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Research Article

Comparison of Technical and Economic Parameters of Cutting of Solid Wood Panels with Numerically-Controlled and Traditional Woodworking Machines

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Abstract

The technology of wood mechanical processing has undergone positive changes, especially during the last two decades, achieving a rapid development through the application of advanced technologies. Numerically-controlled technology (CNC) has significantly improved technical and economic parameters, which has led to increased competitiveness of those companies that have installed this technology. The focus of this paper lies in the study of technical and economic parameters in cutting solid wood plates, used for the production of window frames, with CNC panel saw machines and with traditional saw-blade machines. The same cutting tool is used, cutting disc and pre-cutting disc, with the same geometry of the saw-blades cutting teeth for both machines. The study takes into account the cutting time of the constructive parts of the window frame, measured with the software of a CNC machine, and through a chronometer at the saw-disc machine. On the other side the costs of work force required for the operation are calculated. The results of the measurements and calculations reveal a clear advantage of the CNC saw-disc machines over the traditional saw-disc machines, in terms of operations times, enabling an increase in productivity and quality of the processing.

Keywords: *woodworking machines, traditional, numerically-controlled, solid wood panels, cutting parameters, cutting disc*

1. Introduction

Numeric-controlled (CNC) woodworking machinery has been widely introduced in wood industries for automatically cutting, drilling, and shaping operations (Ohuchi, M. and Murase, Y. 2005). With the use of CNC machinery many production processes in the wood processing industry are revolutionized.

CNC machinery have a positive impact in terms of lowering costs and the realization of large volumes of work in relatively short time and its continuous utilization with minimal operator involvement (FANUC, 2012).

There are many studies in the field literature on efficiency of CNC machinery (Liberman Y.L., 2010) related to many aspects influencing it directly or indirectly. Ohuchi and Murase (2005) studies the cutting instruments consuming effects on efficiency. The monitoring and evaluation of consuming of cutting instruments or other CNC machine tools have been studied by several authors (Weis, W. 1994; Lemaster, R. L. *et al.* 2000; Iskra, P. and Hernandez, R. E. 2012). Tonshoff *et al.* (1988) and Byrne *et al.* (1995) studied the requirements to be meet by sensors for process monitoring of CNC machine tools influencing direct or indirect the process efficiency.

This study focuses on the comparison of the economic and technical parameters of cutting of solid wood panels (Jambrekovic, V. 2004; Figuric, M. S. 2000), used to produce the constructive parts of a window frame, on a CNC and a traditional woodworking machine, using the same saw-disc and geometry of the cutting teeth (Dimoshi, S. and Rrjepaj, B. 1971).

The comparative method has been used, with direct measurement of the above mentioned parameters on the CNC and traditional machine in a furniture factory, which has these machines installed. The results obtained from both machines has been compared among themselves, in order to reveal differences in the technical and economic parameters of both machines.

The study is stressing mainly the importance of investing in advanced technology, especially for final wood processing, in order increases the competitiveness of wood manufacturing companies in the local, regional and even in the EU market.

2. Materials and methods

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2.1. Panel Saw CNC Machine HOLZMA HPP 350 430/430

The machine in question, as seen in Fig. 1, is dedicated to technological operations for cutting of massive, wood-based panels with a thickness of up to d=80 mm, maneuvering dimensions are 4300x 4300 mm. It's mainly installed in factories with large processing capacities, very high cutting quality. In the machine is running CADmatik 4.0 and contains also an optimization program, which is of great help during programming, by affecting the rational use of materials.

Fig. 1 Panel Saw HOLZMA HPP 350 430/430 with CADMATIK 4.0 numeric control program

The cutting tool used is one main cutting disc (blade) with parameters ø350x4.4xø60 mm, Z=72 teeth, rotations up to 5200/min, two lateral holes Y=ø14 mm and distance between them X = 100 mm The cutting speed is up to 87.3 m/s in frequencies to 50 Hz and n = 4387 rotations /min in frequencies of 50 Hz. The pre-cutting tool has parameters ø180x4.4-5.4xø45 mm, Z = 36 teeth, with up to 7000 rotations/min. Cutting speed up to 53.3 m/s in frequencies to 50 Hz and rotations n= 5659 /min. The machine also mounts the profile pre-cutting disc with following parameters: ø280x4.6xø45 mm, Z=84 teeth, in frequencies from 50 Hz cutting speed reaches 83 m/s, while rotations reach n= 5659 rotations /min. The details and the geometry of the cutting tools are given in Fig. 2.

