Ultrasonic Drying of Birch Veneer

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***Abstract* – The article is devoted to studying of drying veneer process under the influence of high-intensity ultrasonic vibrations. The advantages of veneer ultrasonic drying and possibilities of its practical realization are described. Ultrasonic drier of veneer allowing is applied in practice ultrasonic drying process was proposed and developed**

***Index Terms* – Ultrasonic drying, birch veneer, moisture level, wood surface, drying agent.**

I. INTRODUCTION

VENNER - it is a main semi-manufactured product that serves for preparation plywood. Veneer receives two main methods: peeling and slicing. Peeling veneer is the most popular. Its production features are cutting a thin layer preliminary wetted and treated with steam off the cylindrical surface. Thickness of veneer can vary from 0.3 to 4 mm [1].

Initial moisture level of the veneer can vary from 50 to 130 % in dependence of delivery and preparation conditions of the raw minerals. Final moisture level of the veneer must be from 6 to 12 % in dependence of the designation. Three methods are used for its drying: contact one, convection one and the most popular is a combined one [2]. The combined method is applied in the chamber drier of SUR-5 type (drier length is 6.5 m, and the average production rate is 10 m^3/working shift) and SUR-4 type (drier length is 13 m, and the average production rate is 20 m^3/working shift) [3]. The air temperature at the entrance (raw) end of the drier is 120°C and at the output (dry) end is 135°C. Air circulation speed is 1.7-2.5 m/sec. On the entrance and output ends of driers there are some mechanisms for loading and uploading veneer equipped.

II. FORMULATION OF THE RESEARCH PROBLEM

The veneer driers that are used in industry is featured with a number of drawbacks, the main some is high cost requiring significant initial costs of production organization; the large working area (about 300m and more per one drier); difficult cleaning up of the internal hot-air heaters from dust and misfired knots; difficult cleaning up of the surface roller from wood resin (when using a drier of needle trees veneer); the need to create fire-resistant rooms for gas driers; high energy consumption of 200-250 kW·h/ m^3 – it is without energy, used for heating the drying agent; buckle and checking of the veneer when drying due to high temperatures of the drying agent (300-350°C) [4].

Thus, for elimination of the drawbacks mentioned above it is necessary to propose some alternative methods of drying veneer, to develop and introduce practically the constructions and to conduct comparative experiments to confirm their effectiveness.

III. THEORY

Wood drying to consisted freeing moisture from the wood surface in the environment (in air or mixture of air with steam or flue gases). The layers of drying agent are neighboring to the wood quickly impregnated and evaporation of moisture from wood (drying) is terminated. Therefore, for continuous process of drying, drying agent about wood surface must be constantly supplanted by fresh that is necessary is applied of circulation. The higher temperature of drying agent, lower its moisture level and higher motion speed about material surface, the more intensive evaporation and, therefore, material surface drying-up. Increase the motion speed of drying agent with moisture level of material surface below hygroscopic property limit impact not on moisture motion intensify from internal from internal to outer wood layers [5].

Intensifying effect of ultrasonic is possible at different stages of drying process. Factors of acceleration are: decrease thickness diffusion boundary layer; decrease liquid viscosity under ultrasonic influence, is helping to accelerated moisture motion from depth to surface of material; moisture press out from material of cavitations bubbles of gas, is established under ultrasonic vibrations influence and pulsate in liquid; radiation pressure, moisture press out from material [6].

Ultrasonic influence on dryable material is sorting non-contact and contact methods.

Non-contact method (or drying through non-resonant gas spacing) performed by gas-dynamical transducers or piezoelectric ultrasonic vibrating systems with step-variable disk transducer [7]. Usually a non-contact ultrasonic drying is featured low production rate and low effectiveness for wood materials drying.

Contact method performed by magnetostrictive or piezoelectric ultrasonic vibrating systems [8].

Positive effect of ultrasonic influence on wood materials drying is known a long time [9, 10], but not conduct research works oriented at emergence optimal practices and conditions of drying, applied to contact ultrasonic influence of drying veneer process.

IV. WORKBENCH TO VENEER ULTRASONIC DRYING

Workbench to investigation process of veneer ultrasonic drying includes following equipment:

– electronic generator and piezoelectric ultrasonic vibrating system (see Fig. 1);

– mechanism to embodiment hold down at different support blocks and measuring equipment;

Basic specifications of ultrasonic equipment:

– frequency of mechanical vibrations is 18±1.35 kHz;

– maximum of consumed power(total/active) is 1000 V·A/ 300 W;

– vibration amplitude at end surface of work tool at total power is 42±2 μm.

Figure 1 – Ultrasonic equipment to contact method of drying.

Electronic generator with assisted microprocessor control system is provided constantly vibration amplitude of emitting surface of ultrasonic vibrating system at all along technological cycle of veneer drying independently of hold down conditions.

