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DEVELOPMENT OF A HIGHLY EFFICIENT MACHINE FOR DEHYDRATION OF MOISTURE-SATURATED MATERIALS

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Abstract– A technological machine for the dehydration of moisture-saturated materials is developed. In the design of the machine, moisture-saturated materials (for example textile fabrics, leather, and paper) are sequentially drawn between two roller pairs located one above the other by a chain conveyor and a base plate. At that, the base plate is composite, with rollers at the ends, along which the processed wet material moves a certain distance from its initial position, due to friction forces with the lower working rollers. As a result, the untreated strip fold over the base plate is transferred to the sidewall and additionally processed by the upper working roller. Consequently, the area and quality of treating the processed material between the pairs of rotating working rollers increase.

Key words– vertical roller machine; moisture-saturated material; composite base plate, roller pair; dehydration; chain conveyor; processing area

I Introduction

One of the problems with vertical roller machines for mechanical dehydration is poor or insufficient removal of moisture from the fold zone of moisture-saturated sheet materials on the base plate by means of a feeding conveyor chain with vertical feeding between the working rollers. This problem makes it impossible for the multilayer mechanical dehydration of moisture-saturated sheet materials. Therefore, the elimination of excess water from the fold zone of moisture-saturated sheet materials is relevant for science and production.

II Review of literary sources

The reference [1] describes the control of the process of hot rolling of bar and wire, with control of the required clearance between the rollers. The results of that study can be used in improving the design of roller machines for processing sheet materials with variable thickness and surface [2][3] [4]. The study in [5] presents the results of the analysis of factors affecting the power consumed by the drive of the roll module. The authors of [6] proposed a universal conveyor with a concave bearing belt surface for handling operations in leather production and loading raw materials into vehicles. The authors of [7] experimentally determined the costs of power and moment of resistance spent in the contact zone of the rollers of the modules under the strain of their coatings and the processed material. In [8], a dynamic analysis of the rollers of textile machines was conducted on the basis of a numerical method. An algorithm was developed for studying roll modules with an arbitrary number of rollers. In [9], the coefficients of static friction and sliding were experimentally determined for various materials. The dependences of the friction coefficients on the rotation frequency and the values of roller friction were obtained. Study in [10] describes the process stages and materials used in traditional leather tanneries in Ghana, and the scientific principles underlying each process. Traditional and modern processes of leather production were compared, and studies in the field of handicraft leather production were identified and studied. In [11], 39 peer-reviewed articles were reviewed, of which 30 were published over the past 6 years. The publications were subdivided into 4 groups: 1) production process, 2) individual stages of the production process, for example, mechanical processing of materials, 3) waste recycling and 4) long-term strategies in the leather industry. The importance of scientific and practical knowledge for the improvement and implementation of technological operations for the processing of raw materials was noted.

In [12], the author has analyzed existing and new technologies of pressure treatment and revealed signs that determine the complex local loading of the strain zone. A mathematical model of metal forming processes with complex local loading of the strain zone was developed. The stress-strain state and the pattern of plastic flow of the material in the strain zone were determined. The author of the study given in [13]

