Justification of Permissible wear parameters of Lokomotives crest wheel

Svitlana Sapronova, Viktor Tkachenko

Volodymyr Dahl East-Ukrainian National University,
Molodizhny bl., 20a, Lugansk, 91034, Ukraine, e-mail:
e-mail:doc_sapronova@mail.ru, e-mail: v.p.tkachenko@mail.ru.

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Summary. The article is devoted to justifying the choice of admissible tread wheels profile parameters and control technology improvement of locomotive wheels flange wear parameters. The authors conclude that the rational choice of admissible wear parameters depend strongly on the technical and economic performance of the rolling stock, namely mileage wheelset turning between bands, the total number of tires turning life cycle, overall tires life.
Key words: Railway locomotive wheel sets, tires, wheel profiles, wear parameters, ridge thickness parameter.

INTRODUCTION

The most common problems that arise in the operation of the "wheel-rail" in different periods of the development of the railway in the whole world is the problem of high rate of wheels and rails wear and the problem of rolling off the rails [1]. The main objective of almost all known studies of wheel wear was to reduce the rate of ridges wear [2-6]. The authors of this study strongly support any steps to help reduce the rate of wear in contact with the rail wheel flange and consider them not only useful but also necessary for the solution of life extension bandages [7-11]. At the same time, the authors believe that the primary task, aimed at increasing the life cycle of locomotive wheelsets, is the justification admissible parameters evaluation and wheel flange wear control.

PURPOSE AND THE PROBLEM OF RESEARCH

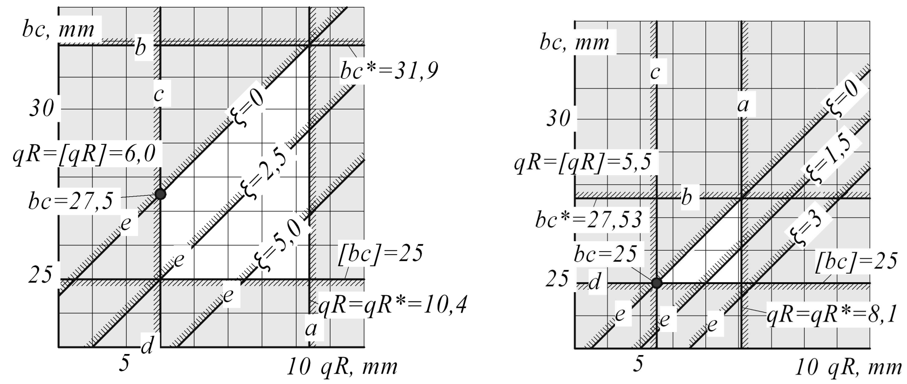
The aim is to justify the choice of admissible values of the basic profile parameters: a minimally admissible parameter of ridge steepness and minimally admissible thickness of the ridge.

RESEARCH RESULTS

To solve the research problem it was proposed by the authors to analyze the dynamics of ridges bandages profile parameters change using block-contours by analogy with contours that are used in the design of gears. Block-contours of possible values of the ridge thickness b_c and ridge steepness parameter qR of profiles GOST 11018:2005 and "MIHETEK" are shown in Fig. 1. The boundary of block-contours are marked by lines "*a*", "*b*", "*c*", "*d*", "*e*".

Line "*a*" – the line limiting the contour by the nominal ridge steepness parameter value:

$$qR = qR^* . \quad (1)$$



a b

Fig. 1. Block-contours of bandage profile parameters possible values in coordinates $b_c - qR$
a – profiles GOST 11018:2005, b – profile "MIHETEK"

Line "*b*" – nominal ridge thickness line defined by the function:

$$b_c(qR) = b_c^* . \qquad (2)$$

Line "*c*" – the line, limiting the contour by the minimally-admissible ridge steepness parameter:

$$qR = [qR]. \qquad (3)$$

Line "*d*" − the line, limiting the contour by the minimally-admissible ridge thickness parameter:

$$b_c(qR) = [b_c]. \qquad (4)$$

Lines "*e*" limit the contour by the ridge form and relate to the function:

$$b_c(qR) = [qR] - qR^* + b_c^* - \xi , \qquad (5)$$

Numerous statistical performance data about the ridges undercut indicate that the wear ξ at point B of the ridge occurs very rarely and only after achieving a significant undercut ridge at point A. Based on these observations, based on the analysis of blocking contours in Fig. 1 with a high degree of probability, we can conclude that in operation at reaching by its crest steepness parameter qR its minimally admissible value $[qR]$, ridge thickness will have stock on 30-40% undercut.

