WHEEL SET RUN PROFILE RENEWING METHOD EFFECTIVENESS ESTIMATION

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At all the repair enterprises, despite decreased rim wear-off resistance, after every grinding only geometry wheel profile parameters are renewed. Exploit wheel rim work edge decrease tendency is noticed what induces acquiring new wheels. This is related to considerable axle load and train speed increase and also because of wheel work edge repair method imperfection.

Key words: Wheel rim, wheel rim metal, thermal wheel profile processing, restoration

1 Introduction

The upper layer hardness of 260-310 HB in pulsate hardening way is reached during primary wheel and bandage manufacturing after upper layer processing in the furnace that are hardened. In the depth of 30 mm metal hardness usually does not exceed 265 HB because of low metal and bandage penetration. That is why in the second repair stage the entire hardened metal layer fully goes off. Trough all the rest time the wheel and the bandage are exploited almost with out layer of hardened metal that is why they wear-off sooner and contact fatigue defects appear. Wheels are repaired more often and during this process useful wheel metal layer is taken off using grinding method. It is required that present wheels and bandages had upper run edge metal layer of 290-300 HB hardness. The same hardness must be trough all the depth which is necessary during all the wheel exploitation. Regenerating wheel work edge to get economic metal use is not purposeful to grind and make metal layer part into the shaving. There are known wheel regenerating methods when upper metal layer is heated to the hardened pearlite and only after that grinding is done.

However, these methods do not ensure physical-mechanical wheel run surface metal characteristics which are necessary to reach durability. The main destination of the methods is to increase grinding process productivity and less hard layer use.

The purpose of using this wheel run surface profile renewing method is achieved firstly by grinding (cut-in profile grinding method) run surface profile what is mostly economic by preserving rim work metal layer. After that wheel run surface is renewed using thermal processing when there is equal gap

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between inductor and worn-off wheel run surface profile. Wheel rim characteristics are regenerated by using this method.

The establishment of this grinding method secures optimal gap between indicator and wheel run surface through all the profile length and the work metal layer is not taken off. Equal wheel size before and after repair is secured, wheel run surface metal layer resistance to contact wear-off increases during this processing method, wheel durability increases in this exploitation period when there is bigger depth.

2 Settings rational limits of using renewing methods

The calculating of processing methods and energy use for the process depending on cut regimes and wheel steel strength were made to set the ideal fields of existing high speed cutting process grinding (HSCPG) and whet depending on physic-mechanical rim metal changes.

At first the showing mass m, which is got during wheel run profile processing, is calculated:

$$m = FL\varphi = W\varphi \quad (1)$$

where: *W* – cut metal range, *F* – cut metal area, *L* – processed surface length.

Time, necessary to remove metal mass *m*, is calculated by formula:
for whet method

$$T_w = L / ns \quad (2)$$

for cut-in grinding method

$$T_w = \frac{t_n}{s_{\min}} K \quad (3)$$

where: s – hand for spin, *n* – spin frequency, S_{min} - minute hand, t_n – cut off allowance.

The metal mass taken of the wheel in time unit is used as manufacturing process measure:

$$P = m / T_w \quad (4)$$

There are used not average T_0 meanings but meanings calculated in formulas 2 and 3 where sizes n and s are chosen depending on wheel steel strength by “Nomograms of setting faceplate spin frequency and support give in during wheel made of steel GOST 10791-81 processing” in formula 4.

The size, which is figure equal to energy used for the process, proportion with cut-off metal mass:

$$E_u = A / m \quad (5)$$

where: $A=A_1+A_2$, A_1 –energy, used for cut process, A_2 - energy, used for finishing wheel run surface property.

The calculating results are shown in the table 1 and table 2.

To compare effectiveness of the discussed run profile renewing methods, the coefficient K_e, which characterizes processing P productivity point to the energy use for the processing E_u, was used (table 1):

$$K_e = P / E_u \tag{6}$$

The HSCPG method is more productive comparing to whetting but processing wheel steel to 300 HB HSCPG method need more energy.

Noticing the productiveness position on energy use (K_e), it is clear that grinding method in wheel axle run profile renewing becomes more effective if there is thermo-processing going after, and the run surface strength can not be less than 260 HB; if there is no thermo-processing the run surface strength can not be less than 280 HB.

