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Raw particleboard machinability experimental test – cutting quality and cutting forces observed during drilling process

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Abstract: *Raw particleboard machinability experimental test – cutting quality and cutting forces observed during drilling process.* Machinability in the case of drilling was analysed according to two separate criteria: quality and cutting forces. Quality was determined by means of two different indicators. Moreover the relationship between the feed speed and the cutting quality and forces was examined.

Keywords: machinability, drilling, particleboard, quality, cutting forces

INTRODUCTION

Raw particleboard is one of the most common wood-based materials used in furniture manufacturing. The machinability of this material may be analyzed from different points of view. There are a lot of criteria and indicators of wood based materials machining [Górski et al. 2010; Podziewski, Górski 2010, 2012]. In this paper two separate aspects were taken into consideration: quality of drilling process and cutting forces observed during drilling. The results of the experimental tests are presented below.

MATERIALS AND METHODS

The tested raw particleboard was commercially available material - tab.1. shows its basic physical properties.

Table.1. Mechanical and physical properties of tested particleboard

Density	IB (EN-319)	Swelling after 24h (EN-317)	MOR (EN-310)	MOE (EN-310)
740 [kg/m^3]	0,48 [N/mm^2]	19,1 [%]	33,90 [MPa]	4179 [MPa]

Test consisted of drilling holes in mentioned above material. Standard CNC machine was used for drilling. Drilling was carried out by means of brand new, 10 mm diameter, single-bladed Leitz drill with a cutting edge made of PCD. Seven sets of feed per revolution were used: 0,1 mm; 0,15 mm; 0,2 mm, 0,25 mm; 0,3 mm, 0,5 mm; 0,7 mm. Spindle speed was set to 6000 rpm.

Quality based machinability was specified as follows: drilled holes were photographed and measured. Two types of quality indicators were determined:

$$A = \frac{D\max - D}{2} \quad ; \quad B = \frac{D - D\min}{2}$$

where:
A, B – external and internal type of drilling quality indicators,

Dmax – a diameter of a circle covering total damaged area which were observed outside the hole,
Dmin – a diameter of a circle covering a real hole (this diameter was generally less than the nominal diameter because of damages which were observed inside the hole),
D - nominal diameter of the hole.

Machinability aspect based on cutting forces was tested by means of piezoelectric measuring system (based on Kistler 9345 sensor) connected to computer data acquisition system (based on NI LabView). In this way the values of axial force and cutting torque were determined.

RESULTS AND DISCUSSION

The effect of feed per revolution on the quality indicators (both, type A and B) is shown in the Fig. 1 and 2.

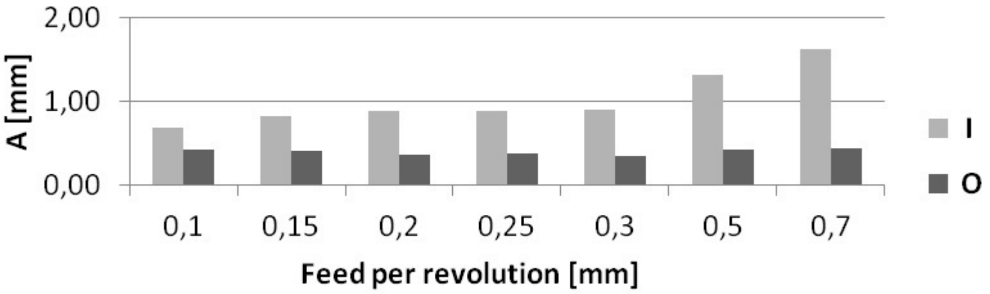

Fig.1. Effect of a feed per revolution on the quality indicator A[mm] determined at the entry (I) and at the exit (O) of the drill