Thus, the existing standard for admissible value for the ridge steepness for GOST 11018:2005 profile $[qR] = 6{,}0$ creates prerequisites for premature bands turning and as a result, ineffective use.

Given that bandages resource is determined not by indicators of wear, but by minimal bandage thickness allowed by the "Instruction" [12], we can say that the operational wear has only a secondary influence on the tires operational life cycle. To a greater extent lifetime tires depends on the thickness reduction brace during turning, the process of wear. Therefore, research to improve the life of the tires should be carried out in two ways: first, the development of methods to reduce the intensity of wear in the trainset operation, secondly, to develop proposals to reduce the wear process.

As to the first direction, a large number of studies are aimed at reducing the bands wear, including undercut ridges. Concerning the second direction, it should be noted that there are not so many works concerning technology wear reduction, improving turning processes, rational profiles search, determination of optimal values of admissible profiles parameter and increasing tires usage coefficient [13-17].

Determination of the optimal value of minimally admissible ridge steepness parameter $[qR]$. Two important characteristics of wheels and rails interaction depend on ridge steepness parameters: the angle of the ridge and "dangerous form" of the ridge [18-20]. The angle of the ridge at the point of contact determines the wheelset stability during rolling on the rail, and dangerous form of the ridge may lead to the derailed wheelset when hit by turnout studs at wrong way movement.

Determination of the of minimally admissible optimal value of ridge steepness parameters $[qR]$ was carried out jointly by two criteria: minimum intensity of ridges wear and safety of wrong way movement at turnouts.

Based on the analysis of experimental data obtained by the authors, there were determined the intensity and average intensity of ridges wear on the current steepness value qR and minimally admissible parameter of the ridge steepness $[qR]$, respectively $I(qR)$ and $Icp([qR])$ (Fig. 2).

Analysis of dependence in Fig. 2 allowed finding out the following:

- at values $qR < 7{,}0$ intensity of ridges wear stabilizes, and with further reduction remains practically constant,

- medium intensity, which determines locomotive overhaul mileage, decreases with decreasing of the fixed threshold steepness parameter - $[qR]$.

In Fig. 3 in the system of coordinates $\sigma - h$ there is shown the area of admissible and non-admissible values of clearance between the point rail and the frame rack σ and vertical deformation of the point rail *h* and the curve of safety *qR*.

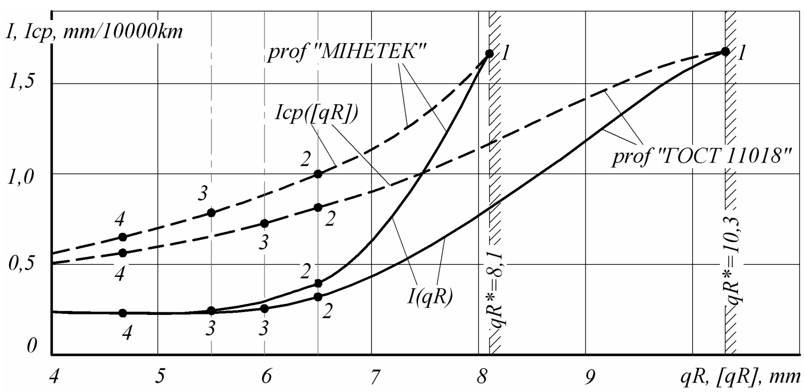


Fig.2. Experimental dependence of wear intensity *I* and medium intensity of ridges wear *Icp* on the current value of ridge steepness qR and minimally admissible ridge steepness parameter $[qR]$ for profiles GOST 11018:2005 and "MIHETEK"