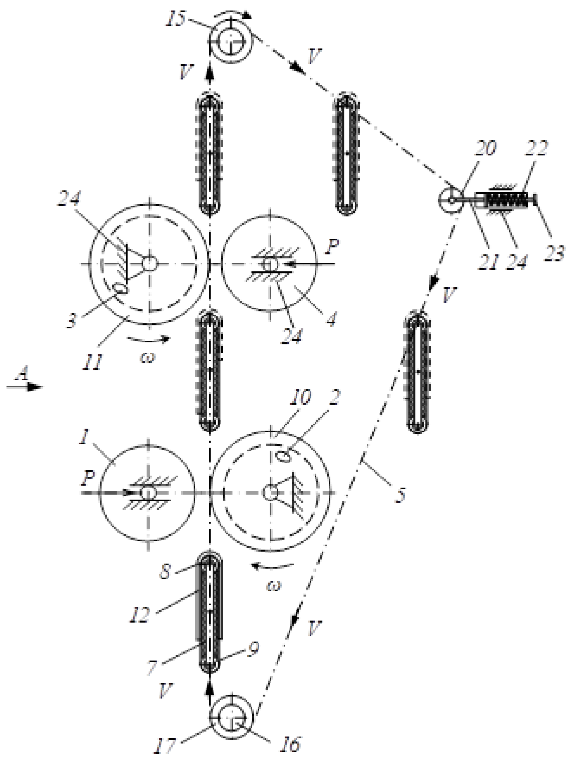

Fig. 1: Schematic diagram of pulling-in of the processed material between pairs of working rollers (a side view) 1, 2 - lower working rollers, 3, 4 - upper working rollers 5, 6 - conveying chains, 7 - base plate with rollers 8, 9; 10, 11, 15, 17, 18, 19 - sprockets, 12 - sheet material, 24 – bed frame

has investigated the relationship between stresses, strains, and density for cases of a stressed state arising in rolling and drawing of powder materials, which made it possible to increase the accuracy of calculating the stress-strain state during the aforementioned technological operations. The influence of the shape, material and thickness of the shell on the geometric characteristics of the strain zone was established. The influence of the thickness and material of the flux-cored strip shell on the energy-power parameters of the flattening process was established. In [14], an improved method for modeling the elastic strains of sheet mills rollers was developed, based on a three-dimensional finite element model of a roller unit. A new analytical method was developed for calculating the elastic strains of six-roller stands and it was revealed that in the production of cold-rolled strips it is more efficient to use six-roller stands than four-roller ones. In [15], a roller machine for squeezing wet fibrous materials was developed, which ensures uniform removal of excess water in all topographic sections of the material of non-uniform thickness and surface. In [16], the design of the pressure device between the working rollers was improved, for the significant thickness of the processed materials. In [17], new types of base plates of a vertical roller machine were developed and the most rational options were recommended to improve the technological process of pressing wet sheet materials. In the current study, the device and the principle of operation of a roller machine for mechanical dehydration of moisture-saturated sheet materials were developed and described. The advantage of the proposed device is evident in the fact that the feed of moisture-saturated sheet material with a base plate to the machining zone of roller pairs, and the operation of the drive of rigidly fixed working rollers with sprockets at both ends, are simultaneously performed by chains (Figures 1 – 5).

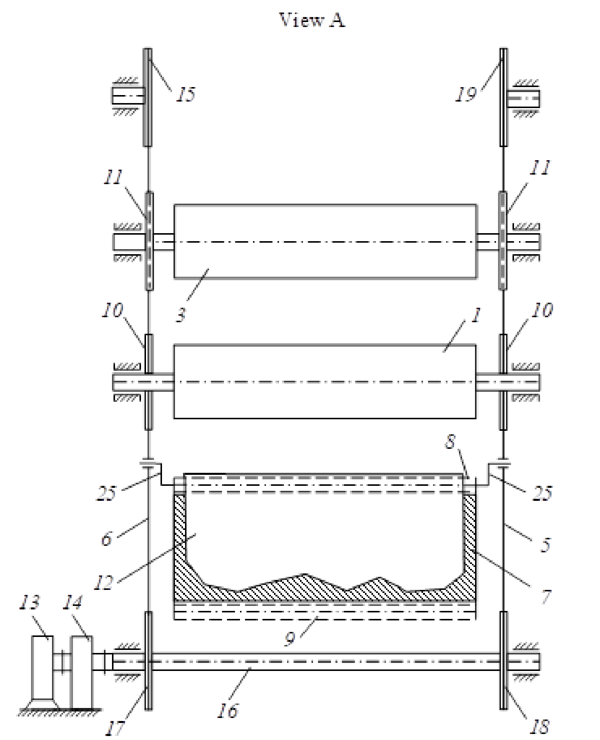

Fig. 2: View A of the chain conveyor and base plate with the processed material (front view) 1, 2 – lower working rollers, 3, 4 – upper working rollers, 5, 6 – conveyor chains, 7 – base plate with rollers 8, 9; 12 – sheet material, 10, 11, 15, 17, 18, 19 – sprockets, 13 – electric motor, 14 – gearbox, 16 – roller

