Report R104/2013

OVERVIEW OF SOUTH AFRICA'S TITANIUM INDUSTRY AND GLOBAL MARKET REVIEW, 2012

Key features between 2002 and 2011

DIRECTORATE: MINERAL ECONOMICS

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Mineral Resources
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1. ABSTRACT

This report looks at the titanium value chain and global titanium markets with the focus on the South African industry. It features market prices, supply and demand conditions and major producing countries and companies. It presents the world market review of titanium mineral concentrates, titanium dioxide pigments and titanium metal sponge in the period between 2002 and 2011. Properties, applications, and manufacturing technologies are covered in this report. Developments and opportunities in South Africa's titanium beneficiation are also explored.

2. INTRODUCTION

Titanium, the ninth most abundant element in the Earth's crust, was discovered in 1791, much later than other metals. It is the fourth most abundant structural metal after aluminium, iron and magnesium. Pure titanium metal was first extracted in 1910 and its industrial use began in the 1950s, mainly as structural material and it was during this time that the metal was dubbed "The Wonder Metal of the Age". It was first used in dentistry and in surgery in the 1940s and 1950s respectively and as an implant material in the 1960s.

Titanium occurs in nature as a chemical compound, in association mostly with oxygen and iron. It occurs in about 45 different minerals, but most commonly as ilmenite, rutile and titanomagnetite. Ilmenite ($FeO.TiO_2$) and rutile (TiO_2) are the most important economic titanium minerals. The titanium dioxide (TiO_2) content in ilmenite ranges from 35 to 65 percent, while rutile concentrates contain 92 to 95 percent TiO_2. However, ilmenite supplies approximately 90 percent of the world demand for titanium minerals. Ilmenite is usually beneficiated to produce synthetic rutile or titaniferous slag. Titanium slag with TiO_2 content of 75 – 95 percent is produced commercially using pyrometallurgical processes.

Titanium occurs in heavy mineral deposits on the shores of lakes, rivers and oceans. In 2011, world titanium reserves were dominated by China (200 Mt), Australia (118 Mt), India (92 Mt) and South Africa (71 Mt) which together accounted for about 70 percent of world reserves. South Africa is the second largest producer of titanium-containing minerals in the world after Australia.

The country's output of 1.16 Mt in 2011 contributed 17.3 percent to total global production of 6.40 Mt.

Titanium metal has a high strength-to-weight ratio, with its strength similar to that of steel but 45 percent lighter. It is twice as strong as aluminium but only 60 percent heavier. These remarkable properties result in titanium being the metal of choice for a wide range of applications mainly in sectors such as aerospace, automotive, power generation, defense, chemicals, sporting goods, dental and medical. Titanium is the most biocompatible of all metals because it is inert in the human body, compatible with bone growth, strong, flexible and can withstand harsh conditions of bodily fluids. These properties make titanium suitable for implantation in human body.

Only about 5 percent of titanium content of global mine production is used for metal production and 95 percent is used in the manufacture of TiO_2 pigments. Because of its opacifying and whitening properties, together with its inertness and non-toxicity, titanium pigments are used in many applications, particularly in paint, plastic and paper. Other TiO_2 pigment application includes foods and pharmaceuticals (tooth-pastes, sun-screens, and cosmetics).

Mineral sands are generally mined by open-pit methods, which may include; wet techniques such as dredging or dry methods using trucks, loaders and bulldozers. South Africa's Richards Bay Minerals (RBM) extracts mineral sands from coastal dunes using dredging and concentration on a gravity separation plant floating on a man-made pond. After concentration, ilmenite, rutile and zircon are separated at the mineral separation plant, which is located at the smelter facility. Ilmenite is upgraded by smelting in an electric arc furnace (a.c) to produce titanium slag with a TiO_2 content of up to 85 percent and a high quality pig iron as a by-product.

In Australia, ilmenite is upgraded by hydrometallurgical methods to produce synthetic rutile. South Africa's titanium slag is milled and classified into two product sizes ready to be sold to TiO_2 pigment producers. Approximately 95 percent of South Africa's titanium mineral concentrates and their by-products are sold to the international market.

Titanium dioxide pigment is produced from titanium mineral concentrates by either the chloride or sulphate processes. The most basic form of titanium metal is titanium sponge, which is produced by processing titanium slag or rutile, using the Kroll process, to a commercially pure form of titanium metal sponge. Titanium ingot is produced by melting titanium sponge or scrap or a combination of both, usually with other alloying elements such as aluminium and vanadium.

3. OCCURRENCE

Titanium minerals are present in most igneous rocks and sediments derived from them. Economic deposits of titanium minerals occur in beach sands in which the highly resistant titanium minerals were concentrated by natural erosion and along ancient and recent shorelines.

Mineral sands refer to sands that have a specific gravity greater than 4.0 g/cm^3. Mineral sand deposits are also referred to as heavy mineral sand deposits, heavy mineral deposits or simply as mineral sands. All economically exploitable ilmenite and rutile deposits occur as recent beach sand or fossilized dune deposits generally referred to as heavy mineral beach sands, though hard-rock resources are known. Other heavy minerals commonly occurring in association with ilmenite and rutile in heavy mineral beach sands are zircon, monazite and garnet, each of which may have economic value.

The heavy minerals found in the dunal deposits along the coast of northern Kwazulu-Natal have their origin from inland. Over the years, weathering of host rock has released the minerals, which, because of their durability, relatively high density, and high chemical stability, withstand the weathering process and are transported down rivers to the ocean. The heavy mineral sands now in the sea are transported up the coast by current and wave action. Wave action deposits the heavy mineral sands onto the beaches. The sand is subsequently blown into dunes by the onshore winds.

4. MINING, PROCESSING AND REFINING OF TITANIUM

4.1 Mining

South Africa's Richards Bay Minerals (RBM) uses dredge mining operation (Fig. 1) to extract and separate the heavy minerals (ilmenite, rutile and zircon) from the sand. These minerals constitute about 5 percent of the total sand volume. The dredger and concentrator plant float on the artificial freshwater pond that is created in the dunes. The dredger removes the material from the front end of the pond while the tailings produced by the separation process are piled at the back, and as such the pond continuously moves in a forward direction. The dredger trudges forward at a rate of 2 – 3 metres per day, depending on the height of the dune, as it channels into the mining face of the dune.

