EXPERIMENTAL STUDY OF IMPROVING QUALITY OF STEEL CASTINGS PRODUCED IN THE SHELL MOLDS

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Cladding method allows to decrease the strength loss of shell molding mixture to a minimum, that may be observed with the introduction of anti defective additives, that means, to achieve the given increase of physical and mechanical characteristics.

Keywords: Carbon steel, castings, shell molds, surface defects, additives, quality

Introduction. Carbon steel castings produced in shell molds in addition to typical for all types of casting defects (the sinks of the gas and shrink origin, breach geometry, etc.), are exposed by specific defects such as the surface sinks and scars-the so-called "orange peel". **Problem**. According to the analysis of produced castings, "orange peel" occurs primarily on the casting surfaces covered by mold (pict. 1): the surface of the casting in the defect zone is carbonized to a depth of 1-2mm. Obtained in shell molds cast iron castings and non-ferrous alloys castings do not have the "orange peel" defect. The high rate of surface sink holes and scars restrains the growth of producing of carbon steel castings in the shell molds.

Pict. 1 The surface of the casting in the defect zone is carbonized to a depth of 1-2mm.

Specificity of surface defects on steel castings, should be explained, obviously, by technology features for their production: high temperatures of alloy filled in mold (1600-1700°C), high shrinkage of solidifying alloy, low carbon content, etc.

Analysis of the latest researches and publications In Foundry practice are known technological measures [1], aimed at improving the quality of casting steel surfaces

obtained in the shell molds: adding additives into the mixture for the shell molds, dissolving by heating with heat absorption (these include, among others, carbonates of calcium and magnesium). Reduction of surface defects is achieved also by introducing iron oxides in a mixture [2]. However, these additives have not found wide usage practically.

Results of the researches. In the study as a model for comparison was taken molding composition: quartz sand K 016, phenolformaldehyde binder in quantity of 5,5% (PC-104 or novolak resin 104 with urotropin (methenamine)). Casting method of the steel sample size 200x150x30 mm was adopted for optimal concentrations of additives and other technological measures to improve the castings surface cleanliness. The research parameters: thickness of shell half mold is 10-12mm, material of casting is steel 15-25L pouring, temperature 1580-1600 °C (in a bucket on the thermocouple dive, location of the casting in the casting mold is vertical, a supply of metal to the casting is situated on side with two feeders, castings cooling duration in the casting mold is 1 hour. In all experiments shell mold halves from tested mixture were joined with shell half molds from mixture selected as a model.

Evaluation of the surface quality of casting specimens was conducted visually. To quantify the quality of the surface conventional 5 scores grade system was adopted: 1- a rough casting surface with roughness height over 3,5 mm; the higher score indicates cleaner surface. The 5 score surface - is devoid of specific defects.

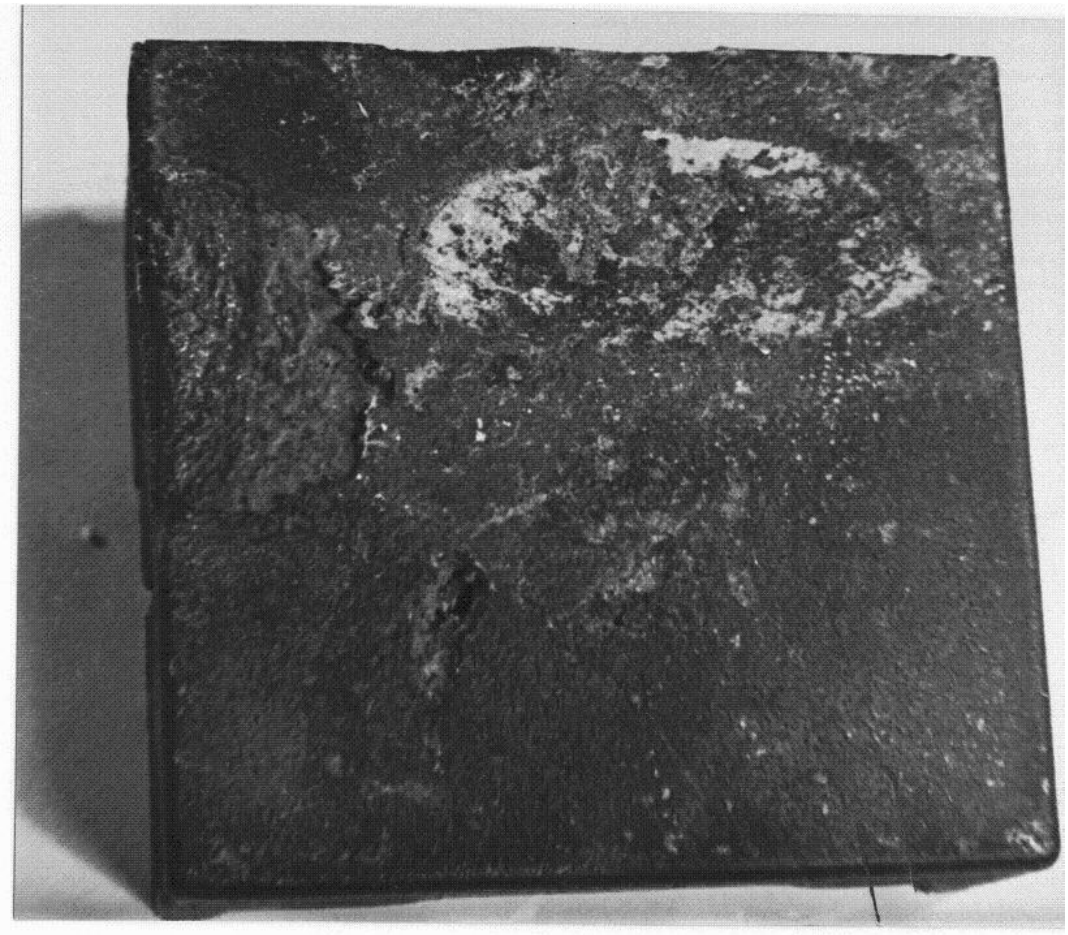
Experiments to determine the influence of additives on castings surface cleanliness have been launched with the use of mechanical mixture of tested additives with the model mixture. Chemically pure additives were introduced with faction size less than 0,1 mm in quantities of 8-10% of the model mixture.