III THE DEVICE AND THE PRINCIPLE OF OPERATION OF THE MACHINE

The proposed machine eliminates the problems mentioned and consists of two pairs of rollers 1 and 2, and 3 and 4, located one above the other. Between these pairs, there are two pairs of chain conveyors 5 and 6, on which the base plate 7 is located. Moreover, the base plate 7 consists of a rotating roller 8, on which plate 9 is suspended. On the lower roller pairs 1 and 2 on the right side on both ends of the axis of roller 2, the sprocket 10 is installed, which is in contact with conveyor chains 6 and 7. A similar sprocket 11 is installed on the upper pair of rollers 4 and 5 on both ends of the axis of roller 3. Roller 1 does not have a drive but rotates due to contact with the left-hand vertical plane of the moisture-saturated sheet material 12. Roller 4 rotates due to contact with the right-hand plane of the moisture-saturated sheet material 12. To drive the transporting chains 5 and 6 above the upper pair 3 and 4, on the left-hand side, there is an electric motor 13 and a gearbox 14 at the outlet end of which sprocket 15 is installed. Under the lower pairs of the working rollers, there is roller 16 at the end of which sprockets 17 and 18 are installed. Above the upper rollers 3 and 4, at the horizontal level of sprocket 15, sprocket 19 is installed, which is in contact with sprocket 18. For tensioning of conveyor chains 5 and 6, two tensioning devices are installed as roller 20 of rod 21 of spring 22 and rod 23. The working rollers 2 and 3 are fixed on bed frame 24. The working rollers 1 and 4 have the possibility of horizontal motion along the guides on bed frame 24. Rotating roller 8 is mounted on crankshaft 25 and has the ability to displace the vertical axis of base plate 7 with sheet material 12 relative to the vertical axis of motion of chains 5 and 6. This makes it possible to machine sheet material 12 of different thicknesses.

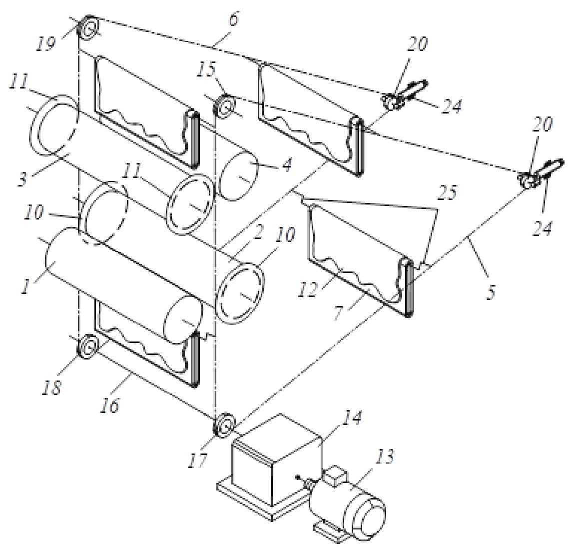

Fig. 3: General view of the roller machine (a perspective view) 1, 2 – lower working rollers, 3, 4 – upper working rollers, 5, 6 – conveyor chains, 7 – base plate with rollers 8, 9; 12 – sheet material, 10, 11, 15, 17, 18, 19 – sprockets, 13 – electric motor, 14 – gearbox, 16 – roller, 20 – tension roller

The roller machine works as follows. When electric motor 13 is turned on, the rotation through gearbox 14 is transmitted to sprockets 10, 11, 15, 17, 18 and 19, and rotates working rollers 2 and 3. Chains 5 and 6 transfer base plate 7 with rollers 8 and 9 and when it moves under working roller 2, then the left plane of the moisture-saturated sheet material 12 contacts working roller 1 by rotating it. The velocity of roller 2 is greater than the velocity of roller 1, and the velocity of roller 1 at the beginning of contact with the sheet material is zero. This leads to the fact that working roller 2 transfers the length of sheet material 12. Since the velocity of chain conveyors 5 and 6 is higher than the velocity of working roller1, then the moisture-saturated sheet material 12 does not pile up in the transition zone of processing and transfers part of the length to the left side of base plate 7 by rotating roller 8. When base plate 7 with roller 8 is under the pairs of working rollers 3 and 4, the opposite happens, and the original moisture-saturated material returns to its initial place.

