1.1.30. MAGNETIC TESTING OF MECHANICAL PROPERTIES MICROALLOYED HARDENED COLD-ROLLED SHEET STEELS AFTER ANNEALING

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At manufacture of articles by the method of cold pressing widely the sheet cold-rolled low-carbon steels are used. Last time increase the production of IF and IFHS steels, DP and HSLA steels, that exhibit high ability to deep elongation. Thus the microalloyed cold-rolled steels without the defects of inner structure (IF-steels) have very high ability for elongation, what is attributed to the rise of plasticity at the decrease of content of the elements of internodal points (carbon and nitrogen) up to ultralow content and to the uniting of the residual nitrogen and carbon at the cost of introduction of the stabilizing elements (for example, titanium and niobium). This distinguish the IF-steels from the usual cold-rolled low-carbon steels of type 08Yu–08kp. In the process of producing for receiving the required mechanical properties the steels for deep elongation are exposed to recrystallization annealing. For testing the quality of annealing of sheet cold-rolled low-carbon steels is used the pulsed magnetic method [1]. In the paper the results of investigation of the influence of the conditions of technological annealing after the cold rolling of the microalloyed steels for the set of their magnetic and mechanical characteristics having the aim to determine the possibility of magnetic nondestructive testing of their mechanical properties.

To receive the differences in mechanical and magnetic properties of the specimens under test of the microalloyed steels 1 mm thick the annealing was undertaken at standardized temperature (nearly at 700°C) with different duration (from 5 up to 10 minutes). The annealed specimens were metallographically tested, their mechanical properties were determined (ultimate strength, yield strength and elongation per unit length) and their main magnetic characteristics in the open and closed magnetic circuits. The magnetic characteristics were determined using the magnetic measuring system UIMX [2] in quasi-static mode of magnetization (the field of magnetization reversal had the triangular form at the frequency of 0.1 Hz and amplitude of 20,000 A/m).

The analysis of the results of mechanical tests show, that for all specimens of the microalloyed steels the holding at the temperature of 700°C up to 6 minutes influences on their mechanical properties weak, as at that conditions of heat treatment (starting from 400°C) only the inner stresses are relieved. At the sixth minute of heating and during the next few minutes (as the metallographic tests show) the recrystallization of metal is completed quickly enough. Besides owing to the structural changes of metal its hardness and strength are reduced sharp at simultaneous increase of its ductility.

The results of magnetic tests show, that for all steels under investigation the best magnetic parameter of testing both in the closed and the open circuits is the coercive force. The residual magnetization can serve as the testing parameter only in the open magnetic circuit owing to big demagnetization factor, that causes the slope of the magnetic hysteresis loops and is responsible for the straightness of the loop section from the coercive force field of residual magnetization. The sheet steel even has the high demagnetizing factor. Therefore for the sheet between the residual magnetization and the coercive force, measured in open magnetic circuit, exists the strong linear connection. Thus at measuring directly on the sheets the residual magnetization not less effective can be used

as the coercive force for the reliable testing of their mechanical properties (ultimate strength and yield strength). What is more the process of measuring of the residual magnetization is easily and the results are more stable. From the point view of increasing the resistance to interferences is preferable to measure not the value of residual magnetization itself, but the gradient of the residual magnetization field strength H_{rn}.

Such magnetic parameter as the maximum differential magnetic permeability on the hysteresis loop can be used potential for the nondestructive testing. But by practice that parameter is undertaken to the influence of different interference factors.

The measurements of ∇H_{rn} were made using the ferroprobe-gradientmeter having the base of 30 mm on the specimens with overall dimensions $450 \times 500 \times 1$ mm^3 after their local pulsed magnetization in static from one side of the sheet using the superimposed solenoid with dimensions $12 \times 6 \times 31$ mm^3 by amplitude of pulses $2{,}1 \cdot 10^5$ A/m (the device ИМА-4М) and in motion in the production line from both sides of the sheet using two solenoids having dimensions $145 \times 15 \times 15$ mm^3 with amplitude of pulses $3{,}2 \cdot 10^5$ A/m (system IMPOK-1B) [3].

The analysis of the results show, that in both cases well can be revealed that specimens the recrystallization of what is not completed because they stay in the furnace less time as required. Besides by the device IMA-4M in consequence of increased locality the areas of heterogeneity of metal are indicated, caused mainly by different level of recrystallization of separate areas of the specimen.

We have analyzed the possibility of unification in one file of the specimens of MA, DP-steels, IF and IFHS-steels. In the figure the correlation connection between the value of ∇H_{rn} and the ultimate strength under deformation R_m of the specimens of MA, DP, IF and IFHS steels for the system IMPOK-1B is done.

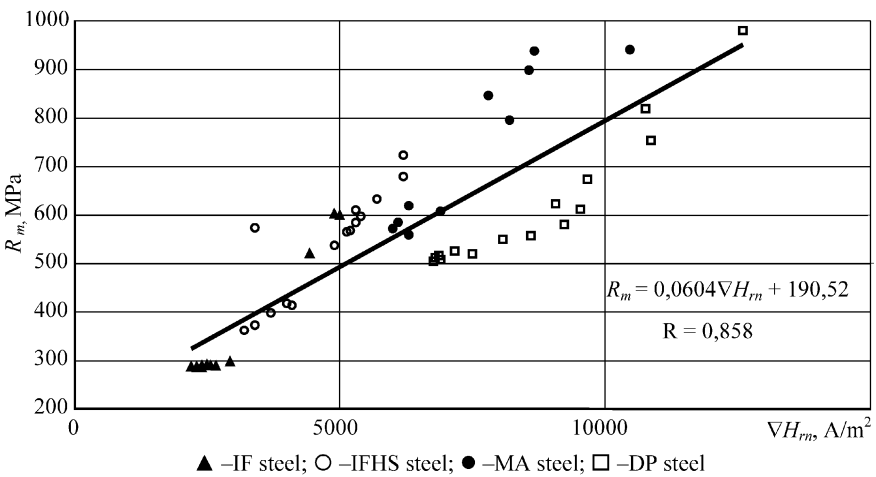

Fig. Correlation connection of the gradient of the residual magnetization field strength ∇H_{rn} and the ultimate strength under deformation R_m of the specimens of IF, IFHS, MA and DP steels at two-sides magnetization and measurement using the system IMPOK-1B

The investigations undertaken have stated the possibility of the sampling test of mechanical properties of the microalloyed steels (the devices IMA-4M) and the testing in the production flow (the devices IMPOK). The possibility is demonstrated of the magnetic testing of IF, IFHS, HSLA and DP steels by the results of the statistical analysis of that data in united file.

References:

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