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Machinability properties of particleboards made with addition of raspberry stem chips (*Rubus idaeus* L.)

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Abstract : *The article describes vulnerability to machinability particleboards with addition raspberry stem chips (Rubus idaeus L.).* Machinability can be analyzed with using of numerous machinability indicators. In this article was assumed as machinability criterions, cutting resistance during milling and drilling regards to percentage contribution of raspberry stem chips. The addition of alternative raw material didn't deteriorated machinability properties based on axial forces during drilling and cutting force during milling. However, at higher amount of mentioned above raw material, increase of torque.

Keywords: machining; milling; drilling; cutting forces; raspberry stem chips; particleboards; alternative material;

INTRODUCTION

In recent years producers were trying to introduce alternative materials to the wood industry for production of particleboard. These steps intends to reduce costs and use materials which were so far supposed as a worthless. Moreover, this type of material may be a good replacement for traditional wood chips. Finding *substitution* which meets expectation concerning structure and properties is not an easy task. On the other hand, scientists and academics are focused on discovering new, highly valuable and not-currently used materials.

For some years now, researchers have been searching for a new kind of raw material for particleboards. There were undertaken numerous attempts to manufacture boards from bagassa, burlap, cotton stems or rice straw [Drouet 1992].Waste branches from fruit orchards were also testified by (Kowaluk et al. 2019).

A large part of examinations were aimed to find a new type of lignocellulosic addition. Woody parts of flax, hemp or marc of sugar cane were taken into consideration. Search of a new material took into account particleboards production from scraps of one-year plants such as rapeseed straw and grain straw [Oniśko 2011], however they did not gain big popularity among producers [Raunkjaer et al. 2016].

In 2016 year were manufactured 410 mln m^3 wood materials on the world which is 120% growth in comparison to the 2000 year. Increasing production of particleboard and oriented strand board between 2000 and 2016 stands for 20% increase across Europe and for 39% across the world. Europe owns 43.5% participation in production of particleboard and oriented strand board on the world in which Poland produces 5 390 000 m^3 of these products [http://www.fao.org]. These data shows how big is the growth of production and how developmental is this market. As it is clearly visible, use of new raw material might have positive effect on the environment, producers and production.

This type of raw material may turn out raspberry plantation stems which might successfully replace traditional raw material. Area of crop in orchards in Poland reached 29317 ha in 2018 year in which crops reached 1044824 dt. On the other hand in polish individual agricultural holdings area of crops reached 29259 ha and crops 1043674 dt [Główny Urząd Statystyczny, 2019]. Data from FAO in a year 2012 indicate that the biggest producer of this fruit is Russia with 133 000 t crops per year and the second producer is Poland with average 127 000 t crops [Food and Agriculture Organization, 2019]. Based on these data there is no doubt that there would not be problems with acquisition this material.

Current studies and literature concerning properties, quality and possible using of this material as an alternative one is rudimentary and limited. Conducted studies have an objective to expand knowledge in this field and test its potential application in wood industry. Particleboards with addition of raspberry stem chips which were produced at laboratory and were examined regards to cutting forces in comparison to particleboards manufactured from traditional, industrial wood chips used commonly in furniture industry.

The aim of the research was influence of raspberry stem chips on machinability and mechanical properties.

MATERIALS AND METHODS

Milling of samples were conducted on machining centre Busselato Jet 130 (Thiene, Italy 2004) using FABA milling head (model FTS-07, one blade milling head, diameter 40mm, replaceable solid carbide blade - KCR08—submicron tungsten carbide). The process was carried out with parameters recommended by the producer of milling head (feed 3.6 m/min, 18 000 rpm). Grooves of a width 40mm and depth 6mm were milled.

To the cutting force measurement was used piezoelectric sensor mounted to moving beam of machining centre Busselato Jet 130. This sensor was measuring forces during milling in two axis, X and Y. The signal was in mV and went through amplifier Kistler 5036. After that the signal was passed to data acquisition card (National Instruments PCI-6111) which was controlled by PC computer. The result of the experiment was the resultant force.

Drilling of samples were also conducted on machining centre Busselato Jet 130 (Thiene, Italy 2004) using Leitz drill bit (Leitz single blade with PCD - polycrystalline diamond - drill - ID No: 091193). Parameters of drilling was set on 4500 rpm and feed stood at 1.5 m/min.

