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Galvanizing treatment as a method to protect tools used in teaching processes

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Abstract: *Galvanizing treatment as a method to protect tools used in teaching processes.* This paper presents the use of zinc coating applied on surfaces of wood machining tools – exhibits in teaching processes. Analyses were conducted to determine resistance of applied coatings to the action of various environments, which in an accelerated manner assessed suitability of coatings as a method of tool protection, mainly in terms of their contact with users. Very advantageous effects of zinc coating application were observed in the analyzed variant. Galvanizing processes and the resulting coatings made it possible to identify defects in the material structure of the tools, being the most frequent results of intensive operation and wear.

Key words: zinc coatings, wood machining tools, teaching exhibits

INTRODUCTION AND AIM OF STUDY

Teaching processes concerning general characteristics of wood machining tools consist mainly in analyses of the structure, assessment and measurements of blade stereometry, methods to prepare tools for work, selection of machining tasks and technical tests. Teaching processes concern new tools, tools used under normal production conditions as well as old generation tools and other metal exhibits.

Tools and their blades are made from the types of metal materials which are suitable for their intended applications, thus exhibiting different properties, first of all aiming at optimal operation and cutting effects. In order to increase performance parameters of tools numerous studies are conducted, resulting in blade surface coating with novel anti-wear coatings [1], [2]. It was stated in papers [3] and [4] that the use of hard coatings such as CrCN/CrN greatly increases blade life and enhances quality of machined wood surface.

Another problem is connected with the presentation and use of tools in teaching processes. Factors markedly affecting wear of tools used as exhibits include environmental conditions and human exposure (touch, sweat, frequent movement of exhibits, etc.). Contact with users results in visible corrosion marks and other damage, which considerably reduce the presentation value and technical parameters of tools.

In order to extent life of such tools, apart from appropriate teaching presentation conditions, various forms of protection may be used. Long-term and effective methods include ways to protect exposed tool surfaces using different protective coatings.

According to [5], the technology of electrolytic coating makes it possible to apply almost all metals as coating materials, on condition it is physically possible to introduce their ions to electrolyte solutions. The primary purpose of coating is to protect tools against electrochemical corrosion. Coatings are divided into cathodic and anodic. Anodic coatings offer good protection of the native material thanks to the electrochemical action. A wide range of applications of anodic coatings is provided by zinc protection coatings.

The mechanism of protective action of electrolytic coatings is determined by the type of underlying metal and the coating [6].

It was decided in this study to analyze suitability of zinc electrolytic coatings in terms of protection of wood working tools, mainly old generation tools used as exhibits in the teaching process.

The objective of galvanizing treatment was to obtain advantageous visual parameters of tools and to protect tools against environmental factors and factors resulting from contact with users (sweat, dirt, fat, scratches, etc.).

GALVANIZING

Tools and exhibits before the galvanizing process had numerous corrosion marks, fat stains and dulling and discoloration connected with use and exposure conditions. Prior to the galvanizing treatment the exhibits were degreased and digested. Digestion was performed in a very weak hydrochloric acid. Special adjustment agents were added in the digestion process and final washing.

Galvanizing was performed in a two-chamber vat with a zinc-free bath. At the height slightly below the bath liquid level special steel baskets were suspended, filled with balls (Ø ~40 mm) of pure zinc (99.9% Zn), (anodes, suspended in the bath). Zinc balls were dissolved in the bath using sodium hydroxide. Current of 24V was flowing through the electrodes placed at vat margins. The drum with exhibits rotated at 3 - 4 min^{-1}. The composition of the alkaline galvanizing bath is given in Table 1.

Table 1. Parameters of galvanizing process

Zinc ions	12 g/l	Temperature	25 ºC
Sodium hydroxide	120 g/l	Cathodic current density	2,5 A/dm^2
Additives: Zinkaslot 52 Zinkaslot 53	15 ml/l 30 ml/l	Anodic current density (zinc anode)	1,5 A/dm^2

Zinced exhibits, washed in a washer with running distilled water, were transferred to bleaching in 0.5% solution of nitric acid and subjected to chromate treatment. Chromate treatment was run in order to increase corrosion resistance and provide decorative effects. Chromate treatment lasted for approx. 2 minutes. Immediately after chromate treatment elements were washed in two stages in vats with water.

Figure 1 presents selected tools subjected to the galvanizing process.

