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RESEARCHES REGARDING TO LASTINGNESS OF THE TAMPING TOOLS

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Abstract: *Tamping is the technological operation of realizing a support of ballast under the inferior part of the sleeper, with the main purposes to assure a specific geometry and resistance of the railway and is being executed with the help of the tamping tools. The tamping tools work similarly as the cutting tools, with the difference that during the technologically tamping process doesn't results splinters and the result is a support of ballast for the sleeper. Increasing the lastingness of the tamping tools is a primordial factor in the efficient exploitation, both technologically and economically. We have achieved for the first time in Romania, the first tamping tools having the active part plated with plates of metallic carbides through brazing.*

Key words: *tamping operation, tamping tools, lastingness, tine, metallic carbides.*

1. INTRODUCTION

Mechanized tamping [1] consists in the vibration (oscillation) and squeeze of the ballast under the inferior part of the sleeper, at frequencies by 35 Hz, amplitude of the oscillation is 3 – 5 mm and the force is 10 kN – Figs. 1 and 3.

Tamping is being executed with the help of the tamping tools [2] – Fig.2.

A tamping cycle [1, 3] of the tamping tool means (Fig. 1): the descent (penetrate) with the active part of tamping tool into the ballast (1-2), until the established depth (which is adjustable), vibration (+0–) and squeeze the ballast (3) with the established parameters values (which are adjustable), detachment and going out of the tamping tool from the ballast (4-5).

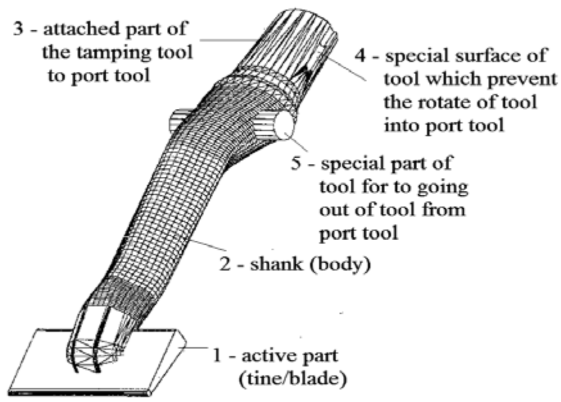

Fig. 2. The tamping tool type P&T 09-32 CSM-curved.

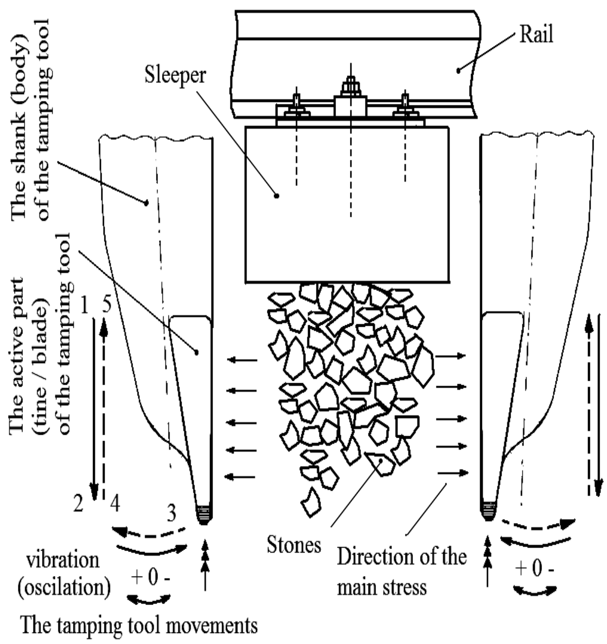

Fig. 1. Tamping operation.

In the most cases, the mechanized tamping is executed with pairs of tamping tools (Fig. 1), which are disposed symmetrically face to face, on both sides of the sleeper, doing opposite movements. These pairs of tamping tools are placed on both sides of the rail.

