STRUCTURAL CHANGES IN CORROSION-RESISTANT STEEL 06Kh18ch

V. G. Mishchenko and V. G. Rakhmannyi

UDC 620.186.4:669.14.018.8

Recently, plates made of corrosion-resistant chrome steels are more often being used in the construction of articles whose manufacture is associated with a high degree of cold-working. However, anisotropic deformation occurs and the steel has little stampability which limits its applications. This makes it necessary to use the more expensive chrome–nickel or chrome–manganese steels of the austenitic class. It was established during detailed studies on the cold working of corrosion-resistant steels that the austenitic steels have several advantages over other types during dual and single axial extension. Anisotropic deformation causes increased surface roughness of articles with decorative finishes. This requires additional labor in order to remove these defects.

Anisotropic deformation in steels of the ferritic and martensitic–ferritic class is significant and arises at lower levels of deformation than in the austenitic steels.

It is known that the appearance of anisotropic deformation depends, not only on the nature of the metal, but also on its structural state. Consequently, in order to increase plasticity and decrease anisotropic deformation of steel 06Kh18ch one can increase the uniformity of its structural state.

An analysis of test results carried out using traditional technology of metallurgical processing showed that changing the ingot rolling regime, and then of the slabs, has little effect on the properties of the metal. The formation of the structure and basic properties

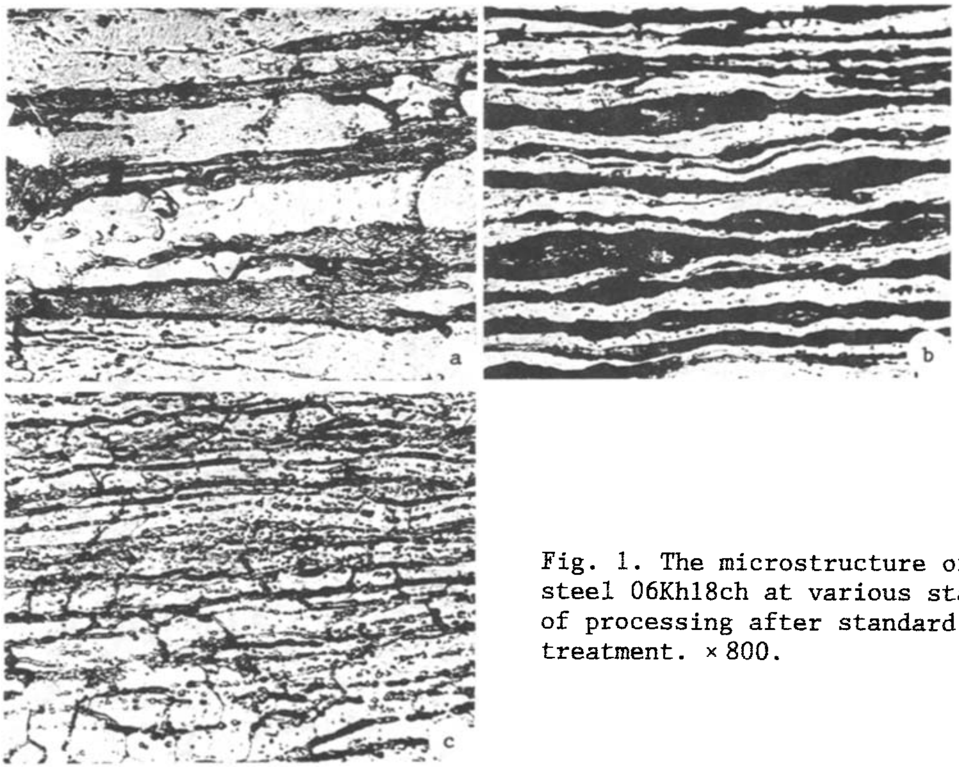

Fig. 1. The microstructure of steel 06Kh18ch at various stages of processing after standard treatment. × 800.

Zaporozh'e Machine Building Institute. Vol'nyansk Table Instrument Factory. Translated from Metallovedenie i Termicheskaya Obrabotka Metallov, No. 5, pp. 57-59, May, 1990.

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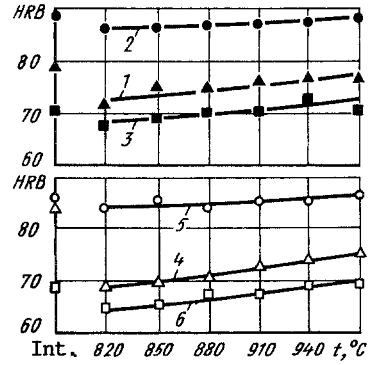

Fig. 2. The hardness of metallurgically processed steel 06Kh18ch as a function as a function of the temperature of preliminary heat treatment: 1) hot rolled; 2) the same as 1 followed by cold-working to ε = 60%; 3) the same as 2 followed by a final recrystallization anneal; 4) the same as 1 followed by a preliminary (before heat treatment) cold-working to ε = 20%; 5) the same as 4 followed by cold-working to ε = 40%; 6) the same as 5 followed by a recrystallization anneal.

of steel 06Kh18ch occurs at a later stage in the technological processing: hot-rolling of the plate (semifinished rolled products) and its further processing.

