STEELS OF PERITECTIC TYPE: PECULIARITIES OF STRUCTURE, ALLOYING TECHNOLOGY AND USE

The article presents analysis of phase transformation characteristics, primary structure formation, alloying technology and usage of steels, which undergo a peritectic transformation during their solidification.

Key words: *peritectic steel, peritectic steel application, alloying technology*

Peritektični čelici: značajke strukture, tehnologije legiranja i primjene. U članku se predočuje analiza značajki fazne transformacije, nastanka primarne strukture, tehnologije legiranja i primjene čelika podvrgnutih peritektičkoj transformaciji pri skrućivanju.

Ključne riječi: *peritektični čelik, primjena peritektičkog čelika, tehnologija legiranja*

INTRODUCTION

At present a steady price rise of alloying constituents such as nickel, chromium, vanadium, molybdenum and others is a common fact. A traditional way of alloyed steels price decrease was to design of new marks of steel with lower degree of alloying and by replacement of expensive constituents for more cheap ones. However the experience of internal and foreign level of development of science of materials shows that such method of approach doesn't always bring positive results, and narrows the range of materials application or deteriorates their technological application.

This article deals with steels which in the process of solidification undergo a peritectic transformation. A distinctive feature of modern alloyed steels is that they have a complicated chemical composition and are characterized by multi-stage process of solidification which brings about a number of phase transformations, the most widespread of which is a peritectic reaction.

A peritectic transformation of δ-ferrite and liquid phase into austenite takes place in all constructional, high-speed, die, many corrosion-resistant and other steels. Peritectic reactions in alloys on the base of iron were studied less than widespread transformations - eutectic, taking place in alloyed steels. The number of publications dealing with the data relative to peritectic reactions is approximately one hundredth of those ones with eutectic.

Such condition is related to the lack of reliable experimental data in the literature. The majority of the iron - base peritectic reactions is carried out at high temperatures (1200 - 1450 °C) and a number of phase transformations was observed: eutectic reaction, secondary phases formation, eutectoid austenite decomposition and others. To identify the phases in peritectic alloys a stepwise investigation of solidification process is needed.

The character of high temperature crystallization processes in the alloyed steels is often judged from experimental data obtained in other metallic and organic systems. The main results on peritectic reactions have been obtained on the basis of study of the solidification processes of double alloys like Sn-Sb, Cu-Ge, Cu-Cd, Al-Cr and others as well as on the parachromiumiodbenzol - paradiiodbenzol systems [1-6]. Upon experimental facts and the analysis of diagrams of double peritectic alloys K. P. Bunin, A. A. Baranov, Y. V. Grechnyy and co-authors [5, 7] during 1950 - 1970 period, managed to discover the mechanism of their crystallization.

First at the beginning a solid phase α crystallizes from the liquid. Upon supercooling below T_p (peritectical), special conditions are created and so another solid phase-β can be formed. Most often β-phase inoculates in the liquid on the surface of α - phase. Diffusion of the alloy components in the liquid and influence of α - phase result in rapid grow of β-phase along the α/L interface thus finally forming a continuous enclosure. Further, the β-phase layer increases

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its thickness as a result of advancement of the border β/L in the direction of the liquid phase and the border β/α in the α-phase direction, and so the transformation: $L + \alpha \rightarrow \beta$ takes place. The rate is not high, because it is determined by the components diffusion through the β-phase enclosure. Such "rim" mechanism of the peritectic transformation is considered to be accepted at present [6-10].

The analysis of the phase diagrams of the two-component systems [7-8] indicates the β phase on the surface of already formed crystals of α-phase, and in the α-phase itself. In the first case the reaction is driven by chemical heterogeneity of the liquid, that divides the of crystals a and β-phases, and in the other one - the concentration gradient in α-phase between the liquid and β-phase. However, these mechanisms of the peritectic transformation are extremely rarely found due to the complexity of the homophase nucleation of the β-phase.

A significant contribution to the development of peritectic solidification concept has been made by Y. V. Grechny and V. N. Platova [1-2], which was performed on the Sn - Sb system. It was established, that at alloys, that have in the beginning of the peritectic transformation a small quantity of the melt and are characterized by the ramified and dispersed structure of the initial solid phase, the peritectic reaction is accomplished rapidly in the conditions of the contact of all phases, which participate in it, and is terminated by the liquid disappearance. In all other cases a traditional "rim" mechanism was fixed. The beginning of the experimental and theoretical investigations of the peritectic crystallization of alloys on the basis of iron was in 1950 - 1970 period contributed by K. Kyu [11-12], K. P. Bunin, A. I. Yatsenko, Y. N. Malinochka, N. M. Repin and others [13-14].

