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RESEARCH ON THE EFFECTS OF THE NUMBER OF CIRCULAR SAW BLADES ON THE CUTTING FORCE AND THE CUTTING POWER

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ABSTRACT

Wood processing with a circular saw is a complex process that involves several factors which affect product quality, tools performance and process safety. It also affects productivity of the machine and the economics of the overall production process. These are the main reasons why optimal determination of the woodcutting process nowadays bears great significance in wood processing industry. The research was focused on creating a mathematical model of the interaction mechanism between tool and wood as a workpiece. Analytical tool was designed for determining some important factors in wood cutting process – cutting force, cutting power, etc. All of these factors were calculated as a function of exactly defined input parameters, grouped in several categories. The mathematical model was supported by an appropriate software.

Key words: woodprocessing, woodcutting tools, circular saw, cutting force, cutting power

1. INTRODUCTION

Woodcutting has a significant effect on circular saw processing, as well as on factors such as: tool efficiency, work safety, economy and productivity of the process. Investigating woodcutting process in details is very important, as it will result in selection of the optimal parameters for different operating modes. The mathematical model of woodcutting process was designed on basis of the empirical correlations among the important parameters in the process of wood cutting with circular saw, obtained by a series of experiments. The mathematical model offers the possibility to determine some important factors in the process of cutting, such 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 tool;
- kinematic, dynamic and technological characteristics of tool
- cutting speed, feed rate, cutting height, dimensions of tool, type of cutting, etc.
- characteristics of material subject to processing (wood species, mechanical properties, the direction of cutting). The simulation model was supported with an appropriate software program.

2. METHODS

Realization of the goals of this research was performed using the computer program for wood cutting process simulation. For simulation of the wood cutting process with circular saw the following parameters were defined as constant:

- Saw diameter	250	[mm]
- Cutting height	20	[mm]

- Speed 3000 [min^{-1}]
- Saw thickness 1,8 [mm]
- Feed speed 18 [m/min]
- Cutting blade radius 10 [μm]
- Cutting angle 68 [°]
- Blades set 0,2 [mm]
- Saw axis-table distance 15 [mm]
- Cutting type Transversally
- Wood species Beech / Pine

A variable input in the cutting process was the number of blades in the range from 24 to up to 72. In the process of wood cutting, cutting force and cutting power are the main output parameters, while the chip thickness, feed by blade, blades pitch, cutting speed, average pressure on front side, fictive specific force on back side, contact angle and average kinematic cutting angle are considered secondary parameters.

3. RESULTS AND DISCUSION

The influence of the number of blades on cutting force and cutting power during woodcutting with circular saw of beech and pine are shown in Table 1 and Table 2 respectively. In order to get better idea of the results obtained,, the results are also shown graphically (Figure 1;2.).

Table 1. *Influence of number of blades on cutting force and cutting power during circular saw processing of beech*

Saw diameter	[mm]	250	250	250	250	250	250	250
Cutting height	[mm]	20	20	20	20	20	20	20
Speed	[min^{-1}]	3000	3000	3000	3000	3000	3000	3000
Saw thickness	[mm]	1,8	1,8	1,8	1,8	1,8	1,8	1,8
Number of blades		24	32	40	48	56	64	72
Feed speed	[m/min]	18	18	18	18	18	18	18
Cutting blade radius	[μm]	10	10	10	10	10	10	10
Cutting angle	[°]	68	68	68	68	68	68	68
Blades set	[mm]	0,2	0,2	0,2	0,2	0,2	0,2	0,2
Saw axis-table distance	[mm]	15	15	15	15	15	15	15
Cutting type	Transversally							
Wood species	Beech							
Chip thickness	[mm]	0,245	0,184	0,147	0,122	0,105	0,091	0,081
Feed by blade	[mm/blade]	0,25	0,19	0,15	0,12	0,11	0,09	0,08
Blades pitch	[mm]	32,71	24,53	19,63	16,35	14,02	12,26	10,90
Cutting speed	[m/s]	39,25	39,25	39,25	39,25	39,25	39,25	39,25
Avg. pressure on front side	[N/mm^2]	59	59	59	59	59	59	59
Fict.spec.force on back side	[N/mm]	1,482	1,482	1,482	1,482	1,482	1,482	1,482
Contact Angle	[°]	9,3	9,3	9,3	9,3	9,3	9,3	9,3
Avg. kinematic cutting angle	[°]	8,8	8,8	8,8	8,8	8,8	8,8	8,8
Start cutting force	[N]	23,9	24,7	25,5	26,0	26,9	27,5	28,3
End cutting force	[N]	24,1	24,9	25,7	26,3	27,2	27,8	28,7
Start cutting power	[W]	939	969	1000	1022	1056	1080	1112
End cutting power	[W]	944	976	1008	1032	1067	1093	1126

