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ПЕРСПЕКТИВИ ЗАСТОСОВУВАННЯ АСИМЕТРІЙНИХ ОРГАНІЧНИХ КАТАЛІЗАТОРІВ ДЛЯ ПОЛІПШУВАННЯ ПОКАЗНИКІВ ПИЛЯННЯ ДЕРЕВИНИ СТРІЧКОВИМИ ПИЛКАМИ

На підставі заналізування хімійних явищ і перетворювання під час готування й експлуатування стрічкових пилок та ймовірного впливу на них асиметрійного органічного каталізатора передбачено й частково засвідчено можливість застосовувати модифікатора складу TREVITAN® під час зварювання і загострювання стрічкових пилок та під час пиляння ними деревини. Це вможливить підвищити довговічність пилок, якість пиляння й продуктивність роботи стрічковопилкових верстатів.

Ключові слова: *хімійні явища, стрічкова пилка, асиметрійний органічний каталізатор, зварювання, загострювання, пиляння деревини.*

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PROSPECTS FOR THE USE OF ASYMMETRIC ORGANIC CATALYSTS TO IMPROVE THE PERFORMANCE OF WOOD CUTTING BY BAND SAWS

Based on the analysis of chemical phenomena and transformations during the preparation and operation of band saws and the probable influence of an asymmetric organic catalyst on them, the possibility of using the TREVITAN®-composition modifier during welding and sharpening of band saws and during sawing wood with them has been predicted and partially confirmed. This will make it possible to increase the service life of the saws, the quality of sawing and the performance of band saw machines.

Key words: *chemical phenomena, band saw, asymmetric organic catalyst, welding, sharpening, wood cutting.*

Problem statement. For the past thirty years, band saws have been the leading machine tools for lengthwise sawing of logs into lumber.

The practice of using band saws shows that a number of factors affect wood cutting performance both at the stages of handling of saws (preparation of saws for operation) and during their operation.

The currently available technologies and methods for handling and operating machines have a number of drawbacks, which leads to a deterioration in the quality, accuracy, and wood cutting performance. The processes of welding band saws, sharpening their teeth, and sawing wood are accompanied by physical and chemical phenomena caused by the interaction of two solid bodies, as well as by the design and technological features of the cutting mechanism of band saws.

The wood on such machines is sawn with a saw in the form of a flexible steel band of a certain length with teeth on one or both longitudinal edges and its opposite ends welded together, forming a one-piece ring-shaped band. On the machines, the saw is mounted on two metal pulleys, giving it the necessary tension and motion trajectory. During sawing, in contact with the driving and driven pulleys, the saw is subjected to continuous unidirectional bending loads, and due to friction between the saw kerf surfaces with sawdust residues, the saw body heats up. This can cause cracks and blade breakage, which can affect cutting performance and the service life of the tool. In order to prevent overheating of the saw body, an aqueous solution is fed into the cutting area. A aqueous-cooling solution is also used during sharpening of the band saw teeth

While the physical phenomena in these processes have been partially investigated, the specific features of chemical phenomena have been hardly studied.

Thus, the optimal operation of band saws is subject to the mutual influence of organic and inorganic material factors in the technological components of band saw formation and its mechanical contact with wood during sawing.

To identify and investigate the components of positive and negative effects on the saw body during these processes, in order to isolate and develop the positive ones, is a complex task that requires the use of innovative means of both methodological and experimental content.

In this context, it would be appropriate to investigate how the use of asymmetric organic catalysts, which are currently effectively used in the agrochemical [1, 2, 3], pharmaceutical [4, 5], and materials science industries [6, 7], will affect these processes. The role of these catalysts is to accelerate chemical reactions.

Therefore, investigating the possibility of using asymmetric organic catalysts (organocatalysts) to prepare and operate band saws is a timely research task.

Analysis of the latest studies and publications.

Catalysis is the process of changing the rate of a chemical reaction under the influence of catalysts [6].

A catalyst is a substance that speeds up a chemical reaction but is not part of the final products.

The term “catalysis” was proposed in 1835 by the Swedish scientist Jens Jakob Berzelius.