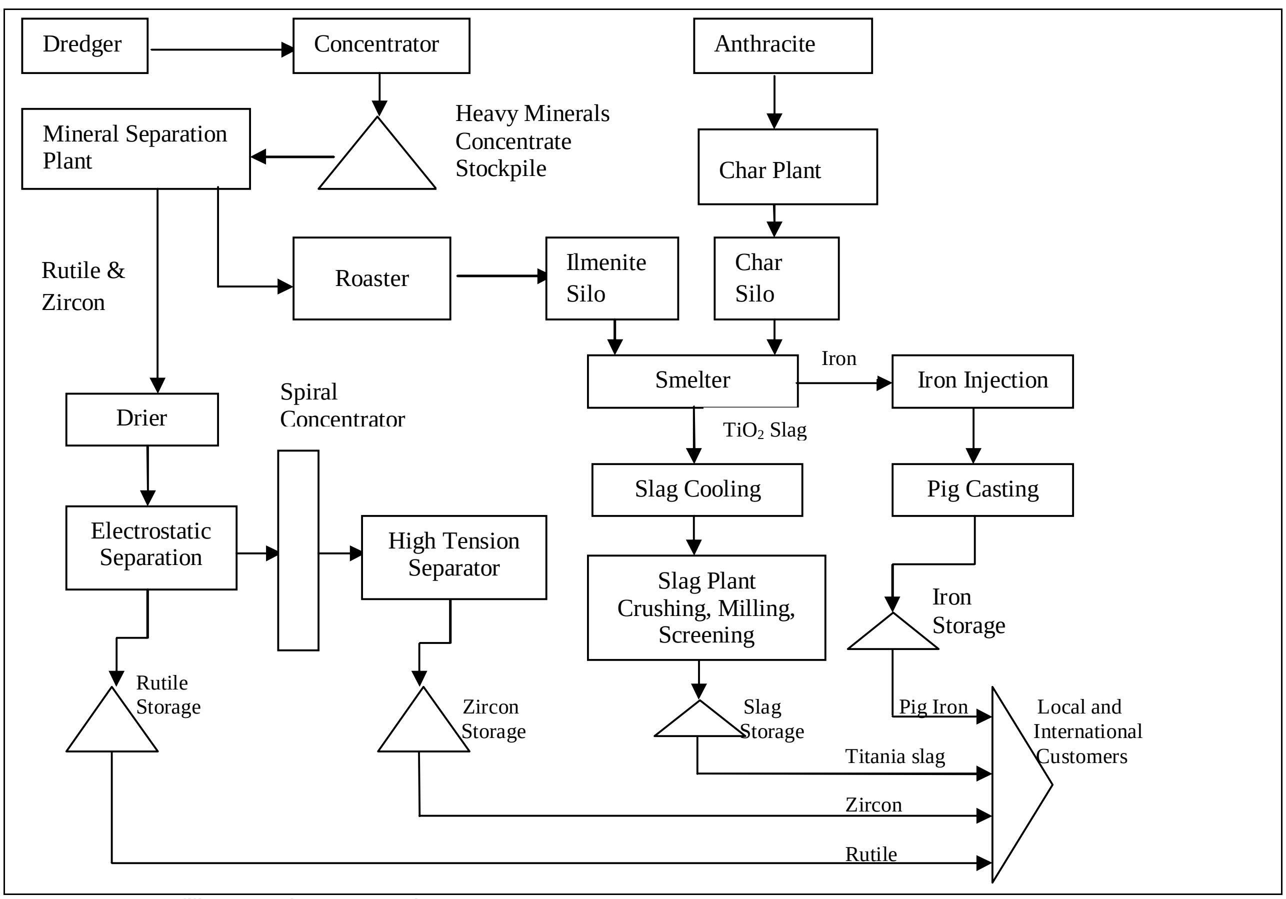
FIGURE 1: RBM'S DREDGER AND CONCENTRATOR PLANT

Source: Rio Tinto's Richards Bay Minerals

4.2 Conversion of Heavy Mineral Sands to Titanium Mineral Concentrates

RBM's heavy mineral sands from the mine are transported to the mineral separation plant, located at the smelter site, where they are re-slurried and pumped into the feed separation circuit (Fig. 2) The slurry is passed over successive stages of low and high intensity magnets to remove the ilmenite that is put aside as feedstock for the smelter. Ilmenite, in this form, has a high Cr_2O_3 content and is not suitable for direct smelting to titania slag. It is roasted at temperatures ranging from 730^0C to 800^0C to remove the Cr_2O_3 content yielding ilmenite suitable for the smelter.

FIGURE 2: RICHARDS BAY MINERALS' PROCESS FLOW DIAGRAM



Source: G.E Williams and J.D. Steenkamp, 2006

Ilmenite from the roasting process is low-grade and hence it requires upgrading as it is not suitable as a feedstock for titanium dioxide pigment process. The TiO_2 content is improved by smelting the ilmenite in an electric arc furnace (a.c), in the presence of anthracite, to produce titania slag containing about 85 percent TiO_2 and a high purity (low manganese) pig iron as a by-product. The smelting process is energy intensive with each furnace being supplied by 105 MV transformers. The TiO_2 slag is crushed and then ground and dried in an aerofall mill. Thereafter, it is classified to produce particle size required by the chloride and sulphate slag markets. The slag is then stored in silos waiting to be transported by rail to the harbor and only a small fraction is consumed locally. Ilmenite accounts for about 91 percent of the world's consumption of titanium minerals.

The non-magnetic zircon and rutile from the separation plant are concentrated for further processing in the dry mill. These two minerals are separated and upgraded in a series of circuits consisting of a number of stages of high tension electrostatic separation, magnetic separation, gravity separation, and screening. Rutile and zircon are separated by their difference in conductivity while the residual material is removed by magnetic and gravity separation circuits. After this process, rutile and zircon are sold in their raw form as mineral sands. Small quantities of zircon are upgraded to produce higher-grade product by removing impurities.

Titanium slag is milled and then classified into two product sizes ready to be sold to TiO_2 pigment producers. The high quality pig iron which is the by-product of the ilmenite reduction process is further processed to produce various grades of low-manganese iron. The products derived from processing heavy mineral sands (titanium slag and rutile) are usually referred to as titanium mineral concentrates or titanium dioxide feedstock. Approximately 95 percent of titanium mineral concentrates and their by-products (zircon and pig iron) are sold to the export market.

4.3 Conversion of Titanium Mineral Concentrates to Titanium Dioxide Pigment

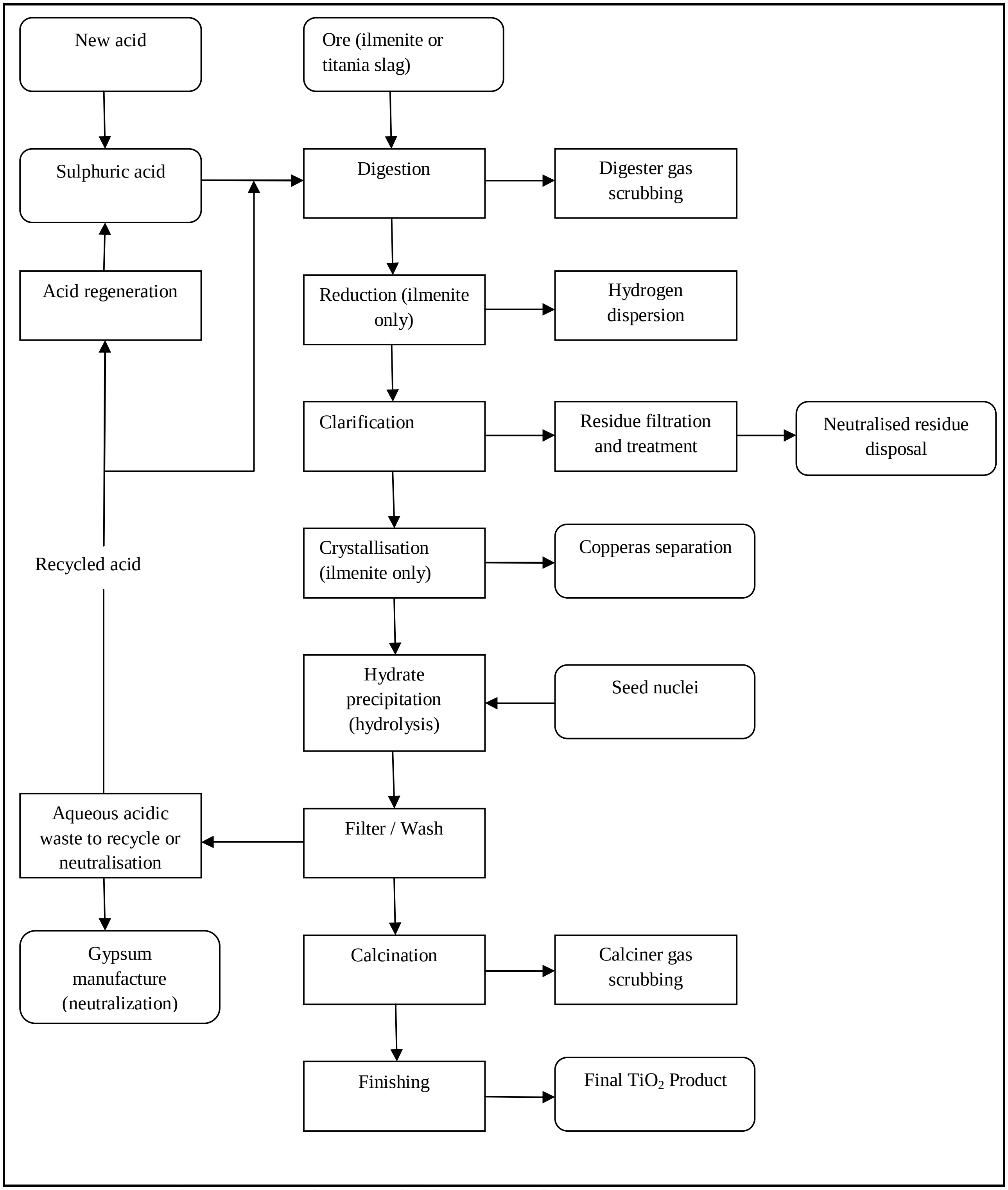
Titanium dioxide pigment (TiO_2) is produced from titanium mineral concentrates by either the sulphate or the chloride process.

4.3.1 The Sulphate Process

The sulphate process was the first commercial scale technology used to convert ilmenite to titanium dioxide. This process uses sulphuric acid to dissolve titanium dioxide, which is then precipitated, washed and calcined, and is followed by a final stage which involves chemical surface treatment of calcined product and sizing to produce various grades of TiO_2 pigments (Fig. 3).

Titanium dioxide pigment industry is moving away from building new sulphate process plant because of large quantities of iron sulphate waste and low quality product for most applications. The only advantage of the sulphate process is that it produces a form of TiO_2 pigment called anatase, which is preferred over the chloride-derived pigment for use on paper and ink. Lower grades of titanium feedstock are suitable for the sulphate process.