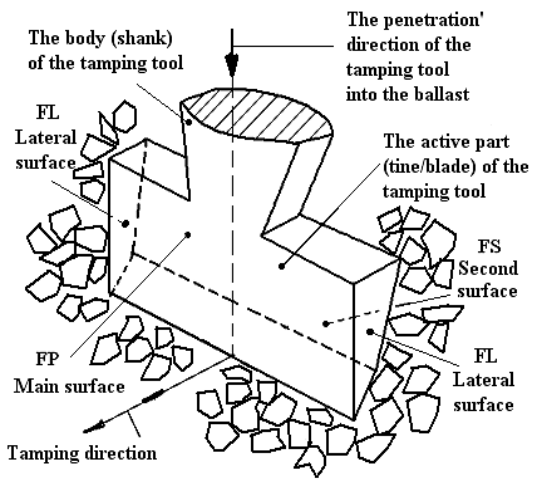

Fig. 3. The tine (blade) surfaces.

The tamping tools for the mechanized tamping [3] are those components of the tamping machines which execute a direct action to the ballast, being the most stressing machine part of the wear process. Over these tamping tools is performed a high stress by bending, shock, compression, tiredness, abrasive wear, shock wear and another. By the construction, quality and the lastingness of the tamping tools depends, in the most cases, the quality of the tamping operation, because the tamping tools are the final elements in cinematically chain of tamping machines.

We have established that the main factor, which has a primordial influence, is the wear of active part of the tamping tool [3]. It is necessary to concentrate the studying and researches to find some ways, materials and technical processes for using these, in the purpose of increasing the lastingness of active part of the tamping tools and researching of the behavior of these in exploitation.

2. THE LASTINGNESS OF THE TAMPING TOOL

2.1. Theoretical considerations

The wear (like the loss of material) can be expressed more easy through weighing in [mg] or [g] (gravimetric wear U_g), through dimensional measuring in [μm] or [m] of tick ness of the loss layer by material (linear wear U_h) or through the volume by the loss material (the volumetric wear U_v).

The wear is cumulative [4] and it is increasing usually with the length by friction L_f or with the length of time by friction D_f, the applied load F (the force of tamping), the speed by work (tamping speed), the hardness, the micro geometry and the material of the tamping tool and s.a.

The reference of wear to the time unit [hour] determine the speed of wear:

$$V_{Ug}, V_{Uh}, V_{Uv} = \frac{U_g, U_h, U_v}{T}, \tag{1}$$

where T – time (duration).

The reference of wear to the length unit [m, km] determines the intensity of wear:

$$I_{Ug}, I_{Uh}, I_{Uv} = \frac{U_g, U_h, U_v}{L}, \tag{2}$$

where L – length.

Regarding to the type of wear and it evolution, the primordial between those four fundamental types of wear (adhesion wear, abrasive wear, tiredness and corrosion) having in view the conditions and environment of work, also the types of materials couple (tools and ballast), they are the abrasive wear and tiredness and also, like particular type, the shock wear.

The abrasive wear, like the degradation process of active part shapes of the tamping tool, it has made through scratching of active shapes (tine) of the tamping tool by the hard particles which are contained by the ballast and also, by striking those shapes by the hard particles at the penetration of the tamping tool into the ballast.

The volume of loss layer material through abrasive wear it can be calculated with experimental relation:

$$U_V = K_U \frac{F_n \cdot L_f}{\text{HB}} \ [\text{mm}^3], \tag{3}$$

where K_U – the wear coefficient, $K_U = 10^{-2} \div 1$, it means that the degradation has made on the first action of the tamping tool, Fn – maximum force by squeeze which are developed in the course of the tamping operation ($Fn \sim$ 10kN);

$$L_f = v \cdot t \ , [\text{m}], \tag{4}$$

where L_f – the length of friction; v – the speed of the tamping tool into the ballast; HB – the hardness of material of the active part (tine) of the tamping tool

The thickness of layer which is loss through abrasive wear it can be determined (calculated) with the relation:

$$h_m = \frac{U_V}{A_n} = K_U \cdot \frac{p_m \cdot L_f}{\text{HB}}, [\text{mm}], \tag{5}$$

where A_n – the surface [mm^2] of active part of the tamping tool which is perpendicular on Fn.

$$p_m = \frac{F_n}{A_n} \quad [\text{N/mm}^2]\,. \tag{6}$$

The intensity of the wear it is calculated with relation:

$$I_{Uh} = \frac{U_V}{L_f} = K_U \cdot \frac{F_n}{\text{HB}} \quad ,[\text{mm}^3/\text{km}]\,. \tag{7}$$

The speed of the wear it is calculated with relation:

$$V_{Uv} = \frac{U_V}{t} = K_U \cdot \frac{F_n \cdot v}{\text{HB}}, \quad [\text{mm}^3/\text{h}]\,. \tag{8}$$

From the relation above it result that the hardness is an important parameter by which has depending the abrasive wear. Experimentally it is proved that the resistance at the abrasive wears is depending in a great extent by the hardness of surfaces.

