TRIESKOVÉ A BEZTRIESKOVÉ OBRÁBANIE DREVA, 9(1): 175–179, 2014
Zvolen, Technická univerzita vo Zvolene, ISSN 1339-8350

COMPARISON OF BOARDS MACHINABILITY MANUFACTURED FROM WASTE RAW MATERIALS ORIGINS FROM AGRICULTURE INDUSTRY WITH STANDARD WOOD-BASED MATERIALS

Jacek Wilkowski – Piotr Borysiuk – Paweł Czarniak – Jarosław Górski – Marek Jabłoński – Piotr Podziewski – Karol Szymanowski – Marcin Kordzikowski

Abstract
Machinability of one layer boards made of by-product obtained during production of sugar from beetroots bonded in two variants (with saccharine and urine–formaldehyde resin) and standard wood-based materials (MDF and three layers particleboard) was determined. Both groups of materials were subjected to drilling with one edge polycrystalline diamond drill on CNC Center Busellato Jet 130. Three levels of feed per revolution were set on: 0,1mm, 0,3 mm and 0,5 mm. Relative machinability indicators was calculated due to values of cutting resistance (axial force and torque). MDF was assumed as reference material. One layer boards based on by-product of sugar production was distinguished by better machinability in drilling regards to cutting resistance in compare to three layers particleboards in wide range of feed per revolution.

Key words: *relative machinability, boards made of by-products, wood-based materials, drilling, axial force, torque*

INTRODUCTION

Nowadays, more and more often approaches of agricultural by-products development as substitute of wood raw material are undertaken. Relevant example of their usage is production of particleboards. Among others, there are carried out experiments with numerous additions of such wastes of agricultural industry as wheat straw, straw and rise husks, cafe husks, husks from arachnid nuts, skins from coconuts or almond, hemp stalks, stalks from sunflower, by-products of sugar production from sugar cane (bagassa), corns on the cob or pineapple rosettes (Ghalehno et al. 2011; Nikvash et al. 2010; Sekaluvu et al. 2013).

Currently more than 90% of wood-based materials is bonded with amine resins (Ońiśko 2011). Moreover, phenol–formaldehyde resins are of big importance. Among amine resins, the most commonly are used urine-formaldehyde one (UF). This kind of resins became so popular because of their low price and satisfactory strenght properties. To disadvantages can be counted weak resistance to humidity (Dziurka 2011). Besides, some limitation is implicatated with

Warsaw University of Life Sciences – SGGW, Nowoursynowska 159, 02-776 Warsaw, Poland
e-mail: jacek_wilkowski@sggw.pl

formaldehyde emission determined by E1 class up to 0,1 ppm. However, these levels are more and more rigorous and it is said literally that emission of this compound should not exceed the value noticed for wood fibres or wood chips. In order to obtain this goal is indispensable analysis of potential application of natural glues.

Gluing properties has for instance soya flour (Prasittisopin and Li 2010) used among others in production of plywood or maize flour. So far, starch and saccharine seems to be the most promising. Starch occurred much earlier as glue in paper mills. However, this kind of bonding was removed by synthetic glues. As result of mixing together starch and saccharine natural glue is obtained.

Mentioned above gluing technology combined with utilization of agricultural industry wastes in form of by-product in sugar production from beetroots allowed to develop extremely ecological product. Additionally, all raw materials used in production process are fully renewable.

But in order to receive comprehend set of their properties is necessary to verify their vulnerability on machining. This area of researches were carried out regards to WPC by Wilkowski et. al. (2013). This innovativ particleboards (by-products of sugar production bonded with saccharine) should be subjected to analogical experiments, too.

MATERIAL AND METHODS

As substitute of wood chips were used chopped and squeezed pieces of beetroot. Juice received in this way is further subjected to further technological processes. One layer particleboard (dried molasses sugar beet pulp bonded with urine-formaldehyde resin UF) distinguished by average density 768 kg/m^3 while average density of boards bonded with saccharine amounted 756 kg/m^3. Exemplary density profiles of described above boards are showed in fig.1 and 2. Slightly bigger spread of density values between upper and lower layer was observed in case of board bonded with saccharine. Moreover, standard (made in factory) three layer chipboards and MDF board with thickness 16 mm were used in experiments.

