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«Influence of the chemical composition of steel on the formation of a stone-like fracture and the microstructure of cast steels»

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Problem statement

- A stone-like fracture formed during the manufacture of cast blanks is a homogeneous fracture surface that passes along the grain boundaries. It is formed at high temperatures and is enriched with highly soluble austenite phases in the form of small particles or films-fused eutectic. On the surface of a rock-like fracture, you can often find a matte light gray color, with a metallic sheen. Clear stone-like grains appear after heat treatment: quenching and tempering, normalization, and other types of heat treatment.
- A stone-like fracture in cast steel is divided into two types: primary and secondary. The primary rock-like fracture can be observed after overheating and cooling, that is, before heat treatment. This fracture is due to the formation of the granulation structure of austenite, which is formed after crystallization under slow cooling at high temperatures. At this time, excess sulfides, nitrides, phosphides, carbides, and some alloying elements, which are limited soluble in the gamma phase, are released at the grain boundaries.
- Secondary fracture occurs after metal overheating before hot deformation, such as forging, rolling, and stamping, and also occurs after overheating during heat treatment.

Solution methods

- The mechanism of formation of a secondary stone-like fracture is as follows. When heated to 1300-1350 °C, the austenite grain grows to a significant size, approximately 1-5 mm, and takes the form of regular polyhedra. At these temperatures, the carbide phase, aluminum nitrides, and sulfides are dissolved. Due to the high surface activity, sulfur and nitrogen are adsorbed at the borders of large austenitic grains and form excess phases-films of iron and manganese sulfides with the conversion of iron sulfide and aluminum nitrides, which were preserved after cooling at the borders of former austenite grains. This leads to the brittleness of the metal under shock loading and the fracture passes partially or completely along these boundaries. Subsequent heat treatment does not eliminate the formed phases.
- The critical superheat temperature at which the formation of a secondary rock-like fracture begins depends on the chemical composition, the smelting method, the deoxidation method, the degree of frequency of the steel, the nature of non-metallic inclusions, and the grain size.
- Electric arc smelting, as opposed to open-hearth smelting, as well as electric arc smelting with subsequent electroslag remelting, are prone to such a stone-like fracture.
- It is customary to distinguish between a stable and unstable rock-like fracture. A stable stone-like fracture is of the first and second kind.
- A rock-like fracture of the first kind requires heating to a temperature slightly below the critical temperature in order to correct it. This rarely happens during heat treatment. The second type of stone fracture is corrected more easily by applying subsequent homogenization or high-temperature normalization.

Conclusions

Results, implementation

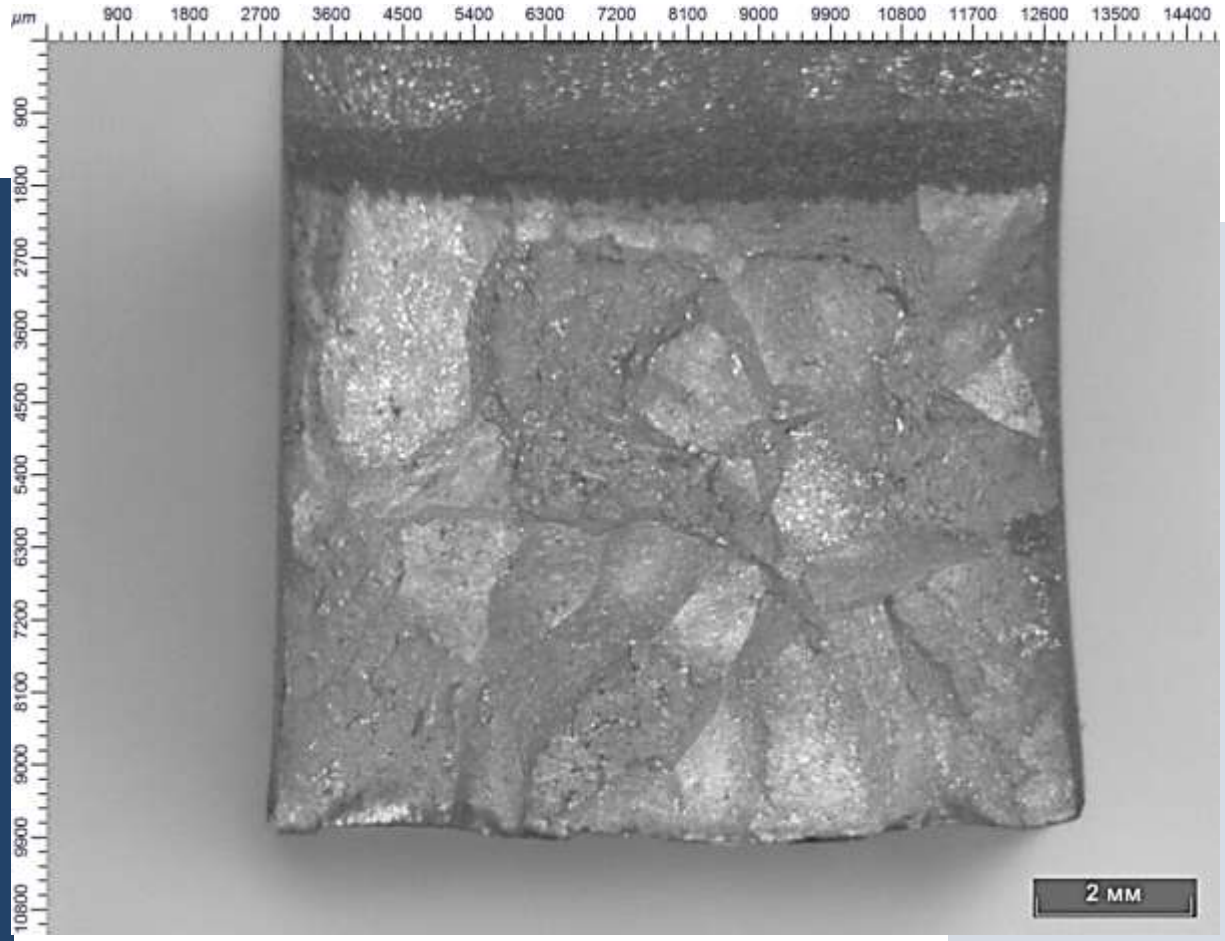

Figure 1. Fracture of a separately cast sample of medium-carbon steel before heat treatment.

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