FIGURE 3: SULPHATE PROCESS FLOW DIAGRAM



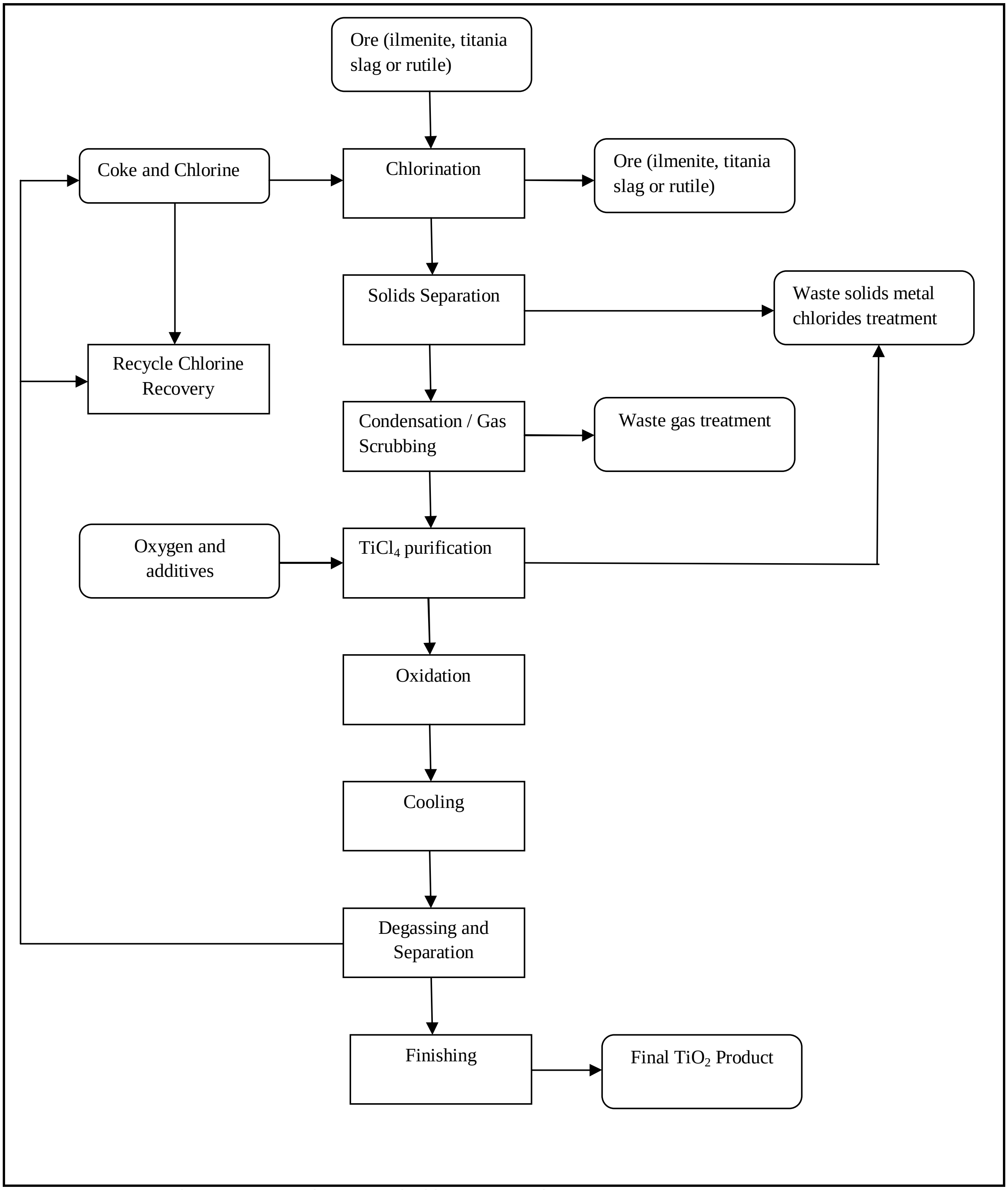
Source: G.S. McNulty, Huntsman Pigments, Tioxide Europe Ltd

4.3.2 The Chloride Process

The newer chloride process eliminates the iron sulphate waste problem and is cheaper to operate. The technology used in this process is closely guarded with a high degree of secrecy. In the chloride process, ilmenite is first converted to the rutile form through a process that removes the iron component to yield synthetic rutile (Fig. 4). Chlorine is reacted with synthetic rutile in the presence of petroleum coke to form volatile titanium tetrachloride which is then oxidised with air or oxygen at about 1 000 ^{0}C to form fine-size TiO_2, leaving behind iron chloride and other impurities. Titanium dioxide is then calcined to remove residual chlorine, which is recycled.

The Chloride plant requires a higher grade of feedstock in the form of rutile or titania slag. The chloride process allows for tighter product control and is less labour intensive, and is environmentally safer. Currently, about 60 percent of the 4 million tonnes of TiO_2 pigment produced globally is produced by the chlorine process.

FIGURE 4: CHLORIDE PROCESS FLOW DIAGRAM



Source: G.S. McNulty, Huntsman Pigments, Tioxide Europe Ltd

South Africa's pigment production of about 20 000 tonnes TiO_2 per year contributes approximately half a percent to total world titanium pigment output and only Huntsman Tioxide in Umbogintwini, Kwazulu-Natal, produces pigment from titanyl sulphate. South Africa does not have a titanium carbon-chlorination facility to produce titanium tetrachloride that could be used as feedstock for a titanium metal production facility.

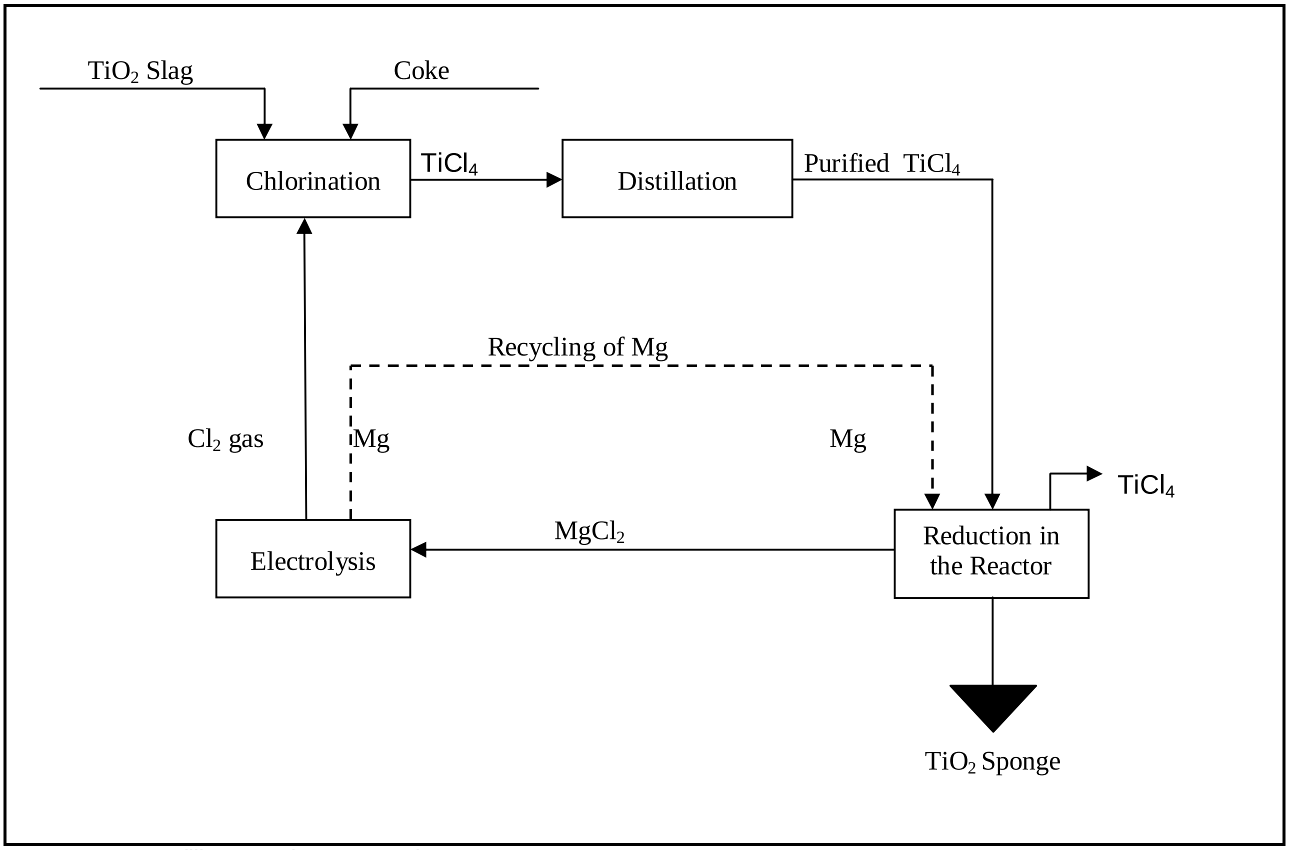
4.4 Conversion of Titanium Mineral Concentrates to Titanium Sponge Metal

Titanium slag or rutile is chlorinated in a fluidized bed reactor at 1 000^0C in the presence of coke to form an impure titanium tetrachloride ($TiCl_4$) and carbon monoxide together with impurities of various chlorides (Fig. 5). Chlorides of iron, vanadium, zirconium, silicon and magnesium are removed by fractional distillation and precipitation. After several purification and distillation steps, the pure $TiCl_4$ so formed is fed to the Kroll reactor where it is reduced by liquid magnesium in a stainless steel reactor vessel, leaving about 15 – 20 percent excess magnesium.