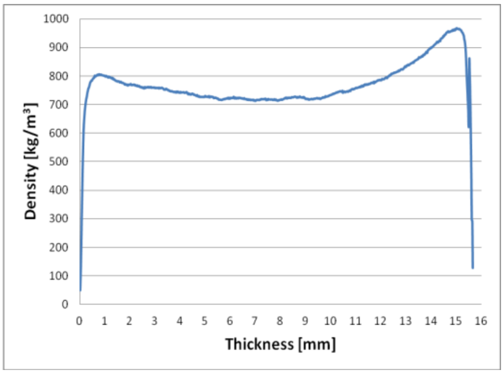

Fig. 1. Density profile of one layer board (dried molasses sugar beet pulp bonded with urine-formaldehyde resin UF)

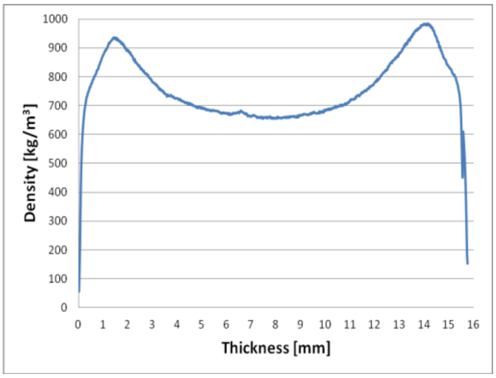

Fig. 2. Density profile of one layer board (dried molasses sugar beet pulp bonded with saccharine)

Samples after dividing on work pieces with dimensions 100x35x17mm were clamped on measurement platform equipped with piezoelectric transducer Kistler 9345A measuring axial force and torque. Above sensor was coupled with amplifier ICAM 5073A. Subsequently, signal was transferred through connection box to acquisition card NI PCI 6034EPC. Sampling frequency amounted 50 kHz. Basic elements of measurement chain was showed in fig.3 and view of one edge drilling bit made of polycrystalline diamond in fig.4. Signal processing took place due to application created in LabVIEW environment. Grip with drill visible below was mounted on CNC working centre Busellato Jet 130. For each value of feed per revolution (Δ=0,1 mm, Δ=0,3 mm, Δ=0,5 mm) and kind of material ten holes were made.

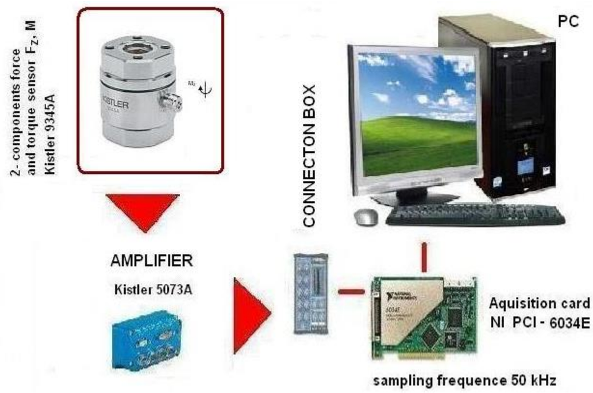

Fig. 3. Elements of measurement chain

Fig. 4. Drilling bit Leitz clamped in grip.

According to obtained data, relative machinability indicators proposed by Wilkowski et al. (2013) were calculated. Described procedure is based on assuming MDF with thickness 16 mm and average density 750 kg/m^3 as reference material. In consequence, appropriate indicators were determined in following way:

$$MI_M = (M_{MDF} / M_i)$$

$$MI_F = (F_{MDF} / F_i)$$

where:

MI_M , MI_F - values of torque and axial force noticed during drilling in MDF board for each feed speed,
M_i , F_i - analogue values noticed during drilling i-th material (particular tested materials compared with MDF).

