mgr inż. Karolina Joanna Kaczmarska
Akademia Górniczo-Hutnicza im. St. Staszica w Krakowie
Wydział Odlewnictwa
Katedra Inżynierii Procesów Odlewniczych

The title of the dissertation:

Sodium carboxymethyl starch (CMS-Na) as a material for use in moulding sand technology

Abstract

The doctoral dissertation concerns the subject connected with the application of modified potato starches received through etherification in form of sodium carboxymethyl starch (CMS-Na) in the molding sand technology (as a binding material and an addition to green sands). While selecting the research material CMS-Na was taken in account with the degree of substitution (DS) of 0,20-0,87 and thanks to it, it was possible to correlate the physical and chemical properties of modifiers with chosen properties of the molding sands made with their participation.

As a part of this dissertation, there were conducted the research in not only structural but also physical and chemical analysis of sodium carboxymethyl starch with DS of 0,20-0,87 in the solid form and water system. A number of experiments were conducted by using the analytical techniques, i.e. spectroscopic, microscopic and thermal (FTIR, FT-Raman, SEM, XRD, TG-DSC). Based on received results, the CMS-Na with the optimal physical and chemical properties was verified and selected. Moreover, it was demonstrated that the degree of substitution determines its physical and chemical properties, which can be meaningful in the context of CMS-Na use as an independent binder in molding sands technology. Furthermore, it was found that the presence of hydrophilic groups placed in matters of etherification causes that CMS-Na becomes active in microwave field and can create cross-linked structures with the participation of intermolecular and intramolecular hydrogen bonds. The course of binding process in the microwave field for the system binder CMS-Na–mineral matrix was recognized. It was also proved that the microwave radiation is a physical factor leading to the activation of silanolate groups (Si-OH), present on the surface of mineral matrix, which then results in creating the system of hydrogen bonds in examined system.

In order to verify the structural research, the series of technological research of physically hardened (conventional heating, microwave radiation) molding sand with the participation of CMS-Na were conducted. It was confirmed that in the binding process the DS of modified starch plays an essential role, the form of inserting the binder to the sand grains and selection of the substance hardening method. It has been shown that microwave radiation is a more efficient curing agent than conventional heating. In addition, the assessment of suitability of CMS-Na use as addition to green sands with bentonite was made. The received results allowed to select the modified starch CMS-Na with the best properties from the point of view of application in molding sand technology.

In the series of CMS-Na thermal research, not only the thermal stability of modifier with low and high degree of substitution was determined but also quantitative and qualitative assessment of volatile products generated during the thermal degradation (TG-DSC, Py-GC-MS) was made. Moreover, it was proved that etherification of potato native starch does not have negative influence on ecological context of examined molding sands with the participation of CMS-Na.