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THE EFFECT OF WHEEL SPEED ON CUTTING FORCE AND CUTTING POWER DURING BANDSAW OPERATION

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ABSTRACT

Identifying and defining the mechanism of influence between the tool and the workpiece when processing with bandsaws is an extremely important process for achieving product quality, tool efficiency and process safety. This mechanism affects the productivity of the machine and the economics of the overall production process.

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

The research was focused on creating a mathematical model of the interaction mechanism between the tool and the wood as a work piece. An analytical tool was designed for determining some important factors in the 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 is supported with appropriate software.

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

1. INTRODUCTION

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

For these reasons it is necessary to investigate the wood cutting process in details, which will result in selection of the optimal parameters for different operating modes.

It is necessary to define a mathematical model on the basis of empirical correlation of important parameters in the process of wood cutting with band saw obtained by a series of experiments.

Mathematical model offers the possibility to determine 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 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 model is supported with adequate software program.

2. METHODS

The realization of the goals of this research was performed using the computer program for wood cutting process simulation.

For the simulation of the wood cutting process with band saw, the following parameters are defined as constant:

- wheel diameter 1100 [mm]
- saw thickness 1,6 [mm]
- saw width 210 [mm]
- tooth pitch 46 [mm]
- initial roundness radius 8 [μm]
- cutting angle 65 [^{0}C]
- feed rate 5 [m/min]
- distance between wheels 2250 [mm]
- teeth swage setting 0,5 [mm]
- cutting height 250 [mm]
- wood species (*Fagus silvatica* L.); (*Pinus silvestris* L.)

As a variable input in the cutting process considered is the wheel speed in the range from 300 rpm up to 800 rpm.

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

3. RESULTS AND DISCUSION

The influence of wheel speed on cutting force and cutting power during wood cutting with band saw of beech and pine is shown in Table 1 and Table 2 respectively. In order to get better understanding of the results obtained, they are also shown graphically (Fig. 1, 2).

Table 1. *Influence of wheel speed on cutting force and cutting power during band saw processing of beech*

Wheel diameter	[mm]	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Wheel speed	[min^{-1}]	300	350	400	450	500	550	600	650	700	750	800
Saw thickness	[mm]	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6
Saw width	[mm]	210	210	210	210	210	210	210	210	210	210	210
Teeth pitch	[mm]	46	46	46	46	46	46	46	46	46	46	46
Cutting blade radius	[μm]	8	8	8	8	8	8	8	8	8	8	8
Cutting angle	[°]	65	65	65	65	65	65	65	65	65	65	65
Feed speed	[m/min]	5	5	5	5	5	5	5	5	5	5	5
Wheels distance	[mm]	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250
Cutting height	[mm]	250	250	250	250	250	250	250	250	250	250	250
Teeth swage setting	[mm]	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
Wood species	-	beech										
Feed by tooth	[mm/tooth]	0,80	0,68	0,60	0,53	0,48	0,43	0,40	0,36	0,34	0,32	0,30
Cutting speed	[m/s]	17,2	20,1	23	25,9	28,7	31,6	34,5	37,4	40,2	43,1	46
Avg. pressure on front side	[N/mm^2]	3,41	3,47	3,52	3,58	3,64	3,7	3,76	3,82	3,87	3,93	3,99
Fict.spec.force on back side	[N/m]	922	922	922	922	922	922	922	922	922	922	922
Start cutting force	[N]	70,9	63,0	57,7	53,1	49,8	46,5	44,6	41,9	40,6	39,3	38,0
End cutting force	[N]	81,1	72,0	65,9	60,5	56,8	52,9	50,7	47,6	46,1	44,6	43,1
Start cutting power	[W]	1219	1266	1327	1375	1429	1469	1539	1567	1632	1694	1748
End cutting power	[W]	1395	1447	1516	1567	1630	1672	1749	1780	1853	1922	1983

Table 2. *Influence of wheel speed on cutting force and cutting power during band saw processing of pine*

Wheel diameter	[mm]	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Wheel speed	[min^{-1}]	300	350	400	450	500	550	600	650	700	750	800
Saw thickness	[mm]	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6
Saw width	[mm]	210	210	210	210	210	210	210	210	210	210	210
Teeth pitch	[mm]	46	46	46	46	46	46	46	46	46	46	46
Cutting blade radius	[µm]	8	8	8	8	8	8	8	8	8	8	8
Cutting angle	[°]	65	65	65	65	65	65	65	65	65	65	65
Feed speed	[m/min]	5	5	5	5	5	5	5	5	5	5	5
Wheels distance	[mm]	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250
Cutting height	[mm]	250	250	250	250	250	250	250	250	250	250	250
Teeth swage setting	[mm]	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
Wood species	-	pine										
Feed by tooth	[mm/tooth]	0,80	0,68	0,60	0,53	0,48	0,43	0,40	0,36	0,34	0,32	0,30
Cutting speed	[m/s]	17,2	20,1	23	25,9	28,7	31,6	34,5	37,4	40,2	43,1	46
Avg. pressure on front side	[N/mm^2]	3,21	3,27	3,33	3,38	3,44	3,49	3,55	3,61	3,66	3,72	3,77
Fict.spec.force on back side	[N/m]	706	706	706	706	706	706	706	706	706	706	706
Start cutting force	[N]	65,2	57,6	52,7	48,2	45,1	41,8	40,0	37,4	36,2	35,0	33,7
End cutting force	[N]	74,9	66,2	60,4	55,2	51,5	47,8	45,7	42,7	41,2	39,8	38,3
Start cutting power	[W]	1121	1158	1212	1248	1294	1321	1380	1399	1455	1509	1550
End cutting power	[W]	1288	1331	1389	1430	1478	1510	1577	1597	1656	1715	1762

