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Features of Mechanical Characteristics of Sand-Clay Mixtures in the Production of a Particularly Responsible Purpose Steel Castings

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Abstract: The formation of sand-clay mixtures (SCM) has become widespread at enterprises producing large-size casting. SCM is a mixture of quartz sand with astringent clay, water and process additives, which can take the form of the necessary configuration when pressed, shaken, inflated and other effects. After casting and solidification of castings, the mold is subject to destruction, its material is prepared for subsequent reuse. At the same time, it is necessary to introduce an additional portion of clay and process additives into the mixture instead of used ones, as well as remove part of the mixture. Researches of moulding sand-clay mixtures of various compositions are presented in this article. A comparative analysis aregiven. The effect of starch on the mechanical properties of the mixture has been researched.

Key words:cast, recycled mixture, sand-clay mixture, bentonite, lining,starch, filling, sand, shape, strength

1. Introduction

In most cases, the loss of the mixture is about 10% of the mass of the casting. Chemically bonded rods, also used in the manufacture of castings in sand-clay forms, usually have very good deformability, the particles of the mixture used for the manufacture of rods become unbound, have good flowability and in this respect behave like grains of the original sand. In many cases, the amount of sand introduced into the SCM from the core mixture during clogging exceeds the required additive in the region of 10% of the mass of the casting and can even reach 100% of this mass, which is a typical situation and amounts to 30-50%.

Two types of mixtures are produced in the foundry: facing and pouring.

Facing sand is the forming sand used to make the working layer of the mold. Such mixtures contain an increased amount of starting molding materials (sand and clay) and have high physical and mechanical properties.

Facing sands come into contact with liquid metal and therefore are subjected to the most severe operating conditions. Therefore, they have high strength and fire resistance, are made of quartz sand and clay without adding burnt earth. Typically, the layer thickness of this mixture is 20-30 mm.

Facing forming sand is used once. Filling forming sands are used repeatedly, so they are called circulating sands.

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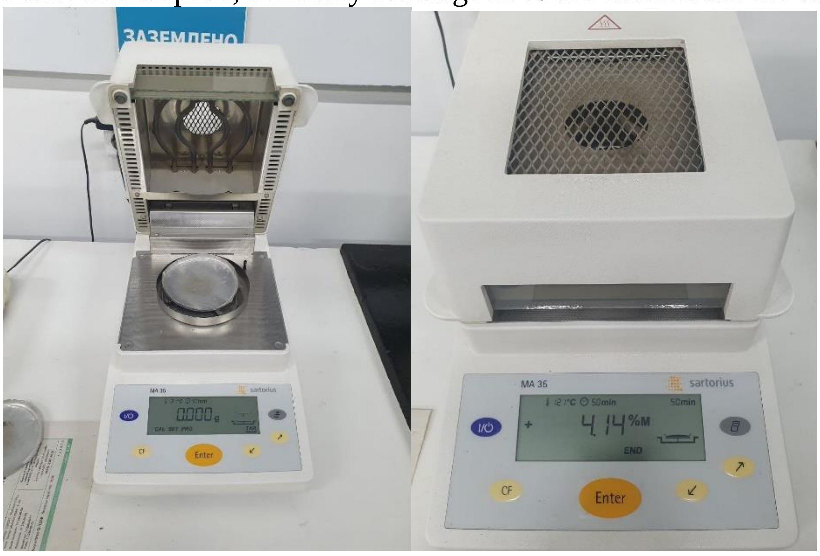
The filler is a molding composition for filling the mold after the veneer is applied to the model. Therefore, it is prepared by treating the processed mixture with a small amount of raw forming materials (sand and clay).
Pouring mixtures consist of recycled earth (calcined, obtained after knocking out castings), to which water, clay substances and quartz sands are added. Facing mixtures should be of better quality than fillers, since up to 40% of fresh earth is injected into them.
It differs from the facing mixture in lower quality and lower cost. It is composed of approximately 95% recycled sand and 5% fresh molding materials. The remaining volume of the flask is filled with this mixture.
To obtain high quality castings, the molding and core mixtures from which disposable molds and cores are made must have a certain set of mechanical, technological and physical properties.
This paper examined the physical and mechanical properties of the molding mixture, such as gas permeability, compaction, and compressive strength.
Gas permeability is the ability to pass through the walls of the mold (rod) gases formed when molten metal contacts the mold (rod), as well as during crystallization of the casting. The molten metal always contains dissolved gases released as it cools and solidifies.
If the gas permeability of the mold is insufficient, gas bubbles may form in the casting and on its surface.
Strength is the ability of a mold or rod to ensure their safety during manufacture and use. Molds shall not be destroyed by shock during assembly and transportation and shall withstand the pressure of the cast metal. Standard strength characteristics are: for crude mixtures - compressive strength (σ_{cj} = 30...70 kPa).

