Annals of Warsaw University of Life Sciences - SGGW
Forestry and Wood Technology № 85, 2014: 230-234
(Ann. WULS - SGGW, For. and Wood Technol. 85, 2014)

Machinability of particleboards bonded with SBR gum granulate

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Abstract: *Machinability of particleboards bonded with SBR gum granulate.* In this work, influence of addition content (in form of SRB gum granulate) applied in particleboards on axial force and torque during drilling was estimated. Examined chipboards which were made in laboratory conditions, contained followings weight percentage of SBR gum granulate: 0%, 10%, 20%, 30% . Moreover, there were also used standard three layers chipboard accessible commonly on market. Relative indicators of machinability were assessed. As reference material was assumed standard MDF board (manufactured in industry). Drilling was carried out on CNC machine equipped with one-edge drill with diameter 10 mm (made from polycrystalline diamond). Three variants of feed per revolution Δ were applied: 0,1mm, 0,3mm, 0,5mm. Addition of SBR gum granulate in manufacturing process of chipboards causes significant improvement of machinability refers to cutting resistance during drilling. Bigger increase of analyzed values was noticed for machinability indicator MI_F at higher amount of SBR granulate (20% and 30% SBR). This indicator turned out definitely more beneficial than this one obtained for chipboards made as well in laboratory as in industry.

Keywords: machinability, particleboards, SBR gum granulate, drilling, axial force, torque

INTRODUCTION

Due to more and more increasing demands of market, traditional particleboard have to fulfill wide variety of expectations. Its dimensional stability as consequence of homogeneity and possibility of not very high quality raw materials usage cause that still its contribution in wood based materials market is dominant [Porankiewicz 2003]. However, there is all the time necessity of introducing new kinds which could have improved some uses properties. For example, usage of such thermoplastics as polyethylene, polypropylene or polystyrene can considerably improve their resistance to humidity. Simultaneously, thermoplastics could origin from recycling what has great importance for natural environment. Because of its wide applications in buildings, acoustic and dumping properties are very relevant, too. Addition which could be taken into account is gum granulate SBR. Mentioned above raw material is received in process of used cars tires recycling. Surface of sport halls also can be made with some amount of fragmented gum. Effectiveness of recycling process achieves very high level of 98% [Gronowicz, Kubiak 2007]. Composite boards produced in this way are called WRCP [Zhao et al. 2008]. So far, researches proved their relevant superiority in compare with traditional floor panels.

Thus, it occurs question how looks their vulnerability on machining. It is namely obvious that these materials will be subjected to typical machining processes, including sawing at the beginning, through milling or drilling. Especially dangerous could be risk of drill bits breakage with small diameter. Crucial role in this circumstances plays cutting resistance. Wilkowski et al. [2013] proved that WPC composites show considerably better machinability in terms of cutting resistance than standard chipboards.

Aim of this work was investigation of relative machinability indicators towards axial force and torque during drilling of innovative wood based materials with addition of SBR gum granulate (raw material received from used tires recycling). As reference material was used standard MDF board. Simultaneously, for comparative objectives, experiments were carried out with particleboard made in laboratory without addition and with three layer standard particleboard produced in industry.

MATERIAL AND METHODS

Three layer particleboards with dimensions 300x300x16mm and assumed density 650 kg/m^3 were made from industrial wood chips with humidity 7% for outer layers and humidity 5% for inner layer in Department of Wood Based Materials Engineering. Dimensions of granulate particles used in inner layer amount 1÷3mm and showed density 1550 kg/m^3. Boards were produced in four variants, two pieces for each variant.

- 0% SBR – control boards without,
- 10% SBR – boards with 10% of SBR granulate in inner layer,
- 20% SBR – boards with 20% of SBR granulate in inner layer,
- 30% SBR – boards with 30% of SBR granulate in inner layer.

