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INVESTIGATION OF THE SURFACE STRENGTHENING TECHNOLOGY OF RAILWAY-CARS' WHEEL AXLES FOR INCREASING OF EXPECTATION LIFE OF THE AXLES

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Abstract: Surface rolling is a cold-rolling treatment for hardening the surface of components made from steel or ductile cast iron. This process can be able to increase the hardness of surface and improve fatigue properties, so it is usually used for axles of railway-cars.

Keywords: *Surface rolling, Hardening, Railway-car axles*

1. INTRODUCTION

During the surface rolling for railway car axles two rolling cylindrical bodies in front of each other are pushed to the axles with a given force for a given time. This process can be able to increase strength of surface and improve fatigue properties resulted by effects in the microstructure of materials. This work's aim is to investigate those microstructural effects and mechanisms what affects the above mentioned parameters, mainly the surface hardening.

However the surface rolling is a widely used technology it is investigated in very few papers. According to a SAE publication [1] during the surface rolling-process the surface layers are loaded cyclically beyond their elastic limit, so they suffer a small, but inelastic compression (it causes 0,01…0,08 mm decrease in diameter of axles according our measurements). The subsurface layers are loaded under their elastic limit so after remove the load they tend to retain but it is resisted by the compressed surface layers. Because of this some amount of residual stress arise in the surface and adjacent layers.

2. PREPARATION AND TESTING METHODS OF SAMPLES

For the investigation two pieces of samples were cut off from axles of M41 series locomotives. One axle of these was surface rolled, the other one was not. All the axles were produced in 2006 and made from A4T signed material. The nominal chemical composition of the base-materials of axles can be seen in the table below:

Element	C	Si	Mn	P	S	Cr	Cu	Mo	V	Ni
Content (%)	0,22-0,29	0,15-0,40	0,50-0,80	0,035	0,035	0,90-1,20	0,30	0,15-0,30	0,05	0,30

Tab.1. Nominal chemical composition of the axles without iron (Fe).

The samples' dimensions: 25×25×26 mm. They were investigated by optical and scanning electron-microscope (SEM – scanning electron microscope) and tested by micro-hardness measurements. For these examinations the surfaces of the samples were grinded, polished and

finally etched by Nital. The composition of Nital: 2% nitric-acid (HNO_3) and 98% ethyl-alcohol (C_2H_5OH)

3. RESULTS OF MICROS-HARDNESS TESTS

During the micro-hardness tests two measuring series per sample were performed from the surfaces of the samples to the depth of 10 mm with a load of 500 g. Their results can be seen on the Fig. 1.

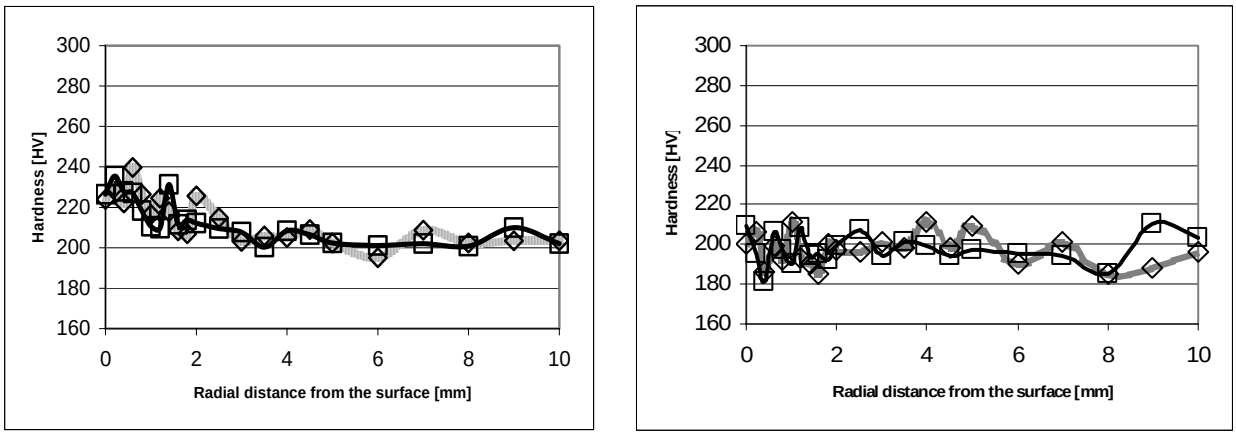

Fig.1. Results of micro-hardness tests: sample from axle surface rolled (left), sample form axle not surface rolled (right). These results are from the surfaces of the samples what are parallel to the axis of the axles.

The figures above shows unambiguously that the surface rolling makes approximately 20…30 HV increase in the hardness of external surface layers and this increase can be detected in depth of 3…4 mm from the surface. The hardness of inner layers is cca. 200 HV.

