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**Beneficiation of South Africa's Titanium Resource
A Long Term Vision is the Key to Success**

by

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Summary

Titanium is a fascinating metal, used for key components in industries, such as aerospace, medical implants, chemical processing and power generation. From its position as the world's second largest producer of the titanium raw material, South Africa has the potential to add significant value to this natural resource. Initial recommendations on this national opportunity dates back to the Mining and Metallurgy report of the National Research and Technology Foresight Project, published by the Department of Arts, Culture, Science and Technology in 1999, which recommended that titanium and titanium oxide production from local raw materials should be pursued. Throughout the following decade a national consensus grew regarding this beneficiation opportunity, which culminated in the establishment of the Titanium Centre of Competence by 2009. This was particularly stimulated by the interest of the major aerospace players, Boeing and Airbus, and the initiative was championed in government by the Department of Science and Technology with the technical leadership of the CSIR.

In this presentation the industrial opportunity of titanium beneficiation is detailed; the nature of the research, development and implementation programme is explained, with emphasis on the role of the Titanium Centre of Competence; and the importance and impact of a shared national vision is discussed. Lessons learned are captured as success factors for such an intervention. The potential future impact of successful local beneficiation of the South African natural resource is illustrated through recent examples from the medical implant industry. In conclusion, some recommendations for success with such an initiative are offered.

Introduction

Beneficiation has become a national imperative for sustained growth of South Africa's economy. Sasol is a proud example of successful beneficiation in South Africa. It beneficiates South Africa's coal resource through the commercial application of the Fischer-Tropsch process on the largest scale in the world. It is informative to note that Anglovaal started exploring the technology in the 1930s. Only some 20 years later Sasol was established as a government-controlled company in 1950 and started producing the first synthetic petrol in 1955. The company is now listed on the Johannesburg Stock Exchange and the New York Stock Exchange and is one of the largest multi-national companies originating in South Africa.

South Africa's Opportunity in Titanium

South Africa is the second-largest titanium producer and the third-largest vanadium producer in the world. However, South Africa does not have a downstream industry for these metals in the country. If processes and technologies could be developed to enable enterprises in South Africa to operate in the areas of primary metal and mill products, as well as downstream components and manufactured products, significant value could be added. There are some lucrative market opportunities where titanium is quite essential, such as aerospace, medical and marine applications.

As a result of some key properties of titanium, it is very effectively used in aircraft, ships and the human body. Titanium has the highest specific strength (strength of a material divided by its density) of all metals, is lightweight and is exceptionally corrosion-resistant in seawater and the human body. Commercial titanium alloys can withstand maximum temperatures of between 540°C and 600°C.

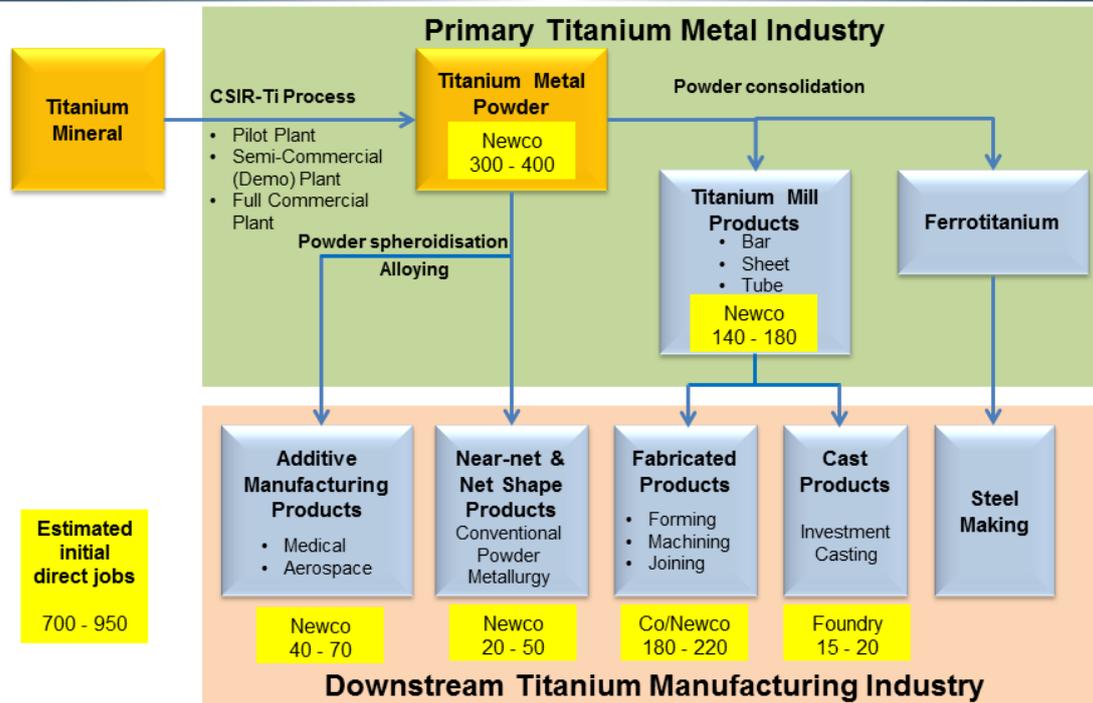
The development of a Titanium Production Capability Roadmap with the focus on downstream manufacturing technologies and products is captured in the latest version of **the dti's** IPAP. The economic rationale is to position South Africa as a lead supply chain participant within the global titanium manufacturing industry, concentrating on aerospace and defence products and new technologies. This is expected to increase the spill-over effect of these new technologies into related activities and adjacent industries such as medical, energy, automotive, chemical processing, marine, oil and gas.

