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Influence of wood thermal modification on cutting resistance during drilling

JACEK WILKOWSKI, MAREK GRZEŚKIEWICZ, PAWEŁ CZARNIAK, MICHAŁ LITWA
Wood Mechanical Processing Department, Warsaw University of Life Sciences– SGGW

Abstract: *Influence of wood thermal modification on cutting resistance during drilling.* Oak wood was used in this work. Work pieces were thermally modified in industry conditions with usage of high temperature steamer, in overheated steam with temperature 165°C. Investigation of influence of wood thermal modifications on axial force and torque during drilling was the aim of this work. Drilll with one edge made from policrystallic diamond (Leitz WB 100-0-50) with diameter 10mm was used in the experiments. Results proved statistically significiant influence modifications on torque and not significiant for axial force.

Keywords: modified wood, drilling, axial force, torque

INTRODUCTION

Different ways of natural wood modification became more and more popular. It results from requirements of the market which demand material with the highest utility properties. The modification based on thermal treatment and compressing seems to be most widely used. First of all, compressing method allow to equalize the mechanical properties between early and late wood. Huang et al. [2003] investigated the influence of fir-wood compressing which was received from Chinese plantations on course of machining. There was noticed the growth of cutting forces due this process. Researches carried out by Tanaka et al. [2004] concern this problem, too. Above authors remarked similar phenomena. However, influence of different modification methods on wood behavior during machining turned out to be different. Namely, according to Tadashi et al. [2004] wood drying with usage of heat smoke results in increasing of cutting forces and prolongation of tool life. In another variant of thermal modification, wood is subjected to overheated steam treatment in temperature about 200°C. Grześkiewicz and Krawiecki [2008] conducted close analysis of modified ash and oak. Mechanical properties of these species after modification were examined. It turned out that modulus elasticity in bending and bending strength were reduced. Author took into account influence of modifications on varnish layer robustness on UV, too. Work pieces treated in the same way were machined in respect of cutting resistance by Orłowski and Grześkiewicz [2009]. Decreasing of cutting resistance was observed during cutting of ash wood on frame saw. However, similar phenomena was noticed during oak machining only at feed per tooth fz<0,1. Thus, topic of new wood based materials, especially wood subjected to different manipulations in order to improve its mechanical properties acquire relevant importance. The influence of thermal wood modification on cutting resistance during drilling was investigated in this work.

MATERIALS AND METHODS

In work were used pieces of oak parquets. Two sets of work pieces with primary dimensions 325x105x22mm (in each 30 pc) which differentiated with arrangement of annual rings were taken to experiment. In one set annual rings were parallel to the top surface and in second perpendicular to the top surface of element. Then, these elements were separated across the fibres on two counterparts groups. One group of them was subjected to thermal

modification and the second left unmodified. Work pieces were thermally machined in industry conditions with usage of streamer W-10 (Hamech). Cycle of thermal modification in atmosphere of overheated steam consisted of five stages:

Stage I – intensively heating up to temperature about 110^{o}C connected with wood drying in air atmosphere,

Stage II – slowed down heating in overheated steam up to temperature correspond to right process of modification and to additional drying,

Stage III – right modification process in overheated steam in temperature 165^{o}C, 4 hours,

Stage IV – cooling by usage of vaporized water or exceptionally wet stream up to about 80^{o}C and wood moistening,

Stage V – further cooling to the final process temperature and acclimatization in wet air atmosphere.

The whole process of thermal wood modification in chamber last 24 to 26 hours. Wood with humidity, equivalent for typical climate conditions was used in experiments and amounts for unmodified in range 10-12%, for modified in range 4-6%.

