THERMOPLASTIC BONDED COMPOSITE CHIPBOARD
PART 2 - MACHINING TESTS

Marcin Zbieć – Piotr Borysiuk – Andrzej Mazurek

Abstract
Paper deals with milling tests of chipboard bonded with waste polystyrene and polypropylene. Test material, chipboard made similarly to regular board, but with utilization of waste polystyrene and polypropylene as a bonding agent. Wood-thermoplastic boards were tested against machineability, especially with machined surface temperature, wear ratio and forces in milling, and then compared to regular chipboard.

Keywords: *polystyrene, polypropylene, WPC, particleboard, machining, milling*

INTRODUCTION

Particleboards use, especially chipboard show high usage increase year by year. Almost all furniture, home furnishings, and even latest building constructions are made with relatively inexpensive particleboard materials. In case of most popular product, regular chipboard, in most cases urea-formaldehyde resin is being used. This most popular bonding material has some serious disadvantages, like low environmental resistance, and especially, harmful formaldehyde emission. Wood particles can be however bonded with other substances, such as thermoplastics.

In general, wood-plastic composites show lower mechanical properties than regular chipboard made of wood particles and urea-formaldehyde resin. However, at the same time they are known for higher environmental resistance and lack of harmful emissions, especially valuable in contemporary highly allergic dwelling environment. WPC are usually made of wood flour and grinded plastic, heated, mixed and extruded into the form required. This paper deals with machining tests of different composites, being fabricated from regular industry standard chips and waste polystyrene and polypropylene. This type of material shows reasonable mechanical properties, at the same time allowing to use waste plastic instead of the harmful urea-formaldehyde resin.

MATERIAL AND METHODS

During the experiment three types of the boards were used:
- Regular reference chipboard
- Chipboard bonded with 30% polystyrene

Warsaw University of Life Sciences, Ul. Nowoursynowska 159, 02 – 776 Warsaw, Poland
e-mail: marcin_zbiec@sggw.pl; piotr_borysiuk@sggw.pl; andrzej_mazurek@sggw.pl

- Chipboard bonded with 50% polystyrene
- Chipboard bonded with 30% polypropylene
- Chipboard bonded with 50% polypropylene

All boards were made of coniferous industrial chips in five variants, with classic urea-formaldehyde resin and with resin replaced by recycled polystyrene and polypropylene. Density of all the boards ranged between 772 and 787 kg/m^3
Boards showed similar density distribution, showed at fig.1

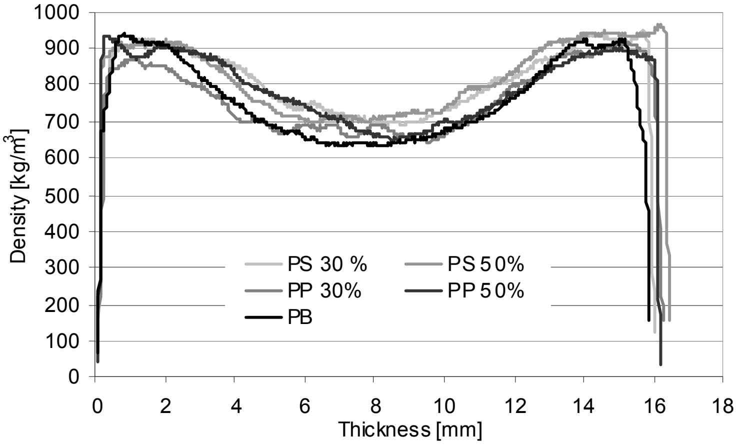

Fig.1 Density distribution of the machined boards

Machining tests consisted of simple edge milling of the manufactured boards, except tool wear following milling parameters were tested:

- Machined surface temperature
- Impact and RMS cutting force
- Impact and RMS thrust (normal)
- Cutting power (not presented)
- Feed power (not presented)

Table 1. Milling parameters

Tool diameter	160mm
Head cutters	1
Milling depth	2mm
Average chip thickness	0,112mm
Rotational speed	3000 rpm
Cutting speed	25,13m/s
Feed speed	3m/min

Basic measurement procedure was presented on figure 2.

