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Ph.D dissertation title:

Organobentonites with acrylic polymers for use in the moulding sand technology

Summary

The doctoral dissertation discusses the issue of developing a new, ecologically friendly binding material capable of use in the technology of synthetic moulding sands.

Bentonite is the most common inorganic binder in synthetic moulding sands, with the use of which the highest percentage of iron castings are made. The production of castings with an appropriate surface quality is a basic parameter in the context of the material development for foundry moulds. To avoid surface defects in castings, carbon additives are used. According to one theory, as a result of their decomposition at high temperature, the so-called lustrous carbon (LC) is formed. LC prevents liquid metal from penetrating into the mould, however, the formation process is often accompanied by the generation of harmful gaseous products.

The obtained organobentonites, being bentonite modified with compounds selected from the group of acrylic polymers: poly(acrylic acid) (PAA) and its sodium salt (PAA-Na), were aimed at binding grains of the mineral matrix acting simultaneously as a precursor of the desired carbon structure. Due to the risk of insufficient polymer efficiency in composites, shungite was used as a new carbon additive in the field of foundry engineering, the effectiveness and reduced environmental footprint of which was confirmed in the patent application.

The spectroscopic, microscopic, diffraction and adsorption analyzes (FTIR, SEM with EDS, XRD, BET analysis) were performed to verify the type of interaction in the bentonite (MMT montmorillonite) - polymer (PAA and PAA-Na) systems. Additional molecular dynamics simulations confirmed the results of instrumental research promoting the nature of poly(acrylic acid) in the formation of structurally stable forms of organobentonites (LAMMPS). Thermal analysis techniques (TG-DTG-DSC) were used to determine the thermal stability of the composites. The reorganization temperature of MMT, having a destructive effect on the binding properties of bentonite, was shifting towards lower values along with the increase in the polymer content in the system. Therefore, it was the organobentonite with the lowest PAA content that was submitted for analysis in the moulding sand and subjected to the evaluation of the potential as a binding material. Technological and strength properties evaluation of the moulding sands prepared with selected organobentonite and shungite as a coal dust substitute in a system with hydrocarbon resin showed that the optimum composition of the sand for the practical use in the foundry technology was obtained. Chromatographic techniques (Py-GC/MS, GC) showed a positive effect of shungite on the quantity and quality of gaseous products generated from the sands during the thermal destruction of its components. Thus, the reduced environmental footprint of the new carbon additive compared to the popularly used lustrous carbon carriers was confirmed.

The casting prepared in a mould of organobentonite and a mixture of shungite/hydrocarbon resin showed a much better shape representation of the stepped pattern and surface finish compared to the casting obtained with the use of a model moulding sand.