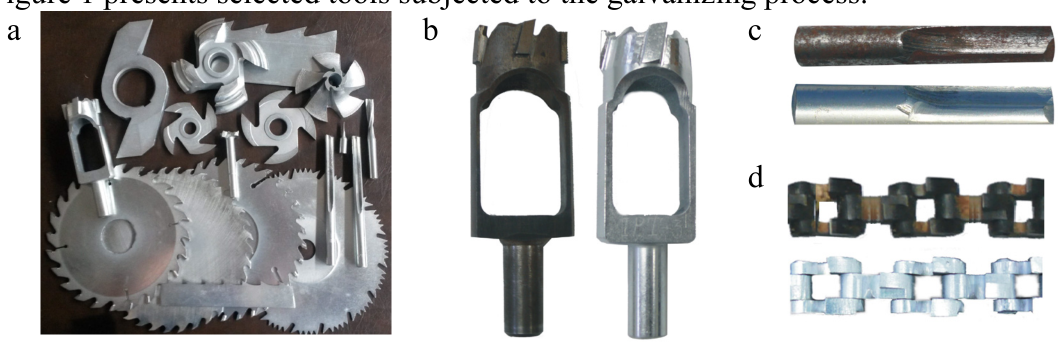

Fig. 1. Tools subjected to galvanizing process; a – tools exhibits after galvanizing; b, c, d - selected tools before and after galvanizing: cylindrical drill, shank cutter, mortising chain

RESISTANCE TESTING OF ZINC COATINGS

Literature sources and standards [7, 8] mention various methods to determine resistance of zinc coatings. This study focused mainly on accelerated failure methods, facilitating relatively accurate and rapid determination of resistance of zinc coatings covering tool surfaces. Original sample testing conditions, developed by the author of this study, were applied, mainly in terms of the effect of conditions connected with the subject of this study.

Resistance of zinc coatings was tested using a previously galvanized mortising chain. Specially cut sections of the mortising chain had surfaces with applied zinc coatings and raw surfaces, which facilitated comparisons in terms of resistance of zinc coatings.

Under laboratory conditions the prepared mortising chain sections (Fig. 2) were subjected to the action of water, salty water (20% NaCl solution) and acid water (20% citric acid solution). The effect of atmospheric conditions was analyzed by leaving mortising chain sections outdoors. Tests were conducted in the autumn period under varied temperature conditions and high humidity. Organoleptic and microscopic assessments of resistance to individual factors were conducted after 72, 336 and 504 h (after 3, 14 and 21 days, respectively). The conditions and percentage losses of coating were estimated.

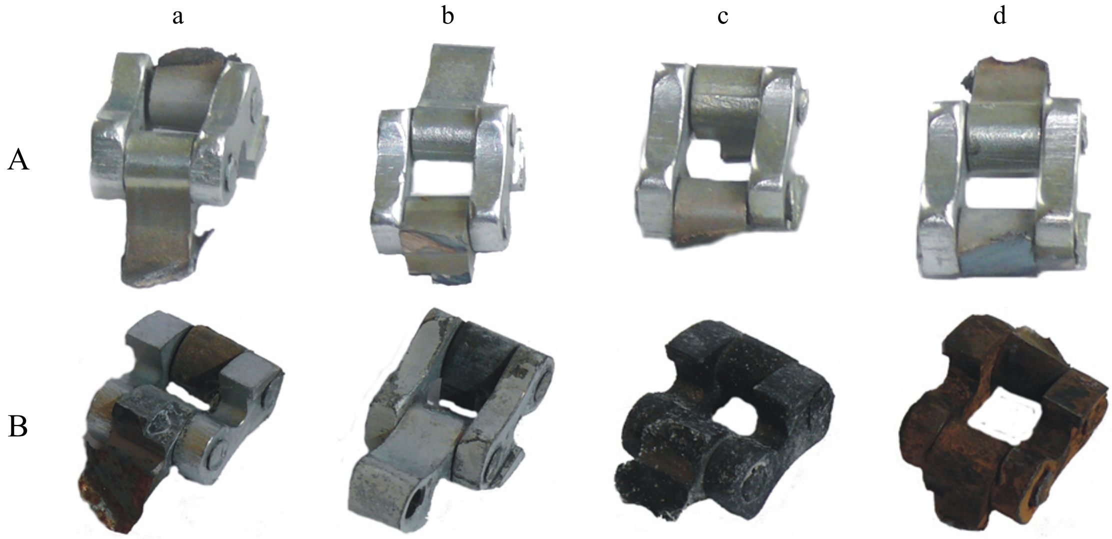

Fig. 2. Sections of mortising chain: A – prepared for resistance testing of zinc coatings, B – upon completion of testing cycle (504 h); a – atmospheric conditions, b – aqueous environment, c – salty water environment, d - acid water environment

Analysis of the effect of atmospheric conditions – upon the completion of the testing period (504 h) no marked damage was observed on coatings, except for slight color changes. Corrosion centers were found already after the first analysis (72 h) in places with no coating applied.

The action of the aqueous environment after 21 days caused slight dulling of coating. Corrosion centers appeared only in moving sections and on surfaces with no coating applied. On rounded and pointed surfaces marked signs of flaking were found on the zinc coating. Losses of coating after 21 days was estimated at 15%. After 3 days zinc coatings showed no changes in color, adhesion to the underlying surface or damage.

