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OBTAINING BINDING MATERIALS FOR MOLDS AND CORE FOUNDRY PRODUCTION BASED ON LOCAL RAW MATERIALS

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Abstract In the research work, to obtain modified starch and establish the chemical structure, chemical and thermal analyzes of the initial raw materials and products based on it were carried out, modern physicochemical methods of analysis were used, including IR spectroscopy, elemental, differential thermal (DTA) analyzes and extrusion. The developed binding materials based on local modified technical starch for the production of molding and core products have a number of advantages compared to other traditional ones.

Key words: Rice starch, modified starch, molding and core compositions, foundry, molding sand and clay, extruder, screw, environment, lignosulfonate, lignosulfonate solution, lignosulfonate suspension, local raw materials.

Introduction. Many of these resources are still untapped. “Uzbekistan is rightfully proud of its riches; almost all the elements of the famous periodic table of Mendeleev were found here.” Currently, Uzbekistan is one of the countries with a developed mining industry. At the same time, on the territory of Uzbekistan there are very large and valuable mineral resources that have not yet been involved in industrial production. Industrial enterprises are rapidly developing, which in itself creates the need for the massive use of local products, one of which is a starch product, which is used in foundries for pouring molding sands. Molding materials and working mixtures consisting of sand, clay and various additives are used for production of one-time molds and cores[1].

The composition of molding sands is varied and depends on the type of alloy, mass, wall thickness, casting configuration and requirements for it, and the nature of production. Based on the nature of their use, molding sands are divided into single, facing, and filling sands; according to the condition of the mold before pouring into mixtures for molds poured in a wet or dry state;

Depending on the class of sand used, natural and synthetic. The choice of molding sand for castings made of cast iron and steel depends on the mass of the casting, the thickness of its wall and the manufacturing technology of the mold. For “wet” molding of cast iron castings, it is recommended to use mixtures containing strongly binding clays, and for “dry” molding, medium-binding clays. This is explained by the increased strength of mixtures with strongly binding clays and their better moldability [2,3].

The main goal of the work is to develop a highly efficient and environmentally friendly, harmless technology for binding materials used for molding and core compositions in foundries, to produce import-substituting and export-oriented materials.

Object and methodology of research.

The object of the study was the weight quantities of grains of various size groups in the sand base of the molding material, determined using grain analysis. To do this, a sample of 50 g of dry, featureless sand base of the molding material obtained by elutriation is sifted through calibration sieves with cells of precise sizes. Sifting is carried out for 15 minutes, after which the remaining sand on each sieve is weighed separately with an accuracy of 0.01 g. The results of the sieve analysis are recorded in a table or depicted graphically in the form of a grain composition diagram.

In this study, to obtain the form, the protective effect (ability) of native and modified starches was studied. The research results are presented in table 1.

Table 1.
Actions (abilities) of native and modified starches

Starch	Concentration,%				
	3,2	2,7	2,3	1,5	1,2
Original	-	-	-	-	-
Modified	+	+	+	-	-

The "+" sign indicates protection

The "-" sign means an unprotected state.

The results presented in the table indicate that in solutions of native starch, the formation of micelles is observed between starch and $Fe(OH)_3$ particles. Coagulation occurs due to intermolecular bonds. Molecular dispersion interaction occurs between neutral molecules. In modified starch solutions obtained by oxidation, coagulation is not observed. Here, only the iron hydroxide sol is coagulated. This modification is explained by conformational changes in starch, the disintegration of macromolecules into small chains due to their destruction during oxidation. But at very low concentrations these properties change [4,5].

The main research method was refractometric analysis, based on determining the refractive index of the substance under study. Determination of the refractive index allows one to determine the purity and structure (identification) of a substance. If light passes from one medium to another medium, then it partially returns from the surface boundary and partially changes its original direction, i.e., it is refracted. The refractive index (n) is the ratio of the sine of the angle of incidence to the sine of the angle of refraction.

$$n = \frac{\sin \alpha}{\sin \beta} \qquad (1)$$

When light passes from a vacuum or air into another medium, the angle of incidence is always greater than the angle of refraction, and equation (1) is satisfied. If light passes from a highly refractive medium to a low refractive medium, the angle of incidence is less than the angle of refraction, and for this case the above equation is:

$$\frac{\sin \alpha}{\sin \beta} = \frac{1}{n} \qquad (2)$$

At a light capture angle of 40 ^{0} or more, the light is completely reflected from the surface boundary. This angle is called the total interior angle of return. In formula (2), if yes, $Sin\beta = 1$

$$\sin \alpha' = \frac{1}{n} \qquad n = \frac{1}{\sin \beta'}$$

Here's the full angle of return

Therefore, knowing the total internal angle of return, you can determine the value of the refractive index. Most refractometers are based on this principle to determine the refractive index.

