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STUDY ON PHYSICAL AND CHEMICAL PROPERTIES OF STEEL 60C2XA ON A RETRACTABLE ROLLER CONVEYOR

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These days, ensuring the high quality of thin products (0,6 – 2,0 mm) is the most promising direction for the development of hot-rolled strip production. Hot-rolled strips can be used in place of a more expensive cold-rolled strip. The effect of cooling modes on quality of hot-rolled metal was observed heating at different temperature, the degree of deformation was observed after cooling by water-air mixture. It was observed that the micro hardness of the samples decreases and the amount of structurally free ferrite increases by decreasing the cooling time and increasing the temperature.

Key words: steel 60C2XA, roller conveyor, temperature-deformation, microstructure, physical modelling

INTRODUCTION

Numerous schemes of thermomechanical processing (TMO) rolled products have been developed and are being actively used [1]. In the production of carbon sheets, it is great interest to provide a scheme for the formation of perlite, based on the plastic deformation of steel in the austenite state and the subsequent isothermal transformation of austenite in the pearlite region [2]. Other things being equal, an increase in the cooling rate leads to an increase in the strength properties of the rolled metal. This reduces the plastic properties. At a very high cooling rate, a padded layer of metal forms on the surface of the strip. To the discrepancy between the mechanical properties of hot-rolled steel and the requirements of standards, i.e. to get a marriage can lead to heterogeneity of the microstructure along the thickness of the strip, increased hardness and “brittleness” of the incandescent surface. Thus, the microstructure of hot-rolled thin strips produced on known mills is often characterized by considerable grain size (large grain on the surface), which leads to the formation of various defects when using such metal for cold stamping.

Thus, the microstructure of hot-rolled thin strips produced on known mills is often characterized by considerable grain size (large grain on the surface), which leads to the formation of various defects when using such metal for cold stamping. The main reason for the heterogeneity of thin strips is the incorrect assignment of temperature-deformation modes of rolling and cooling. Technological solutions are effective for one mill is often unacceptable for another [3]. Therefore, the study of the influence of temperature regimes rolling and quenching, as well as the cooling of strips on the quality of hot-rolled steel, rolled and chilled in a new mill and a retractable roller table is great importance [4]. The plastic deformation of samples from steel A1 was carried out on the “tension-compression” module. The samples were heated at a rate of 100 °C/s to a temperature of 1 100 °C and held at these temperatures 1 h. Further, each heated sample was cooled to temperatures of 800, 900 and 1 000 °C, deformed by cyclic compression at the rolling speeds of the longitudinal-wedge mill.

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MATERIALS AND METHODS

The purpose of this section’s thesis is to study the effect of the austenitization regime, hot deformation and subsequent water-air cooling with the speeds of the new outlying roller table on the structure and properties of carbon steel sheets in Figure 1. The effect of cooling with a water-air mixture on the structure and properties of rolled sheets of steel 60C2XA having the following chemical composition / wt. %: C 0,64, Si 1,6, Mn 0,6, Ni 0,23, S 0,21, P 0,025, Cu 0,2, Cr 0,8. To study the austenitization, samples were taken 25 ± 2 mm in length and subjected to heating to temperatures of 800 - 1 050

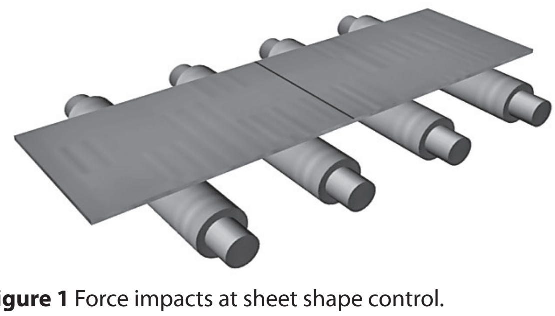


Figure 1 Force impacts at sheet shape control.

°C in 50 °C increments and a holding time of 1 min/mm, followed by gradient quenching in Figure 2.

