recovery of wheel pairs; turning; milling; grinding

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RECOVERY TREAD WHEEL PAIRS OF MACHINING

Summary. The basic methods of resurfacing wheels are determined and analised. It's shown that for raising resource of used wheels and decreasing requirements of railway transport for new wheels it's reasonable to use methods of recovering not only geometric parameters of rim, but also its mechanical properties. It's marked that use of infeed profile high-speed grinding (VPVSh) enables to intensify significantly process of mechanical treatment of wheel rim profile both when its resurfacing in service and when manufacturing new wheel.

ВОССТАНОВЛЕНИЕ ПРОФИЛЯ КАТАНИЯ КОЛЕСНЫХ ПАР МЕХАНИЧЕСКОЙ ОБРАБОТКОЙ

Аннотация. Проанализированы основные методы восстановления колес. Показано, что для повышения ресурса использования колес и уменьшения потребностей железнодорожного транспорта в новых колесах разумно использовать методы восстановления не только геометрических параметров обода, но и его механических свойств. Отмечено, что использование врезного профильного высокоскоростного шлифования позволяет значительно улучшить процесс механической обработки профиля поверхности катания колеса при его эксплуатации и при изготовлении.

1. INTRODUCTION

Recovery of wheel pairs tread profile of machining (turning, milling, grinding) during repair have typical properties of dissipative systems that convert mechanical energy into thermal energy, energy of friction and plastic deformation. Foundation systems are mathematical display cutting schemes, technological methods restore of tread profile that link their kinematic and parametric characteristics.

2. KINEMATIC QUESTIONS FORMING AND MACHINING

Fundamental work on the kinematics of mechanical cutting is the G. Granovsky work [1]. His classification was the basis for the development and forecast of new cuttings. At the same time, a comparative analysis of methods of restoration wheel pairs tread profile based on their classification on the kinematic characteristics (a combination of movements) is insufficient. With the same combination of movements can be a variety of processing technique depending on the ratio of velocity movements, type of instrument and form its cutting edges.

E. Konovalov [2] proposed universal kinematic scheme where any simple traffics of detail that make up basic kinematic schemes are part of the complex movements of this pattern. Cutting tool also has similar movements in its coordinate system (three rotary and three progressive movements around and along axis). Disadvantages of this classification are the uncertainty of technological characteristics and implicit their expression through quantitative ratios speeds.

A certain step in design theory and improving ways of bit machining is method of kinematic analysis, which was proposed by A. Etin [3]. Classification by means of technological characteristics (conditions), depending on the main traffic and feed traffic.

Classification methods of shaping by A. Fedotenok [4] built the assumption that a formation many surfaces can be accomplished by a movement of a forming line to a guide of the corresponding form and length. Each of them can form the four methods with the following number of movements of shapes:

- the method of copying (without traffic shaping);
- the method of running-in (with one traffic shaping);
- the track method (with one traffic shaping);
- the touch method (when two or more movements forming).

This classification is not so much of the diversity of possible in each case movements, how many of the specific characteristics of surfaces forming.

The existing large number of systems of classification methods of forming processing determines trend identification and analysis of internal connections and patterns of the various processes and methods for processing.

In [5], dedicated to system analysis of shaping processing methods, formulated the principles of analysis and systematization of the processes and methods for processing with one voice. It is shown that any way forming treatments can be considered as a technical system of metalworking. Optimal control system shall ensure that the maximum (minimum) of the selected criterion of optimality (productivity, prime cost of processing, etc.).

In [5] all the diversity of methods a bit treatment appears to be lots of movements of the cutting blade, including the main movement, the movement of the feeding and the reconfiguration of the cutting blade during cutting. Cutting blade can be simple (rectilinear) and complex spatial configuration. In the base of general mathematical description of methods to restore the wheel tread [6] introduces the following assumptions:

- the shaping process is forming a movement process of a piece's spatial line simulation blade;
- a movement of the blade is relatively stationary half-finished product, although through the appropriate selection of parameters relating to the movement, the movement can be entered as blades and half-finished product.
- while moving a line that simulated a blade, can change their configuration;
- a line's element is infinitely small rod length *ds*, zero thickness, thus having five degrees of freedom:

a) three progressive described three components of the mass center's velocity $\vec{V}(s,t) = \dfrac{d\vec{r}}{dt}$, having the radius-vector $\vec{r} = \vec{r}(s,t)$ (t – the time, s – the coordinate of the point blades);

b) two rotating around the center of mass (rotating around an axis, concurrent with the element *ds* is ignoring), characterized by vector $\vec{\omega}(s,t)$.