Argon is pumped into the reactor to remove air and prevent contamination with oxygen and nitrogen. The reactor is heated to a temperature of 800^0C to 900^0C, with $TiCl_4$ slowly fed over a period of several days. Magnesium reduces $TiCl_4$ to produce solid titanium and liquid magnesium chloride. The titanium solid is removed from the reactor by boring and then treated with water and hydrochloric acid to remove excess magnesium and magnesium chloride. The formed titanium solid is a porous metal called sponge.

The porous metallic titanium sponge is purified by leaching or heated vacuum distillation. The sponge is then removed, crushed, and pressed before it is melted in a consumable electrode vacuum arc furnace. The melted ingot is allowed to solidify under vacuum. It is often remelted to remove inclusions and ensure uniformity. The low-yield (10 tonnes batch/2 weeks) Kroll batch-process, reheating and sponge melting steps contribute significantly to the problem of cost-intensive titanium metal production process.

FIGURE 5: KROLL PROCESS FLOW DIAGRAM



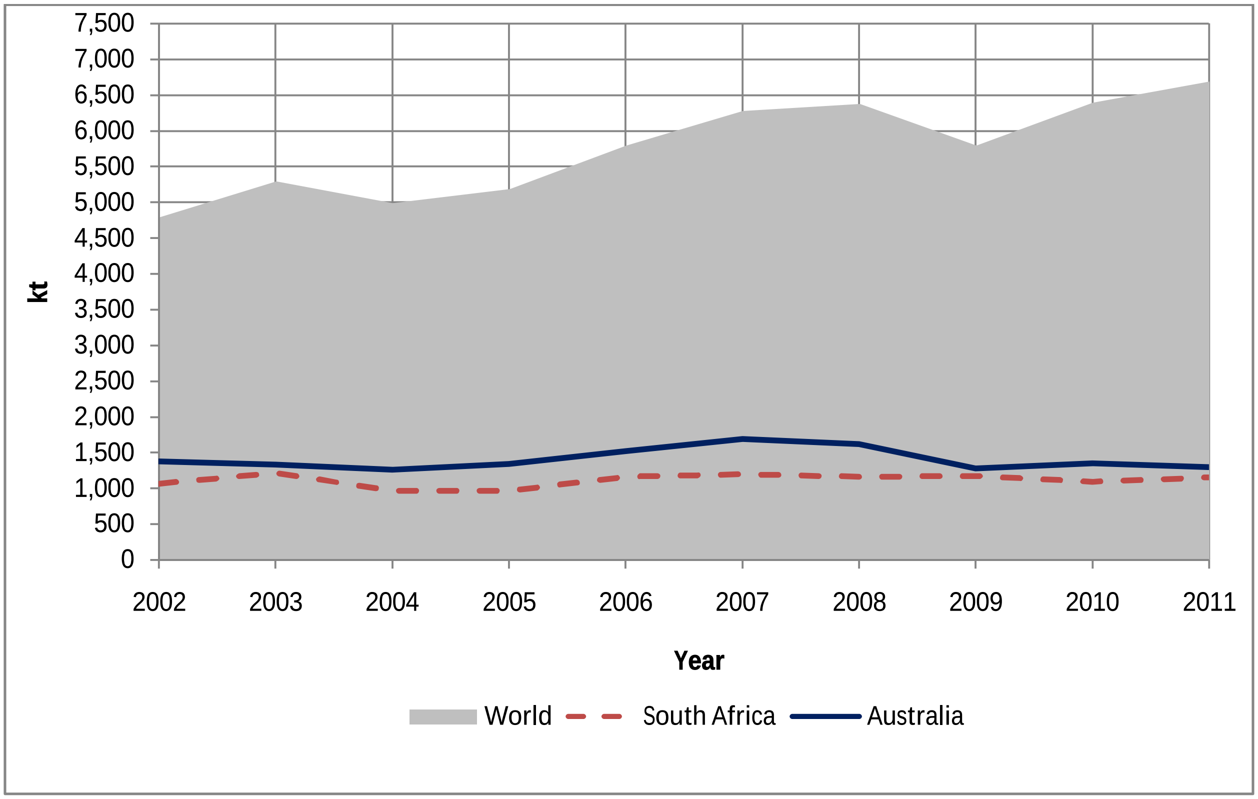
Source: G.E Williams and J.D. Steenkamp, 2006

5. GLOBAL MARKET REVIEW

5.1 Titanium Dioxide Feedstock Market Dynamics

Global production of titanium mineral concentrates increased by a compounded growth rate of 3.4 percent per annum from 4.8 Mt in 2002 to 6.7 Mt in 2011 (Fig. 6). Outputs from South Africa and Australia have been fluctuating marginally from year to year with an average production of 1.1 Mt and 1.4 Mt per annum, respectively. The gradual increase in world output of titanium minerals over the years is attributable to new entrants from various countries, such as Mozambique, Sierra Leone, Madagascar, and Canada.

FIGURE 6: PRODUCTION OF TITANIUM MINERAL CONCENTRATES: 2002 – 2011

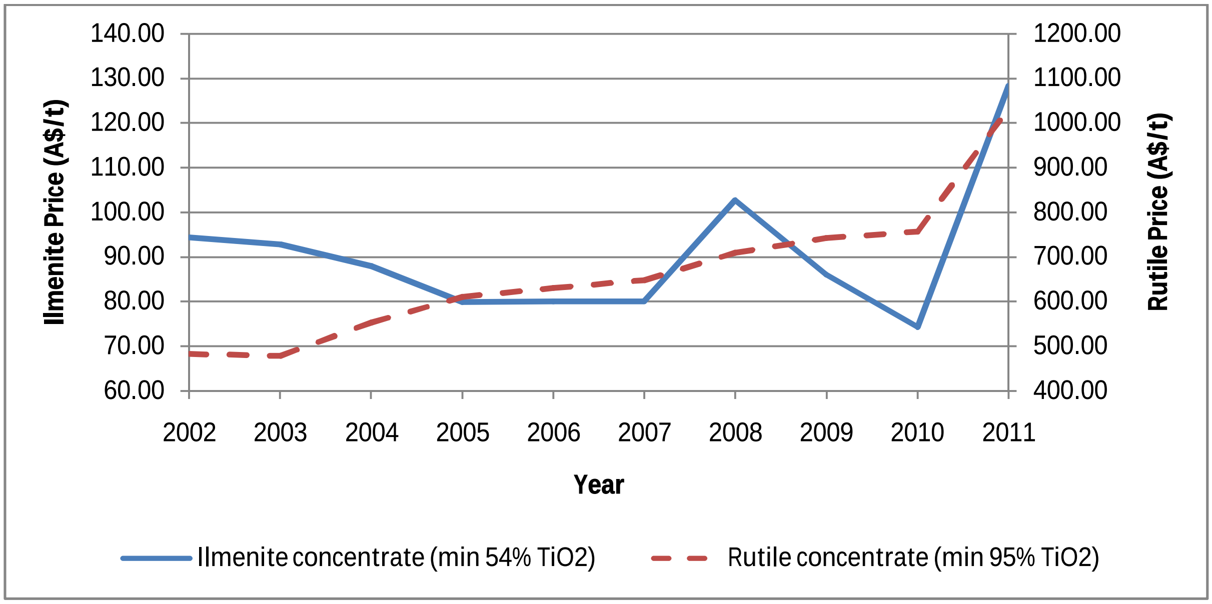


Source: USGS figures, 2012

Average annual prices of Ilmenite were erratic in the past decade while rutile prices increased by a compounded growth rate of 7.2 percent per annum from A$483/t in 2002 to A$1 032/t in 2011 (Fig. 7). Prices of ilmenite declined by 3.0 percent, compounded annually from an annual average of A$94/t in 2002 to A$80/t in 2007, and rose sharply by 28.4 percent in 2008 to an average of A$102/t compared with the previous year, while rutile prices climbed by 9.6 percent to A$709/t. The rise in prices was due to producers increasing prices owing to a surge in costs, particularly transportation costs.