To determine the size of austenitic grain, a special reagent consisting of 1 - 4 g of picric acid, 3 - 5 ml of hydrochloric acid, 95 - 100 ml of ethyl alcohol was used [1]. The grain size of the austenite was counted by means of an eyepiece with a ruler on the MIM-7 microscope with an increase of 100. To determine the influence of the degree deformation and subsequent water-air cooling with the speeds of the new discharge roller table on the structure of 60C2XA steel, samples with a size of Ø 10,0 × 15,0 mm were tested by compression on the Gleeble-3800 test complex. Plastic deformation of samples from steel 60C2XA was carried out on the module «stretching - compression». The samples were heated at a rate of 100 °C/s to 850 °C and 1050 °C and held at these temperatures 1 h. Further, each heated sample after cooling or heating to 700, 800, 900 and 1 000 °C was deformed by compression and cooled for 3 and 6 s by air blasting and by flowing with water. Subsequently, the resulting samples were cooled naturally to room temperature [2]. With an increase in the austenitization temperature, the average grain size of the austenite increases. Up to a temperature of 850 °C, the size of the austenite grains practically increases little and amounts to 12,95 μm.

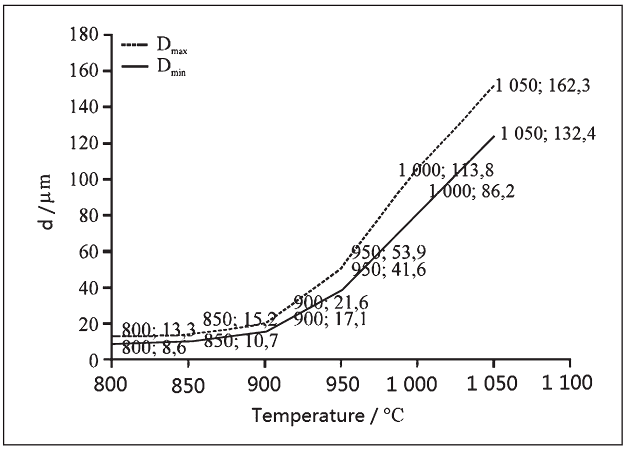


Figure 2 Dependence of the grain size d / μm on the austenitization temperature / °C at a specific exposure of 1 min/mm cross section.

RESULTS AND DISCUSSION

The results of the study showed that deformation at a temperature of 1 000 °C and cooling by a water-air mixture for 3 and 6 s promotes the formation of a completely recrystallized ferritic-sorbitol structure in a coarse-grained austenite structure in Figure 3 (a) and Figure 3 (b). Deformation at 900 °C and cooling for 3 and 6 s leads to a decrease in the degree of recrystalliza-

