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Cristinel S. Besleaga, Radu Mihai Negriu, Ionel I. Popescu, Sorin George Badea

CASE STUDY REGARDING THE TAMPING TOOL TYPE BNRI 85

ANALIZA LOMA ALATA ZA NABIJANJE TIPA BNRI 85

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Author's address:
SC ECONET PROD SRL Bucharest, Romania

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- tamping tools
- stress
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- CAD (computer aided design)

Abstract

The geometry of a railway is obtained through tamping operation. The tamping operation is one of the most important operations for building and maintenance of railway and is executed with the help of different tamping tools, like BNRI- 85 tamping tool. This type of tamping tool comes in different models. We have improved this type of tamping tool to decrease stress, tension concentrators, fatigue, wear and breakages. We used two methods. One of them was to make and test a new model of tamping tool BNRI- 85, under real workplace conditions. For the second method we used a CAD programme to design and verify this new model of tamping tool. Using these two methods, we could determine critical areas, the wear mechanism, potential breakage sections and compare the results in order to improve this new tamping tool. Because the tamping operation involves vibration movement, we have determined the eigen frequencies of the tamping tool through the CAD method, establishing that the resonance phenomenon does not appear. For the active part of this tamping tool we used tungsten carbides scrap to increase the consistency.

Ključne reči
- alat za nabijanje
- napon
- ispitivanje
- CAD (računarsko projektovanje)

Izvod

Geometrija železničkih šina se ostvaruje operacijom nabijanja. Operacija nabijanja je jedna od najvažnijih operacija za izgradnju i održavanje železničkih šina i izvodi se pomoću alata za nabijanje, kao što je alat za nabijanje BNRI- 85. Ovaj tip alata za nabijanje postoji u više modela. Mi smo poboljšali ovaj tip alata za nabijanje kako bi smanjili napon, koncentratore zatezanja, zamor, habanje i lom. Upotrebili smo dve metode. Jedna je upotrebljena za izradu i ispitivanje novog modela alata za nabijanje BNRI-85 u stvarnim radnim uslovima. A druga metoda se sastojala iz CAD programa za projektovanje i proveru ovog novog modela alata za nabijanje. Korišćenjem ove dve metode u stanju smo da odredimo kritične zone, mehanizam habanja, potencijalne preseke za lom i da uporedimo rezultate u cilju poboljšanja ovog novog alata za nabijanje. Kako u operaciji nabijanja postoje vibracije, odredili smo sopstvene frekvencije alata za nabijanje CAD metodom, pri tom utvrđujući da se ne javlja fenomen rezonance. Kao aktivni deo ovog alata za nabijanje, upotrebili smo otpatke karbida volframa radi povećanja trajnosti.

INTRODUCTION

Tamping is a technological operation for maintenance of the railway and is made with tamping machine like BNRI 85 (Fig. 1). Mechanised tamping consists in the vibration and squeeze of the ballast, under the inferior part of the sleeper, at frequencies of 35 Hz, amplitude of oscillation 3–5 mm and the force of about 10 kN, using tamping tools (Fig. 2). The tamping tool works similarly as cutting tools, with the difference that during the technological tamping process does not result in splinters. The old model of tamping tool BNRI 85 is presented in Fig. 3. The use of this old model has met some of the failures which are presented in Fig. 4.

Figure 1. Tamping machine type BNRI 85
Slika 1. Mašina za nabijanje tipa BNRI 85

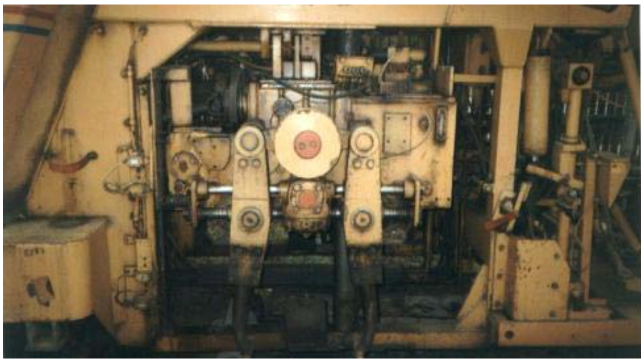


Figure 2. Tamping mechanism with an old model of tamping tool.
Slika 2. Mehanizam za nabijanje sa starim modelom alata