The result of the study is an indicator with an increase in the starch content in the solution, where the refractive index of the solution decreases.

To study the viscosity of a starch solution, first prepare a 5% starch solution. To do this, 5 g of starch was weighed on a technical scale and mixed well in 95 ml of water, thus obtaining a starch suspension. The resulting mixture was heated for 5-10 minutes with stirring until a starch paste was formed, which was added to the molding mixture[6].

The results obtained and their analysis.

In foundry production, two types of ethyl silicates are mainly used: ETS-32, ETS-40. The numbers mainly indicate the amount of SiO_2. The preparation of binders based on ethyl silicates is used mainly in ceramic forms and colloidal solutions. Lignosulfonate is second only to sand and clay in its use.

This binder is used to coat molds. Lignosulfonate belongs to class B-2 and B-3 binders. Lignosulfonate is a waste-free technology and is used for filling substances with a density of at least -1230 kg/m^3. Although solid lignosulfonate is easy to transport, transportation problems arise during the cold season. Therefore, 20 kg is transported in block form, but causes some difficulties in sticking to each other. A 20% solution prepared from lignosulfonate has a pH of 4.4, and other additives are used when forming wet and dry lignosulfonate. These are materials such as quartz sand, bentonite, caustic soda, etc. Preparation of solid lignosulfonate for use: 500 kg of solid lignosulfonate is added to 600 liters of water in a bunker, then the mixer is heated to a temperature of 80-120 0C. The resulting mixture is stirred in an electric mixer for 30-40 minutes and the density of the resulting solution is measured using a hydrometer; its density should be 1.26-1.28 kg/m^3[7].

To obtain high-molecular compounds, the composition of bitumens was prepared in accordance with the requirements of GOST 6617-76, which provides three grades designated “BN” - petroleum bitumen: BN 50/50, BN 70/30 and BN 90/10, where the numerator of the fraction corresponds to the indicator softening temperatures according to “K and Sh” (ring and ball), and the denominator indicates the average values of the limits of change in penetration at 25°C (table 2).

Table 2.

Indicators	BNK 40/180	BNK 45/190	BNK 90/30
Penetration at 25 °C, 0.1 mm	160-210	160-220	25-35
Temperature, °C:			
softening	37-44	40-50	80-95
fragility, no higher	-	-	-10
After warming up:			
weight change, %, no more	0,8	0,8	0,5
penetration at 25 °C, % of the original, not less	60	60	70

Characteristics of viscous bitumen

In addition to solid and visco-plastic bitumen of the indicated grades, there are liquid bitumens used as insulating materials (Table 3) . Liquid bitumens at room temperature have low viscosity, i.e. liquid consistency, and are used in construction in a cold or slightly heated (up to 50-60°C) state [8].

Table 3.

Physico-chemical parameters of bitumen

More than 60 million tons of starch are produced worldwide, and its production volumes are increasing from year to year. On the one hand, this is explained by the increased use of starch in the food industry, on the other hand, by its use in other areas, in various areas of production. One of the new areas of application of starch and its composites is dust suppression of highways

Indicators	BND 200/300	BND 130/200	BND 90/130	BND 60/90	BND 40/60	BN 200/300	BN 130/200	BN 90/130	BN 60/90
Penetration, 0.1 mm, at temperature:									
25 °C	201-300	131-200	91-130	61-90	40-60	201-300	131-200	91-130	60-90
0 °C, not less	45	35	28	20	13	24	18	15	10
Temperature, °C:									
Softening, not lower	35	40	43	47	51	33	38	41	45
Fragility, no higher	-20	-18	-17	-15	-12	-14	-12	-10	-6
Flashes, not lower	220	220	230	230	230	220	230	240	240
Ductility, cm, not less at temperature:									
25 °C	-	70	65	55	45	-	80	80	70
0 °C	20	6,0	4,0	3,5	-	-	-	-	-
Change in softening temperature after heating									
0 °C, not less	7	6	5	5	5	8	7	6	6
Penet walkie talkie index	От -1,0 до +1,0					От -1,5 до +1,0			

and residential areas. In practice, it is important to study the rheological properties of starch solution compositions. The work presents the results of studying the technical properties of industrial starch using the Stokes method at various temperatures and concentrations.

The viscosity of starch solution was studied at various concentrations and temperatures. The results of the study are presented in Table 4.

Table 4.