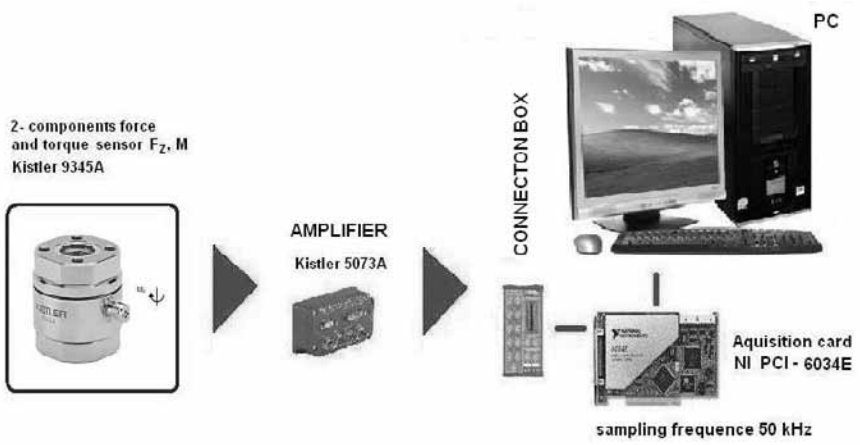

Fig.1. Measurement stand schema

Investigations were carried out in Department of Wood Machining WTD-SGGW on CNC Centre Busellato JET 130. Through drill LEITZ with one edge made from policrystallic diamond with diameter 10mm was taken to the experiments. Force measurement platform equipped with two components sensor of axial force and torque KISTLER 9345A cooperated with amplifier KISTLER 5073A was used. Signal after registering with usage of acquisition card National Instruments PCI 6034E was next analyzed in application created in LabView environment. Schema of measurement stand was showed in Fig.1. Work pieces were across drilled with constant cutting parameters in following two variants: feed direction parallel to annual rings and perpendicular to annual rings what describes Fig.2. Feed per revolution amounts Δ=0,33mm at rotational spindle speed 3000 RPM.

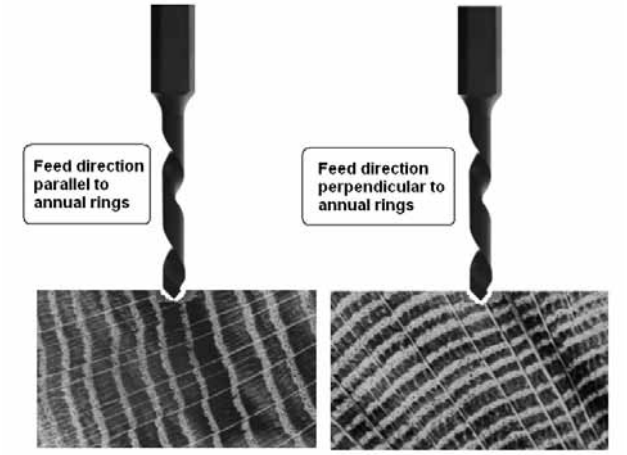

Fig.2. Variants of drilling in direction parallel and perpendicular to annual rings

RESULTS AND DISCUSSION

Level of axial force for both variants of drilling direction show Fig.3÷4. Slightly increasing of axial force was observed in both cases. This growth was not statistically significant. But very relevant turned out increasing of axial force during drilling when feed direction is parallel to annual rings in compare with situation when feed direction is perpendicular to annual rings (both for modified and modified work pieces).

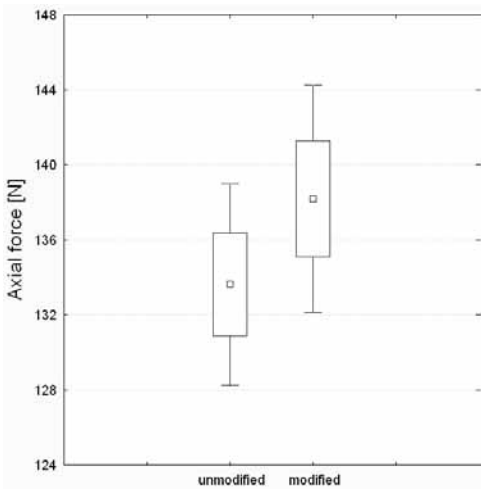

Fig.3. Level of axial force for unmodified and modified wood during drilling parallel to annual rings.

