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MECHANICAL CHARACTERISTIC INFLUENCING UPON GAMOGENIZACIYU METAL

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Annotation: In article are considered influence factors, influencing upon gomogenizaciya and her (its) using. Dendritnaya the phial appears during repeating over and over again as a result different element in melt and in hard metal; besides, she depends on distances between balances line liquid's and line solidus. Gomogenizaciya products from become is concluded in her(it) during several hours under high temperature (above 950 With). The Temperature gomogenizaciya follows to support possible more high to accelerate the diffusion, however, she must be vastly below the temperature T_{th}, which answers the theoretical line solidus, since above T_t exists the danger of the melting the areas with big degree the phial.

Keywords: gomogenizaciya, diffusion, active element, gradient to concentrations, the temperature of the melting, spottinesses composition, atom of the admixtures, modification ferric, small grain, pulverizing grain, alloy, migration, boiling bullion

INTRODUCTION

Dendritic liquation occurs during solidification as a result of the different solubility of alloying elements in the melt and in the solid metal; in addition, it depends on the distance between the equilibrium liquidus line and the solidus line. Carbon is the most active element in this regard. It greatly enhances the elimination of other elements (F.565/1-6).

When the entire melt has crystallized, the steel is in a solid state, and there is a tendency to equalize the heterogeneity of the composition by diffusion of impurity atoms from the liquation zone to the pure one (Fig. 1).

This migration occurs inside dendrites already during their growth and continues after the metal has completely solidified, however, below a certain temperature (in the order of 900°), diffusion can practically be neglected [1].

The rate of diffusion of impurity atoms increases very rapidly with temperature; it depends on the nature of the alloying element of the corresponding atomic radius [see the difference between phosphorus and arsenic (F. 566/1,2)], the composition of steel (the presence of other alloying elements in iron) and the crystalline modification of iron: δ or γ or even α. This effect of the structure is very high in some chromium and nickel special steels, where equilibrium between the δ- and γ-phases is rarely achieved.

The higher the achievable degree of homogenization, the faster the alloying element diffuses, the longer the exposure at high temperature, the greater the concentration difference between the dendritic axes and the dendritic space, and the shorter the diffusion path of the alloying element atoms (dendrite size). However, the last two factors are expressed through a concentration gradient [2].

Thus, at a high rate of solidification, small dendrites with a high degree of liquation are obtained, which is enhanced if the exposure at high temperature is low. Reheating at temperatures below the solidus line increases the rate of homogenization.

There may be dendrites of different sizes in the same ingot. Columnar dendrites have smaller transverse dimensions than the equiaxed dendrites following them, which often contain large amounts of impurities. Thus, better homogenization can be obtained in the zone of columnar crystals than in the layers lying further from the surface. In the areas of the dark bands and the axial zone of the liquation, homogenization practically does not occur due to their large size. In fact, the macrouniformity of the composition in the transverse or longitudinal directions does not change at all. Good homogenization can be achieved by remelting the ingot under appropriate conditions (for example, with a consumable electrode), during which the steel is cleaned of undesirable elements as much as possible [3].

METHODOLOGY AND MATERIALS

The homogenization of a steel product consists in annealing it for several hours at a high temperature (above 950 ° C). This operation can be performed either by reheating after cooling. The first case is answered by holding the ingots in a heating well before rolling. For the central part of the high-carbon steel ingot, which after solidification was immediately placed in the furnace for several hours, grain-scale homogeneity can be schematically traced in Fig.1, where Tp is the furnace temperature, Tq is the limit temperature of the practical homogenization zone. After extraction from the furnace, the products are deformed, and the mutual convergence of the liquation regions allows for a new homogenization from r-s to t–u.

Table 1. The effect of heat treatment on the strength of the product and the type of fracture perpendicular to the zone of columnar crystals (ingot samples with a thickness of 250 mm; structural steel with 0.10% C, 1.0% Cr, 4.0% Ni according to Lightner).

Condition	Endurance		Relative elongation, %	Relative narrowing, %	View of the fracture
	kG/mm²	*Mn/m²*			
Cast	51,6	516	1,4	2,6	Fine-grained
	49,7	497	1,4	1,1	Coarse-grained
Excerpt					
½ hour at 810°C	67,3	673	4,3	3,9	Fine-grained
	77,1	771	4,3	6,9	Coarse-grained

½ h at 1000°C	82,5	825	16,8	27,5	Fine-grained
	78,0	780	14,2	25,0	Coarse-grained

When the ingots or castings are cooled to room temperature after solidification (in some products, this cooling is necessary for technical reasons), they must be reheated to the homogenization temperature, kept at this temperature for several hours, and then cooled in an oven to approximately 500 ° C. This treatment is called diffusion annealing, and it is characterized by the heating temperature, exposure at this temperature, and cooling method. It should also be noted that cooling with a furnace during passage through the α→γ transformation region can lead to a secondary dendritic structure; this can be avoided by cooling the product in air, if the weight of the casting and the composition of the steel allow it [4].