2. Methods

A sample of a molding lining mixture with a moisture content of 3.9 ± 0.1 was selected for the research.
To prepare a 100% facing mixture, quartz molding sand 1K3O2025 or 2K2O2025 according to GOST 2138-91 is required in an amount of 89%, bentonite R1T1 11% according to GOST 28177-89, water according to the required moisture mixture. For large casting, humidity ranges from 3.5 - 4.2% in winter, 3.5 - 4.4% in summer.
After selecting the traditional mixture, experiments were carried out using starch in an amount from 0.05 to 0.25% as additives.
First, the humidity of the mixture was determined on the PWG MA35M minilaboratory equipment (Figure 1, a).
The method is based on the loss of sand mass of the molding mixture after drying to a constant mass. A mass of up to 5 g is isolated from the mixture, placed in a humidity measuring device PWG MA35 and dried for 5 minutes. After the time has elapsed, humidity readings in % are taken from the device (Figure 1, b).



a) b)

Figure 1 – PWG MA35M humidity measuring device:

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a - general view; b - test results

Then, samples were made with a size of 50 x 50 mm (Figure 3) according to GOST 23409.7-78 for compaction tests. The samples were made using PVF-C minilaboratory equipment (Figure 2, a). In the manufacture of samples, the density of the mixture is determined by the method based on determining the change in the height of the mixture in the sleeve (Figure 2, b) before and after.

a) б)

Figure 2 – PVF-C minilaboratory equipment for adaptability:
a) general view; b) sleeve with a mixture.

For determining the compactness, 155 g of the molding mixture is weighed, the sleeve is filled and tested in a minilab for creating samples and measuring the mechanical properties of sand-clay molding mixtures PVF-C.

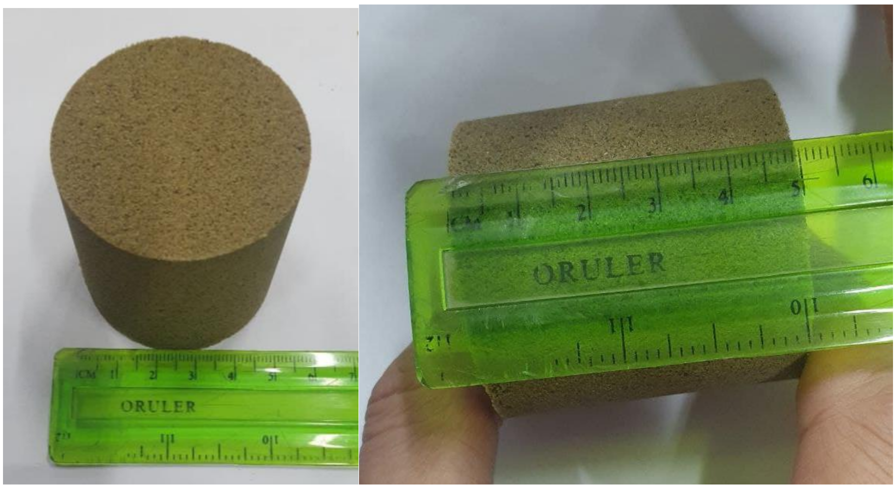

Figure 3 - Test samples with dimensions of 50 x 50 according to GOST 23409-78

3. Results and Discussion

The results obtained by testing the mechanical properties of the molding mixture are shown in Table 1.

Table 1 – Comparison of the mechanical properties of the molding mixture

Mode	Mixture Composition	Compressive strength in the wet state, kGf/cm2	Compressibility, %
0	Traditional mixture	1,08	48,5

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		1,09	48,6
		1,07	48,4
		1,08	48,5
I	Traditional mixture + 0.05 % starch	1,11	49,6
		1,10	49,7
		1,10	49,8
		1,10	49,7
II	Traditional mixture + 0.10 % starch	1,14	49,9
		1,16	49,8
		1,15	49,9
		1,15	49,9
III	Traditional mixture + 0.15 % starch	1,19	50,7
		1,20	50,7
		1,21	51,0
		1,20	50,5
IV	Traditional mixture + 0.20 % starch	1,20	50,6
		1,20	50,7
		1,21	50,9
		1,20	50,7
V	Traditional mixture + 0.25 % starch	1,15	49,4
		1,14	49,3
		1,16	49,4
		1,15	49,4

Based on Table 1, Table 2 is compiled with arithmetic averages.