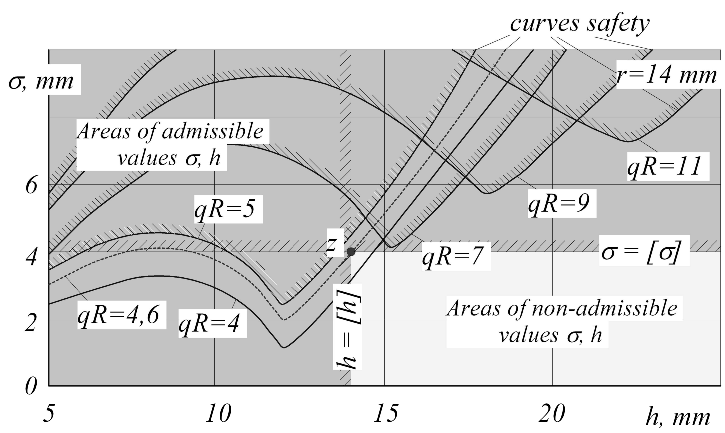


Fig. 3. Areas of admissible and non-admissible values of clearance between the point rail and frame rack σ and vertical deformation of the point rail *h* and curves of safety qR, at which safety is fulfilled: $\gamma_3 = [\gamma_3] = 60^o$

Curves of safety are the locus of points which are a combination of critical values σ, h, qR, at which there is fulfilled the condition of secure wrong way movement at turnouts, namely:

$$\gamma_3 = [\gamma_3], \quad (9)$$

where: γ_3 – ridge angle profile at the point of contact with the edge of the studs turnout - angle of contact, $[\gamma_3] = 60^o$ - minimally admissible value of contact angle at which there is no danger of inrolling of the wheel at turnouts. Safety isoline $qR = 4{,}6$ mm in Fig. 3, which passes through the critical point z, under current rules on the rejection of turnout parameters ($[h] = 14$ mm, $[\sigma] = 4$ mm) defines minimally admissible value of ridge steepness $[qR] = 4{,}6$ mm.

Determination of minimum permissible ridge thickness $[b_c]$**.** It is known that the minimum permissible ridge thickness is defined by "Technical operation rules of railways in Ukraine" (PTE). According to p.10.3 PTE "it is forbidden to operate and let the movement on main tracks with a maximum rolling stock with speed of 120-140 km/h when the thickness of the ridge is less than 28 mm, and for the movement with a maximum speed of up to 120 km/h - less than 25 mm. "Measuring the thickness of the ridgeby ridge-measurer GU-1 is based, unlike PTE, not on top of the ridge (point G in Fig. 4), but on the rolling circle (point D).

In Fig. 4 there are shown the profile options without rolling and with rolling. In fig. 4 it is shown that the measurement of the ridge thickness for PTE does not depend on steel, and the measurement of GU-1 - does. Thus, when $\delta = 0$ $b^*_{cPTE} > b^*_{cGU1}$, and for worn-out profile $b_{cPTE} < b_{cGU1}$.

Calculated relationship between the results of the ridge thickness measurement by different methods – according to PTE and ridge-measurer GU-1 - is shown in Fig. 5.

In particular, Fig. 5 shows that when the ridge thickness is measured according to the requirements of PTE equals the minimally admissible value, namely $b_c = [b_c]$, the ridge thickness, measured by ridge-measurer GU-1, depending on the rolling, varies from 22.9 mm (for $\delta = 0$) to 26 , 6 mm (for $\delta = 7$ mm). During rolling, approximately 3 mm measurement results of the two methods are the same.

Thus, during rolling less than 3 mm, in determining of the ridge thickness by the ridge-measurer, there is a systematic measurement error with the sign "minus", i.e., the measurement results are lower than the actual thickness of the ridge. In the absence of rolling, the error reaches minus 2 mm. Negative measurement error is a metrological prerequisite for unreasonably early turning bands and as a result, reduce the term of their service through inefficient use.

