Electronic Journal of Polish Agricultural Universities is the very first Polish scientific journal published exclusively on the Internet, founded on January 1, 1998 by the following agricultural universities and higher schools of agriculture: University of Technology and Agriculture of Bydgoszcz, Agricultural University of Cracow, Agricultural University of Lublin, Agricultural University of Poznan, Higher School of Agriculture and Teacher Training Siedlce, Agricultural University of Szczecin, and Agricultural University of Wroclaw.

ELECTRONIC JOURNAL OF POLISH AGRICULTURAL UNIVERSITIES

2003
Volume 6
Issue 2
Series WOOD TECHNOLOGY

CZARNECKI R., DZIURKA D., ŁĘCKA J. 2003. THE USE OF RECYCLED BOARDS AS THE SUBSTITUTE FOR PARTICLES IN THE CENTRE LAYER OF PARTICLEBOARDS **Electronic Journal of Polish Agricultural Universities**, Wood Technology, Volume 6, Issue 2.
Available Online http://www.ejpau.media.pl

THE USE OF RECYCLED BOARDS AS THE SUBSTITUTE FOR PARTICLES IN THE CENTRE LAYER OF PARTICLEBOARDS

Rafał Czarnecki, Dorota Dziurka, Janina Łęcka
Department of Wood-Based Materials, The August Cieszkowski Agriculture University of Poznań, Poland

ABSTRACT

The research investigated the possibility of substituting, in the process of producing particleboards, a part of wood particles with recycled boards such as raw and laminated particleboards glued with urea resin, water-resistant particleboard glued with phenolic resin and MDF. Reduced waste was added to the centre layer of experimental particleboards in the amount from 0 to 60%; the boards were then glued with urea resin, and the waste from water-resistant boards was also glued with phenolic resin. The obtained results lead to the conclusion that a great part of waste wood-based materials can be used in the process of producing particleboards.

Key words: waste particles, recycling, particleboards

INTRODUCTION

One of major problems that woodworking industry constantly faces is logging lingocellulose material. The cost of the material increases gradually and its availability is limited. At the same time, growing requirements in terms of environment protection make the utilization of lingocellulose waste necessary. The wood-based materials industry also shows growing interest in using these materials [5, 11]. So far, the wood-based materials industry has been using waste from such annual plants as linen and kemp shives, sugar reed, jute and cotton fibers [7, 8]. In the recent years, researchers have investigated the use of straw [6, 9, 10] and other grain waste,

e.g. oak scale [1]. It is estimated that in Western Europe, approximately 70% of particleboards are manufactured with use of wood waste, such as edgings, offcuts, shavings, sawdust and particles obtained from e.g. sawmills and furniture works; about 10% of particleboards are produced from post-use timber [4]. Among the applied post-use materials there are mainly used furniture and wood-based materials used as interior furnishings. Therefore, the possibilities of applying recycled wood-based materials focuses still more attention of researchers. So far, particles have been recovered mainly from particleboards [2, 3] using methods such as hydrothermal, chemical-mechanical, chemical-thermal-mechanical and mechanical. These methods, apart from the mechanical reduction of post-use elements of particleboards, are quite complex. Moreover, particles are recovered from the waste particleboards mainly in a hydrolytic manner, which can be applied only in terms of boards glued with urea resin.

The aim of the present work is to investigate the possibility of substituting the particles in the centre layer of the board with the particles obtained from post-use boards directly after their mechanical reduction.

MATERIAL AND METHODS

In order to produce particleboards, pine particles obtained in industrial conditions were used as well as particles obtained from:

- three-layer particleboards glued with urea (UF) resin, both raw and laminated
- three-layer particleboards glued with phenolic (PF) resin
- MDF boards glued with UF resin.