For to obtain a great resistance at the abrasive wear, the ratio between the hardness of tools H_s and the hardness of ballast H_m, it must be:

$$\frac{H_S}{H_m} \rangle\ 0.6 \div 0.8\,. \tag{9}$$

2.2. The limit of the wear of the tamping tools

The lastingness of the tamping tools can represent the period of time in which the tamping tool is working in determined parameters until a new reconditioning.

The lastingness of the tamping tools is measured in hours or in meters of tamping.

The lastingness of the tamping tools can be presented as the way crossed until the tamping tools (Fig.4) reaches to maximum wear [1].

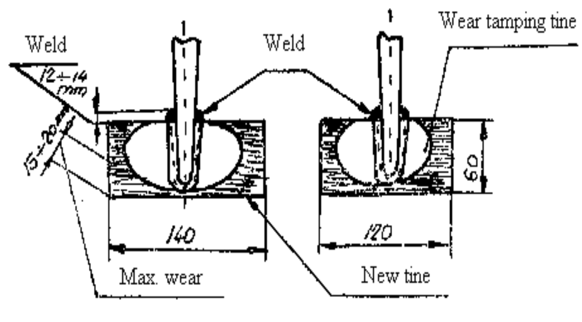

Fig. 4. The maximum wear of active part of tamping tool.

In literature and technical practice are known materials and technical processes to obtain a satisfactory wear for a specific type of tool which works in a specific technical system (the work regimen, the work environment). In the case of the tamping tools, the using of some materials (alloys) having in their composition in different percents Cr, Mn, Mo, W and some adequate technical process, like forging in the matrices for to maintain the materials fibers and thermo or thermo chemical treatments, offers special mechanical properties (breakage resistance, shock resistance, wear resistance).

3. EXPERIMENTAL RESEARCHES

The researches in specialized literature regarding at the present stage of the researches, designing, manufacturing and exploitation of the tamping tools have showed a low level of information and technical details regarding to these types of tools. The collected information is in the most cases summary information, with general character and especially commercial, with a few references at dimensions, geometrical shapes of different parts and surfaces of the tamping tools, at the reciprocal positions, at the qualities of surfaces, at the materials and technical process used to manufacture the tamping tools. The information is even more summary or is missing regarding at the lastingness of the tamping tools, at the wear and evolution of this (about the wear curves).

3.1. The weariness' forms

The experimental researches for increasing the lastingness of the tamping tools we have made through: the collection, the processing and the interpretation of the information that refers to the tamping tools and the exploitation of these tools; using new materials to increase the lastingness of active part of the tamping tools; using adequate technological process with the new utilized materials depending by working regimen and the exploitation conditions; studying the evolution of the weariness of active part for different materials, geometrical shapes and the technological process which are used; graphical drawing of the weariness curves of active part of the tamping tools.

The wear by tiredness of active surfaces of the tine (the active part of the tamping tool) has appeared as a result of some repetitions stress which makes the deformations by plastic nature in the superficial layer or the appearance of some fissures. These fissures are propagated in the tool material and at the union of two fissures are produced the detaching by material.

The shock wear through crumbles is produced at the penetration of the tamping tool, with high speed, in ballast, having a contact with shock. This type of wear is amplified in the case of the prism of ballast which is strong clogging (a similar phenomenon with the appearance of binder between the stones, phenomenon which is increasing in the significant mode depending by the size of clogging, the cohesion forces between the stones) and also, in the case of bodies with high hardness which are being accidentally in the prism of ballast (metallic bodies like bolt, screw, metallic plates for sleepers, break – pieces from rail, break – pieces from sleepers and so another) or the striking of tamping tool with the sleepers or metallic pieces of sleepers with rail as a result a mistakes of operator.