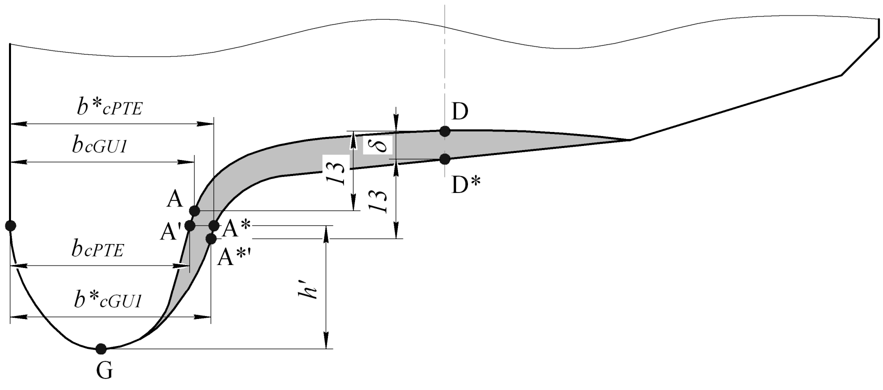


Fig. 4. Scheme for measuring the ridge thickness according to PTE and "Regulation":
b^*_{cPTE}, b_{cPTE} – thickness of the ridge, measured by PTE under new and worn profiles,
b^*_{cGU1}, b_{cGU1} – ridge thickness measured by GU-1 under the new and worn profiles

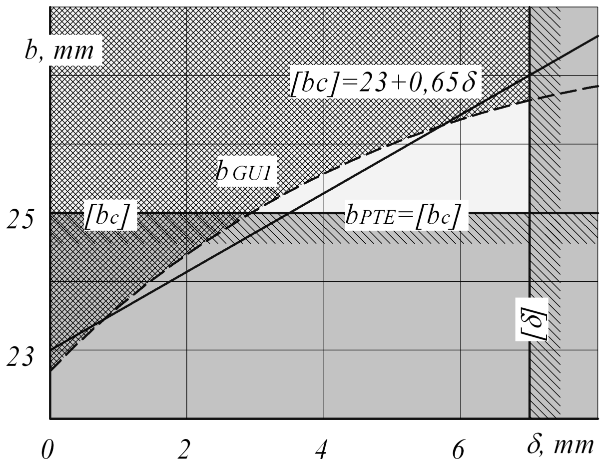


Fig. 5. Relationship between the results of the ridge thickness measurement according to PTE and ridge-measurer GU-1

In contrast, at rolling greater than 3 mm there is a measurement error with the sign "plus" in consequence of which the measurement is greater than the actual thickness of the ridge. The maximum error is plus 1.6 mm at maximum rolling of 7 mm. Positive measurement error is a metrological precondition for violation of PTE regulation as for minimum thickness of the ridge.

The authors see two possible ways of maintaining PTE demands and methods of measuring the ridge thickness by a ridge-measurer GU-1.

The first is that the minimum permissible thickness of the ridge is defined as a variable, i.e. $[b_c] \neq const$, that depends on the rolling. In this case, each measurement parameters of wear surface rolling wheels minimum permissible ridge thickness should be determined as a function of the actually measured rolling δ by the approximate formula:

$$[b_c] = 23 + 0{,}65 \cdot \delta \,. \qquad (10)$$

The second is to change items of PTE and introduce as a rule, determination of ridge thickness at its intersection at a distance of 13 mm from the wheel bearings, i.e. from point D in Fig. 4.

CONCLUSIONS

1. The authors conclude that the rational choice of admissible parameters of ridges wear depend strongly on the technical and economic performance of locomotives.

2. There was suggested the method of optimal values determination of the minimum-admissible ridge steepness parameter and minimally admissible thickness of the wheel flange.

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ОБОСНОВАНИЕ ПРЕДЕЛЬНО-ДОПУСТИМЫХ ПАРАМЕТРОВ ИЗНОСА ГРЕБНЕЙ КОЛЕС ЛОКОМОТИВОВ

Светлана Сапронова, Виктор Ткаченко

Аннотация. Статья посвящена обоснованию выбора допусковых параметров профилей поверхностей катания колес и усовершенствованию технологии контроля параметров износа гребней колес локомотивов. Авторы делают вывод, что от рационального выбора допусковых параметров износа существенно зависят технико-экономические показатели работы подвижного состава, а именно: пробег колесных пар между обточки бандажей, суммарное количество обточек бандажей за жизненный цикл, общий срок службы бандажей.

Ключевые слова: колесная пара локомотива, бандажи, профиль колеса, параметры износа, толщина гребня, параметр наклона гребня.