Figure 3. A lot with the old model of tamping tools type BNRI 85.
Slika 3. Skup starih modela alata za nabijanje tipa BNRI 85

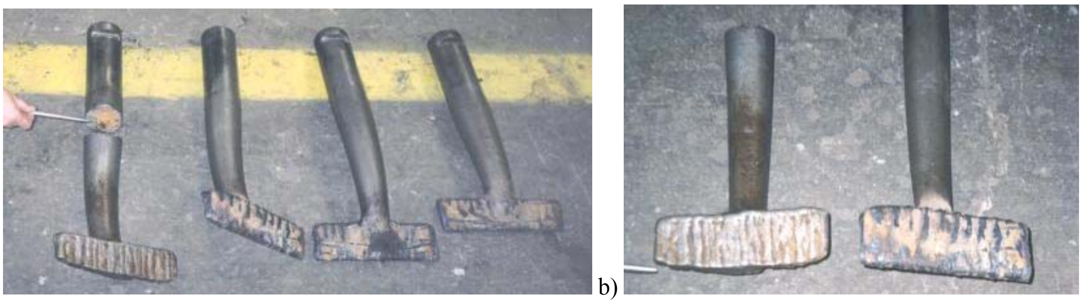


Figure 4. a) b) Failures of old model of tamping tool type BNRI 85
Slika 4. a) b) Lom starijih modela alata za nabijanje tipa BNRI 85

NEW MODEL OF TAMPING TOOL BNRI 85

For improving design and behaviour of old tamping tools BNRI 85 a new model of tamping tool BNRI 85 is proposed (Fig. 5). For the testing of the new model of tamping tool BNRI 85 in real conditions, in the workplace, we made some new tamping tools which are presented in Fig. 6.

The simulation of mechanical stresses of the new model of tamping tool (Fig. 7) is achieved by means of two complex aided design programmes ANSYS /1, 2/, in collaboration with the Thermal Research Centre, from the Faculty of Mechanical Engineering and Mechatronics of the Polytechnic University in Bucharest.

The cases of stressing presented (Case 1 and 2) represent extreme cases – the situation of actual values being situated between these values (Figs. 8–11).

THE FAILURE MECHANISM

The main mechanism of failure is wear. The mechanism is as follows:

- Contact between the active part of the tamping tool and the stone leads to a local failure caused by a tension state equivalent to values much higher than the breaking limit of the material (we can approximate that the situation applies up to a contact between the tamping tool and about 5-7 stones);
- The equivalent stress value is greater if the rock is sharper;
- A cutting phenomenon of the surface of the active part of the tamping tool determined by the corners of the stone takes place during the tamping tools work movement. Thus the first cut is made on the surface of the tine;
- The following contacts tamping tool – stones create new cuts. There is a statistical probability that the following cuts could be near an already made cut and if the distance is small enough, they will join.