Annual average rutile prices continued to rise reaching A$756/t in 2010 in the midst of a decline in ilmenite prices as a result of an increase in demand for concentrates with a high TiO_2 content. Rutile prices held up fairly well in 2009 due to contracts that were concluded before the onset of the recession. In contrast, ilmenite prices fell below levels of 2007, because of a lack of demand from the pigment industry.

FIGURE 7: TIO_2 FEEDSTOCK PRICES: 2002 – 2011



Source: Metal Bulletin figures, 2012

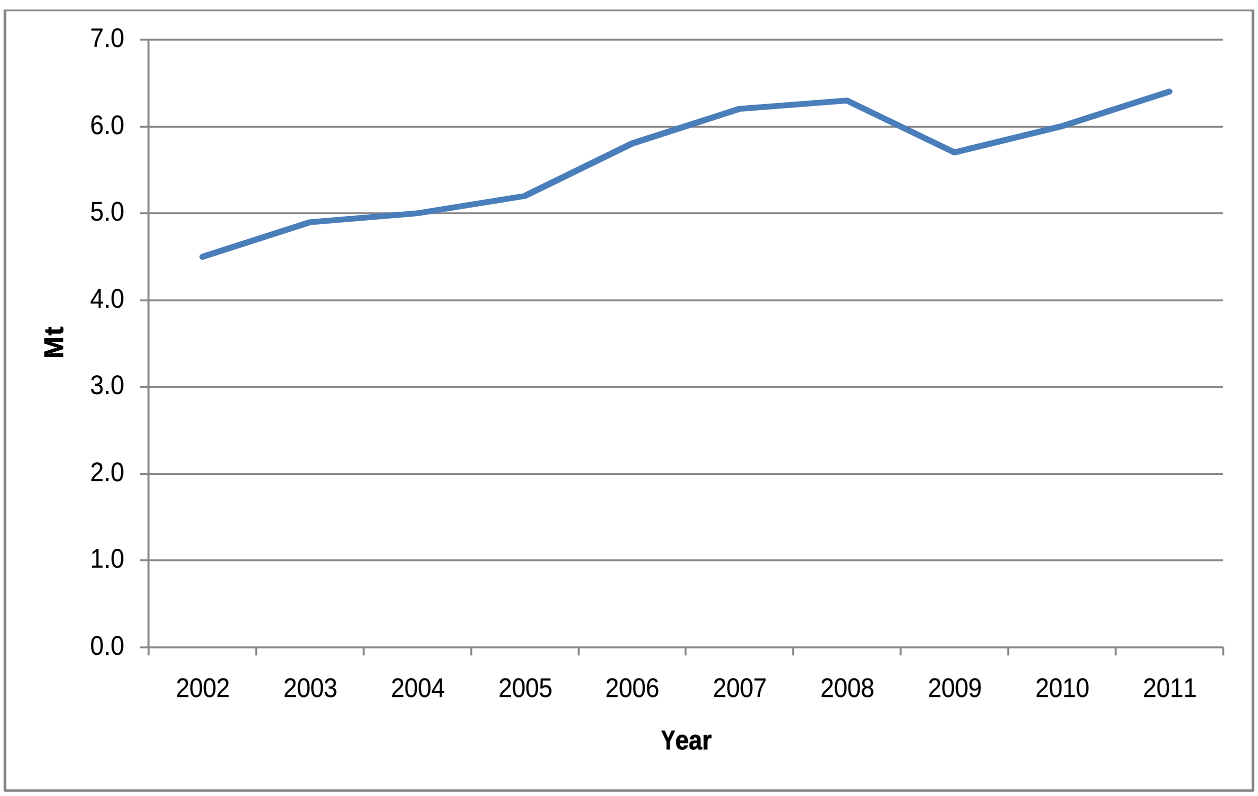
A rebound in the titanium mineral industry in 2011 has seen both rutile and ilmenite prices skyrocketing to unprecedented levels, due to the stronger demand that has been outstripping supply. The sharp increase in prices has not come as a surprise to the industry due to chronic shortages of feedstock, albeit at rates that exceeded expectations. The buoyant market conditions have propelled both rutile and ilmenite prices to historic highs.

Ilmenite (min 54% TiO_2) prices surged from a monthly average of A$70/t in December 2010 to A$195/t in December 2011, an increase of about 178 percent. Rutile (min 54% TiO_2) rose by about 77 percent from A$762/t in December 2010 to A$1 350/t in December 2011. In 2011, the annual average prices of ilmenite and rutile ascended steeply by 73.0 and 36.5 percent to A$128/t and A$1 032/t, respectively, compared with 2010. The rising prices have prompted a number of titanium dioxide pigment producers to embark on backward-integration to secure feedstock supplies in an attempt to curtail future cost increases.

5.2 Titanium Dioxide Market Dynamics

World production of titanium dioxide pigment rose by a compounded growth rate of 3.5 percent per annum, from about 4.5 Mt in 2002 to approximately 6.5 Mt in 2011 (Fig. 8). This increase is attributable to increasing demand for TiO_2 pigment in the construction and automotive industries over the years under review. During the last decade, a decline in production was only experienced during the world recession (2008/9) when demand for commodities, including TiO_2 pigment, fell drastically. Output decreased by 9.5 percent from about 6.4 Mt in 2008 to nearly 5.7 Mt in 2009. In the aftermath of the recession, recovering demand led to an increase in global production of TiO_2 pigment by 5.3 percent and 6.7 percent to 6.0 Mt and 6.4 Mt in 2010 and 2011, respectively.

FIGURE 8: GLOBAL PRODUCTION OF TIO_2 PIGMENT: 2002 – 2011



Source: TZMI and USGS, estimates

TABLE 1: MAJOR PRODUCERS OF TITANIUM DIOXIDE PIGMENT

Producer	Head Quarter location	Capacity (tpa)
1. DuPont	USA	1.17m
2. Cristal Global	Saudi Arabia	691,000
3. Huntsman Corp.	USA	630,000
4. Kronos Worldwide	USA	573,000
5. Tronox Inc.	USA	535,000

Source: Heavy Minerals Symposium Series S57, 2009, p 2

Titanium dioxide pigment prices were largely depressed during the global recession until 2010, due to a weakness in automotives markets and other TiO_2 pigment end user products. After the recession, titanium dioxide (TiO_2) pigment production capacity has been lagging behind the rebound in demand creating a supply deficit at the end of 2010. Part of the supply pressure stemmed from nearly depleted North American inventories and some idled capacity.

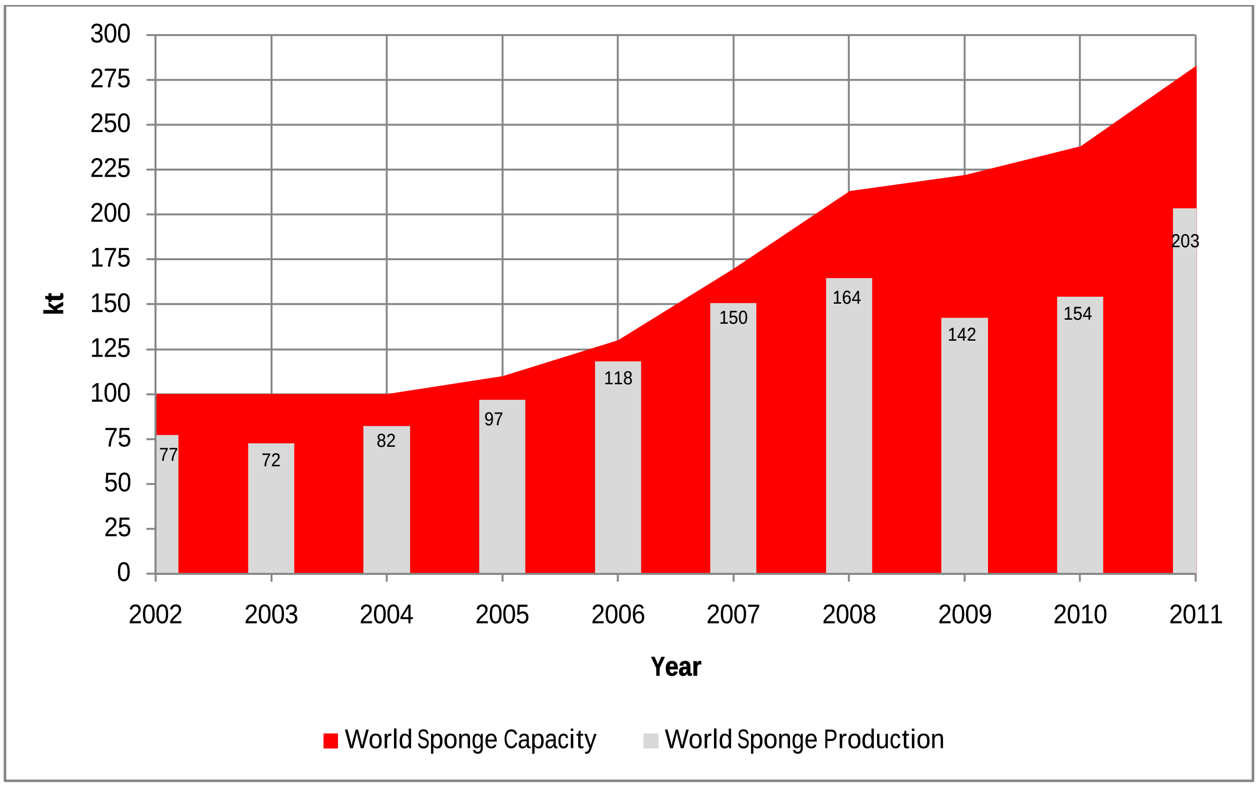
Titanium dioxide pigment prices started to increase towards the end of 2010 on the back of strong growth in demand coupled with supply, which was struggling to keep pace with the demand. Demand for titanium dioxide pigments was driven mainly by the construction sector in China, and this sector remained a key influence in the Chinese economy in recent years, driven mainly by stimulus packages offered by the government. TZMI, an Australian consultancy, describes the global TiO_2 sector as more buoyant than at any other time in the last ten years. Healthy TiO_2 prices are also supported by low pigment inventory levels and current production capacity, which is very close to market demand.