Ultrasonic vibrating system is possessed of working emitting surface of cylindrical form (radius is 25, length is 190 mm, width is 20 mm).

Flat foundation is used as mechanism of hold down where is used different support blocks is providing different hold down options of ultrasonic vibrating system and, therefore, different options ultrasonic influence (see Fig. 2).

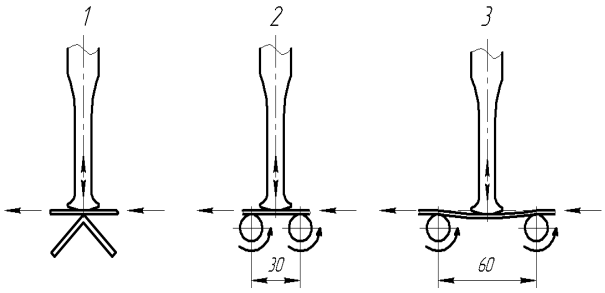

Figure 2 – Hold down options of the emitting surface to the surface veneer.

Option number 1 provide to contact dryable veneer and emitting surface of work tool in the line; options number 2 and number 3 - over the surface. Experiments have shown that option number 3 is unacceptable, because when increased distance between press rollers take place veneer disintegration.

Measuring of samples moisture level is embodiment with assist weighing process method at electronic weighting unit with accuracy to 0.1 g.

V. EXPERIMENTAL RESULTS

For emergence optimal conditions of veneer drying take place research works of different drying practices: convective one (natural), forced one (airflow by drying agent) with assist ultrasonic influence and combined one.

Birch veneer manufacturing company “Petroneft-Biisk” used as experimental samples. Veneer is obtained at moment of shearing, initial moisture level according to preliminary estimates more than 100 %. For research works manufactured samples with size is 300x160 mm and thickness is 2 mm. Additionally used similar experimental samples and samples with size is 300x1200 mm and thickness is 1.5 mm and 2 mm from birch veneer, manufactured by plywood mill of Novokuznetsk.

To the end that results to be reproducible, veneer dried samples is moisten during 10-12 hours in hot water for process adulteration preparations of dimension parts for veneer production. It is possible to obtain data on the same samples, and confirmations were always on freshly cut veneer. For obtain the static data and increase validity of results for each of drying practices was prepared on 10 veneer samples of different thickness. Thus, the graph shows average results.

Samples unwinding speed between emitting surface and support block in drying process is 0.3 m/min.

Initially experiments were performed with hold down option number 1, and then was changed hold down conditions (option number 2). As support block platform used two cylinders with diameter is 15 mm, positioned on distance is 30 mm (between centers). All next experiments were performed with hold down option number 2.

Obtained results are shown in graph (see Fig. 3 and Fig. 4), is featured ultrasonic drying process as against natural drying (25°C), and also as against with results of drying option number 1.

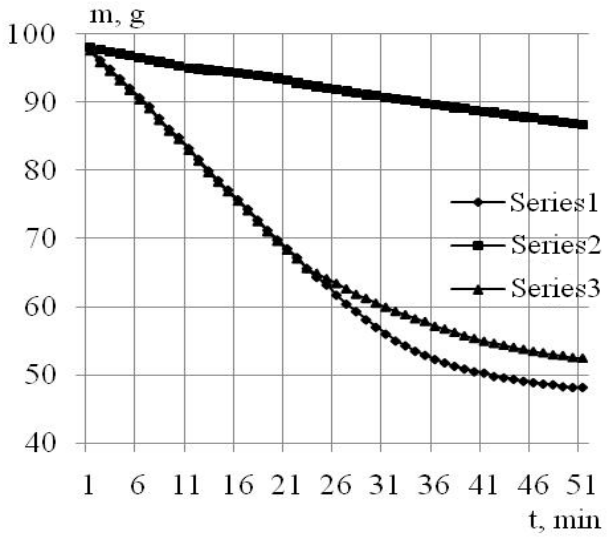

Figure 3 - Dependence of mass veneer samples from drying time.

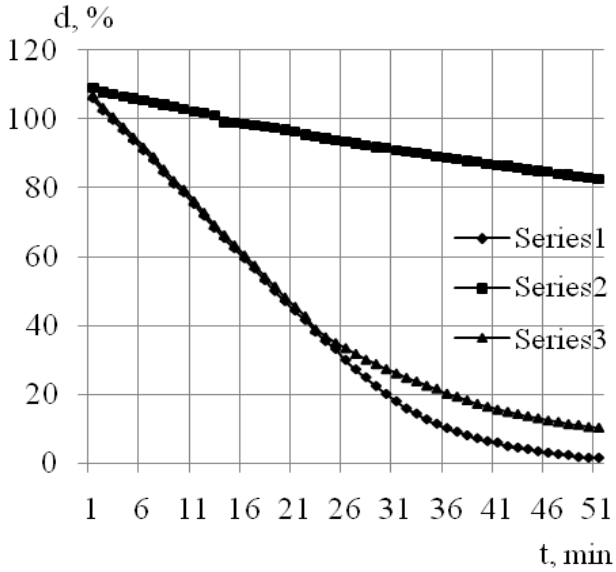

Figure 4 - Dependence of moisture level in veneer samples from drying time.