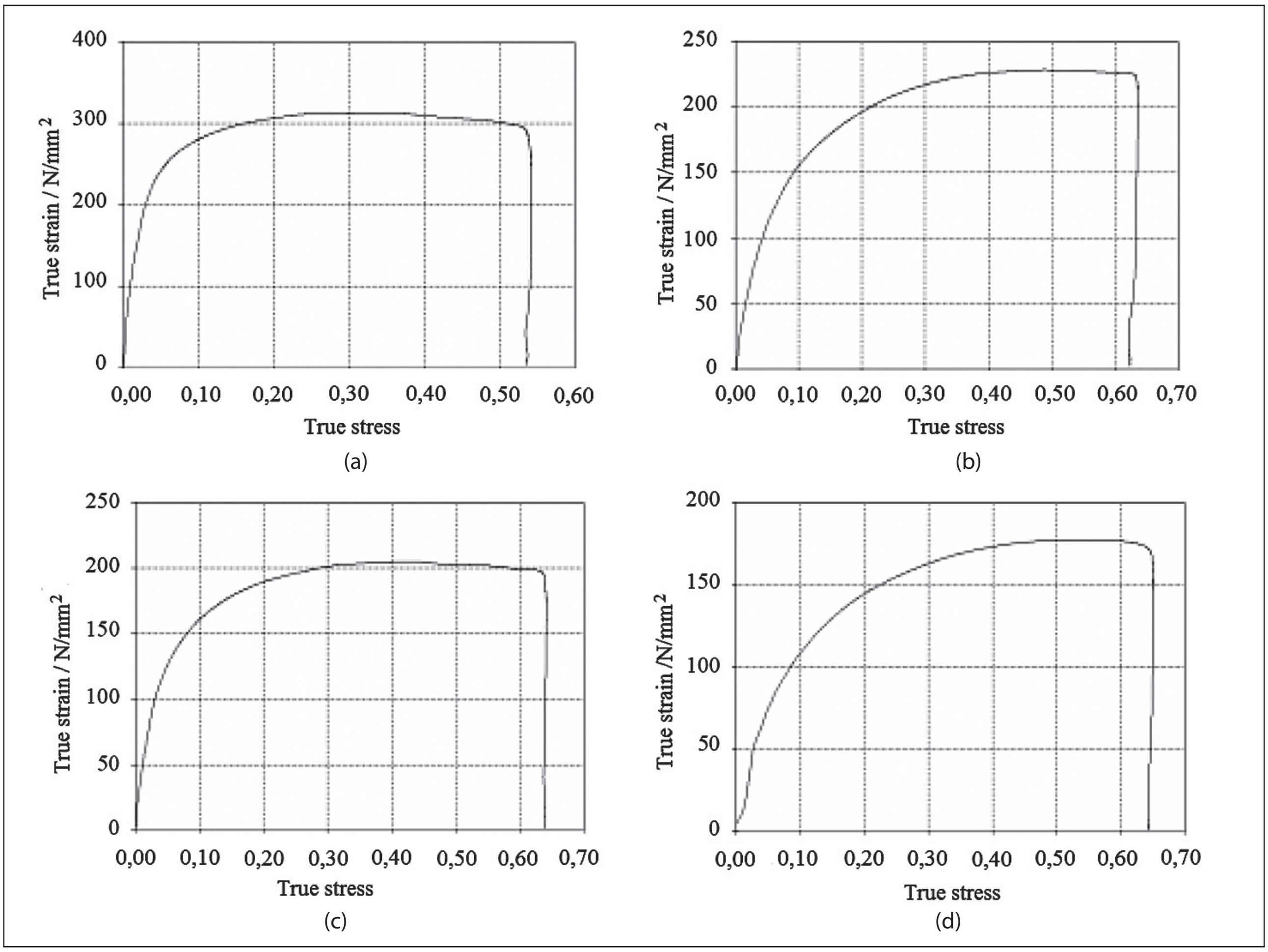


Figure 3 The change in the deformation resistance of 60C2XA steel at the temperature of the precipitation: 700 °C (a), 800 °C (b), 900 °C (c) and 1 000 °C (d).

Table 1 **The experimental design of physical modeling**

№.	ε_1/ %	t_1/ s	ε_2/ %	t_2/s	ε_3/ %	t_3/ s	ε_4/ %	t_4/ s	ε_5/%	τ_B/ s	τ_{B0}/ s
Test temperature 800 °C											
1	25	4	22	3	18	2,2	18	1,6	12	2	10
2	25	4	28	2,6	17	2,1	15	1,8	15	8	4
3	35	3	22	3	18	2,2	11	1,9	9	6	6
Test temperature 900 °C											
1	25	4	22	3	18	2,2	18	1,6	12	2	10
2	25	4	28	2,6	20	2,1	15	1,8	15	8	4
3	35	3	22	3	18	2,2	11	1,9	9	6	6
Test temperature 1000 °C											
1	25	4	22	3	18	2,2	18	1,6	12	2	10
2	25	4	28	2,6	20	2,1	15	1,8	15	8	4
3	35	3	22	3	18	2,2	11	1,9	9	6	6

Note: ε1-single reduction in the first stand, t1-interdisciplinary pause after the first stand, ε2-single reduction in the second stand, t2-interdisciplinary pause after the second stand, ε3-single reduction in the third stand, t3-interdisciplinary pause after the third stand, ε4-single reduction in the fourth stand, t4-interdisciplinary after the fourth stand, ε5-single reduction in the fifth stand, τB time cooling in air, τB0-time for cooling with water-air mixture.

tion to 15 % and 30 %, respectively, as shown in Figure 3 (c) and Figure 3 (d). In the case of precipitation at 700 and 800 °C and cooling for 3 and 6 s, the metal structure is not recrystallized in Table 1.