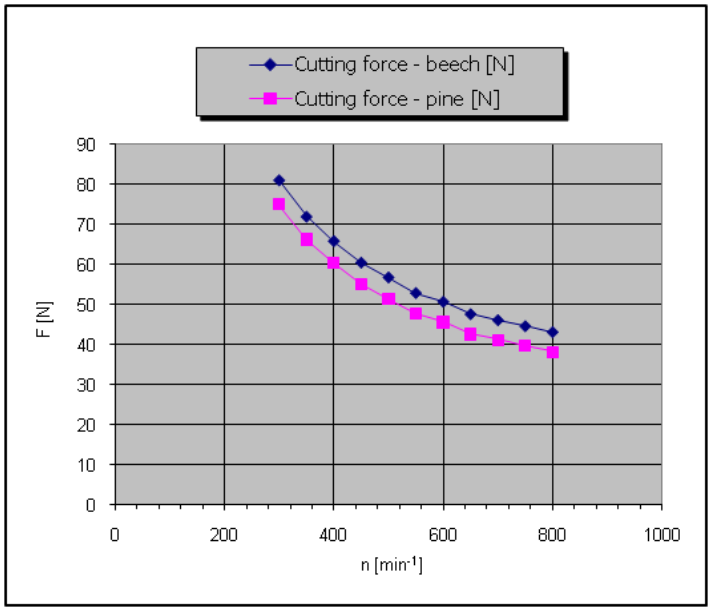

Figure 1. *Relation between cutting force and wheel speed during band saw wood processing of beech and pine*

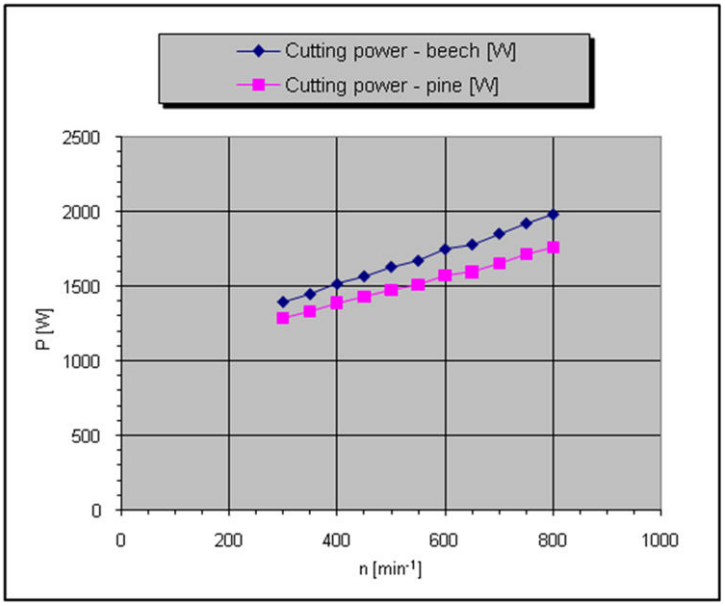

Figure 2. *Relation between cutting power and wheel speed during band saw wood processing of beech and pine*

Based on the data shown in Table 1, it can be concluded that ten different values of wheel speed were selected, from min of 300 min^{-1} to max. of 800 min^{-1}, with step by 50 min^{-1}. Beside the influence of wheel speed on cutting force and cutting power, this parameter also influences the value of feed by tooth and cutting speed.

Figure 1 evidently shows significant influence of wheel speed on cutting force and also the curve of power is approximately linear, with proportional dependence.

A similar conclusion can be drawn from the diagram shown in Figure 2 where graphically is shown the influence on the picture which shows the dependence of power cutting on wheel speed.

4. CONCLUSION

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 on the influence of wheel speed on cutting process were carried out.

2. Elementary output parameters which are the basis for assessment of cutting are the cutting force and the cutting power.

1. The influence of wheel speed on cutting force is significant. With increment in the wheel speed for every 50 min^{-1}, cutting force decreases by 2 - 10 %.

3. The influence of wheel speed on cutting power is moderately significant. With increment in the wheel speed for every 50 min^{-1}, cutting power increases by about 3,3 %.

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 simple and based on data from new experimental investigations.

6. Simulation programme for wood cutting with band saw cannot replace classical experimental investigation, but it can be a good basis for it.

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