Series number 1 – drying with ultrasonic influence (hold down option number 2), series number 2 – drying in natural conditions (25°C), series number 3 – drying with ultrasonic influence (hold down option number 1).

Analysis of results is showed possibility of acceleration drying process in 5-7 times as against convective drying in natural conditions. Increase contact area is possible increase effectiveness of ultrasonic influence: acceleration drying process in 1.5-2 times as against with drying in case hold down option number 1, at that detectable disarrangement in depending on begin with moisture level to approximate in 40 %.

As drying process speed is depend up circulation speed of drying agent along wood surface, then performed experiments on intensification drying process under ultrasonic vibrations influence by airflow of veneer samples with hot air – the closest to manufactured drying practices. Parameters of drying agent: temperature is 60-70°C, flow rate is 25 m^3/h and consumed power of heater is 1-1.2 kW.

For research works to drying of hot air be prepared veneer samples of different thickness. Drying results of birch veneer with thickness 1.5 mm are shown in graph (see Fig. 5 and Fig. 6) and birch veneer with thickness 2 mm are shown in graph (see Fig. 7 and Fig. 8). Series number 1 – drying with ultrasonic influence, series number 2 – combined drying with ultrasonic influence and series number 3 – drying by airflow with hot air.

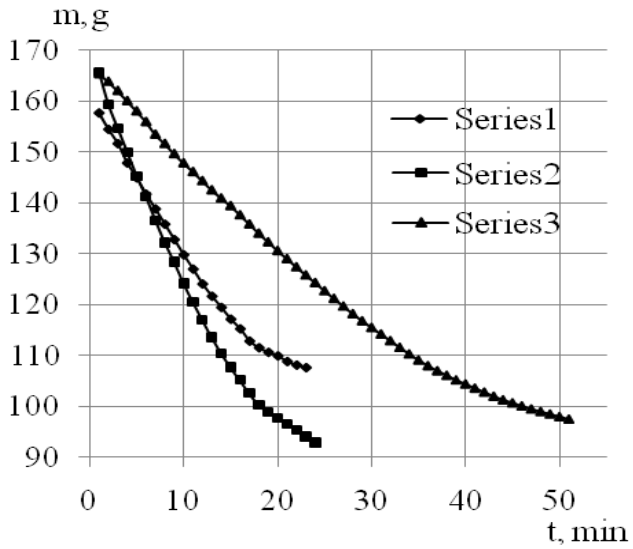

Figure 5 - Dependence of mass veneer samples from drying time.

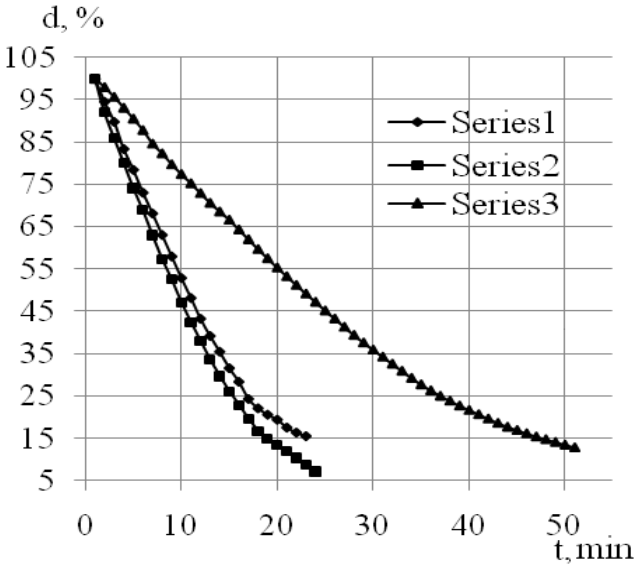

Figure 6 - Dependence of moisture level in veneer samples from drying time.