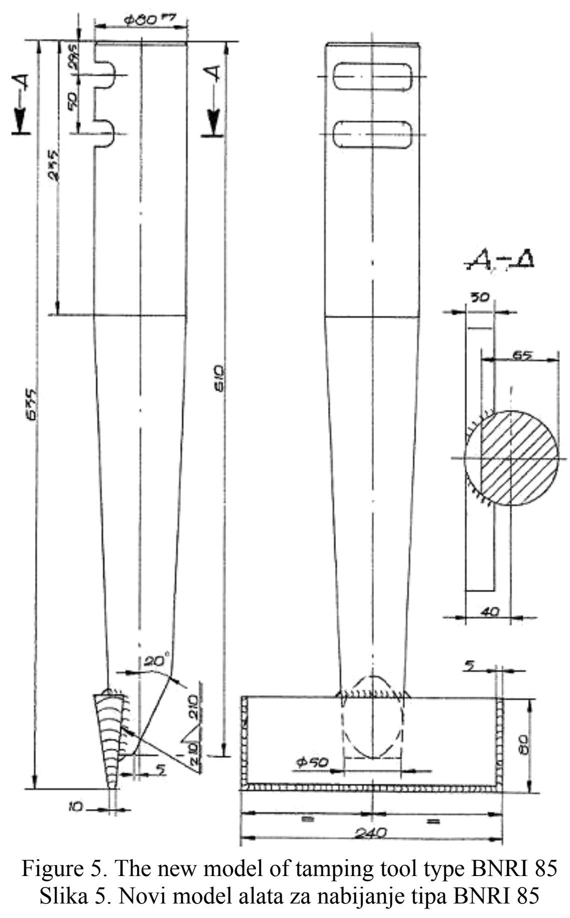


Figure 5. The new model of tamping tool type BNRI 85
Slika 5. Novi model alata za nabijanje tipa BNRI 85

Figure 6. A lot with the old model of tamping tools type BNRI 85
Slika 6. Skup starijih modela alata za nabijanje tipa BNRI 85

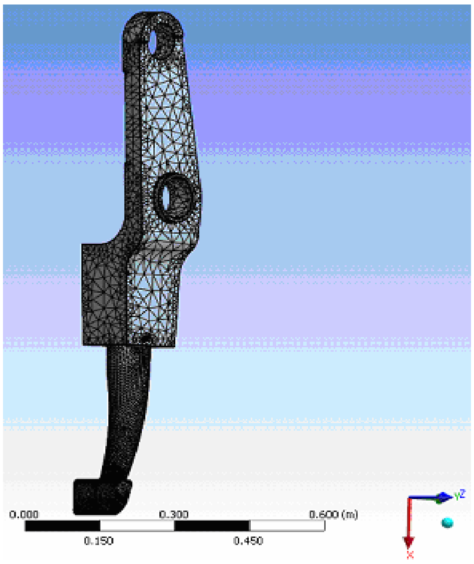


Figure 7. Mesh and model of new tamping tool type BNRI 85.
Slika 7. Mreža i model novog alata za nabijanje tipa BNRI 85

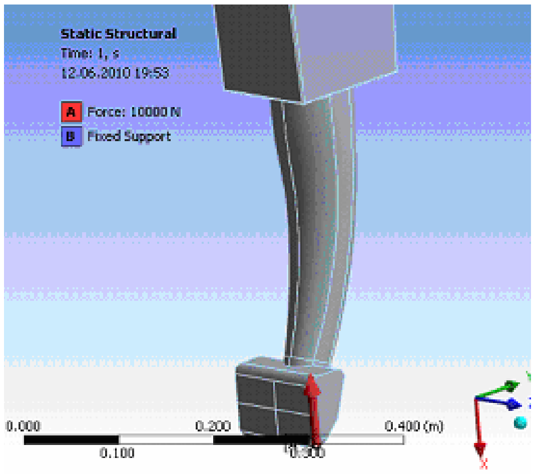


Figure 8. Case 1 of extreme stress determined by the force in the vertical movement of the tamping tool.
Slika 8. Slučaj 1 ekstremnih napona određenih silom pri vertikalnom kretanju alata za nabijanje