The shock wear is showed through the appearance of some breaches on the surfaces of active part of tamping tool, surfaces which are enclosed parts of tool with small volume (sharp edges, round edges, corners), these are being the result of some tears out by material at the shock of tool with the prism of ballast. The wear is more quickly when the size of shock force (the penetration force with which the tool penetrate the prism of ballast) is more great and the number of shock per time is more great.

In the case of experimental researches [3] of some different types of tamping tools (P&T 08 – 275 UM, P&T 09 – 32 CSM curved or straight, BNRI – 85) we have determined the common characteristics of the types of wear of the active part (tine) of the tamping tools.

The evolution of wear and the forms of this, which are experimentally determined, are presented in the Figs. 5, 6, 7 and 8.

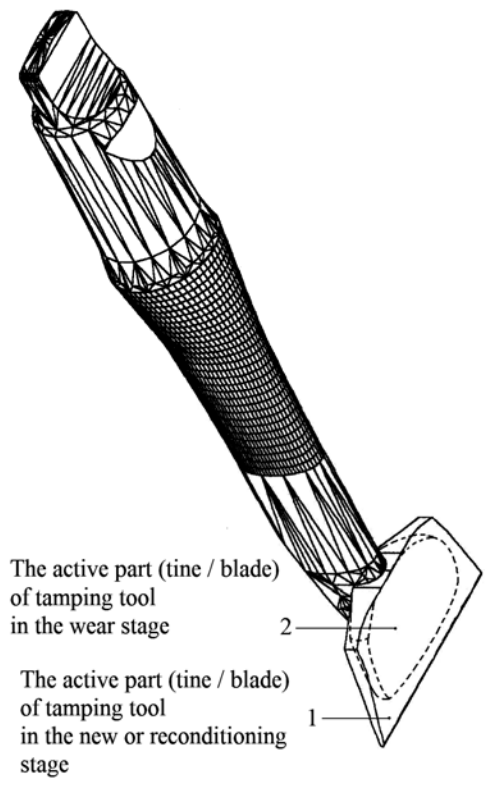

Fig. 5. The normal wear of active part (tine).

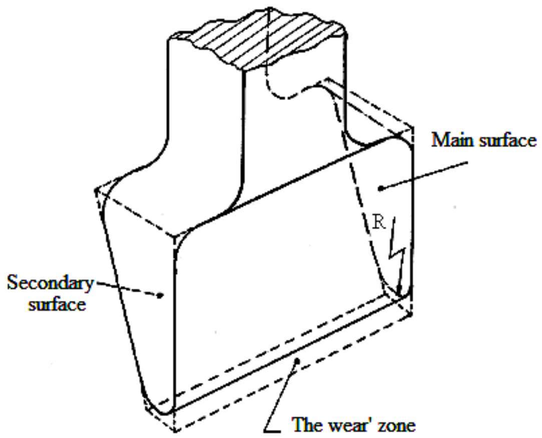

Fig. 6. Wear' zones of active part (tine).

The zone's wear of the active part (tine) of the tamping tools which are intensive solicitations by the different types of wear are presented in Fig. 6.

The intensity and the speed of wear have the greatest values at the inferior corners of the active part (tine). This fact is established through the quickly round of the tine corners like following a losing of material through abrasive wear and shock wear (the high solicitations on the contact zones with very small surfaces, fact which has a result the appearance of the high efforts / stress which exceed the admissible limits and its have a result at losing by material and also to increasing the contact surfaces with consequences in the regarding the reduction of efforts /stress).

The evolution in time of wear, in longitudinal section of tine, shows the forming of some convex surfaces, with greater radius at the inferior side and more small at the superior side (Fig. 7).

The evolution in time of the wear, in transversal section shows the forming of some convex surfaces, with smaller radius at inferior side and more great at superior side (Fig. 8).

It is very important to having in view these weariness' forms, in course of designing forms, dimensions and positions of shapes of the active part (tine/blade) and manufacturing of tamping tools.