Considering the value chain of titanium, South Africa is currently at the bottom of the chain, mining and exporting the mineral as a titanium-bearing slag, while all titanium metal has to be imported at high cost to the country. This is considered to be a market failure. Significant value addition could be achieved if South Africa's industry would move higher up the value chain.

An New Titanium Metal Industry for South Africa

South Africa's vision is to establish a new titanium metal industry sector that potentially offers economic and job-creation opportunities. The currently envisaged industry is illustrated in the following diagram:

A New South African Titanium Industry Economic and Job Creation Opportunities



CSIR Light Metals 2013

In pursuing beneficiation opportunities for South Africa, the Titanium Centre of Competence was established to integrate and coordinate R&D and commercialisation across the value chain. The Centre is developing a number of technology platforms. These technologies are essential for the local production of a range of products. If the technologies are industrialised and commercialised successfully, the establishment and development of South Africa suppliers would result.

In the process of value addition, there should be a focused movement through different technology phases and technology readiness levels:

Phase 1: Technology assessment and proving (readiness levels 1–4)

Phase 2: Pre-production (readiness levels 5–6)

Phase 3: Production and implementation (readiness levels 7–9).

Implementation through the Titanium Centre of Competence

The Titanium Centre of Competence has mobilised and aligned R&D groups across South Africa that are contributing towards achieving the national objective. Each group has international linkages and at any particular point, a team of at least 80 permanently employed South African researchers are working in the field and at least 20 postgraduate students are studying towards qualifications in this field. A Titanium Inter-Departmental Task Team was established that includes several government departments:

- Department of Science and Technology
- Department of Trade and Industry
- Industrial Development Corporation
- Department of Mineral Resources
- Department of Public Enterprises

This is a clear indication of government's support for titanium beneficiation. The team meets regularly to facilitate the cooperation required among the departments.

Success Factors

Success factors for the beneficiation of South Africa's titanium resources include:

- Agreement on the national strategy by all key players;
- Securing a mandate to implement the strategy;
- Mobilise the best South African talent and facilities;
- Identify and empower a champion in each collaborating unit;
- Ensure early industry involvement;
- Share and continuously promote the vision with all stakeholders;
- Sustain effective communication throughout the collaborator network;
- Recognition of each contribution to ensure ongoing buy-in;
- Remaining focused and persevering.

Impact of Beneficiation: Changing Lives through Titanium Additive Manufacturing / 3D Printing

Examples will be presented of the impact of customised medical implants, locally designed and manufactured through titanium powder additive manufacturing, on the quality of life of South Africans. While the imported powder used at present is very expensive, successful titanium powder production through the CSIR-Ti process, followed by local alloying and spheroidisation of the powder, will result in more affordable production of customised medical implants through additive manufacturing of local Ti6Al4V powder. Application of this technology to produce parts for other industry sectors, such as aerospace, power generation, chemical processing and marine, would stimulate broad downstream industry development.

Recommendations

- A long term vision is the key to success. Share this vision with all stakeholders and establish national support for the vision.
- The development and commercialisation of beneficiation processes do not happen overnight – perseverance is required, especially when unforeseen stumbling blocks or delays are encountered.
- Put South Africa's best resources to the task, empower them and ensure their on-going buy-in. The global competition is immense; we cannot afford not to utilise our best expertise and experience, or waste our energy on non-productive issues.

- We have examples of successful beneficiation, such as Sasol, which are inspiring, but we should also keep in mind how long it took Sasol to reach the current level of globally competitive performance.
- Use proven approaches and models, such as the Centre of Competence model, to focus and manage the R&D and implementation efforts.
- The two areas with the most potential for South Africa's titanium beneficiation programme are the primary production of titanium metal powder and the downstream manufacturing of titanium components through additive manufacturing. Government support for these should be sustained.