

THE DETERMINATION OF THE RESISTANCE FORCE WHEN THE TAMPING TOOL GOING IN THE BALLAST

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Abstract: The investigations in specialized literature regarding at the actual stage of the researches, design, manufacture and exploitation of the tamping tools have showed a low level of information and technical details regarding these types of tools. The theoretical researches of the tamping tool and particularly of the active part have permitted accomplishments regarding to calculation the resistance force at penetration into the ballast. Known the resistance force is necessary to designing and manufacturing of the different tamping tools for the different tamping machine.

Keywords: wear, tamping, lastingness, tamping tool

1. INTRODUCTION

Tamping is the technological operation of realizing a support of ballast under the inferior part of the sleeper, with the main purpose to assure a specific geometry and resistance of the railway [1].

Tamping is being executed with the help of the different tamping tools type: BNRI – 85, Matisa, P&T 08 – 275 UM, P&T 09 – 32 CSM a.s.o. (Fig. 1).. Mechanized tamping 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 1000 kf (10 KN).

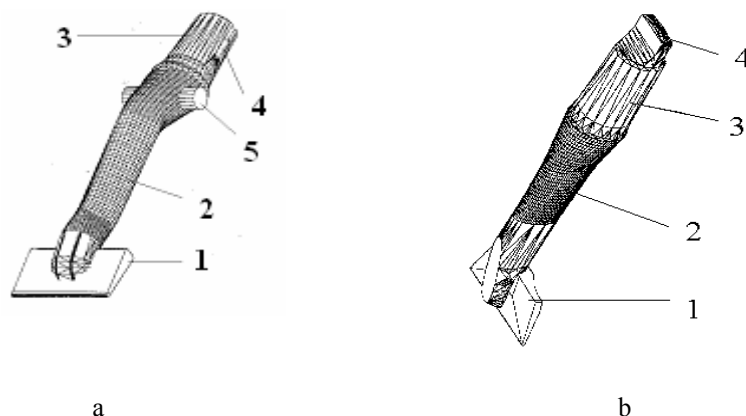


Fig.1 The tamping tool P&T 08-275 UM – a and P&T 09-32 CSM curved - b for the mechanized tamping:
1-active part – tine; 2-body of the tool; 3-the part of the tamping tool which is attach to the port tool; 4-part of the tamping tool which prevent the rotate of the tamping tool into the port tool ; 5- special part of tool for drawing out the tool from the port tool

The tamping tools are mounted on the tamping mechanisms (Fig. 2). The tamping tool is working similarly as the cutting tools, with the difference that during the technological tamping process doesn't results splinters, but is taking place the vibration (oscillation) and squeeze of the ballast under the sleeper (Fig. 3).

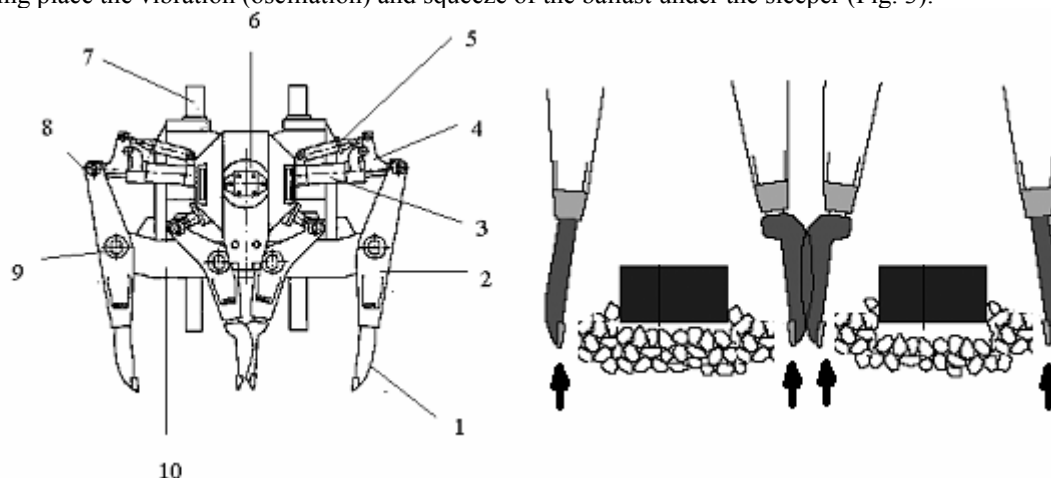


Fig. 2 Tamping mechanism: 1-tamping tool; 2-port tool; 3-hydraulic cylinder for squeeze movement; 4-mechanical limitation for squeeze movement; 5-pneumatic cylinder for mechanical limitation movement; 6- axle with eccentric for vibration movement; 7- guiding for vertical movement of the tamping mechanism; 8,9-joints; 10- chassis of the tamping mechanism