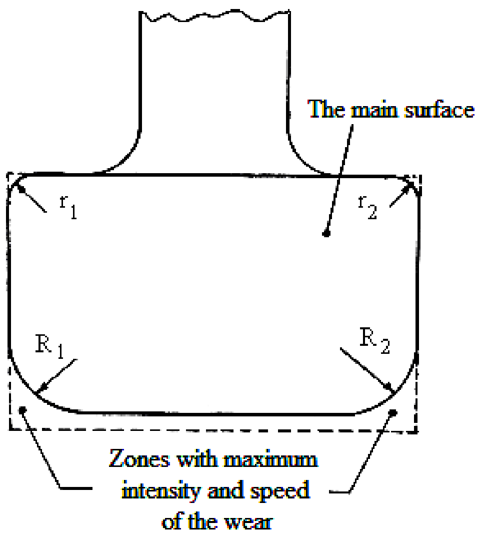

Fig. 7. Wear' zones of active part (tine) in longitudinal section.

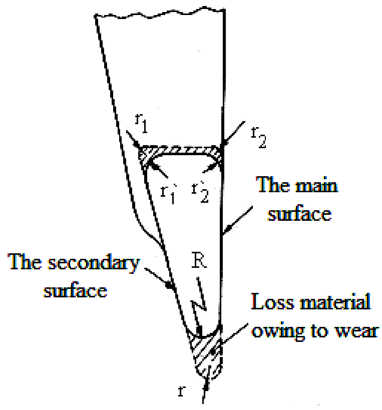

Fig. 8. Wear' zones of active part (tine) in longitudinal section.

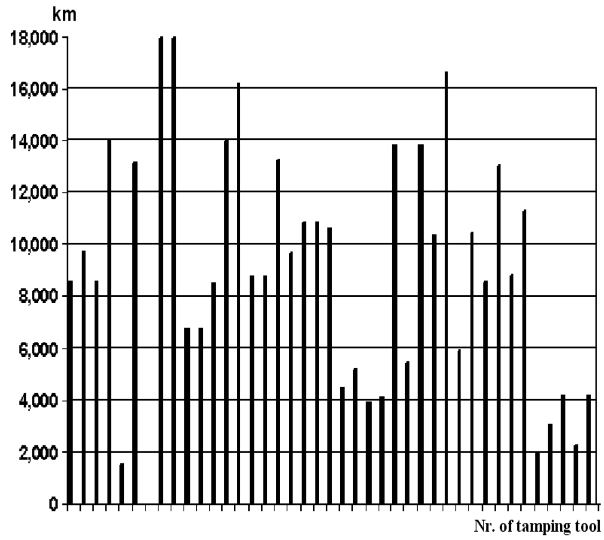

Fig. 9. The lastingness of the tamping tools type P&T 09–32.

3.2. The actual lastingness of the tamping tools

At the actual level from all factors, the main factor is the weariness of active part of the tool, with direct consequences on the lastingness of the tamping tools.

The lastingness of the tamping tools used in the present (armed with conventional material for the wear resistance), experimentally determined (see subchapter 3.4 and Fig.13) is: between 4000 – 6000 m of tamping, for a lastingness of 26 – 39 hours of working for the tamping tools type BNRI-85; 6000 – 7000 m of tamping for a lastingness of 12 – 14 hours of working for the tamping tools type P&T 09-32 CSM (Fig. 9) and 20 – 24 hours of working for the tamping tools type P&T 08-275 UM.

The lastingness of the tamping tools type P&T 09 – 32 CSM armed on the active part of the tools with hard materials (with hard electrode through electrical manual welding process or tungsten carbide attach with hard paste process – brazing – pos.8, 9), experimental determined between 1997 – 2005 are showed in Fig. 9.

3.3. Increasing the lastingness

The experimental researches regarding the lastingness of the tamping tools were concentrated at the active part (tine) of the tamping tools, having in view the evolution of the wear, depending by the quantity (the distance) of tamping accomplished, identification the factors and elements that influences the lastingness, also the solutions for increasing it.

In the course of researches we have been in view the assemble of factors that influence the lasting of tamping tools, from manufacture, exploitation and reconditioning of these, also the advantages and disadvantages which appear in the case of using some hard or extra hard materials and the technological process for application of these [5, 6], on the active part of the tamping tool.

