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MONITORING OF THE INFLUENCE OF CHOSEN FACTORS ON TORQUE, THRUST AND SURFACE ROUGHNESS OF HOLES

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ABSTRACT

The aim of this article is monitoring of the influence of cutting speed, boring direction, and kind of wood on torque and thrust during boring of beech, oak, maple, acacia, poplar spruce, and pine samples by drills with diameter of 8 mm. The influence of wood moisture content on torque and thrust during boring of beech samples was also investigated in our experiment. Monitoring of the influence of revolutions per minute, wood moisture content, and measuring position on some chosen roughness parameters of holes bored to beech samples in longitudinal direction by drills with diameter of 20 mm was also the aim of this article.

KEY WORDS: boring, torque, thrust, roughness of bored holes

INTRODUCTION

Research of the influence of individual technical, and technological factors on cutting forces and holes quality is important in woodworking processes. Cutting forces and also holes quality are markedly affected by correct selection of technical and technological factors. Boring process is influenced by cutting speed, feed speed, feed per revolution, revolutions per minute, boring direction, properties of work – piece, geometry of drill, wear of drill etc. Holes surface roughness is necessary from the view - point of monitoring of strength of glued dowel joints. Spreading of knowledge about boring process of our commercial wood is necessary. Scientific literature sources contain mainly information about boring of Japanese woods, woods of North America, and tropical woods.

Kollmann (1955) described dependency of torque and feed force from cutting speed. Kollmann presents, that torque and feed force slightly decrease with increasing of cutting speed from 0 to 1 $m.s^{-1}$.

Cutting forces and also holes quality are markedly affected by moisture content of wood. Komatsu (1978) found, that the values of torque and thrust were maximal at moisture content of 5 – 20 %, then the values of torque and thrust decreased with increasing of moisture content to fibre saturation point, and at moisture content above 30 % were almost constant.

Lisičan (1996), Záchenský (1993), Komatsu (1979), Koch (1964) found, that the values of torque and thrust are influenced by boring direction. Cutting models perform important function. Feed of drill is parallel with the grains during boring along the grains. Cutting edges work during one revolution of drill in same conditions considering to grains. During boring across the grains is drill feed perpendicular to grains. Cutting model changes during one revolution of drill. All cutting edges of drill cut in two positions parallel with the grains, and in two positions across the grains (Lisičan 1988).

MATERIAL AND METHODS

A/ Measuring of torque and thrust

Preparation of test samples

The test samples to monitoring of the influence of individual factors on torque and thrust were made from beech *(Fagus sylvatica L.)*, oak *(Quercus robur L.)*, maple *(Acer pseudoplatanus L.)*, acacia (*Robinia pseudoacacia L.)*, poplar *(Populus nigra L.)*, spruce *(Picea abies (L.) Karst.)*, and pine *(Pinus sylvestris L.)* wood. The test samples were air – conditioned to moisture content 12 ± 1 %. The sizes of samples were 50 x 50 x 50 mm. The densities of chosen kinds of woods were following:

$\rho_{\text{(beech wood)}} = 0.711\ g.cm^{-3}$, $\rho_{\text{(oak wood)}} = 0.720\ g.cm^{-3}$,
$\rho_{\text{(maple wood)}} = 0.560\ g.cm^{-3}$, $\rho_{\text{(acacia wood)}} = 0.727\ g.cm^{-3}$,
$\rho_{\text{(poplar wood)}} = 0.483\ g.cm^{-3}$, $\rho_{\text{(spruce wood)}} = 0.421\ g.cm^{-3}$,
$\rho_{\text{(pine wood)}} = 0.532\ g.cm^{-3}$.

The part of beech test samples was conditioned above the saturated solution of $(NH_4)_2SO_4$ to moisture content 18 ± 1 %.

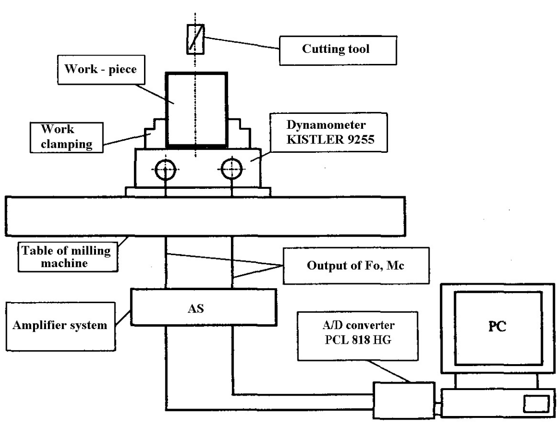

Fig. 1: Scheme of measuring equipment

Characterization of drills

Boring tests were realised by twist drills with one brad point and two spurs made from high – speed steel. Diameter of drills was 8 mm.

