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Study of thermal resistance of cold mixtures with clay addition

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ABSTRACT

The article analyzes the results of heat resistance of cold-harmful mixtures with the addition of clay. The article presents the results of an experimental laboratory study of the properties of samples from CTS, obtained by various methods. The scientific novelty of the technology lies in the fact that the technology of casting in cold-rolled steel ensures high quality of the casting surface, the absence of gas defects and blockages in the casting. The selection of the composition and technological parameters for the manufacture of the mold, contributing to the production of high-quality defect-free castings, will significantly reduce their cost, which will have a positive effect on the economy of our country. The study of the change in density over time depending on the applied load was studied in a series of experiments. The density of the mixture was determined every thirty seconds during the entire time of the formation of the dispersed medium. These experiments showed that at the beginning of the formation of the shell, its density increases significantly. In works on the thermal stability of polymers, the general laws of thermal decomposition and carbonization of cyclic, spatially crosslinked hot curing polymers were investigated and it was shown that the kinetics of destruction, the composition of gaseous products, the amount of coke formed and its properties depend on the properties of the initial polymers - the degree of crosslinking of molecular chains, chemical structure, the presence of impurities of catalysts and other curing conditions, as well as the heating conditions - speed and temperature. The article summarizes some of the results of the study, which is most appropriate for thin-walled steel castings to use the following mixture composition: filler - quartz sand; binder - clay of the Kazakhstani deposit, epoxy resin, hardener.

Keywords: mixture, shape, properties, heating, metal, heat resistance.

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Introduction

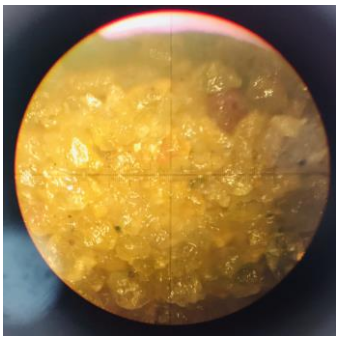
An important problem of modern foundry technologies is the mechanization and automation of the manufacture of casting cores and molds, the complexity of the manufacture of which is very significant. The development of technological processes based on the use of cold-hardening mixtures (CTS) plays a significant role**.**

In works on the thermal stability of polymers, the general laws of thermal decomposition and carbonization of cyclic, spatially crosslinked hot curing polymers were investigated and it was shown that the kinetics of destruction, the composition of gaseous products, the amount of

coke formed and its properties depend on the properties of the initial polymers - the degree of crosslinking of molecular chains, chemical structure, the presence of impurities of catalysts and other curing conditions, as well as the heating conditions - speed and temperature.

Experimental Procedure

The composition of the cold-hardening mixture in the studies was as follows: filler - sand, binder, catalyst and hardener, characterized in that the composition of the mixture is used as follows: sand grade 1K0316-75%, clay (Beloe Glinische minefield) - 35%, epoxy resin EP- SM-PRO 1.8-2%, hardener consumption 921 OP 0.8-1%.



Picture 1 – CHM structure: c - 100 g cvar. sand + 15g epoxy with a mole with a hardener + 10% white clay

Defects in castings, depending on cores and molds, form defects in castings. The process of interaction of mixtures with metal. The most important characteristic of this interaction is the heat transfer between the casting and the mold. Temperature fields in the casting - mold system at different moments or periods of time determine the conditions for the occurrence of almost all processes at the metal - mold interface and in the volume of the mold [1-5].

Analyzing heat transfer from the stated positions, three parameters can be considered as determining:

1. τ_0 - the duration of direct contact of the liquid metal with the mixture. During this period, almost all types of surface defects are formed (burn-in, notches, snakes, etc.), therefore, the properties of cold-hardening mixtures during the period τ0 are of particular interest. Knowledge of τ0 is also necessary to assess the probability of certain physical and chemical processes occurring at the interface.

2. Temperature field in a rod or mold at a given time:

$$t_x=f(\tau,x) \qquad (1)$$

where t_x - mixture temperature at a distance x from the interface, °C; τ - time.

Temperature fields can be used to study the effect of mixtures on the solidification of castings, to investigate and analyze temperature transformations in mixtures under conditions close to real ones, the nature of gas release during heating, the formation of the properties of spent mixtures as an object of reuse or regeneration, etc.

3. Heating rate of the mixture at a given point of the rod or mold υ_x, °C/мин. This parameter, determined from the previous one, is necessary for the development of methods for studying the properties of mixtures at high temperatures, for the maximum approximation of the experimental conditions to the conditions of real interaction.

The mass of castings varies from tens of kilograms to several tens of tons with a wall thickness of 20-30 mm to 500-600 mm, therefore, the issues of interaction of mixtures with metal should be considered with such a degree of generalization, which, at least in the first approximation, corresponded to the actual variety of cast parts. ... With this formulation of the problem, the most reliable is a combination of theoretical and experimental methods. Fundamental work in the field of the theory of heat conduction and heat transfer in a casting mold makes it possible to solve the problem in the following way.

