Heat-insulating moulding sand with the glycol addition

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Abstract

The article presents a selection of the composition and basic properties of highly insulating moulding sand. Sandmix is designed especially for thin-walled castings with high tendency to oxidation - particularly in spatial cores skeleton castings. An example of matrix of sandmix are aluminosilicate microspheres and the binder is bentonite plasticized with water and polyglycol. By using the microspheres high insulation, high mechanical strength and low specific weight core sand was obtained. Addition of polyglycol improved the mechanical properties, deformation characteristics, surface smoothness and reduced friability of sandmix.

Keywords: Polyglycol, Moulding Sand, Core, Skeleton Castings

1. Introduction

Commonly used in the foundry industry are synthetic sandmixes with bentonite, which main component is montmorillonite [1]. The main technological properties of moulding sand with hydrophilic bentonite depend mainly on the humidity. The best properties are obtained within a narrow range of content of individual components. Knowledge about the binding mechanism of bentonite and its rheology is important for the practice of industrial applications, quality control, storage stability and effective, useful properties of moulding sand. In industrial conditions it is difficult to maintain a stable composition of sandmix - mainly the water content in the narrow range that provides optimal technological properties.

For many alloys water in mold is unwanted or even harmful. It creates a overmoisture zone in mold, thereby significantly reducing the mechanical properties of sandmix [1]. The water content is particularly disadvantageous for copper alloys. It causes hydrogen absorption from the evolved water vapor [2]. Due to the adverse effects of water content moulding sands with organophilic bentonite were applied. In this types of sandmixes, as a plasticizing ingredient, instead of water, mazout and lubricating oils were used [1, 3].

In order to change properties of bentonite polymer additives, salts or surfactants are also used. Such an addition may be also glycols. They allow a reduction water content while maintaining the mechanical properties on the desired level [2]. Polymer additives interact with the bentonite in different ways. Ionic polymers are absorbed on the surface of bentonite particles by electrostatic interactions. And nonionic polymers are absorbed by steric interactions [4]. The concentration of polymer, its molecular weight, temperature and contact time affect the reactions taking place between the bentonite and polymers [5]. Polyglycol molecules are not able to interact electrostatically with the negatively charged Na-bentonite particles because it is a non-ionic water soluble polymer which consists of polar ethylene glycol units. These molecules can be adsorbed on the surface of Na-bentonite by H-bond formation or they can place between the layer [4].
After the addition of glycol to sand it displaces bound water and bentonite. Approximately one mole of glycol is replaced by two moles of water [5, 6].

In practice, the glycol is very rarely used, until now mostly as an additive to the facing sands and only to improve the quality of casting surface. Glycol prevents oxidation of alloys by the generation in the mold a reducing atmosphere. With gases evolved from the glycol repels oxides and slag from molten metal, which ultimately prevents the formation of folds, cold shots and cracks. Sandmix with the addition of polyethylene glycol is recommended for cast iron alloys with high content of easily oxidizable components such as chromium and manganese. It is also found in a magnesium alloys [3].

Similar additions are used in industry, in grinding raw dolomite, as so called activators of grinding. These substances, often containing polyglycol, or mixtures of different glycols, lower the surface tension and reduces internal friction. Thanks to this raising performance milling up to 15-20%. In this way can save electricity by about 10% [9, 10]. The essence of their actions in most of practical applications depends on the small surface tension which facilitates wetting and penetration of microporous solids.

2. Aim and range of research

The aim is to produce moulding sand with aluminosilicate microspheres. This sandmix is characterized mainly by low thermal conductivity, low density and high fire resistance. Aluminosilicate microspheres is a lightweight, heat-resistant material. It is used mostly as:

- filling component in composites
- component for casting powders
- plastic material filler
- component of the thermal and sound insulation materials

Material properties of aluminosilicate microspheres make it an excellent moulding material for thin and super thin-walled castings. This material is particularly well suited to prepare geometrically complex and thin-walled core of skeleton castings. The study investigated the effect of the addition of polyglycol on the strength properties of moulding sand. In the sandmixes with microspheres, addition of polyglycol is beneficial because of ability to reducing of their large friability. Partial replacement of bentonite plasticizing water, with high boiling polyglycol is used for reduction of gas emission from moulding sand with creating a desired reduction atmosphere on cast mold boundary contact. Basic properties of sandmix, including compressive strength, friability, permeability and hardness was marked.

The goal is to produce, inter alia, the core with properties allowing the simultaneous use it as a matrix of composite cast skeleton structure. Such core has two functions: first - the technological, as reproducing the surfaces of the connectors and nodes of skeleton castings, second - operating as the filing, increasing dynamic mechanical properties of the composite structure.

3. Methodology of research

Basic research of moulding sand were performed. That is compressive strength, permeability, hardness and friability. Samples of sandmixes were prepared in accordance with PN-H-11070:1983. For the cylindrical samples constant height of 50 mm was assumed. In this sample weight ranged between 65 and 78 g. The discrepancy of weight is because of a natural separation of light particles with significantly different grain. A sample with similar size prepared with the traditional moulding sand weighs about 160 g. Prepared samples before testing the compressive strength and hardness and friability were dried at 70°C for 5 hours.