Thus, measuring the interplastic distance shows that heating the samples to 700 °C, deforming with a degree of hot deformation of 55 – 65 %, and cooling for 3 and 6 s leads to the formation in a fine-grained austenite structure of thin-plate perlite with an interlattice distance of about 1,32 - 1,36 and 1,12 - 1,23 μm, respectively in Figure 4. At the same time, deformation of samples with a degree of hot deformation of 55 - 65 % at a temperature of 800 °C and subsequent cooling of 3 and 6 s leads to the formation in a fine-grained austenite structure of thin- plate perlite with an interplanar distance of about 0,92 - 0,96 and 0,74 - 0,82 μm, respectively in Figure 4. Austenitization at a temperature of 850 °C, heating to a temperature of 900 and 1 000 °C followed by a deformation of 65 % and cooling with a water-air mixture of 3 s leads to the production of high-carbon sorbitol steel in the structure with an interplanar distance of the order of 0,45 – 0,51 and 0,37 – 0,41 μm respectively [3]. As the holding time increases to 6 s, the interplanar distance decreases to 0,22 – 0,28 at 900 °C and up to 0,14 – 0,18 μm at – 1 000 °C.

Measurement of the interplate distance of the ferritic-sorbitol colony showed that heating for austenitization at 1 050 °C, a subsequent precipitate with a degree of 55 – 65 % at 700, 800 °C, and water-air mixture cooling with a time of 3 s leads to the formation of a micro-

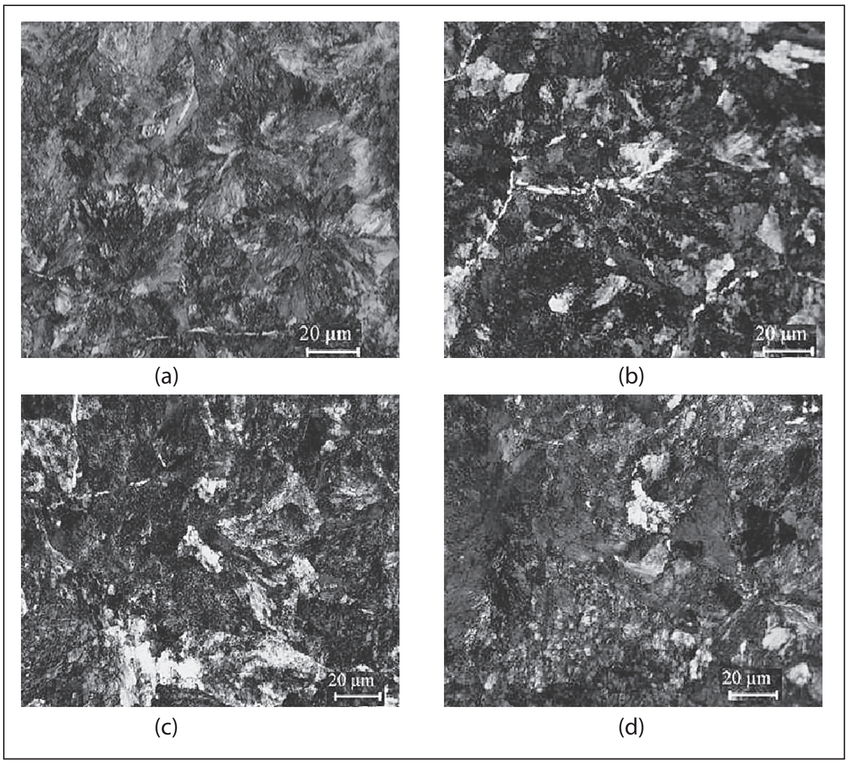
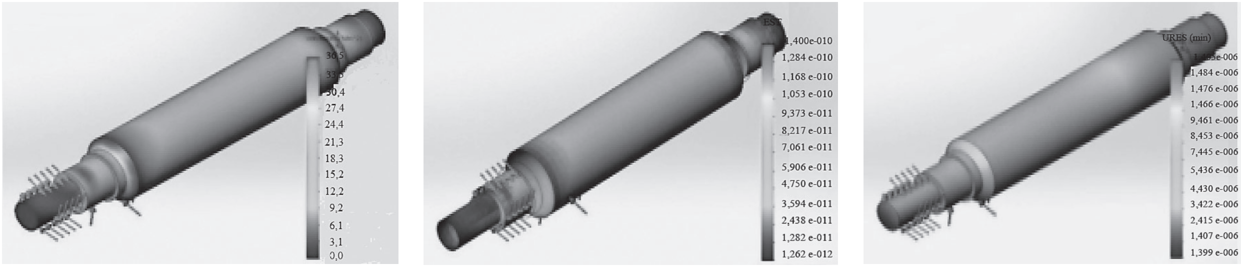