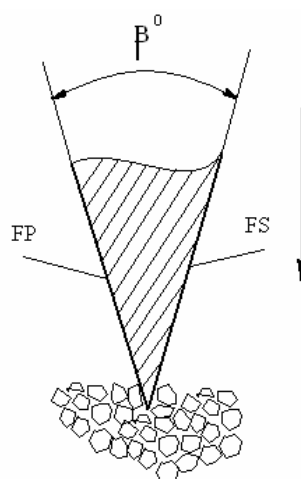


Fig. 3 FP – Main surface of active part of the tamping tool; FS – secondary surface; β – sharp angle

2. THE VERTICAL RESISTANCE FORCE OF THE BALLAST

To discover the resistance forces that is opposite on the penetration of active part of the tamping tool into the ballast [2], the resistance force system is view in the Fig. 4, with the functional angles. Regarding the opposite resistance of the ballast at the penetration of active part of the tamping tool, on the main surface FP and on the secondary surface FS, like an uniform charge and considering the result of these charges like a force perpendicular on the surface center:

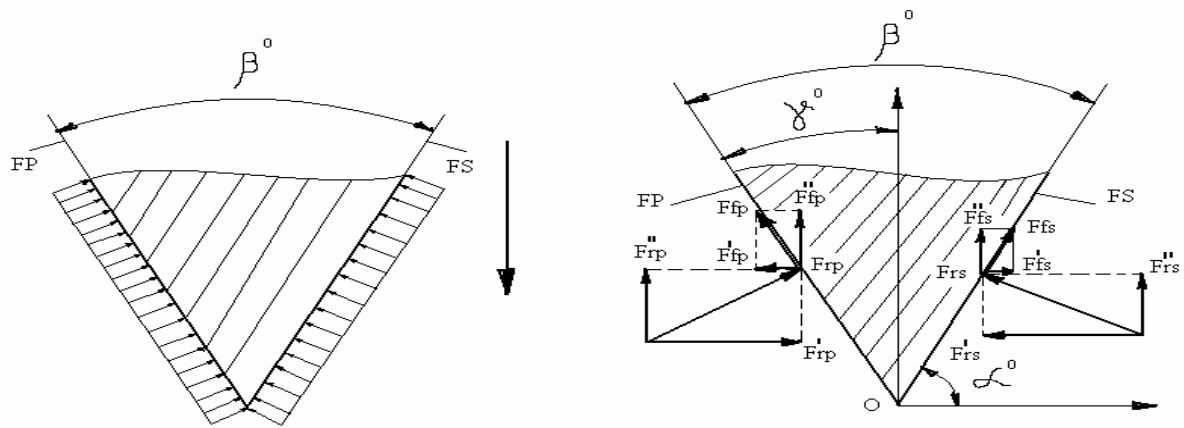


Fig. 4 The resistance force system, with functional angles, for determine the resistance force of the ballast

Thus, on the main surface and on the secondary surface appears a resistance force at the penetration of the tamping tool into the ballast:

$$Fr_p = p \cdot Ap; \quad F'r_p = p \cdot Ap \cdot \cos \gamma; \quad F''r_p = p \cdot Ap \cdot \sin \gamma \quad (1)$$

$$Ff_p = \mu \cdot Fr_p = \mu \cdot p \cdot Ap; \quad F'f_p = \mu \cdot p \cdot Ap \cdot \sin \gamma; \quad F''f_p = \mu \cdot p \cdot Ap \cdot \cos \gamma \quad (2)$$

$$Fr_s = p \cdot As; \quad F'r_s = p \cdot As \cdot \sin \alpha; \quad F''r_s = p \cdot As \cdot \cos \alpha \quad (3)$$

$$Ff_s = \mu \cdot Fr_s = \mu \cdot p \cdot As; \quad F'f_s = \mu \cdot p \cdot As \cdot \cos \alpha; \quad F''f_s = \mu \cdot p \cdot As \cdot \sin \alpha \quad (4)$$

μ – the friction coefficient between the ballast and the tamping tool ($\mu = 0,5 \div 0,7$ steel-ballast)

p – the pressure into the ballast ($p \leq 2 \text{ N/mm}^2$)