Comparing run profile renewing process effectiveness by using machine 1836 which is made in Russia and "Hegenscheidt" machine 165. Whetting wheel axles with thermo-processing going after (310 HB) and with no thermo-processing the machine 1836 is more effective (according to K_e) but machine 165 needs 25% less energy for the cut process.

According to all the discussed wheel run surface strength characteristics (in the range from 250 to 400 HB) using technological process with following thermo-processing, machine 165 is more effective than machine 1836.

Whetting wheels with thermo-mechanical defects (TMD) profile renewing process productivity declines (exact calculating is not possible because of different TMD types and their number on the wheel axles) about 50% on machine 1836 (on primal processing and regime decline account) and energy use increases 50%; machine 165 accordingly (lack of secondly processing and regime decline) about 30 and 20%. Drawing this with table 1 and table 2 data, it clears out that whetting with primal thermo-processing with TMD is less effective than with no primal thermo-processing (by K_e) because the process needs more energy. Using primal thermo-processing it becomes appropriate for both machines when it is on TMD run surface, if used run surface metal strength is higher that 300 HB. Processing wheel axles (with TMD on wheel run surface) is more effective with machine 165 and used metal is more than 280 HB. HSC grinding method preference with or without following thermo-processing is obvious from counting results which are shown in table 1 and table 2.

Finally, whetting for run profile renovation in nowadays processing begins from wheel steel strength of 340 HB is characterized by not very good productivity data (n<10 spins/min; S<0,9mm/spin) and tool wear off. In this case, the use of whetting with plasma warming increases.

3 The economic estimation of renewing methods

The account value method was used and economic characteristics of the processing method were used as indices on the third analysis stage. This is ascertained counting expenditure of wheel efficiency renewing by using different methods in conditional wheel department working with different programs. And branch economic effect separately from wheel resource increase at renewing not just geometry but and physic-mechanical characteristics of the rim metal, economic transport metal expenses.

Table 1 The quantities of wheel run profile renewing productivity and energy use depending on wheel axle strength

Strength	Whetting								Grinding						
	Machine 1836														
	With primal (<310 HB) thermo-processing			With no thermo-processing (no TMD)			With following thermo-processing		With no thermo-processing (with TMD and with no TMD)				With following thermo-processing		
	P	E_u	K_e	P	E_u	K_e	P	E_u	K_e	P	E_u	K_e	P	E_u	K_e
250				0,138	0,4	0,345	0,138	1,42	0,097						
260				0,119	0,46	0,259	0,119	1,64	0,073						
270				0,101	0,54	0,187	0,101	1,92	0,052						
280				0,09	0,61	0,148	0,09	2,16	0,042						
290				0,077	0,72	0,107	0,077	2,54	0,030						
300	0,055	3.84	0,014	0,058	0,94	0,062	0,058	3,34	0,017	0,263	2,39	0,110	0,263	4,07	0,065
320				0,039	1,42	0,027	0,039	5,02	0,008						
340				0,022	2,54	0,009	0,022	9,0	0,003						
360				0,011	4,88	0,002	0,11	17,33	0,000						
400				0,003	16,5	0,000	0,003	58,5	0,000						

Table 2 The quantities of wheel run profile renewing productivity and energy use depending on wheel axle strength

Strength	Whetting								
	Machine 165								
	With primal (<310 HB) thermo-processing			With primal (<310 HB) thermo-processing			With primal (<310 HB) thermo-processing		
	P	E_u	K_e	P	E_u	K_e	P	E_u	K_e
250	0,062	3,91	0,016	0,162	0,53	0,305	0,162	1,38	0,117
260				0,169	0,61	0,228	0,138	1,61	0,086
270				0,118	0,72	0,164	0,118	1,9	0,62
280				0,105	0,81	0,13	0,105	2,15	0,049
290				0,088	0,97	0,091	0,088	2,56	0,034
300				0,066	1,29	0,051	0,066	3,39	0,019
320				0,044	1,94	0,023	0,044	5,13	0,009
340				0,023	3,72	0,006	0,023	9,84	0,002
360				0,012	7,34	0,0016	0,012	19,4	0,0006
400				0,003	25,3	0,0001	0,003	86,8	0,0005

