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Studies of the influence of the composition of the CHM on the properties of the casting

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ABSTRACT
The quality of the finished casting is largely determined by the quality of the mold. Currently, there are a large number of variations in the composition of CHM (cold hardening mixes), differing both in the nature of the main component and in the nature and ratio of binders and other technological additives. As cleaning dust has a very developed surface due to technological reasons. According to various estimates, the specific surface area of gas cleaning dust is from 8, 000 cm^2/g and higher. In order to verify this assumption, studies were conducted on the effect of the composition of the mixture using SCF (sand-clay forms), on some of its properties. In conclusion, the conducted studies have shown that in order to ensure the maximum performance of the technological properties of CHM, the optimal content of SCF in the mixture should be 2.0 - 10.0 wt.% in the ratio with orthophosphoric acid is not higher than 1.25.
Keywords: CHM, SCF, casting, properties, mixture, strength, surface.

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Introduction

The quality of the finished casting is largely determined by the quality of the mold. In the manufacture of castings from alloys with high hardness, such as Nihard cast iron, such casting quality parameters as surface cleanliness and compliance with geometric dimensions are of particular importance, because the high hardness, wear-resistance, and relative fragility of these alloys complicate the machining of the finished casting. Accordingly, in the manufacture of castings from these alloys, it is necessary to strive for the maximum possible surface cleanliness and accuracy of geometric dimensions.

Casting in sand-clay molds (SCF) does not provide these quality parameters, the use of other casting technologies (investment casting, casting on gasified patterns, coquille casting) is limited due to various reasons: the complexity of the process, high cost, etc. In this case, a good alternative to these methods is the production of casting into molds made using cold-hardening mixtures (CHM).

The essence of the CHM method is the approval of a sand-resin mixture under the influence of a catalyst. The main advantages of this method are high surface cleanliness and accuracy in the geometric dimensions of the castings obtained; the minimum number of casting defects formed; there was the possibility of regeneration of the molding mixture. In addition, the drying and heating stage of the mold is completely eliminated, which leads to a significant reduction in the time of the mold manufacturing process.

The main disadvantage of using the CHM method is the toxicity of some components of the mixture and in this regard, the need for special conditions for their storage and use [1].

Currently, there are a large number of variations in the composition of CHM, differing both in the nature of the main component and in the nature and ratio of binders and other technological additives [[2], [3], [4]].

For example, in the work of CHM [[5], [6], [7]], a mixture is proposed that contains synthetic resins and inorganic binders: liquid glass, cement, iron scale, iron ore concentrate, magnesite, and chromomagnesite. This CHM includes a refractory filler based on silicon dioxide, a material based on iron oxides, and orthophosphoric acid. Its peculiarity is that in order to reduce crumbling, the mixture contains such a technological additive as aminopropyltriethoxylane. However, the cost of this additive is quite high, in addition, this mixture has fairly low survivability (3 - 15 min) and low compressive strength (0.1-0.49 MPa).

Based on a brief information analysis, it can be concluded that the composition of CHM should be selected based on the optimal cost–property ratio. In turn, this ratio will be determined by the availability and availability of available raw materials.

In this paper, it is proposed to use a mixture as a CHM, which consists of a refractory filler based on SiO_2, a highly dispersed component, and orthophosphoric acid as binders and water. The purpose of introducing a highly dispersed material into the composition of the CHM is to increase the interaction surface between the reagents, which should ensure a rapid reaction and reduce the curing time.

Methods and materials

The composition of CHM is proposed for the manufacture of molds containing a refractory filler, iron oxides, orthophosphoric acid, and bauxite. The disadvantage of such a mixture is the need for preliminary preparation of bauxite before use in CHM [8], namely grinding and drying. In addition, the instability of bauxite in chemical composition significantly affects the possibility and amount of formation of iron phosphate ligaments. The composition of CHM is given [9], including a material based on oxide and iron oxide in the form of waste dust from electric steelmaking, orthophosphoric acid and chromium anhydride. The main disadvantage of this mixture is the presence of a poisonous and carcinogenic substance - chromium anhydride.

It is proposed to use aqueous solutions of phenolic substances reacting with aldehydes and gaseous acetals as a binder. In [[10], [11]], it is proposed to use a mixture containing epoxy resin and furfuryl alcohol as a catalyst.