On the basis of the modus operandi in [6], using the generalized mathematical display schemes of cutting during processing of tread wheels in [7] was received:

- the graphical display of top cutting blade;
- dependences of distribution of cut stratum's thickness along the length of the cutting edge;
- dependences of specific cutting forces of the same options.

3. METHODS OF A RECOVERY AND PROCESSING A TREAD PROFILE OF WHEEL PAIRS

Comparison of analyzed methods of grinding and cutting wheel for profile based on the characteristic of each instrument parameters, whereas by view effort of cutting on the cutting edge one can say about methods in general.

In the paper [8] based on the paper [3] have been organizing methods to restore and processing tread wheel pairs to combine them into three main groups (fig. 1):

1 – the mechanical cutting by the cam (the programme);

2 – the processing of profile tool;

3 – the combined processing.

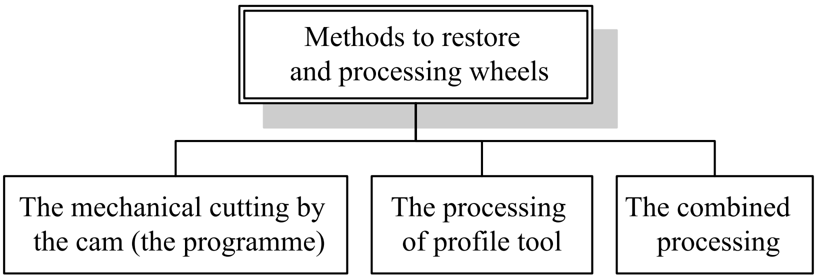

Fig. 1. Ways of treatment and recovery of wheels
Рис. 1. Методы обработки и восстановления колёс

Systematization forecast the possibility of using new ways to recover, not currently used.

For the first group is characterized by specifying the required motion path of tool through the use of mechanical, hydraulic and electric imitation or software control (fig. 2).

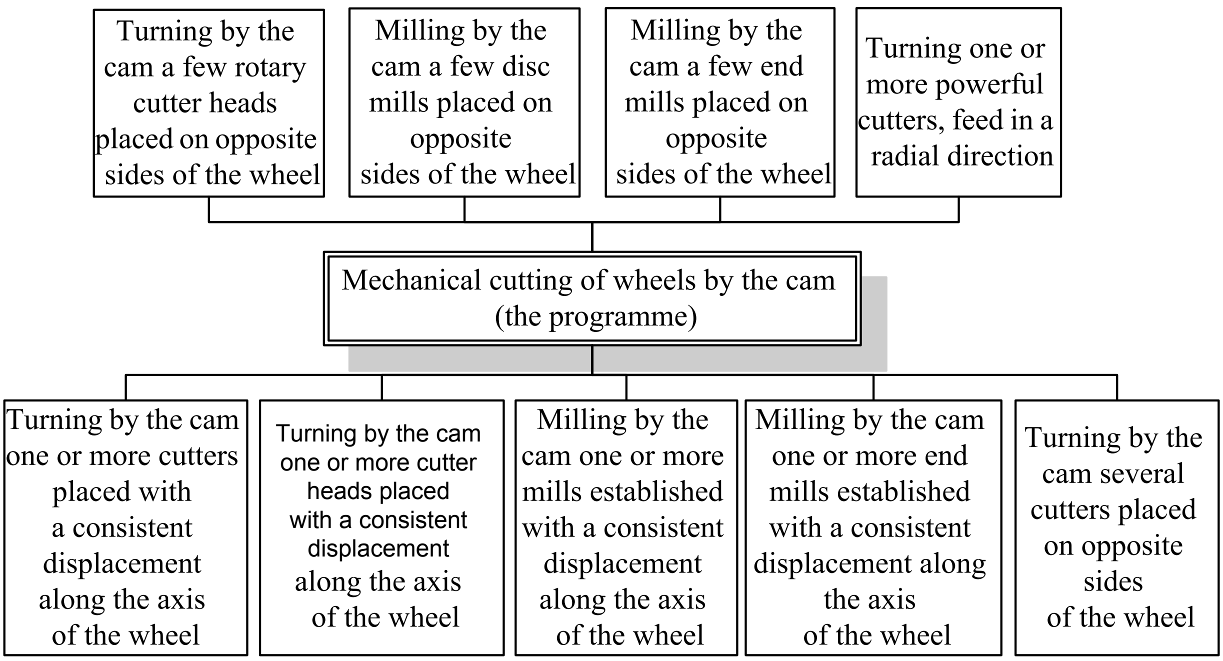

Fig. 2. Means of mechanical cutting of wheels by the cam (the programme)
Рис. 2. Способы механической обработки обода колёс (по программе)

