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INFLUENCE OF FEED RATE ON CUTTING FORCE AND CUTTING POWER DURING WOODPROCESING ON BAND SAW

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ABSTRACT

The defining and determining of the cutting process between the tool and the wood is the crucial factor for the product and production quality, tool efficiency and industrial safety. The economy of the machine as well as the whole production depend on it.

These are the main reasons why the optimal determining of the woodcutting process today attains greater importance in the wood processing industry.

The research was focused on creating a mathematical model of the interaction mechanism between the tool and the wood. An analytical tool is designed for determining some important factors in the wood cutting process – cutting force, cutting power, etc. All of these factors are calculated as a function of exactly defined input parameters, grouped in several categories. The mathematical model is supported with appropriate software.

Key words: woodcutting, wood processing, woodcutting tools, dynamic process simulation.

INTRODUCTION

The quality of wood cutting has a significant importance on saw mill processing such as: efficiency of tools, work safety, economy and productivity of the process.

For these reasons, it is necessary to investigate wood cutting in detail, which will result in the selection of the optimal parameters for work regimes. In other words, it is necessary to define a mathematical model on the base of empirical correlation of important parameters in the process of wood cutting with band saw obtained by a series of experiments.

The mathematical model offers the possibility of determining some important factors in the process of cutting as the cutting force, cutting power, wear of the tool, surface quality etc. All these factors are correlated with exactly defined input parameters, previously set and grouped into several categories:

- geometric characteristics of a tool;
- kinematic, dynamic and technological characteristics of a tool
- cutting speed, feed rate, cutting height, dimensions of the tool, type of cutting, etc
- characteristics of the material subject to processing (wood species, mechanical properties, the direction of cutting).

The model is supported with an adequate software program.

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MATERIAL AND METHODS

The realization of the goals of this research was performed using a computer program for simulation of the process of wood cutting. For the simulation of the wood cutting process with band saw as a constant the following parameters are defined:

- Wheel diameter 1100 [mm]
- saw thickness 1,6 [mm]
- saw width 210 [mm]
- kerfs' step 46 [mm]
- initial roundness radius 8 [μm]
- cutting angle 65 [^{0}C]
- feed rate 5[m/min]
- distance between wheels 2250 [mm]
- Kerf pressing 0,5 [mm]
- cutting height 250 [mm]
- wood species (Fagus silvatica L.); (Pinus silvestris L.)

As a variable input in the cutting process is the feed rate which, increasing from 5 to 50 m/min, increased in steps by 5 m/min.

In the process of wood cutting, cutting force and cutting power are the main parameters while feed by kerf, cutting speed, average pressure on the front side of the kerf and Fictive specific force on the back side of the kerf are secondary parameters.

RESULTS AND DISCUSSION

The influence of feed rate on the cutting force and the cutting power during wood cutting of beech and pine with a band saw is shown in Tab. 1 and Tab. 2 respectively. In order to get a better access of the obtained results, the results are also graphically shown (Fig.1;2.).

Tab.1: Influence of the feed rate on cutting force and cutting power during wood cutting of beech with band saw

Wheel diameter	mm	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400
Rotatingspeed	mm^{-1}	550	550	550	550	550	550	550	550	550	550
Saw thickness	mm	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8
Saw widht	mm	195	195	195	195	195	195	195	195	195	195
Kerf step	mm	75	75	75	75	75	75	75	75	75	75
Cutting blade radius	μm	12	12	12	12	12	12	12	12	12	12
Cutting angle	^{0}	65	65	65	65	65	65	65	65	65	65
Feed speed	m/min	5	10	15	20	25	30	35	40	45	50
Distance between wheels	mm	2950	2950	2950	2950	2950	2950	2950	2950	2950	2950
Cutting height	mm	250	250	250	250	250	250	250	250	250	250
Kerf pressing	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6
Wood species		beech	beech	beech	beech	beech	beech	beech	beech	beech	beech
Feed by kerf	mm/kerf	0,55	1,11	1,67	2,23	2,79	3,35	3,91	4,47	5,03	5,59
Cutting speed	m/s	40,2	40,2	40,2	40,2	40,2	40,2	40,2	40,2	40,2	40,2
Average pressure on front side	N/mm^2	3,66	3,66	3,66	3,66	3,66	3,66	3,66	3,66	3,66	3,66
Fict,spec,force on back side	N/m	922	922	922	922	922	922	922	922	922	922
Start cutting force	N	40,8	71,9	102,9	134,0	165,1	196,1	227,2	258,3	323,7	358,4
End cutting force	N	45,9	80,6	115,3	150,0	184,8	219,5	254,2	288,9	323,7	358,4
Start cutting power	W	1640	3240	4635	6030	7429	8824	10219	11614	13013	14408
End cutting power	W	1845	3240	4635	6030	7429	8824	10219	11614	13013	14408