The concept of classical "rim" mechanism of the peritectic reaction was carried out both, on the patterns of threefold alloys and with steels of industrial production [16-27].

In 1972. under the guidance of K. P. Bunin , Y. N. Malinochka, G. Z. Kovalchuk and others [28], at investigation of Fe-C-Si crystallization revealed that δ-ferrite for a long time can partly be in contact with liquid. The components diffusion of the alloy in this case is accomplished through the liquid phase and the peritectic austenite is charecterized by the high growth velocity until it forms enclosure.

The primary realization of three - phase contact (δ-ferrite - liquid - austenite) results by advancement of the front of austenite growth into the liquid along the surface of δ - ferrite and to formation of an enclosure at the end. To such conclusion came the authors who studied crystallization of Fe-C-Si alloys [19-20].

Significant results have been obtained by H. Fredrikson [29-30], who investigated the process of solidification of W-Mo high-speed steels and Fe-C-Cr alloys.

Owing to the lack of reliable data about the mechanism of the peritectic transformation in iron - base alloys discrepant interpretation of the phase and structural transformations regarding solidification of industrial steels was given.

Carbide precipitation ("peritectic centers") in the axial section of austenite dendrites some authors [24, 25] explain by four-phase peritectic reaction: $\delta\text{-f} + L \rightarrow A + K$, which would take place at the temperatures by 20 - 30 °C lower than three-phase transformation, $\delta\text{-f} + L \rightarrow A$. The indication was a slight insignificant bend of differential therma1 analysis (DTA) curve. Other authors explain this data by carbides MC grow [26-27].

However, it remains the cause of localization of carbides in the central sections of the austenite grains. The authors of the work [32] assumed, that at the final stages of the three-phase peritectic reaction $\delta\text{-f} + P \rightarrow A$, δ-ferrite was transformed into austenite and carbides. The most part of them is dissolved in the peritectic austenite during the subsequent cooling, but same quantity of carbide phase remains up to the room temperature and is perceived in the final structure, as "peritectic centers".

The analysis of articles, dealing with solidification of Fe-C-Ni alloys and chromium-nickel corrosion resistant steels indicates that interpretations are different not only about the understanding of the mechanism of the three-phase (δ-f, L, A) transformation, but also in understanding of its character itself. Some authors, using DTA data and microstructural analysis, believe, that upon cooling of alloys, which contain 17 - 20 % of chromium and 8 - 10 % of nickel, a peritectic reaction of austenite formation from the liquid and δ-ferrite ($\delta\text{-f} + L \rightarrow A$) [33- 35] takes place, and other [36-38], proceeding from the analysis of the structure, draw conclusion about eutectic transformation availability, which is followed by the common growth of δ - ferrite and austenite ($L \rightarrow \delta + A$) from the liquid.

EXPERIMENTAL STUDIES

Owing to the lack of a common theory of a peritectic transformation in alloyed steels difficulties arise in planing the solidification and thermalkinetics conditions, which is a feature of modern technologies of steel making: casting, electroslag, vacuum arc refining and powder metallurgy. Taking into account the specific character of peritectic reaction, its interdependence and interrelation with eutectic crystallization process, makes possible to raise technological and in some cases mechanical properties of steels.

Most of these investigations were performed by vacuum furnace of horizontal type with quenching tank, equipped with a precision computer temperature control system.

The experiments represented heating of 1 g mass of load in the argon atmosphere up to 1500 - 1750 °C, isothermal endurance and cooling in 10 % salt solution. High

precision of heating and cooling rate (0.5 %), the temperature stabilization in the working space of a furnace (at ± 0.5 °C), as well as the high rate of cooling of a sample in the quenching bath (2000 - 6000 K/s) enabled to get a good reproduction of the experimental data upon gradual investigation of structure formation. In order to produce the samples of steels crystallized at the rate of 10^3-10^6 K/s a method of quenching from a liquid state over a quick - reversed disk - crystallizer was used. The installation, made for this purpose represented a vacuum furnace of a vertical type with a molybdenum heater located coaxially relative to a taper aluminium - oxide crucible with a sample, in the lower part of which there was an opening through which the molten metal was shot by a stream of argon. The rate of cooling upon solidification of alloys was determined according to the sample thickness or using the interaxial distance of the primary dendrites.