From earlier prepared boards, samples with dimensions 30x100x16mm designated for machining were made. In each sample 15 through holes (Fig.1) for each of three variants of feed per revolution Δ which amounted namely: 0,1mm, 0,3mm, 0,5mm (at steady rotational speed of spindle n=6000rpm) were drilled. Measurement signals (axial force and torque) were registered by means of measurement chain based on piezoelectric transducer *Kistler* 9345A. In order to enhance signal coming from sensor there were used amplifier KISTLER 5073A. Then, these elements were connected with acquisition card National Instruments 6034E PCI installed on PC through connection box (National Instruments BNC-2110). Measurement card gathered signal with sampling frequency 50kHz. Scheme of measurement chain was showed in Fig.2. CNC centre Busellato Jet 130 had mounted one edge drill bit (*Leitz*) with diameter 10mm made from polycrystalline diamond (cutting edge geometry: α=7,5°, b=75°, γ=7,5°). Processing of signal and estimation of signal measures took place with usage of software developed in LabVIEW environment.

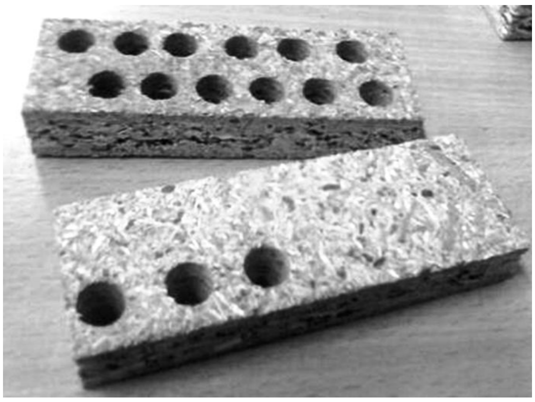

Figure 1. Samples of boards with 10% of SBR gum granulate after machining

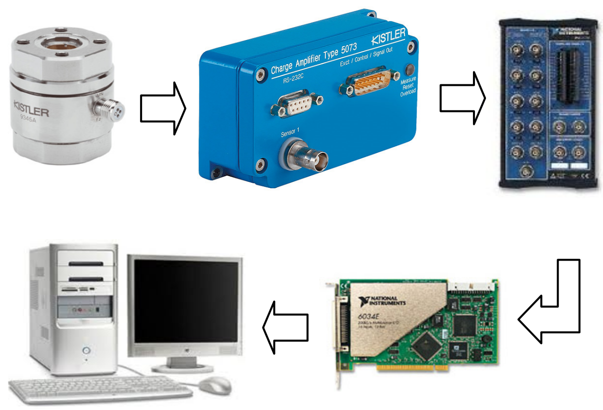

Figure 2. Scheme of measurement chain

RESEARCH RESULTS

Relative indicators of machinability refereed to torque (MI_M) and axial force (MI_F) were estimated. Standard MDF board was assumed as reference material. Procedure of calculations was in accordance with this one presented by Wilkowski et al. [2013]. There were used following equations:

$$MI_M = \left(\frac{M_{MDF}}{M_i}\right),$$

$$MI_F = \left(\frac{F_{MDF}}{F_i}\right)$$

where: M_{MDF}, F_{MDF} – value of torque and axial force obtained during drilling of MDF board (mean of 15 repetitions),

M_i, F_i – value of torque and axial force obtained during drilling of examined materials (mean of 15 repetitions).

