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The effect of feed speed on planning quality of wood

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Abstract

Planing is the first operation during mechanical processing of wooden work pieces. The quality of this operation is determined by finished surface which consists of a series of waves formed due to milling process. Step "l" and depth "y" of waves are two parameters that determine the quality of the surface. In our study, we have measured the depth of the wave corresponding to the magnitude of surface irregularities. Planing of samples was realized applying four different feeding speeds: U1=3 m/min, U2=7 m/min, U3=10 m/min and U4=23 m/min. It was noted a strong relationship between feed speed and the quality of planed surface. For feeding speed 3 m/min a high smooth class (Δδ9) of surface was obtained, while increasing feeding speed the smoothing class descended below. An optimal combination between surface quality and output of planning machine is achieved for feed speed 10 m/min. To increase the output without downgrading the surface quality, cutterhead with many knives need to be applied.

Keywords: planning; surface quality; wave; feeding speed.

1. Introduction

The first mechanical processing operation of wooden work pieces (pieces that have emerged from sawing process) is their planing, which is performed by planing machine. Planing process is designed to plan wooden work piece on one side and one edge, in order that both finished surfaces to be positioned at angle of 900 related to each other, as well as to eliminate completely the surface irregularities and roughness caused by sawing process of the wood. The planing process also serves to create the base for further processing of work pieces with the right accuracy. The quality of this operation is determined by finished surface which consists of a series of waves formed due to milling process. In practice, there is no perfectly smooth surfaces, especially when it comes to wooden materials, which, however to be worked out accurately, cannot be entirely smooth, due to knife traces, scratches and various marks caused during milling process.The magnitude of surface irregularities depends on the structure of wood, on kinematics of the knife's movement, on knives consumption etc. [1]. Based on the quality of the finished surface is determined feed speed as well (figure 1).

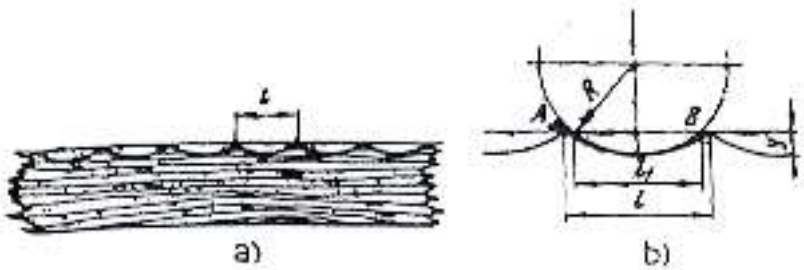

Figure 1. Planed surface of wooden work piece

a-general appearance; b-shape of tool's movement; l-step of the wave; y-depth of the wave; R-circle radius of rotation of knives edges

2. Material and Methods

Measurements were carried out with regard to smoothness (roughness) of wooden planed surface changing the feeding speed of the work piece. The measurements were performed at the Wood Processing Laboratory at the Faculty of Forestry Sciences of Tirana. It was selected a planing machine with diameter of cutterhead 128 mm, with three knives and 5600 revolutions per minute. Planing of samples was realized applying four different feeding speeds: U1=3 m/min, U2=7 m/min, U3=10 m/min and U4=23 m/min. Step "l" and depth "y" of waves are two parameters that determine the quality of the surface. In our study, we have measured the depth of the wave corresponding to the magnitude of surface irregularities. Evaluation of surface roughness of the samples was carried out by means of a surface roughness tester, type MITUTOYO, model SJ-201P (Japan), for each feeding speed. This instrument applies the direct contact technique, using a pick-up stylus which traces irregularities of the surface, reproducing in this way its 2D profile and calculates its roughness based on respective standards. Nowadays, this technique is the most popular for roughness assessment, although it presents some important limitations regarding to contacting in principle (possible damage of the surface), non-zero tip radius (missing fine irregularities), cone angle of the tip (sliding on the steep fragments of the profile) and slow feed (limitation for in-process evaluation) [2]. The stylus traverses the surface at a constatnt speed 0.5 mm/s applying on the surface a negligible measuring force 4 mN. The depth of wave can be calculated by means of formula:

$$Y = \frac{I^2}{8R} \quad [\text{mm}] \qquad (1)$$

where R = circle radius through the knives in mm and I = step of the wave in mm.
The step's wave is in relation with feeding speed and is calculated by means of formula:

$$I = U_Z = \frac{1000 \times U}{n \times Z} \quad [\text{mm}] \qquad (2)$$

where UZ = feed per cut in mm, U = feed speed in m/min, n = revolutions of cutterhead per minute and Z = number of cutting edges (knives).

