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Choosing the materials performance and the form of an indenter for arrangement of texture at the surface of skin mill rolls

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Abstract. The fraction for forming texture of rolls surface of the training mills is investigated in this work. The fraction from various manufacturers has been estimated by comparing the most important characteristics. Metallographic studies of the steel fraction microstructure were carried out on the MEIJI 2700 optical microscope (Japan). Automated processing of measuring results of various shapes indenters microhardness was conducted. Comparing the obtained results with the characteristics declared by the manufacturers was carried out. The rolling roll surface microstructure with which the texture of the cold-rolled strip surface is formed, is investigated in the paper. Roller steel widely used at present as well as the most common methods of rolling roll surface microrelief forming, such as mechanical and electroerosion ones, are discussed in the work. It was established that with the electroerosion method, a more uniform structure with a smoothly changing microrelief was formed on the surface of the roll as compared with the mechanical action of the abrasive. According to the results of the research, recommendations were formulated on the use of the fraction that has the best performance characteristics and which allows one to obtain surface roughness by transferring it to the surface of a cold-rolled strip in accordance with the requirements of consumers.

1. Introduction

Surface treatment with shot is widely used at present for formation of regulated micro-profile [1-3]. Particularly, on the surface of mill rolls for the skin rolling of the cold rolled strip [4, 5].

The surface treatment with the shot under different modes allows obtaining the surfaces with different frequency of peaks of microgeometry and value of the hardened layer [6, 7].

An actual task is to study physics of interaction of an indenter with a highly hard surface of a roll. For this purpose, the initial microstructure of the roll was investigated using the MEIJI 2700 optical microscope at magnification of 500x (Figure 1).

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Figure 1. Microstructure of roller steel.

2. Materials and methods

For this work, the research was conducted at the resource center of nanotechnologies and nanomaterials at the Research Institute of Nanosteels of the Magnitogorsk State Technical University named after G.I. Nosov.

For this purpose, the samples of different fractions and forms were prepared. The sample preparation of shot fraction of 0.6 mm and 2.0 mm was carried out using the pressing machine Simplimet 1000 (Belgium), the grinding and polishing machine Phoenix 400V (Belgium).

The metallographic studies of the steel shot microstructure were carried out on the MEIJI 2700 optical microscope (Japan) at magnifications of 500 and 1000 times and on the JSM-6490LV scanning electron microscope (Japan) at magnifications from 500 to 10000.

The automated processing of the micro-hardness measurement results on the Buehler micromet instrument (made in Belgium) with a motorized drive and a table management system was carried out on the industrial image processing and analysis system Thixomet PRO.

3. Study of the microstructure of the roll steel and the indenter material

The initial structure consists of cryptocrystalline martensite, uniformly distributed fine carbides and residual austenite, in the amount of 8-12 %. Such a structure can be obtained after quenching at the temperature of 900-950 °C with rapid cooling in water. Excess of the hardening temperature of 50-100 °C is not recommended, because this leads to a decrease in hardness of 4-12 %, respectively.

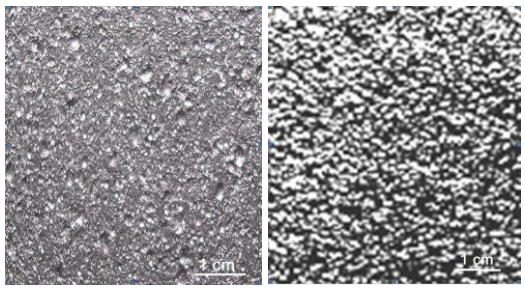
According to the industry standard OST 24.013.20-90, work rolls of pinch pass and finishing stands of cold rolling mills with a roller body size of not more than 900x3150 mm should have hardness of HSD of 95-105 units, depth of the active layer for roller steel is at least 10 mm.

In the production of a cold-rolled sheet used for manufacture of automotive parts, the important quality parameter is the microgeometry of the surface of the rolls, which affects the formation of roughness on the tempered strip connected with stampability, wettability and adhesion [1, 2, 4].