In the second group is used a form tool with a profile, inverse wheel rim profile (fig. 3). Third party provides the possibility of combining methods of cutting tool by the cam and the form tool. At the same time expedient combination such cutting method, which angular speeds a wheel pairs rotation clash. Velocity mismatch leads to need for consistent use combined approach to processing and increase the block time. The third group includes separate cutting by the cam or form tool, but with an additional utility power (electrical, chemical, thermal, etc.) into an area of processing before, after or during the cutting process, and methods to restore using a weld deposition. In other words is expected to recover not only geometrical parameters, but also mechanical characteristics of metal rim to new wheels (hardness on the plane of the rim falls, reducing the durability and service life of wheel) (fig. 4).

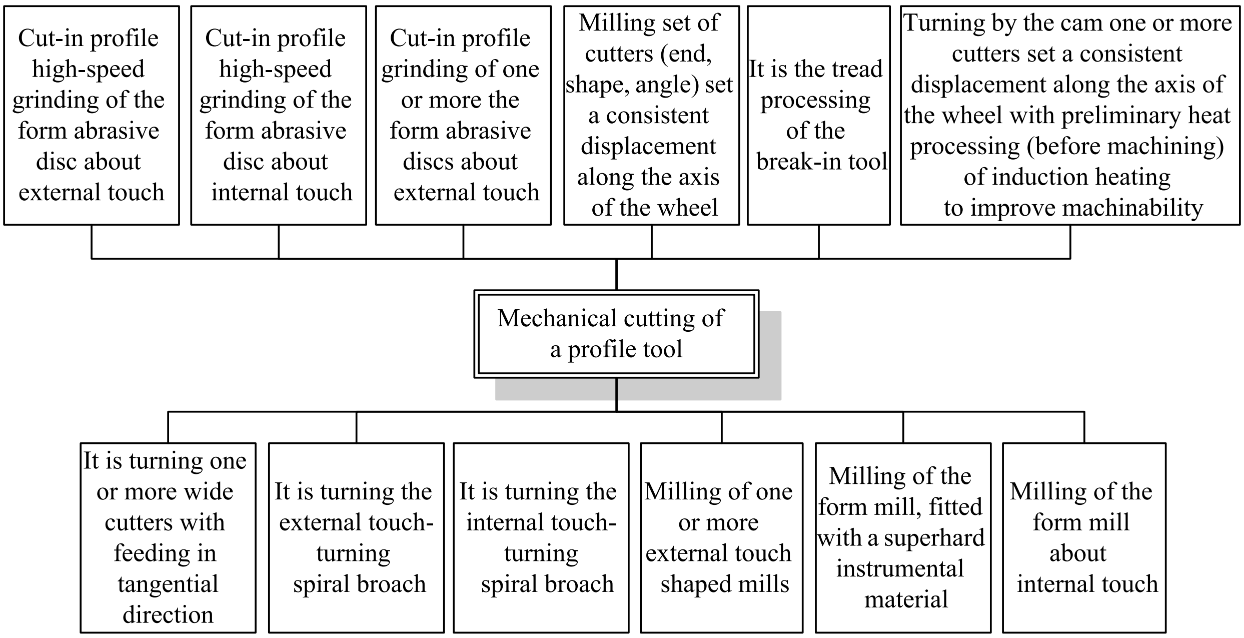

Fig. 3. Methods of a mechanical cutting of a profile tool
Рис. 3. Методы механической обработки профильным инструментом

