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НАПРЯМКИ ВДОСКОНАЛЕННЯ КОНСТРУКЦІЙ РЕЙСМУСОВИХ ВЕРСТАТІВ

Наведено аналіз принципової схеми рейсмусового верстата і виявлені основні механізми, які впливають на точність оброблення. Проаналізовані конструкції механізмів подавання заготівок рейсмусових верстатів, механізми базування заготівок на верстаті та нова конструкція різального інструменту. Встановлені основні переваги наведених конструкцій, їх недоліки та запропоновано напрямки їх подальшого вдосконалення.

Ключові слова: *рейсмусовий верстат, механізм подавання, механізм базування, різальний інструмент*

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DIRECTIONS FOR IMPROVING THE DESIGNS OF PLANER MACHINES

The analysis of the schematic diagram of a planer machine has been presented, identifying the main mechanisms that influence processing accuracy. The designs of the feeding mechanisms of planer machines, the work piece clamping mechanisms, and the new cutting tool design have been analyzed. The main advantages and disadvantages of these designs have been established, and suggestions for their further improvement have been proposed.

Keywords: *planer machine, feeding mechanism, clamping mechanism, cutting tool.*

Introduction. The primary goal of woodworking production is to obtain parts and products of the required shape, size, and surface roughness with minimal costs, which remains a crucial task for modern manufacturing. Regulation of accuracy and surface roughness is of significant practical importance because performing the initial operations with the required precision reduces the actual allowances for machining in subsequent operations, thus enabling wood conservation and resulting in an environmental benefit. Furthermore, this improves the final accuracy of the parts and creates a more feasible opportunity to automate finishing processes due to more precise preliminary calibration of work pieces during the initial operations.

Problem statement. The high requirements for machining accuracy are particularly relevant for a type of longitudinal milling machine, such as planer machines, whose task is to form the required thickness of workpieces with the necessary surface roughness. An analysis of the use of planer machines, the typical schematic diagram of which is shown in Fig. 1, reveals that the quality of the products obtained after processing on these machines primarily depends on the design of the workpiece feeding mechanisms (1), their clamping on the machine (2), and the design of the cutting tool (3).

Presentation of the main material. Let us consider the main designs of the mentioned mechanisms and their directions for improvement.

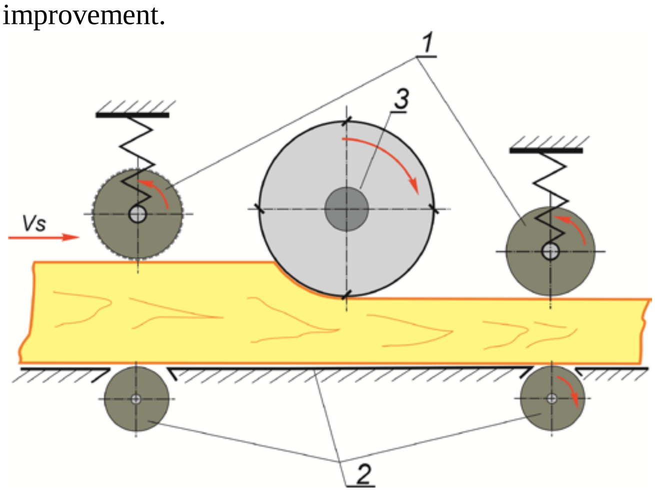

Fig 1. **Schematic diagram of a planer machine: 1 – workpiece feeding mechanism; 2 – basing mechanism; 3 – cutting tool.**

To simultaneously process several workpieces with different allowances for machining, the front roller in the workpiece feeding mechanism is made sectional [1], and each section can independently tilt upwards when feeding workpieces of varying thickness. The front roller of a single-sided planer is made corrugated. The corrugations provide good grip and reliable feeding of the processed workpieces into the machine. Additionally, the roller is made sectional (Fig. 2), consisting of a set of corrugated rings 1 mounted on a common shaft 2. Elastic elements, such as steel springs 3 or rubber bushings-dampers 4, are placed in the gap between the rings and the shaft.