Boring of test samples

Boring tests were realised in radial, tangential, and longitudinal direction on upper milling machine type of FA 4 AV. The scheme of this measuring equipment is plotted on Fig. 1. This machine is situated on the Department of Technological Engineering on Engineering Faculty of Technical University in Žilina. The four - component dynamometer KISTLER 9255 was used in this experiment. Its action is based on piezoelectric effect. Measurement method is based on generation of piezoelectric potential in different crystals during activity of external farces. Crystals are loaded in neutral axis direction. Static electrical charge with opposite mark corresponds to magnitude of actuating cutting force. Electric charge fade – out after unloading, and because the potential is rather low, is led to amplifier. The amplification electric charge is fed into computer. Computer recorded corresponding values of potential signal by card ADVANTECH PCL 818 HG (Czán and Novák 1999).

Feed per revolution f was 0.225 mm and cutting speeds v_c were 0.297 $m.s^{-1}$, 0.419 $m.s^{-1}$, 0.586 $m.s^{-1}$.

B/ Measuring of holes surface roughness

Characterisation of test samples

Chosen parameters of surface roughness of holes were monitored at test samples made from beech wood. Moisture content of samples were 12 ± 1 % and 18 ± 1 %.

Measuring of individual parameters of surface roughness of holes

Parameters of surface roughness were measured on holes bored in longitudinal direction by drills with diameter of 20 mm. Holes were bored at 710, 1000 and 1400 revolutions per minute. Arithmetical mean deviation of the profile R_a, root – mean square deviation of the profile R_q, maximum height of the profile R_y, ten points height of irregularities R_z were measured by MITUTOYO SUPERTEST – 301. Measurements on one hole were realised in four measuring positions (Fig. 2).

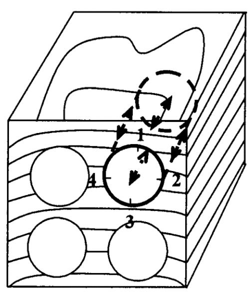

Fig. 2: Measuring possitions of surface roughness

RESULTS AND DISCUSSION

The values of torque and thrust were measured in our experiment. We can say, that the values of torque and thrust in some cases decreased and in other cases increased with increasing of cutting speed (Fig. 3 - 8). Only little knowledge about the influence of cutting speed on cutting forces exist in scientific literature sources. Záchenský (1993) also found ambiguous influence of revolutions per minute on cutting forces. Kollmann (1955) presents, that torque and feed force slightly decrease with increasing of cutting speed from 0 to 1 $m.s^{-1}$.

The influence of wood moisture content on cutting forces was monitored in case of beech test samples. Considerably lower values of torque and thrust were measured at beech samples with moisture content 18 ± 1 %, than at samples with moisture content 12 ± 1 %. Mechanical properties of wood decrease with increasing of wood moisture content. Results of Mc Millin and Woodson (1972), Komatsu (1978), and Koch (1964) correspond with our results.

The influence of kind of wood on the values of torque and thrust was investigated in this experiment. Almost the same values of density were determined in case of beech, oak, and acacia test samples. We can say, that higher values of torque and thrust were measured during boring of woods with higher densities and lower during boring of woods with lower densities (Fig. 3 - 8). Komatsu (1977) found the similar results. On the other hand Lubčenko (1986) found, that higher values of cutting force per unit area of cut were measured during wood – working of woods with lower densities.

Higher values of torque and thrust were measured during boring of beech, oak, maple, pine, and spruce test samples in longitudinal direction and lower in radial and tangential direction. It was connected with cutting models. Boring tests were realised also in longitudinal direction by twist drills with one brad point and two spurs. Záchenský (1993) determined the similar results. On the contrary higher values of torque and thrust were measured during boring of acacia and poplar samples across the grains, than along the grains (Fig. 3 - 8). Acacia wood includes abrasive intermediate particles (Frais 1987). Higher values of drills wear were determined during boring of acacia wood.

Wood structure (for example reaction wood) plays expressive function in case of monitoring of the influence of individual factors on the values of torque and thrust.

Definite influence of revolutions per minute on surface roughness has not been found in our experiment. Komatsu (1976) presents, that during boring with Japanese drill with spurs and brad point were the values of surface roughness constant in the range of revolutions per minute from 1500 to 5000 min^{-1}. Koch (1964), Mc Millin and Woodson (1972) present, that the values of surface roughness are not been influenced by revolutions per minute.

