AMG TITANIUM ALLOYS & COATINGS
GfE Metalle und Materialien GmbH

MASTER ALLOYS

Future Security of Supply With Master Alloys From a European Point of View

ITA conference Las Vegas, October 9th 2013

Overview

- AMG Titanium Alloys & Coatings (GfE)

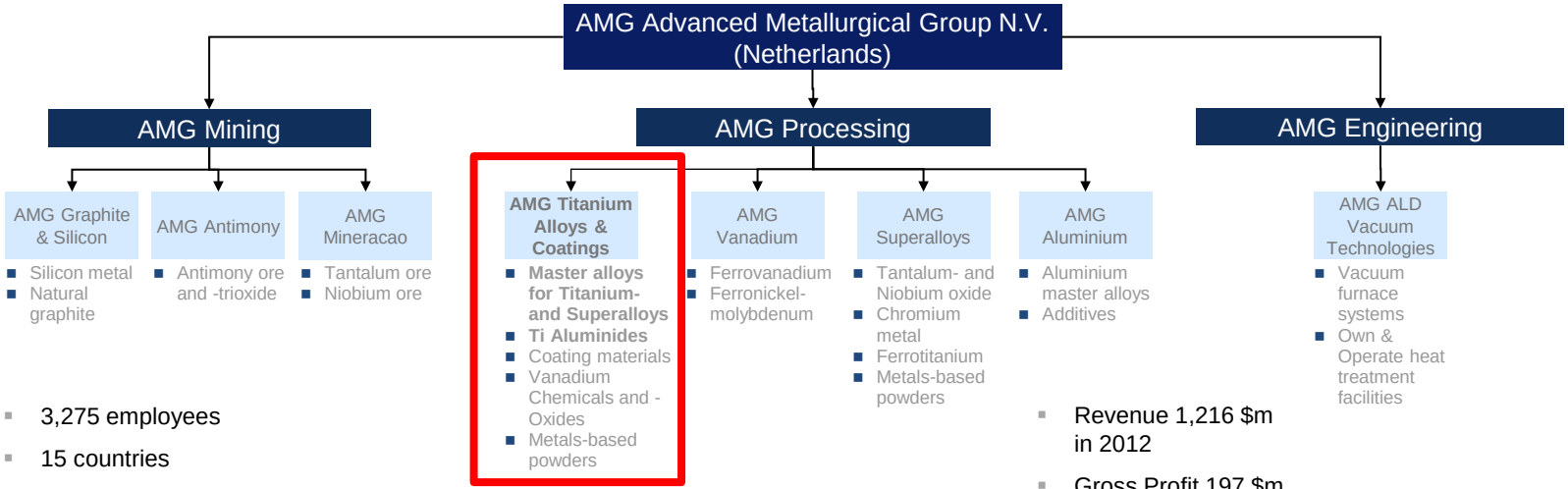
- Master alloys for titanium alloys
  - Alloy systems, raw materials and production
  - Properties, applications and suppliers

- Influences on future supply and demand

- Resulting challenges for the supply chain

- Summary

AMG Titanium Alloys & Coatings (GfE)



- 3,275 employees
- 15 countries
- 4 markets

  (energy, **aerospace**, infrastructure, specialty metals & chemicals)
- 3 business segments

- Revenue 1,216 $m in 2012
- Gross Profit 197 $m in 2012
- EBITDA 85 $m in 2012

Master Alloys for Titanium Alloys
- Alloy Systems -

What is a Master Alloy?