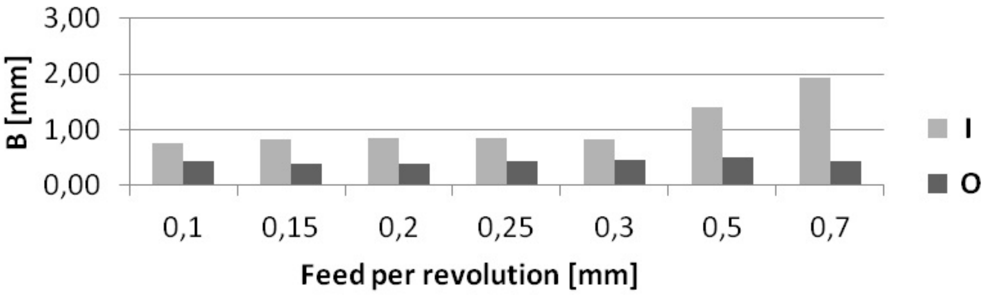

Fig.2. Effect of a feed per revolution on the quality indicator B[mm] determined at the entry (I) and at the exit (O) of the drill

Table 2 shows the ANOVA results for the A indicator. Only one of considered factors turned out to be statistically significant (p-value of 0,05 was treated as a "border-line acceptable" error level). On the basis of percentage contribution of the factor its significance rate (ω^2) was estimated in standard way. The value of feed per revolution in this case explained more than 61% of the total variation of the A quality indicator (Fig.3).

Table.2: ANOVA of the A indicator

	Sum of Squares	Degree of Freedom	Mean Square	F test	p value	significance rate ω^2
Intercept.	226,83	1	226,83	2804,18	<0,05	
O/I	0,12	1	0,12	1,52	0,22	
Feed	26,83	6	4,47	55,28	<0,05	61,60%
O/I*Feed	0,74	6	0,12	1,52	0,17	
Error	15,85	196	0,08			

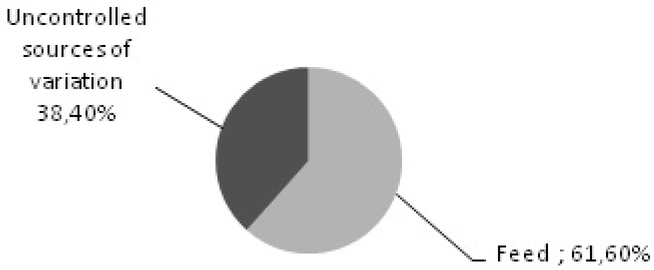

Fig.3. Graphical interpretation of ω^2 from Tab. 2

The results of ANOVA for the B indicator are presented in Table 3.

Table 3. ANOVA of the B indicator

	Sum of Squares	Degree of Freedom	Mean Square	F test	p value	significance rate ω^2
Intercept.	36,62	1	36,62	3424,38	<0,05	
O/I	0,09	1	0,09	8,4	<0,05	3,37%
Feed	0,16	6	0,03	2,43	<0,05	3,91%
O/I*Feed	0,1	6	0,02	1,49	0,18	
Error	2,1	196	0,01			

The data presented in Tab. 3 shows that both factors turned out to be statistically significant but their interaction not. Moreover it is worth noting that each of considered factors - place of observation (O/I) and feed per revolution - explained only below 4% of the total variation of the B quality indicator (Fig.4).

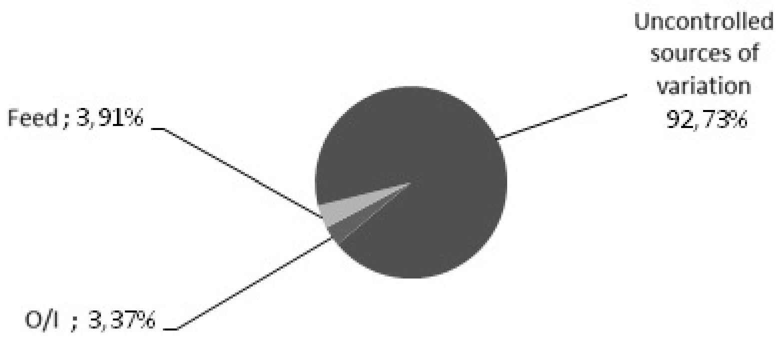

Fig.4. Graphical interpretation of ω^2 from Tab. 3

The effect of feed per revolution on the cutting forces is shown on the Fig. 5 and 6. This relation is highly linear for both axial force (F) and for cutting torque (M). Coefficient of determination R^2 were respectively as follows: 0,99 and 0,97.