To the axial force and torque measurement was used piezoelectric sensor (Kistler 9345) mounted to moving beam of machining centre Busselato Jet 130. This sensor was measuring forces during drilling in axis Z and torque.

Signals for both type of operation were analyzed using LabView environment (Austin, USA). The statistical analysis was conducted in computer program called Statistica.

Particleboard was made from industrial chips and melamine –urea –formaldehyde (MUF) resin. Particleboards were made with the addition of raspberry stems in several variants shows in tab 1. Tested materials were made in Department of Technology and Entrepreneurship in Wood Industry SGGW in Warsaw.

Table.1. Some mechanical and physical properties of particleboards which machinability was tested

Density [kg/m^3]	Addition of raspberry wood chips [%]	Modulus of rupture [N/mm^2]	Bending strenght [N/mm^2]
650	0	2550	13
	10	2300	12
	25	2450	14
	50	1600	10
	100	1600	10

To attach above mentioned boards to the platform with piezoelectric sensor, they were cut to the dimensions 160mm x 105mm for milling and 40mm x 100mm for drilling.

During the experiment, five 160 mm long grooves were milled and 10 through holes were drilled.

RESULTS AND DISCUSSION

Fig. 1 shows results concerning impact of participation of raspberry stems on cutting forces. Apparently, differences between examined samples are minor. Conducted analysis of variation haven't shown statistically significant contribution of raspberry stem parts impact on cutting forces during milling.

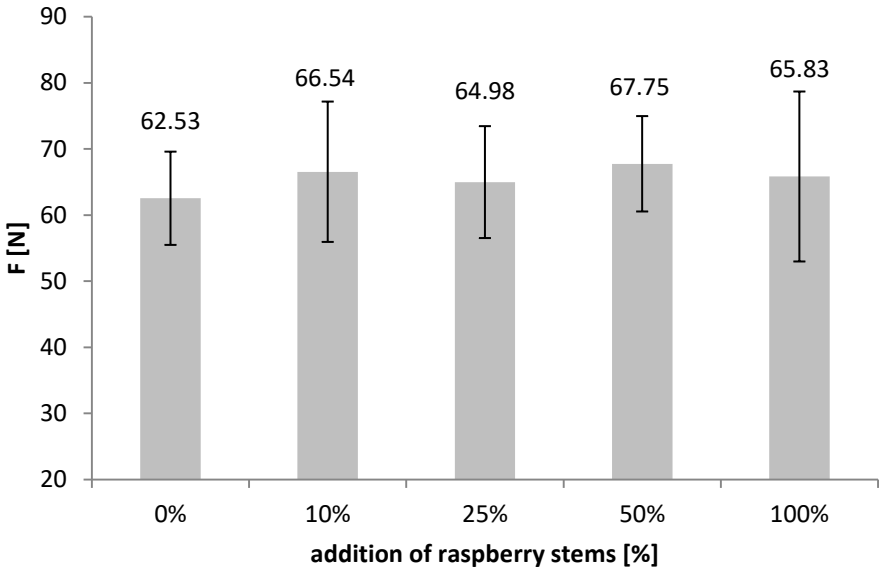

Figure 1. The impact of addition of raspberry stems on the resultant cutting force during milling

Fig. 2 and Fig. 3 show results of measurement of axial force and torque during drilling. Also in this examination statistical analysis haven't proved significant importance of raspberry stems parts in examined particleboard.