Over 115 years of work on catalysis, Nobel Prizes have been awarded 14 times. The first Nobel Prize in Chemistry in this field was awarded in 1909 to the Baltic German Wilhelm Ostwald "for his studies of the nature of catalysis and for his fundamental research into the rates of chemical reactions." In 2007, German Gerhard Ertl won the Nobel Prize for the study of chemical processes on the surfaces of solids [6].

The 2021 Nobel Prize in Chemistry was awarded to German Benjamin List and Scottish-born American David McMillan for “the development of asymmetric organocatalysis.” Until the 21st century, chemists believed that there were only two types of catalysts in the world: metals and enzymes. In 2000, Benjamin List and David McMillan independently developed a third type of catalysis called asymmetric organocatalysis. This type of catalysis makes it possible to synthesize molecules using organic catalysts. Organic catalysts have a stable structure of carbon atoms to which more active chemical groups can attach. Often, these catalysts contain common elements such as oxygen, nitrogen, sulfur, or phosphorus. This makes asymmetric organocatalysis cheaper to manufacture and more environmentally friendly. Benjamin List and David McMillan showed that organic catalysts can be used for many chemical reactions [8, 9].

Organocatalysts are organic molecules that accelerate chemical reactions, resulting in the creation of new molecules that are used to develop and improve various products, including medicines, plastics, and other materials [1–7]. These catalysts fundamentally improve chemical synthesis, making processes more environmentally friendly, efficient, and opening up unprecedented opportunities for creating complex chemical compounds.

The TREVITAN®-composition modifier is a high-tech product developed by the company “TREVITAN Ukraine” in the form of a liquid concentrate [1–3]. This product is a carbon (C) asynchronous asymmetric organic catalyst with an energy-information mechanism for directing the reaction based on a colloidal composite of high-molecular-weight oxycarboxylic aromatic (C ha) and aliphatic organic (C fa) acids.

Setting the task.

The aim of the paper is to demonstrate the possibility and formulate the scientific and practical basis for the use of an asymmetric organic catalyst during the preparation for operation and the use of wood-cutting band saws, which increases the service life of the saws and the performance of band saw machines.

Solving the problem.

The object of the study is the process of preparation and operation of wood-cutting band saws.

The subject of the study is wood-cutting band saws with asymmetric organic catalysts used during welding, sharpening, and operation.

Welding of band saw blades is accompanied by a complex of chemical and physicochemical processes, including: metal oxidation, carbon release and carbide formation, diffusion of alloying elements, recrystallization and structural changes, and formation of slag impurities.

When sharpening the blades, especially when performed with full-profile borazone wheels on a grinding machine, friction occurs, which leads to heating of the steel. High temperature can: change the structure of the metal in the cutting area (tempering, reducing hardness); cause overheating and the appearance of cracks or microdefects on the teeth; impair the cutting properties and performance of the saw; cause metal particles to stick to the working surface of the abrasive tool, causing it to wear out more quickly.

Therefore, when sharpening band saws, an aqueous solution (often with anti-corrosion or lubricating additives) is used, which is intended for several purposes: cooling the saw; improving the quality of sharpening; removing cut metal shavings and worn abrasive grains from the sharpening zone, which also extends the service life of the grinding wheel.

The lower heating of the saw and the wheel, and the interaction of their clean surfaces ensure precise tooth geometry and reduce the roughness of the ground surface, which has a positive impact on the service life of the saw. If you use a special aqueous solution with anti-corrosion additives, it also protects the saw from rust after sharpening.

During wood cutting, a number of chemical phenomena occur, caused by mechanical stress on the material, increased temperature in the cutting area, and the interaction of the wood with the environment. The main chemical processes: oxidation and hydrolysis of polymers; release of volatile substances, reactions with the environment.

Wood contains cellulose, hemicellulose and lignin. During cutting, especially at high temperatures or friction, these compounds are partially oxidized. The moisture contained in the wood can contribute to the hydrolysis of hemicellulose, which changes its chemical composition.