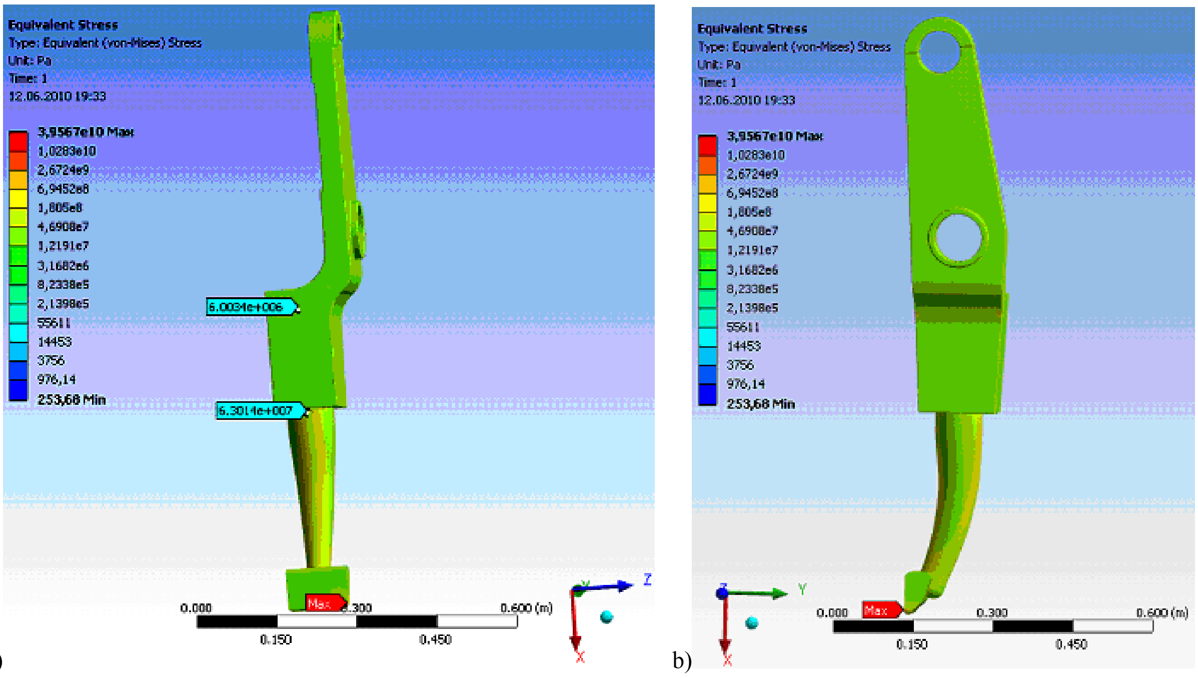
a)


Figure 9. a) b) Stress state determined with von Mises criteria, for case 1.
Slika 9. a) b) Naponsko stanje određeno kriterijumom fon Mizesa, za slučaj 1

One of the most frequent questions that has not found an adequate answer up to the present is that whether the specific operating frequency f = 35 Hz and, at the same time, an important constituent part of the tamping technological process, overlaps one of the eigen frequencies of the tamping tool at the risk of occurring a resonance phenomenon.

Eigen frequencies for the first three vibration methods are presented in Fig. 12.

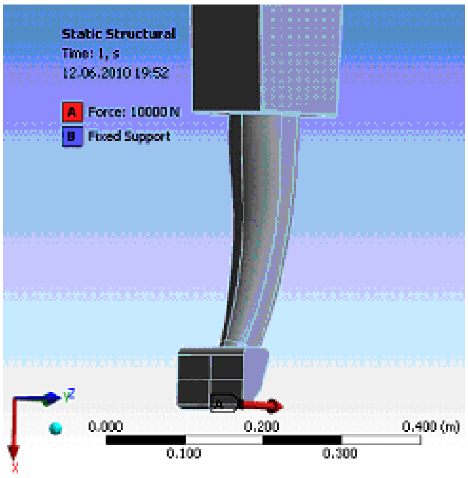


Figure 10. Case 2 of extreme stress determined by the force in the horizontal movement of the tamping tool.
Slika 10. Slučaj 2 ekstremnih napona određenih silom pri horizontalnom kretanju alata za nabijanje

From the performed analysis, after establishing the 3 eigen frequencies (173.81 Hz, 248.71 Hz, 568.41 Hz) of the new tamping tool BNRI- 85 type, it can be concluded, that the operating frequency $f = 35$ Hz is not found in any of the ranges (0.8–1.2) from the values of those three eigen frequencies and, therefore, there is no danger of resonance phenomena occurrence. From the analysis of results presented in Figs. 9 and 11, one can conclude:

– Besides the areas around the points of application of concentrated forces, the stress condition is inferior to the allowable limits;
– In the areas around the points of application of concentrated forces (these concentrated loads simulate the application of force through a tip of a stone in contact with the tamping tool), the tension condition exceeds the allowable limits of the tension condition – this situation explains the “deterioration” by loss of material (wear), that occurs during the actual operation (the tip of the stone is practically “splitting” the tamping tool).

a) b)

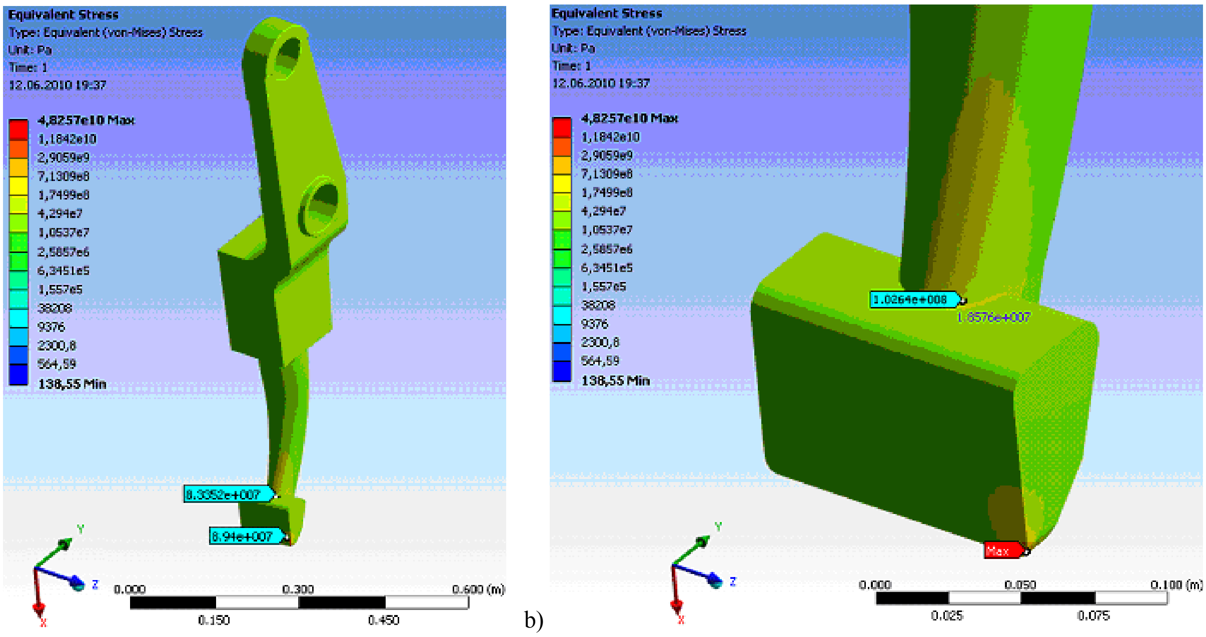


Figure 11. a) b) Stress state determined with von Mises criteria, for case 2.
Slika 11. a) b) Naponsko stanje određeno kriterijumom fon Mizesa, za slučaj 2

– If the crushed stone is strongly clogged or the tamping tool meets in its working motions objects/materials, that are found accidentally in the ballast prism (track material, concrete railway sleepers or pieces, rails or pieces) even though the speed of running- in (and possibly in horizontal motion, too) of the tamping tool/ tamping tine is “quite low”, the occurrence of a shock stress situation could be taken into consideration. This type of stress leads to appearance of some higher values of the stresses – what leads to the increase of equivalent tension values and, consequently, it will cause deformation of the tamping tool until obtaining forms that can render it useless or even in the case of this type of repeated stresses, breaking of the tamping tool may occur. It can be seen that the deformations obtained by modelling, coincide with those that can be actually met. Breaking or intense damage of the tamping tool can also be caused by repeated deformation of the tool. In case the tool is being distorted, the tension condition is different at a new stress, because the “model” is different and the forces (even if they have the same value) lead to other tension and deformation conditions.