Tab. 2. Influence of the feed rate on cutting force and cutting power during wood cutting of pine with band saw

Wheel diameter	mm	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400
Rotatingspeed	mm^{-1}	550	550	550	550	550	550	550	550	550	550
Saw thickness	mm	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8
Saw widht	mm	195	195	195	195	195	195	195	195	195	195
Kerf step	mm	75	75	75	75	75	75	75	75	75	75
Cutting blade radius	μm	12	12	12	12	12	12	12	12	12	12
Cutting angle	^{0}	65	65	65	65	65	65	65	65	65	65
Feed speed	m/min	5	10	15	20	25	30	35	40	45	50
Distance between wheels	mm	2950	2950	2950	2950	2950	2950	2950	2950	2950	2950
Cutting height	mm	250	250	250	250	250	250	250	250	250	250
Kerf pressing	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6
Wood species		pine	pine	pine	pine	pine	pine	pine	pine	pine	pine
Feed by kerf	mm/kerf	0,55	1,11	1,67	2,23	2,79	3,35	3,91	4,47	5,03	5,59
Cutting speed	m/s	40,2	40,2	40,2	40,2	40,2	40,2	40,2	40,2	40,2	40,2
Average pressure on front side	N/mm^2	3,66	3,66	3,66	3,66	3,66	3,66	3,66	3,66	3,66	3,66
Fict,spec,force on back side	N/m	706	706	706	706	706	706	706	706	706	706
Start cutting force	N	37,1	66,8	96,6	126,3	156,1	185,8	215,6	245,3	275,1	304,8
End cutting force	N	41,8	75,2	108,6	142,0	175,4	208,8	242,3	275,7	309,1	342,5
Start cutting power	W	1491	2685	3883	5077	6275	7469	8667	9861	11059	12253
End cutting power	W	1680	3023	4366	5708	7051	8394	9740	11083	12426	13769

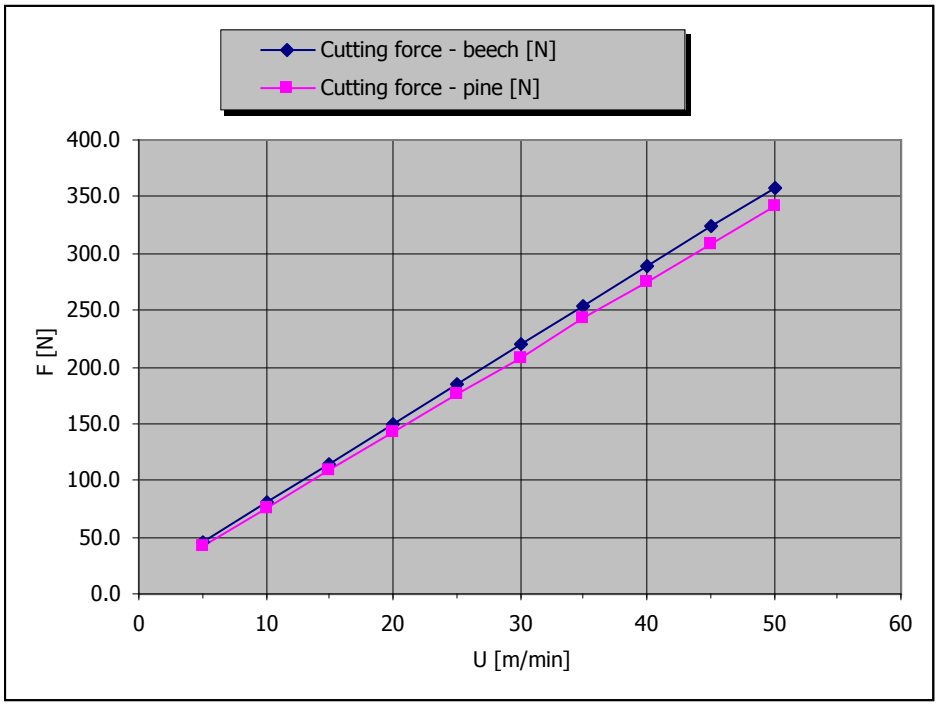

Fig.1: Relation between cutting force and feed rate during wood cutting of beech and pine with band saw