Super-high-speed heating of steels was carried out by the method of the straight pass of an electric current through the samples having cylindrical or cone section by means of a fast-acting electronic trigger, and non-impact pyrometer used to control the temperature. The construction of the installation envisaged steel solidification from the chosen temperatures in the 10 % solution of salt as well as an oscillography control over the kinetics of heating.

The samples being quenched from a solid - liquid state were subjected to a complex examination and analysis by the method of the optical and scanning - electronic microscopy and also by the method of microprobe X-ray analysis.

Volume of constituent phases and their chemical composition were determined quantitatively in each sample, which gave the opportunity, from the one hand, to receive an exhaustive and comprehensive information about the structural state of alloys at the moment of quenching and from the other hand, to estimate a summary error of metallographic investigations by means of counting out components content in all phases and to compare them with the data on composition of the alloy.

MECHANISMS OF PERITECTIC REACTIONS

The authors studied the mechanism and kinetics of a peritectic transformation in alloys on the basis of iron using slow (1.0 - 12.0 K/minute) cooling. Solidification of all steels and alloys of the peritectic type starts with nucleation of the δ-ferrite crystals. Increasing of δ-ferrite is accompanied by displacement into liquid both austenite stabilizing elements and many ferrite stabilizing elements, and this process stimulates the formation of different kinds of dendrites branching ramifications.

In all investigated and analyzed steels and melts on the initial stage of peritectic transformation δ-ferrite + L → A the first crystals of austenite appear on the interphase boundary δ-ferrite / liquid and quickly grow along it, form-

ing thin (1 - 5 μm) interrupting enclosure. In majority of cases a number of centers of origin of the peritectic austenite is insignificant and its increase is accomplished by means of formation on the surface of δ-ferrite flat ramified austenite dendrites.

The most important peculiarity of peritectic reaction, which defines its further kinetics is the formation on the boundary of the division of δ-ferrite/austenite a thin entire or interrupting interlayer of the liquid, united through the gaps in the austenite enclosure with an interdendrites melt. This phenomenon is explained by the following way:

1. The analysis of the forces of the surface tension, wedging pressure of the liquid in the places of contact of austenite and δ-ferrite as well as the bulk volume effects, connected with various compactness of a crystal lattice of δ- and γ-solid solutions, shows that the tension P on the interphase boundary δ-f/A may be approximately estimated for different values of thickness of the austenite rim L and its external radius R, according to the formula:

$$P = E \frac{L}{R}\left(K^{-\frac{1}{3}} - 1\right) + \frac{2\sigma_L}{d} - \frac{\sigma_L}{R} \tag{1}$$

where:

E - is a modulus of elasticity,
K - is a ratio of specific volumes of δ-ferrite and austenite,
σ_L - is a coefficient of surface tension of the liquid,
d - is a mean thickness of a wedge-shaped chink between δ-ferrite and austenite.

Estimation of quantity P for alloyed steels gives the value of 10^{15} - 10^{16} which significantly exceeds critical tension of the formation of quasi-fragile crack. Formation of cracks between δ-ferrite and austenite enables further penetration of the liquid phase there. It was shown that the viscosy of a liquid phase does not limit its motion in the interphase intervals and the entering expression (1) and the wedging pressure $2\sigma_L/d$, presented in the expression (1) has a physical meaning.

2. Upon enough convergence of branches of flat dendrites of austenite a liquid phase adjoining them is significantly richer with ferrite stabilizing elements, that impedes a tangency growth of an austenite enclosure. At the same time favorable conditions are created on the boundary δ-ferrite/A for formation of austenite in the places close to the liquid location. This phenomenon is explained by the influence of δ-ferrite, by its close chemical composition relative to austenite and by its

high diffusive mobility of elements in a liquid phase. As a result increased thickness is formed on the end face of austenite boundary layer, which get their further development along the surface δ-ferrite. Owing to the difference in specific volumes of δ-ferrite and austenite a line of contact of solid phases with liquid advances in the same direction and as a result a thin interlayer of melt is, formed on the boundary of division δ-ferrite/A.