4. OPTICAL AND SCANNING ELECTRON-MICROSCOPIC EXAMINATIONS

To study the influence of surface rolling on the microstructures of samples optical and scanning electron-microscopic micrographs were taken about the microstructures of samples: from the subsurface and inner regions. On these micrographs some differences were expected between the grain structures of the surface and subsurface regions. The optical micrographs can be seen on the Fig.2-3.

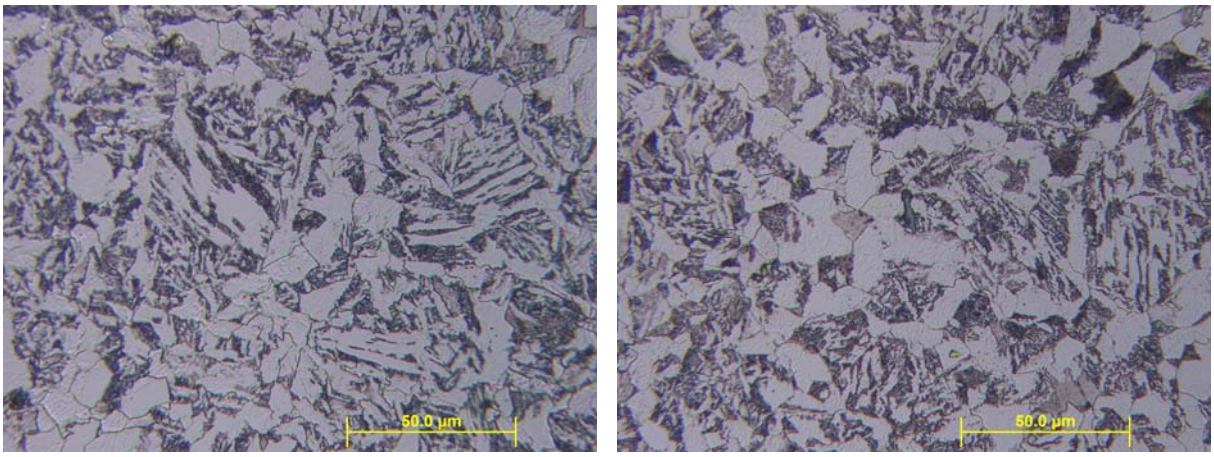

Fig.2. Microstructure of the surface rolled sample on optical micrographs: in the depth of 0,2 mm (left), in the depth of 10 mm (right).

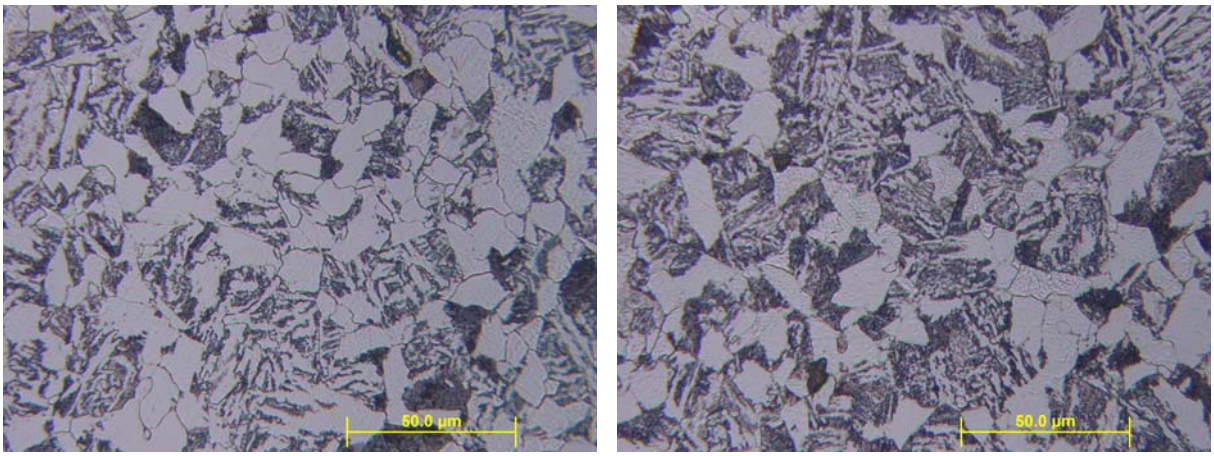

Fig.3. Microstructure of the not surface rolled sample on optical micrographs: in the depth of 0,2 mm (left), in the depth of 10 mm (right).

On the optical micrographs of the microstructures seem to be very similar. Compared the micrographs taken about the samples significant differences can not be seen between the microstructures of surface rolled and not surface rolled axles.