We have determined the lastingness of the tamping tools having in view the numbers of cycles of raising and descent of the tamping tool into ballast, number that is established from difference between the numbers of cycles of raising and descent of the tamping mechanism at the disassembling of the tool and the mounting of it, numbers which were read on the indicator from Plasser & Theurer 09 – 32 CSM tamping machine.

Regarding to the hard or extra hard materials which can be used for increasing the lastingness [7], having in view the specifically conditions of functioning of the tamping tools, we have identified and selected for researches, the bodies from metallic carbides, which are attached at the active part (tine) of the tamping tools through brazing (pasting), using induction method with high frequency currents (10^5 Hz).

The metallic carbides which have been used are:

- group of utilization: G 40
- composition: 80% WC, 20% Co
- density: 13.5 [g/cm^3]
- hardness: 1100 [50HV]
- resistance at bending: 2600 N/mm^2
- elasticity module: 500000 N/mm^2
- resistance at compression: 3800 N/mm^2
- thermo dilatation (0 – 600 °C) : $6.5 \cdot 10^{-6}$

In the case of tamping tools type P & T 09 – 32 CSM – curved, the experimental researches regarding to utilizing the plates from metallic carbides consisted in the experimental plating (armed) of 7 pieces of tamping tools type Plasser & Theurer 09-32 CSM – curved, having following identifications numbers: 92 N, 150 N, 169 N (Fig. 10), 36, 123 (Fig. 11), 67 and 217 (Fig. 12). The tamping tools having identification numbers 150 N, 169 N, 36, 123, 67 and 217 were mounted and tested on the tamping machine type Plasser & Theurer 09 – 32 CSM.

3.4. The interpretation of the experimental researches

For drawing the graphic regarding the evolution of the wear (Fig. 14), we measured the wear of the active part of the tine, on the vertical direction in 4 (Fig. 13) equidistance points (depending by length L) and we have determined the average wear (Table 1) as arithmetical mean between these 4 measured values. The wear value [mm] in these 4 points was determined by calculation as being the difference between the nominal value of the high of tine and the measured value in that point.

4. CONCLUSIONS

Through the experimental researches we have determined that the lastingness of the tamping tools is influenced by factors like:

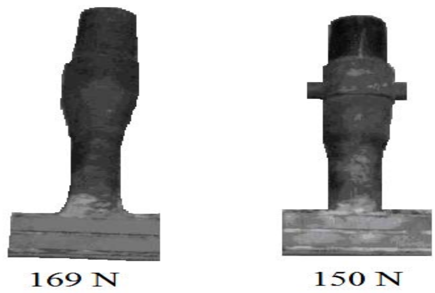

Fig. 10. Tamping tool, brazing with metallic carbides – version 1.

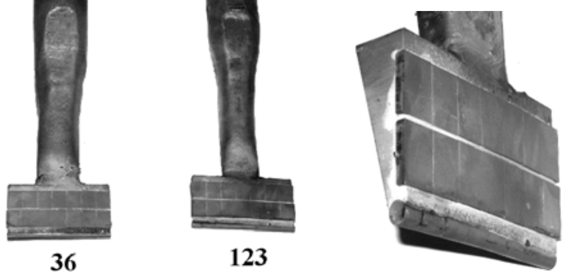

Fig. 11. Tamping tool, brazing with metallic carbides–version 2

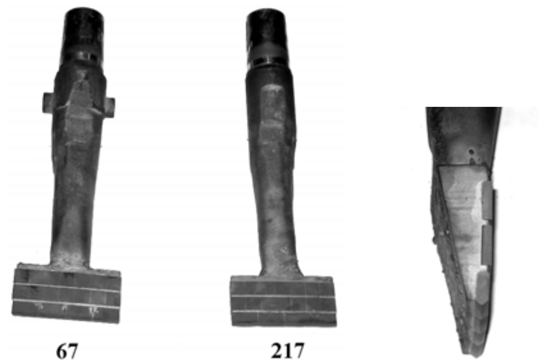

Fig. 12. Tamping tool, brazing with metallic carbides–version 3.

