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Features of roughness formation during production of the hot-rolled temper-rolled band

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Abstract. Active implementation of new technology processes is applied as one of way to increase the competitive ability of metal products. Today one of the modern trends is transfer of requirements of intermediate to final technological operations. The new production technology of a hot-rolled pickled temper-rolled band of a wide dimensional and branded range is developed by scientist of Nosov State Technical University jointly with specialists of PJSC Iron & Steel Works. Field of use this band is automobile wheel disk production at JSC AVTOVAZ. Researches on forming of band final properties showed a basic possibility of ensuring the rate band parameters at an exception of operation of cold rolling.

1. Introduction

The hot-rolled strip, inclusive pickled, annealed and temper-rolled is one of the mainstream metal product. This type of metal products is used for the production of welded building structures, pipes, car parts (in particular, wheel disks, rear suspension link connectors). This is due to the reduction in the number of technological process stage, in particular due to operation exception of cold rolling, and also the transformation of some mechanical properties and performance parameters of cold-rolled products to pickled hot-rolled products [1].

Studies on the development of a new production technology of the pickled hot-rolled strip with increased quality are conducted by scientists of the Nosov Magnitogorsk State Technical University and specialists of PJSC Iron & Steel Works [2,3].

2. Research objective

The developed technology (figure 1) makes it possible to produce a pickled tempered strip at the of PJSC Iron & Steel Works with using a continuous two-stage temper-rolling mill 630 (CTRM 630) to give uniform surface roughness.

The strip of 07GBYu steel in the size 3.5×410 mm has been made according to this technology. Its chemistry is presented in the table 1.

Further, according to presented scheme the hot-rolled steel with the dimensions of 3.5×1270 mm was subject to cutting to 410 mm length, hydrochloric pickling and temper rolling.

Process conditions of temper rolling are given in table 2.

3. Methodology

The anisotropy of mechanical properties and, in particular, roughness, was studied to establish the features of the final properties formation of hot-rolled pickled strip [4].

Measurements on the roll of the pilot lot were made every 50 meters along its length of 282 m in order to estimate the changes in the anisotropy of the roughness.

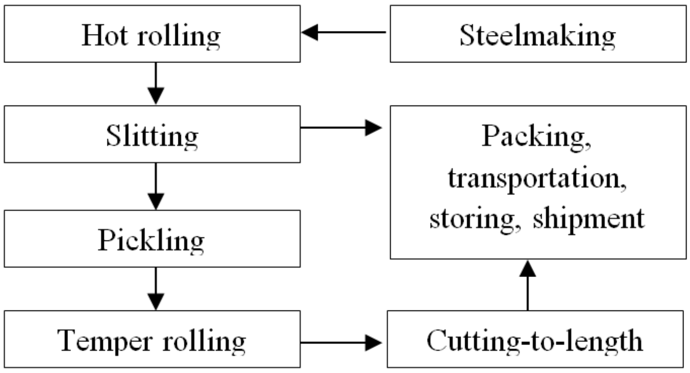


Figure 1. Scheme of hot-rolled strip production with temper rolling.

Table 1. Chemistry of 07GBYu steel.

Chemical elements content, %											
C	Si	Mn	S	P	Cr	Ni	Cu	N2	Al	Nb	Ti
0.08	0.28	0.69	0.003	0.012	0.04	0.02	0.04	0.005	0.038	0.020	0.015

Table 2. Process conditions of temper rolling for 07GBYu steel.

Thickness, mm	Roughness of working rolls Ra, μm	Linear speed of rolling, m/s	Percent reduction, %	Coiler tension	Decoiler tension
3.5	3.3-3.5	10.1 10.2 10.1 10.3 10.4 10.7 10.5 10.5	1.3 1.2 1.4 1.4 1.3 1.3 1.5 1.3	7.0	9.0

Surface roughness measurement was performed on a roughness integrator HOMMEL-TESTER T8000, as well as on a portable Surtronic 25. According to modern customer requirements the measurement was carried out at a base length of 2.5 mm, in directions oriented at 0 °, 45 ° and 90 ° to the rolling direction. The measurements were made at 5 points. The mean value was taken from the arithmetic mean of 5 measurements. The results of the average values of Ra are given in table 3.

It can be seen from the presented results that the anisotropy of the surface roughness before temper rolling between different angles to the rolling direction with respect to the averaged value of the Ra index is of the order of 0.15-0.25 μm and after temper rolling 0.07-0.15 μm. In addition to reducing the roughness anisotropy, temper rolling increases the degree of surface homogeneity ($\Delta Ra_{befortemperrolling} \approx 0.4$ μm, $\Delta Ra_{aftertemperrolling} \approx 0.3$ μm) and reduces the general level of roughness by 0.2 μm.

Besides, according to ISO 4287:1997, the roughness estimate can be performed in 3D tasks, evaluating the Primary profile as a rough profile (Roughness profile) and a Waviness profile. The ISO 4287:1997 standard defines three sets of parameters: P-parameters calculated on the basis of the primary profile, R-parameters calculated from the roughness profile, and W-parameters calculated on the basis of the ripple profile.

Table 3. Ra2.5 roughness measurement results.