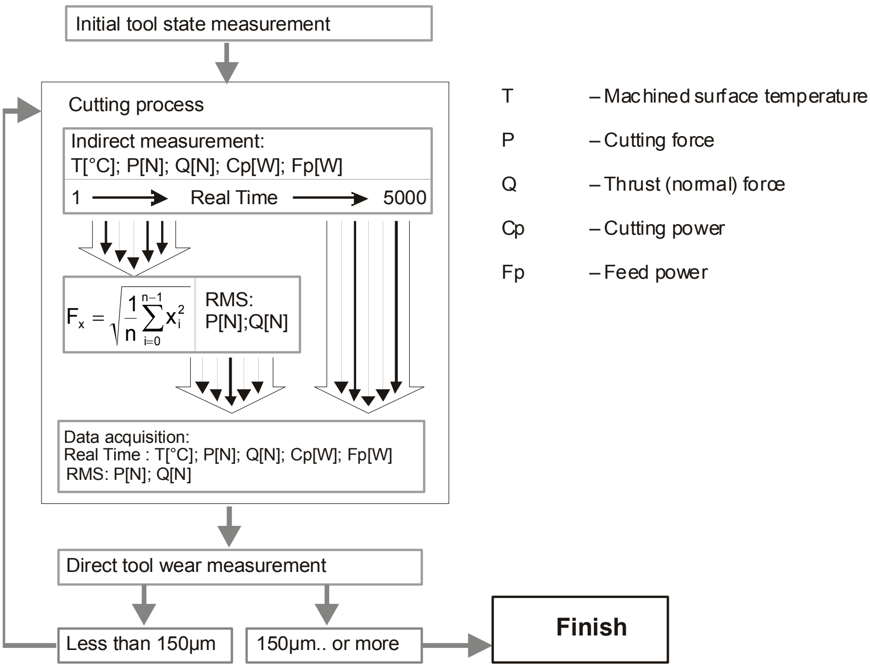

Fig.2 Machining test procedure, with simple edge milling.

RESULTS

Machining tests of the wood-polystyrene, wood-polypropylene and control reference boards are presented on the following figures:

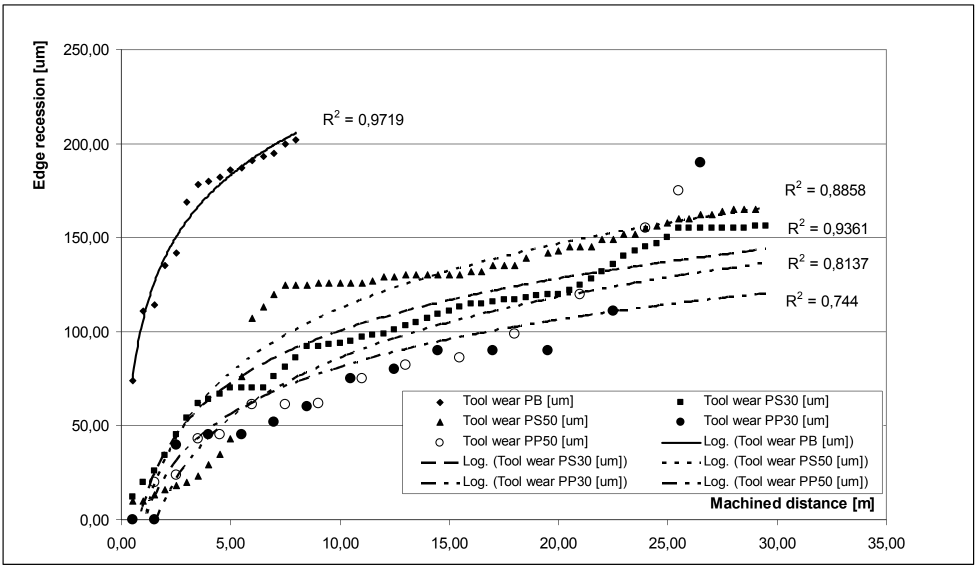

Fig.3 Tool wear in dependence on cutting distance.