The duration of contact of a liquid metal with a mixture for a wide range of wall thicknesses under certain assumptions can be determined analytically for the plate-semi-infinite form system, if there is data on the thermophysical properties of the metal and mixtures [3-4]

Results and Discussion

The theory and, in particular, the principle of heat flux stability provides methods of transition from plates to bodies of more complex shapes and a corresponding approximation to practical conditions. You can also analytically analyze the temperature fields in the bars for slabs with a given thickness interval.

If now experimental temperature measurements are carried out on real castings with a wide range of geometric parameters, then it seems possible, firstly, to check the results of

theoretical calculations, secondly, to clarify the calculation methods, and thirdly, to determine the limits of their application, taking into account the assumptions made.

The thermal stability of molding mixtures with resins in the manufacture of large castings is one of the most difficult and poorly studied problems in the technology of casting molds. However, there is a certain analogy between the thermal stability of mixtures and the thermal resistance of polymers, which is devoted to a special section of polymer chemistry.

In polymer chemistry, thermal stability is the limiting temperature at which a chemical change occurs in the polymer, which affects its properties. More accurate, apparently, is the determination of thermal stability as the limiting temperature at which the thermal or thermochemical degradation of the polymer begins [5].

For a molding mixture with resins, the definitions of thermal stability adopted in polymer chemistry should be significantly expanded [5]. Traditional polymers, as a rule, are operated for a long time at low (up to 300 ° C) temperatures, and under the conditions of their operation, significant chemical changes in the material are not allowed. It is this circumstance that is reflected in the definition of thermal stability. On the other hand, a molding mixture is operated for a short time at very high temperatures and its thermal stability as a physical concept should reflect these conditions.

A similar problem is being addressed in the field of polymer chemistry. So, for example, when assessing the thermal stability of high-molecular compounds, it is necessary to take into account not only the maximum temperature at which certain properties of the material do not significantly deteriorate, but also the holding time at this temperature, as well as the kinetics of polymer heating.

In principle, synthetic resins [6] used in foundry for cores and large casting molds have similar properties. All of them in the cured state are thermosetting polymers, infusible and insoluble. As already indicated, this property is necessary because it provides the overall stability of the mixture against metal pressure. The thermosetting properties of casting resins are due to their three-dimensional, spatially cross-linked structure. From a chemical point of view, high thermal stability is explained by the presence in the structure of resins of six-membered (PFS) [7-9] or five-membered (furan resins) cycles with a high concentration of carbon atoms in each structural unit of the polymer.

The studies carried out confirm the presence of a direct relationship between the structure and thermal resistance of resins. The least heat-resistant resins do not contain aromatic cycles in their link; an increase in thermal resistance is associated with an increase in the concentration of atoms in the structure. On the other hand, a comparison of coke numbers allows one to make a preliminary forecast about the possibility of using certain classes of polymers as foundry binders.

The important role of coke in form resistance to the action of liquid metal is determined by the fact that, unlike the initial polymer, it can exist for some time at temperatures up to 3000 ° C. Thus, there is a fundamental correspondence between the heating conditions of the molding sand and the properties of the binder.

In works on the thermal stability of polymers, the general laws of thermal decomposition and carbonization of cyclic, spatially crosslinked hot curing polymers were investigated and it was shown that the kinetics of destruction, the composition of gaseous products, the amount of coke formed and its properties depend on the properties of the initial polymers - the degree of crosslinking of molecular chains, chemical structure, the presence of catalyst impurities and other curing conditions, as well as the heating conditions - speed and temperature [10].

The study of the change in density over time depending on the applied load was studied in a series of experiments. The density of the mixture was determined every thirty seconds during the entire time of the formation of the dispersed medium. These experiments showed that at the beginning of the formation of the shell, its density increases significantly. This is due to the removal of interstitial air from the volume of the mixture and a more compact packing of sand grains and particles of unmelted resin under the action of the applied static pressure. A further increase in density occurs insignificantly and is associated with the melting and hardening of the resin, which fills the remaining pores between the grains of sand. Prolonged thermal exposure to EPS will lead to resin burnout and, as a result, to decompaction. A similar distribution of density over time is observed for any degree of compaction used in the experiments.

A series of experiments was carried out to determine the effect of the filling height of the mixture into the filling frame (flask) on the strength properties of the shell (Table 1).

Table 1 - Mixture into the filling frame on the strength properties of the shell

No. of experiments	*Density, kg / m³*	*Applied load, MPa*	*Initial density*
1	1420	0	
2	1560	0,1	Initial density
3	1690	0,2	1400 kg / cm³
4	1740	0,3	
5	1790	0,4	
6	1420	0	
7	1630	0,1	Initial density
8	1780	0,2	1500 kg / cm³
9	1790	0,3	
10	1805	0,4	
11	1310	0	
12	1530	0,1	Initial density
13	1705	0,2	1300 kg / cm³
14	1880	0,3	
15	1900	0,4	

Experiments have shown that, within the filling frame, the filling height does not have a significant effect on the properties of the shell mold due to the small height of the PSS column (Table 2). Except for the backfill height, which is close to the shell thickness. The filling height with the mixture was determined from the highest point of the model plate. The pressure at which the shell was formed was 0.30 MPa.