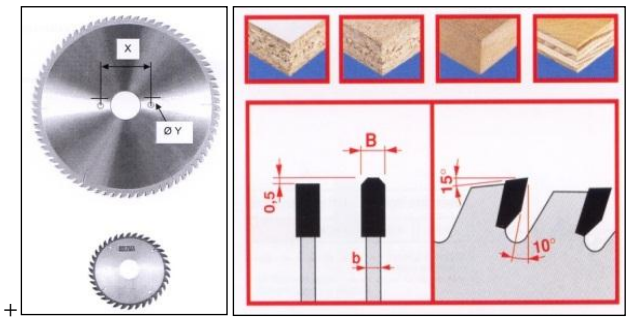


Fig. 2 The geometry of the main cutting tool (blade)

2.2. Traditional Panel Saw Machine KASADEI KS 340M

The machine in question, as seen in Fig. 3, is used for cutting different types of panels in the wood industry (Marku, P. and Bajraktari, A. 2006). It mounts the cutting and the pre-cutting disc; it has a very adequate working table, coupled to the assisting sliding table, which carries the panel, while the discs are mounted on the main body.

Fig. 3 Traditional Panel Saw Machine KASADEI KS 340M

The sliding table disposes of a pneumatic clutch, which secures stability to the details on the table. The sliding table is operated mechanically. This type of machine is suitable to medium-capacity workshops in the wood industry.

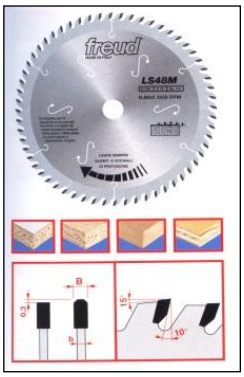


Fig. 4 The geometry of the main cutting tool (blade)

The nominal dimensions of the constructive parts of a window-frame have been first determined. For both the traditional Panel Saw Machine KASADEI KS 340M and Panel Saw CNC Machine HOLZMA HPP 350 there are no differences in these dimensions.

The constructive parts are cut then with KASADEI KS 340 M and the cutting operation time in this machine is measured by a chronometer. In the case of HOLZMA HPP 350 the nominal dimensions of the constructive parts are first fed into the software of the machine as shown in Fig. 5.

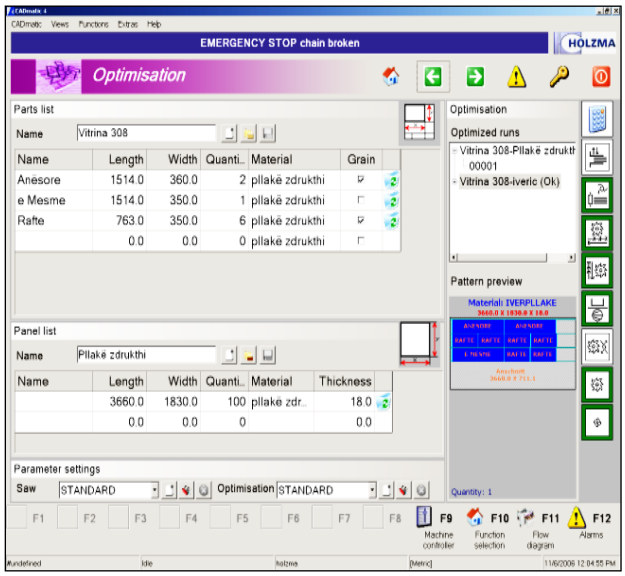


Fig. 5 A screen of the software showing the data entered

Before the cutting operation took place from the software of the CNC machine (Smid, 2006) we got an automatic optimization of the parts for the cutting process, which was not possible in the traditional machine.

3. Results and Discussions

In the tables 1 and 2 are given the nominal dimensions of the constructive parts of the window frame and the operations needed for each of the six specific constructive parts of the window frame.

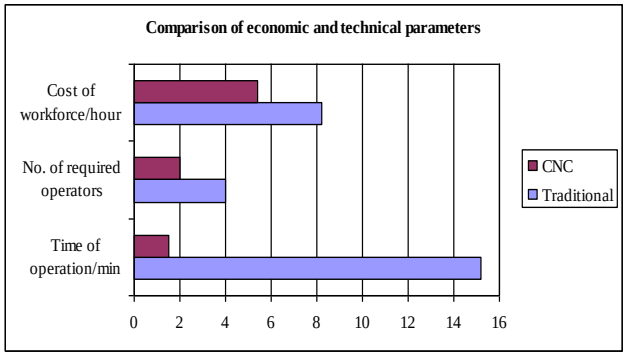
For the Panel Saw Machine KASADEI KS 340M the total time of all the single cutting processes is measured using a chronometer, meanwhile for the Panel Saw CNC Machine HOLZMA HPP 350 the total time of the operation is given automatically by the machine.

