Rebuilding the wheelset flanges of locomotives by surfacing without wheeling out

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Abstract. The most effective method to increase the surface life of wheel tires, the flange wear of which outpaces the growth of tire wear significantly, is surfacing of worn flanges of electric locomotive wheel sets. This method, in comparison with the restoration by turning and forming a profile configuration by reducing the thickness of the tire has undeniable advantages: flange surfacing combined with the shape of female profile minimizes the technological wear of the tire before its retirement; idle time of locomotives caused by the need of intermediate turning is eliminated; the costs of maintaining the machines for turning without removing the wheels and purchasing hard-alloyed cutting tools are decreased; wage savings are achieved. The work presents basic information on wheel sets, theoretical data on surfacing, analyzes previously used surfacing materials and provides metallographic studies of the surfaced material. The technology of flange surfacing without removing the wheels from under the electric locomotive was developed and described, that allows reducing the time spent on repair significantly. The use of alloyed surfacing materials instead of low-carbon ones allows reducing the time of surfacing and increasing the resistance to wear of wheel set flanges of traction vehicles. Efficiency of NP-18H1G1M.01 surfacing wire application for wear-resistant surfacing of tire flanges and increase of the overhaul cycle is shown. Increased wear resistance of electric locomotive wheel flanges surfaced with alloyed wire is confirmed by the production test data.

1. Introduction

Intense lateral wear of rails and rolling stock wheel set flanges especially in curved tracks, is a threat to the safe movement of a traction vehicles and causes increased costs. The urgency of this issue grows as the service life of rails, flanges of locomotive wheel sets and solid wheels of wagons decreases.

When the rail track and rolling stock interact, contact stresses occur at the contact points between the wheels and the rails. As a result of these stresses, the movement of the wheels on the rails results in natural wear and tear of the mating surfaces, as well as their elastic and plastic deformation and fatigue damages.

The rules of technical operation of the railways do not allow traveling the trains with a transverse crack in any part of the axis of a wheel set, as well as in the presence of wear and damages that disturb the normal interaction between the rail track and the rolling stock.

These malfunctions include:
- wear around the taping line more than permissible dimensions;
- flange wear below the maximum permissible thickness;

...
- thin flange and sharp flange;
- thickness and width of wheel rim less than permissible dimensions, as well as local widening;
- defects on the running surface in the form of flat spots, shelled tread, ring wear above the permissible ones.

When the set values of the wear are achieved or the damages which threaten the safe running occurred, the wheel sets shall be taken out of service for maintenance.

2. Materials and methods

The most effective method to increase the service life of a wheel set tires of industrial electric locomotives in which the wear of the flange significantly outpaces the growth of tire wear (Figure 1), is surfacing of worn flanges without wheeling out. This method allows keeping the profile of the wheel thread and reducing the maintenance downtime of electric locomotives [1] in comparison with the restoration by turning and obtaining a profile by reducing the thickness of the tire.

![Figure 1. Flange wear](image)

Until recent times the design documentation was developed and the unit for wheel set flangessurfacing under a flux without removing the wheels was manufactured during the restoration of the flanges of OPE and NP industrial electric locomotives at PJSC "Mikhailovsky GOK".

For surfacing the flanges Sv-08GA GOST2246-70 wire and AN-348AM flux as per GOST9087-81 were used that provided the hardness of the surfaced material surface ≈205 HB that is less than hardness of the flanges in the delivery condition 231 ... 241 HB made of steel grade 2 according to GOST 398-96 [2].

Flange restoration practice by low-alloyed wire SV-08GA under a layer of flux of AN-348AM grade has shown that the wear resistance of the surfaced material is insufficient and makes 25-35% of flange metal wear resistance.

This became the basis for a study on the use of new material to increase the hardness of the surfaced metal and increase the service life of the surfaced flanges [3-5].

