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Studies regarding the influence of forces and torques on the quality of surfaces obtained at wood drilling

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***Abstract*:** The paper presents some results and discussions regarding the influence of forces and torques on the wood drilling in radial, longitudinal and tangential section on surfaces qualities obtained using helical drills with diameter ϕ10 mm. Surface quality was analyzed in two ways: the appearance of the surface hole (entry and exit of the drill from the workpiece) and processed surface roughness.

Keywords: Beech, Forces, Torques, Helical drill, Quality, Surface roughness

INTRODUCTION

Starting from the hypothesis that the quality of processed surface is influenced by the variation of forces and torques during the process (namely: the size of forces have an influence on the processed surfaces roughness and affect the appearance of the surface when the drill entry and exit from the workpiece), the authors of the paper presents some results obtained on the basis of research on these issues.

METHOD AND EXPERIMENT

To carry out the experiment was designed a physical analogue model (measurement of dynamic parameters (F, P) using models that kinematic parameters (v_c, v_f) are reduced-scale (F = f (v_c, v_f) P = f (F , v_c)), but still retains the original system ratio (v_c / v_f)), using tangible representation.

Nomenclature

v_c	cutting speed
v_f	feed rate (feed speed)
n	rotational speed
F	force
M	torque moment

A. Determination of forces and torques in drilling

Equipment and materials

Test bench for determination consists of: FUS-22 milling machine, FT 100 device for measuring forces and torques in drilling, FT 100 amplifier, National Instruments NI USB-6210 data acquisition board and a torque key. (Fig.1)

For making the holes it was used a helical drill plated with CMS with cylindrical shaft flattened ϕ10 mm diameter, with two channels, the top angle 2 $\kappa_r = 60^0$ and the propeller angle $\omega = 13^0$.

From beech timber with 8-12 % humidity was cut samples in radial, longitudinal and tangential section with the size L x W x T= 50 [mm] x 19 [mm] x 25 [mm].

Working method
The determination was taken by the following steps:
- Before starting the work the amplifier was left to go 30 minutes to stabilize the temperature, during that time was checked the working parameters.
- Each sample was collected in the device with a torque key with the same force of 9,58 N.
- Each sample was carried a hole, and for each working parameter were performed five repetitions.
- Experiments were performed in these working conditions: speed 345, 550, 874 and 1371 rot/ min and feed rates 100, 160 and 250 mm/min.
- Before measuring the values for forces and moments from the amplifier, these values were brought back to zero.
- Measurement frequency is 172 Hz per second (we have a value at 0.00581 seconds)
- Data obtained were acquired in Excel using an application in LabView software
- The values for forces and torques were recorded in volts, and the conversion in Nmm was done by multiplying registered values with - 4000 for torques and in N by multiplying the values with 400 for forces, for the case when the amplifier was set to 10.