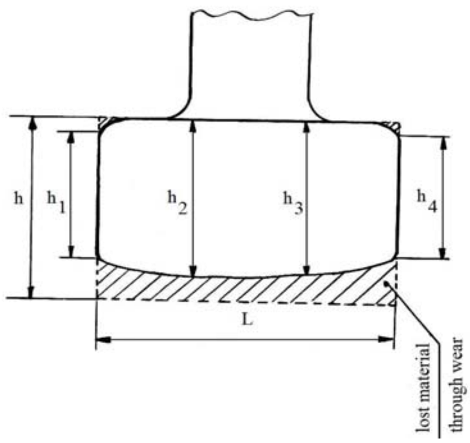

Fig. 13. Points of measures for the wear of the tine/blade.

- the type and shape of the tamping tools,
- the materials used to manufacture the tamping tools,
- the dimensions and shape of active part of the tamping tool,

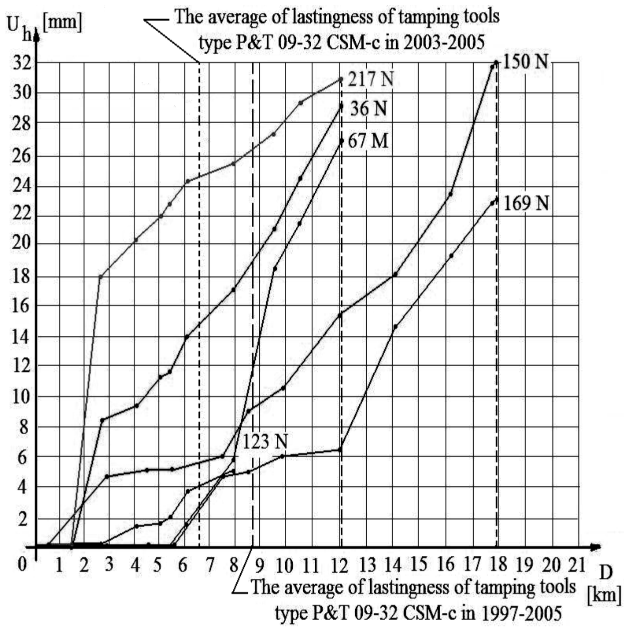

Fig. 14. The wear curves experimental determined.

Table 1

The average intensity of the wear of the tamping tools

Nr.	*L* [km]	Type and number of the tamping tool/ Average intensity of the wear [mm/km]					
		P&T 150N	P&T 169N	P&T 123N	P&T 67M	P&T 36N	P&T 217N
1	0 ÷ 1.550	1.290	0.065	0	0	0	0
		$I_{\text{med P\&T}} = 0.226$ [mm / km]					
2	2.500 ÷ 5.500	0.267	0.033	0.733	0	1.267	1.733
		$I_{\text{med P\&T}} = 0.672$ [mm / km]					
3	0 ÷ 5.500	0.927	0.036	0.485	0.103	2.242	4.236
		$I_{\text{med P\&T}} = 1.338$ [mm / km]					
4	0 ÷ 10.585	1.134	0.586	-	2.040	2.324	2.778
		$I_{\text{med P\&T}} = 1.772$ [mm / km]					
5	0 ÷ 12.037	1.279	0.523	-	2.226	2.409	2.559
		$I_{\text{med P\&T}} = 1.799$ [mm / km]					
6	0 ÷ 17.942	1.783	1.282	-	-	-	-
		$I_{\text{med P\&T}} = 1.533$ [mm / km]					

- the characteristics of the ballast,
- the type of tamping (Bi, BI, BII, BIII, BG, B maintenance),
- nonconformities of the technical process of manufacturing,
- nonconformities of exploitation of the tamping tools,
- nonconformities of reconditioning of the tamping tools.

The world wide using of some materials and technologies to increase the lastingness of active part of the tamping tools is less known and wide spread, an example in this way is using metallic carbide like the tungsten carbide. Internal matter doesn't have achievements in this area, this problem is ignored because the information is less and there are a lot of difficulties at technical level. We have achieved so, for the first time in Romania, the first tamping tools having the active part (tine) plated with plates of metallic carbide through brazing. By experimentally covering with plates from metallic carbide of the tamping tools type P & T 09 – 32 CSM, using hard paste process (brazing), the obtained lastingness is until 270 % higher (Fig.14) than the lastingness obtained in the present.

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