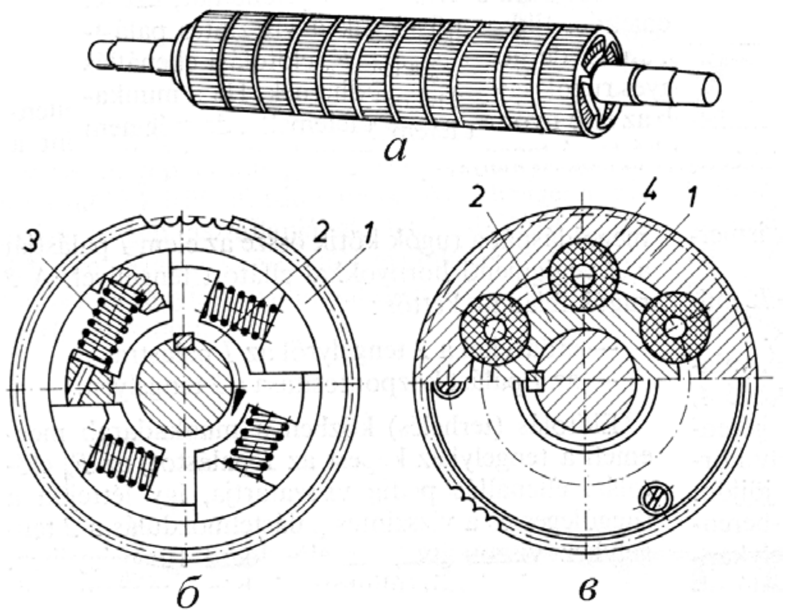

Fig 2. **Sectional feeding roller: a – general view; b – cross-section of the spring sectional roller; c – the same with rubber rings; 1 – outer grooved ring; 2 – drive shaft; 3 – springs; 4 – rubber bushings.**

The elastic elements allow the outer rings to move independently of each other and the shaft in the vertical plane. This makes it possible to process several workpieces with different allowances simultaneously.

Such a design is widely used in various models of planer machines, but it has the following disadvantages. Due to the use of rubber elastic rings or springs, the pressure of the roller on the upper surface of the workpieces will depend on their thickness, and in some cases, the teeth of the roller sink into the workpiece to such an extent that further allowance removal is done to a lesser degree, leaving traces of tooth indentation on the processed surface. Another disadvantage is that rubber rings or springs are under continuous load, and after some time, they lose their elastic properties and need to be replaced. To ensure uniform pressure on the surface of the workpiece, other designs of sectional rollers are used. Let's consider one such design, which is based on the use of a viscous fluid hydroplastic [2].

The sectional roller (Fig. 3) consists of steel grooved sections 1 and a drive shaft 2 with an internal cavity 3, which is filled with hydroplastic. The left and right trunnions 4 are rigidly connected to the shaft 2. Bearings 5 are installed on them in housings 6, which are mounted on the machine frame 7. A drive sprocket 8 is fixed on the right trunnion 4. The left trunnion has a rod 9, which interacts with a spring 10, adjusted by a nut 11.

Between the shaft 2 and the section housing 1, three plungers 12 are installed, which are located on the shaft in bushings 13 and one end enters the groove of the section. The sectional roller is positioned above the planer machine table 14, along which the bar workpieces 15 are fed.

During the operation of the machine and the feeding of blanks with varying thicknesses, the grooved sections 1 shift by an amount corresponding to the thickness variation relative to the drive shaft 2. In this process, a row of plungers 12 enters the cavity of the shaft 3, displaces the hydroplastic, and simultaneously transmits torque from the shaft 2 to the sections 1. The change in the volume of the shaft cavity 3, due to the plungers 12 entering it, is compensated by the movement of the rod 9. The working pressure force of the sections 1 on the blanks 15 is adjusted using the nut 11.

The main advantage of the considered design of the sectional roller is that it has a single damping element for all sections, can provide an adjustable pressing force that does not damage the surface of the blanks, and ensures a uniform force for all blanks that are simultaneously fed through the roller.