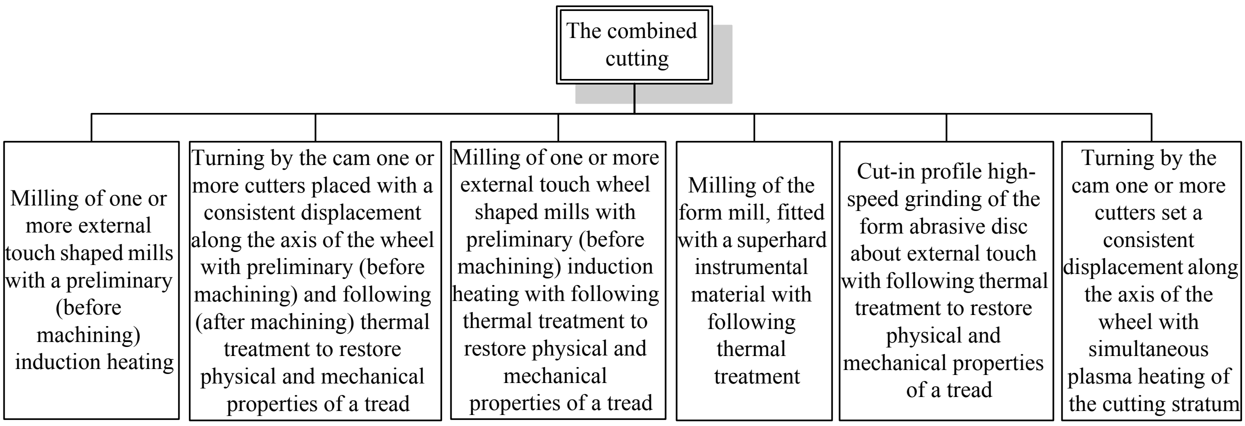

Fig. 4. Methods of combined cutting of wheels
Рис. 4. Способы комбинированной обработки колёс

4. ASSESSMENT OF THE QUALITY LEVEL OF RECOVERY OF A TREAD PROFILE OF WHEEL PAIRS

On the basis of this classification compared to recovery and evaluated their quality. In fig. 5 shows the sequence of the choice of rational recovery method.

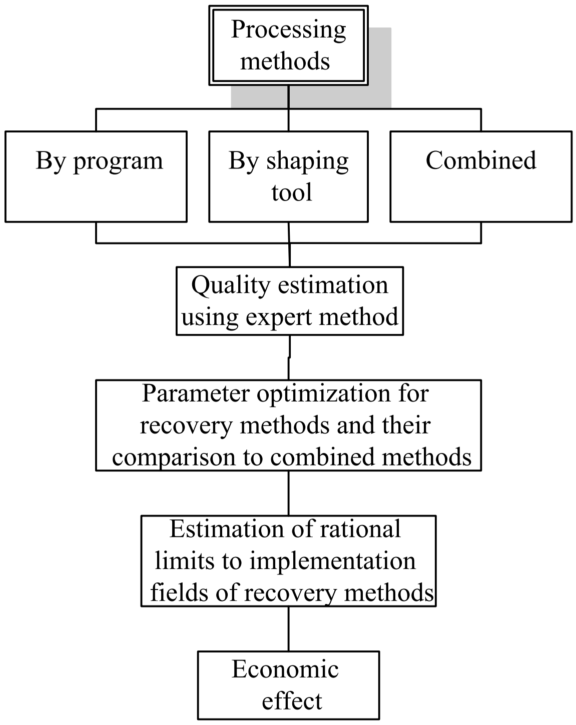

Fig. 5. Selecting the way of recovering the wheel
Рис. 5. Выбор способа восстановления работоспособности колеса

Initially comparison was done using expert method. Basic operation of expert assessment undertook in accordance with РД 50-149-79. Individual quality indices take into account the possibility of using methods in other industries and can process up to the hardness of the wheel, heat-treated to 360, 600 HB; an economy of cutting wheels with defects on the tread; rehabilitation of physical and mechanical properties of the rim; forming a convenient and transportable chip; the need for subsequent processing chips, etc. Summary measures of quality defined by the formula:

$$Q = \sum_{i=1}^{n} P_i k_i, \tag{1}$$

where P_i - is a unit rate, measured in points; k_i - coefficient weight assigned to a single figure;
n - number of individual indicators.

In assessing the magnitude of generalized measure of any way to apply a three approach: the first - calculation of summary measures Q taking into account all individual indicators; the second - calculation Q without taking into account the potential surface of the rim wheels, hardened to 600 HB hardness; the third - calculation Q without possibility to restore physical and mechanical properties of metal rim. Synthesis quality score has zero, if at least one of the few indicators stood at zero.

Calculation of basic parameters of processing during restoring [8] for comparison is made based on kinematic analysis of treatments [5]. Results of calculation and subsequent analysis showed some benefits described below treatments to the rest.

Increase the efficiency of wheels means primarily that the process of their manufacture and repair of a shift to such processes that allow for the required quality wheels to their maximum performance when processing minimize losses material rim, time labour machinists, energy and other resources.

With new technological processes of grinding (depth, HSG) can greatly increase performance [9]. In particular, the Guring method (HSG) recommends the cutting speed 60-250 m/s, the blank feeding 1,0-10 m/min, the depth of cut 1,0-30 mm. A lack of burns is determined by the speed of feeding which exceeds the speed of spread heat output with chips.