3. Results and Discussion

Mean values of measurements are shown in Table 1.

Table 1. Roughness surface in relation with feed speed

Nr.	Feed speed m/min	Wave's depth mm (μ)	Classes of surface roughness (smoothness)	
			According to ISOS-S	Old terminology
1	3	0.035 (35)	32	Δδ9
2	7	0.065 (65)	60	Δδ8
3	10	0.1 (100)	100	Δδ7
4	23	0.2 (200)	200	Δδ6

From measurements was noted a strong impact of feeding speed on the quality of planed surface. For the lowest feed speeds 3 m/min, a high smooth class Δδ9 was achieved, while increasing feeding speed the smoothing class descended below. Always after planing, moulding, shaping etc. on the surface of the work piece remains visible traces and irregularities. To increase the surface smoothness class, work pieces have to be processed afterwards by sanding machines [3]. This process is necessary if worked pieces will be varnished, because only in this way irregularities and knives traces of previous processes will be reduced. Condition of wood surface greatly influences the quality of varnishing. Hardness, brightness, longevity and adhesion of coating layer vary greatly, depending on the surface condition and its smoothness.The quality of previously finished surfaces of wooden work pieces greatly affects on the smoothness class of finished sanded surfaces. As smoother to be the surface which is going to be sanded, the smaller are going to be the layers of wood that will be removed during this operation. So, less is going to be the sanding process before coating. The roughness (smoothness) class of sanded surfaces that are going to be subjected of coating should be Δδ10 ÷ Δδ12.By the other hand, the quality of planed

surfaces is greatly influenced by feed speed of material. For feed speed of 3 m /min, the surface smoothness is good, but the output of planning machine is reduced, as feeding speed is the main factor affecting its productivity, expressed by means of the formula:

$$P = \frac{T \times U \times K_1 \times K_2}{L \times m \times c} \quad \text{[pieces/shift]} \qquad (3)$$

where T = time lasting of shift, U = feed speed in m/min, K1 = coefficient of working hours use, K2 = coefficient of useful work of the machine, L = mean length of work pieces, m = number of passes of a work piece through the planing machine, c = number of faces and edges to be processed in a work piece. An optimal combination between surface quality and output of planning machine is achieved for feed speed 10 m/min. The number of cutterhead's knives affects on the quality of the surface as well as on planing machine's output. Increasing the number of knives by the minimum of two knives to three or four knives significantly improves the quality of the surface, creating conditions for increasing the feed speed, thus increasing the output. This is also evident from the following formula see formula 2):

$$U = \frac{Z \times U_Z \times n}{1000} \quad \text{[m/min]} \qquad (4)$$

The roughness (smoothness) of the surface highly influences the quality of wood gluing. A fundamental condition to achieve a suitable adhesion is the full smothering of both surfaces to be glued, in order to have the ability to create a uniform adhesive layer in thickness [4]. Surfaces to be glued should be planed and should have a wave step not more than 3 mm and a depth of 0.02 mm. In this way these surfaces can provide a large contact surface and uniform thickness of the glue layer.

4. Conclusions

Based on results and discussion presented above we can say:

- The quality of planing operation is largely determined by the depth of the wave that knife leaves on the wood surface.
- Increasing feed speed leads to deterioration of surface quality.
- The reduction of feed speed is accompanied by improvement of surface quality, but the output of the machine is reduced.
- An optimal combination between surface quality and productivity of planning machine is achieved for feed speed 10 m/min.
- Increasing the number of knives significantly improves the quality of the surface, creating conditions for increasing the feed speed, thus increasing the output of the machine.

5. References

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