Table 2 - Experimental data

Backfill height of the PSS in the flask, mm	*Tensile strength of the shell, MPa*
20	4,3; 4,2; 4,1
40	4,9; 4,8; 4,3
60	5,3; 4,6; 4,4
80	5,4; 4,9; 4,5
100	5,4; 4,9; 4,6

Conclusions

To sum up, the content of the binder in the CTS is the main indicator of the composition, which determines the level of strength characteristics of rods and molds, the quality of castings, the sanitary and hygienic characteristics of the process and its technical and economic efficiency.

Conflicts of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Құрамына балшық қосылған суықтай қататын қоспаның термотұрақтылығын зерттеу

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ТҮЙІНДЕМЕ

Мақалада суықтай қататын қоспаларға (СҚҚ) балшық қосу арқылы ыстыққа төзімділігін зерттеу нәтижелері талданады. Мақалада әртүрлі әдістермен алынған СҚҚ үлгілерінің қасиеттерін тәжірибелік зертханалық зерттеудің нәтижелері келтірілген. Технологияның ғылыми жаңалығы - суықтай қататын қоспалар арқылы алынатын құймалардың беттік сапасының жоғары болуын, құймаларда газ көпіршіктері болмауын қамтамасыз ететіндігінде. Жоғары сапалы ақаусыз құю

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өндірісіне үлес қосатын қалып дайындауға арналған композиция мен технологиялық параметрлерді таңдау олардың құнын едәуір төмендетуге мүмкіндік береді, бұл біздің еліміздің экономикасына оң әсер етеді. Тығыздықтың уақыт бойынша қолданылатын күшке байланысты өзгеруі бірқатар тәжірибелерде зерттелген. Қоспаның тығыздығы дисперсті ортаның пайда болуының барлық кезеңінде әр отыз секунд сайын анықталды. Бұл тәжірибелер қабықтың пайда болуының басында оның тығыздығы едәуір арта түсетіндігін көрсетті. Полимерлердің термиялық тұрақтылығы туралы жұмыстарда циклдік, кеңістікте өзара байланысқан полимерлердің термиялық ыдырау және карбонизациялаудың жалпы заңдылықтары зерттеліп, жойылу кинетикасы, газ тәріздес өнімдердің құрамы, түзілген кокстың мөлшері және оның қасиеттерінің бастапқы полимерлердің қасиеттеріне - молекулалық тізбектердің өзара байланысу дәрежесіне, химиялық құрылымына, катализатор қоспаларының болуына және басқа да қатаю жағдайларына, сонымен қатар қыздыру жағдайларына - жылдамдық пен температураға байланыстылығы көрсетілді.. Бұл тәжірибелер қабықтың пайда болуының басында оның тығыздығы едәуір арта түсетіндігін көрсетті. Мақалада зерттеудің кейбір нәтижелері жинақталып, бұл жұқа қабырғалы болат құймалар үшін келесі қоспаның: толтырғыш - кварц құмы; байланыстырушы - қазақстандық кен орнының балшықтары, эпоксидті шайыр, қатайтқыш құрамын қолдану өте қолайлы болатыны көрсетілді.

Түйін сөздер: қоспа, қалып, қасиеттері, қыздыру, металл, ыстыққа төзімділік.

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Исследование термостойкости холоднотвердеющих смесей с добавкой глины

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АННОТАЦИЯ

В статье анализируются результаты термостойкости холоднотвердеющих смесей с добавкой глины. В статье приведены результаты экспериментальных лабораторных исследований свойств образцов из ХТС, полученных различными способами. Научная новизна технологии заключается в том, что технология литья в ХТС позволяет обеспечить высокое качество поверхности литья, отсутствие газовых дефектов и засоров в отливке. Подбор состава и технологических параметров изготовления формы, способствующей получению качественных бездефектных отливок, значительно снизит их себестоимость, что положительно скажется на экономике нашей страны. Исследование изменения плотности во времени в зависимости от приложенной нагрузки изучали в серии экспериментов. Каждые тридцать секунд в течение всего времени формирования дисперсной среды определялась плотность смеси. Эти эксперименты показали, что вначале формирования оболочки ее плотность значительно повышается. В работах по термостойкости полимеров исследованы общие закономерности термического распада и карбонизации циклических, пространственно сшитых полимеров горячего отверждения и показано, что кинетика деструкции, состав газообразных продуктов, количество образующегося кокса и его свойства зависят от свойств исходных полимеров - степени сшивки молекулярных цепей, химического строения, наличия примесей катализаторов и других условий отверждения, а так¬же от условий нагрева - скорости и температуры. Статья подводит некоторые итоги изучения, что наиболее целесообразно для тонкостенных отливок из стали использовать следующий состав смеси: наполнитель – кварцевый песок; связующее – глина казахстанского месторождения, эпоксидная смола, отвердитель.

Ключевые слова: смесь, форма, свойства, нагрев, металл, термостойкость.

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