Investigation of the effect of the method of extracting a part from a mold on the presence of stone-like defects in cast steels

M L Skryabin
Vyatka State Agricultural Academy, 133, Oktyabrsky prospect, Kirov, 610017, Russia

E-mail: max.dvs@mail.ru

Abstract. The article deals with the concept of casting defects in steelmaking and their classification. A special place among the existing defects is occupied by a stone-like fracture, which reduces the mechanical properties of finished products and is an irreversible defect. Often, a stone-like fracture appears when receiving products based on smelted models and the reasons for its formation are not fully studied. This article discusses the influence of the method of extracting a part from a mold on stone-like defects in cast steels. The results were analyzed.

1. Introduction
Defects are an integral part of any production process and should be kept to a minimum in order to improve product quality. In addition to casting defects, defects in the form of cracks (chips, layered cracks), layers with burnt carbon and carbonized layers, naphthalene and stone-like fractures, etc. can be found in castings [1-3].

Naphthalene and rock-like fractures are the result of severe overheating of the metal before deformation or heat treatment. A naphthalene crack is classified as planar, with the characteristic luster of large grains in cross-section that reflect light. Stone-like fracture-classified as a matte fracture, according to the boundaries of large and small grains that reveal their cut. The naphthalene fracture has the reflectivity of the grain faces and is weakly dependent on the direction of illumination. To determine a rock-like fracture, on the contrary, certain conditions of heat treatment of samples enclosed in quenching and tempering are required [4-7].

2. Defects in cast steel
Especially often, a stone-like fracture occurs when casting on the produced models. This technology uses a single model made of a refractory ceramic coating that forms a ceramic mold. At the end of pouring and solidifying the metal, it is removed by knocking out.

The model is manufactured in metal split molds. Molds are divided into two types: single and multi-seat. Single molds are soldered using a soldering iron to the Gating system, which makes the molds look like multi-seat model links[8-10].

After this operation, a refractory mixture is applied to the surface, which has the form of a liquid suspension. The next layer is a suspension of dry refractory material, drying is performed in special chambers. For a uniform and high-quality refractory layer, 4-6 layers of liquid and dry suspension are alternated.

After solidification, the model is melted, removed, and washed with hot water to form a cavity for pouring metal.
Investment casting has the following advantages:

- getting accurate castings in size, which reduces the consumption of metal for chips during machining of parts;
- surface cleanliness of castings from all alloys, starting with a wall thickness of 1-3 mm;
- low probability of formation of gas sinks.
- Defects in castings, which are made by casting on investment models, are formed at certain stages of the process, or rather in the preparatory processes [11-14]:
- production of smelted models is the main stage for the production of serviceable castings; for this purpose, it is necessary to maintain the accuracy of dimensional tolerances;
- installation of smelted models in the unit, it is necessary to strictly observe the position of the model in the block section sizes of risers, feeders and reservoirs, these actions can prevent the appearance of shrinkage cavities, porosity, slag blowholes and non-metallic inclusions[15-18];
- mold production, at this stage, you should conduct a thorough control of the raw materials, drying and calcination modes – this will allow you to provide high accuracy and quality of castings;
- melting and pouring of metal requires strict compliance with the parameters for the quality of the casting surface, their density and uniformity, this will also allow you to get good mechanical properties.

3. Ways to solve the problem
To study the effect of knocking out castings from ceramic molds on the presence of a stone-like fracture of 35XGSL steel, several batches of samples were examined after appropriate heat treatment.

In addition to homogenization, tests were carried out on knocking out the casting from ceramic molds 15 minutes after pouring the metal, as well as after complete cooling of the casting. The hardness of the cast samples did not differ from each other, 285 HB, in contrast to the microstructure (figure 1, 2).

**Figure 1.** Microstructure of cast samples with different exposure times before casting: a) knocking out 15 minutes after casting; b) knocking out after complete cooling of the casting.
Figure 2. Inhomogeneity of etching of the microstructure of a sample knocked out after complete cooling.

Preliminary heat treatment was carried out according to the annealing mode and then acquired a homogeneous structure on both samples (figure 3).

Figure 3. Microstructure of samples after annealing:

a) knocking out 15 minutes after casting; b) knocking out after complete cooling of the casting.

After the final heat treatment, the samples were subjected to destruction to determine the presence of a rock-like fracture[19-21]. No stone fracture was found on both samples (figure 4, 5).
4. Conclusion
According to the results of research on the topic of stone-like fracture, the following was revealed:

- a rock-like fracture is the result of a strong overheating of the metal during the heat treatment of the metal at temperatures of 1250°C and above, which can be detected after the final heat treatment. But at the same time, homogenization prevents the appearance of a stone-like fracture under the following condition: the larger the stone-like fracture, the longer the exposure time during homogenization should be [22-24];
• formation of a rock-like fracture occurs on aluminum nitrides;
• prevention of stone-like fracture is possible with the help of rare earth elements with remelting of own production waste, using different deoxidizers for each subsequent melting.
• silicocalcium helps prevent the appearance of a stone-like fracture;
• knocking out the casting after complete cooling of the metal pouring into ceramic molds and knocking out 15 minutes after pouring does not affect the appearance of a stone-like fracture in the samples under study.
• other regularities of the appearance of a stone-like fracture were not identified.

Considering and analyzing the conducted studies, the following conclusion was made: homogenization and deoxidation with silicocalcium contribute to the correction of a stone-like fracture, but the full causes of its formation have not been identified. To identify all the regularities of the formation of a stone-like fracture, more in-depth studies should be carried out with the study of the chemical composition using an x-ray luminescent spectrometer.

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