Synthesis of Ti-Al-V alloys by Aluminothermic Reduction to Produce Pressed Electrodes for ESR

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Motivation

- due to high material and production costs alternative production processes are highly demanded
- aluminothermic reduction offers a least expensive process through:
  - ➡ high temperatures
  - ➡ short reaction times
  - ➡ self-propagating reaction behavior
- direct synthesis of titanium alloy by co-reduction of alloying element oxides

➡ reduced production costs via decreasing amount of Titanium sponge

Process Idea

ATR - production → **ESR - refining**

1 ATR Master Alloy

- determination of β for master alloy Ti-6βAl-4βV
- definition of process window by adjusting
  - ➡ adiabatic reaction temperature
  - ➡ reaction enthalpy
  - ➡ phys. properties of input material

2 Pressing Electrodes

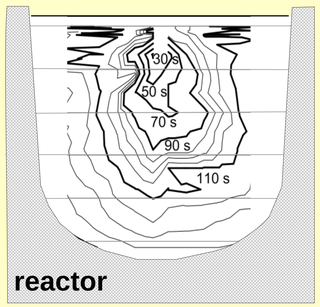
- adding Ti-sponge to obtain Ti-6Al-4V
- Ti-sponge acts as binder
  - ➡ high binder content required
  - ➡ high ATR metal input favored

3 Electroslag Remelting

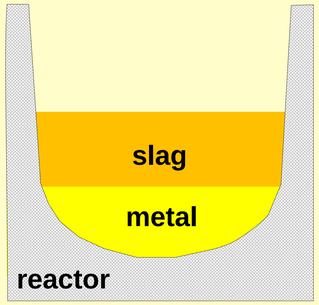
- used slag system CaF_2-CaO-Ca
- monitoring of metal droplet transfer during remelting process
- deoxidation target < 500ppm
- lab-scale ESR unit
- power supply: 724 kW
- electrode weight: 1,0 kg
- protective argon atmosphere

ATR Process

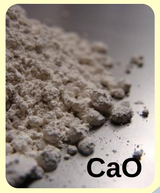
- reactor lining based on Al_2O_3
- charged material as powder
- electrical ignition from mixture surface
- self-propagating reaction through entire mixture
- settling of metal phase at reactor bottom

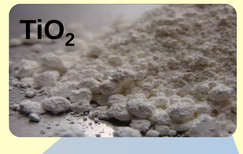


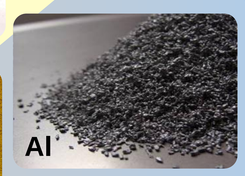
➔ reaction front propagation



➔ metal slag separation







Titanium dioxide reduction

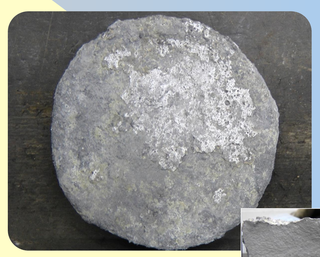
$$TiO_2 + \frac{4}{3}Al \rightarrow Ti + \frac{2}{3}Al_2O_3 \qquad \Delta H^R_{Ti} = -184{,}1kJ$$

Vanadium oxide reduction

$$\frac{1}{2}V_2O_5 + \frac{5}{3}Al \rightarrow V + \frac{5}{6}Al_2O_3 \qquad \Delta H^R_{V_2O_5} = -621{,}1kJ$$

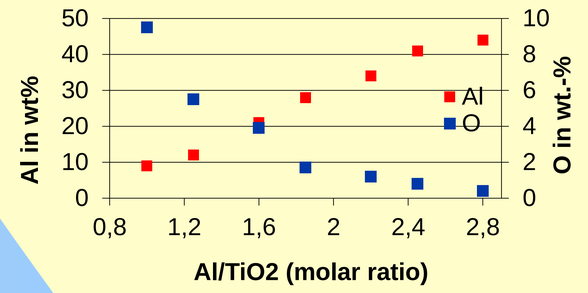
Booster reaction

$$KClO_4 + \frac{8}{3}Al \rightarrow KCl + \frac{4}{3}Al_2O_3 \quad \Delta H^R_{KClO_4} = -2241{,}3kJ$$

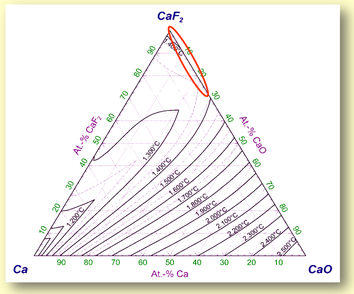


ATR product

metal cross section



➔ Al-O-interaction in TiO_2 reduction

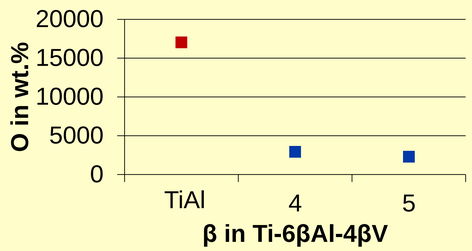


➔ ESR slag system CaF_2-CaO-Ca

chrushed ATR metal

Titanium sponge

➡ Vanadium decreases oxygen content in ATR metal to 2900 ppm



➡ β = 4: Ti-26Al-16V
➡ β = 5: Ti-30Al-20V
➡ TiAl produced via ATR

Ti-6Al-4V compact

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