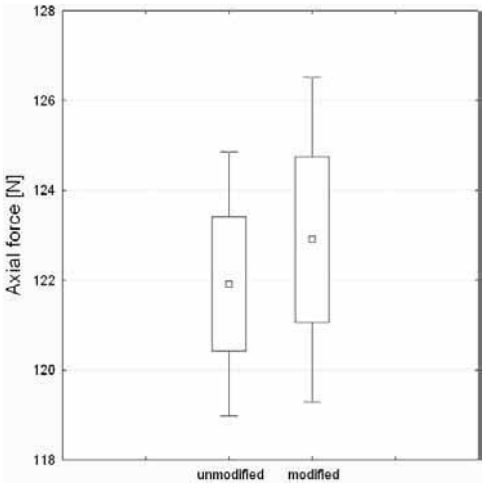

Fig.4. Level of axial force for modified and unmodified wood during drilling perpendicular to annual rings

However, distinct decreasing of torque can be observed for modified work pieces in both drilling directions. Drilling direction has not statistically significant influence on torque level The comparing for both drilling directions is showed in Fig. 5÷6.

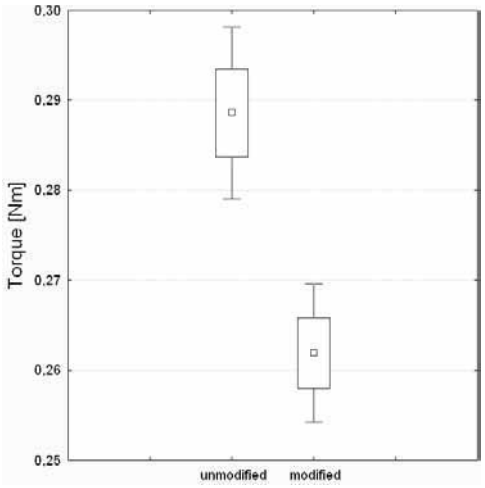

Fig.5. Level of torque for unmodified and modified wood during drilling parallel to annual rings.

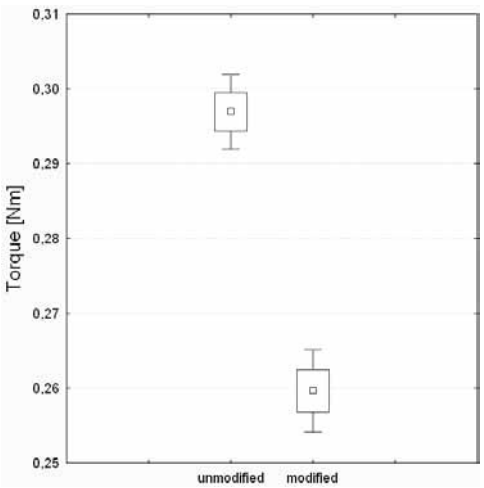

Fig.6. Level of torque for unmodified and modified wood during drilling perpendicular to annual rings.

CONCLUSION

Obtained results allow to formulate following conclusions:

1. Statistically insignificant increasing of axial force for modified wood, as well for drilling parallel to annual rings as for drilling perpendicular to annual rings was noticed.
2. Torque turned out to be much lower for modified work pieces in both variants of drilling direction. These differences were for unmodified and modified wood statistically significant.
3. Significant differences between variants of drilling directions were obtained for axial force but not for torque. This dependences were confirmed for modified and unmodified wood.

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Streszczenie: *Wpływ termicznej modyfikacji drewna na opory skrawania podczas wiercenia.* W badaniach wykorzystano drewno dębowe. Próbki modyfikowano termicznie w warunkach przemysłowych z wykorzystaniem parzelni wysokotemperaturowej w atmosferze przegrzanej pary wodnej w temperaturze 165^{o}C. Celem pracy było zbadanie wpływu modyfikacji termicznej drewna na siłę osiową i moment obrotowy podczas wiercenia. W eksperymencie użyto wiertła jednoostrzowego z diamentu polikrystalicznego o średnicy 10mm. Wyniki pokazują istotny statystycznie wpływ modyfikacji na moment obrotowy i nieistotny wpływ na siłę osiową.

Corresponding authors:

Jacek Wilkowski
e-mail: jacek_wilkowski@sggw.pl
Marek Grześkiewicz
e-mail: marek_grzeskiewiczi@sggw.pl
Paweł Czarniak
e-mail: pawel_czarniak@sggw.pl
Faculty of Wood Technology SGGW
Wood Mechanical Processing Department
ul. Nowoursynowska 159, 02-776 Warsaw, Poland