- A Master Alloy is an alloy containing two (binary), three (ternary) or more elements (multinary) with a defined composition, e.g.
  - ➢ binary: VAl (for Ti 6-4), MoAl, NbAl
  - ➢ ternary: MoAlTi (for Ti 6-2-4-6), VAlFe
  - ➢ mulitnary: AlSnZrMoCr (for Ti 17), AlMoVCrTi (for Ti 5-5-5-3)

  and is a semi-finished product manufactured for use as a raw material by the titanium industry

Master Alloys for Titanium Alloys
- Raw Materials and Production (1) -

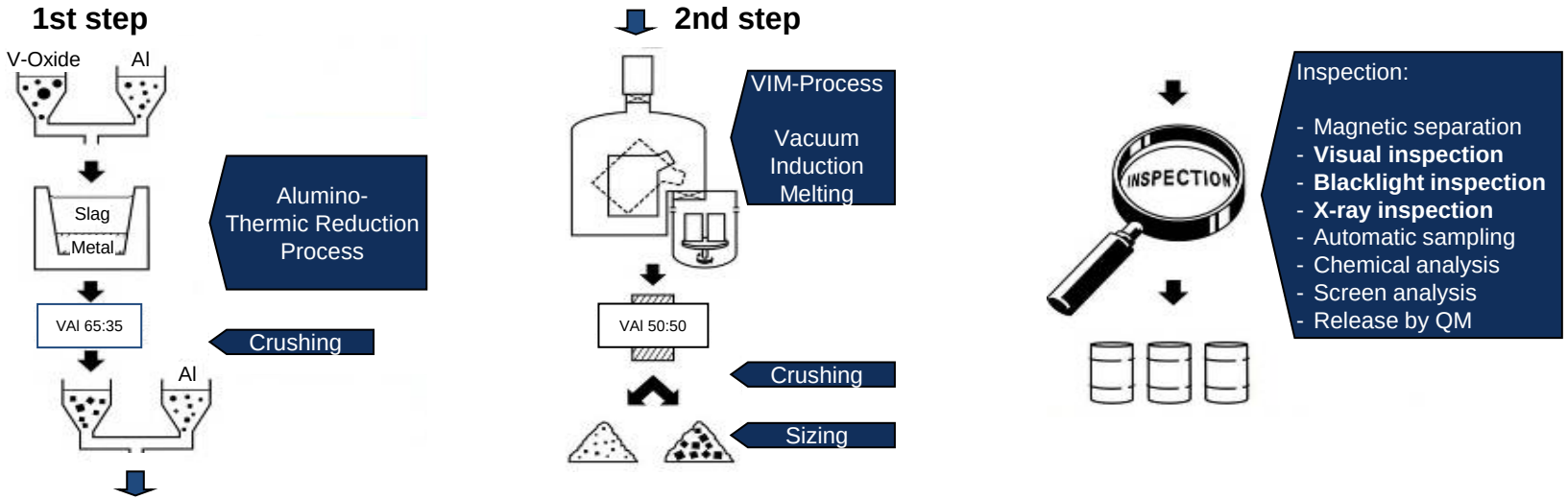
How is a Master Alloy produced?

- Raw materials are metal oxides + aluminum as well as auxiliary materials which will be mixed/homogenized
- The alloy is produced via an aluminothermic (thermite) smelting process within a refractory-lined or copper vessel

$V_2O_5 + Al \rightarrow VAl + Al_2O_3 + heat$

Master Alloys for Titanium Alloys
- Raw Materials and Production (2) -

How is a Master Alloy produced?



Master Alloys for Titanium Alloys
- Properties -

Why are Master Alloys used?

- Improve heat and corrosion resistance
- Improve mechanical properties of base titanium

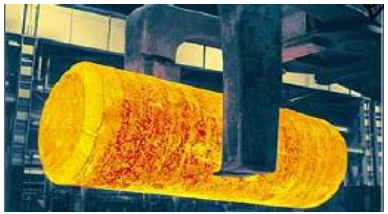
… are used to metallurgically create microstructural stabilization providing associated physical and chemical properties …

→ … **Master alloys** are mandatory in order that titanium alloys meet with the **performance targets** of the final application …

Master Alloys for Titanium Alloys
- Applications (1) -

What are potential titanium alloy applications?

- Master alloy (e.g. VAlFe) + Ti sponge form an electrode
- This electrode will be made molten via a **V**acuum-**Arc**-furnace (VAR) to form a Ti alloy ingot (e.g. Ti 10-2-3)
- The ingot will be mechanically processed to a final part



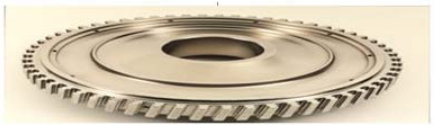
e.g.

undercarriage / bogie

structural part

Master Alloys for Titanium Alloys
- Applications (2) -

What are potential titanium alloy applications?