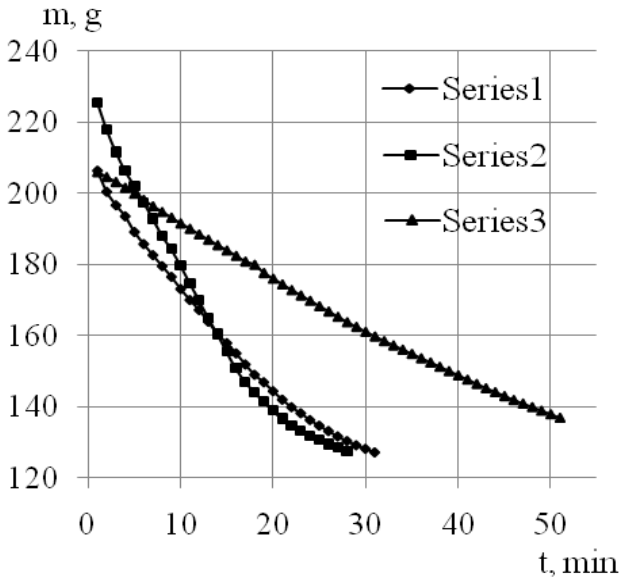

Figure 7 - Dependence of mass veneer samples from drying time.

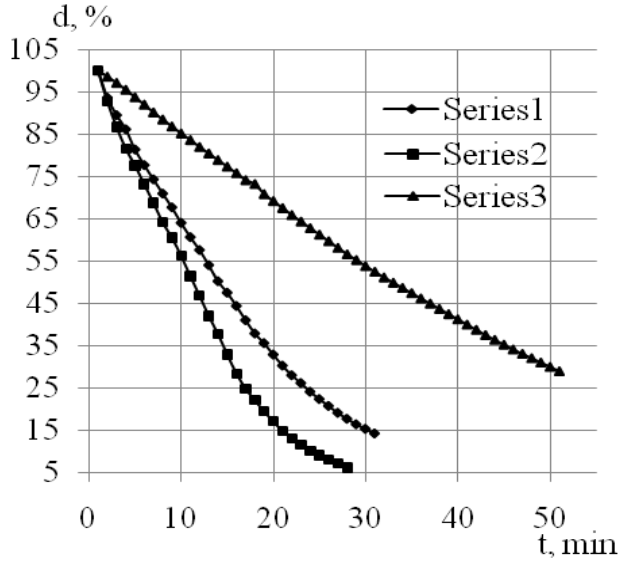

Figure 8 - Dependence of moisture level in veneer samples from drying time.

Final moisture level is 7 % provided when combined drying of veneer with thickness 1.5 mm (with ultrasonic influence and airflow with hot air) in 25 min of drying and veneer with thickness 2 mm in 29 min of drying. When drying with ultrasonic influence veneer the drying time of veneer with thickness 1.5 mm to determined moisture level is 30 min and veneer with thickness 2 mm is 40 min. When drying without ultrasonic influence veneer the drying time of veneer with thickness 1.5 mm to rated moisture level is 60 min and veneer with thickness 2 mm is 88 min.

V. DISCUSSION OF RESULTS

Intensifying ultrasonic vibrations influence has been visually demonstrate on drying of birch veneer.

Analysis of experimental results is allowed establish that maximum drying speed is providing when combined ultrasonic influence with hot air on frequency is 18±1.35 kHz and vibration amplitude is 42±2 μm. As against with natural drying – the drying process is accelerated in 2.4-3 times and airflow with hot air is accelerated in 1.2-1.4 times for final moisture level is 7 %.

Analysis of energy consumption is established: drying of different samples to rated moisture level to airflow with hot air used around 1.2-1.8 kW·h, drying of similar samples with ultrasonic influence used around 0.15-0.2 kW·h and drying with combined ultrasonic influence with hot air used around 0.6-0.7 kW·h.

Veneer width, obtained in industrial conditions, depends on dimension part length and approximately is 1m. Because for creation industrial ultrasonic mechanism necessarily provided with emitting surface of conforming length. For that end necessarily on the one bearing element is installed several ultrasonic vibrating systems in line (five systems per meter). Dryable veneer is constricted between support block and emitting surfaces of ultrasonic vibrating systems. Suggested mechanism is allowed support of processing area with size 1000x20 mm. Provide for ultrasonic influence necessary and sufficient hold-down pressure is 1.5-2 kN. Parameters of hot air forced feed: temperature is 60-70°C, flow rate is 125 m^3/h. Consumed power of mechanism is about 7.5-8 kW (it is without energy, used for feeding of veneer). The veneer sheet with size 1000x1000 mm will be dried to final moisture level is 7 % for 3-3.5 hours, when feeding rate is about 0.3 m/h. Total consumed power of mechanism is 22.5-24 kW·h.

VI. CONCLUSION

In the course of analytical review is shown necessary of ultrasonic influence for increase effectiveness of wood veneer drying.

For introduce practically of ultrasonic drying was proposed and developed equipment for embodiment of ultrasonic drying contact method and performed experimental research works for drying of birch veneer.

Results of research works is established that combined ultrasonic influence with hot air as against with natural methods of drying not only accelerated technological process rate, as well as decrease of energy consumption.

Based on data was suggested creation option of veneer drier industrial sample performed by copying created equipment.

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