The year 2011 was characterised by strong growth in demand for titanium dioxide pigment. The robust demand was mainly driven by growth in emerging economies, led by Brazil, Turkey, Russia and India. Consumption of titanium dioxide pigment increased by 1.4 percent to 5.4 Mt in 2011 compared with the previous year. The Asia Pacific region contributed about 30 percent to global demand, followed by North America, Europe, Middle East, Africa and Latin America. Increasing demand and low inventory levels during 2011 have resulted in a tight pigment market.

5.3 Titanium Metal Market Dynamics

From 2002, global production of sponge increased at a compounded growth rate of 14.6 percent per annum to 164 kt in 2008, as producers ramped up output in anticipation of stronger demand (Fig. 9). The world economic slowdown, which intensified in the last quarter of 2008 together with derailments in the production of high-titanium content aircrafts such as A380 and B786 resulted in a sudden drop in titanium sponge metal demand and consequently production.

FIGURE 9: GLOBAL PRODUCTION AND CAPACITY OF SPONGE: 2002 – 2011



Source: WBMS figures, 2012

Global titanium sponge production decreased by 13.4 percent to 142 kt in 2009, due mainly to delays in aircraft construction triggered by poor economic conditions. Production increased annually by 8.3 percent and 31.8 percent to 154 kt and 203 kt in 2010 and 2011 respectively, due to capacity expansions in producer countries. Titanium sponge capacity greatly exceeded demand in 2009 and 2010 causing prices to fall and prompted producers to delay further expansions, idle some of the plants and close smaller marginal plants.

China has been the main driver for growth since 2010, and the country is ramping up its production with a number of new large scale sponge facilities under construction. The strong growth in industrial applications of titanium in China has tilted the scale away from aerospace. However, demand for the higher grade titanium sponge and ingot is still dependent on the cyclical nature of the aerospace industry.

Negotiations of long-term contracts between producers and consumers are the norm in the market for sponge, unwrought metal and mill products. Traders have little or no role to play in influencing supply agreements between the buyer and the seller. Nonetheless, the decline in sponge supply in 2006 led to the increase in sponge prices to $30/kg by the end of the year from its historic low levels of around $7/kg. New sponge capacity was introduced to the market thereby depressing prices in the market and by 2010, sponge prices traded below $10/kg. Ingot and mill products prices also followed the same trajectory, trading much lower than the highs reached in 2006 and 2007.

It is the nature of the titanium metal industry for large scale producers to beneficiate further down the value chain by producing titanium ingot and mill products. Melting of sponge and milling are important stages in the production of titanium metal products. Melting capacity is normally double that of sponge production, partly because of the practice of double and triple melting and also due to use of scrap in the melt feedstock. The USA is the major producer of mill products for the aerospace industry while producers in Japan and China are geared towards industrial and consumer applications for titanium metal.

Manufacturers are increasingly using composites which are compatible with titanium than aluminium, thus supporting incremental use of titanium in landing gear ducting, wing carry through structures and weight critical forgings. The growth in chemical and petrochemical plants end use markets has been phenomenal over the last 6 years, due to expansions in construction of chemical and power plants in China.

Titanium is still not used in the entire spectrum of potential applications, due mainly to its high cost of production relative to other metals such as aluminium and steel. The cost of producing titanium ingot from its ore is approximately 30 times and 6 times more expensive per tonne than steel and aluminium respectively. The high cost inhibits titanium from competing with other metals in the full range of potential applications, such as the automotive, construction, maritime and defense industries. Industry experts estimate that the market for titanium metal is limited to about 5 percent of its potential size, which equates to about 200 000 tonnes per annum. However, there is promising research that is currently being undertaken by various countries including South Africa to find a more efficient metallurgical solution to convert enriched ilmenite or rutile into titanium metal.

6. PRODUCERS OF TITANIUM MINERAL CONCENTRATES IN SOUTH AFRICA

6.1 Richards Bay Minerals

Richards Bay Minerals (RBM) is the trading name for two registered companies, Tisand (Pty) Ltd and Richards Bay Iron and Titanium (Pty) Ltd (RBIT). Tisand undertakes the dune mining and mineral separation operations, while the smelting and beneficiation processes are carried out at RBIT. RBM has been mining the coastal sand dunes of northern KZN for more 36 years.

RBM is owned by Rio Tinto plc, the world's biggest miner, as a majority shareholder (74 percent), 24 percent is owned by Blue Horison, a BBBEE consortium consisting of lead investors and the four host communities, and the remaining 2 percent is owned by employees. RBM is amongst the largest single mining operations in South Africa. The mine is regarded as one of the world's lowest cost producers of heavy mineral sands. It is also a global leader in restoration of ecological diversity that is disturbed by mining activities.

6.2 Namakwa Sands

Namakwa Sands, previously owned by Anglo American and acquired by Exxaro in 2007, is one of the producers of titanium mineral concentrates in South Africa. This heavy mineral sands mine is located at Brand-se-Baai, 385 km north of Cape Town, and is divided into an east and west section where open-cast strip-mining activities occur, together with primary and secondary concentration of heavy mineral sands containing zircon, rutile and ilmenite. Mining and preliminary concentration of heavy minerals take place on the mine site. Processing and separation of heavy mineral fractions (ilmenite, rutile and zircon) are carried out at a mineral separation plant, 60 km south of the mine, near Koekenaap. The ilmenite concentrates are then taken to a smelting operation, situated 7 km from the Saldanha Bay export terminal. The smelter facility produces about 250 kt of titanium slag per annum.

6.3 Hillendale Mine

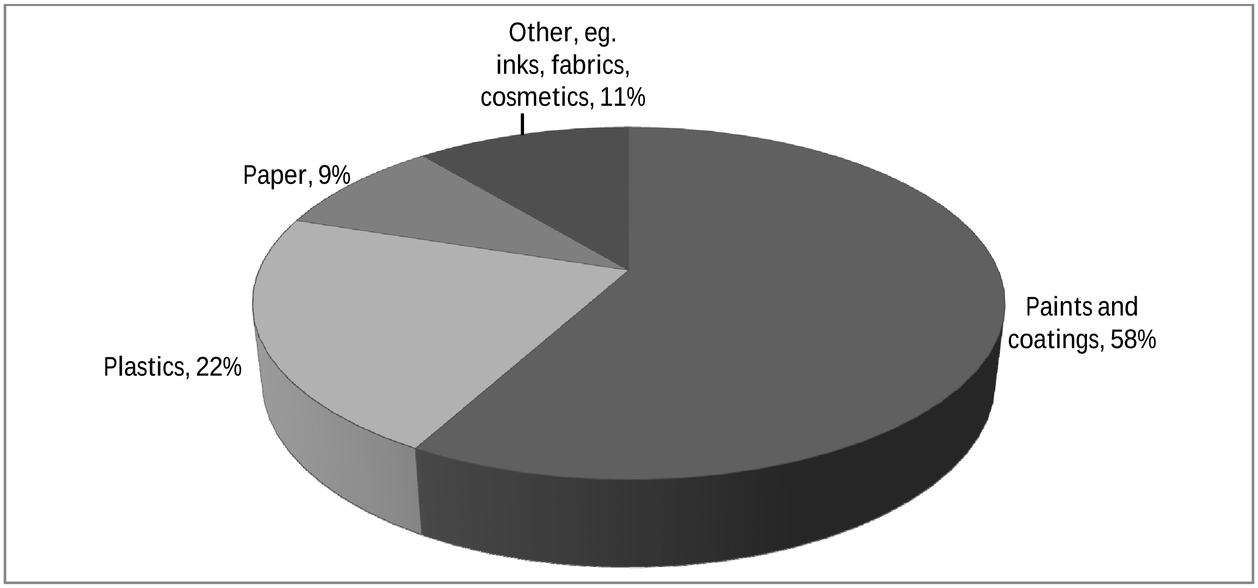
KZN Sands, another Exxaro subsidiary, operates the Hillendale mine and smelter closer to the town of Empangeni in Kwazulu-Natal. The mine uses hydraulic mining. At the mine site, 20 km south-west of Richards Bay, hydraulic mining techniques are used to produce the slurry for the primary wet plant. Further processing including smelting of ilmenite to produce titanium dioxide slag then takes place at the central processing plant at Empangeni, 20 km west of Richards Bay. KZN Sands produces ilmenite, slag fines, zircon, rutile, leucoxene, low manganese pig iron and chlorinable titanium dioxide slag.

