PESR processing of TiAl-electrodes made by aluminothermic reduction

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Motivation

- γ-titanium aluminides show superior mechanical properties at high temperatures
- Large scale application of these alloys is still hindered by high material cost
- TiAl is currently produced by VAR from titanium sponge, aluminium and master-alloys
- Challenges in today´s production include homogeneous alloying and the high price of materials

➡ An alternative processing route was designed and has reached pilot scale, starting from readily available, cheap raw-materials.

Flowchart

Raw materials:
TiO_2 pigment
alloying oxides
Al powder, booster

Aluminothermic reduction

Liquid, homogeneous metal-melt

In-line-casting

Raw γ-TiAl electrode

Calcium feed

Deoxidation by PESR

Deoxidized γ-TiAl ingot:
Ø 160 mm
50 kg

Pilot scale PESR
Max. P=50 bar
Power supply:
400 kVA

PESR results

Characterisation of obtained ATR electrodes

Section	1	2	3	4	5	6	7	8
wt.% Ti	46.58	44.73	47.46	47.48	47.38	47.40	47.96	48.35
wt. %Al	27.41	28.20	26.75	27.30	23.35	27.43	27.13	26.30
wt.% Nb	16.66	16.26	17.34	17.16	17.04	17.16	17.33	17.08
wt.% C	0.17	0.092	0.122	0.071	0.12	0.076	0.087	0.075
wt.% O	1.69	2.57	1.36	1.19	1.85	1.14	0.69	1.34
ppm N	132	75	39	86	108	90,5	59	55

Modelling for PESR control

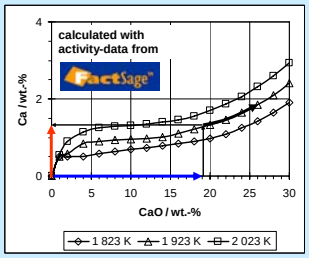
$$K = \frac{a([CaO]_{slag}) \cdot a([Ti]_{metal})}{a([Ca]_{slag}) \cdot a([O]_{metal})} = f(T) \equiv const$$

variable — constant

- slag system: CaF_2 - CaO – Ca_{met}
- deoxidation and formation of CaO

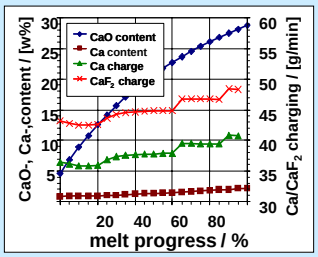
$[TiO]_{TiAl} + [Ca]_{CaF2} \Leftrightarrow [Ti]_{TiAl} + [CaO]_{CaF2}$

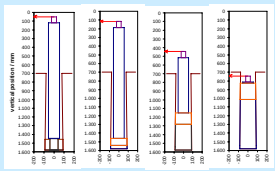
Slag metal equilibrium



- slag temperatures ~1700°C, strong reducing conditions, fluorine melt
- no possibility at present for on-line measurement of Ca and/or O activity
- control of slag chemistry by modeling using equilibria calculations and mass balancing

Model for calcium feed





predicted metal/slag progress during PESR of oxygen containing TiAl ingots

Conclusions

- IME proves a concept for direct TiAl production starting with aluminothermic reduction of pigment.
- Oxygen uptake during ATR could easily be reduced from 16.000 ppm to 2000 ppm by PESR
- Process optimisation by adjusting Ca-feed aims on final oxygen contents of <500 ppm
- Inevitable Ca uptake amounts to 1000 ppm and has to be removed by final VAR
- TiAl cost can be reduced by factor 2-3

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