During cutting of wood, essential oils (especially in conifers), resins and other organic compounds can evaporate, which affect the odour and physico-chemical properties of the wood. During the processing of wood containing moisture, partial decomposition of organic acids can also occur.

Wood dust generated during cutting can interact with moisture in the air, forming weakly acidic or neutral solutions that can affect the tool or the wood itself.

Although wood cutting is largely a mechanical process, the chemical phenomena that accompany this process can affect the quality of the processing and change the physical properties of the wood.

It is in order to improve the quality of processing, increase the tool service life, and ensure a productive wood-sawing process that an aqueous solution is used.

Thus, when sharpening a saw, we have two solid reagents (abrasive wheel and a saw blade) and a cooling liquid solution; when sawing wood, we have a saw and wood, and a cooling liquid solution. Liquid solutions can be used as catalysts by adding to them the TREVITAN®-composition modifier in certain proportions. Thus, we will have an inverse heterogeneous catalysis, when the catalyst is in a liquid state and the reagents are in a solid state. The ends of band saws up to 10 cm long can be kept in the specified TREVITAN®-composition modifier (or in its liquid solution) for a certain period of time before welding, in order to evaluate the effect of the catalyst on the quality of the weld seam.

Based on the analysis of the use of asymmetric organic catalysts [1-7], it can be assumed that during the handling and operation of wood-cutting band saws, where chemical phenomena and transformations occur, organocatalysts can be used in different ways:

1 To use as part of a cooling liquid solution to further reduce friction between moving solids and to accelerate tool cooling.

2 To influence the microstructure of surfaces by catalytically modifying the surface layers of the material, which will affect their hardness and the wear of the tool.

3 To create a nanostructured protective layer on the surfaces of the band saw, which will increase its resistance to wear.

4 To use as an impregnating agent for wood or metals to improve their machinability, reduce resin and sawdust adhesion on the surface of the saw.

Based on studies [10], it was found that, due to pre-wetting the 10 mm long ends of saw blades by dipping them in the TREVITAN®-composition modifier before welding the band, the number of bending cycles before the destruction of joints made of wetted saw blade ends increased by 16 % compared to saw blade joints welded using conventional technology.

The average number of bending cycles to failure of joints welded using conventional technology is 9% less than the average number of bending cycles to failure of saw blade samples made of the base material without joints, and this is the main cause why the saw blades are the most prone to cracking and breaking in the area of the weld seam. The average value of the number of cycles before destruction of welded joints obtained with the use of the TREVITAN®-composition modifier is 6% higher than the number of cycles before destruction of samples of the saw blade made of the base material without joints. Such an increase in the number of cycles before failure of the resulting welded joints will reduce the likelihood of cracks in the saws and their rupture in the area of the weld seam.

To confirm the validity of the results, it is necessary to test the saws welded using the two technologies on a bending bench at the European *Wood-Mizer* plant and in production conditions.

The initial experiments [11] showed that the use of the TREVITAN®-composition modifier in the cooling liquid solution during sawing wood on a band saw increases the volume of sawdust removed from the kerf, which reduces the friction of the tool against the kerf walls. At the same time, it was found that when sawing wood with the addition of the TREVITAN®-composition modifier to the liquid solution, noise is reduced, a smoother machined surface is obtained, sawdust sticks to the band less, and cutting power decreases.

Conclusions.

The initial experiments have demonstrated the suitability of using an asymmetric organic catalyst in the welding of band saws and in the sawing of wood.

Therefore, in order to attain the goal, the following tasks need to be performed:

• to establish the relevance of using an asymmetric organic catalyst when welding a band saw to increase service life of the tool;

• to establish the expediency of using an asymmetric organic catalyst in an aqueous solution when sharpening band saw teeth, as well as in an aqueous solution used for sawing wood with such a saw in order to increase the tool service life;

• to develop, based on the results of experiments, an asymmetric organic catalyst-based improver for

the processes of sharpening band saw teeth and sawing with a band saw, in order to use it at industry enterprises;

• to elaborate recommendations for the use of the sharpening and sawing improver - the TREVITAN®-composition modifier.

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