The particles were subjected to screen classification in order to remove dust and the fraction that was unable to pass square mesh (2 mm on a side in case of pine particles for the outer layers and 5 mm on a side in case of recycled particles for the centre layer). Yet, particles obtained from MDF boards did not undergo screen classification since the material was very homogenous and contained 85% of fraction of 6.5 mm. The reduction conditions for all kinds of boards were the same; yet, in terms of boards other than MDF, the obtained material was inhomogeneous and considerably small. Five series of boards were produced, each of them with a various type of recycled particles. The boards were glued with UF resin; however, the particleboards produced from recycled water-resistant boards were glued with PF resin. The resin level of the centre layer was 8% and that of outer layer was 12%. The waste material was added to the centre layer of the experimental boards in the amount of 10, 20, 30, 40, 50 and 60%. The weight ratio of dry particles of the centre layer to dry particles of the outer layer was 2:3. The tree-layer particleboards with density of 700 kg/m^3 and dimension of 450 × 450 × 19 were produced in laboratory conditions using the following pressing parameters: pressure, 2.5 MPa; temperature, 180°C and time, 7.5 min.

The produced particleboards were subjected to the following tests:

- modulus of rupture (MOR) according to PN-EN 310 “Wood-based panels – Determination of modulus of elasticity in bending and of bending strength”
- internal bond (IB) according to PN-EN 319 “Particleboards and fiberboards – Determination of tensile strength perpendicular to the plane of the board”
- swelling in thickness after 24 hours according to PN-EN 317 “Particleboards and fiberboards – Determination of swelling in thickness after immersion in water”
- free formaldehyde content according to PN-EN 120 “Wood based panels – Determination of formaldehyde content – Extraction method called the perforator method”

DISCUSSION OF RESULTS

Tables 1-5 show the influence of the amount of the recycled particles added to the centre layer upon properties of the boards. It is easily noticeable that results presented in tables 1 and 2 are quite similar, which proves that waste particles obtained from both raw and laminated particleboards glued with UF resin comparably affect the properties of experimental particleboards. The increase in the amount of waste particles up to 50% results in slight, yet systematic decrease in MOR of the investigated boards. A more distinct decrease in this property is observed when the amount of recycled particles is 60%. A direct comparison of the achieved results of MOR shows a slightly worse result in case of particleboards produced with use of particles obtained from laminated board. The effect of the addition of waste particles on the value of IB is a bit different. Here, even 10% addition of recycled particles leads to a remarkable decrease in this value. Further increase in the amount of the introduced waste particles slightly, yet systematically deteriorates this property. No significant differences are

observed when properties of boards produced with the two kinds of waste material are compared. As the amount of the added waste grows, the value of swelling in thickness after 2 and 24 hours of soaking in water decreases. Here, the decrease is more distinct in case of waste from raw particleboard. As for the free formaldehyde content, no significant changes are observed.

Table 1. The influence of the fraction of waste particles obtained from raw particleboard glued with UF resin added to the centre layer upon properties of experimental particleboards glued with UF resin

Properties		Unit	Fraction of waste particles [%]						
			0	10	20	30	40	50	60
Modulus of rupture MOR		MPa	14.7	14.6	14.5	14.5	14.2	14.3	13.8
Internal bond IB		MPa	0.41	0.34	0.32	0.33	0.36	0.30	0.31
Swelling in thickness	after 2 h	%	9.7	9.8	10.2	8.4	7.0	9.1	6.7
	after 24 h		19.3	18.4	19.3	18.3	16.8	17.9	16.8
Free formaldehyde content		mg CH_2O/ 100 g d.m.b.	7.85	8.28	9.21	8.52	8.11	9.12	8.81

Table 2. The influence of the fraction of waste particles obtained from laminated particleboard glued with UF resin added to the centre layer upon properties of experimental particleboards glued with UF resin

Properties		Unit	Fraction of waste particles [%]						
			0	10	20	30	40	50	60
Modulus of rupture MOR		MPa	14.7	14.2	13.4	13.4	13.2	13.3	12.3
Internal bond IB		MPa	0.41	0.36	0.34	0.33	0.33	0.32	0.33
Swelling in thickness	after 2 h	%	9.7	9.6	10.3	9.8	8.7	9.2	8.4
	after 24 h		19.3	18.6	18.8	19.2	18.7	17.4	17.2
Free formaldehyde content		mg CH_2O/ 100 g d.m.b.	7.85	8.21	7.61	6.84	7.57	8.04	7.92

