358	1,1744	0,6647	4,2159	2,7156	0,7556	0,9305	0,3988	0,0760	3,1144	0,1463
1984	2,8886	1,1627	0,6904	4,4691	2,8159	0,7630	0,9447	0,5067	0,0545	3,2708	0,2138
1985	3,2039	1,0210	0,7042	3,8729	2,8519	0,7394	0,7922	0,4929	0,0528	3,0631	0,2857
1986	3,5997	0,7714	0,6171	4,5253	2,9140	0,5828	0,6685	0,3085	0,0686	3,1711	0,4286
1987	3,7865	0,7307	0,5979	5,2314	3,2883	0,5481	0,6477	0,3986	0,1827	3,1721	0,1886
1988	3,6735	0,6202	0,5884	5,4227	3,7530	0,5725	0,5067	0,4135	0,1590	3,1646	0,2857
1989	3,9463	0,6012	0,6012	5,1024	4,0079	0,5549	0,5087	0,4316	0,2312	3,0676	0,1016
1990	3,9790	0,6933	0,6180	5,0491	4,1146	0,5878	0,6481	0,4069	0,4220	3,0747	0,0758
1991	4,0555	0,8211	0,5257	5,5726	4,4160	0,6309	0,7210	0,3605	0,4506	3,4996	0,1296
1992	3,8643	1,1993	0,4686	5,4189	4,4713	0,6218	0,6366	0,2369	0,3553	3,5386	0,1111

Note: Calculated from tables A2 and A3.