3. High wetting ability of metals by their melts favors implementation of the effect of Rebinder. At the beginning, a streaking has a capillary character and a melt meniscus takes a concave form. Further a mechanism of liquid spreading changes: active atoms of steel components are absorbed on the surface of solid phases and penetrating onto the boundary δ-f/A continue to move along it, when the looseness of fcc and bcc lattices in the places of their contacts promoting it. Thus, formation of a liquid-phase layer between δ-ferrite and austenite is carried out at the velocity of surface migration of atoms, corresponding to spreading of a thin layer of liquid due to the gain in the surface energy during a solid back wetting by a melt. The succession of stages of liquid-phase layer formation between δ-ferrite and austenite as a result of a total influence of the above mentioned factors is presented by Figure 1.
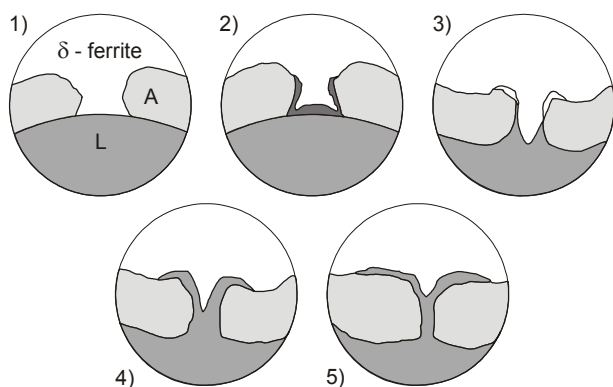

Figure 1.   **The scheme of the primary stage of the peritectic reaction**
Slika 1.   **Shema primarnog stupnja peritektične reakcije**

According to the composition of a temperature interval of solidification and some peculiarities which preceded to crystal1ization of δ-ferrite, peritectic austenite is characterized by various growth morphology and kinetics. In steels which are alloyed by a large amount of ferrite stabilizing elements, a front of austenite growth moves exclusively along the surface of δ-ferrite upon practically constant amount of liquid phase. This fact is explained by a common mechanism of interphase diffusive redistribution of components. Being active ferrite stabilizers, the main part of alloying elements of steels are faintly dissolved in

the growing austenite and are educed in the zone of δ-ferrite → A recrystallization , where they are absorbed by a liquid layer.

PERITECTIC TRANSFORMATION

However in steels with small content of ferrite stabilizing elements or in steels alloyed with nickel, manganese and corrosion resistant (heat-resistant) steels, austenite growth is assumed to be possible both in the direction of δ-ferrite and of primary melt. This is to a certain extent changes the mechanism of a peritectic reaction, making it to be multistage. Just the same as it was revised in earlier cases on the first initial stages of transformation on the boundary of division δ-ferrite/A a broken, interrupted austenite enclosure is formed, which is either completely or partly isolated by a liquid phase from δ-ferrite (Figure 2.). In alloys with sufficient amount of austenite stabilizing elements in a melt at the moment of termination of the crystallization of δ-ferrite the conditions are created for the austenite growth directly into the liquid.
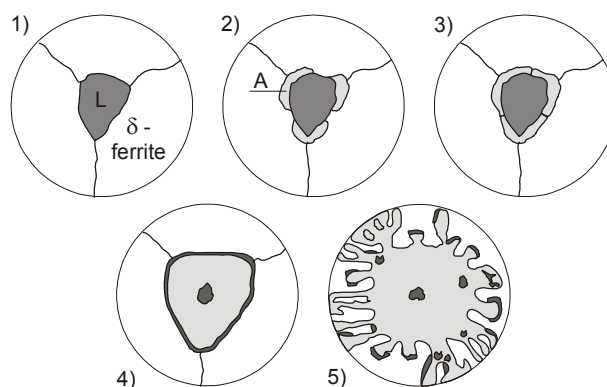

Figure 2.   **The scheme of a peritectic transformation at partial austenite crystallization from the primary melt**
Slika 2.   **Shema peritektične transformacije pri djelomičnoj kristalizaciji austenita iz primarne taline**

As a result a liquid phase becomes heterogeneous in structure, and initial melt is entirely isolated by an austenite enclosure from the liquid in the section of austenite growth to the direction of δ-ferrite. Upon further cooling a number of austenite increases both owing to the initial melt and to δ-ferrite, however these processes take place practically independently from each other.