Next, we will consider the workpiece clamping scheme on the planer table according to position 2 in Fig. 1. In the modern scheme of combined clamping of the bottom surface of the workpiece on rollers and the table surface, it is difficult to adjust the machine depending on the wood species and the workpiece parameters. The workpiece clamping scheme should be chosen in such a way as to minimize wood loss, reduce deviations from the flatness of the base surface formed during planing, and simultaneously ensure the required roughness of the processed surface.

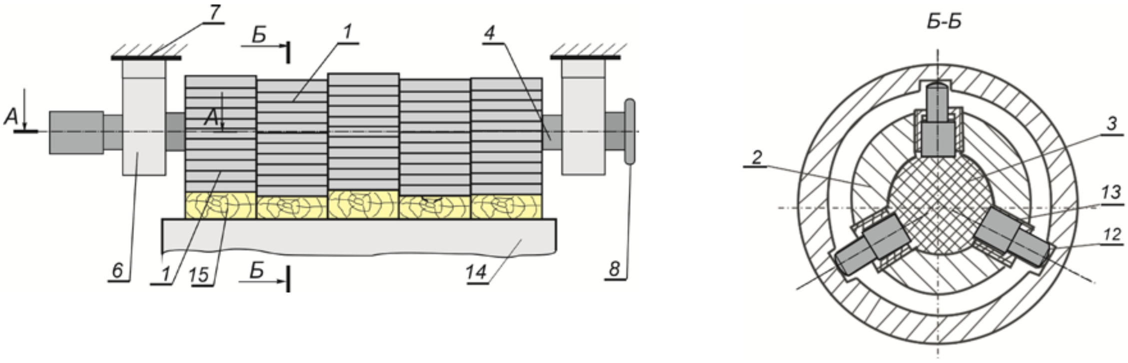

Fig 3. **Sectional roller with hydroplastic: 1 – grooved section; 2 – roller shaft; 3 – axial hydro cavity; 4 – trunnion; 5 – bearing; 6 – bearing housing; 7 – planer machine frame; 8 – drive sprocket; 9 – rod; 10 – spring; 11 – adjusting nut; 12 – plunger; 13 – bushing; 14 – planer machine table; 15 – workpiece.**

During the processing of workpieces on a planer, at the entry and exit points of the workpiece in the cutting zone, a clamping error occurs due to wood deformation and workpiece deflection under the cutting force. The instantaneous cutting force along the tool's contact arc with the wood varies in magnitude due to changes in the chip thickness. The maximum cutting force is generated practically when the cutters engage with the workpiece, which occurs in the form of a shock during operation. Under the influence of this force, the workpiece bends and presses against the surface of the table.

In order to eliminate the arm between the point of application of the cutting force and the clamping point of the workpiece, it is proposed [3] to install an additional intermediate non-driven roller (Fig. 4) in the cutting zone as auxiliary support.

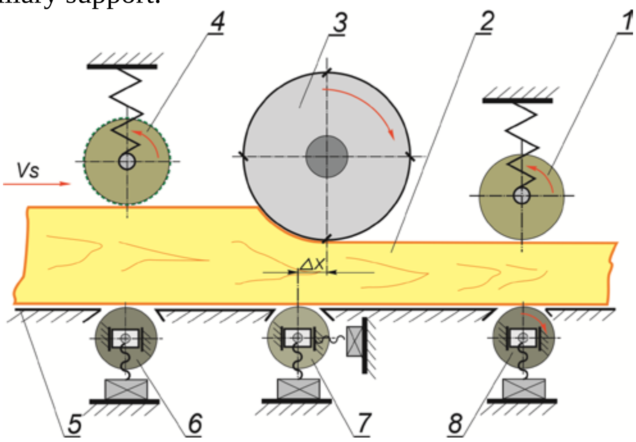

Fig 4. **Schematic diagram of the new workpiece clamping mechanism for the planer: 1 – rear feed roller; 2 – workpiece; 3 – cutter shaft; 4 – front feed roller; 5 – table; 6 – table support roller; 7 – additional supporting roller; 8 – base roller of the table.**

To ensure better cutting conditions and prevent workpiece vibration, the vertical axis of the roller must be displaced from the cutter shaft axis in the direction of the workpiece feed by a distance equal to half of the contact arc *Δx*, which is determined by the formula:

$$\Delta x = \frac{\sqrt{h \cdot (D - h)}}{2},$$

where h – thickness of the removed layer, mm; D – diameter of the cutter shaft.