Figure 4 The microstructure of 60C2XA steel after austenitization at 850 °C with a holding time of 1 h and subsequent hot deformation at temperatures of 700 and 800 °C and cooling for 3 and 6 s; (a) sediment at 700 °C and cooling 3 s; (b) sediment at 700 °C and cooling 6 s; (c) sediment at 800 °C and cooling 3 s; (d) sediment at 800 °C and cooling 6 s.



(a) (b) c)

Figure 5 The distribution of equivalent stresses (a) and deformations (b), as well as the total displacements (c) in the rollers during the transportation of the strips in a roller conveyor with lower air pressure.

structure with an interplanar distance 1,83 - 1,89 μm and 1,56 – 1,64 μm, that is, structures of coarse-lamellar perlite [4]. As the holding time increases to 6 s, the interplanar distance decreases to 1,36 - 1,44 μm and 1,24 – 0,31 μm, respectively, and the sizes and number of pearlite colonies increase. Austenitization at a temperature of 1 050 °C, heating to a temperature of 900 and 1 000 °C followed by deformation with a degree of 55 – 65 % and cooling with a water-air mixture of 3 s leads to the production of high-carbon sorbitol steel in the structure with an inter-plate distance of about 0,67 – 0,72 μm and 0,57 – 0,62 μm. As the holding time increases to 6 s, the interplanar distance decreases to 0,57 – 0,61 μm at 900 °C and up to 0,31 – 0,37 μm at 1 000 °C.

The average micro hardness of fine-grained samples precipitated at 700 and 800 °C and cooled by water-air mixture 3 s is 3 658 MPa (3 364 MPa at the center and 3 823 MPa at the surface) and 3 593 MPa (3 294 MPa at the center and 3 976 MPa - at the surface), and cooled 6 s is equal to 3 805 MPa (3 618 MPa in the center and 3 992 MPa at the surface) and 3 735 MPa (3 417 MPa in the center and 3 942 MPa at the surface), respectively. The micro hardness of the samples deposited at 900 and 1 000 °C and cooled by the water-air mixture 3 s is equal to 3 319 MPa (3 246 MPa at the center and 3 393 MPa at the surface) and 3 078 MPa (2 932 MPa in the center and 3 224 MPa - at the surface), and the cooled 6 s is, respectively, 3 416 MPa (3 141 MPa in the center and 3 691 MPa at the surface) and 3 287 MPa (2 958 MPa in the center and 3 617 MPa at the surface), as shown in Figure 5.

CONCLUSIONS

1 To ensure the rational structure of rolled steel A1, it is necessary to roll strips with the end-of-rolling temperature of 900 °C, the cooling temperature is 600 - 650 °C, while the hot-rolled strips on the outgoing roller table must be cooled by the water-air mixture according to the early cooling regime;

2 Heating to temperatures of 700 - 800 °C and deformation with a degree of 65 – 70 % when cooling with a water-air mixture of 3 and 6 s does not always ensure the formation of a fine-grained ferritic-sorbitol structure in high-carbon samples;

3 Heating of the samples to temperatures of 900 and 1 000 °C, deformation with a degree of 65 – 70 %, and cooling by a water-air mixture 3 and 6 s leads to the formation of a sorbitol structure in samples of high-carbon steel with an interplastic distance of 0,23 – 0,62 μm.

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