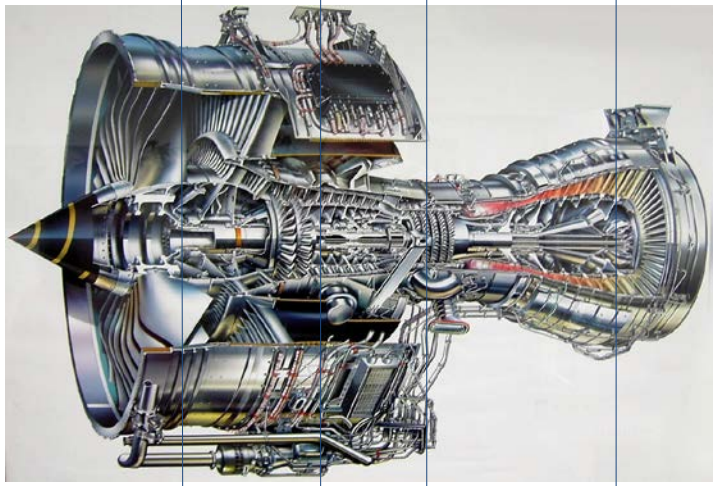


disc

e.g.

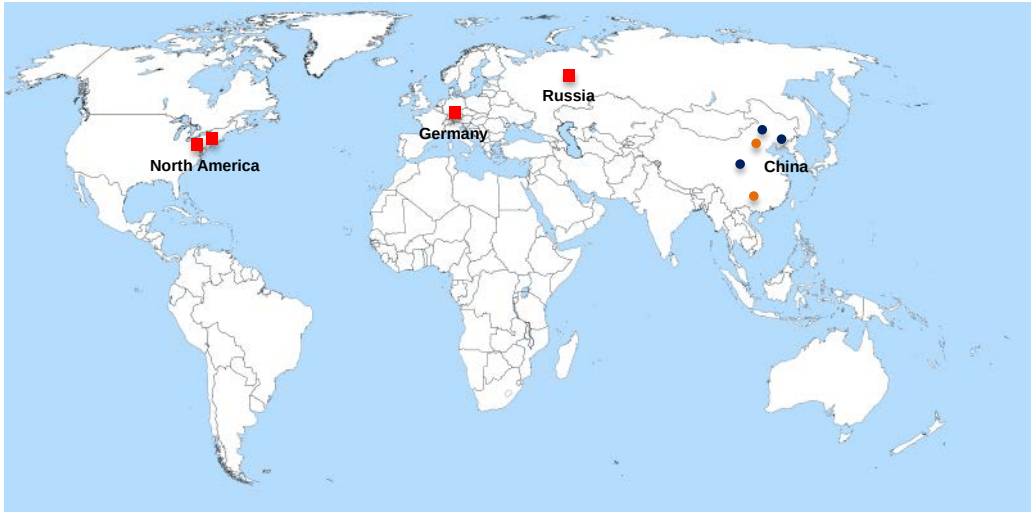
blade

	e.g.	Ti-64	Ti-6246	Ti-834	Titanium Aluminides
Operating temperature [°C]		up to 400	up to 550	up to 600	up to 730