Sampling site	Sample orientation	Measuring point along the length of the strip, m					
		0	60	110	160	220	270
Before temper rolling	0° (along)	1.71	1.78	1.71	1.8	1.63	1.71
	90° (across)	2	1.89	2.1	1.97	1.92	1.88
	45°	1.96	1.85	1.9	1.86	1.72	1.73
After temper rolling	0° (along)	1.6	1.52	1.56	1.5	1.47	1.5
	90° (across)	1.69	1.77	1.71	1.59	1.68	1.62
	45°	1.72	1.64	1.56	1.52	1.57	1.61

The study of these parameters was carried out using a modern scanning probe microscope (SPM) at the research institute “Nanosteels” of the Nosov Magnitogorsk State Technical University. The measurements were carried out on specially prepared samples, which were taken from the initial preform before and after temper rolling. The sample’s surface has features characteristic of the entire strip. The maximum area of the base of study sample is 1.5 cm^2, the maximum height is 10 mm. When scanning samples the microscope probe was positioned at a right angle to the investigated surface.

To estimate the roughness parameters of the investigated samples the diagonal segment was selected as the sample length according to figure 2. The quantitative altitude distribution is based on the entire area of the image.

As a result of scanning SPM images were obtained which were visualized using computer graphics mainly in the form of two-dimensional brightness (2D) images of roughness profiles (figure 3). With 2D visualization each point of the surface Z = f(x, y) is associated with a tone of a certain color (or position in the scale of a multicolor palette) depending on the height (z-coordinate) of the surface point.

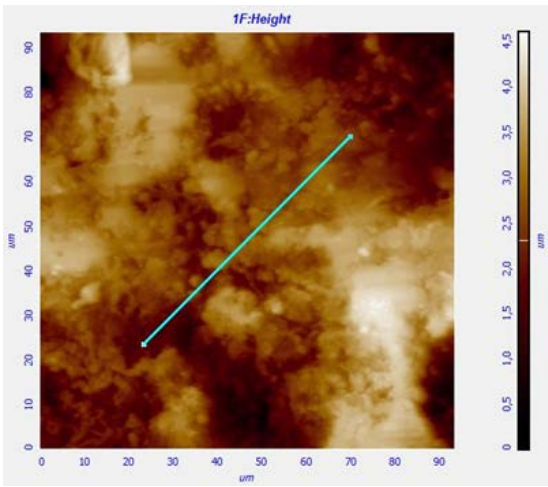
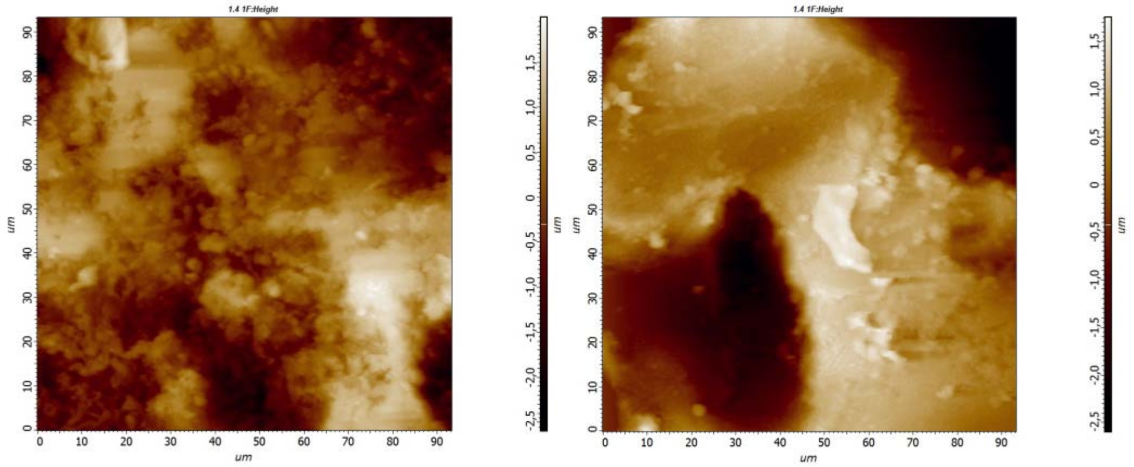


Figure 2. The sample length location for the roughness parameters estimating.



(a) (b)

Figure 3. SPM images of interested area (a – before temper rolling, b – after temper rolling).

Thus, from the presented graphical results, we can see a visual decrease in the roughness level and uniformity of the surface, which is confirmed by the numerical calculations presented above.

4. Conclusion

Figure 4 presents a comparative analysis of the experimental strip (a) with the serial tape (b). The results of processing the rolled stock into the finished product are shown in figure 5.

(a) (b)

Figure 4. Tempered strip surface of pilot run (a) and non-tempered strip surface of batch (b).

Based on the visual estimate, the tempered strip has a higher uniformity of roughness without the line of fracture, which is favorable for the process of paint coating applying.

Figure 5. Stamped wheel from pilot run of pickled temper-rolled strip of 07GBYu steel for the LADA automobile of JSC Avtovaz.

Thus, the carried out researches have established the formation features of the finished pickled hot-rolled strip and also ways of its management, for example by gage interference reducing, on-line management of the reduction process, more detailed processing of the strip ends with cutting out of off-grade pieces.

References

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