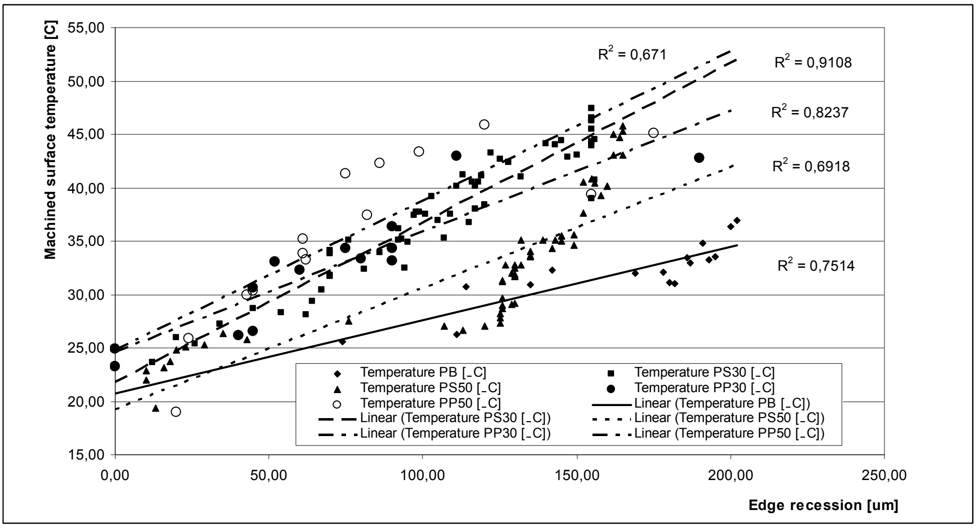

Fig.4 Machined surface temperature in dependence on tool wear.

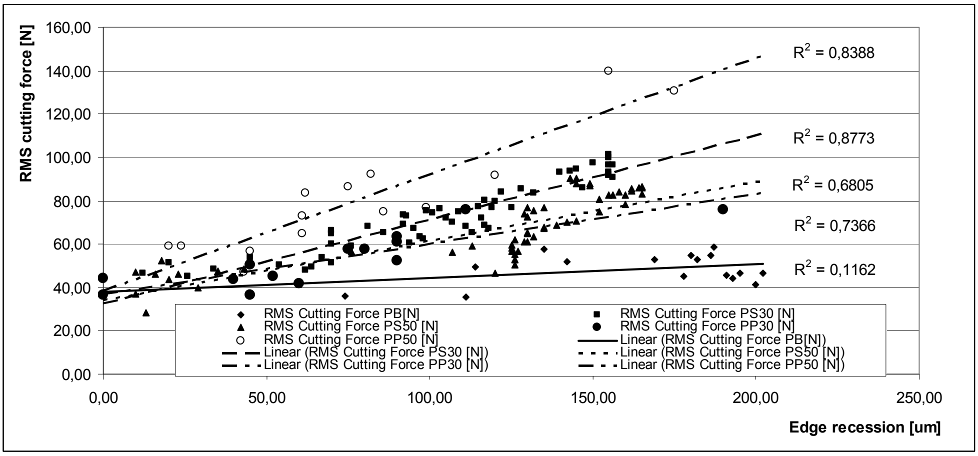

Fig.5 RMS cutting forces in dependence on tool wear.