In order to select affordable and available additives calcium carbonate in the form of limestone and chalk of Balaklava mine, magnesium carbonate in the form of industrial magnesite (which contains $MgC0_3$) and iron oxides as iron ore of mines in Kryvyi Rih were tested.

Experiments have shown roughly equal effectiveness of calcium and magnesium carbonate (chemically pure), chalk and limestone, as well as Krivyi Rih ore. Application of industrial magnesite gives less effect, due to the low content of $MgC0_3$.

The evaluation results of obtained casting surface were subjected to statistical processing: there was determined the arithmetic mean value of the scores of surface cleanliness, the standard deviation of this magnitude, using Student's T-ratios were determined the confidence level of these statistical values. Pict. 2 shows the surface of the casting on the side of the shell of the mixture without additives.

The lower third of the castings has a mechanical burn. Above is the "orange peel". Pict. 3 shows the surface of steel castings in a mixture of magnesium carbonate 10%. As it has been revealed, introducing up to 5% of additives has no significant impact on the surface quality of casting. At 8-10% additives there are no surface defects. Data obtained by steel pouring into mold, one half of which was shell of the tested compounds, and the other from the control. The obtained results show that the increase in the additives concentration in tested half mold enhances not only the surface cleanliness of the casting half mold with additives, but also the opposite side surface which is processed by control half-mold.



Pict. 2 The surface of the casting from shell mold without additives

Pict. 3 Qualitative surface of steel casting

This fact can be explained, if we admit the role of gas atmosphere change (composition and gas pressure): thermal destruction of additives changes the gas atmosphere in the entire mold. The change of mold gas atmosphere (the composition and

gases quantity) as the result of introduction of antidefect additives was confirmed when determining the gassing of mixtures by burning the hinge in the tubular electric furnace. The gassing of mixtures with 10% carbonate is about one and a half times higher than the standard. The nature of the gas atmosphere in the mixture with carbonate additives becomes oxidative (the concentration of carbon dioxide increases-about 6-8 times).

Some researchers [1] explain the influence of carbonates on the surface quality by cooling ability that prevents melting of hardened carbonated steel crust on the edge metal form. However, from the results of this study derives an important conclusion that the mechanism of carbonates action is, first and foremost, to create oxidative atmosphere in the mold that excludes castings carburizing, which is confirmed by the study of the speciments microstructure.

The endothermic effect at the carbonates dissolving decreases the temperature in the mold, which also causes an increase in oxidative capacity of produced gas [3].

Powdered additives consisting of 8-10% led to a sharp decline the shell strength (about 3 times). The experiments have been performed with double-layer shell, which inner layer was made from the mixture with additives, and outside-of the mixture without additives. Double-layer shells had high overall strength, however, the surface quality of casting increases to a lesser extent than in single-layer shells. Application of double-layer shell mold in production due to the necessity of creation of forming equipment with two forming units (for building cladding and pouring layers) involves significant capital costs.