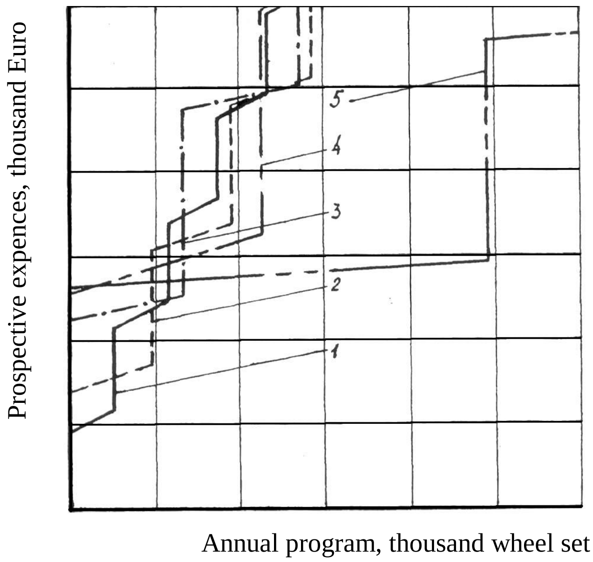


Fig.1: Realized consumption dependence on annual programs processing wheel profiles. Here: 1 – profile processing using 1836 machine method; 2 – profile processing using early inductive heating; 3 - profile processing using 165 machine method; 4 - profile processing using early inductive heating; 5 – profile processing using Russian railways method.

Annual economic effect, connected with work equipment intensification in conditional department level was estimated by calculated expenditure differences.

Economic possibilities of compared variants are shown in the graphic of calculated expenditure dependence on the annual conditional department program (figure 1). Expenditure not related to some program limits (capital investment, equipment and industrial area springing, present repair and supply between the repairs) are shown like slating straight parts when drawing graphics.

The ordinate difference in setting annual program describes effectiveness of one method comparing to another. As it is seen in figure 1 using whetting with primal and following thermo-processing methods with machines 1836 and 165 and CPHSG with following high rate tension (HRT) is appropriate with programs accordingly to 5 and 13 thousand wheel pairs per year. However, the marginal programs decrease markedly with the inclusion of the wheel work length increase.

According to Russian railways, the whetting with primal inductive heating is already effective with the whet 2,5-3 thousand wheel pair program. The larger program is, the bigger effect is received. The expected branch wheel resource increase economic effect because of using CPHSG and HRT is calculated with formula:

$$E_e = B\left[p\left(\frac{1}{T_1} - \frac{1}{T_2}\right) + \frac{C}{2}\left(T_1 + T_2\right)\right] \tag{7}$$

Here: B - made production annual amount, T_1, T_2 – wheel work length after 1 and 2 renewing variant, p– wheel pair price, C – repair cost price.

The expected economy sum effect of using CPHSG and thermal processing with high rate tension (TPHRT) would come to 55 000 Euro for each renewed wheel pair (according to prices of year 1995).

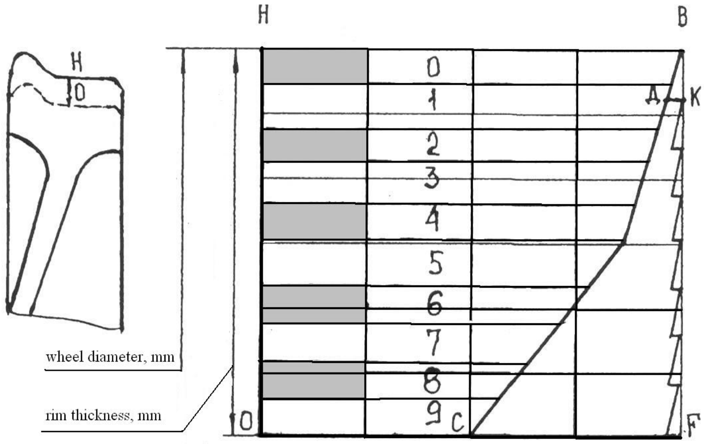
Applying recommendations of perfecting wheel repair technological supply (regimes, equipment and tools), according to Russian railways data, provided for wheel work length increase not less than 20% and gave confirmed economical effect.

Wheel producing and renewing methods systematization and analysis revealed wheel cut-in profile high speed grinding (CPHSG) with following physic-mechanical wheel rim feature renewing.