Viscosity of industrial starch at different temperatures and concentrations

№	Composite name	Mass concentration	Temperature, ^0C

		%	Viscosity , cП a			
			20	30	40	50
1.	Starch	2.0	0,082	0,077	0,0700	0,0570
2.	Starch	5,0	0,087	0,082	0,0740	0,0200
3.	Starch	8,0	0,290	0,280	0,230	0,207
4.	Starch	10,0	0,592	0,587	0,270	0,233
5.	Starch	15,0	4,140	4,130	3,080	2,730

Analysis of the research results (Table 5) showed that the viscosity of the system increases with increasing starch concentration. The effect of temperature on the viscosity of the starch mixture was also studied. According to research results, as a result of increasing temperature from 20 0C to 50 0C, the viscosity of the solution decreases from 0.082 to 0.05770 cPa. This is explained by a decrease in the forces of intermolecular interaction between the molecules of the solute in the solution.

In the laboratory of the molding shop, the physical and mechanical properties of the resulting molding mixtures were determined, such as humidity, gas permeability, soil compression test, and thermal test. The gas permeability of the mixture according to GOST 29234.11-49 is determined by a low compression test according to GOST 23409.13-78 . The results of these experiments are presented in table 6.

Among the listed molding compounds, starch molding compounds are the most useful, since this binder can be extracted without any harm to human factors, without excessive costs and without unnecessary mixing in the production of metals in the mass

Table 5.
Physical and mechanical testing of molding sands.

Name of molding sand	Humidity, %	Gas permeability, (бар) Мпа	Raw food, Trial кg*с/см^2	Thermal tests, МПа
Single molding, EF-1	4,5-5,5	100	0,4-0,6	1,1-1,2
Single molding, EF-2	3,7-4,0	100	0,8-1,2	0,9-1,0
Molding lining, FO-4	4,5-5,5	100	0,5-0,6	1,1-1,2
Molding bentonite lining, FBO-6	4,0-5,0	100	0,2-3,5	1,0-1,1
Composition of oil pans, SM-1	4,5-5,5	100		1,1-1,2

Rod anti-burn, SP-2	4,5-5,5	70		1,1-1,2
Cold hard core, XTS	1,5-2,0	50		0,3-0,5
Rod chrono-magnetic, SX-4	3,5-4,5	50		0,6-0,8
Sandy-clay core, SG-5	5,5-6,5	100		1,2-1,3

The results obtained when using the starch binder by the above test methods are presented in Table 6. Among the mentioned molding sands, starch molding sands are useful in all respects, since this binder is completely harmless to the human factor, firstly, secondly, without additional costs, and thirdly, it can be separated without additional costs. labor in metal casting.

Table 6.
Results of research on obtaining new components of binder molding sands, (consumption, %)

	Options	Quartz sand, (%)	Quartz. sand, (g)	Bentonite, (%)	Bentonite, (g)	Binders, (%)	Lignosulfonate/starch (g)	Process water, % (winter - summer)
1	Initial lignosulfonate mixture	97	2910	5	150	2	600	11-13
2	Starch mixture No. 1	100	3000	5	150	0,5	150	16-18
3	Starch mixture No. 2	100	3000	5	150	0,7	210	16-18
4	Starch mixture No. 3	100	3000	5	150	1	300	16-18

The studies carried out show that we can observe less water consumption in the winter and summer months of the lignosulfonate based mixture, but the main raw material of lignosulfonates is 600 g. This indicates that lignosulfonate, which is an imported product, is used in large quantities. A mixture of 3 different compositions was prepared from local starch raw materials and the optimal option was selected. As can be seen from Table 7, option 3 of the starch mixture is optimally calculated, and the 1% starch binder added to it completely replaces the lignosulfonate currently used as an import.

Table 7
Physico-mechanical properties of molding sands

	Name of molding sand	Humidity %	Gas permeability (Bar)	Strength, Н/мм²
1	Initial lignosulfonate mixture	4,5-5,5	100	0,50-0,65
2	Starch mixture No. 1	4,5	110	0,40
3	Starch mixture No. 2	4,5	110	0,45-0,5
4	Starch mixture No. 3	4,5	110	0,5-0,65

The values of the basic properties of the binders listed above are equal to each other. Lignosulfonate binder is imported from the People's Republic of China, and the preparation time is long, the need for additional labor, energy consumption and the long time required to prepare bulk mixtures (the prepared lignosulfonate is in a liquid state, and the components are in a dry state, mixing between them takes time) and the economic cost of this binder product increases the cost of metal castings prepared using this binder.

Conclusion

Thus, comparative analyzes carried out on testing various types of binding materials for obtaining molds showed that starch binders prepared on the basis of local raw materials, first of all, are completely harmless to humans, and high results were achieved due to the ease of preparation of mixtures and the fact that they do not require additional mixing and do not require excessive mechanical processing when separating prepared castings from the surfaces of parts.

It was determined that storage, gas permeability and hardness of the mixture gave the same result. It can be seen that starch binders from local raw materials turned out to be of higher quality and useful.

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