New treatment Nanotechnology for Hardening Steels, Ceramics and Diamond Materials

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The main purpose of this work is the development of simple, inexpensive and high productive method for hardening ready-made parts and tools made from steels, hard alloys,ceramics and diamond materials to obtain high service and anti-friction properties.

The new hydro chemical treatment method (HCT) includes the two processes:

(1) Chemical Treatment of the surface in water dispersive and nanocompositions of superhard, refractory and wear-resistant materials (oxides, carbides, diamond, graphite, etc.) at temperature of 95–100 °C for 20–60 min (2) subsequent Heat Treatment at temperature of 130–200 °C for steel surface and at 1030–1050 °C for ceramic surface during 30–60 min.

The HCT process has a dual strengthening effect. First, solid lubricant nano-structure thin-film (about 0.5 μm) coatings are formed. Second, in materials at a depth of 1 mm; a zone of compression stress (180–470 MPa) is formed. The observed phenomena can be explained within the Rebinder effect and others.

The proposed HCT method has the advantages over the known processes:

1. The process is simple, traditional equipment are used;
2. After processing the initial structure and dimensions of items do not change;
3. The coatings are formed on steels, hard alloys, diamond and other materials;
4. The process has high productivity by using a chemical bath of an arbitrary size;
5. The technology is energy-efficient: electric current on surface is not required;
6. The process is inexpensive: additional expenses are 1–10% of items cost;
7. The friction coefficient of solid coatings without lubrication is 0,07–0,11;
8. High thermal stability of nano and nanocomposite structures for coatings (up to 1050 °C);
9. After resharpening, the tools retain up to 80–100 % of wear resistance.

Optimization of the active composition and temperature – time parameters of the processes were performed for the friction coefficient of the films on tool steel and hard alloy. The diagrams “property vs. process parameters” were plotted using the obtained mathematical expressions. Treatment with optimal regimes permits decreasing the friction coefficient of the tool steel surface in 8,3 and hard alloy surface in 3,9 as compared with untreated (Fig. 1).

Results of the technology testing in industry are the following:

Increase of service life of processed tools and parts

Item	*Company name*	k_w
mills(HSS)	*“Motovelo” (Belarus)etc.*	**2 – 8**
screw taps(HSS)	*“VUHZ” (Czechia), “Daewoo”(Korea) etc.*	**1.7 – 4.8**
band saws(HSS)	*“VUHZ” (Czechia) etc.*	**2.5 – 3**
drills(HSS)	*“Stock” (Germany), “PS” (Slovakia) etc.*	**1.8 – 4.2**
knives(HSS)	*“Skloplast” (Slovakia)etc.*	**1.9 – 2.2**
stamps	*“ZVL-LSA” (Slovakia)etc.*	**1.8 – 3**
diamond drills, tool-grinding wheels	*“BELAZ” (Belarus)etc.*	**1.8 – 3.5**
disposable hard alloy pellets		
used for turning	*“SALUT”(Russia), “Dynatherm”(India) etc.*	**1.5 – 4.5**
used for milling	*“BELAZ”, “Motovelo” (Belarus) etc.*	**1.5 – 3**
hard alloy draw plates	*“BMZ” (Belarus)etc.*	**1.5 - 2**
bushes of dump-track BELAZ	*“BELAZ” (Belarus)*	**1.5 – 2**

Application of the process in industry requires minor expenses.
The process is used by several enterprises in Belarus and Russia.

Friction pair: material to be tested (plain surface) - ШХ15 steel (∅4 mm sphere)

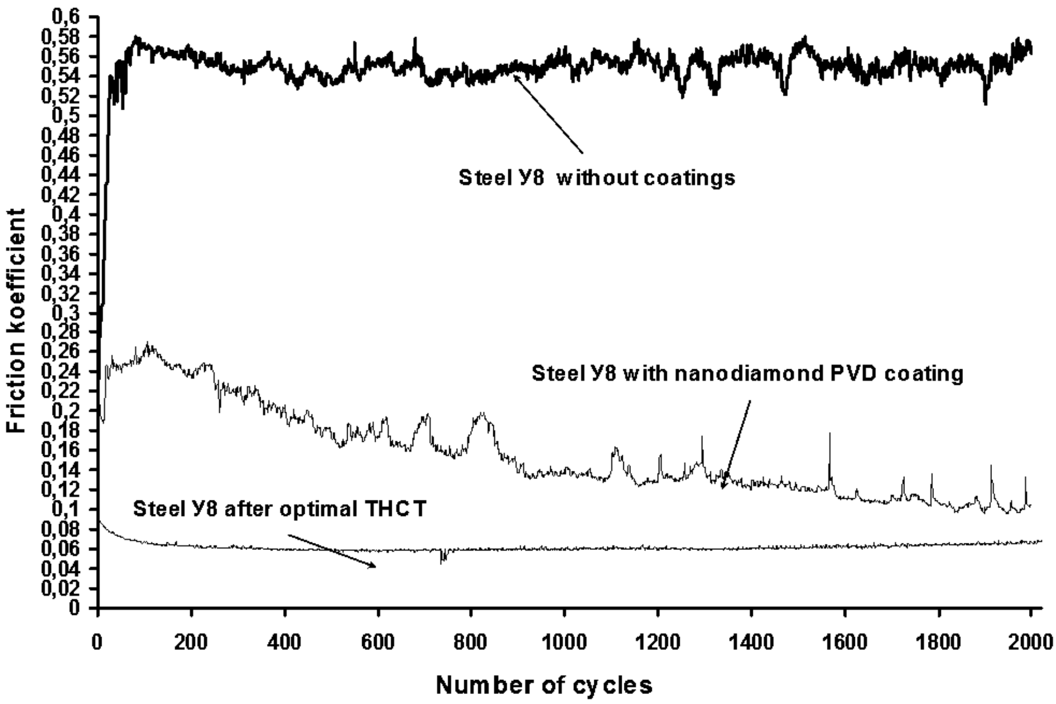

Fig. 1 – Comparative diagram of friction coefficient changes due to wear-and-tear lifespan of (a) tool steel and (b) hard alloy prior to and after THCT at dry sliding friction (without lubrication):
Test conditions: 1 H load; stroke length (track) - 3 mm, speed - 4 mm/s

Friction pair: material to be tested (plain surface) - ШХ15 steel (∅4 mm sphere)