Technological scheme of wood resources utilization model development

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Abstract. In the present work the justification of the urgency of solving the issue of environmental friendliness of materials produced from wood resources is given. The analysis of the production technology of semifinished wood-fiber products is carried out at the current stage of development of the board industry. The estimation of board formation properties of the wood fiber mass produced in disk blade grinding machines is given, and the inefficiency of the used equipment is substantiated. The expediency of using the equipment with cavitation effect as the second grinding stage in the production of wood pulp was substantiated. As a result, the purpose of the present work was the development of the technology for the production of the semifinished wood fiber product with the use of a rotor-pulsation apparatus as the second stage of the wood pulp mill. To achieve the goal, an analysis of modern technologies used in the production of fiberboard was carried out. The model of technological scheme of production of wood fiberboards by wet method in the environment of AnyLogic program package was developed. Based on the technological scheme developed, a dynamic model of the fiberboard production process was built using a rotor-pulsation apparatus in the second stage of wood pulp milling. In the course of research, statistical analysis methods and simulation modelling of technological processes were applied. The results obtained can find application in the production of fiberboard, as well as in the improvement of technological processes at the enterprises of the forest complex.

1 Introduction

The analysis of scientific works of modern domestic and foreign researchers [1-4] has shown that the production of wood fiber semi-finished products is one of the most effective directions in the field of wood waste processing. It is established that the main consumers of wood fiber semi-finished products are the board and pulp and paper industries, the demand for finished products of which has a constant tendency to increase. The stable demand for fiberboard is primarily due to the fact that this material is widely used as a structural, finishing and insulating material both in construction and furniture production. At the same time, due to the weak fibrillation of the resulting wood fiber and as a consequence of low bonding properties in the modern production of fiberboard use phenol-formaldehyde and urea-

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formaldehyde resins. It is known that phenolic resins are synthetic polymers obtained by chemical reaction of phenol and formaldehyde. Due to the presence of formaldehyde, both the synthesis of resins and the process of manufacturing fiberboard, as well as the operation of finished products are dangerous. As a result, the use of this type of binder in the technological process reduces the environmental friendliness of manufactured products and increases their cost. One of the possible ways to solve the problem of binder exclusion from the technological process is to increase the fibrillation of wood fiber surface due to cavitation effect in the milling process. This effect can be achieved by replacing the refiner at the second stage of wood pulp milling with a rotary-pulsation device.

2 Materials and Methods

The material for the present research is the results of the analysis of practical experience of operating plants for the production of fiberboard, as well as the works of domestic and foreign researchers involved in the production of fiberboard semi-finished products. In the course of research were applied methods of statistical analysis and simulation modeling in the environment of AnyLogic software package.

3 Results, Discussion, and Findings

In order to substantiate the effectiveness of the developed technological solutions in the environment of AnyLogic software package, a simulation model of the technological process of wood fiberboard production was built, shown in Figure 1.