The character of euthectic solidification in steels of the peritectic type depends on the place of location, quantity and composition of the initial liquid. Crystallization of the interdendritent melt and closed regions of the intracrystalline liquid metal results in formation of the euthectic colonies. The product of the eutectic crystallization of the liquid in narrow, interphase is a structure of a thin conglomerate of phases. As a rule the composition of a crystallizing eutectic and the initial liquid is significantly

different. It stimulates diffusion processes in liquid and solid phases both in coincident and in opposite according to the direction of a mass transfer of components on the stage preceding a peritectic transformations. In titanium stabilized corrosion resistant and heat-resistant steels the eutectic reaction takes place simultaneously with a peritectic one, that is a multiphase peritectic transformation takes place liquid; and δ-ferrite transforms info austenite and into sulphide, phosphorus and other phases. The mechanism of peritectic austenite growth in these conditions does not change and is characterized by the presence of liquid on δ-f/A boundary. Squeezing of the liquid phase layers is prevented due to a small quantity and a low degree of interaction of sulphide and phosphorus euthectic.

DISCUSION OF THE STUDY

This research work enabled to establish that acceleration of cooling rate leads to reduction of dendrite fragments of the initial δ-ferrite, increasing dissolubility of ferrite stabilizing elements in them, promotes closing of micro-fields of the liquid phase in the axial sections of δ-solid solution. The most effective and many-sided influence on the mechanism of structure formation as it was found consists in the velocity of cooling on the stage of peritectic reaction. In the conditions of lack of solid phase contact between δ-ferrite and A acceleration of cooling rate changes the morphology of austenite growth front in the following succession: flat - front - cells - dendrites - fiat front. It is explained by the origin of the concentrated super-cooling of δ-ferrite and a liquid with the acceleration of crystallization and by its liquidation under super high rates of heat irradiation. Much less influence has the kinetics of cooling on the morphology of austenite which is formed in the places of three-phase, contact (liquid, δ-ferrite, A). The rise of the velocity of cooling increases dispersion of austenite component; at velocity of cooling of $V = 10^4 - 10^5$ K/s degree of branching of a plastic or cellular (porous) structure becomes slightly lower.

In majority of cases the dependence of the content of ferrite stabilizing elements in austenite on cooling rate is extreme: in the beginning their concentration increases and then decreases. The content of austenite stabilizing components is changed in reverse order. It was proven experimentally that it is explained by a partial inheritance by austenite of the composition of the initial δ-ferrite under low velocity of cooling and the tendency for decreasing of ferrite stabilizing elements dissolubility in austenite upon acceleration of crystallization.

Rising the velocity of solidification of high-speed, die steels and other iron-carbon alloys not monotonously effects the degree of peritectic reaction completion: the quantity of residual δ-ferrite at first decreases and then increases (Figure 3.). Acceleration of austenite formation along with

the rise of velocity of cooling is explained by the joint effect of the following factors:

- extension of the space of austenite growth front as the result of dendrite cell structure formation,
- by decreasing of the size of dendrite of the initial δ-ferrite and their more quick transformation into austenite,
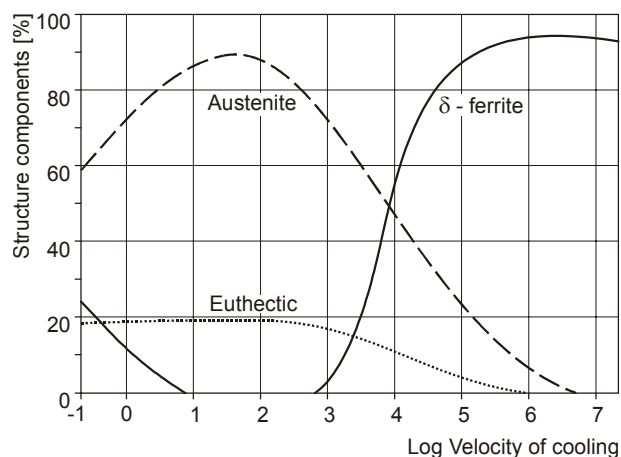- by expanding of the temperature interval between eutectic and peritectic reactions.