The required microgeometry on the sheets is obtained by skin rolling with textured rolls with roughness of Ra = 0.63-2.5 μm, the application of which is carried out by mechanical and electrophysical methods (Figure 2). When the microgeometry is formed by the mechanical action of an abrasive, solid particles of shot are introduced into the less hard material of the roll, leaving recesses on the surface. The height of the microgeometry depends on the depth of penetration.

Figure 2a shows the surface notched by the shot. When texturing rolls using erosion, the more uniform surface is observed, with a smoothly changing microrelief (Figure 2b).

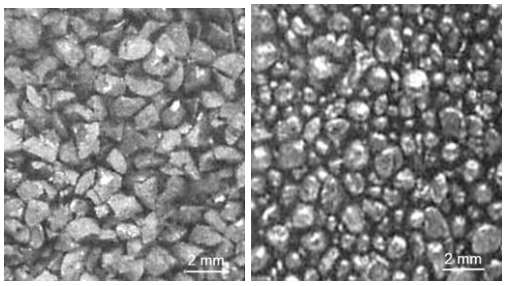
The textured hard surface of mill rolls is formed not only with high kinetic energy, but also with high indenter hardness. Therefore, the hardened steel shot is now widely used. According to the authors of [8, 9], the most effective abrasive for shot-blasting treatment today is the steel punctured improved fraction of the brand GP, produced in strict accordance with modern standards.



a b

Figure 2. Formation of texture on the rolls surface: a – mechanically; b – by electophysical methods.

In the process of work, sharp edges become blunt, and working mixture is formed, 80-85 % consisting of round-shaped particles and 15-20 % of acute-angled ones (Figure 3)**.**



a b

Figure 3. Shot shape: a – grade WG -18, with sharp-angled particle shape before ragging; b – work mixture, formed from WG -18 with a partially round-off form in the process of ragging.

Production of high-quality steel shot is carried out in two directions. In one case, repeated heat treatment is performed, including quenching from temperatures slightly exceeding the critical point and tempering, allowing one to obtain the more uniform fine-crystalline structure of released martensite and significantly improve the functional properties of the cast fraction [7, 10]. The positive effect from the repeated heat treatment of cast steel shot consists in obtaining, after tempering, the higher units of hardness and breaking load when tested in compression. This method has significant drawback associated with an increase in energy consumption of the process.

In the second case, the cast shot of high carbon steel (with a carbon content of 0.8-1.2 %) is subjected to a full heat treatment cycle (quenching from 850-900 °C and tempering at 400-450 °C). The resulting high-quality steel shot has a structure of tempered martensite or troostite (HV 470-600). Such a structure provides high operational characteristics of the fraction, in particular, an increase in wear resistance and reduction in the fraction consumption [8, 11].

In the course of the conducted research, the characteristics of the fraction of various manufacturers were analyzed, namely: “Ural GRIB” (Yekaterinburg), Foundry (Temir-Tau), “Willibrator” (Italy). The research results are summarized in table 1. According to the information presented, it can be concluded that the W Abrasives shot has the best characteristics, which was subsequently studied in more detail. Usually, manufacturers present more overstated characteristics, in relation to the actual values, in order to expand the market.

The microstructure of the shot was subjected to the study of the cast steel grade WS-280, WS-780 and split shot WG-12, WG-50 from Willibrator.

The microstructure of the tested shot at 5000 magnification is shown in figure 4. The microstructure of the split shot of grades WG-12 and WG-50 is fine-needled martensite and finely-divided carbides of a spherical form and retained austenite (Figure 4a, 4b). The structure was obtained by quenching of the investigated steel at temperatures within the intercritical range of A_{c1}-A_{c3} and subsequent rapid cooling

in water to prevent complete dissolution of carbides.

The microstructure of the cast fraction grades WS-280 and WS-780 is small-needle martensite and residual austenite (Figure 4c, 4d), which was obtained by quenching the steel under study at temperatures above A_{c3} and subsequent rapid cooling in water. In this case, there is complete dissolution of cementite type carbides.

Table 1. Comparison of main shot characteristics of domestic and foreign producers.