The results obtained from the measurements of technical parameters conducted on the technological cutting operation at the mill and comprising the time of cutting operation and economical parameters related to the costs of the work force required to operate both machines are given in the tables 3 and 4.

The costs of the work force for both machines are calculated based on the number of the operators required to operate the machines and labor cost per hour usual for the local standards of the area in which the factory is operating.

In the Graph. 1 are shown graphically compared the technical and economical values of parameters measured for the traditional and CNC machine, meanwhile in the Tab. 5 are shown the differences in the values of the parameters measures for both machines. As can be seen in Tab. 5 the measurements reveal significant differences between the CNC and the traditional machine related to the cutting operation of solid wood panels.

The most significance difference between both machines is in the time needed to perform the cutting operation of the plate, with the CNC machine being 9 time faster in performing the operation. By observing the results obtained by the technological operations with CNC and traditional machines it is clear, that referring to the time savings achieved using the CNC technology is great advance in terms of operation times.



Graph. 1 Comparison of technical and economic parameters measured for both machines

Time savings and minimizing the work force required for the operation enables the manufactures to a wide scale increase in productivity. An important role in this difference in the operation time plays the automatic optimization of the constructive parts performed by the CNC machine, which is not possible with the traditional machine.

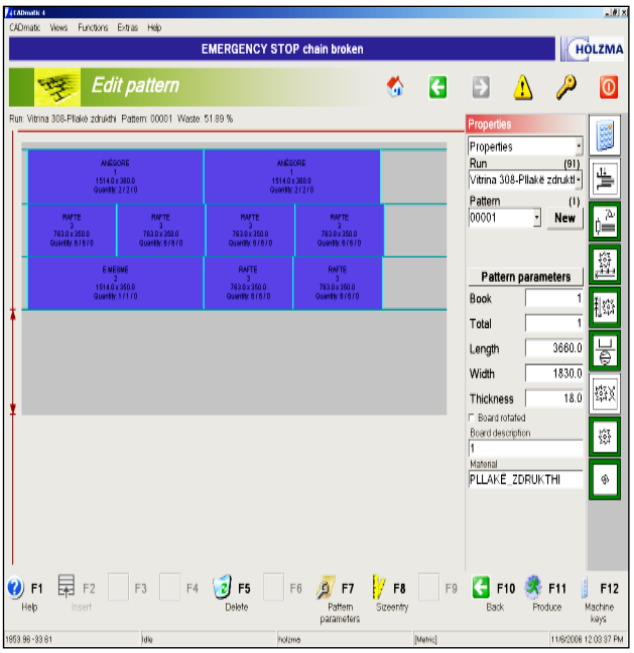


Fig. 6 Screen of the results of the automatic optimization achieved by HOLZMA HPP 350

From Tab. 5 we can see work force cost savings per hour of about 35%, which is a good basis for higher cost savings potential in total cost of production taking into account the higher production capacities and higher productivities/hour of CNC production lines.

Table. 1 Nominal dimensions of the constructive parts and cutting operation time for KASADEI KS 340 M

PRODUCT NAME		WINDOW-CASE item 308				**PRODUCT DIMENSIONS**		160x160x40 cm
Nr.	**Constructive**	**Type**	**Dimensions of constructive parts**			**Name of the Machine:** TRADITIONAL HORIZONTAL PANEL SAW KASADEI KS 340M		
	Parts		thickness	width	length	**Tech. Operation:** PANNEL CUTTING		
			in cm	in cm	in cm	Time of Technological operation [min]		
						No. of parts	**TYPE OF OPERATION**	**TIME [min]**
1	Upper Panel	Solid wood panel	1.8	40	160	**1**	CUTTING	
2	Door	Solid wood panel	1.8	39.35	151.4	**4**	CUTTING	
3	Sill	Solid wood panel	1.8	40	160	**1**	CUTTING	
4	Shelves	Solid wood panel	1.8	35	76.3	**6**	CUTTING	
5	Laterals	Solid wood panel	1.8	36	151.4	**2**	CUTTING	
6	Middle Laterals	Solid wood panel	1.8	35	151.4	**1**	CUTTING	
						15	**TOTAL TIME [min]**	**15.20**