Table 3. The influence of the fraction of waste particles obtained from particleboard glued with PF resin added to the centre layer upon properties of experimental particleboards glued with PF resin

Properties		Unit	Fraction of waste particles [%]						
			0	10	20	30	40	50	60
Modulus of rupture MOR		MPa	18.3	16.9	16.6	16.6	16.7	16.0	16.0
Internal bond IB		MPa	0.42	0.28	0.25	0.26	0.26	0.24	0.26
Swelling in thickness	after 2 h	%	16.0	14.0	14.5	13.7	14.9	12.4	13.0
	after 24 h		17.6	17.2	17.8	16.6	15.9	15.2	15.2
Free formaldehyde content		mg CH_2O/ 100 g d.m.b.	3.67	3.48	3.83	3.15	3.63	3.69	3.53

Table 4. The influence of the fraction of waste particles obtained from particleboard glued with PF resin added to the centre layer upon properties of experimental particleboards glued with UF resin

Properties		Unit	Fraction of waste particles [%]						
			0	10	20	30	40	50	60
Modulus of rupture MOR		MPa	14.7	14.0	13.1	13.1	12.0	9.6	5.4
Internal bond IB		MPa	0.41	0.26	0.18	0.15	0.09	0.06	-
Swelling in thickness	after 2 h	%	9.7	13.1	13.1	13.1	15.1	15.5	-
	after 24 h		19.3	19.6	19.5	19.8	19.3	20.1	-
Free formaldehyde content		mg CH_2O/ 100 g d.m.b.	7.85	8.40	8.35	8.21	8.26	8.06	8.48

Table 5. The influence of the fraction of waste particles obtained from MDF board added to the centre layer upon properties of experimental particleboards glued with UF resin

Properties		Unit	Fraction of waste particles [%]						
			0	10	20	30	40	50	60
Modulus of rupture MOR		MPa	14.7	14.4	13.8	12.8	12.4	12.2	11.4
Internal bond IB		MPa	0.41	0.47	0.57	0.71	0.61	0.58	0.53
Swelling in thickness	after 2 h	%	9.7	9.1	8.2	7.6	7.4	7.1	6.9
	after 24 h		19.3	18.6	18.5	16.8	16.2	15.6	15.2
Free formaldehyde content		mg CH_2O/ 100 g d.m.b.	7.85	7.92	8.06	8.11	8.16	8.16	8.18

A separate analysis is necessary as for the results shown in Tables 3 and 4, for boards produced with use of waste particles obtained from water-resistant particleboards glued with PF resin. The experimental particleboards were produced with PF resin (Table 3) and UF resin (Table 4). Data presented in table 3 prove that 10% addition of waste particles in the centre layer of the board results in a remarkable decrease in MOR. Further growth of the amount of the recycled particles up to 60% only slightly, yet systematically decreases this value. The results of IB are similar: 10% addition of waste particles decreases this property by 1/3 and further increase in the waste fraction does not actually affect the IB value. The use of waste particles favourably influences the swelling in thickness. The free formaldehyde content remains in fact almost unchanged. The results shown in Table 4, obtained for the series of experimental boards glued with UF resin, are much worse. Only 10% addition of the recycled particles can be considered safe in terms of properties of the obtained boards. When the waste particles fraction is greater, all properties, apart from free formaldehyde content, decrease significantly. With the waste particles amount greater than 40%, a serious destruction of the produced boards occurs right after taking them out of the press. This probably results from the fact that the waste from particleboards glued with resol PF resin contains certain amounts of alkalis which unfavourably affect the polycondensation process of PF resin.

CONCLUSIONS

The research results prove that adding to the centre layer of particleboards up to 50% of particles obtained from recycled boards glued with UF resin does not significantly deteriorate properties of the experimental boards. Similar conclusions can be drawn for boards produced with use of particles obtained from recycled laminated particleboards. Presumably, particles from both raw and laminated boards can be introduced together to the centre layer of the experimental boards without deteriorating their properties.