It should be noted that the variations in the compositions of CHM concern not only binders and technological additives but also the main component – a refractory filler. For example, in [[12], [13], [14]] it is proposed to use a material extracted from rice husks as a refractory filler since it contains a large amount of SiO_2.

As a highly dispersed material, it is proposed to use gas purification dust produced by ferrosilicon (SCF), the average composition is given in Table 1.

Table 1 - Composition of gas purification dust produced by ferrosilicon, %

SiO_2	Fe_2O_3	Al_2O_3	MgO	CaO
80-95	0.2-4.5	1.8-8.6	1.3-1.5	0.4-2.6

It should be noted that gas cleaning dust has a very developed surface due to technological reasons. According to various estimates, the specific surface area of gas cleaning dust is from 8, 000 cm^2/g and higher [[15], [16]]. Such a developed surface provides a high degree of contact between reagents (silicon dioxide and orthophosphoric acid) with the formation of a compound of silicon pyrophosphate and silicophosphate of variable composition of the type x $xSiO_2 *YP_2O_5$. The formation of this compound causes the mixture to harden, which ensures the formation and properties of the mold.

Conducted studies and their results

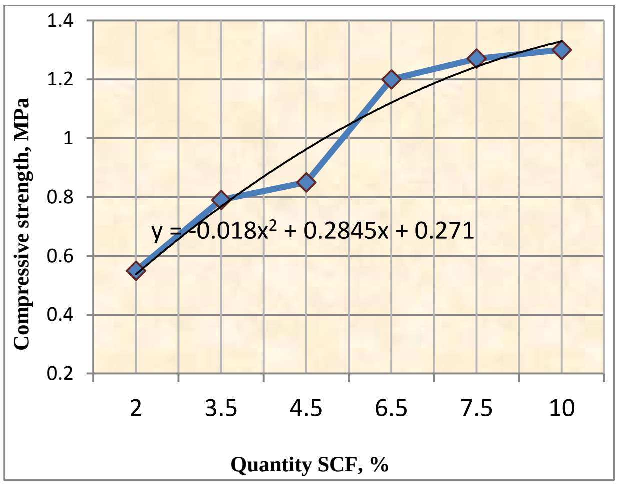
In order to verify this assumption, studies were conducted on the effect of the composition of the mixture using SCF on some of its properties.

The mixture was prepared as follows. Refractory filler (quartz sand) and highly dispersed filler (SCF) were loaded into the paddle mixer and mixed for 5-10 minutes. Then orthophosphoric acid was added, previously diluted with water to a density of 1.5 -1.6 g / cm^3, and mixed for another 5-10 minutes. During the manufacture of the mixture, the number of components varied, the compositions of the mixtures are shown in Table 2.

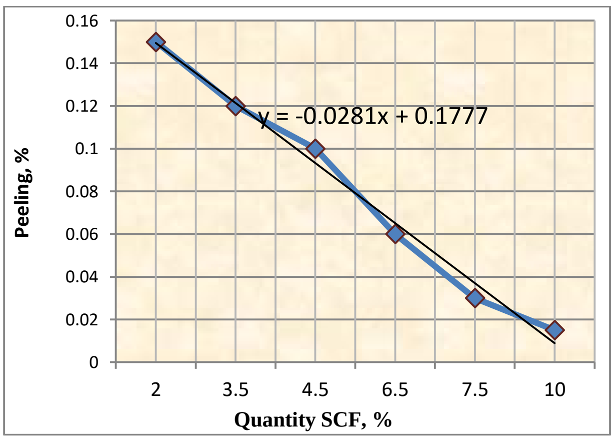
Table 2 - Composition of the studied mixtures, %

Mixture number	Orthophosphoric acid	Highly dispersed filler (SCF)	Water	Quartz sand
1	3	2	4	other
2	4	3.5	4.5	other
3	5	4.5	5	other
4	6	6.0	5.5	other
5	7	7.5	6	other
6	8	10.0	6.5	other