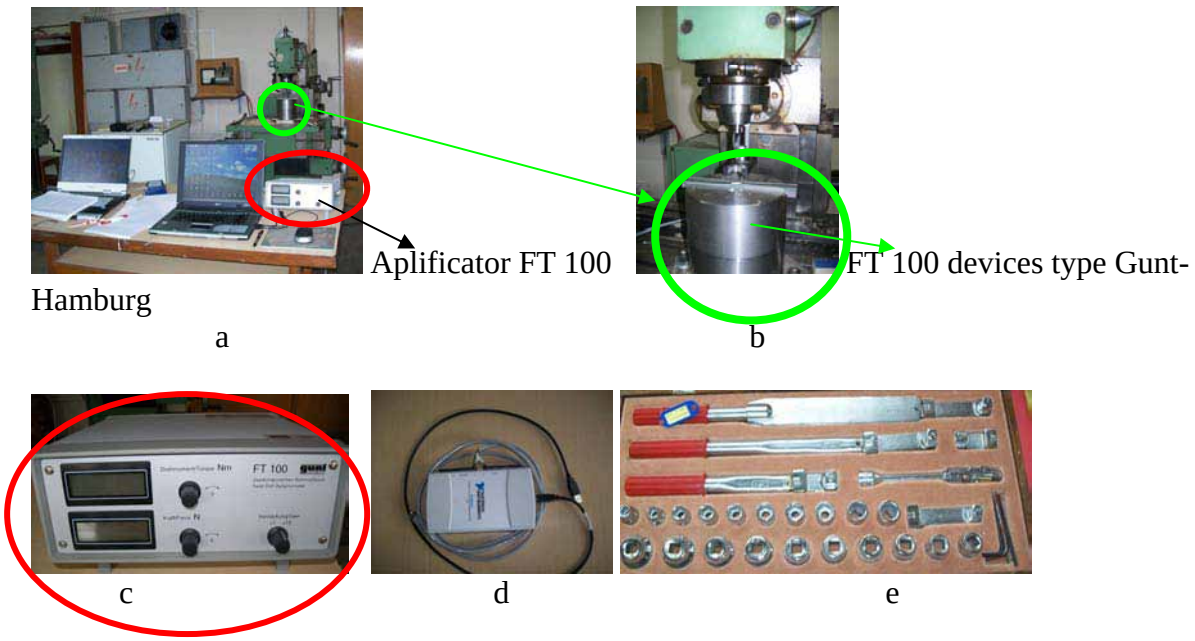


Fig 1. Equipment used for testing:
a. Experimental bench for determination of the forces and torques during drilling
b. FT 100 devices for measuring forces and torques during drilling
c. FT 100 Aplificator
d. National Instruments card NI USB-6210 data acquisition
e. Kit torque keys

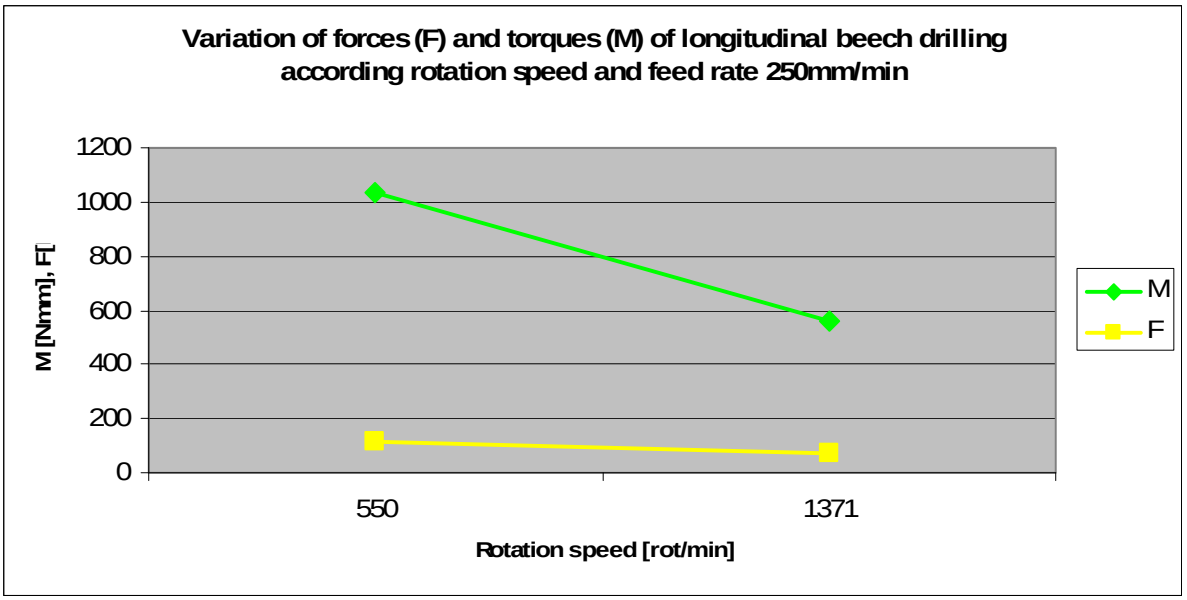
B. Equipment for determining the surface roughness processed
The drilled surface roughness was measured with Mitutoyo roughness type SJ-201P with PC connection and for acquisition and filtering data was done using software Surftest SJ-201P ver. 3.20.
Working method
To obtain more conclusive results, the measurement of surface roughness at wood drilling was made in 8 points for each hole by rotating the sample with a period T = 45 ° and on depth of the hole in three points H1, H2 and H3. For roughness measurements was chosed the wavelength l = 0.8 mm (without damaging the hole), length of assessment contains five lengths of the n=5 and 50 PC filter (Gaussian).