As for particles obtained from recycled boards glued with PF resin, it is possible to add them to the centre layer of the board even in the amount of 60%, providing the experimental particleboard is produced using the same kind of resin. Gluing these boards with UF resin results in a remarkable decrease in their properties. However, best results are achieved when particles from recycled MDF boards are introduced to the centre layer of the

boards. Here, 60% addition of the waste particles slightly decreases the value of MOR; on the other hand though, it improves the values of swelling in thickness and IB. It ought to be emphasised that none of the applied substitutes of particles affects the health issues associated with the particleboards.

REFERENCES

1. Czarnecki R., Dziurka D., Mirski R., 2001. Możliwość wykorzystania łuski owsianej jako substytutu wiórów w produkcji płyt wiórowych [Possibility of using oat scale as substitute for particles in production of particleboards]. Przem. Drzew. 3, 21-231 [in Polish].
2. Deppe H-J., Ernst K., 2000. Taschenbuch der Spanplattentechnik [Guide to particleboards technology. DRW-Verlag. Weinbrenner [in German].
3. Dobrowolska E., Pawlicki J., 1997. Możliwości zastosowania wiórów wtórnych do wytwarzania tworzyw drzewnych [Possibility of using recycled particles in production of wood-based materials]. Utylizacja odpadów w przemyśle meblarskim i płytowym na tle wymagań europejskich [Waste utilization in furniture and wood-based materials industry in the context of European standards]. Poznań 14-15.10.1997. Conf. materials, 199-208 [in Polish].
4. Fleischer O., 1997. Entsorgung von Holzabfällen in der Möbel - und Holzwerkstoff-Industrie – eine Bestandsaufnahme vor dem Hintergrund der europäischen Gesetzgebung. Utylizacja odpadów w przemyśle meblarskim i płytowym na tle wymagań europejskich [Waste utilization in furniture and wood-based materials industry in the context of European standards]. Poznań 14-15.10.1997. Conf. materials, 47-56 [in German].
5. Ferens P., 1996. Drewno odpadowe a przemysł płyt drewnopochodnych [Waste timber and wood-based materials industry]. Przem. Drzew. 12, 30-33 [in Polish].
6. Girgoriou A. H., 1998. Straw as alternative raw material for the surface layers of particleboards. Holzforsch. Holzverwert. 50(2), 32-34.
7. Kozłowski R., Mieleniak B., Przepiera A., 2001. Odpady roślin jednorocznych jako materiały surowcowe do produkcji płyt lignocelulozowych [Annual plants waste as raw material used in production of lingocellulose boards]. Przem. Drzew. 3, 17-20 [in Polish].
8. Noskowiak A., Piotrowski Z., 1997. Płyty cząstkowe z łodyg bawełny [Chipboards made of cotton stems]. 3 Kraj. Konf. Nauk. Las-Drewno-Ekologia ’97 [3rd National Conference Forest-Wood-Ecology ‘97], Poznań 21-22.10.1997. Conf. materials, 189-194 [in Polish].
9. Piotrowski Z., 1997. Problematyka przerobu słomy pszenicznej na płyty cząstkowe [Problem of processing wheat straw into chipboards]. 3 Krajowa Konferencja Naukowa Las-Drewno-Ekologia’97 [3rd National Conference Forest-Wood-Ecology ‘97], Poznań 21-22.10.1997. Conf. materials, 195-206 [in Polish].
10. Piotrowski Z., 1999. Słoma zbożowa alternatywnym surowcem lignocelulozowym w produkcji materiałów płytowych [Grain straw as alternative lingocellulose material in production of wood-based materials]. Przem. Drzew. 10, 27-29 [in Polish].
11. Wnuk M., 1999. Uwarunkowania produkcji płyt wiórowych z wtórnych surowców drzewnych w Polsce [Conditions of producing particleboards from recycled timber in Poland]. Przem. Drzew. 7-8, 16-17 [in Polish].

Rafał Czarnecki, Dorota Dziurka, Janina Łęcka
Department of Wood-Based Materials
The August Cieszkowski Agriculture University of Poznań
Wojska Polskiego 38/42, 60-627 Poznań, Poland
e-mail: rczarnec@woodcock.au.poznan.pl
