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THERMO-INSULATING MOULDING SAND FOR THIN WALLED CASTINGS

TERMOIZOLACYJNA MASA FORMIERSKA NA ODLEWY CIENKOŚCIENNE

In paper the selection of the composition and determination of main properties of novel moulding sand was described. The mail goal was to create moulding sand characterized by high thermal insulating properties in relations with low specific weight. This type of moulding sand will find application in thin walled castings with complex geometry, in particular for cores of the skeleton castings. In this work the results of the compressive strength, permeability and friability was presented. It was noted that aluminosilicate microspheres are suitable as moulding sand matrix. Influence of the polyglicol addition on quality and properties of the moulding sand was described. The use of the aluminosilicate microspheres allowed to obtain the moulding sand characterized by high insulation rate, low specific weight and good mechanical properties.

Keywords: moulding sand, core, skeleton castings

W artykule przedstawiono dobór składu oraz określenie podstawowych własności nowoczesnej jakościowo masy formierskiej. Głównym celem pracy było wytworzenie masy formierskiej charakteryzującej się wysoką termoizolacyjnością w połączeniu z niską masą właściwą. Masa taka znajdzie zastosowanie do wytwarzania cienkościennych odlewów o rozbudowanej geometrii ze szczególnym przeznaczeniem na rdzenie odlewów szkieletowych. W pracy przedstawiono wyniki badań wytrzymałości na ściskanie, przepuszczalności, oraz osypliwości. Stwierdzono przydatność mikrosfer glinokrzemianowych, jako osnowy masy formierskiej. Określono korzystny wpływ poliglikolu na jakość i własności wytworzonej masy. Zastosowanie mikrosfer glinokrzemianowych pozwoliło na uzyskanie masy o wysokiej izolacji cieplnej w połączeniu z niską masą właściwą i dobrymi własnościami mechanicznymi.

1. Introduction

One of the technology parameters influencing the skeleton casting manufacturing process is total surface area of the casting. It is related directly with total distance of metal flow in mould during casting process. Due to such conditions, as low thermal conductivity and low thermal capacity, while maintaining high mechanical properties that have to be met for production of complex skeleton castings it is necessary to use specific moulding materials. There is lack of commercially available moulding materials that meet those criteria and are easy to knock out from inside of complex shape castings at the same time.

Maintaining the level of moulding or core sand properties is particularly important while manufacturing thin wall castings. Besides relatively high strength properties, is has to, due to specific thermophysical properties, allow for directed heat flow in mould.

Castings particularly responsive to properties of the moulding sand are Composite Reinforced Skeletons (CRS). From properties point of view the CRS can be placed between metallic foams and microlattice structures [1-4] and could be characterized by possibility of effective design of mechanical properties with high accuracy and repeatability. Good rheological properties of liquid alloys in connection with advanced techniques of core and mould making, and designed properties of moulding sands allow to obtain highly complex castings with small diameters of ligaments (Fig. 1).

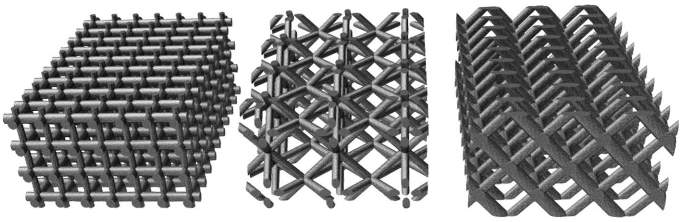

Fig. 1. Topologies of skeleton castings (CRS)

2. Aim and scope of the research

One of the assumptions of conducted research was to create a casting core with properties allowing to use it as a component of composite matrix with skeleton casting as re-

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inforcement. Such a core would perform two purposes. First- technology, as foundry core which repeats surfaces of ligaments and nodes of CRS. Second- operational, as composite matrix which increases mechanical properties of construction. The aim was to create material which meets those two features.

This kind of innovative approach allows for many improvements from technology point of view. Obtaining lightweight and strong core, with low thermal conductivity allows for create complex shape casting with proper feeding. Knocking out of the core in finishing operation is particularly difficult in highly surface-developed castings. Adhesion also should be taken into account. The concept is to utilize advantages like low weight and good strength and use of core as matrix for novel composite with unusual, spatial and continuous reinforcement. Such matrix after minor modification of composition will have significant impact on mechanical properties of CRS. Moreover, creating moulding sand based on bentonite allows for knocking out the core in case of other utilization of internal space of skeleton.

Analysis of commercial available moulding materials shows that most suitable will be synthetic bentonite binder sands. In this case aluminosilicate microspheres will be used as matrix. Thermophysical properties of microspheres determine that it is exquisite moulding material for thin wall castings, particularly well suited for cores of skeleton castings. The following basic properties of moulding sand was investigated:

- compressive strength;
- permeability;
- friability.

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 [5, 6]. In order to change properties of bentonite, polymer additives, salts or surfactants are also used. Such an addition may be also polyglycols. They allow for reduction of water content while maintaining the mechanical properties on the desired level [7]. After addition of polyglycol to sand it displaces bound water in bentonite. Approximately one mole of polyglycol replaces two moles of water [8]. In practice, the polyglycol is very rarely used, until now mostly as an additive to the facing sands and only to improve the quality of casting surface. Polyglycol prevents oxidation of alloys by reducing atmosphere generation in a mold. With gases evolved from the plolyglycol it repels oxides and slag from molten metal, which ultimately prevents the formation of folds, cold shuts 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 used in a magnesium alloys [9]. Important factor that was taken into account in case of core material for skeleton casting was low weight of core with relatively good strength [10-13].