The wheel work length increase estimation

Hatched parts are OHBC areas, which show technical wheel resources, marked as areas 2, 4, 6, 8 are not used because of not economic run profile geometry renewing technology. Because of defects on the run surface (carriers, burns, etc.) and possible tool break the profile processing is made "under crust", which means that shavings are made of cut rim metal layer. The wheel resource decreases in 35-40% and sometimes even to 60%. The used resource makes about 60% of the intended resource.

The wheel resource scheme which gives possibility to value wheel resource increase using compared renewing methods: method 1 – turning wiht one or several knives wich are put coherently wheel set using early thermal processing with inductive heating wich improves processing (TPHRT + whetting) and method 2 – high speed cutting profile outside grinding using thermal procesing after it, wich restore physicalc – mechanical roll profile features (CPHSG + TPHRT).



Rim metal wear off resistance, thousands km/mm
Fig.2: Wheel resource description scheme

Using primal thermo-processing HRT to renew wheel run profile by whetting practically does not influence wheel resource technical changes, because all the "under crust" defects are distinctive to this method.

After every whetting (figure 2 function wear off resistance BC) wheel strength characteristics declines. The main TPHRT destination increased wheel run surface processing with Russian railways that is why the amount of not used wheel resource T_{unused} (figure 2 BFC area) does not change. The CPHSG method with following TPHRT allows rim metal layer work economy and physic-mechanical property repair. Minimizing amount of not used T_{unused} resource on economic renewing account, the amount of not used T_{used} resource will get close to fixed T (resource):

T_{unused} ->min; T_{used} -T, T_{used} = 0 + 1 + 2 + 3+…+ 8 + 9.

New used resource T_{used} meaning makes about $T_{used\ 1}$ = 0,95T.

Like it was mentioned earlier, sing thermo processing HRT 2 method after renewing wheel rim profile geometry parameters allows to renew physic-mechanical rim metal surface layer property. Then new wear off resistance function (figure 2) will be reflected on BDFK line. Technical wheel resource will increase to area CDKF and will make about 20% of OHBC area. The new possible to use wheel resource $T_{used\ 2}$:

$T_{used\ 2} = T_{used\ 1} + 0{,}2T = 1{,}15T$; $T_{used\ 2} / T_{used} = 1{,}15T / 0{,}6T = 1{,}9$

Comparing to existing used resource T_{used}, it increase in 1,9 times. The same size decrease of the need of Russian railways in wheels processing using given technology is possible.

4 Conclusion

- The methodic based on wheel pair renewing method processing calculations and energy use for renewing process including wheel steel strength and processing regimes was created and limits of optimal grinding and whetting methods existence were set.
- It was recovered that CPHSG method becomes more useful comparing to whetting: with primal TP, begins from wheel surface metal strength of ≥260HB, with no thermal processing (TP) – begins from ≥280 HB.
- The processed wheel pair renewing method realization on the wheel rim geometry parameter economical renovation using CPHSG method and physic-mechanical property of its' metal account, allows an increase of technical wheel pair resource comparing to already used existing resource in 1,9 times. It is possible to decrease the need of Russian railways in wheels, processed with this technology, the same size.

Reference literature

1. BAZARAS Žilvinas, SOMOV Dmitrij. Axle renewing characteristics quality estimation methodic. ITELMS'2009: Intelligent Technologies in Logistics and Mechatronics Systems, June 4-5, 2009, Panevezys, Lithuania: proceedings of the 4th International Conference Kaunas: Technologija, 2009. ISBN 9789955257059. p. 31-34.
2. BAZARAS Žilvinas, SOMOV Dmitrij. The wheel run pair profile renewing with high speed cut profile grinding investigation process. EURO-Žel 2009: Increasing the Competitiveness of the European Rail System: 17th International Symposium, 3.4.06.2009, Žilina, Slovak Republic [proceedings]. Žilina: University of Žilina, 2009. ISBN 9788055400358. p. [1-9].
3. LINGAITIS, Leonas Povilas, Mikaliūnas Šarūnas, Vaičiūnas Gediminas. The analysis of wear intensity of the locomotive wheel - sets // Eksploatacja i niezawodność / Polskie Naukowo-Techniczne Towarzystwo Eksploatacyjne. ISSN 1507-2711. 2004, Nr. 3, p. 23-28.