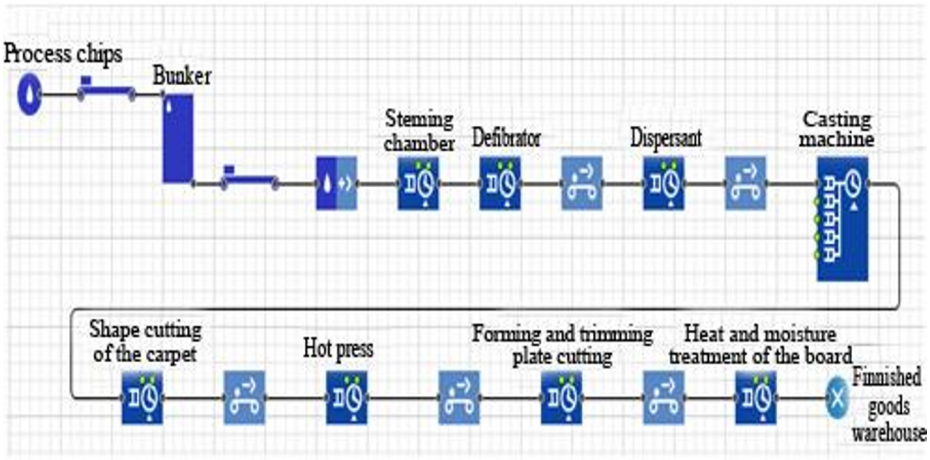

Fig. 1. Model of technological process of wood fiberboard production

As can be seen from Figure 1, the process chips from the open warehouse are conveyed by pneumatic conveyor to the hydraulic washer where they are cleaned from mineral impurities, and then go to the metal trap to remove metal inclusions and then fall into the hopper. Obtaining of wood fiber semi-finished product is carried out by grinding chips in two stages. The primary grinding of technological chips is carried out in the defibrator, in the steaming chamber of which is carried out thermohydrolytic treatment of wood raw materials, there is a weakening of bonds between the fibers as a result of plasticization of the middle plate of the wood cell. The steamed wood chips then enter the milling chamber of the

defibrator. As can be seen in the photo in Figure 2, most of the wood fiber is not significantly damaged during the wood chip milling process.

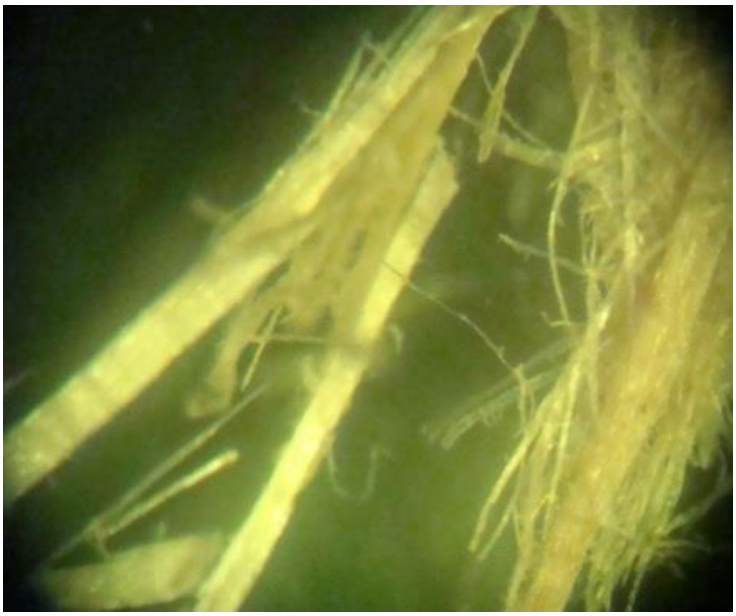

Fig. 2. Wood fiber after the defibrator

In the total volume, coarse and medium-sized wood fibers are the most abundant, while fine fibers are practically absent. In the course of milling of technological chips there are friction, crumpling, cutting forces, which result in the following types of damage: combing of fiber bundle ends and individual fibers, local removal of individual sections of the primary and outer layer of the secondary wall, transverse breakage. Separation of bundles into individual fibers occurs in the longitudinal direction to the fiber axis due to the formation of microcracks, which lead to the separation of fibers from bundles. Transverse fractures are mainly observed as broken or rounded ends of bundles and individual fibers, and less frequently as fibers with even cuts [5-7]. After the defibrator, the wood pulp enters the rotor-pulser. As can be seen from the photo shown in Figure 3, unlike the defibrator, the rotary pulsation machine has a cavitation effect on the fiber rather than a knife effect, which undoubtedly contributes to an increase in the specific surface area of the wood pulp, the formation of cohesive bonds and improvement of the structural formation of the board [8-10].