Table 2. *Influence of number of blades on cutting force and cutting power during circular saw processing of pine*

Saw diameter	[mm]	250	250	250	250	250	250	250
Cutting height	[mm]	20	20	20	20	20	20	20
Speed	[min^{-1}]	3000	3000	3000	3000	3000	3000	3000
Saw thickness	[mm]	1,8	1,8	1,8	1,8	1,8	1,8	1,8
Number of blades		24	32	40	48	56	64	72
Feed speed	[m/min]	18	18	18	18	18	18	18
Cutting blade radius	[μm]	10	10	10	10	10	10	10
Cutting angle	[°]	68	68	68	68	68	68	68
Blades set	[mm]	0,2	0,2	0,2	0,2	0,2	0,2	0,2
Saw axis-table distance	[mm]	15	15	15	15	15	15	15
Cutting type	Transversally							
Wood species	Pine							
Chip thickness	[mm]	0,245	0,184	0,147	0,122	0,105	0,091	0,081
Feed by blade	[mm/blade]	0,25	0,19	0,15	0,12	0,11	0,09	0,08
Blades pitch	[mm]	32,71	24,53	19,63	16,35	14,02	12,26	10,90
Cutting speed	[m/s]	39,25	39,25	39,25	39,25	39,25	39,25	39,25
Avg. pressure on front side	[N/mm^2]	36	36	36	36	36	36	36
Fict.spec.force on back side	[N/mm]	0,981	0,981	0,981	0,981	0,981	0,981	0,981
Contact Angle	[°]	9,3	9,3	9,3	9,3	9,3	9,3	9,3
Avg. kinematic cutting angle	[°]	8,8	8,8	8,8	8,8	8,8	8,8	8,8
Start cutting force	[N]	14,7	15,2	15,7	16,1	16,7	17,1	17,6
End cutting force	[N]	14,8	15,3	15,9	16,3	16,9	17,3	17,9
Start cutting power	[W]	577	597	617	632	655	671	692
End cutting power	[W]	581	602	623	639	662	679	701