The homogenization temperature should be kept as high as possible in order to accelerate diffusion, however, it should be significantly lower than the temperature Tth (see Fig.52), which corresponds to the theoretical solidus line, since above Tt there is a danger of melting areas with a high degree of liquefaction (burnout). However, the melting point of these regions gradually increases during homogenization and may then exceed the annealing temperature.

The kinetics of heating also plays a role in this process: the power of the furnace, the location of the burner, the shape of the sample (corners, ingots, thin place of casting, F. 566/5,6).

During diffusion annealing, a very high temperature causes warping, decarburization, and degomogenization of the sample.

In production, diffusion annealing is carried out between 950 and 1100 ° C, constantly reducing the exposure time; in practice, the exposure time is 1 hour for a sample with a diameter of 25 mm, or 30 minutes 1 cm thick; this is an empirically established time, which is sufficient to achieve the desired degree of homogenization. Thick samples are annealed at high temperature for 12 hours.

Only castings are usually subjected to diffusion annealing, while ingots are processed by other methods (reheating or deformation), which lead to even better homogenization. In addition, diffusion annealing is not required for common carbon and low-alloy steels, it is effective only for alloy steels.

They are often satisfied with relatively low temperatures of the order of A3c+100 degrees, at which homogenization is limited; it is significant only in areas with a high concentration gradient. The results obtained by diffusion annealing can be studied on macroglyphs by chemical and physical methods, however, these results depend on the sensitivity of the methods used, so it is impossible to reliably judge the success of heat treatment. At the same time, the sensitivity of some research methods (especially macro-etching) is so high that it makes it difficult to assess the technical suitability of the product. Usually, after macro-etching, distinct traces of dendritic liquation are found. The application of this method requires the destruction of the finished product

after the final heat treatment, or it can be used simultaneously with the testing of mechanical properties (Table 1).

RESULTS AND DISCUSSION

After the steel is poured into the mold, the metal begins to solidify, which develops continuously around the entire perimeter of the ingot. Solidification begins with the formation of nuclei in the melt, which then grow into close contact with each other and form a structure characteristic of a solid metal.

The appearance of nuclei is possible only due to the supercooling that accompanies the transition of a metal from a liquid state to a solid state. This process is influenced by temperature, pressure, and other factors. Nucleation can be homogeneous when the nuclei have the same origin as steel, and heterogeneous when the nuclei are foreign solid particles [1].

The embryo that forms in the melt of the melting point Tpl is short-lived. Below the Tpl temperature, the embryo is stable only if its size is large enough, i.e. if it has a critical rc size. Such an embryo can grow even under the condition of constant heat removal. At temperatures below T', the critical radius of the embryo decreases, and the probability of embryo formation increases. This is evidenced by the time-to-time crystal growth curves.

Pressure also plays a role, albeit a small one, as increasing the pressure decreases the critical radius of the embryo. To use this property, the liquid mass of the metal is subjected to vibration; it is only difficult to transfer sufficient energy to the metal [2].

Homogeneous nucleation requires supercooling of more than 100 degrees, and can occur with slow cooling in the absence of solid nuclei. This requires cooling in a melting furnace with smooth glazed walls, as in the manufacture of single crystals.

In industrial practice, supercooling does not exceed 1 degree; this means that the steel poured into the mold is already two-phase, i.e. solid nuclei in the form of a suspension are in the melt. Thus, a quasi-constant temperature is maintained in the core of the ingot during solidification.

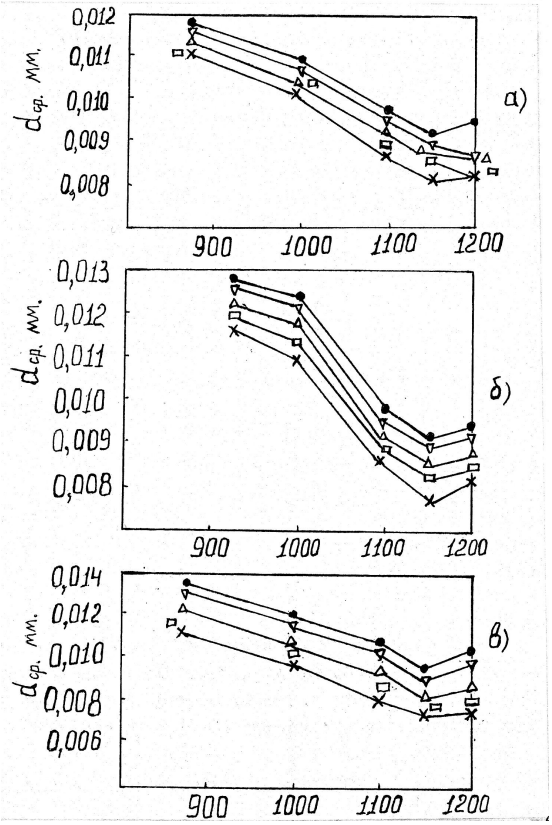
Since their own nuclei cannot withstand overheating of ~ 80 degrees under normal production conditions, the presence of solid nuclei during casting into the mold can be explained by the following reasons: either these are their own (homogeneous nucleation) from among those formed when metal came into contact with a cold base or walls of the mold, or were carried away by a liquid stream [3], or the construction of germs formed before or during solidification.