Computational and experimental data on turning wheel [10] and grinding [11] are listed (for example) for cutting stratum from the surface of the rim depth of 5 mm in the tab. 1.

Table 1

Processing modes when restoring a tread wheel rim

GOST 10791-2004 (285 HB)			TU 0943-157-01124328-2003 (360 HB)		
Turning					
S, mm/r	n, r/min	S_M, mm/min	S, mm/r	n, r/min	S_M, mm/min
1,2	12,0	14,4	1,0	7,0	7,0
Cut-in grinding					
V_c, m/s	n, r/min	S_M, mm/min	V_c, m/s	n, r/mn	S_M, mm/min
80	70	10	80	70	10

As can be seen from table 1, basic (machine) time of a cut-in grinding is 0,5 min (an allowance - 5 mm), and in the process of turning basic time one-cutter processing by depth 5 mm is 12 and 24 min respectively while processing the profile according to GOST 10791-2004 and TU 157-0943-01124328-2003.

To determine the best areas of a cut-in grinding and turning in response to changes in physical and mechanical properties of metal rim performed calculations of productivity this method and power inputs on the process depending of cutting conditions and hardness steel wheel.

Originally calculated chips mass m derived when processing wheel profile.

Basic of the time required to rent the metal mass m is:

for turning

$$T_o = \frac{L}{nS}; \tag{2}$$

for insert grinding

$$T_o = \frac{t_n K}{S_{\min}}, \tag{3}$$

where L – the path of cutting; S – feed per revolution; n – the rotational speed; $S_{\min}$ – minute feed; t_n – cutting tolerance.

For measure of productivity took a mass of metal layer, removing with wheel at a time:

$$P = \frac{m}{T_o}. \tag{4}$$

Values of n and S when calculating T_o selected depending on the hardness of wheel steel.

The measure of process power inputs adopted value numerically equal to the energy expended in the process to mass cutting metal:

$$E = \frac{A}{m}, \tag{5}$$

where: $A = A_1 + A_2$; A_1 – the energy spent on cutting; A_2 – the energy expended on improving prop erties of tread wheels.

Calculation results are summarized in tab. 2.

Analyzing the results of calculation, it may be noted that the most productive (when comparing only for this parameter) is a method of a cut-in grinding. But while processing wheel steel with hardness up to 320 HB it consumes more energy, i.e. more energy-intensive process.

By comparing effectiveness of the recovery process of the tread when using machine 1836, and the German model – model 165, more effectively use the machine 1836 (by K_e) due to its lower energy intensity, but by the cutting productivity machine 1836 (one-tool processing) yields of machine 165 up to 25%.

Advantage of the cut-in grinding method obvious from the options listed in table 2 results of calculation and data [12].

Starting with a wheel steel hardness HB 340 turning application to recover the tread in the modern production is characterized by low productivity by cutting efficiency and persistence tool.

Table 2

Values of productivity and power inputs of restore tread wheels methods depending on the rim surface hardness

Hardness of the surface of the wheel rim	With preliminary thermal treatment (300 HB) to improve machinability			Without thermomechanical damages		
	P, kg/s	E, $\frac{\text{kJ}}{\text{kg}}$	K_e, $\frac{\text{kg}^2}{\text{s}\cdot\text{kJ}}$	P, kg/s	E, $\frac{\text{kJ}}{\text{kg}}$	K_e, $\frac{\text{kg}^2}{\text{s}\cdot\text{kJ}}$
Turning (the machine 1836)						
260				0,119	0,46	0,259
280				0,090	0,61	0,148
300				0,058	0,94	0,062
320	0,055	3,84	0,014	0,039	1,42	0,027
340				0,022	2,54	0,009
360				0,011	4,88	0,002
400				0,003	16,5	0,0002
Turning (the machine 165)						
260				0,169	0,61	0,228
280				0,105	0,81	0,130
300				0,066	1,29	0,051
320	0,062	3,91	0,016	0,044	1,94	0,023
340				0,023	3,72	0,006
360				0,012	7,34	0,0016
400				0,003	25,3	0,0001
Grinding						
250…400				0,263	2,39	0,110

To compare the effectiveness of the methods to restore of a tread was introduced rate K_e (tab. 1), describing the ratio of the processing productivity P at the power inputs E:

$$K_e = \frac{P}{E}. \tag{6}$$

5. CONCLUSION

To increase the resource of exploitation wheels and reduce the requirement in new wheels during the repair ways to recovery mechanical properties is used expedient.

Results showed that the use of grinding would greatly intensify the process of machining the wheel rim profile as if you restore its geometry in the operation and production of wheels.

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