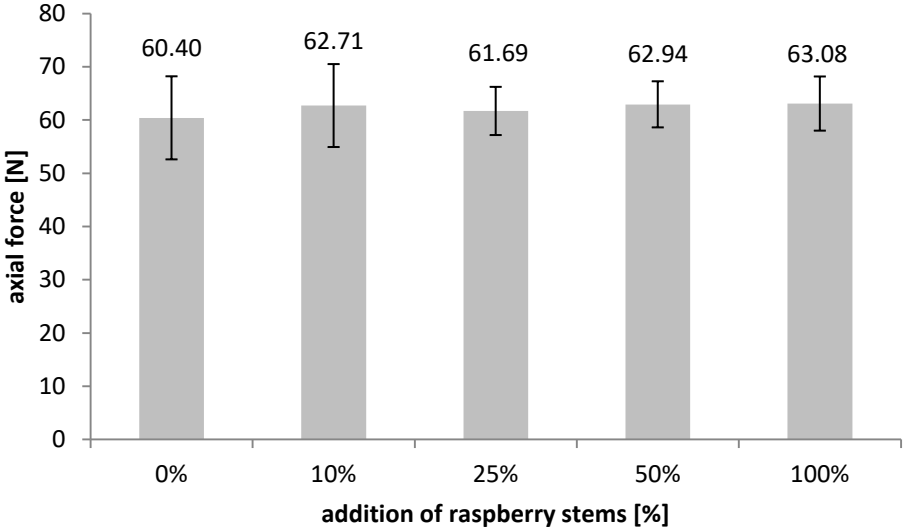

Figure 2. The effect of addition of raspberry stems on axial force during drilling

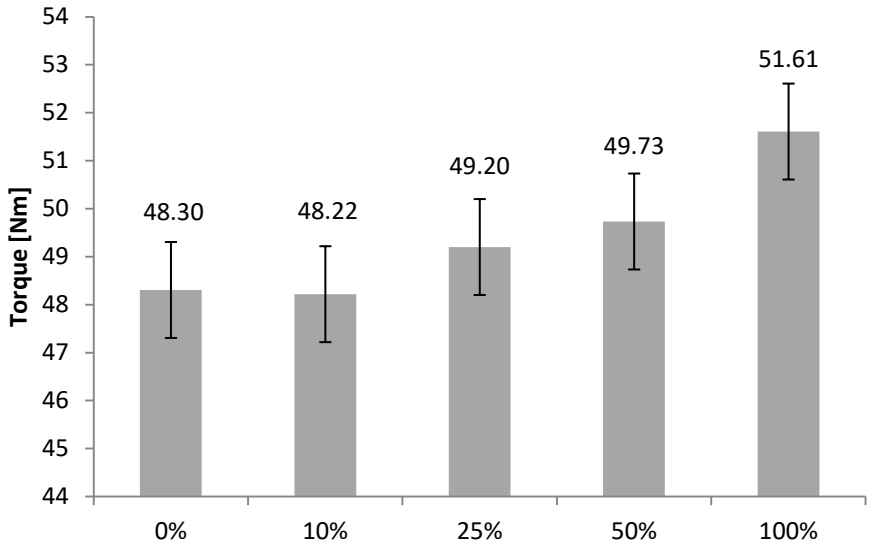

Figure 3. Impact of raspberry stem chips content in particleboards on resultant cutting force

CONCLUSION

Based on the performed analyzes the following conclusions can be drawn:

1. Impact of raspberry (*Rubus idaeus* L.) stem chips content in particleboards is statistically irrelevant in terms of cutting forces during milling and axial force during drilling. It should be stressed that all of boards meet expectations concerning strength requirements.
2. The content of raspberry stem particles in particleboards had the influence in case of torque during drilling, when the torque values raise with the raspberry particles content increase.
3. Stems of raspberry (*Rubus idaeus* L.) may be used as a source of alternative material to production of particleboard without relevant unbeneficial impact on its machinability.
4. In range of raspberry stems contribution 0÷25% changes of torque level is negligible however above this values it can be observed slightly increase of torque in contrary to axial force. Especially, above 25% up to 100% level of torque became clearly higher.
5. Unfortunately, with increase of raspberry stems contribution there was noticed deterioration of mechanical properties of produced in this way product, although as it was earlier enhanced all values are in coincidence with strength requirements. This phenomena should be perceived as an limitation in industry practice.

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Streszczenie: *Podatność na obróbkę skrawaniem płyt wiórowych z dodatkiem łodyg maliny właściwej (Rubus idaeus L.).* Istnieje wiele kryteriów oceny skrawalności materiałów drewnopochodnych. Jednym z nich są opory skrawania. Artykuł opisuje wpływ dodatku alternatywnego surowca na opory skrawania podczas wiercenia i frezowania. Przeanalizowano zarówno opory skrawania podczas obróbki frezowaniem jak i wierceniem w zależności od zawartości surowca pochodzącego z łodyg maliny właściwej. Dodatek alternatywnego surowca nie spowodował pogorszenia skrawalności określonej na podstawie siły osiowej rejestrowanej podczas wiercenia i sił skrawania występujących podczas frezowania. Zauważono natomiast, że przy wyższej zawartości wspomnianego wcześniej surowca alternatywnego wzrosła wartość momentu obrotowego podczas wiercenia.

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