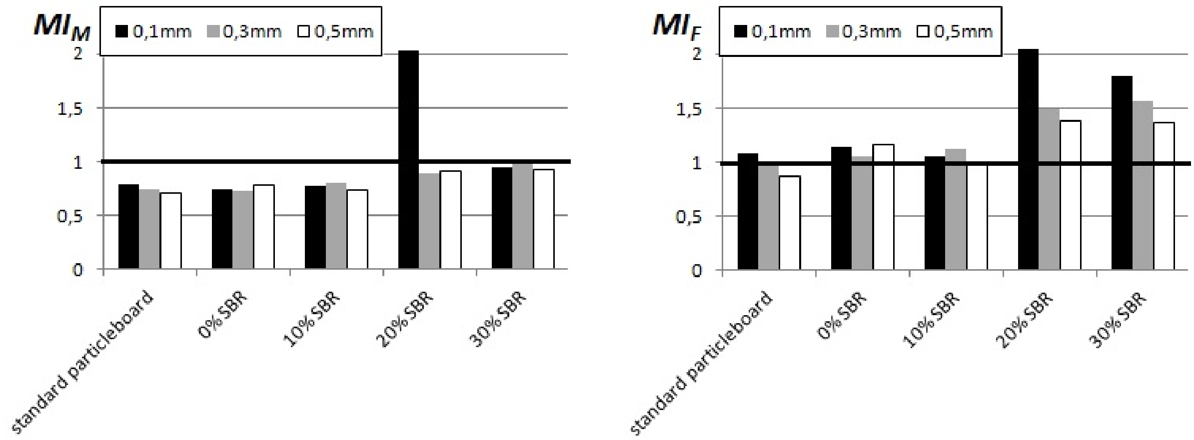

Figure 3. Relative machinability indicators of examined materials for three values of feed per revolution (0,1mm, 0,3mm, 0,5mm), based on torque (on the left) and axial force (on the right)

Increase of weight content of SBR granulate in particleboards causes increases of relative machinability indicators refereed to torque MI_M and axial force MI_F, what means the improvement of their machinability. Additionally, relative indicators based on torque MI_M for all variants are below 1 (value of indicator for reference material – MDF board). Exception makes board with 20% SBR granulate at cutting parameters Δ=0,1mm where MI_M turned out considerably higher and amounted 2,02 (Fig.3). This phenomena can point out on high heterogeneity in boards structure. Relative indicators based on axial force MI_F for material with SBR granulate are above 1, what mean that this one distinguish by better machinability than considered commonly as very well machined MDF boards and simultaneously much and much better than particleboards without SBR granulate (Fig.3). Changes of feed per revolution Δ within whole investigated range significantly influences only for relative indicator MI_F calculated for boards with 20% and 30% content of SBR granulate (Fig.3). Control samples made in laboratory without SBR granulate showed similar level of relative machinability indicators (differences were not statistically significant) in compare with this one received for standard particleboards produced in industry.

CONCLUSION

The results are summarized as follows:

1. Addition of SBR gum granulate causes significant improvement of their machinability towards cutting resistance during drilling. Higher increase of these values was noticed for relative indicator MI_F in case of boards with higher content of SBR granulate (20% and 30% SBR). According to mentioned above indicator, machinability of new materials turned out better than for MDF board and much better than for particleboards produced as well in laboratory as in industry.
2. Changes of feed per revolution Δ within whole analyzed range influences were significant only for relative indicator MI_F obtained for boards with 20% and 30% of SBR granulate content.

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Streszczenie: *Skrawalność płyt wiórowych z granulatem kauczukowym SBR.* W pracy zbadano wpływ zawartości dodatku (w postaci granulatu SBR) do płyty wiórowej na wartość siły osiowej i momentu skrawającego podczas wiercenia. Analizowano płyty wykonane w warunkach laboratoryjnych o wagowej zawartości granulatu SBR: 0%, 10%, 20%, 30 % oraz płytę wiórową trójwarstwową wyprodukowaną w warunkach przemysłowych. Wyznaczono względne wskaźniki skrawalności. Jako materiał referencyjny zastosowano płytę MDF (wyprodukowaną przemysłowo). Wiercenie przeprowadzono na obrabiarce CNC wiertłem jednoostrzowym o średnicy 10mm wykonanym z diamentu polikrystalicznego. Zastosowano trzy warianty posuwu na obrót: 0,1mm, 0,3mm, 0,5mm. Dodatek granulatu kauczukowego SBR do płyty wiórowej powoduje znaczącą poprawę skrawalności tych płyt związanej z oporami skrawania podczas wiercenia. Większy przyrost wartości zaobserwowano dla względnego wskaźnika skrawalności MI_F płyt z wyższą zawartością granulatu SBR (20% SBR and 30% SBR). Dla tego wskaźnika uzyskano skrawalność lepszą niż dla płyty MDF, oraz zdecydowanie lepszą niż dla płyty wiórowej wyprodukowanej laboratoryjnie i przemysłowo.

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