Figure 3. **A typical dependence of a phase composition of peritectic type steels on the velocity of cooling at crystallization**
Slika 3. **Tipična zavisnost faznog sastava peritektičnog tipa čelika o brzini hlađenja pri kristalizaciji**

The effect of the latter factor can be so significant that the peritectic reaction ends earlier then the beginning of the eutectic one, this is a specific feather for the steels, the eutectics of which are based upon several carbides of various thermodynamic stability. In this case the proper crystallization of austenite is observed from liquid within the temperature interval between peritectic and eutectic transformations. The decrease of completion of peritectic reaction upon cooling of the analyzed steels at the velocity of $10^2 - 10^4$ K/s connected with that the increase of the quantity of the residual δ-ferrite (Figure 3.) is assumed to be the consequence of the limitation of the components diffusion in liquid state Metallographic investigations and the estimations made by them showed, that in the conditions of the super speed cooling the growth of the peritectic austenite is limited by the diffusive mass transfer of the alloyed elements through the liquid phase beginning from the front of transformation in the interdendrite melt and is entirely suppressed at the velocity of cooling of $V = 10^6 - 10^7$ K/s.

So the influence of thermal and kinetic conditions of melting and solidification of the alloyed steel s can be very significant. The cooling of heat resistant steels at the rate of more than 100 - 150 K/minute indicates transition from austenite initial crystallization to δ-ferrite with subsequent peritectic transformation.

Upon cooling of the crystallizing peritectic steels from the region of resistance of δ-ferrite at the rate close to the quenching the shifting martensite - like δ-f → A transformation takes place.

Peritectic transformation in high-speed steels and alloys of systems Fe-C-W, Fe-C-Mo is carried out in the conditions of the lack of a solid-phase contact of δ-ferrite and austenite. Increasing the content of ferrite stabilizing elements decreases the degree of completion of peritectic reaction while alloying of steels and alloys by austenite stabilizing elements on the contrary promotes the growth of a peritectic austenite. Besides exerting effect on the temperature interval of the peritectic transformation the alloying components can determine the morphology of an austenite growth due to the influence on the characteristics of diffusive mass transfer in the liquid phase.

For peritectic solidification of corrosion resistant steels and alloys of system Fe-Cr-Ni a specific feature lies in a partial formation of austenite from the initial liquid and in connection with a structural melt exfoliation.

In these conditions a peritectic reaction is carried out step-by-step and the duration of each stage is determined by the equivalent content of chromium and nickel. In Cr-Ni steels the temperature of melt overheating exerts more influence on the austenite growth kinetics than the velocity of cooling upon crystallization.

Formation of peritectic austenite in heatproof steels with the heightened toughness takes place upon a small quantity of the liquid phase in the conditions of lack of the steady phase contact between δ- and γ-solid solutions. This causes formation of the ramified cellular structure, dispersion of which rises with the increase of the content of the ferrite stabilizing elements.

The character of solidification Cr-Ni-W high-temperature is defined by the ratio of ferrite stabilizing and austenite stabilizing elements: upon fluctuations in chemical composition even within the range of high marks both a single-phase, ferrite crystallization and multi-phase peritectic crystallization are possible.

A peritectic reaction in Fe-C-Cr systems takes place in the conditions if on the boundary of devision δ-f/A there is an interrupting interlayer of liquid metal with a small difference in content of chromium between δ-ferrite and austenite. Upon peritectic transformation in Fe-C-Al alloys the process of a melt enrichment by the atoms of iron and its depletion by aluminium is carried out. This promotes the growth of austenite into the liquid phase and formation a dendrite structure in the inter-grain spaces of crystals of the primary δ-ferrite.

It has been established that the estimation of the specifications of the peritectic solidification of steels enables with out substantial capital expenditures to increase their quality in various means of production.

Upon steel making process in the electric furnaces with further bottom casting a positive effect can be gained due to the proper regulation of the thermal and kinetic conditions of the melting process implementation and cooling the metal in ingot molds. Using example of W-Mo high-speed steel it is shown that upon the temperature of metal tapping into the ladle 1545 - 1560 °C the following changes are observed: a sharp decrease of a quantity of initial dendrites and the per cent of carbide portion and decrease of a part of MC carbides in eutectic. The optimal time of steel hold up in the ladle which ensures retain of fine-grained structure after crystallization was 15 minutes. The gain in the hot plasticity slightly decreases, when steel blowing operation by argon under vacuum is used. It is established that this fact is explained by chemical and structural heterogeneity connected with bringing - down the degree of peritectic transformations completion and as a consequence of which increase of residual δ-ferrite quantity in the axial sections of the carbide grains. At the same time the presence of partly dissolved carbides of δ-eutectoid in austenite positively influences the steel operational properties making its thermal treatment to be more effective.