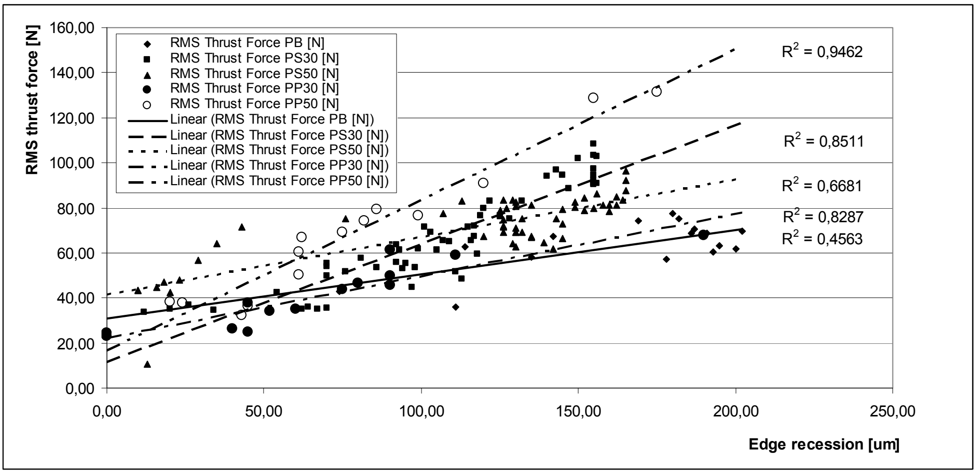

Fig.6 RMS thrust (normal) forces in dependence on tool wear.

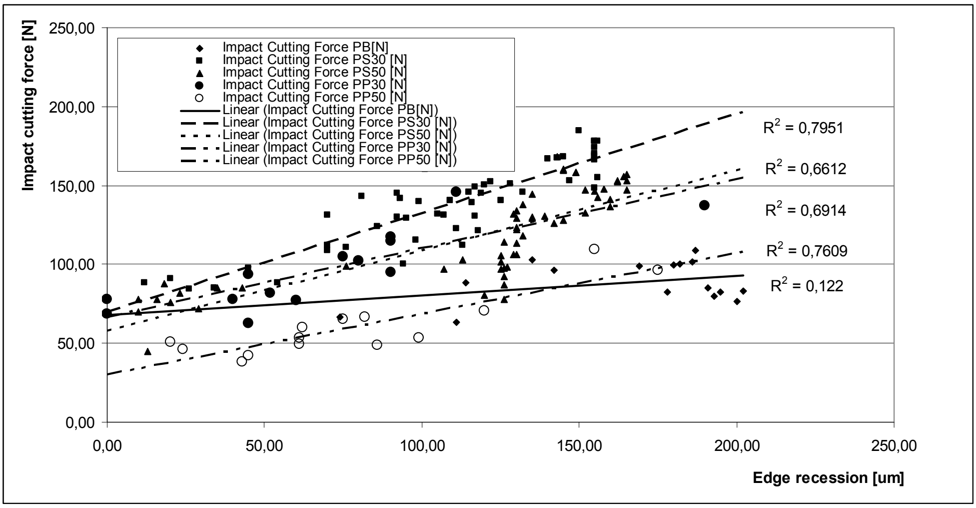

Fig.7 Impact cutting forces in dependence on tool wear.

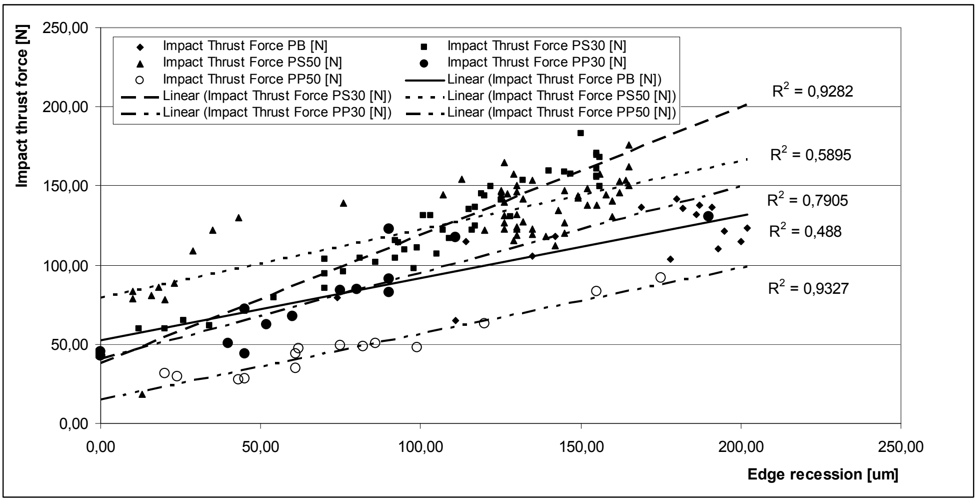

Fig.8 Impact thrust (normal) forces in dependence on tool wear.

