Lighter, greener and as strong: Developing light metals for application in the aerospace industry

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Outline of presentation

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  • Drivers of the South African Titanium Industry

• The South African Innovation Opportunity

• The Titanium Centre of Competence

• Titanium Processing
  • Investment casting
  • Near-net shaping of powder

• Semi-Solid Metal Casting of Aluminium alloys

• Conclusions
Drivers of the International Titanium Industry

Cold War:
  Titanium in military aircraft (USA)
  Titanium in submarines (USSR)

Space Missions:
  Titanium in satellites
  Titanium in launch vehicles

Commercial Aircraft:
  From less than 4% in Boeing 747 to >17% in Boeing 787
  Similar increase for Airbus
  Growth of >50% over next decade
The SR-71 Blackbird

- Designed & built in 1959 - 1963
- Fastest airplane ever:
  - Mach 3.2 (3700 km/h)
  - at 80,000 ft ~ 24 km
  - New York - London: 1h 55min
- Fuselage skin temperature:
  - 200º - 370ºC
  - Needed to be lightweight
- Constructed for 90%+ from Titanium alloys
- 50 million pounds Ti used during development
  - 67 tonnes per SR-71
Drivers of the South African Titanium Industry

SA’s Space Programme (mid ’80s – mid ’90s):
Titanium (Ti-6Al-4V) in satellites

Medical applications ('90s – present):
Titanium orthopaedic implants
Titanium dental implants

Chemical processing:
Commercially pure Titanium in processing plants (corrosion resistance)

Commercial aircraft industry needs:
Boeing’s need for alternative suppliers
Growing relationship with Airbus
South African Ti-6Al-4V products of the early 1990s

Technologies:
Design & analysis
Die design & production
Forging
Superplastic forming
Machining
Electron beam welding
Laser welding
Non-destructive testing
(X-Ray microfocus)


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South African Ti-6Al-4V products of the early 1990s

Technologies:
Design & analysis
Die design & production
Forging
Machining
Hydroxyapatite coating

Titanium Content per Airframe

(J. Monahan, ITA Conference, 2006)
The South African Innovation Opportunity

Significant Ti ore reserves

Primary metal and mill product technologies

Component manufacturing technologies

Existing markets:
- Aerospace
- Automotive
- Medical
- Recreational
- Industrial
  (e.g. Power plants)
- Chemical

The Titanium Centre of Competence integrates and coordinates R&D and commercialisation across the value chain
Titanium Centre of Competence
Developing and Commercialising the Technology Building Blocks of the South African Titanium Industry

Technology Development

- Simulation and Modelling:
  - ULim (Ab Initio), CSIR (FEM, ProCast, Ab Initio), UCT (FEM, Proc. Mod.), CPUT (Weld Sim)

- Laboratories & R&D Facilities:
  - CSIR, UCT, UP, US, NMMU, CUT, Mintek, Necsa, NLC

R&D Platforms

www.csir.co.za
Titanium Centre of Competence Collaborators

**International**

**R&D Institutions:**
- NIMS (Japan)
- Univ California (USA)
- ESRF (France)
- Univ of Birmingham (UK)
- Univ of Plymouth (UK)
- ALD (Germany)

**Industry Players:**
- Snecma (France)
- Airbus (France)
- Boeing (USA)
Only a few players in the world can cast Titanium successfully on commercial scale.

They handle this as proprietary knowledge and do not publish detail.

CSIR had to develop the key processes in the casting process chain.

We upgraded facilities used successfully in the 1990s for casting turbine blades in Nickel-based superalloys, to enable us to investment cast Titanium alloys.
Investment Casting of Titanium Alloys

- Developed and packaged the Titanium mouldmaking and crucible melting processes

- Developed and packaged the chemical milling process

- Casting an aerospace part
Titanium Powder Processing

- Our primary Titanium metal production process delivers a Titanium powder.

- More affordable Titanium powder will unlock a much broader market for Titanium products produced from powder.

- Therefore we have been developing a Titanium powder processing competence since 2006.

- Through strong support from the DST we have been able to acquire essential equipment.
Titanium Powder Processing

- Establishment of our metal injection moulding process with first test samples

- Patent on novel Ti-Mg alloys via direct reduction of TiO$_2$

- Compaction and sintering of powder produced through the CSIR process
Semi-Solid Metal Casting of Aluminium

Development of the CSIR Rheocasting System

Establishment of a High Pressure Die Casting cell
Redesigned an automotive component for SSM forming

SSM Forming of Aluminium Alloys

Casting Alloys:
- A356
- A201/206

Wrought Alloys:
- 7075

Establishing an HPDC facility with the capability to perform short production runs (industrial simulation)
CSIR Aluminium Rheo Casting Cell

Dosing Furnace

SSM billet machine

650 Ton LK shot control die casting machine
Conclusions

- The Titanium Centre of Competence has successfully aligned Titanium related R&D across the country and focused these strongly on needs of the aerospace industry.

- The Investment Casting process for Titanium castings has been successfully developed and packaged and the commercialisation effort has started.

- The patented CSIR Rheocasting technology for semi-solid metal casting of high strength Aluminium alloys is also ready for commercialisation and offers interesting opportunities for aerospace application.
I would like to acknowledge the contributions of my colleagues and their research teams:

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- Semi-Solid Metal Casting: Dr Sagren Govender
Thank You