Twist drills with spurs and brad point were used during boring of holes in longitudinal direction. Main cutting edges separated the chip in direction across the grains. Roughness parameters (R_a, R_q, R_y, R_z) were measured in tangential planes in direction parallel with the grains in measuring positions 1 and 3. Parameters of roughness were measured in radial planes in direction parallel with the grains in measuring positions 2 and 4. Higher values of surface roughness parameters were measured in positions 1 and 3, then in positions 2 and 4. We can say, that roughness in tangential planes in direction parallel with the grains is higher, than the roughness in radial planes in direction parallel with the grains (Fig. 9). Our results permit with results of Prokeš (1982). Prokeš measured higher washboard in tangential planes, than in radial planes.

We can say, that the values of surface roughness parameters mainly increased with increasing of wood moisture content. Koch (1964) presents, that smoother holes are developed during boring to dry wood, than to wet wood.

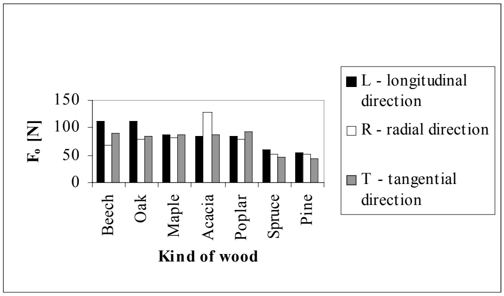

Fig. 3: The influence of kind of wood and boring direction on thrust F_o at cutting speed v_c = 0.297 m.s^{-1}

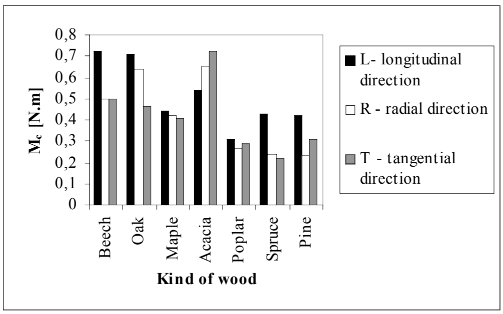

Fig. 4: The influence of kind of wood and boring direction on torque M_c at cutting speed v_c = 0.297 m.s^{-1}

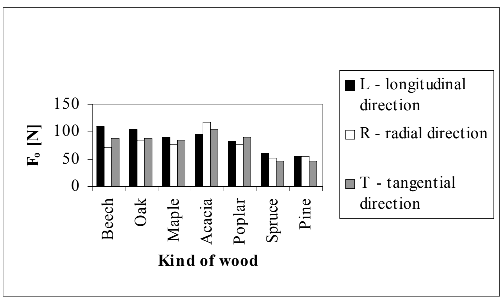

Fig. 5: The influence of kind of wood and boring direction on thrust F_o at cutting speed v_c = 0.419 m.s^{-1}

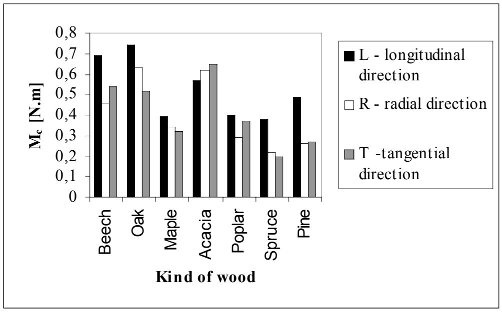

Fig. 6: The influence of kind of wood and boring direction on torque M_c at cutting speed v_c = 0.419 m.s^{-1}

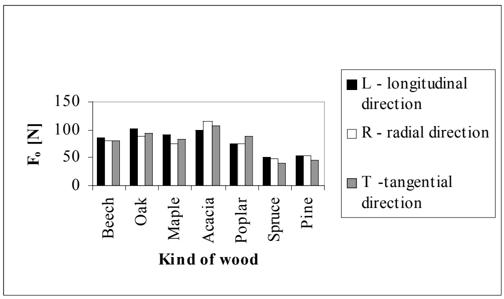

Fig. 7: The influence of kind of wood and boring direction on thrust F_o at cutting speed v_c = 0.586 m.s^{-1}

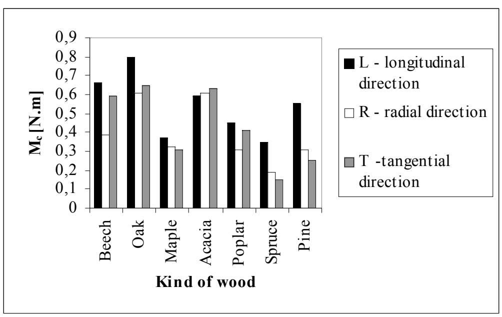

Fig. 8: The influence of kind of wood and boring direction on torque M_c at cutting speed v_c = 0.586 m.s^{-1}