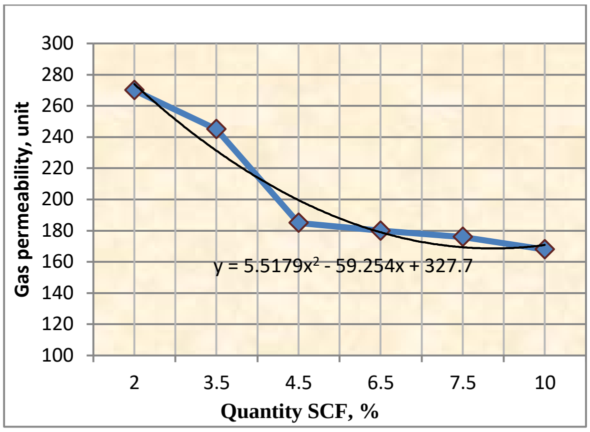
Samples were prepared from the finished mixture to determine compressive strength, survivability, gas permeability and crumblability. Compressive strength was determined on the INSTRON device [17], crumbling on the PP-1100 (02212) device, gas permeability on the P04315-M device according to generally accepted methods. The survivability of the mixture was determined every 30 minutes for 3 hours. In this case, survivability was understood as the minimum time during which the strength drop is more than 30%. The results of the research are shown in Figure 1.



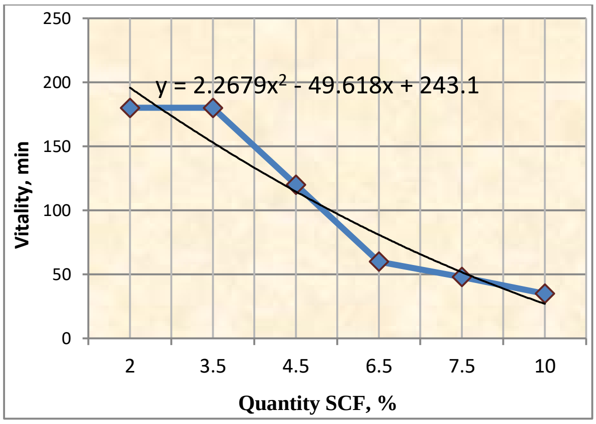
a) change in compressive strength



b) change in crumbling



c) change in gas permeability



d) change in survivability

Figure 1 - Change of properties depending on the amount of PGPF

As can be seen from the above figures, an increase in the amount of SCF in the range of 2-10% has a positive effect on such an indicator as the strength of the mixture, but an increase in the amount of SCF over 6.5% practically does not affect the strength. At the same time, such indicators as survivability, crumbling and gas permeability of the mixture are falling. According to the requirements for the specified parameters, the compressive strength should be at least 0.45 MPa after 1-hour exposure; survivability - at least 10 minutes; gas permeability greater than 150 units; shedding less than 0.3% [[18], [19], [20]].

A comparative analysis of the results obtained with the minimum requirements for the properties imposed on the CHM allows us to draw the following conclusion. The content of SCF in the composition of CHM in the range of 2 - 10% provides the necessary indicators of the mixture within the norm.

A further increase in the amount of SCF in the mixture is impractical since an increase of more than 7-8% practically does not affect the strength. However, at the same time significantly reduces such indicators as survivability, gas permeability and crumbling, which leads to an increase in the cost of the mixture and is economically impractical. A decrease in the amount of SCF below the lower limit (3.0%) is also undesirable since the contact surface created will not be sufficient for active interaction of reagents, which leads to a deterioration in strength indicators.

As can be seen from the data in Table 2, the content of orthophosphoric acid increased with the content of SCF. This is necessary in order to ensure the completeness of the curing reaction and the formation of the complex compound $xSiO_2 *YP_2O_5$. Figure 2 shows the effect of the ratio of the amount of SCF and orthophosphoric acid (OPA) on the strength of the mixture.

As can be seen from Figure 2, with an increase in the ratio of SCF / OPA, the strength of the mixture increases, but then when the ratio is reached equal to 1.25, the strength of the mixture begins to fall. This indicates that with an increase in the proportion of PGPF relative to orthophosphoric acid in the mixture above 1.25, the formation reaction of silicon silicophosphate practically does not proceed, and the curing process does not develop further. Accordingly, it is impractical to exceed the specified ratio.

