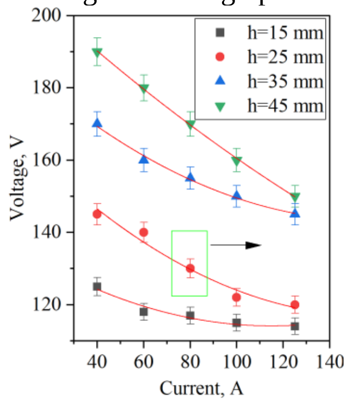
PLASMA MELTING METHOD OF ALUMINUM-MAGNESIA SPINEL*

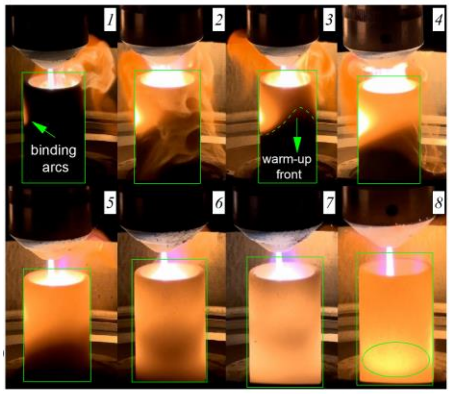
V.V. SHEKHOVTSOV[1]*, A.B. ULMASOV*[1]

[1]*Tomsk State University of Architecture and Building, Tomsk, Russia*

Aluminum-magnesia spinel (MAS) – special class of refractory materials used to provide thermal insulation of laboratory and industrial furnaces, blast furnaces and steel ladles at operating temperatures above 2000 °C [1, 2]. Materials such as the rules have a high melting point, high strength and fracture toughness, as well as high resistance to chemically aggressive environments. Experimental work on the synthesis of MAC products was carried out on an electroplasma stand. The main elements of the electroplasma stand are: an electric arc plasma torch with a nozzle diameter of 5 mm (cathode); a graphite crucible (anode). The stand is equipped with water cooling systems, plasma-forming gas (nitrogen) supply and ventilation. Fig. 1, *a* shows the volt-ampere characteristic at different interelectrode distance (the distance from the nozzle to the upper end of the graphite crucible). Fig. 1, *b* shows freeze frames of the anode spot binding sites on a graphite crucible.



a



b

Fig. 1. Dynamics of heating of a graphite crucible depending on the power input:
a – volt-ampere characteristic;
b – freeze frames of video recording of the anode spot binding and dynamics of heating of a graphite crucible

The conducted studies show that with electric power costs in the range of 10-18 kW, taking into account the thermal exposure time of 60 s and heat losses of ~ 5-8% for bypassing thermally stressed structural elements of a plasma generator, the thermal power ranges from 600 to 9000 kJ. Thus, when using a graphite crucible with an internal diameter of 22 m, the specific heat flux ranges from $1.57 \cdot 10^6$ to $2.37 \cdot 107$ kW/m^2. Considering the dynamics of heating of a graphite crucible (Fig. 1, b), it can be seen that at the initial stage the arc is bound to the inner wall of the graphite crucible, followed by an increase in the area of the anode spot (frag. 1-4). In the future, when the heating front moves to the base of the graphite crucible, its electrical conductivity increases, which allows for the movement of the arc in the working area (frag. 5-7). When fully heated, the anode spot moves to the base of the graphite crucible (frag. 8), which will increase the contact area and thereby ensure uniform melting of the material.

The morphology of the spinel obtained according to the proposed method is represented by clear crystals stacked on an area of ~ 1.75 µm, with the formation of a textured surface with different angles of inclination. It is worth noting that the formation of morphology is realized in two conjugate stages: primary - surface crystallization of crystals with a diameter of 85 µm, half-width into the body of the matrix 100 µm; secondary - localized crystallization of crystals with diameter of 10 µm, located randomly throughout the matrix of the melting product.

REFERENCES

[1] V. V. Shekhovtsov, N. K. Skripnikova, A. B. Ulmasov, “Neorgan. Materials,” vol. 59, no. 8, pp. 888-895, 2023. [in Russian].

[2] V. V.Shekhovtsov, “Thermal Plasma Synthesis of Forsterite with Cubic Matrix,” High Energy Chem., vol. 57, pp. 204–208, 2023.

* This work was financially supported by the Ministry of Science and Higher Education of the Russian Federation (Project FEMN-2022-0001).