NEW COMPOSITE MATERIAL FOR TINES

We made a new composite materials with improved characteristics in terms of wear /3-7/, obtained by infiltration of refracted particles of hard metal having the contact metal (Co, Ni) in a melted metal matrix (steel alloy) to achieve the tines of tamping tools.

Through this process composite materials can be made characterised by high compressive strength, hardness, excellent resistance to abrasion that can be prepared by infiltration of angular or spherical granules of refractory hard materials with different melting alloys in a temperature range of 1450–1550°C.

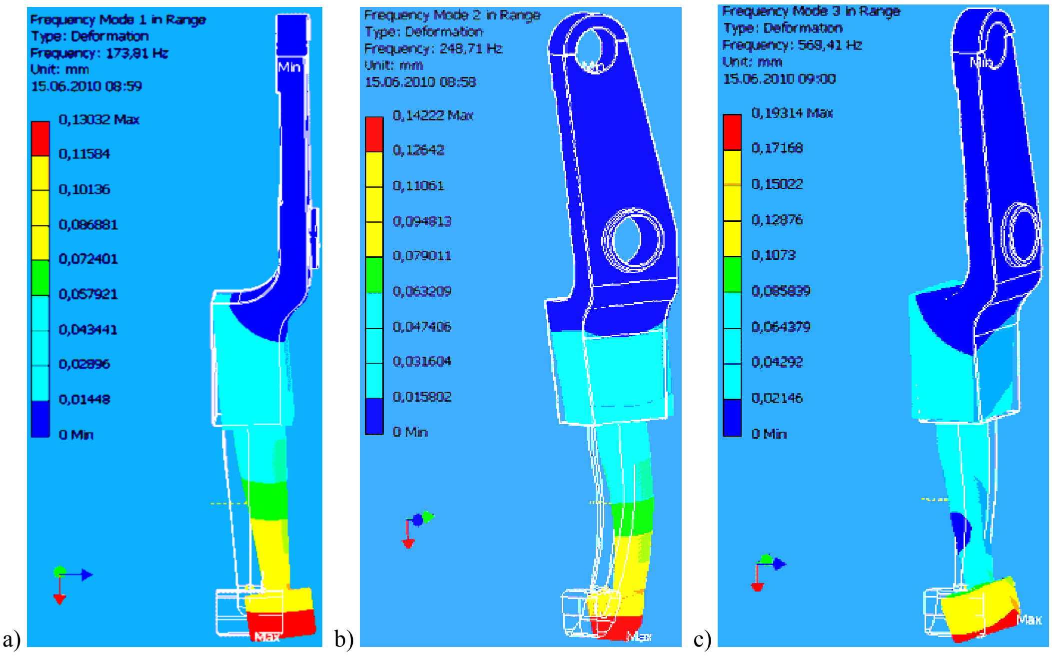


Figure 12. a) b) c) The eigen frequencies of the new tamping tool model.
Slika 12. a) b) c) Sopstvene frekvencije novog modela alata za nabijanje