Table 2 – Arithmetic mean of the results

Mode	Starch Amount, %	Compressive strength in the wet state, kGf/cm2	Compressibility, %
Traditional	0	1,07	48,5
1	0,05	1,11	49,5
2	0,1	1,17	50,3
3	0,15	1,21	51,0
4	0,2	1,20	50,7
5	0,25	1,16	49,4

A comparative index of compressive strength in the wet state is obtained in Figure 4.

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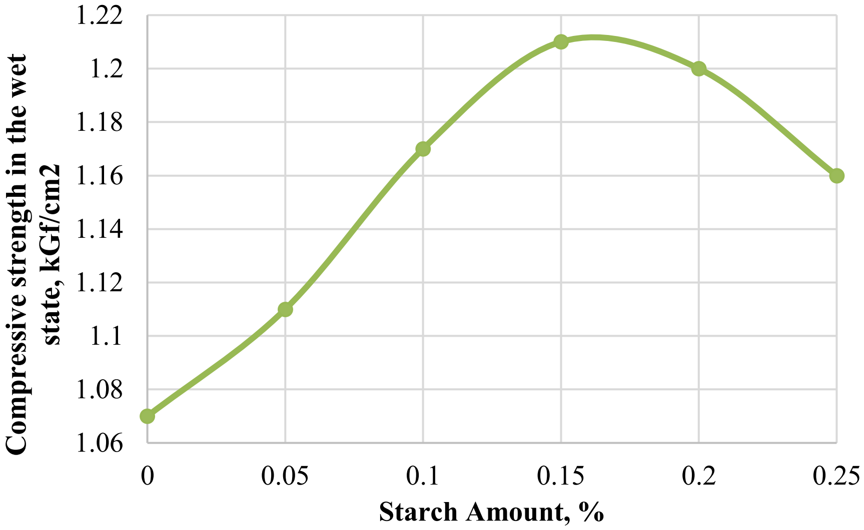

Figure 4 – Dependence of the compressive strength in the wet state on the percentage of starch in the SCM.

As can be seen from Figure 4, with an increase in the amount of starch in the SCM, the compressive strength has an extreme character. Up to 0.15% starch in SCM, the tensile strength increases from 1.07 to 1.21 kGf/cm2, from 0.15% to 0.25% starch in SCM, the tensile strength decreases to 1.16 kGf/cm2.

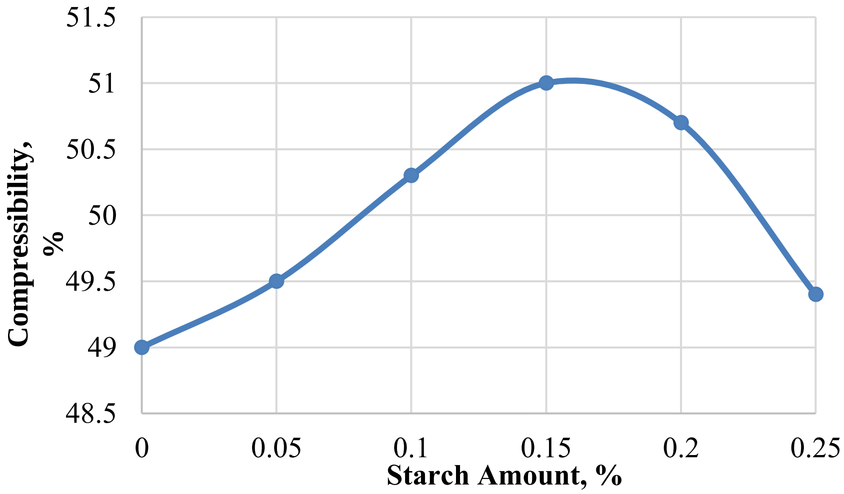

Figure 5 – The dependence of the compaction of the mixture on the percentage of starch in the SCM.

Figure 5 shows that with an increase in the amount of starch to 0.15%, the density increases from 49 to 51%, after 0.15% to 0.25% it decreases to 49.4%, since the starch density is lower than that of the sand-clay mixture.

4. Conclusion

As the results of the experiment showed, the addition of starch to the SCM has a positive effect. At the same time, when starch (consisting of 89% quartz sand and 11% bentonite) was added to the SCM, the mechanical characteristics of the mixture increased:
- wet strength limit by 11.6 %;
- seal by 4%.
The optimal starch content is shown, which is 0.15% of the volume of the sand-clay mixture.

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