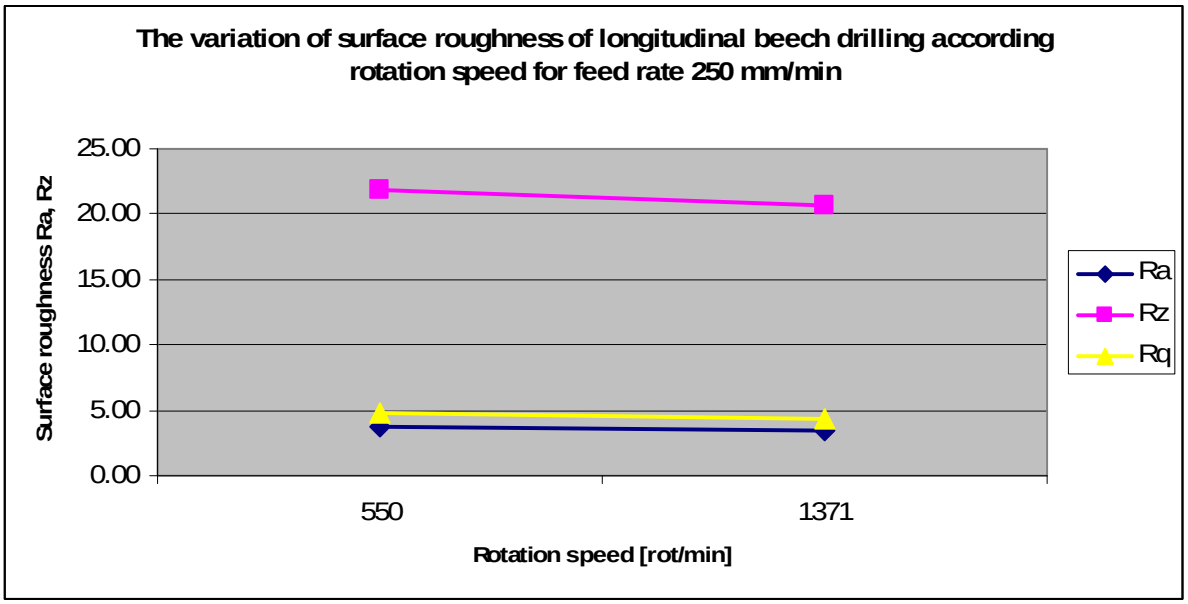
The analysis of surfaces roughness was made by measuring parameters roughness Ra, Rz and Rq.
The experimental model designed through tangible representation for measuring the roughness is proposed a patent in consequently can not be presented in this article.

RESULTS

A. Forces and torques

In figure 2 is showed the variation of forces, torques and surface roughness of the drilling of beech in radial and longitudinal section for the feed rate 250 mm/min depending on the speed.