Manufacturer	Shot grade	Fraction number	Deviation in form	Hardness HV, units	Weakness availability	Impurity, %
"Ural GRIB," Ekaterinburg	pounded fraction	0.3	1.52	394	-	0.24
		0.5	1.61	372	-	0.28
		0.8	1.86	436	1.42	0.34
Foundry, Temir-Tau	cast fraction	0.3	1.26	388	-	0.44
		0.5	1.28	406	1.62	0.38
		0.8	1.32	374	2.44	0.44
"Villibrator," Italy	cast fraction	0.3	1.22	436	-	0.11
		0.5	1.18	451	-	0.05
		0.8	1.14	429	-	-

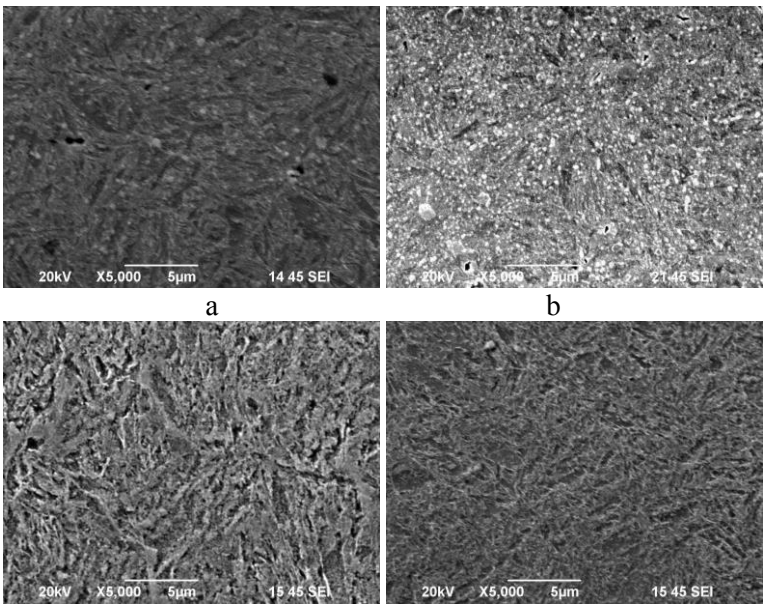
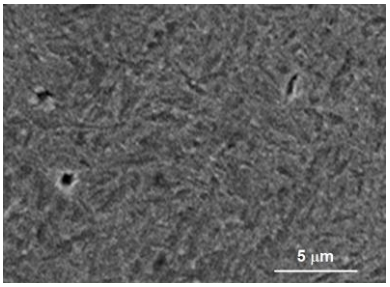


Figure 4. Microstructure of shot samples of grades: a – WG-12; b – WG-50; c – WS-280; d – WS-780.

4. Conclusion

The research results showed that the average microhardness of the cast steel shot is 550 HV_{150}, compared with the declared by the manufacturers 450 HV_{150}, and the split shot is 621 HV_{150} as compared to 550 HV_{150}. Therefore, the characteristics declared by the manufacturers of the fraction are underestimated by more than 20 % compared with the actual values that were obtained with the Buehler micromet instrument.

It is probably connected with the presence of Mn and Si which contribute to production of alloyed cementite, and, as a consequence, to an increase in integral microhardness of shot (Figure 5).



a

Element	Weight, %	Atomic, %
C K	12.39	39.42
Si K	0.91	1.24
Mn K	1.07	0.75
Fe K	85.62	58.59
TOTAL	100.00	

b

Figure 5. Research results: a – microstructure; b – chemical composition of shot WG-12.

The conducted studies allow us to conclude that it is preferable to use crushed fraction, since it has higher hardness and microhardness due to the presence of finely dispersed round carbides in its structure. To ensure such a structure, following the heat treatment mode is recommended: quenching above A_{c1} by 30-50 °C, but lower than A_{c3} and cooling in water. This shot will have higher wear resistance and cyclic resistance compared to the cast fraction, as a consequence of reduction in the fraction.

The obtained results are recommended when choosing of a type of the shot for processing of a surface of a roll of skinrolling mill, in order to obtain regulated microgeometry on the surface of the cold-rolled strip by reproducing it. This is necessary to obtain a competitive cold rolled strip in accordance with the requirements of consumers.

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