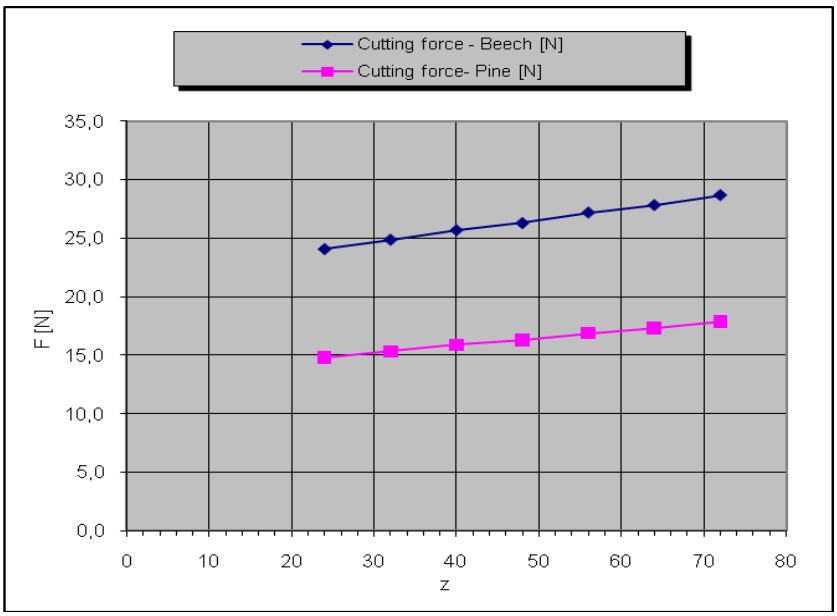

Figure 1. *Relation between cutting force and number of blades during circular saw wood processing of beech and pine*

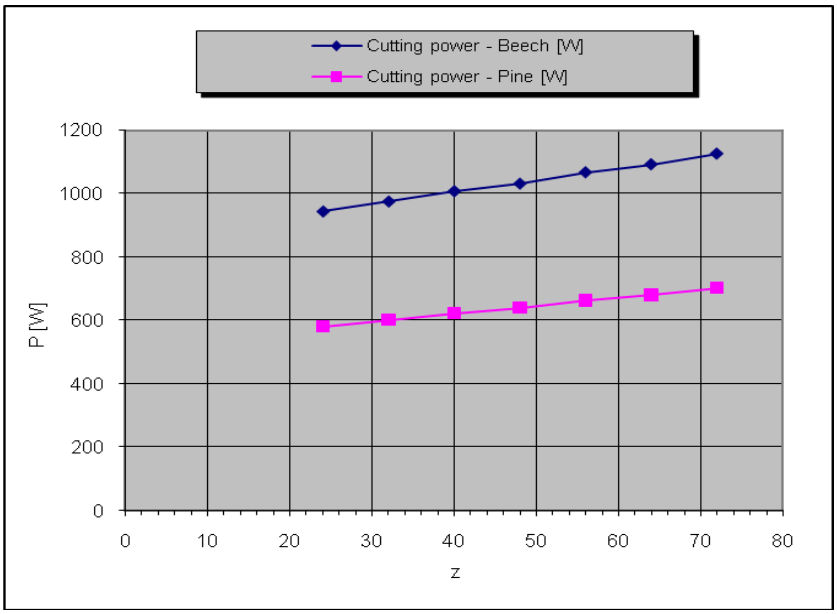

Figure 2. *Relation between cutting power and number of blades during circular wood processing of beech and pine*

Based on the data shown in Tab.1, one can conclude that seven different values of number of blades, from min 24 to max. 72, with step of 8, had been selected. Beside the impact of the number of blades on cutting force and cutting power, this parameter also affects the value of chip thickness, feed by blade and blades pitch.

Figure 1 shows moderate influence of number of blades on cutting force, with approximately proportionall dependance.

Similar conclusion can be drawn from the diagram shown in figure 2, which graphically shows the influence on the picture, which shows the dependence of cutting power on the number of blades.

4. CONCLUSION

According to the data presented and the results obtained during simulating wood cutting of beech and pine with circular saw, one can draw the following conclusions:

1. Using the simulation program investigations were carried out on the influence of the number of blades on cutting process.
2. Elementary output parameters which are the basis for assessment of cutting are cutting force and cutting power.
3. The influence of number of blades on cutting force is moderate. With an increase of the number of blades by 8 blades, cutting force decreases by 3,3 %.
4. The influence of number of blades on cutting power is also with moderate significance. With increment in the number of blades by 8 blades, cutting power increases by about 3,4 %.
5. The results obtained from the program correspond to the real situation of wood cutting with circular saw, with tolerances due to the complexity of the interaction between the tool and the physical and mechanical characteristics of wood.
6. In the analytical procedures for defining the system, modifications and changes in the program are relatively simple and are based on data from new experimental investigations.
7. A simulation programme for wood cutting with circular saw cannot replace classical experimental investigation, but it can be a good basis for it.

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