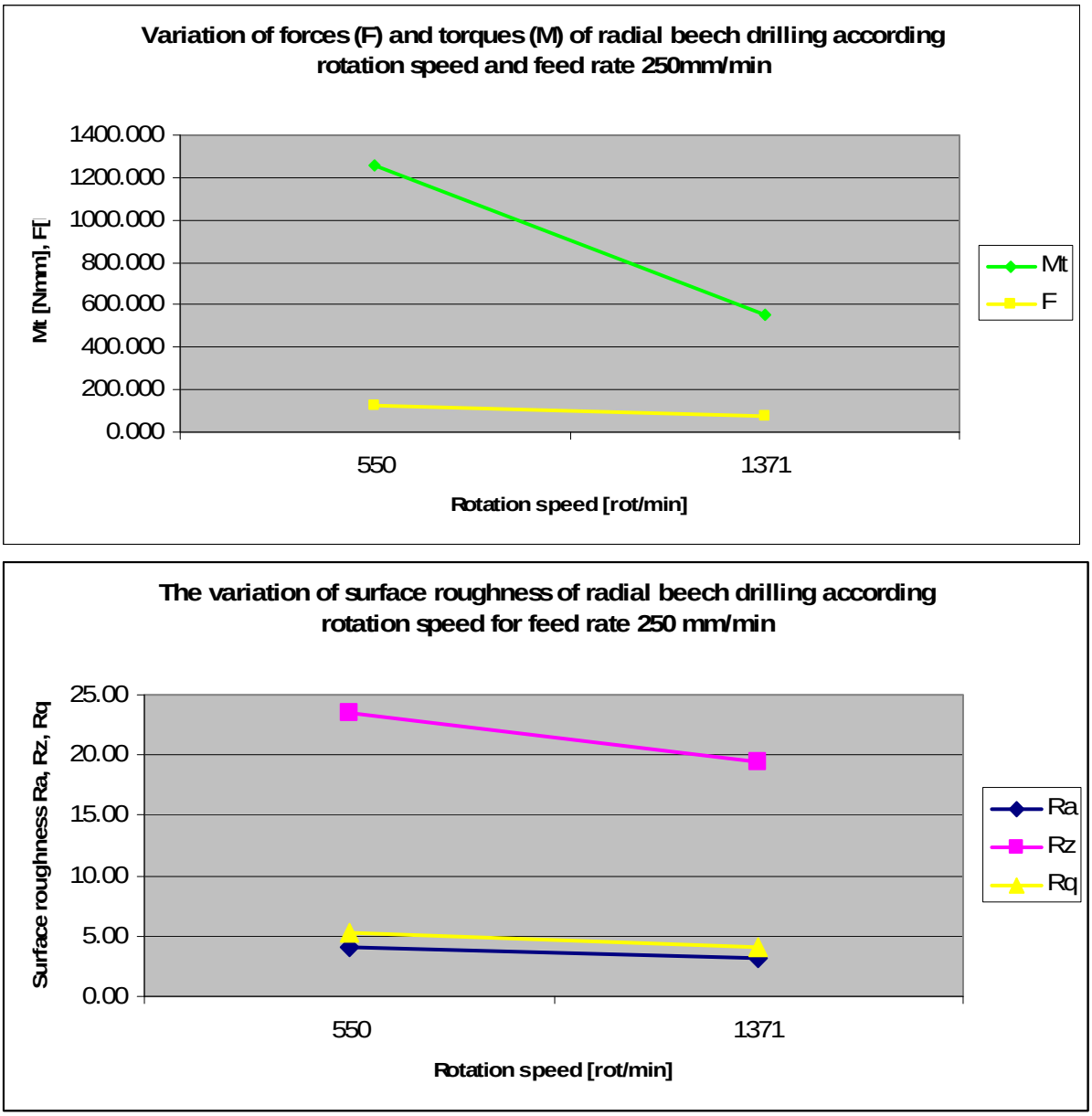


Fig. 2. The variation of forces, torques and surface roughness of the drilled beech in radial and longitudinal section for the feed rate 250 mm / min depending on the speed.

B. The state of surfaces

In figure 3 is showed the surface appearance at the entry and exit of the drill from the workpiece (beech) cutted in tangential section (a), longitudinal (b) and radial (c) at the feed rate 250 mm/ min and rotation speed 1371 rot/min.

a	b	c

The surface appearance at the entry the drill in the workpiece

a	b	c
The surface appearance at the exit the drill from the workpiece		

Fig.3. The surface appearance at the entry and exit of the drill from the workpiece (beech) cutted in tangential section (a), longitudinal (b) and radial (c) at the feed rate 250 mm/min and rotation speed 1371 rot/min.

DISCUSSION AND CONCLUSIONS

Analyzing the appearance of holes at entrance and exit of the drill from the wood and the variation of cutting forces, we see that the holes made along the fibers are of high quality. Resulted surface in this case does not present pulling fiber compared with the holes made in tangential and radial direction. The explanation could be that the geometry of drill used is specific at the longitudinal cutting.

Regarding the roughness, utilization of the same geometry of drill, show that surface condition resulted does not depend decisive by the drill geometry. Confirmation this conclusion is brought by the averaging values both for Ra, Rq and Rz roughness parameters, as well as dynamical parameters F and M, depending on the direction of processing and parameters of cutting used, presented in Table 1:

Table 1. Ra, Rz and Rq roughness parameters and dynamic parameters F and M in drilling of beech

Beech	Diameter of drill (mm)	Cutting direction	v_f (feed rate) (mm/min)	n (rotation speed) (rot/min)	Ra [µm]	Rz [µm]	Rq [µm]	M [Nmm]	F [N]
	10	Longitudinal	100	345	3.30	19.30	4.19	866.73	96.96
	10	Longitudinal	160	874	3.41	19.86	4.35	546.51	83.08
	10	Longitudinal	250	550	3.74	21.87	4.77	1037.65	114.25
	10	Longitudinal	250	1371	3.40	20.71	4.35	558.16	74.87
					3.46	**20.43**	**4.41**		
	10	Radial	100	345	3.56	21.74	4.58	1183.83	123.72
	10	Radial	160	874	3.32	19.88	4.19	730.06	84.00
	10	Radial	250	550	4.14	23.53	5.23	1261.04	127.33
	10	Radial	250	1371	3.16	19.43	4.05	550.67	78.13
					3.55	**21.15**	**4.51**		
	10	Tangential	100	345	3.27	19.59	4.11	685.91	95.85
	10	Tangential	160	874	2.97	18.38	3.75	563.53	74.97
	10	Tangential	250	550	4.20	26.05	5.43	906.63	107.31
	10	Tangential	250	1371	2.62	15.99	3.36	718.17	82.85
					3.27	**20.00**	**4.16**		

In consequence, we can say that drill geometry **influencing insignificant** both the roughness (variations of roughness values in tangential and radial cutting compared with the longitudinal cutting, between 0.2 and 0.8%) and cutting forces and torques (different values between 1 and 3.6%), but can influence significantly the apperance of the holes at the entry and the exit from the material.

According to specialized literature, the quality of processing varies depending on the direction of processing and the drill geometry. For increasing the productivity, reducing the use of tools

and of auxiliary adjusting time, based on data obtained without taking into consideration the power consumption, the authors recommend using this type of drill for processing of beech in either direction (radial, longitudinal or tangential) if the hole is not visible.

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Streszczenie: *Wpływ sił i momentów na jakość powierzchni po obróbce wierceniem.* Praca prezentuje wyniki ich analizę wpływu sił i momentów przy wierceniu wiertłem ϕ10 mm wzdłuż, w poprzek i prostopadle do włókien, na jakość powierzchni. Jakość analizowano na dwa sposoby, oceniając jakość krawędzi otworu (krawędź otworu wejścia oraz wyjścia wiertła) oraz powierzchnię wewnątrz.

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