**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**

<table>
<thead>
<tr>
<th>ATR - production</th>
<th>ESR - refining</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATR Master Alloy</td>
<td>Pressing Electrodes</td>
</tr>
<tr>
<td>determination of β for master alloy Ti-6Al-4V</td>
<td>adding Ti-sponge to obtain Ti-6Al-4V</td>
</tr>
<tr>
<td>definition of process window by adjusting adiabatic reaction temperature</td>
<td>Ti-sponge acts as binder</td>
</tr>
<tr>
<td>reaction enthalpy</td>
<td>high binder content required</td>
</tr>
<tr>
<td>phys. properties of input material</td>
<td>high ATR metal input favored</td>
</tr>
<tr>
<td>ATR Process</td>
<td>monitoring of metal droplet transfer during remelting process</td>
</tr>
<tr>
<td>reactor lining based on Al₂O₃</td>
<td>deoxidation target &lt; 500ppm</td>
</tr>
<tr>
<td>charged material as powder</td>
<td>high binder content required</td>
</tr>
<tr>
<td>electrical ignition from mixture surface</td>
<td>high ATR metal input favored</td>
</tr>
<tr>
<td>self-propagating reaction through entire mixture</td>
<td>settling of metal phase at reactor bottom</td>
</tr>
</tbody>
</table>

**Titanium dioxide reduction**

\[
TiO_2 + \frac{4}{3} Al \rightarrow Ti + \frac{2}{3} Al_2O_3 \quad \Delta H^\circ_{\text{R}} = -184.1 \text{kJ}
\]

**Vanadium oxide reduction**

\[
\frac{1}{2} \text{V}_2O_5 + \frac{5}{3} Al \rightarrow V + \frac{5}{6} Al_2O_3 \quad \Delta H^\circ_{\text{V,O}} = -621.1 \text{kJ}
\]

**Booster reaction**

\[
KClO_3 + \frac{8}{3} Al \rightarrow KCl + \frac{4}{3} Al_2O_3 \quad \Delta H^\circ_{\text{KClO,3}} = -2241.3 \text{kJ}
\]

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

**ATR**
- Reactor lining based on Al₂O₃
- Charged material as powder
- Electrical ignition from mixture surface
- Self-propagating reaction through entire mixture
- Settling of metal phase at reactor bottom

**ESR**
- Master alloy
- Pressing electrodes
- Electroslag remelting

**ATR Product**
- ATR product
- Metal cross section

**ESR Slag System**
- CaF₂-CaO-Ca

**ATR Product**
- Titanium sponge
- Crushed ATR metal

**Ti-6Al-4V compact**

**ATR Master Alloy**
- Determination of β for master alloy Ti-6Al-4V
- Definition of process window by adjusting:
  - Adiabatic reaction temperature
  - Reaction enthalpy
  - Phys. properties of input material

**ATR Process**
- Reactor lining based on Al₂O₃
- Charged material as powder
- Electrical ignition from mixture surface
- Self-propagating reaction through entire mixture
- Settling of metal phase at reactor bottom

**ESR Process**
- Master alloy
- Pressing electrodes
- Electroslag remelting

**ATR Master Alloy**
- Determination of β for master alloy Ti-6Al-4V
- Definition of process window by adjusting:
  - Adiabatic reaction temperature
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  - Phys. properties of input material