Cavitation Technologies of Wood Impregnation

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***Abstract* – The article is devoted to study of impregnation process of capillary-porous materials. Efficiency increase of the technological process of wood impregnation due to the cavitation action is described.**

***Index Terms* – Impregnation, ultrasonic vibrations, cavitation, capillary-porous materials.**

I. INTRODUCTION

THE IMPREGNATION is the processes of introduction of the substances into the capillary-porous material, which change its properties (increase biostability and fire resistance, reduce electroconductivity, hygroscopicity, increase strength and etc.).

The impregnants vary greatly in properties and character of their interaction with capillary-porous material. They can penetrate into material mechanically, chemically react with it or they can be adsorbed by its substance. The character of physical-chemical phenomena following by impregnation is very complicated and they are not well-studied yet.

In many cases the impregnants do not react with the material (for instance, wood) and they are adsorbed by them. That is why the impregnation process is considered to be collection of the following physical phenomena: motion of liquid in capillary-porous material under the action of capillary pressure, motion of liquid in the material under the action of excess pressure; diffusive displacement of molecules and ions of the impregnants in the material along cell cavities filled with water.

Industrial processes of impregnation normally occur in the conditions of combined action of all stated phenomena, but relative efficiency can be different at various methods of impregnation [1].

II. PROBLEM DEFINITION

The ultrasonic impregnation in liquid medium is one of the most high-production and high-quality impregnation methods of different capillary-porous articles. This method allows replace two-phase impregnation cycle by one-phase with simultaneous exception of intermediate drying.

Ultrasonic impregnation is the most widely used in the impregnation technologies of winding electrotechnical articles: relay coils, electric motors, transformers and chokes, bands from fibrous and textile materials, fiber glass fillers, cardboard and paper, articles from wood. Ultrasonic impregnation of biological objects and articles made of graphite is also possible.

High efficiency of ultrasonic impregnation is the deep and relatively quick penetration of the impregnants into the pores and capillaries of the articles; it is caused by influence of cavitation processes occurring in liquid at the propagation of powerful ultrasonic vibrations in it [2,3].

The cavitation is the appearance and growth of steam bubbles or gas dissolved in liquid generated by pressure fall at constant temperature. The growth of generated bubble is accompanied by liquid evaporation in it (vaporous cavitation) or gas diffusion (gas cavitation). But as a rule both processes take place and the cavitation is steam and gas. The cavitation bubbles appear in the points of liquid flow, where pressure falls up to the value, which is close to the pressure of saturated steam at given temperature, but it depends on number of factors: saturation of liquid by dissolved gas, presence of admixtures and solid particles, state of streamline surface [4].

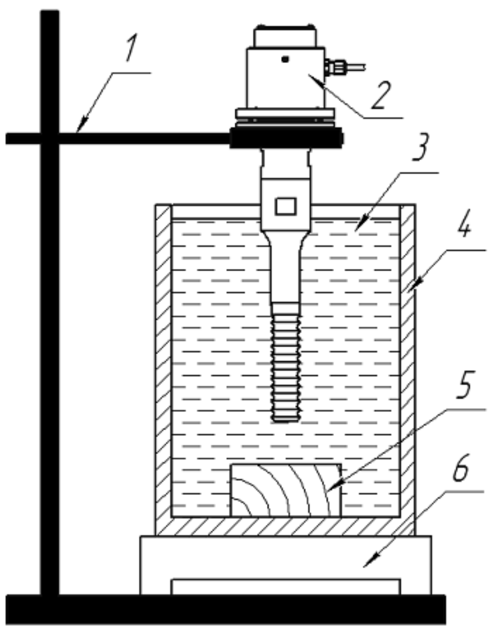
Thus, to increase efficiency of impregnation of capillary-porous materials it is necessary to study alternative methods of action on the impregnation process on the base of steam and gas and ultrasonic cavitation.

III. TEST BENCH FOR ULTRASONIC IMPREGNATION

For the carrying out of studies we developed test bench (see Fig.1) allowing impregnation of capillary-porous materials in boiling liquid.

The test bench for studying of ultrasonic drying of veneer sheets consists of following equipment:

– piezoelectric ultrasonic vibrating system;
– stand for control of the distance between the ultrasonic vibrating system and sample to be impregnated;
– technological volume with impregnating liquid;
– heating element.