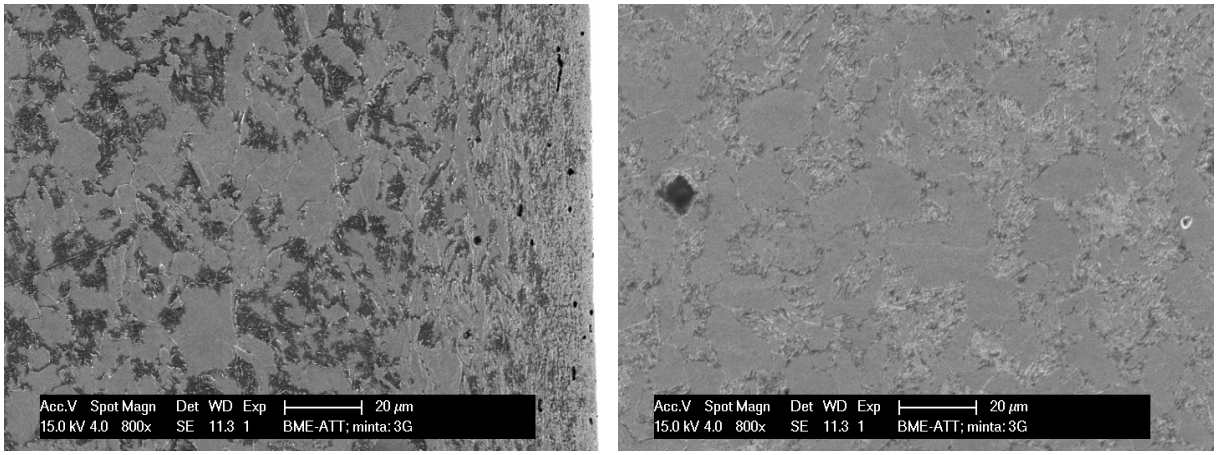

Fig.4. Microstructure of the surface rolled sample on SEM micrographs: in the subsurface region (left), in the depth of 10 mm (right).

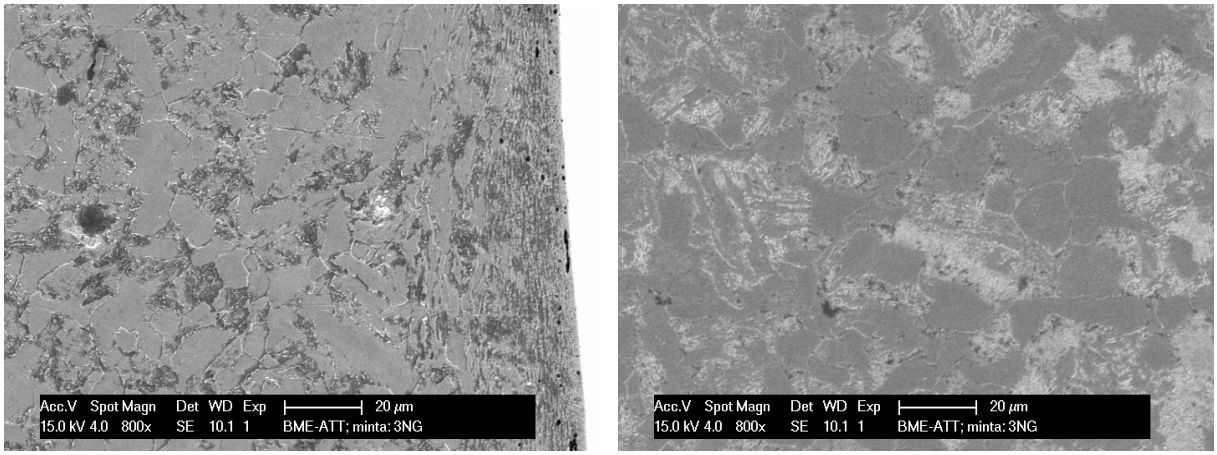

Fig.5. Microstructure of the surface rolled sample on SEM micrographs: in the subsurface region (left), in the depth of 10 mm (right).

The Fig.4-5. show the SEM micrographs about the outer and inner layers. No significant differences between the microstructures of surface rolled and not surface rolled axles can be seen according to these micrographs. On every micrograph can be seen the lack of grain structure in the upper 20…30 µm thick layer (on the left pictures) while grains can be observed only below this outer layer, in the subsurface region.

4. CONCLUSIONS

The effects of surface rolling were studied in this paper by micro hardness tests, optical- and scanning electron microscope. Among its effect only the strengthening of surface could be confirmed by micro hardness-test. Any microstructural changes were not observed on the optical and SEM micrographs. The surface hardening seems to be as an effect of work hardening due to the growth of dislocations' number in the surface region.

REFERENCES

[1] Surface Rolling an Other Methods for Mechanical Prestressing of Metals; SAE Int., SAE J811, 1981.