Testing of resistance to salty water showed that zinc coating did not provide adequate protection against aggressive salt ions. Analysis performed after 72 h indicated a relatively good condition of zinc coatings. After 14 days corrosion centers appeared on most coating surfaces, greatly damaging pointed and rounded surfaces. Larger flat surfaces showed slight dulling and color changes. Loss of coating amounted to 70%. After 21 days a total (100%) loss of the zinc layer and extensive damage to the base metal structure were observed.

The effect of acid environment showed limited resistance of zinc coatings. After 72 h corrosion centers started to appear on coating surfaces. Loss of coating was approx. 20%. After 14 days corrosion covered all analyzed surfaces. Acid environment damaged and destroyed applied zinc coatings in 100% and damaged (by pitting corrosion) the structure of metal constituting the mortising chain structure. The next stage of testing brought no major changes.

For the zinc coating applied on the flat surface of a section of cleaving saw testing comprised the action of nitric acid and sanding. Exposure of the surface of coating to concentrated nitric acid applied at 5 drops caused formation of a coating loss of approx. 20 mm in diameter, while the material of the saw body was not damaged (1) (Fig. 3A). Manual sanding of the coating (abrasive paper, aloxite, grit 400), using a typical operating pressure, caused dulling of coating with a large number of small scratches (2) (Fig. 3A).

Thickness of applied zinc coatings was measured using microscopy on specially prepared sections of the cleaving saw body with the applied zinc coating (Fig. 3B). Mean coating thickness was 55 μm.

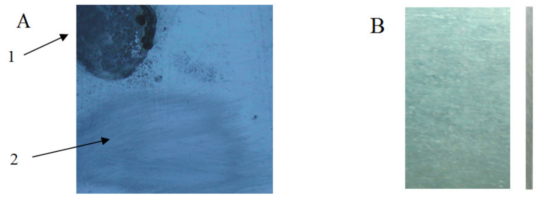

Fig. 3. A – surface of cleaving saw with applied zinc coating: 1 – the effect of nitric acid, 2 – the effect of sanding; B – section of cleaving saw prepared for coating thickness testing

MATERIAL DEFECTS

In the course of galvanizing processes the potential to detect material defects of tools and metal elements was observed. These defects are frequently formed during tool use and prevent further safe operation of wood machining tools.

Corrosion and impurities of surface in exhibits to be galvanized prevent detection of existing cracks and other damage as well as changes in the structure and color of metal. Defects and traces of wear on tools were detected in the first stage of galvanizing, during degreasing and digestion. The dissolved rust and removed grease particles revealed damage, thus facilitating preliminary assessment of the type and size of damage. Following the main galvanizing stage in the alkaline bath and after bleaching during chromate treatment distinct differences in color of applied coatings were observed. In sites of damage the material structure of the tools changed and electric conductivity deteriorated greatly, which considerably hindered the application of zinc coating.

Figure 4 presents examples of defects on the surfaces of tools and exhibits revealed during the galvanizing process.

Fig. 4. Examples of revealed defects on surfaces of tools and exhibits, a – cracks in the blade structure and color changes in working section of circular saw, b – site of regeneration in the surface of exhibit, c – changes in material structure in the site of mounting of the cleaving saw

CONCLUSIONS

Results of evaluation and testing indicate that the adopted and described technology of the galvanizing process used on the surface of tools and teaching exhibits guarantees the formation of effective protective coatings. Advantageous effects of surface protection were confirmed by the use of tools with described coatings in teaching processes over the last three years.

Surfaces of tools covered with zinc coatings, tested under the assumed environmental conditions, in comparison to uncoated surfaces, as analyzed in the period up to 72 h, are markedly more resistant to corrosion.

Performance of galvanizing processes makes it possible to detect latent material defects in the structure of tools and metal elements.

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7. Czermiński J. (1986): Poradnik. Ochrona Przed Korozją. Wydawnictwo Komunikacji i Łączności. W-wa.
8. PN-EN ISO 10289:2002 Metody badań korozyjnych powłok metalowych i innych powłok nieorganicznych na podłożach metalowych. Ocena próbek i wyrobów gotowych poddanych badaniom korozyjnym.

Streszczenie: *Procesy cynkowania w aspekcie zabezpieczania narzędzi w procesach dydaktycznych.* W pracy przedstawiono zastosowanie powłok cynkowych nanoszonych na powierzchnie narzędzi do maszynowej obróbki drewna stanowiących eksponaty wykorzystywane w procesach dydaktycznych. Przeprowadzono analizy odporności nanoszonych powłok na działanie różnych środowisk, które w sposób przyspieszony pozwalały określić przydatność powłok jako zabezpieczeń narzędzi, głównie w aspekcie kontaktu z użytkownikami. Stwierdzono bardzo korzystne efekty zastosowania powłok cynkowych w analizowanym zakresie. Realizacja procesów i efekty cynkowania umożliwiły rozpoznanie w strukturze materiału narzędzi, wad będących najczęściej efektem intensywnej eksploatacji i zużycia.

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