It was established that the temperature of the final rolling 850-950°C does not always ensure that there will be complete recrystallization of the rolled products as a result of its rapid cooling before reeling in the rollers. And independent of the fact that the temperature of the metal in the rollers remains high for a substantial period of time (500-700°C), its structure shows little change.

Therefore, the structure of steel before cold rolling is nonuniform and consists of structurally free ferrite and small amounts of low-carbon martensite, or the decomposition products of the austenite (Fig. 1a).

The hardness of hot-rolled bands is 85-92 HRB and is determined by the temperature of the final roll (Fig. 2) and the chemical composition of the steel within the limits of the technological conditions (mainly the concentration of carbon). The final cold-rolling of the semifinished product with a nonuniform structure often leads to the formation of torn edges and rips in the cold-rolled bands.

Form changes in the metal during rolling are to a large degree a result of plastic deformation in the ferritic component (see Fig. 1b). Such inhomogeneity in the deformation during rolling causes a nonuniform crystallographic orientation of the crystals in the cold-worked metal after the recrystallization heat treatment. In order to decrease the hardness of the semifinished rolling and to improve its structure before cold-working, various preliminary heat treatment regimes were tried: anneal at 760-780°C or harden in a transition furnace in the temperature interval from 820-970°C for 2-3 min. The holding time is chosen to approximate the working conditions of the hardening unit of the cold-rolling department of the "Zaporozhstal'" complex.

As a result of the studies, it was established that the optimum heat treatment regime for the semifinished rolled products is the hardening treatment at 820-850°C (holding for 2-3 min) or annealing at 760-780°C in the bell furnaces. However, annealing worsens the etchability of the bands. The hardness of the semifinished rolled products was from 79 HRB to 70-71 HRB (Fig. 2). The structure consisted of grains of recrystallized structurally

