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The Causes of Defects in Iron Castings

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With the expansion of the use of cold-box-amine process cores in foundry, it became possible to almost completely eliminate casting defects connected with insufficient strength of rods, poor surface quality or geometry mismatch, to significantly reduce gas defects, and also to reduce specific energy costs while manufacturing rods and reduce the cost of core tooling. However, with a general decrease in the percentage of defects, their structure has substantially changed; other types of defects have occupied a more significant share, primarily, finning.

According to GOST 19200-80 «Castings from cast iron and steel. Terms and Definitions», finning is a surface defect in the form of low veins that have arisen as a result of metal flowing into cracks on the surface of a mold or a core.

Increasingly, finning has become the main cause of defective products, especially for critical castings with complex internal channels. Fissures are fixable defects, but the costs of detecting (to detect tearing in internal, closed channels it is necessary to use special means of control - endoscopes) and removing these defects in hard-to-reach places often make this operation economically disadvantageous. In some cases, for example, in the internal channels of a cylinder head, the correction of this defect becomes practically impossible.

Today, despite the already obvious significance of the problem, there are still no scientifically based recommendations and elaborated methods for dealing with this

type of defect. The analysis of the causes of its occurrence is difficult due to the lack of targeted statistics: often in foundries, finning is not distinguished as a separate type of defect, and statistics about this is not kept. The development of effective methods of dealing with finning is difficult due to the lack of methods and objective difficulties in studying the processes occurring in the bulk of the foundry core or mold at high temperatures, heating rates and significant temperature gradients [1].

The object of our research is the processes that occur in the core during casting and crystallization of the casting.

The subject of research –phase composition, rheological and mechanical properties, thermal stability.

The purpose of the work is to establish and systematize the main causes of defects that affect the quality of cast iron castings made with the use of cores produced by the cold-box-amine process.

The purpose and objectives of the work require the use of various research methods. Since currently there is not enough data in this area of foundry, and they are rather general, there is a need to resort to experiment to test the hypothesis, which is an empirical method of research. The aim of the work is not only the development of integrated technology, but also the scientific basis of the laws of structural changes on the surface of the rod that occur while casting, which in its turn requires the use of theoretical research methods.

While considering this problem we should pay special attention to multiple interactions of the system components:

• the connection of individual grains of sand with each other under the action of adhesion/cohesion forces of the binder. The effect of high temperatures and exposure times on these bonds;

• volumetric expansion of the grains of sand of the core mixture as a result of phase transformations, and consequently the appearance of tensile and compressive stresses;

• temperature effect of liquid metal;

• uneven distribution of thermal loads in the core volume.

The analysis of these interactions separately and in the general system will allow to compose a general picture of the processes occurring in the rod while pouring liquid metal into the mold.

The purpose of this work is to systematize and analyze all the factors that influence the occurrence of such defects and make a computer model of the processes occurring in the core.

The results of this work will form the basis for further research and development of additives and coatings for rods that contribute to the elimination of defects such as finning.

As a result of the studies, the following parameters were identified that have a significant impact on the intensity and depth of the finning in the core:

– granulometric composition of the used sand and the degree of its *contamination* with a fine fraction;

– temperature in the metal-rod contact zone;

– exposure time to the rod of high temperatures;

– bending strength of the core;

– presence (absence) of non-penetration coating;

– the presence of special additives in the core mixture which reduces the tendency of the rods to form finning;

– metal pressure on the core in the contact zone;

– rate of temperature distribution over the entire depth of the core.

Obviously, in real conditions, the above-mentioned parameters have a complex effect on the core. However, it is required to study the influence of each parameter separately to understand the processes occurring in the core.

To conduct the study, a technique was developed that allows to control changes in the geometric dimensions of the sample, temperature and exposure time, strength, the start time of the destruction of binding, the time of occurrence of the first cracks in the sample and the time of complete destruction.

All the tests were carried out on 6 samples, 2 of which were made from a core mixture of conventional composition, and 4 – from a core mixture with modified parameters. This allowed us to evaluate the effect of certain changes in the composition of the core mixture on the controlled parameters.

As a result, we established the following:

– a change in temperature in the metal-core contact zone does not significantly affect the result, only the duration of this effect has some influence. This is due to the fact that the destruction of the binding components of the core mixture occurs at ~ 600 ° C and a decrease in temperature from 1420 ° C to 1350 ° C still leads to complete destruction of the sample in the contact zone;

– contact time significantly affects the ability of the rod to withstand the occurrence of finning;

– a change in the particle size distribution of the sand of the core mixture does not have any significant effect on the occurrence of defects. However, it was found that the use of a finer and more concentrated fraction leads to an increase in phase expansion of the samples. This is explained by the greater length of the sand grain boundaries, and, accordingly, the large volume expansion during the phase transition.

– mechanical effects on the core at the time of heating accelerate its complete destruction;

– the presence and thickness of the non-penetration coating layer significantly affect the rate of defects occurrence. This is explained by the creation of a protective layer on the surface of the samples, which increases the time until the surface of the sample is heated above critical temperatures (~

600 ° C) and slows down the heating of the samples. However, the applied non-stick coatings do not exclude defects such as finning by 100%;

– the use of special additives in the core mixture show that some of them can increase the time until the first cracks on the samples occur (compared with the control ones), however, the overall gas release from the surface of the samples increases. This is due to the burnout of the additives used. The degree of gas evolution and its pressure has not been studied and is the subject of additional analysis;

– the use of special additives in the core mixture with simultaneous application of a non- penetration coating shows the best result from the entire series of experiments. The time before the first cracks appeared on the surface of the samples was maximum, which indicates the correct choice of direction - the use of a set of measures to counter such defects.

The systematic approach used in this work allowed us to make a detailed analysis of a whole range of reasons that affect the occurrence of defects in cast iron castings while using rods made by the cold-box-amine process. Based on the studies, data were prepared and systematized a computer model of the processes occurring in the core. The results were obtained and a theoretical basis was prepared for conducting research with pouring samples with liquid metal.

A technique has been developed that allows simultaneous monitoring of a number of parameters in the test samples and a comprehensive assessment of the impact on the sample of the system external and internal factors.

References:

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