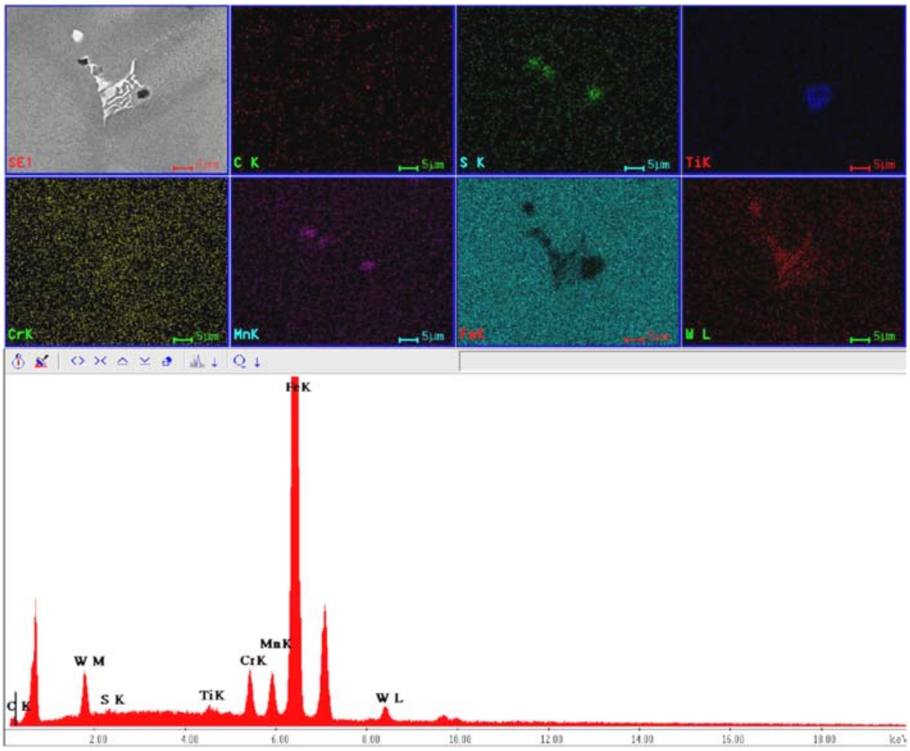


Figure 13. Microstructure of the new composite material for the active part (tine) of the tamping tool.
Slika 13. Mikrostruktura novog kompozitnog materijala za aktivni deo (zub) alata za nabijanje

In a melted state, they have the potential of wetting the angular or spherical granules of hard metals, obtaining a composite material with a hard metal structure in the contact area with the aggregates with a minimum of 580–610 HB.

Metallographic studies and tests on matrix metal infiltration allow the production of composite materials that have superior physical and mechanical properties than the known steels and effective results are obtained by infiltrating granules under conditions leading to the precipitation of crystals of hard metals in the metal matrix as the infiltrated mass is cooled.

These crystals, as cooling of the composite mass occurs, lead to the formation of a material that contains a hard metal structure, having the content of inter-granular spaces filled with the designed metal matrix. This material is more resistant to abrasion, erosion and other types of wear than other earlier materials containing particles of hard metal (WC), refractory and bonding metal (Co, Ni) in the form of plates.

Preferred metals are those containing metals from the eighth group, fourth series of the periodic table that melt at temperatures of 1450–1500°C. The projected composite metal matrix is melted beyond the melting point of the bonding metal (Co, Ni) from the compound of metal carbides scrap, and it is poured into pre-heated form.

The designed metal matrix can contain, besides Fe (balance metal), Co, Ni, Mn, Cr, Mo, Al, Cu, P, Si and S, elements leading to melting point reduction, increased hardness and wetting of hard metals (W, Nb, V).

The making of tamping tool tines reinforced with metal carbides scraps in mixture with melted tungsten carbide in a metal matrix made from a steel alloy has the following advantages:

- leads to the increase of consistency of tamping tools;
- leads to lower operating costs;
- possibilities for reconditioning the tines the tamping tools;
- increase of the utilization factor of the tamping machine and an increase of the tamping operation productivity;
- ensures an adequate quality of the tamping operation;
- increases the utilization time of tamping tools.

The characteristics of the composite material with a metal matrix with reinforcement of tungsten carbide particles obtained from waste grinding tungsten carbide with contact metal (Co/N) are presented:

- breaking resistance at traction = 917–925 N/mm²;
- flow limit = 651–662 N/mm²;
- breaking elongation A_5 = 13–14.8 %;
- KCV resilience 300 = 241–259 J/cm³;
- Brinell hardness = 580–610;
- Wear resistance: squeeze of ballast 14.85 g/Km tamping, microDeval abrasive wear coefficient = 13.85%.

Microstructure area corresponding to the tine is shown in Fig. 13.

The consistency of the old model (B21- B28 and B21 (R1)-B28 (R1)) with classic materials and the new model (G4, G6, G8 (7)) with new material for the tine tamping tool BNRI 85 is presented as wear curves in Fig. 14.