The first from these relative machinability indicators refers to torque and the second to axial force.

RESULTS AND DISCUSSION

Results for feed per revolution Δ=0,1 mm were showed in fig.5 and fig.6, for feed per revolution Δ=0,3 mm in fig.7 and fig.8. Finally, results for feed per revolution Δ=0,5 mm are visible in fig.9 and fig.10.

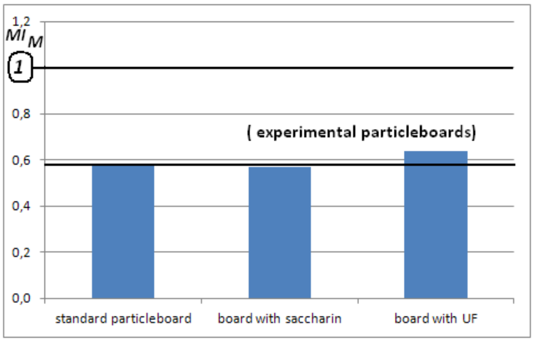

Fig. 5. Relative machinability indicator MI_M for feed per revolution Δ=0,1 mm

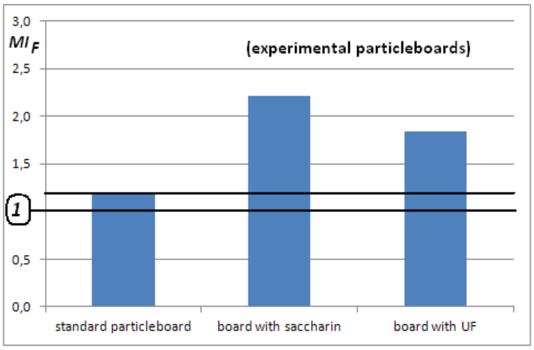

Fig. 6. Relative machinability indicator MI_F for feed per revolution Δ=0,1 mm

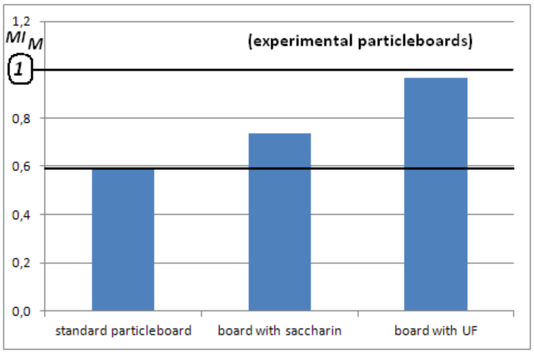

Fig. 7. Relative machinability indicator MI_M for feed per revolution Δ=0,3 mm

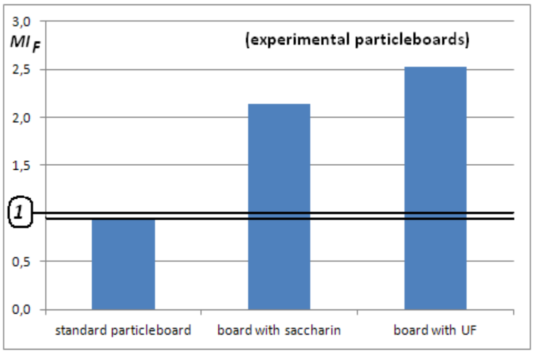

Fig. 8. Relative machinability indicator MI_F for feed per revolution Δ=0,3 mm

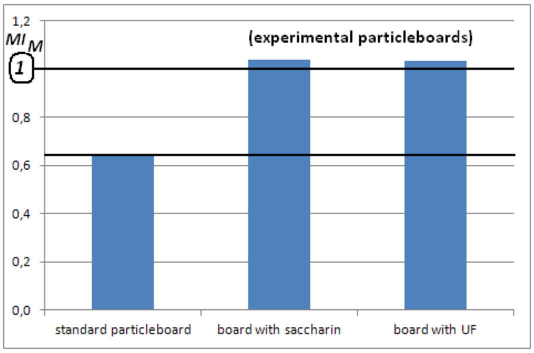

Fig. 9. Relative machinability indicator MI_M for feed per revolution Δ=0,5 mm

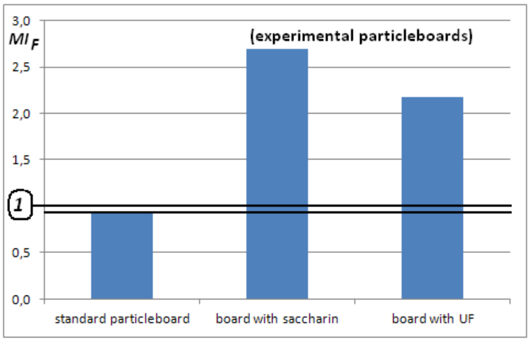

Fig. 10. Relative machinability indicator MI_F for feed per revolution Δ=0,5 mm

Boards made of waste raw materials from agricultural industry regards to relative machinability indicators MI_M (corresponded to torque) proved worse machinability than standard MDF board for lower values of feed per revolution (up to Δ=0,3mm) in spite of comparable density whereas better than standard three layers particleboard. With increasing of feed per revolution (Δ), machinability properties of these experimental boards get better. Charts show that machinability of standard particleboard in case of indicator MI_M by 0,4 lower than MDF.

Analyzing relative machinability indicator MI_F (corresponded to axial force) it is claimed that experimentally made materials based on (dried molasses sugar beet pulp) independently from way of gluing (bonded with saccharine and urine-formaldehyde resin) are definitely easier to machine than three layers standard particleboards or MDF for each value of feed per revolution. So huge differences in compare with reference board can be in coincidence with decreased strength properties of these materials (lower strength on bending and modulus of elasticity).