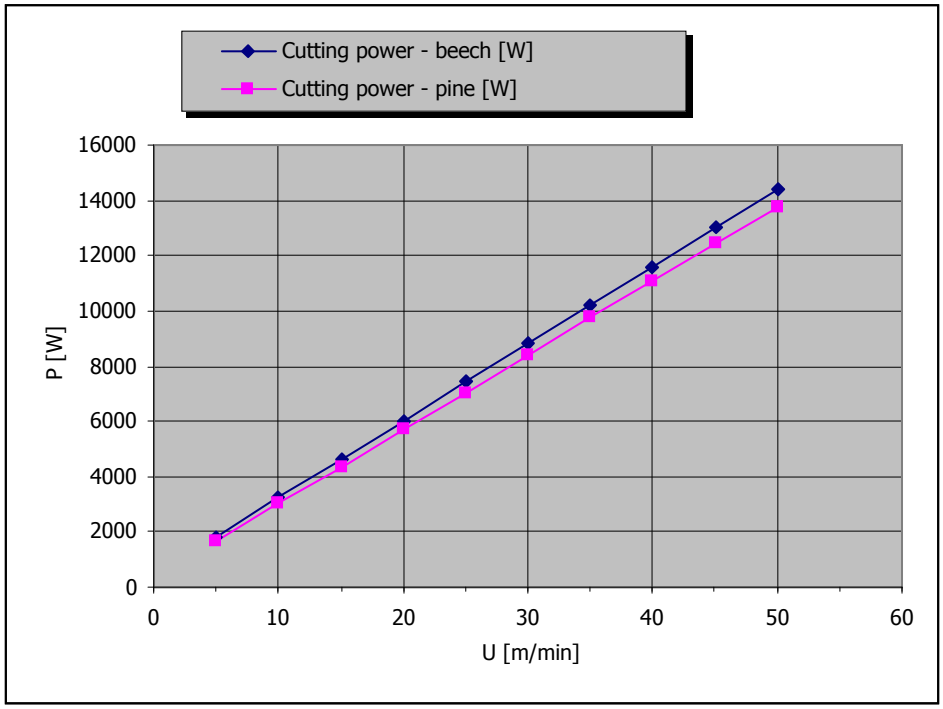

Fig. 2: Relation between cutting power and feed rate during wood cutting of beech and pine with band saw

Based on the data shown in Tab.1, it can be concluded that ten different values of feed rate have been selected, from minimum of 5 m/min to maximum of 50 m/min, with a step by 5 m/min. Besides the influence of the feed rate on cutting force and cutting power, this parameter also has an influence on the value of feed by kerf.

Figure 1 evidently shows a significant influence of the cutting force on the feed rate and also the low of changing of power is approximately linear, with proportional depending.

A similar conclusion comes from the diagram shown in figure 2, where the graphically represented influence on the picture shows the dependence of power cutting on feed rate.

CONCLUSIONS

According to the presented data and results obtained during wood cutting of beech and pine with band saw, it can be concluded that:

1. Using the simulation program, investigations were carried out on the influence of feed rate on the cutting process.
2. Elementary output parameters which are the basis for assessment of cutting are the cutting force and cutting power.
3. The influence of feed rate on the cutting force and cutting power is significant. With the increasing of the feed rate for every 1 m / min, the cutting force and cutting power increase from 7,5 to 9,0%.
4. The results obtained from the program correspond to the real situation of wood cutting with band saw, with tolerances due to the complexity of the interaction between the tool and the physical and mechanical characteristics of wood.
5. In the analytical procedures for defining the system, modifications and changes in the program are relatively simply based on data from new experimental investigations.
6. The simulation program for wood cutting with band saw cannot replace the classical experimental investigation, but it can be a good basis for it.

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