Slightly less influence over the steel structural characteristics shows the use of variety of thermal-kinetic conditions of melting and solidification upon the use of Electroslag remelting (ESR) process. Nevertheless in Cr-Mo steels by reduction of the remelting velocity from 800 to 600 kg/hour we managed to decrease a quantity of a grain boundary eutectic by 1.2 - 1.3 times and increase the uniformity of its distribution across the ingot section. At the same time the increase of dendritic liquation of molybdenum (by 1.1 - 1.2 times) was observed and decrease of grains and decrease of the percentage of δ-eutectoid carbides, which is explained by larger extent of peritectic reaction.

Technological properties of tube centrifugal casting enables within the significant range to change both the temperature of the metal superheating before its casting and increase of its crystallization. In particular by means of regulation of the temperature of casing and the rate of cooling upon solidification in the process of the tube billets manufacture from Cr-Ni-Mo-Nb at 1600 °C and 100 K/m respectively we managed to gain the decrease of a quantity of grain boundary eutectic by 2 - 3 times, and to increase significantly the metal structural homogeneity. Metallographic analysis and estimation of mechanical properties of the billet which was cast according to the recommended regime showed that it is comparable to the steel made by the Vacuum arc remelting (VAR) and Electroslag remelting (ESR) processes and possesses plasticity grade which make possible to use it for production of special thin -walled tubes by means of cold deformation, omitting the hot rolling process. The positive effect in this case was achieved owing the initiation of multiphase

peritectic crystallization in steel instead of preparation of initial austenite directly from the melt.

The authors suggested the method of rational usage of granular raw materials for alloyed steels manufacture by the method of powder metallurgy. It has been established that dependent on fraction, the steel powder, produced by means of gas spraying of the melt was characterized by various correlation of δ-ferrite and austenite, which affected its technological properties. On the example of high-speed steels it has been shown that the efficiency of sintering and cold and hot isostatic extrusion, which consist chiefly of δ-ferrite small granules was by 15 - 25 % higher than using large ones.

Application of the initial powder with increased quantity of small fractions ensures the presence of carbides of δ-eutectoid in steel after compacting. The eutectoid carbides restrain the growth of grains when steel is heated for quenching, prevent their irreversible loss of strength so improving many properties of tools and instruments.

Availability of δ-f → A transformation upon a super speed cooling of steels of the peritectic type enables to work out the method of increasing of effective mechanical grinding of powder of high - speed steels.

A substantial rise of quality of laser, microplasma and other welded joints of corrosion-resistant and high-temperature Cr-Ni steels has become possible owing to the initiation of the A → δ-f shirt transformation in the process of super speed heating of the billet edges. The appeared micro-tension due to this action will change the kinetics of steel melting, making it to be independent on grain boundaries. The welded joint, which was formed at these conditions possess a high level of chemical and structural homogeneity and ensures strong endurance characteristics of the joints, which are close to the properties of the main metal.

In the process of preparation of composite materials on the base of alloyed steels it is necessary to take into account the transformation ability of the reinforcing particles in the liquid phase on the stages of crystallization of δ-ferrite and peritectic transformation, as well as their diffusion interactions with melt.

CONCLUSION

This article provides - substantiation to apply the WC + Co alloying compositions, which are obtained from the waste carbide tools, to high-speed steels melts. It has been shown that when the optimal quantity of carbide WC is introduced into the steel at the process of pouring, their particles while moving in the melt during the peritectic solidification are uniformly dispersed in the austenite. Besides the ferrotungsten economy, it positively affects the structural characteristic features of the steel at delivery, preventing the grain increase at quenching.

At large- scale metallurgical enterprises if alteration of thermo sensitive regime of melting and crystallization is impossible owing to technological or economic reasons the production quality increase and ferroaloys economy can be achieved by optimization of steel composition. Thus, the use of available data about the solubility of alloying components W-Mo of high-speed steels in the peritectic austenite and about the eutectic component in the intervals of the cooling rate, which are typical for cooling of different 1150 kg, industrial billets gave the opportunity to substantiate the possibility to decrease the content of molybdenum in W-Mo steel from 5.0 - 5.5 % up to 4.8 - 5.3 % without decreasing its technological and operational properties.

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