The rate of crystallization depends on the chemical composition, on the crystal modification in which the steel hardens (γ or α), and on the crystallographic direction. Since crystal formation is slowed down by the release of latent solidification heat, crystallization also depends on the cooling rate. This last factor is very important.

The growth of embryos leads to the appearance of grains bordering each other, and a grain will grow from each embryo. The final grain size depends on the total number of nuclei and their distribution in the metal volume. In turn, the total number of nuclei depends on the rate of crystallization, since if, under a given supercooling, the rate of nucleation increases over time, the volume of liquid metal decreases accordingly.

However, it should be noted that the possibility of regulating the cooling rate during crystallization, during solidification, is very limited (there is only casting of dry, wet earthen and metal molds). In order to regulate grain sizes, artificial introduction of substances into molten metal that create crystallization centers is widely used, since spontaneous nucleation of crystallization centers in metals and metal alloys occurs, but is not always decisive [4]. All kinds of foreign, non-metallic inclusions that enter the metal during melting or are introduced specifically play a much greater role as crystallization centers in industrial metals.

The artificial introduction of refractory small particles into liquid metal, which serve as additional crystallization centers, is the most progressive and effective method of regulating grain sizes, their shapes, and, consequently, the properties of metals and alloys.



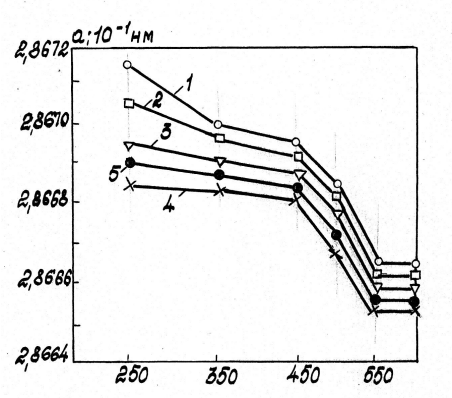
Pre-quenching temperatures, °C

Fig.1 Results of the study of U85A steel, the change in the lattice period of the α phase depending on the temperature of pre-quenching and intermediate tempering: a) 450°C; b) 550°C; c) 600°C.

The results of the study are the change in the lattice period of the α phase depending on the temperature of pre-quenching and intermediate tempering.

Intermediate release	Change in the lattice period of the α phase as a function of the pre-quenching temperature, *nm*

temperatures, °C	870	1000	1100	1150	1200
250	2,8667	2,8660	2,8622	2,8619	2,8645
350	2,8645	2,8635	2,8631	2,8610	2,8615
450	2,8659	2,8656	2,8644	2,8632	2,8637
500	2,8643	2,8641	2,8629	2,8609	2,864
550	2,8646	2,8642	2,8628	2,8620	2,8625



Intermediate release temperatures, °C

Fig.2 Results of the study of the change in the lattice period of the α phase depending on the temperature of pre-quenching and intermediate tempering.

So, the number of grains is determined by the ratio between their growth rate, which shows that when they cool very quickly, a large number of nuclei appear, resulting in a fine-grained structure.

At the cooling rates common in industry, it is difficult to predict the grain size. There is no single point of view regarding the shape and position of Tamman curves for metals. In particular, Siegel emphasizes that additives in steels affect the number of nuclei rather than the position of the corresponding curve [5]. He showed that with significant supercooling (few nuclei) and a low rate of grain crystallization, the steel is finer than with low supercooling and a high rate of crystallization.

CONCLUSION

The grain size also depends on the distribution of the nuclei; in the melt, their relative positions may change during solidification due to the decantation of nuclei with a higher density. The latter can sink to the bottom of the mill and produce fine grains in a limited area. The melt above them is capable of producing crystallization centers again.

In conclusion, it can be said that the grain size is very difficult to predict, since it depends on numerous factors that are difficult to determine, such as the rate of nucleation, the rate of their growth, and the rate of cooling at the solid–liquid interface. Other factors: chemical heterogeneity,

gravitational effect (precipitation of free crystals), mass effect (the effect of different cooling rates of different parts of the ingot)– complicates the problem even more.

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