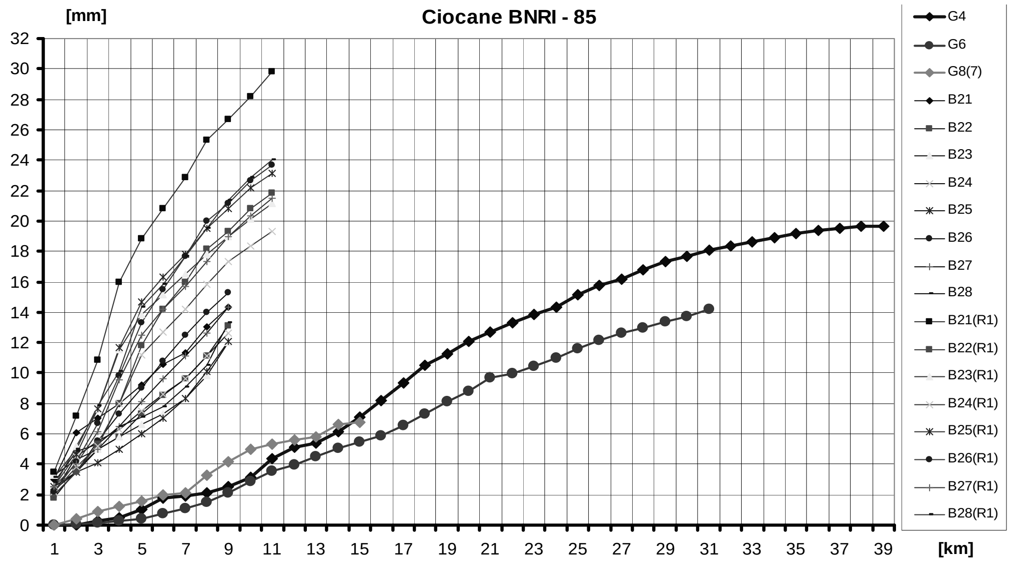


Figure 14. Wear curves of the active part (tine) for the experimental tamping tool.
Slika 14. Krive habanja za aktivni deo (zub) eksperimentalnog alata za nabijanje

CONCLUSIONS

Designing a tamping tool and checking of this, to the different stress level with especially CAD software may offer many advantages, possibilities and reduce a lot of time and more accurate results.

- The new composite material with tungsten carbide, which we have proposed, has a good potential and good properties for wear, being cheap and using the waste from different damaged parts of tungsten carbides.
- In comparison, the average of weariness of tamping tools, after 9 km, with new composite material (with tungsten carbide) for the tine (lot 1: G4, G6, G8 (7)) is 4.5 times smaller than the average of weariness of new tamping tools (lot 2: B21–B28) and 6.5 times smaller than the average of weariness of reconditioned tamping tools (lot 3: B21 (R1)–B28 (R1)). In the end, the average of consistency for lot 1 (G4, G6, G8 (7)) is 2.8 times bigger than the average of consistency for lot 2 (B21–B28) and lot 3 ((B21 (R1)–B28 (R1)). This fact gives the possibility to reduce the cost of the tamping tool, the tamping operation and the maintenance of railways.

REFERENCES

1. Popescu, I.C., Introduction in computer aided analysis of the process equipments, Printech Publisher, ISBN 973-652-951-7, Bucharest, 2004.
2. Popescu, I.C., Prisecaru, T., Finite elements Analysis of Pressure Equipment, Computer Aided Engineering Solutions for Design, Analysis and Innovation, (ANSYS & FLUENT User Group Meeting), 26-27 April 2007, Sinaia.
3. Georgeoni, P., Arnici, N., Popescu, I.C., *Using the isostatical pressing at the manufacturing of big machine parts by high performances from sintered metallic carbides*, Metallurgical Researches, ICEM, Vol.26, pp.463-475, 1985, Bucharest.
4. Georgeoni, P., Popescu, I.C., *Considerations regarding to manufacturing of machine parts from metallic carbides type WC-Co with A.I.P. destination*, Metallurgical Researches, ICEM, Vol.26, pp.477-483, 1985, Bucharest.