Surfacing flux-cored wire PP-Np-18H1G1M.01 Technical Specification 1274-025-37392360-2012 produced by LLC “Interpro” was chosen to conduct the research. According to the certificate, the hardness in the fourth surfaced layer is 280 HB, which meets the tasks of increasing the overhaul cycle when surfacing the flanges of industrial electric locomotives flanges without removing. The hardness of surfaced layer 393 … 415 HB was obtained on testing samples during surfacing of wheel set flanges with abovementioned wire. The hardness was measured by TK-2M gauge.

To determine further prospects for the use of the wire a comparative production tests of wheel sets and flanges on railway tracks in the open mine, which were surfaced with SV-08GA and PP-Np-18H1G1M.01 wires, were carried out. Flanges were surfaced up to the thickness of 33 mm with preheating of ≈ 2650 C at flange wear up to min allowed thickness of 25 mm [6]. The heating temperature was calculated using a formula that takes into account the chemical composition and thickness of the metal. During the tests wear fixation of restored tires was done as per the time.
According to the conducted tests and collected data, the dependences of wear and tear of flanges were deduced for tested wires Sv-08GA and PP-Np-18H1G1M.01. From the composed dependencies it can be noted that the operating time up to the min allowed wear of the flanges surfaced with PP-Np-18H1G1M.01 wire is 3 times longer than that of Cv-08GA wire (Figure 2).

Figure 2. Wheel set flanges surfacing wear resistance diagram.

To study the macro- and microstructures of the surfaced metal, the templates (Figure 3) were made by surfacing a worn-out tire with wires Sv-08GA and PP-Np-18H1G1M.01.

Figure 3. Wheel set tire template with surfaced flange
During the study of the flange template macrostructure the cracks in the surfaced layer and heat affected zones were not revealed.

![Microstructures](image-url)

**Figure 4.** Microstructures (×500) of surfaced and base metal of flange: a – with PP-Np-18H1G1M.01 wire, b – SV-08GA (b); c, d – 3TV; e, f – base metal.
Microstructure of the surfaced layer was analyzed with the help of metallographic optical inverted microscope METAM LV 32. The images of surfaced samples microstructures were obtained in a reflected light with resolution magnification of the microscope × 500. Micro sections of surfaced samples were prepared to high finish by preliminary abrasive grinding and three-stage polishing using ASM pastes with abrasive grain sizes of 6, 3 and 1 micron. For clearer identification of the microstructure the etching with previously prepared 15% alcohol solution of nitric acid was carried out.

The microstructure of base and surfaced metal is shown on Fig. 4. Microstructure of the tire is a finely dispersed secondary sorbite with metal hardness of 231 ... 241 HB (Fig. 4, e, f). In the microstructure of the layer surfaced with SV-08GA wire the ferrite component with hardness of the surfaced layer 205 HV prevails (Figure 4, b). During the study of the microstructure of the layer surfaced with Np-18H1G1M.01 wire, the prevalence of sorbite with the hardness of the surfaced layer of 305...415 HB is observed (Figure 4, a).

| Surfac ing wire      | Average hardness, HB | Surfac ed metal | Base metal |
|----------------------|----------------------|-----------------|------------|
| Sv-08GA              | 205                  |                 | 241        |
| PP-Np-18H1G1M.01     | 404                  |                 |            |

From the table it follows that the metal surfaced with PP-Np-18H1G1M.01 wire has a hardness of ≈ 404 HB, which corresponds to the hardness of the rails material. As the hardness of heat-strengthened rails is 311 ... 420 HB, it corresponds to the correlation of a tribo-system “wheel flange-rail” in the range of 1.0 -1.2. It is appropriate to note here that at this level of wheel hardness no accelerated wear of rails was noticed.

Hardness of metal surfaced with Sv-08GA wire, turned out to be below the hardness of flange metal surfaced with tested wire, i.e. the results of practical application of PP-Np-18H1G1M0.1 wire were confirmed.

3. Conclusion
1. The service life of wheel set flanges surfaced with PP-Np-18H1G1M.01 wire during performance tests is almost 3 times higher than those surfaced with Sv-08GA.
2. The change of the tribo-system “wheel flange – rail” hardness correlation in the range of 1.0-1.2 (for PP-Np-18H1G1M0.1 wire) does not cause accelerated wear of rails.

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