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ABRASIVE WATER JET CUTTING (AJWC) WOOD MATERIAL – JET INTERACTION

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- Introduction

Abrasive water jet cutting-(AWJC) technology presents a highly efficient machining method for wood and wood-based composites. A very important property of AWJC is the reduced trim waste produced during the process (in this paper expressed as longitudinal mass loss) and an unchanged wood tissue structure. Kinetic energy of water jet and abrasive particles has power magnitude enough to cut even through steel plates and consequently could be used for cutting lumbers or high density wood based materials. Areas of research concerns the problem of generating jets basic research and development equipment, material interaction - running water (with or without abrasive) and the creation of industrial production database on optimum processing schemes for different types of materials, as well as the efficiency of the process.

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- Objectives

The aim of this paper was primarily to establish a relationship between processing parameters and material characteristics. These parameters include the feeding rate (u), nozzle distance from the upper surface (h) of material and jet pressure (p). The materials characteristics include the material (oak wood, particleboard and OSB) mass loss (Δm) as measure of wood or wood-based material waste and the condition of the cutting surface after machining. The last characteristic mentioned is of extreme importance for quantitative yield in the case of cutting standard dimensional boards as well as solid wood in the final phases of wood processing.

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- Materials and Methods

This paper focused on 18 mm thick particle board, 16 mm thick OSB and 20mm thick oak specimens. This was considered a triple parameter test. The magnitude level of the selected parameters was set to three: zero or referent level, lower and upper level, denoted as 0, -1, and 1, respectively. A multifactor experimental plan was applied for the purpose of establishing a relationship between selected parameters and experimental output presented as longitudinal mass loss. Moisture content of the specimens was determined before and after AWJC was applied and throughout the drying and conditioning phase. After samples reached the initial moisture content it was possible to determine the difference in the mass. Selected cutting parameters values:

- p = 200; 230; 250 MPa
- h = 2.5; 5; 10 mm
- u = 500; 600; 700 mm/min

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- Materials and Methods

According to these results and by applying the orthogonal plan matrix (Box-Wilson matrix) the mathematical model has been established for all three observed materials. Presumed mathematical model was in exponential form:

$$R = C \cdot f_1^{p_1} \cdot f_2^{p_2} \cdot f_3^{p_3}$$

Other correlated investigations were conducted simultaneously, such as electronic microscope abrasive detection and wood tissue examination with SUPER EYE digital USB microscope.

Moisture content of investigated speciments elavate only by 2% after cutti in the case of oak, and for wood-based panels from 10 u to 14%.

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- Results

Results obtained showed that the proposed mathematical model is adequate in the case of all investigated materials. However, none of the influences of processing parameters were significant, except for the nozzle distance (*h*) in the case of wood-based panels (particleboard and OSB).

Results and analysis gave the following mathematical models for particleboard, OSB and oak, respectively:

$$\Delta m = 0,767 \cdot p^{0,057} \cdot h^{1,309} \cdot u^{0,316}$$

$$\Delta m = 2,826 \cdot p^{-0,662} \cdot h^{0,874} \cdot u^{0,601}$$

$$\Delta m = 1,657 \cdot p^{0,0482} \cdot h^{0,0903} \cdot u^{0,3125}$$

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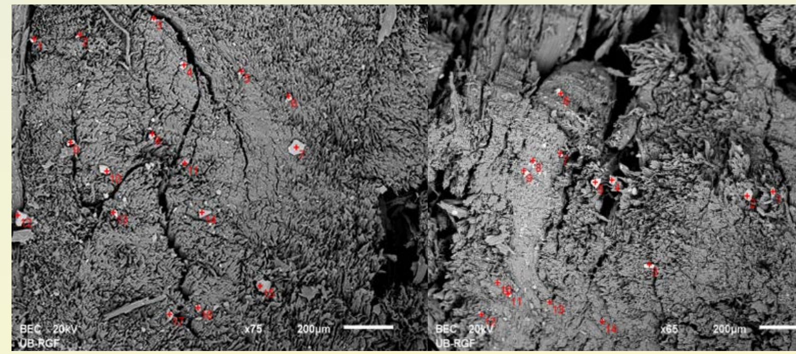
- # Results

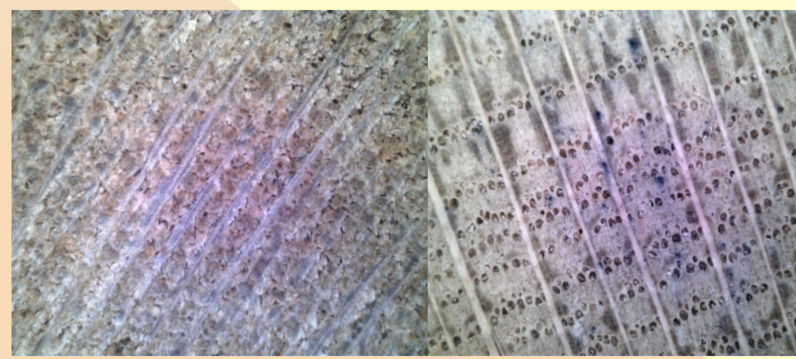
Detailed microscopic examination of the surface showed the presence of abrasive particles originating from the garnet mineral and its alterations, but did not show a significant amount of mass deposed on the cutting surfaces. Calculations showed small changes in the mass, but not enough to be considered as an influential factor for final results. In the case of oak, pictures of the cutting surface made by AJWC compared to those made by conventional cutting by band saw, showed wide opened vessels in the wood tissue. No presence of deposed abrasive particles was detected by means of optical microscopy.

Deposed garnet particles



Estimated amount of deposed mass of garnet partic was at about $4.15 \cdot 10^{-4}$ g/cm^2

Conventionally machined **AJWC machined**



- Conclusions
- Proposed mathematical model is proved to be adequate;
- Cutting process parameters significance is weak according to *F*-test;
- The presence of deposed garnet is not significant to total amount of mass loss; No presence of deposed abrasive particles was detected by means of optical microscopy;
- The cutting surface of oak made by AJWC compared to those made by conventional cutting by band saw, showed wide opened vessels in the wood tissue;
- Future research should take density variation into the consideration.