V. GORYANY, I. MAMUZIĆ, V. RADSINSKY

ISSN 0543-5846
METABK 42 (4) 245-247 (2003)
UDC - UDK 621.771.252:621.97.07=111

INFLUENCE OF COOLING ON THE RESISTANCE OF CHROM-NICKEL IRON ROLLS

Received - Primljeno: 2002-12-11
Accepted - Prihvaćeno: 2003-05-01
Preliminary Note - Prethodno priopćenje

The work deals with findings of possibility to increase the wear resistance of grooves of 250 wire mill finishing stand rolls by improving their cooling conditions, which provides increase in operating resistance of rolls 1.5-2 times.

Key words: *wear resistance, iron rolls, cooling*

Utjecaj hlađenja na otpornost valjaka od krom-nikal čelika. Rad se bavi iznalaženjam mogućnosti povećanja otpornosti na trošenje valjaka promjera od 250 mm na završnom valjačkom stanu valjaonice za valjanje žice. Radi se o poboljšanju uvjeta hlađenja što dovodi do povećanja radne sposobnosti od 1.5-2 puta.

Ključne riječi: *otpornost na trošenje, čelični valjci, hlađenje*

INTRODUCTION

The distinctive feature of operating conditions of the rolls of this type is high rolling speed of 40 m/s and rather a short-term determining contact of grooves surface with the rolling metal (about 0.008 s), unit pressure of 280-244 MPa and intensive water-jet cooling of grooves at the outlet from the deformation zone. These factors cause intensive wear of working layer of rolls and demand heavy expenses for the new ones.

PERSONAL RESEARCH

The rolls of mottled chromium-nickel iron with diameter of 270-300 mm and hardness of the working layer of 62-64 HSh the microstructure of which is built by graphite austenite, cementite and ledeburite have been investigated. The form of the graphite is lamellar.

A visual inspection of the quality of roll grooves surface after operation revealed that the base of the groove is subjected to the most intensive wear. The depth of hollows at these places was measured by binocular microscope and ranged from 0.05 to 0.08 mm. Austenite on the grooves surface acquires the form of a rarefied thin and fine-lamellar perlite (0.3-1.3 μm). In the surface layer of grooves the microcracks, the depth of propagation of which is as great as 0.25 mm, are disclosed. They are located in cementite inclusions, their distribution in the surface layer was uneven, i.e. on the side walls of the groove the depth of microcrack propagation ranged between 0.03 and 0.05 mm and at the base of the groove it reaches 0.22-0.25 mm which is due to higher heat concentration at this area. The ratio of an area destroyed by cracks to that without cracks is 40:60.

Mechanism of formation of cracks on the working surface of hot rolls, considered by us carefully before, represents accumulation of residual tensile strain during heating and cooling of the working layer of rolls which leads after sufficient number of "heating-cooling" ("tension-compression") cycles to creation of a crack (thermal fatigue).

Action of thermal fatigue is intensified to a great extent by cyclically varying plastic deformation of the barrel surface and presence of an abrasive in a friction zone, the function of which is performed by a scale and spalling particles of the carbide phase [1-3].

Filling of cracks with any material (scale, wear products, water and so on) depresses the possibility of the working layer to expand freely on heating, descreases effective value of a crack gap, may produce a wedging-out effect and promote setting and build-up formation. A crack formed can't be sealed as the operating roll is cooled by water which penetrates into a crack and prevents its sealing. Water or vapour aid in destruction, particularly at the moments, when a microcrack is covered by a rolling metal.

When cooling the working surface of grooves by high pressure water from the outlet of pass, the probability of

V. Goryany, Institute for Applied Materials Technology University of Duisburg, Germany, I. Mamuzić, Faculty of Metallurgy, University of Zagreb, Sisak, Croatia, V. Radsinsky, National Metallurgical Academy of Ukraine, Dnepropetrovsk, Ukraine

water entry into a deformation zone is significantly decreased with resulting effective heat rejection from their surface. Temperature of the surface layer of rolls defines its structure and physical and mechanical properties at the moment of abrasion, pattern of friction and wear, friction coefficient, efficiency of lubricant-coolant utilization and a number of other factors. That's why, in this paper, consideration is being given to an influence of consumption of coolant (from 0.15 m^3/min to 0.375 m^3/min), when feeded under varying pressure (from 0.7 to 1.5 MPa) upon the grooves surface from the outlet of pass, on the wear resistance of rolls for the purpose of determining the optimum cooling conditions.

Analysis of quality of the grooves surfase of rolls cooled from the outlet of pass revealed that they were less intensive, the depth of hollows at the groove base being from 0.03 to 0.055 mm. On the unetched transversal metallographic specimen of roll grooves the cracks running parallel to the grooves surface have been found. As to the microstructure of metal, austenite takes the form of sorbitic perlite.