Ap – the main surface area

As – the secondary surface area

α, β, γ – the functional angles of active part of the tamping tool

Similarly, the resistance forces on the lateral surfaces:

$$Fr_l = p \cdot A_l; \quad F'r_l = p \cdot A_l \cdot \sin K; \quad F''r_l = p \cdot A_l \cdot \cos K \quad (5)$$

$$Ff_l = \mu \cdot Fr_l = \mu \cdot p \cdot A_l; \quad F'f_l = \mu \cdot p \cdot A_l \cdot \cos K; \quad F''f_l = \mu \cdot p \cdot A_l \cdot \sin K \quad (6)$$

A_l – the lateral surfaces areas

K – the functional inclination angle on the lateral surfaces

The lateral surfaces areas are usually equals, so results that the resistance forces on the two lateral surfaces are equals too.

The inertial force of the ballast Fi at the penetration of the tamping tool into the ballast is determined considering the weight of the ballast from the active part surface of the tamping tool – m_p and the acceleration of the tamping tool, at the penetration into the ballast:

$$Fi = m_p \cdot a_t \quad [N] \quad (7)$$

$$m_p = \rho \cdot V = \rho \cdot L \cdot At \quad [kg] \quad (8)$$

ρ – the ballast density $\rho_{\min} = \min. 2400 \text{ [kg/m}^3\text{]}$

L – the penetration drive of the tamping tool into the ballast $L = 0,3 \text{ [m]}$

A_t – the transversely section area of the tine, on the penetration direction into the ballast

$A_t = 140 \cdot 30 \text{ [mm}^2\text{]} = 4,2 \cdot 10^{-3} \text{ [m}^2\text{]}$ – the transversely section area of tine of the tamping tool P & T 09-32 type

a_t – the acceleration of the tine, at the penetration into the ballast

F_t – the penetration force of the tamping mechanism into the ballast (maximum force for one tool) [N]

$$F_t = m \cdot a_t \Rightarrow a_t = \frac{F_t}{m} \text{ [m/s}^2\text{]} \quad (9)$$

$$F_t = F + G = p_1 \cdot S + m \cdot g \quad (10)$$

$$a_t = \frac{p_1 \cdot S + m \cdot g}{m} \quad (11)$$

p_1 – pressure in the hydraulic cylinder which actions on the tamping mechanism to penetrate the tamping tools into the ballast

S – the stroke area

m – total weigh of the tamping mechanism, including the tamping tools

g – the gravitational acceleration

$$F_i = m_p \cdot a_t = \rho \cdot L \cdot A_t \cdot \frac{p_1 \cdot S + m \cdot g}{m} \quad (12)$$

In comparison with the tamping mechanism weight ($m = 1,5 \div 2 \text{ to}$), the ballast weight m_p is some kg and the inertial force F_i of the ballast is the decimal order of N, so it can be ignored in comparison with the other resistance forces.

The total resistance force Fr_v at the penetration of active part of the tamping tool into the ballast:

$$Fr_v = F''r_p + F''r_s + F''f_p + F''f_s + 2 \cdot (F''r_1 + F''f_1) + F_i \quad (13)$$

$$Fr_v = p \cdot A_p \cdot \sin \gamma + p \cdot A_s \cdot \cos \alpha + \mu \cdot p \cdot A_p \cdot \cos \gamma + \mu \cdot p \cdot A_s \cdot \sin \alpha + 2 \cdot (p \cdot A_l \cdot \cos K + \mu \cdot p \cdot A_l \cdot \sin K) + \rho \cdot L \cdot A_t \cdot \frac{p_1 \cdot S + m \cdot g}{m} \quad (14)$$

From the relative force analyses Fr_v , it is noticed that for the values less than one of the friction coefficient μ and ignoring the value F_i , it is shown that Fr_v takes minimum values when: $\gamma = 0$; $\alpha = \pi/2$ and $K \geq \pi/2$. From the constructive point of view, for $\gamma = 0$ and $\alpha = \pi/2$ that might mean that the main and secondary FP and FS are superimposed (theoretical case) or that FP and FS are parallel.

On the other hand, during the tamping operation of the ballast, to obtain a maximum force on the main surface FP of the tine, it's ideal that the angle $\gamma = 0^\circ$ for all tamping course. How $\gamma \neq 0^\circ$ all the tamping course, because of the circle track it is necessary that the γ_e angle to take values closed to 0° the entire tamping course. This thing is possible if $\gamma_e = [-\theta/2, +\theta/2]$ where θ – is the center angle of the circle described by the track of the tamping tool.

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