At the extreme values of feed per revolution (for relative machinability indicator MI_F) worse machinability (for Δ=0,1 mm) has board bonded with urine –formaldehyde resin and for Δ=0,3 mm with saccharine.

CONCLUSION

According to obtained results can be concluded that:

- One layer boards (dried molasses sugar beet pulp) proved better machinability during drilling regards to cutting resistance (axial force and torque) in compare with three layers particleboard within used in researches feeds per revolution.
- Method of bonding in case of experimental boards (saccharine or urine- formaldehyde resin UF) has no statistically significant influence on analyzed relative machinability indicators of these boards.

REFERENCES

1. Dziura D., 2011: Żywice aminowe do wytwarzania wodoodpornych tworzyw drewnopochodnych. Biul. Inform. OBRPPD w Czarnej Wodzie, 3-4/2011: 95-102;
2. Ghalehno M.D., Nazerian M., Bayatkashkooli A., 2011: Influence of utilization of bagasse in surface layer on bending strength of three-layer particleboard, European Journal of Wood and Wood Products, Volume 69, Issue 4: 533-535;
3. Nikvash N., Kraft R., Kharazipour A., Euring M., 2010: Comparative properties of bagasse, canola and hemp particle boards, European Journal of Wood and Wood Products, Volume 68, Issue 3: 323-327;
4. Oniśko W., 2011: Emisja formaldehydu z wiórów i włókien. Biul. Inform. OBRPPD w Czarnej Wodzie 1-2/2011: 79-84;
5. Prasittisopin L., Li K., 2010: A new method of making particleboard with a formaldehyde-free soy-based adhesive, Composites Part A: Applied Science and Manufacturing, Volume 41, Issue 10, October 2010: 1447–1453;
6. Sekaluvu L., Tumutegyereize P., Kiggundu N., 2013: Investigation of Factors Affecting the Production and Properties of Maize Cob-Particleboards, Waste Biomass Valor;
7. Wilkowski J., Borysiuk P., Górski J., Czarniak P. 2013 „ Relative machinability indexes of wood particle boards bonded with waste thermoplastics – Experimental study based on drilling torque and thrust force measuring “ Drewno , (56) 190: 139 – 144.