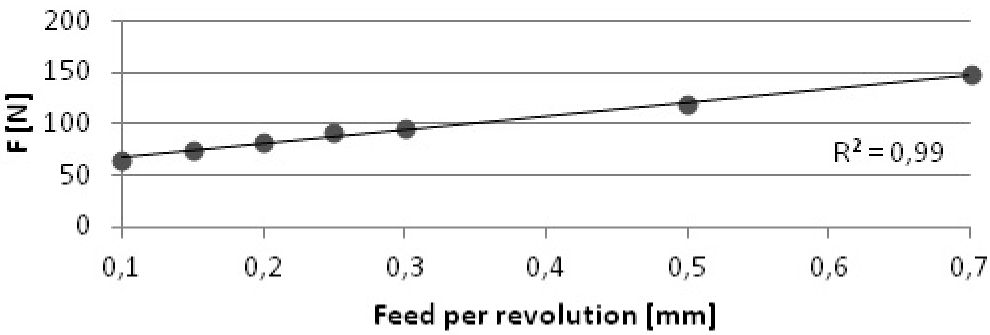

Fig.5. The effect of feed per revolution on the axial force F.

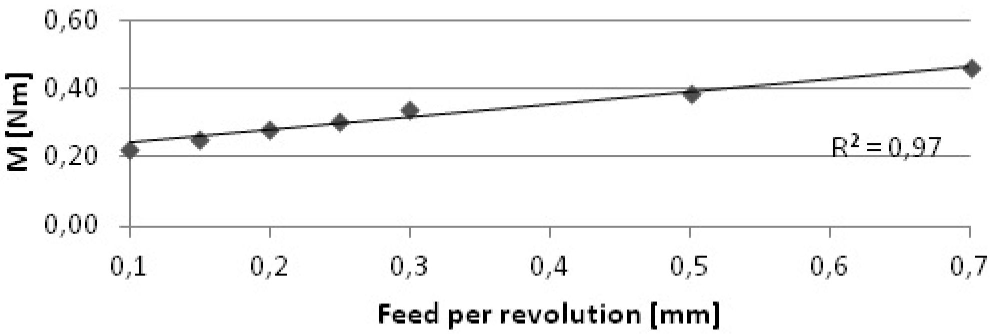

Fig.6. The effect of feed per revolution on the cutting torque M.

CONCLUSIONS

The external quality of drilling (A indicator) turned out to be relatively highly dependent on the freed force (standard significance rate ω^2 was above 60%) and absolutely independent on the place of observation (at the entry and at the exit of the drill). In the case of the internal quality of drilling (B indicator) turned out to be dependent on both above factors. However it is worth noting that their real (practical) significance was rather low (their total standard significance rate ω^2 was below 8%). It means that the more than 90% variation of internal quality of drilling come from uncontrolled sources.

The relatively high level of linear correlation between the feed speed and the cutting forces (both in the case of the axial force and torque of cutting) was observed.

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Streszczenie: *Eksperymentalne badanie skrawalności surowej płyty wiórowej – jakość obróbki i siły skrawania obserwowane podczas wiercenia.* Skrawalność podczas wiercenia w płycie wiórowej rozpatrzono według dwóch odrębnych kryteriów: jakości obróbki oraz oporów skrawania. Jakość określono przy pomocy dwóch różnych wskaźników. Ponadto określono zależność między prędkością posuwu a jakością obróbki i siłami skrawania.

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