3. Methodology

Basic research of moulding sand that is of compressive strength, permeability, hardness and friability were performed. Samples of sandmixes were prepared in accordance with PN/H/11070:1983 standard. European standards for sampling in this case are unavailable. For the cylindrical samples constant height of 50 mm was assumed. A sample with similar size prepared with the traditional moulding sand has the mass of 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 changing the bentonite content in range from 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.

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

4. Results

Figure 2 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.

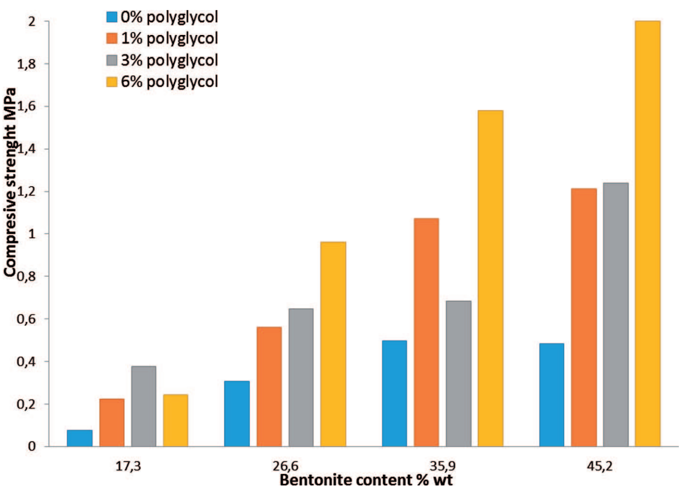

Fig. 2. Compressive strength of moulding sand in function of bentonite and polyglycol content

It was impossible to determine the maximum compressive strength of tested sandmix. Measuring range of LRu universal type machine is up to 2 MPa. Measuring range was exceeded for a sandmix with 45.2% wt. of bentonite and 6% wt. of polyglycol addition. At 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 the polyglycols the viscosity changes rapidly with the rate of change of the shear stress. In the studied samples the sign of stress gradient changed. Lowering the 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 the thixotropic phenomena and strongly depends on the kinetics of stress change.

With the further increase of bentonite and polyglycol content, sandmix deformation changes its character from plastic deformation to elastic deformation. Even six time testing of samples did not cause its damage or dimensional changes. Because of particularly high mechanical properties of produced sandmix compressive strength testing cannot be carried out on equipment designed to test the traditional mould and core sandmixes.

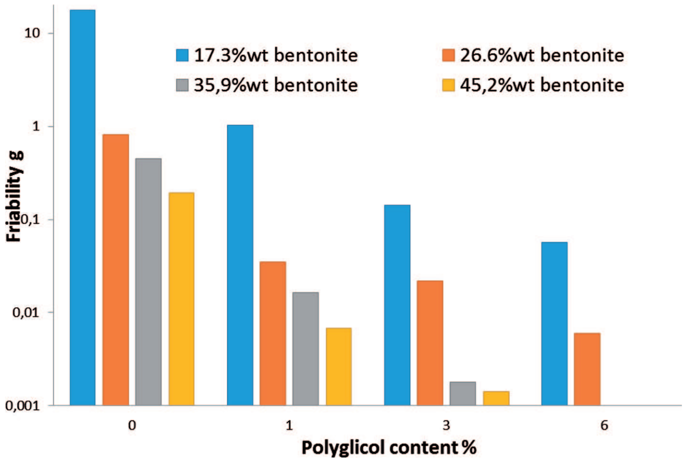

Fig. 3. Friability of moulding sand depending on the share of polyglycol and bentonite

Figure 3 shows the averaged results of the friability of moulding sand with aluminosilicate matrix depending on the percentage 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 3 addition of 1% 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. The hardness ranges from 90 to 95 on the ”C” scale.

Also the effect of polyglycols on the permeability 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 as 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. Reclaiming treatment, however, requires a separate, precise determination. Necessary, high content of bentonite in comparison to the classical moulding sands occurs mainly because of a difference in the total surface development between the homogeneous graininess sand and of 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 increase in content of bentonite by weight to maintain advantageous mechanical properties of the sandmix. The volume 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. It is the heat of adsorption. The amount of heat suggests that the strength is derived mainly from the van der Waals force of adsorption [14].

Microspheres due to the low density are predestined as fulfilment in skeleton casting. They create a lightweight, durable construction, which complemented by the addition of polyglycol will carry the load by thixotropic phenomena. This results in fundamental for material engineering possibility of designing component deformation – from plastic to elastic. Such knowledge creates the conditions for optimal design of skeleton casting with cell geometry matched to the loading with concentrated force perpendicular to the walls closing the 3D skeleton casting [15, 16].

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 a matrix - binder complex. Furthermore, the addition of polyglycol to bentonite allows to change its rheological properties [7], which coupled with the possibility of obtaining an elastic or plastic core will allow the design the composite skeleton structure of properties depending on the particular application and desired method of impact energy dissipation.

It is important that exceeding of measuring range of the test machine for typical moulding sand made impossible the 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 mould or from cores.

This study is the subject of patent application.

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