7. APPLICATIONS OF TITANIUM

7.1 Titanium Dioxide Uses

Titanium dioxide pigment has been in use as a pigment and opacifier for more than 50 years. It is used to enhance colour and quality. Titanium dioxide has excellent whitening, high refractive index and light scattering capabilities. These superior properties have made titanium dioxide a valuable pigment opacifier for a variety of uses such as in paints, paper, plastics, ink and rubber. The paint and coatings sector is the largest consuming market for TiO_2 pigment (Fig. 10), with a contribution of 58 percent to global usage, followed by plastics (22 percent), paper (9 percent) and other. Other uses of TiO_2 pigment include catalysts, ceramics, coated fabrics and textiles, floor covering, printing ink, and roofing granules.

FIGURE 10: GLOBAL CONSUMPTION OF TIO_2 PIGMENT BY SECTOR



Source: Rio Tinto and TZMI, 2012

7.2 Titanium Metal Uses

Since the aftermath of the Cold War, titanium has extended its predominant use in military to commercial applications, including artificial hips, golf clubs, tennis rackets, bicycles, even wedding rings. Industrial applications of titanium metal are mainly in chemical and petrochemical plants and heat exchangers. Due to its superior resistance to seawater, titanium is also used in offshore rigs, ships' propellers and rigging, and desalination plants.

A titanium laptop computer was recently introduced in the market by Apple computers because of its light weight. Titanium which has been traditionally used as an industrial material has only recently been included as a jewellery material and its popularity is gaining momentum. Titanium bicycle frames are widely considered to be the most durable in comparison to steel frame.

Titanium is the most biocompatible of all metals because it is inert in the human body, compatible with bone growth, strong, flexible and can withstand harsh conditions of bodily fluids. Properties required for biomedical applications are biocompatibility, corrosion behavior, mechanical behavior, processability and availability. Property requirements for medical applications are best met using titanium and its alloys compared with materials such as stainless steels, chromium-cobalt alloys, commercially pure niobium and tantalum.

8. DEVELOPMENTS IN SOUTH AFRICA AND AFRICA

8.1 South Africa

BHP Billiton, a company with a dual listing on the Australian Securities Exchange and London Stock Exchange as well as a secondary listing on the Johannesburg Stock Exchange, sold 37 percent of its shareholding in Richards Bay Minerals for $1.91 billion to Rio Tinto, its former joint partner in RBM in 2012. This transaction was necessitated by BHP exercising a put option agreed with Rio Tinto as part of RBM's restructuring in 2009.

In June 2012, Tronox, an Australian holding company, announced that it has concluded the amalgamation of its assets and that of Exxaro Resources' heavy mineral sands business. The new company, named Tronox, was created through the disposal of Exxaro's Namakwa Sands and KZN Sands (Hillendale mine), together with its 50 percent stake in the Tiwest joint venture in Australia. This transaction makes Tronox the world's largest fully integrated producer of titanium minerals and titanium dioxide pigment. New Tronox subsequently listed on the New York Stock Exchange in June 2012.

In 2011, Exxaro gave its Fairbreeze mineral sands project in Richards Bay a green light. The project was put on hold in 2009 due to lower prices as a result of the financial turmoil. The mine is estimated to cost about R2.4 billion to develop. Tronox (formerly Exxaro Resources) received environmental and water approval in early 2012, for its Fairbreeze mineral sands project in Richards Bay, KwaZulu-Natal. Fairbreeze mine, which is expected to have a mine life of between 12 and 15 years, has a planned annual capacity of 500 kt ilmenite and 60 kt zircon.

The long-awaited project is expected to start mining operations in the second half of 2014. During the construction phase, approximately 1 000 temporary jobs could be created and about 1 000 employees will be absorbed from Hillendale mine on a permanent basis. The Fairbreeze mine will replace the feedstock of Tronox's Hillendale mine in KwaZulu-Natal, which is coming to the end of its life. According to Tronox, a mine closure process was initiated in 2006 and all mining operations are expected to cease around the first quarter of 2014. The closure of Hillendale mine will involve the decommissioning of the mine and all infrastructure as well as the rehabilitation of the area for agricultural purposes.

Mineral Commodities (MRC), an Australian-based company, has commenced with the construction of Tormin mine in the third quarter of 2013. Tormin mine is a heavy mineral sands project located about 400 km north of Cape Town, in the Western Cape Province of South Africa. Tormin's planned run-of-mine is about 1.1 Mt per annum, producing 47.8 kt per annum of non-magnetic concentrate grading at approximately 12 percent rutile and 80 percent zircon. The concentrates will be shipped to China for further processing into a final product. However, the mine is expected to produce about 100 kt per annum of finished ilmenite which could also be destined for China.

The project, which is projected to cost approximately $A16 million, is anticipated to produce its first concentrate by December 2013. Tormin is expected to have a life of mine spanning 5 years with a potential to be extended for another 5 years. During the construction phase, the mine will employ about 40 local people and about 100 permanent jobs will be created during the operation of the mine.

There is a great potential for heavy mineral sands development in the Pondoland, Eastern Cape Province of South Africa. MRC is the owner of the Xolobeni Mineral Sands Project, which is situated approximately 250 km south west of Durban and about 60 km south east of Mbizana and 30 km south of Port Edward. The Xolobeni Mineral Sands Project is a major heavy mineral sands deposit of an estimated 346 million tonnes graded at about 5 percent heavy minerals.

Pre-feasibility study estimates a 25-year life of mine and capital development costs of US$200 million including the construction of a mineral separation plant and a smelter. MRC has reapplied for prospecting rights for the Kwanyama block of the Xolobeni project, after its conditional right was revoked by the DMR in 2011, due to environmental concerns which were raised by interested and affected persons. The company has already renewed prospecting licences for the other four blocks at Xolobeni. MRC is currently conducting prospecting work with the aim of applying for a mining right for the Xolobeni project. The Xolobeni project is expected to create about 300 jobs during the construction of the mine and 600 jobs during the duration of the life of mine.

8.2 Africa

Base Resources, an Australian miner, is developing the Kwale heavy mineral sands deposit in Kenya, 40 km south of Mombasa. The mine, scheduled to start production in the second half of 2013, is expected to produce about 330 kt ilmenite, 80 kt rutile and 40 kt zircon per annum. Ilmenite and rutile from Kwale mine could contribute about 10 percent and 14 percent of global output, respectively. The deposit has an estimated resource of 138.8 Mt of heavy minerals. The mine is expected to have a mine life of about 13 years. Base resources has an off take agreement with DuPont, the world's largest titanium dioxide pigment producer, for 72 percent of its rutile production for a period of six years.

Mineral deposit is developing Grand Cote mine sands project, in Senegal, 50 km north of Dakar. The mine has a measured and indicated resource of 1.03 bt at 1.7 percent heavy minerals. The mine, which is expected to commence production in early 2014, is projected to produce approximately 575 Mt ilmenite, and 85 Mt zircon per annum, as well as small quantities of rutile and leucoxene. The life of the mine is expected to be more than 20 years and further drilling could extend the life of mine.

9. TITANIUM BENEFICIATION IN SOUTH AFRICA AND OPPORTUNITIES

South Africa's pigment production of about 20 kt TiO_2 per year contributes approximately half a percent to total world titanium pigment output and only Huntsman Tioxide produces pigment from titanyl sulphate. South Africa does not have a titanium carbon-chlorination facility to produce titanium tetrachloride that could be used as feedstock for a titanium metal production facility.