Table. 2 Nominal dimensions of the constructive parts and cutting operation time for HOLZMA HPP 350

PRODUCT NAME		WINDOW-CASE item 308				**PRODUCT DIMENSIONS**		160x160x40 cm
Nr.	**Constructive**	**Type**	**Dimensions of constructive parts**			**Name of the Machine:** HORIZONTAL PANEL SAW HOLZMA HPP 350		
	Parts		thickness	width	length	**Tech. Operation:** PANNEL CUTTING	**Installed Program:** CADMATIK 4.0	
			in cm	in cm	in cm	Time of Technological operation [min]		
						No. of parts	**TYPE OF OPERATION**	**TIME [min]**
1	Upper Panel	Solid wood panel	1.8	40	160	**1**	CUTTING	
2	Door	Solid wood panel	1.8	39.35	151.4	**4**	CUTTING	
3	Sill	Solid wood panel	1.8	40	160	**1**	CUTTING	
4	Shelves	Solid wood panel	1.8	35	76.3	**6**	CUTTING	
5	Laterals	Solid wood panel	1.8	36	151.4	**2**	CUTTING	
6	Middle Laterals	Solid wood panel	1.8	35	151.4	**1**	CUTTING	
						15	**TOTAL TIME [min]**	**1.53**

Table. 3 Time of operation measured and calculated work force costs for KASADEI KS 340 M

Nomination of Technological operations	**Time of technical operation (min)**	**No. of required operators**	**Labor costs per (h)/€**	**No. of required operator assist.**	**Labor costs (€/h)**	**Total work force costs (€/h)**
1	2	3	4	5	6	7
Technical cutting operation	**15.2**	1	2.5	3	1.9	**8.2**

Table. 4 Time of operation measured and calculated work force costs for HOLZMA HPP 350

Nomination of Technological operations	Time of technical operation (min)	No. of required operators	Labor costs per (h)/€	No. of required operator assist.	Labor costs (€/h)	Total work force costs (€/h)
1	2	3	4	5	6	7
Technical cutting operation	**1.53**	1	3.5	1	1.9	**5.4**

Table. 5 Differences in parameters measured between the CNC and traditional machine in %

No.	Parameters measured/calculated	CNC machine	Traditional machine	Difference between CNC and traditional machine (%)
1	Time of operation per product in min.	1.53	15.2	-899
2	Number of required operators	2	4	-100
3	Cost of workforce per hour in €	5.4	8.2	-34

4. Conclusions

This study focuses on the comparison of the economic (Ymeri, 2007) and technical parameters of cutting of solid wood panels used to produce the constructive parts of a window frame, on a CNC (HOLZMA HPP 350) and a traditional woodworking machine (KASADEI KS 340 M). Both machines are using the same main cutting tool (blade).

Technical parameter of the cutting process related to the time of operation has been measured in both machines, manually for the traditional one. Economic parameters related to the no. of required operators and labor costs per hour has been calculated.

The measurements reveal significant differences between the CNC and the traditional machine related to the cutting operation of solid wood panels. The most significance difference between both machines is in the time needed to perform the cutting operation of the plate, with the CNC machine being 9 time faster in performing the operation.

There is a work force cost savings per hour of about 35%, which is a good basis for higher cost savings potential in total cost of production taking into account the higher production capacities and higher productivities/hour of CNC production lines.

Other advantages of the CNC technology related to the cutting process studied are a higher quality of product processing of CNC machines, which gave a advantage in the price of the product. There is a significant drop of the need for internal transport of processing parts, decreasing the total costs of the production.

Automatic optimization of the material during technological operations with CNC machines, which is missing in traditional machines, has an increasing effect on the level of the raw material use.

The annual value of depreciation of CNC machines is much higher compared to the traditional woodworking machines, due to their high initial investment cost, but cost benefits from much higher productivity and revenue benefits from the higher quality of the products fully justify these costs.

Enterprises that plan for well-organized and high quality production, should consider raising the capacities of well trained operators for these types of machines and programs, when ordering these machines.

The study is stressing mainly the importance of investing in advanced CNC technology, especially for final wood processing, in order increases the competitiveness of wood manufacturing companies in the local, regional and even in the EU market.

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