DISCUSSION

Main aim of the work was to determine tool wear in machining of new mateials. Figure 3 shows serious improvement, in all the tested materials on tool lifetime in milling, in comparison to regular particleboard. Tool lifetime increased around 10 times, with getting rid of urea-formaldehyde resin and replacing it with the thermoplastics. Despite the similar density distributions tool wear on the thermoplas-bonded board was more uniform in character, not showing typical high density wear zones as with regular chipboard. Increased temperature in milling of the thermoplasts-bonded particleboards did not cause any melting of the bonding material, on the cutting edge only traces of residue were visible, similar to the resin residues from wood. All plastic bonded boards showed higher force parameters, in some cases twice as high in comparison to regular particleboard. Increased forces however, in case of the woodworking machinery, should not cause any problems, because of high allowances of the working spindles, supports and engines. Machined surface in the thermoplastics-bonded chipboard was very clear, non-porous of an excellent quality; worn tools did not cause chip ripping as in regular chipboard.

Another, not presented tests were made on power consumption of the machinery between tested board variants in milling, differences were negligible and not important.

CONCLUSION

Basing on the performed tests, one may conclude as follows:

- Application of the polypropylene and polystyrene bonded significantly increases tool lifetime in the regular usage range (0-150μm of edge recession), performed test showed 10 times increase.

- Temperature, cutting forces and thrust forces when milling of polypropylene and polystyrene bonded boards showed significant increase (around 100%) when comparing with regular chipboard.
- Thermoplastics bonded particleboards seem to be machining-comparable with regular chipboard, have much lower affect on the tool wear process and do not show any properties causing technological problems in machining.

REFERENCES

1. Borysiuk P., Mamiński M., Nicewicz D., Boruszewski P., Zado A., 2008: Waste thermoplastics as binder for green and recycled wood bonding in particleboard manufacturing. Proceedings: International Panel Products Symposium 2008, 24–26 September Espoo, Finland: 249-254.
2. Borysiuk P., Pawlicki J., Nicewicz D., 2006: New types of raw materials in technologies of wood-based materials. Proceedings of COST Action E44-49 Wood Resources and Panel Properties, Valencia, p. 277-281
3. Kowaluk G., Pałubicki B., Marchal R., Frąckowiak I., Zbieć M., Beer P.. 2007: „Friction and cutting forces when machining particleboards produced from different lignocelluloses' raw materials". Annals of Warsaw University of Life Sciences – SGGW, Forestry and Wood Technology No 61 2007 s. 362 - 365.
4. Zbieć M., Rousek M., Kopecký Z.. 2006: „ Diagnostic importance of various cutting parameters in milling of MDF. Part I", Annals of Warsaw Agricul. Univ. Forestry and Wood Technology No 59 2006 s. 410-414
5. Zbieć M., Rousek M., Kopecký Z.. 2006: „ Diagnostic importance of various cutting parameters in milling of MDF. Part II", Annals of Warsaw Agricul. Univ. Forestry and Wood Technology No 59 2006 s. 415-419.
6. Zbieć M., Mazurek A., Kopecký Z.. „ Influence of chip thickness on various cutting parameters in milling of chipboard". 5th International Science Conference „Chip and chipless woodworking processes" 12 - 14 października 2006, Stary Smokovec s. 299 - 304.
7. Zdeněk Kopecký, Miroslav Rousek, Emil Svoboda, Marcin Zbieć 2006: **„** Problems of measuring the blunting of coated milling knives**",** Annals of Warsaw Agricul. Univ. Forestry and Wood Technology No 58 2006 s. 417-423.
8. Zbieć Marcin, Mazurek Andrzej, Rousek Miroslav 2008: „Tool wear diagnostics in milling of selected wood species. Birch wood". (*Diagnozowanie stopnia stępienia narzędzia przy frezowaniu wybranych gatunków drewna. Brzoza*). Annals of Warsaw University of Life Sciences – SGGW, Forestry and Wood Technology No 66 2008 s. 265-269.