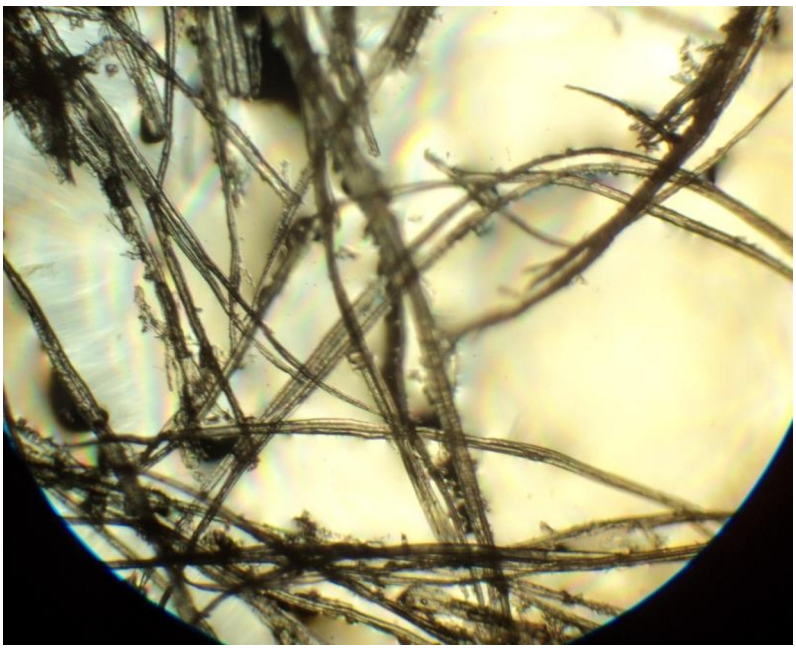

Fig. 3. Wood fiber after rotor-pulsation machine

The obtained fiber is fed to the casting machine through the gluing units, the continuous carpet of fiber is cut to size. Then the boards go to the press, are cut to size and after the hardening chamber are sent to the warehouse of finished products. In order to determine the productivity of the line for the production of fiberboard by wet method after replacing the refiner with a rotary-pulsation machine, a simulation of the process model presented in Figure 1 was realized in real time. As a result, a dynamic model of the line operation was obtained, shown in Figure 4.

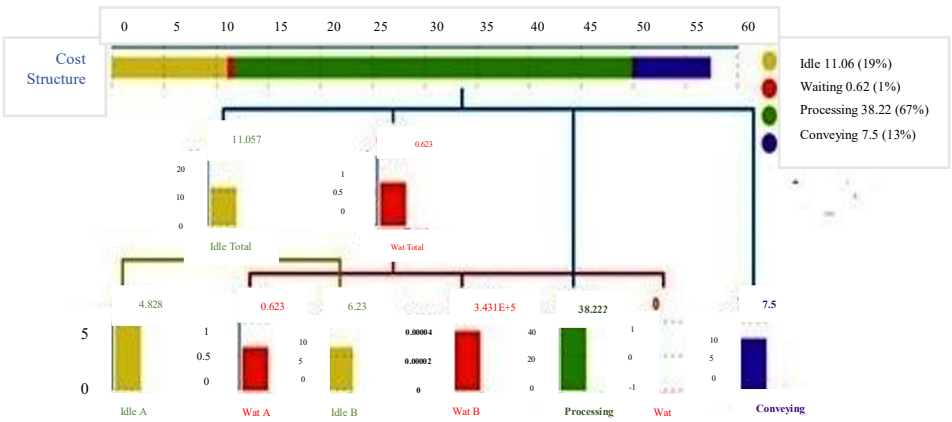

Fig. 4. Dynamic model of fiberboard production line operation

As can be seen from the dynamic model of the wood fiberboard production line, the rotor-pulsation device does not reduce the productivity of the line and does not lead to downtime of the head equipment, the load of which is not less than 67%, which gives sufficient time reserve in case of inevitable technological downtime of individual sections.

4 Conclusions

Thus, in the process of work the properties of wood-fiber mass produced in disk knife milling machines were investigated and their qualitative and quantitative characteristics were evaluated. The reason of decrease of ecological friendliness of wood-fiber boards produced by wet method was substantiated. The expediency of using the equipment with cavitation effect in the form of rotor-pulsation apparatus for wood pulp production is evaluated. Investigations of fiber microstructure obtained after defibrator and rotor-pulsation apparatus are realized. The model of the modernized technological scheme of production of wood-fiber boards by wet method is developed. On the basis of the developed technological scheme the dynamic model of the production process of manufacture of wood-fiber boards with the use of rotary-pulsation apparatus at the second stage of milling of wood mass is constructed, which showed the possibility of realization of the proposed technological solutions at the operating enterprises of the board industry.

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