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Simulation of aluminothermic smelting of the carbon-containing ligature for titanium alloys

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Abstract

The article reports the results of thermodynamic simulation of the Al-V-Ti-C (AVTU), Al-Mo-Ti-C (AMVTU) and Al-Mo-Nb-Ti-C (AMNTU) ligature alloys smelting from aluminothermic charges containing an appropriate set of oxides (V_2O_5, MoO_3, Nb_2O_5), elemental titanium and carbon. Modeling was performed with the help of the HSC-6.1 Chemistry software package. Melting temperatures, equilibrium phase and elemental compositions of alloys and slags as well as a distribution of carbon to carbide phases were defined according to the material and the thermal balances (subject to "zero" heat loss). According to the simulation results thermic properties of finance charge allow to reach temperatures of up to 3100 °C, thus providing an autogenous process and the possibility of ligatures smelting by the off-furnace method.

In the AVTU alloy titanium has to be mainly in the form of carbide TiC and vanadium – in the form of aluminides VAl_3, V_3Al_2. Vanadium in the AMVTU ligature is represented by aluminides, carbides VC, V_2C and elemental vanadium. The main titanium-containing phases of the AMVTU ligature – carbide TiC and aluminides TiAl, $TiAl_3$. In the AMNTU ligature aluminides Mo_3Al, $NbAl_3$ and TiAl are dominating species, and carbide phase consists of TiC and Nb_2C.

There are predominantly Al_2O_3 (more than 70 wt.%) and calcium aluminates $CaO{\cdot}2Al_2O_3$, $CaO{\cdot}Al_2O_3$ in the slag of alloy smelting. In the slags of AVTU and AMVTU smelting vanadium and titanium are in the form of oxides TiO and VO. Becides it is probable a formation of oxides TiO, Ti_2O_3, TiO_2, as well as titanates $CaO{\cdot}TiO_2$ and $Al_2O_3{\cdot}TiO_2$. Titanium transition to the slag of AMNTU smelting is not more than 2.0% of its amount in the charge.

The article shows the ligatures compositions, designed by the thermodynamic model and obtained experimentally by melting under industrial environments. It is noted a good agreement between the calculated and experimental compositions of ligature alloys. We concluded about the possibility of applying the method of thermodynamic modeling to forecast estimation of aluminothermic smelting of carbonized ligature alloys based on the rare refractory metals.

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