For the CP6-9 machine, with the diameter of the knife shaft D = 125 mm and the thickness of the cutting layer h = 5 mm, the amount of displacement:

$$\Delta x = \frac{\sqrt{5 \cdot (125-5)}}{2} = 12{,}2 \text{ mm.}$$

This clamping scheme ensures better surface quality of the processed workpiece.

Next, we will consider the improvement of the cutter shaft of the planer (position 3, Fig. 1). Recently, a new design of the planer cutter shaft with a spiral arrangement of cutting inserts (shear-type cutter shaft) has been gaining popularity [4].

Fig. 5 shows the cutter shaft with a spiral arrangement of cutting inserts.

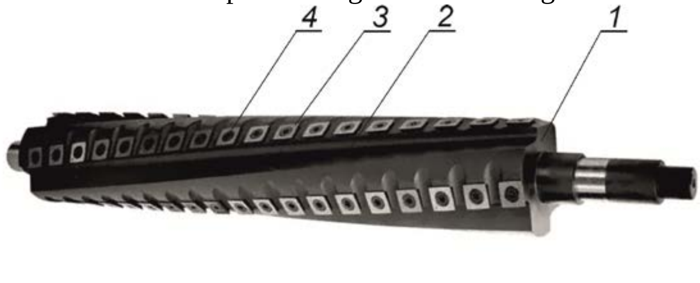

Fig 5. **Construction of the cutter shaft of a planer machine with cutting inserts arranged in a spiral: 1 – shaft housing; 2 – spiral projection; 3 – cutting insert; 4 – screw for securing the insert.**

The shaper shaft has a housing (1) with six spirals (2), on which cutting elements are mounted. These cutting elements are made of hard alloy and have the form of thin square inserts (3). The inserts have a central hole for fastening with screws (4). The inserts are 2 mm thick, have cutting edges on all sides, and are installed with a twist along the axis of the cutter shaft in a spiral pattern.

Advantages of the design:

- The shaft design allows the cutting elements to smoothly enter the woodcutting process, ensuring high-quality surface processing of the workpiece by cutting the wood fibers at an angle.
- If the inserts encounter a hard knot or nail during processing and get damaged, only the damaged inserts need to be replaced.
- The shaper shaft lasts 15 to 20 times longer than the planer shaft because the rotary inserts have four cutting edges. When one edge dulls, the insert is rotated by 90 degrees, and the next edge begins to work.
- The shaft is precisely balanced and does not require additional balancing after knife replacement.
- Due to its design, the shaper shaft generates a low noise level during operation.
- The cutting edge arranged in a spiral pattern relative to the workpiece surface provides superior surface quality for woodworkpieces.

In addition to the mentioned advantages, the design of the shaper shaft has the following disadvantages:

- Significant time expenditure for reinstalling the knives in the form of inserts, the number of which can reach up to 132 pieces for a shaft length of 630 mm.
- The complexity of manufacturing the shaft itself to ensure the precise positioning of the insert-knives.
- The increased cost of the shaper shaft compared to a standard cutter shaft by several times.

Conclusions. As a result of the analysis of the proposed improvements to planer machines, it should be noted that they significantly address the task of improving processing efficiency for planer machines. However, there have been no attempts to make greater use of electronic devices for tuning planer machines based on artificial intelligence. This task should be addressed through further theoretical and experimental studies of the processes of workpiece positioning and their processing with the new tool – the shaper shaft.

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