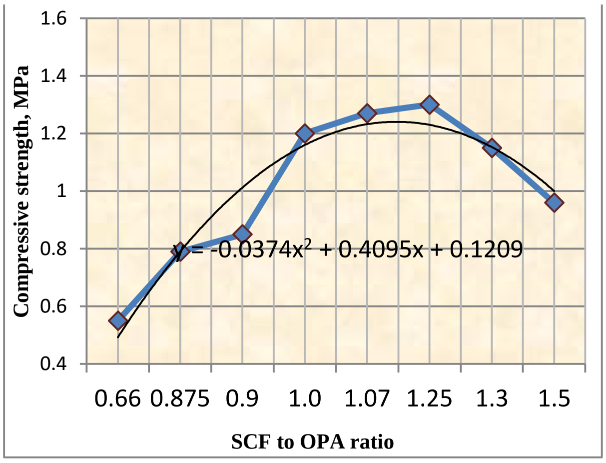


Figure 2 - The effect of the ratio of SCF to OPA on the strength of the mixture

Conclusion

Thus, the conducted studies have shown that in order to ensure the maximum performance of the technological properties of CHM, the optimal content of SCF in the mixture should be 2.0 - 10.0 wt.% in the ratio with orthophosphoric acid is not higher than 1.25. A further increase in the ratio of SCF / OPA in the composition of the mixture leads to a drop in the strength of the mixture.

The proposed mixture has a high survivability (35 - 180 minutes), low crumbling (0.03 - 0.1%) and a wide range of strength from 0.55 to 1.3 MPa with a required minimum of 0.45 MPa, depending on the ratio of SCF / OPA, and the content of SCF should be organic to the specified limits. Consequently, by changing the amount and ratio of SCF and orthophosphoric acid, under other equal conditions, it is possible to regulate the technological properties of the proposed CHM in a wide range.

The studied mixture can be used for the production of small, medium, and large molds and the manufacture of rods of all five complexity classes in conditions of both small-scale production and serial and mass production. The preparation of the mixture can be carried out on standard equipment, which does not require additional costs for the purchase of specialized equipment. The most important advantage of the composition of this mixture is the use of waste from metallurgical production, which contributes to the solution of two tasks: reducing the cost of molds and rods and solid waste disposal and, consequently, improving the environmental situation of the region.

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Суықтай беріктенетін қоспа құрамының құйма қасиеттеріне әсері

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ТҮЙІНДЕМЕ
Дайын құйманың сапасы көбінесе қалыптың сапасымен анықталады. Қазіргі уақытта негізгі компоненттің табиғаты бойынша да, байланыстырғыштар мен басқа да технологиялық қоспалардың табиғаты мен қатынасы бойынша да ерекшеленетін СҚҚ (суықтай қатаятын

қоспалар) құрамында көптеген вариациялар бар. Тазалаған кезде шаңның технологиялық себептерге байланысты өте дамыған беті болады. Әртүрлі бағалаулар бойынша газ тазартатын шаңның үлестік ауданы 8000 см^2/г және одан да көп. Бұл болжамды тексеру үшін ҚСҚ (құмды-сазды қалыптар) көмегімен қоспа құрамының кейбір қасиеттеріне әсеріне зерттеулер жүргізілді. Қорытындылай келе, зерттеулер көрсеткендей, СҚҚ (суықтай қатаятын қоспалар) технологиялық қасиеттерінің максималды өнімділігін қамтамасыз ету үшін қоспадағы ҚСҚ-ның, оңтайлы мөлшері фосфор қышқылымен 1,25 жоғары емес қатынасында 2,0 – 10,0 масс. % болуы керек..

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Исследования влияния состава ХТС на свойства отливки

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Аннотация

Качество готовой отливки во многом определяется качеством формы. В настоящее время существует большое количество вариаций состава ХТС (холодно-твердеющие смеси) различающихся как по природе основного компонента, так и по характеру и соотношению вяжущих и других технологических добавок. При очистке пыль имеет очень развитую поверхность по технологическим причинам. По разным оценкам удельная поверхность пыли газоочистки составляет от 8000 см^2/г и выше. Для проверки этого предположения были проведены исследования влияния состава смеси с использованием ПГФ (песчано-глинистых форм) на некоторые ее свойства. В заключение проведенные исследования показали, что для обеспечения максимальных показателей технологических свойств ХТС оптимальное содержание ПГФ в смеси должно составлять 2,0 - 10,0 мас.% в соотношении с ортофосфорной кислотой не выше 1,25.

Ключевые слова: ХТС, СКФ, литье, свойства, смесь, прочность, поверхность.

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