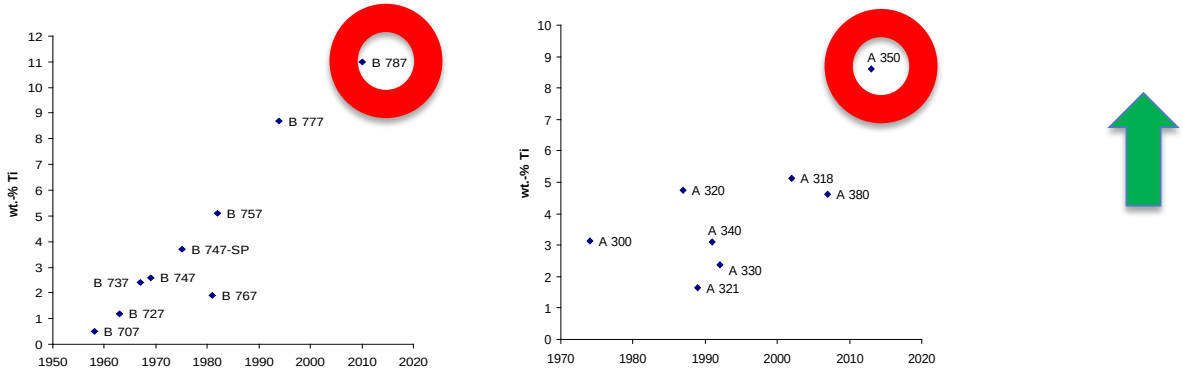
Master Alloys for Titanium Alloys
- Supplier Base -

Where are approved and certified suppliers located?



Influences on Future Demand (1)

- Estimated current global master alloy consumption: ~ 6,000 mt/a
- New civil aircraft designs require much more titanium alloys per aircraft than past models



Influences on Future Demand (2)

- Number of new airplanes will increase – mainly driven by the Asian/Pacific region expansion …

- … but the general tendency is to use more Ti alloy scrap

- Performance targets of particular titanium applications may require a shift to different types of titanium alloys which requires different types of master alloys …
- … but there may be technological changes in materials (composites, Ti Aluminides) which will decrease the usage of master alloys

Influences on Future Supply

- Political
  (trade barriers, strikes, shortage in energy, etc.)
- Pricing
  Raw materials are depending on other industry sectors
  (e.g. Vanadium quotation is linked to the steel industry)
- Currency exchange rates
  (USD, EUR, RMB, REAL, etc.)
- Strategic focus of the approved and certified suppliers
- New market participants

Influences on Future Demand and Supply

Therefore it may be seen that consumption of titanium alloys will increase and with it the importance of master alloys will be unquestioned …

… but at the same time the supply chain may be subject to external influences.

Is the supply chain in danger and is there a need for action?

Necessary Commitments of the Supply Chain

- **Suppliers** to the **master alloy producers** are**:**

  - ➢ expected to provide clear strategic commitments supporting the titanium industry with sustained supply of consistent quality materials
  - ➢ encouraged to show more flexibility regarding pricing (fixed prices, formula prices, settlement basis, etc.)
  - ➢ encouraged to have the willingness to share commercial risk (e.g. consignment stock, payment terms, etc.)

Necessary Commitments of the Supply Chain

- **We,** as **master alloy producers,** must:

  - balance the expectations of our customers and the capabilities of our raw material suppliers while taking into consideration our own constraints
  - provide our products to specification, on time and at a price level manageable for all participants of the supply chain
  - be innovative in developing technical solutions for present and future master alloy requirements as well as leading cost reduction programs

Necessary Commitments of the Supply Chain

- **Master Alloy producer** expectations from the **Customers** include:

  - balancing purchasing orders within the approved and certified supplier base
  - understanding and accepting the influence of currency exchange rates outside the USD economic area with regard to master alloy pricing

Necessary Commitments of the Supply Chain

- (cont'd) Master Alloy producer expectations from the **Customers** include:

➢ Intensifying cooperation with the master alloy producers, for example, by:
- early involvement in R&D activities
- providing reliable mid/long term forecasts

bringing us to a position of adjusting capabilities and capacities at the right time…because we cannot simply „turn on and off"…

Necessary Commitments of the Supply Chain

Only a **close alliance** of

… all suppliers to the master alloy producers
… us as master alloy producers and
… all of our customers

will **increase the security of supply for the future!**

Summary

- A master alloy is not a commodity
- Without master alloys there are no titanium alloys
- The titanium industry requires a healthy master alloy supplier base
- Commitments along the supply chain are essential, at the end of the day, the message … „prices must go down“ is much too simple …

Thank you for your attention!

GfE‘s team during the 100 year anniversary in 2011