1 – stand, 2 – ultrasonic vibrating system, 3 – impregnating liquid, 4 – technological volume, 5 – sample to be impregnated, 6 – heating element

Fig. 1. Scheme of the laboratory test bench.

For carrying out researches the ultrasonic technological apparatus of series “Volna” model UZTA-0.8/22-OMU intended for treatment of liquid medium was used. The appearance of the ultrasonic technological apparatus is shown in Fig.2.

Fig. 2. Ultrasonic technological apparatus of “Volna” series, model UZTA-0.8/22-OMU.

The main performance characteristics of the ultrasonic equipment are presented in Tab. I.

TABLE I
MAIN PERFORMANCE CHARACTERISTICS OF ULTRASONIC TECHNOLOGICAL EQUIPMENT

Name	Volna
Model	UZTA-0.8/22-OMU
Power, VA	800
Frequency of ultrasonic vibrations, kHz	22±1.65
Intensity of radiation, W/cm², no less	3.5

The test bench allows study influence on impregnation efficiency both at steam and gas and acoustic cavitation and at their combination.

IV. EXPERIMENTAL RESULTS

To determine influence of cavitation on efficiency of impregnation of capillary-porous materials, three methods of studies were carried out:

– ultrasonic vibrations;
– boiling of liquid;
– ultrasonic vibrations simultaneously with boiling.

As an experimental sample the pine bars with the dimensions of 100x50x50 mm were used. The experiments were carried out on totally dried samples. The humidity of wood was determined by weighing of the samples in dry and in impregnated states.

For the collection of static data and increase of reliability of the results for each method of impregnation 5 series of the experiments were made. Thus the graphs show averaged results.

The results of studies are shown in the graph (see Fig.3), where row 1 is the action of ultrasonic vibrations, row 2 is the boiling of liquid, row 3 is the ultrasonic vibrations simultaneously with boiling of liquid.

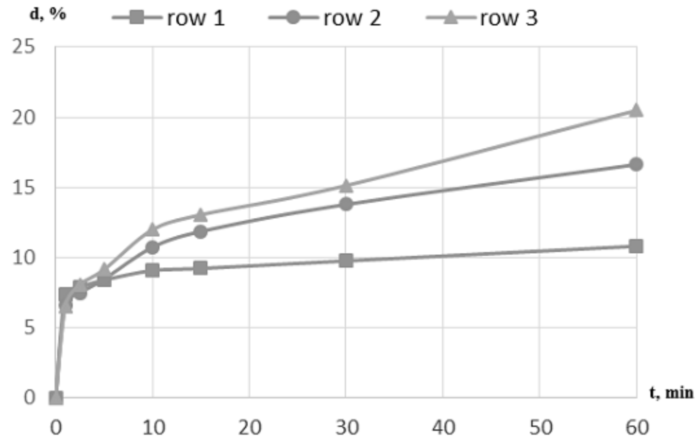


Fig. 3. Results of studies of cavitation influence on efficiency of impregnation of capillary-porous materials.

As it is evident from the graph, the impregnation process of capillary-porous materials by the example of wood can be devided into 2 stages for all three methods. The first stage is practically identical for all methods and it is fast penetration (from 2.5 to 5 minutes) of impregnating liquid into surface layer of the sample. The second stage is different for each of the methods, that allows study of cavitation influence on impregnation of capillary-porous materials.

The results of impregnation shows, that influence by ultrasonic vibrations is less efficient in comparison with the impregnation in boiling liquid.

The difference of impregnation efficiency in boiling liquid in comparison with ultrasonic vibrations achieves 50-55%. At the same time the difference of impregnation efficiency with ultrasonic vibrations in boiling liquid achieves 20-25% in comparison with impregnation efficiency in boiling liquid and 85-90% in comparison with ultrasonic vibrations.

Impregnation efficiency at simultaneous influence can be explained by rapid diffusive impregnation of the sample by liquid (due to heating and cavitation) and ultrasonic vibrations acting on absorbed liquid and thereby accelerating impregnation (cavitating action in thepores and capillaries filled with water).

V. CONCLUSION

During analytic survey it was shown the necessity to increase efficiency of the technological processes of wood impregnation.

For laboratory studies the test bench, which allows impregnation of capillary-porous materials in boiling liquid, was developed.

As a result of studies it was determined, that the difference of impregnation efficiency with ultrasonic vibrations in boiling water in comparison with impregnation efficiency in boiling liquid achieves 20 – 25% and 85 – 90% in comparison with ultrasonic vibrations.

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