Because of this, the problem of maintaining strength of cladding mixture, when adding the additives had to be resolved only through technological methods. To optimize technology of adding additives into the mixture, the experiments have been conducted in which the components were added in the following sequence: a) sand + PC-104 + acetone; b) sand + limestone + PC-104 + acetone; c) sand + PC-104 + limestone + acetone; d) sand + PC-104 + acetone + limestone. The smallest decline in the strength of the mixture has been observed in the latter case. The decline was lower when using additives the large factions.

To avoid a substantial decline of the cladding mixture strength at adding additives it was proposed and tested a new method of additives introduction. Limestone (additive) was cladded by 10% of PC-104 "cold" then cladded limestone was introduced into cladded master mix (strength reducing was only 10-15 per cent).

Control pouring into molds made from mixtures of cladode additives obtained casts, without surface defects. The shell molds had sufficient strength. The developed method of adding antidefect additives is protected by inventors certificate [4]. Table 1 shows the properties of the mixtures obtained by known and suggested methods**.**

Conclusions. When adding in known methods into caddied sand antidefect additives, containing iron ore (oxides of iron) strength decrease in terms of the experiment was:

for mixture p1.2 (36-32.8) .5/36.5· 100 = 10%

for mixture p1.3 (36.5 -32.2)/36.5· 100 = 12%

At the same time, when adding by known methods the same additives the strength decline was only:

for mixture p2.2 (42-41)/42 · 100 = 2,5%

for mixture p3.2 (33-35, 5)/35·100 = 1,2%

Thus, according to the present invention cladding method compared to applicable allows to minimize the strength loss of shell mounding mixture, that are observed with the

introduction of antidefective additives, that is, to achieve a given increase of physical and mechanical characteristics.

Table 1 The properties of the mixtures obtained by the known and suggested methods

№№ p/p	The order of mixture preparation	Mixture strength during the break test, MPa
1.1	Quartz sand, cladode 5% Binder PC-104 (covered with the mixture without anti defect additives)	36.5
1.2	In quartz sand, cladode 5% Binder PC-104 by p.1.1, introduced when mixing 3% iron ore (known method)	32.2
1.3	In quartz sand, cladode 5% Binder p. 1.1, introduced when mixing additive, consisting of 2% limestone (known method).	32.8
2.1	Quartz sand, cladode 5% Binder pK-(I)04 (cladode mixture without anti defect additives)	42.0
2.2	In quartz sand, cladode 5% Binder PC-104 on p. 2.I, introduced when mixing additive, consisting of 3% iron ore and 5% limestone, previously cladode with the same binding (the proposed method)	41.0
3.1	Quartz sand, cladode 5% Binder PC-104 (cladode mixture without anti defect additives)	35.0
3.2	In quartz sand, cladode 5% Binder PC-104 on p. 3.1, was introduced anti defect additive consisting of 3% iron ore and 5% limestone, cladode with the same binding (the proposed method)	35.5

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ЭКСПЕРИМЕНТАЛЬНОЕ ИССЛЕДОВАНИЕ ПОВЫШЕНИЯ КАЧЕСТВА СТАЛЬНЫХ ОТЛИВОК, ПОЛУЧАЕМЫХ В ОБОЛОЧКОВЫХ ФОРМАХ

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Ключевые слова: отливки, углеродистая сталь, оболочковая форма, поверхностные дефекты, добавки, качество

Резюме

Предложенный способ плакирования позволяет свести потери прочности оболочковой формовочной смеси, наблюдаемые при введении противодефектной добавки, к минимуму, то есть добиться заданного повышения физико-механических характеристик

ЕКСПЕРИМЕНТАЛЬНЕ ДОСЛІДЖЕННЯ ПІДВИЩЕННЯ ЯКОСТІ СТАЛЕВИХ ВІДЛИВКІВ, ОТРИМУВАНИХ В ОБОЛОНКОВИХ ФОРМАХ

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Ключові слова: відливки, вуглецева сталь, оболонкова форма, поверхневі дефекти, добавки, якість

Резюме

Запропонований спосіб плакирування дозволяє звести втрати міцності оболонкової формувальної суміші, що відбуваються при введенні протидефектної добавки, до мінімуму, тобто добитися заданого збільшення фізико-механічних характеристик

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Summary

Cladding method allows to decrease the strength loss of cladded shell molding sand observed by introduction of anti defect additives to minimum, ie to achieve a given increase of physical and mechanical properties