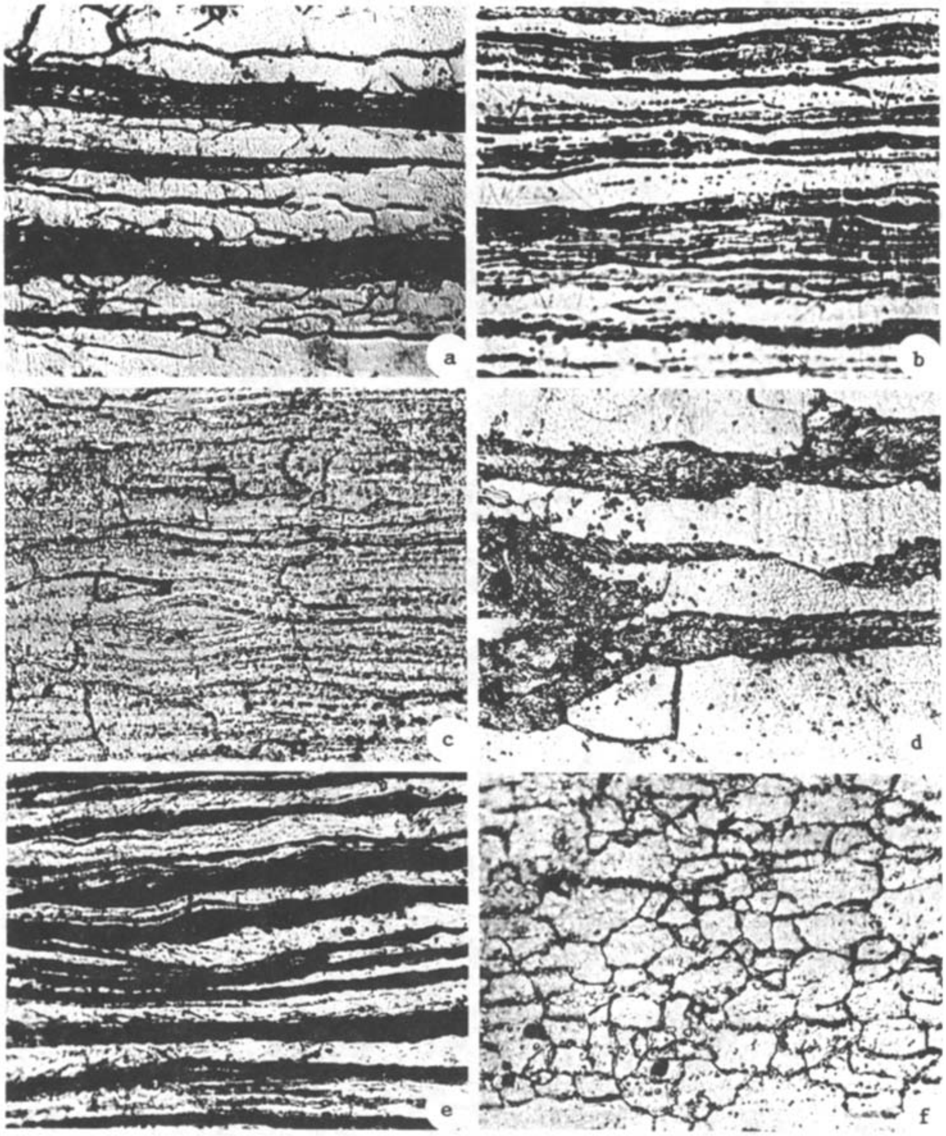

Fig. 3. The microstructure of steel 06Kh18ch at various stages of the treatment with preliminary heat treatment over the optimum regimes (a-c), and at higher temperatures (d-f). ×800.

free ferrite (light-field component) and isolated finely dispersed ferrite-cementite mixtures (dark-field component) (Fig. 3a). With increase in temperature to 880 and 970°C, the hardness of the metal increases to 74 HRB and 77 HRB respectively, and the structure becomes similar to the initial since the partial $\alpha \to \gamma$ transformation in this steel occurs at 870°C (see Fig. 1a and Fig. 3d). The cold-rolling which follows, both with and without a preliminary heat treatment, occurs as a result of plastic deformation of the ferritic component. The structure consists of structurally free ferrite grains which are extended along the rolling direction. These are alternated with wavelike regions of low-carbon martensite (Fig. 3e).

The structure of the steel which has undergone preliminary heat treatment over the optimum regime followed by cold-working consists of grains of structurally free ferrite extended along the rolling direction. This ferrite forms as a result of separation of the decomposition products and alternates with the carbides (see Fig. 3b).

In order to determine the optimum process regime, an intermediate rolling of the semi-finished products was carried out to a thickness of 3.0 mm with a preliminary heat treatment over the optimum regime. Judging from the hardness and the structural state of the steel, such a treatment is the most preferred (see Fig. 2). Howwever, an additional alkaline-acid etching process is required which complicates and increases the expense of cold-rolling plates.

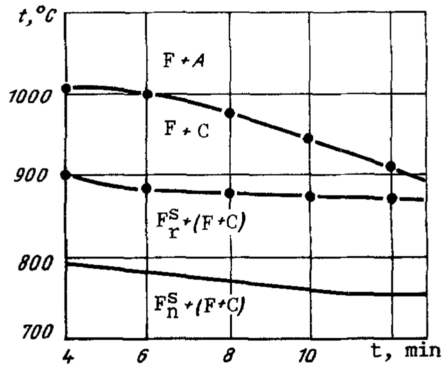

Fig. 4. Diagram of the structural components of steel 06Kh18ch used to choose the recrystallization heat treatment regimes of the cold-worked metal: F + A) ferrite and austenite; F + C) ferrite and carbide; F_r^s structurally free recrystallized ferrite; F_n^s nonrecrystallized ferrite.

The structure of the steel after cold-rolling of the semifinished products to a given thickness followed by a final recrystallization anneal (without any intermediate treatment) consists of relatively fine grained recrystallized ferrite with a segregation of the coarse carbide inclusions primarily to the grain boundaries (see Fig. 1c and Fig. 4). A similar structure is seen in steels that have the intermediate treatment in the interval from 880-970°C (see Fig. 3f).

The preliminary heat treatment of the semifinished products over the optimum regime (t = 820°C) facilitates a decrease in the hardness in the cold-rolled state to 65 HRB, and forms a fine-grained structure of ferrite with a uniform distribution of the carbides (see Fig. 3c). The final recrystallization anneal of the cold-rolled plates was carried out in accordance with the diagram given in Fig. 4 [1].

The application of a preliminary heat treatment to the plates of corrosion-resistant steel 06Kh18ch significantly improved their mechanical properties. For example, the ductility increased from 35 to 40-50%, and the hardness decreased to 65 HRB.

The increased ductility of the steel has a beneficial effect on its stampability. Also, the appearance of anisotropy in the deformation only occurs at intense levels of deformation $\varepsilon = 0.22$ as opposed to $\varepsilon = 0.175$ (without a preliminary heat treatment of the product).

The elimination of anisotropic deformation, which arises in steel 06Kh18ch during the preparation of table instruments, permits us to recommend it in industrial production. We can expect a savings of about 300,000 rubles.

LITERATURE CITED

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