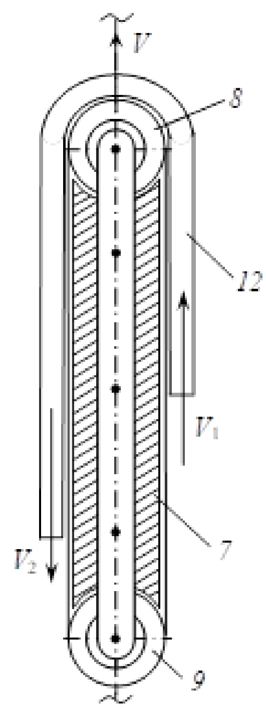

Fig. 4: Composite base plate 7 – base plate, 8 – upper roller, 9 – lower roller, 12 – sheet material

If necessary, the composite base plate 10 can be additionally equipped with a rotation lock (stop) on rollers 2 and 3; this stop will control and ensure the rotation of the roller at a required angle. Significant differences of the developed machine from the existing designs of roller machines consist in the simultaneous operation of the feed and drive mechanisms of working rollers, through the operation of continuous chains installed parallel to each other. Another feature consists in using the effect of the difference in linear velocities between the working rollers and the motion of the moisture-saturated sheet material to one or another side plane of the composite base plate without additional drive devices, sprockets, gear wheels or racks, thereby greatly simplifying the design of the device, and reducing the overall material consumption of the machine.

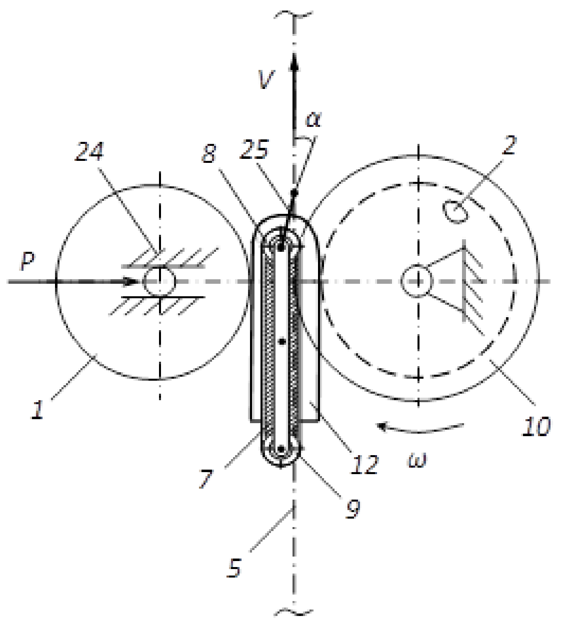

Fig. 5: Displacement of the base plate from the conveyor chain at an angle () depending on the variable thickness of the sheet material 1, 2 – working rollers, 5 – conveyor chain, 7 – base plate, 8 – upper roller, 9 – lower roller, 10 – sprocket, 12 – sheet material, 25 – crankshaft

IV Conclusion

The advantages of the proposed design of technological machines in comparison with similar machines are obvious since the proposed design performs a set function in a simpler way and using simple mechanisms. The design of the machine is simplified, providing uniform processing over the entire area of the wet sheet material, including the fold section at the nose of the base plate. The uniform moisture content in all areas of the processed sheet material (for example, textile fabrics, leather) contributes to improving the quality, reducing defects in subsequent technological operations. The proposed design of a machine for mechanical dehydration of sheet materials, in comparison with other existing machines, increases productivity by several times due to dehydration of sheet multilayer materials folded over the base plate. The results of experimental studies showed [2] that it is possible to remove excess water from wet sheet materials with a pressing force of the working roller equal to 32 kN/m and a feed rate of 20 m/min, which shows the process acceleration in comparison with known machines. This will increase the productivity of the technological process of squeezing the moisture from wet sheet materials by 200%, in comparison with existing roller squeezing machines.

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