The most rough cracks at the depth of 0.12 mm were observed on the grooves surface of rolls cooled with minimum volume of water under minimum pressure. The ratio of the surface demaged by cracks to that without cracks is 40:60. With increase in pressure and water discharge the depth of cracks propagation is reduced to 0.040 mm. The ratio of the surface damaged by cracks to that without them also changes becoming 15:85. Further rise in pressure and water discharge significantly lowers the number of cracks on the working surface of grooves, the above-mentioned ratio is 10:90. Under maximum pressure and water discharge cracks on the surface of the metallographic specimen over the whole pass were not revealed.

Influence of method and intensity of cooling on the process of formation of cracks on the working surface of rolls are presented in the Table 1.

Table 1. **Influence of method and intensity of cooling on the process of formation of cracks on the working surface of chrom-nickel iron rolls**

Tablica 1. **Utjecaj metode i jačine hlađenja na proces nastajnja pukotina na radnoj površini krom-nikal valjaka**

No	Water pressure [MPa]	Water discharge [m^3/min]	Qantity of the metal rolled [t]	Depth of crack propagation [μm]	Area damaged by cracks [%]
1	0.3	0.050	140	250	60
2	0.7	0.150	190	120	40
3	1.0	0.225	220	90	35
4	1.1	0.270	239	400	15
5	1.2	0.300	350	100	10
6	1.4 - 1.5	0.375	400	0	0

Microhardness of structure components over the cross-section of a roll and on the surface of grooves was measured with hardness gauge. Change in microhardness of perlite over the cross-section of rolls cooled by a new and traditional method is characterized by the presence of three clearly defined zones.

In zone I (surface layer) with the depth of 0.1 mm microhardness of perlite in the rolls cooled by a new method is 4664 MPa and by a traditional one is 4400 MPa.

In zone II (undersurface layer) with the depth up to 10 mm microhardness of perlite cooled by a new and traditional method is 4567 and 4018 MPa respectivelly.

In zone III (roll core) microhardness of perlite ranges from 3822 to 3528 MPa.

Microhardness of cementite over the cross-section of rolls cooled by a new and traditional method is almost the same and is in the range from 9604 to 9085 MPa.

These results are in good agreement with those we obtained before [4]. Thus, cooling of rolls by water under high pressure from the outlet of pass results in some hardening of perlitic component in the grooves surface layer with the depth up to 1 mm as compared to a traditional cooling of rolls. Perlitic grains at the depth of 0.1 mm undergo the strongest hardening.

Analysis of microstructure of metal of the roll working layer and surface of grooves enables to presuppose the mechanism of increasing the wear resistance of chrom-nickel rolls subjected to intensive cooling by water under high pressure. In the surface layer of a roll subjected to high unit pressure and contact frictional forces significant stresses arise. When coming in contact with hot metal (1000 °C) the surface layer of the roll is heated up to a temperature ranging 800-850 °C. High temperature and substantial stresses in the surface layer promote increase in diffusive mobility of carbon [5, 6]. Mass transfer of carbon in one and the same matrix from carbon - bearing areas (graphite, cementite) to carbon-depleted perlitic areas takes place. Saturation of a solution with carbon is increased with the elevation of temperatures and stresses from inner layers to surface ones. Absence of holding at the maximum temperature and subsequent sharp cooling of rolls by high-pressure water supplied from the outlet of pass provide the formation of fine-disperse and intermediate metal structures hardening. This effect is more pronounced in the surface layer of grooves at the depth up to 0.01 mm having a microstructure of sorbitic perlite with microhardness from 4694 MPa to 4576 MPa and is less pronounced in the undersurface layer at the depth up to 0.1 mm with a microstructure of sorbitic fine-lamellar perlite microhardness from 4567 to 4038 MPa.

CONCLUSIONS

Cooling of the working surface of rolls by high-pressure water supplied from the outlet of pass results in upgrading of resistance of their working layer due to mass transfer of carbon from carbon-bearing areas of graphite and cementite to carbon-depleted areas of perlitic grains under the action of high temperatures and stresses that leads to saturation of a solution with carbon within one grain. Sharp cooling of the surface on its outlet from the deformation zone by high-pressure water favours hardening of perlitic component at the depth up to 0.1 mm, decreases the probability of water entry into the deformation zone, washes out abrasive particles from the surface of a roll and improves the resistance of rolls 1.5-2 times.

REFERENCES

[1] V. Goryany, Livarski vestnik, 44 (1997) 3, 66-77
[2] V. Goryany, M.Trbižan, I.Mamuzić, International Journal of Cast Metals Research, 11 (1998) 1, 43-50
[3] V. Goryany, V. Jokanović, Metaloznavstvo ta termična obrobka metaliv, (1999) 2, 37-42
[4] V. M. Goryany, Production and use of heat-hardened rolled products in construction, Dnepropetrovsk, DISI, 1989, p. 72-75
[5] A. A. Baranov, A. A. Minaev, A. P. Geller and others, Problems of combination of hot deformation and heat treatment of steel. Metallurgy, Moscow, 1985, p. 128
[6] L. N. Larikov, V. F. Mazanko, Z. M. Falchenko and others, Reports of Ukrainian Academy of Science, Series A, (1975) 7, 36-63