Opportunities for titanium beneficiation in South Africa are twofold: the first is the production of TiO_2 pigment from titanium mineral concentrates, and the second is the production of titanium metal from titanium mineral concentrates. The need for making aircrafts lighter in a bid to save on fuel presents great opportunities for titanium mining and beneficiation in South Africa. The titanium metal in aircrafts is lighter and more durable than aluminium. In line with the Beneficiation Strategy of South Africa, the New Growth Path policy has targeted mineral beneficiation as one of the growth sectors mainly because of value addition which contributes significantly to GDP growth and employment opportunities that can be created by downstream processing.

In 2003, the Department of Science and Technology (DST) established the Advanced Metals Initiative (AMI) with the primary objective of developing an internationally competitive metal industry in South Africa through extensive and collaborative research innovation and commercialisation. The titanium initiative focuses on both the primary titanium metal production and further downstream fabrication of the metal. This initiative supports the New Growth Path, the Beneficiation Strategy and the National Industrial Policy Framework of South Africa as well as the National Development Plan.

Consistent with these policies the overarching strategic imperatives of the AMI are to generate economic growth, skills, employment and productive competitiveness. The Council for Scientific and Industrial Research (CSIR) and the research community, supported by the DST are pioneering a novel process to produce titanium metal powder. The titanium research programme began within the Light Metals Development Network (LMDN) of the AMI. It eventually reached a point where a Centre of Competence had to be established for the development of the titanium industry in South Africa. According to the DST, approximately R200 million has been allocated to the project since its inception until March 2015. Of this, approximately R30 million has been allocated to the establishment of the bench-scale pilot plant. The titanium metal powder has been branded CSIR-Ti.

The CSIR-Ti process produces titanium metal powder in a continuous process from titanium tetrachloride. This process substantially reduces the energy requirements and costs of production. Other research initiatives at the CSIR include titanium investment castings, powder metallurgy and selective laser sintering. Further costs reduction would also result from powder metallurgy, which allows the use of near-net-shape (NNS) technology in downstream fabrication of titanium metal. Industry experts have estimated a 50 percent reduction in manufacture and processing costs. According to CSIR, this process is being developed in phases to manage the inherent scale-up risks.

The construction of the bench-scale pilot plant for this process, which uses less energy than the Kroll batch process, commenced in the fourth quarter of 2012 at the CSIR complex in Pretoria.

The bench-scale pilot plant, which is expected to produce titanium powder at a rate of 2 kg per hour, is scheduled to produce its first powder by the second quarter of 2013. The DST Minister, Derek Hanekom, officially inaugurated the CSIR-Ti powder pilot plant on the 7th of June 2013 at the CSIR campus. He indicated that this project "is moving South Africa from a resource-based to a knowledge-based economy that will create high quality jobs". The next phase of the project is the construction of a semi-commercial test facility, which should begin around 2017. This plant is expected to have a capacity of 500 t/y and its success could see the construction of a full commercial plant in about a decade from now.

Following the inauguration, CSIR and Boeing, a US aerospace company, signed a memorandum of understanding (MoU) on the 11th of June 2013. The MoU seeks to advance research synergies and pull resources between the two organisations with the aim of using titanium powder in industrial manufacturing, particularly in making aircraft components and spare parts. The titanium metal in aircrafts is lighter and more durable than aluminium.

Titanium powder technology has the potential to change the face of the global titanium industry and is viewed by many as the product of the future. Titanium in a powder form gives rise to the following and numerous other advantages.

- Production of titanium metal-based products from powder yields a superior component and eliminates the costs associated with melting and milling the metal.
- Over and above the titanium powder process, CSIR has made major technological inroads in the production of fabricated products using metal powder.

Rare Metals Industries Pty LTD (RMI), in conjunction with the South African government, through the Industrial Development Corporation (IDC) and National Empowerment Fund has completed a R50 million pre-feasibility study of the RMI Specialty Metals Complex project. Saldana Bay in the Western Cape is the possible location for the plant. This plant is expected to be the world's first integrated specialty metals plant that could beneficiate titanium, zirconium, and silicon. According to RMI, part of the pre-feasibility study was earmarked at identifying alternative sources of power supply. The construction of a cogeneration plant to feed the plant's electricity requirements could also be considered.

The entire project will require an investment of approximately R20 billion and could create about 5 000 jobs during the building phase and 2 500 permanent jobs in the operation of the plant. The Definitive Feasibility Study (DFS) which is estimated to cost R315 million is projected to commence in August 2013. Construction of the plant is expected to start in the second quarter of 2015 and could take about 30 months to complete. Commissioning of the plant is planned towards the end of 2017. When operating at full capacity, the plant is projected to produce approximately 15 kt/y of titanium, 2 kt/y of zirconium, 1.9 kt /y of silicon and derivative products.

10. OUTLOOK

According to Gary Gianfichi of Ti Insights, the supply of titanium dioxide pigment is projected to grow at about 3.5 percent, compounded annually, reaching about 6.8 Mt by 2015. This would represent an effective increase of 21.4 percent compared with 5.6 Mt in 2011. Approximately 65 percent of this additional capacity is expected to come from China. DuPont, one of the major producers, is expected to increase its capacity by 350 kt per annum by the end 2014.

In the first half of 2012, demand for titanium dioxide pigment began to soften owing to inventory build-up and continued global economic uncertainty as some of the European member countries experienced negative GDP growth due to waning consumer confidence and austerity measures. However, demand for titanium dioxide feedstock is forecast to outstrip supply in the short to medium term, driven, mainly, by urbanisation in emerging countries, with China leading the pack. The market deficit is expected to ease when projects currently in the pipeline, come on stream.

Supply-demand dynamics have changed in favour of pigment suppliers demonstrating a fundamental shift from the historic upper hand of downstream paint producers. According to TZMI, further price support is needed over the long term in order to support re-investment in greenfields projects. Future investments in the titanium dioxide pigment industry are expected in Asia-Pacific, the Middle East and North America.

Demand for titanium metal is projected to grow by 7 percent per annum compounded annually, due to expected increase in consumption of the metal in commercial aircraft and industrial applications, to a large extent, in desalination plants in the Middle East. Titanium metal sponge prices are expected to hover around $10/kg until 2014. The recent expansions in production capacity from Japan and China are envisaged to support the expected rise in demand. According to Roskill Information Services, the demand for titanium metal is expected to grow by 6 percent per annum until 2015.

Nonetheless, titanium metal production capacity is expected to continue to exceed demand for the next few years. Titanium metal sponge capacity is expected to reach 400 kt per annum by 2015, provided that all the expansion plans come on stream. China's four new projects coupled with expansions in Japan and Russia could add 85 kt per annum to the total increase in capacity.

The use of titanium metal in medicine is expected to increase in the future, driven by the aging baby boomer generation, the trend toward more active lifestyles, and the need to curtail health care costs. The realisation of a technological breakthrough in low-cost production of titanium metal would trigger a greater demand for titanium in existing applications and also open up opportunities for a quantum of new applications.

As the second major producer of feedstock, South Africa is well placed to benefit from the current upbeat market conditions. The country's position in the global supply of titanium minerals will be cemented by the commissioning of the Fairbreeze project. According to Exxaro, the Exxaro/Tronox transaction is expected to improve the possibility of establishing a pigment plant in South Africa as demand increases and growth strategies are developed.

A titanium metal powder industry in South Africa is estimated to have the potential to generate revenues of R3 billion to R5 billion per annum, which could allow the country to capture about 10 percent share of international market by 2020. Annual turnover could increase to between R10 billion and R30 billion upon the establishment of the downstream industry.

11. CONCLUSION

Successful commercialisation of the CSIR-Ti process followed by the establishment of the titanium industry in South Africa is expected to pave way for a myriad of other related industries and could make the country the leader in the titanium powder industry, consistent with the objectives of the country's Beneficiation Strategy. The need for making aircrafts lighter in a bid to save on fuel presents great opportunities for titanium mining and beneficiation in South Africa.

There is a clear indication of commitment by the government of South Africa, which is on track to putting its foot in the titanium metal industry through beneficiation of its vast titanium mineral resources. This assertion is supported by the construction of the CSIR-Ti process pilot plant and the completion of the pre-feasibility study to develop the world's first integrated titanium-zirconium beneficiation facility.

12. RECOMMENDATIONS

One of the reasons why South Africa has not developed a pigment industry, to leverage on its comparative advantage of available titanium resources and pigment feedstock, is the secrecy surrounding the chloride process technology required to convert titania slag to titanium pigment. However, the country must seize the opportunity presented by the Exxaro/Tronox amalgamation to explore the possibility of establishing a pigment industry. This is the area that needs to be looked into in future, in order for the country to extract maximum benefits from the exploitation of its titanium resources.

All the role players in the heavy mineral sands industry should leverage on this amalgamation with a view to setting up a pigment facility consistent with the Beneficiation Strategy of South Africa and the New Growth Path. Titanium dioxide pigment production would create a substantial value add for the country, considering that the pigment industry consumes about 95 percent of global mine output of titanium-bearing minerals.

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