Determination of compressive strength were made by LRu universal-type machine. Friability was determined by LS type machine.

The experiment plan provides for changing the bentonite content in range of 17.3 to 45.3% by weight. Water content correlated with bentonite was 1/3 of its content by weight. Minimum and maximum levels of individual components was established by preliminary experiments.

In determining the preferred range of test sands configurations the typical compositions of synthetic moulding sands with bentonite were taken into account, but also taking into account the difference in mass density of quartz sand, and aluminosilicate microspheres. The content of polyglycol ranged to 10% by weight. For research Quickbond IKO bentonite was used.

4. Results

Figure 1 shows the average compressive strength values of moulding sand with aluminosilicate microspheres, depending on the percentage content by weight of bentonite. Strength was tested at different content of polyglycol.

It was unable to determine the maximum compressive strength of tested sandmix. Measuring range of LRu universal type machine amounts to 2 MPa. Exceeding of measuring range is for a sandmix with 45.2% of bentonite and 6% of polyglycol addition. With small amount of bentonite polyglycol addition increases plasticity of sandmix. In the sandmixes with increased content of polyglycol a clear plastic deformation can be observed during test of the sample. Characteristic destruction of the sample through the brittle fracture occurs only after removing the load. This might indicate thixotropic properties of produced sandmix. At high contents of polyglycols with the rate of change of shear stress, viscosity is changing rapidly. In the studied samples has changed sign of stress gradient. Lowering of internal friction in non Newtonian fluid such as bentonite-polyglycol-water mixture may cause rapid decomposition - destruction of the sample. This effect is analogous to thixotropic phenomena strongly depend on the kinetics of stress change.
With the further increase of bentonite and polyglycol content, sandmix changes of its character from plastic deformation to elastic deformation. Extremely even six time testing of samples does not cause its damage or dimensional changes. Because of particularly high mechanical properties of produced sandmix compressive strength testing cannot be carry out on equipment designed to test the traditional mold and core sandmixes.

Figure 2 shows the averaged results of the friability of moulding sand with aluminosilicate matrix of the microspheres depending on the percentage content by weight of polyglycols. It can be seen a very high decline of friability. It was also found a significant improvement in surface smoothness. As shown in Figure 2 addition of one per cent of polyglycols in the sandmixes with higher bentonite content reduces or eliminates the problem of high friability of sandmix.

Moreover, the polyglycol content did not significantly affect the hardness of tested sandmixes. Hardness ranges from 90 to 95 on a "C" scale.

Also the affect on the permeability of polyglycols on the sandmixes was studied. Determination of permeability was carried out just after forming of samples in wet state. There was no significant effect of polyglycol addition on the permeability of sandmixes compared to similar water content. As expected, permeability typically decreased with increasing of bentonite content.

5. Conclusions

The use of aluminosilicate microspheres and polyglycols allows to reuse them. Refresh treatment, however, requires a separate, precise determination.

Necessary high content of bentonite in comparison to the classical moulding sands mainly because of a difference in the total surface development between the homogeneous graininess sand and random graininess aluminosilicate microspheres. Despite the fact that graininess of the main fraction of sand and the microspheres is at the same level. However, it is necessary more than fourfold (corresponding) increase in content of bentonite by weight to maintain advantageous mechanical properties of the sandmix. The mass amount of bentonite remains unchanged in relation to the classical moulding sandmixes with bentonite and sand matrix.

Moreover it was observed that the addition of polyglycol to sandmix with bentonite results in the emission of small amounts of heat. Is the heat of adsorption. The amount of heat suggests that the main strength is the van der Waals's force of adsorption [8].

Microspheres due to the low density are predestined as fulfillment in skeleton casting. Create a lightweight, durable construction, which complemented by the addition of polyglycol will carry the load by thixotropic change of properties. This results in fundamental for material engineering possibility of design component deformation - from plastic to elastic. Such knowledge creates the conditions for optimal design of skeleton casting with cell geometry matched to the load by concentrated force perpendicular to the wall closing the 3D skeleton casting [7].

Noticeable increase of mechanical strength of sandmix allows to perform complex core for skeleton castings with satisfactory surface smoothness and dimensional tolerance. Additionally, it may suggest a proper effect of core supersaturated with polyglycols on mechanical properties and capacity of energy absorption in the skeleton casting.

Addition of polyglycol allows to shape the characteristic of skeleton casting core in full plastic-elastic range The increase in plasticity is related to the reduction of surface tension and reduction of internal friction of matrix - a binder complex. Furthermore, the addition of polyglycol to bentonite allows to change its rheological properties [4], which coupled with the possibility of obtaining a elastic or plastic core will allow the design of composite skeleton structure with properties, depending on the particular application and desired method of impact energy dissipation.
Important is that excess of measuring range of the test machine for typical moulding sand made impossible to precise strength identification of developed sandmix. It is known for sure that the sandmix has more than doubled the compressive strength compared to the classical synthetic moulding sand.

It was also observed as expected, a significant increase in surface smoothness and solidity of test samples. As a result, this will improve flow of liquid metal in channels with very small diameters.

Thanks to a significant lowering of friability of sandmix polyglycol additive can prevent casting defects such as nonmetallic inclusions from the mold or from cores.

This study is the subject of patent application.

References