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APPLICATION OF WASTE PAPER IN MANUFACTURING OF PARTICLEBOARDS*

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Abstract. One-layer particle boards with addition of particles of waste paper were manufactured. Two sorts of waste paper (mixed waste paper and waste paper bags) and two glues (urea-formaldehyde resin – UF and melamine-urea-formaldehyde one – MUF) were applied in the process. Properties of the boards (bending strength, modulus of elasticity, perpendicular tensile strength and thickness swelling after 24 h soaking in water) were examined. As a result it was found that waste paper can be a supplementary addition in the production of particleboards. Boards had sufficient properties if maximum content of waste paper should not exceed 50% (with the MUF resin) and 30% (with the UF resin).

Key words: particleboards, waste paper, recycling

INTRODUCTION

Recycling of paper is a problem which the mother paper industry does not always cope with. Its typical form, production of secondary paper pulp requires at the beginning removing from the waste paper chemical substances used in the process of manufacturing, i.e. purifying substances, glues, dyestuffs, impregnates and substances spread on paper during usage: printer's ink, drawing ink, toners etc. Additionally, sorting and washing of fibres obtained from waste paper is necessary. These treatments can cause diminishing of strength of cellulose fibres and hence lowering the quality of products obtained from them [Kordsachia 1992, Groom et al. 1994].

Thus, the paper industry is not interested in some sorts of waste paper, e.g. office and mixed waste paper, because usage of them can cause disturbances in the operation of a paper mill [Przybysz et al. 2001]. This is why the index of paper recycling in Poland in 2002 amounted to only 31.8% [Fornalski 2003].

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Particleboard industry is a potential place in which an attempt at recycling waste paper can be made. The following facts are propitious to it:

1. The technologies of particleboards for years of development had to be accommodated to the usage of worse and worse raw materials, mainly waste ones, maintaining the board properties at decent level.
2. Accommodation of waste paper to its usage in the technology of particleboards is far easier than in the case of paper technologies.

The text presented below is a report on research work aiming at examination of a possibility of using waste paper as a supplementary raw material for the production of particleboards.

RESEARCH ASSUMPTIONS

At the first stage of the research it was assumed that the technique of manufacturing particleboards with an admixture of waste paper should be possibly similar to the standard technology of particleboards. Preparation of waste paper should be as simple as possible i.e. without removing from the waste paper purifying substances and paints, which should not make an obstruction to the discussed technology. Disintegration of waste paper should be exclusively mechanical and allow for obtaining paper particles of dimensions close to those of wood particles applied in the typical technology. Glues used in the production should be identical as in the technology of standard particleboards. The parameters of board production can also be similar.

METHODS

Disintegration of waste paper has been worked out during the first research on the usage of waste paper in the technology of particleboards [Pawlicki et al. 2005]. It was found that the optimum is a two-stage disintegration – firstly by means of a cutting disintegrator, than by means of a breaking one.

In the research, it was decided to apply the following standard parameters and conditions of board manufacturing:

– glue content of 12% (dry glue relative to dry wood),
– pressing temperature of 195°C,
– pressing time of 280 seconds,
– maximum pressure of pressing 3.6 MPa.

One-layer boards of thickness 18 mm and density 700 $kg \cdot m^{-3}$ were manufactured. Two sorts of waste paper (mixed waste paper and waste paper bags) and two glues (urea-formaldehyde resin and melamine-urea-formaldehyde one – MUF) were applied in the process.

Typical particles of pine wood, obtained in industrial conditions, devoid of dust, were used.

The admixture of waste paper of each mentioned sort to wood particles amounted to 0, 20, 30, 50, 70 and 100% (0% – boards of wood particles only, 100% – boards of waste paper particles only).

The produced boards were conditioned for 48 h in normal conditions then cut to samples for examination of bending strength, modulus of elasticity, perpendicular tensile strength and thickness swelling after 24 h soaking in water.

ANALYSIS OF RESULTS

The results of boards' examination are presented in the Table 1.

Table 1. Properties of wood-paper particleboards
Tabela 1. Właściwości drzewno-papierowych płyt wiórowych

Kind of waste paper Typ makulatury	Kind of glue Rodzaj kleju	Waste paper content, % Zawartość makulatury, %	Thickness swelling, % Spęcznienie na grubość, %	Tensile strength Wytrzymałość na rozciąganie poprzeczne $N \cdot mm^{-2}$	Bending strength Wytrzymałość na zginanie statyczne $N \cdot mm^{-2}$	Modulus of elasticity Moduł sprężystości przy zginaniu $N \cdot mm^{-2}$
Mixed Gazetowa	UF moczn ikowy	0	23.1	0.73	28.1	3 787
		20	22.3	0.45	21.0	2 979
		30	22.0	0.35	18.4	2 248
		50	30.3	0.25	14.7	2 217
		70	32.0	0.22	13.4	1 860
		100	31.7	0.09	8.9	1 178
	MUF melani nowy	0	14.5	0.87	33.1	3 554
		20	15.9	0.56	26.9	3 207
		30	17.2	0.42	22.3	2 465
		50	19.7	0.29	19.8	2 076
		70	21.0	0.20	14.9	1 682
		100	22.9	0.15	11.7	1 189
Waste paperbags Mocna	UF moczn ikowy	0	23.1	0.73	28.1	3 787
		20	23.7	0.52	22.9	3 350
		30	26.1	0.48	20.4	2 554
		50	31.8	0.34	14.5	1 892
		70	34.2	0.26	9.8	867
		100	39	0.12	5.6	–
	MUF melani nowy	0	14.5	0.87	33.1	3 554
		20	15.8	0.72	28.7	3 406
		30	16.5	0.54	25.6	3 222
		50	17.4	0.36	22.0	2 760
		70	18.7	0.29	15.1	1 750
		100	20.5	0.19	8.8	565

Figure 1 presents the dependence of bending strength of boards on the content of waste paper in the case when mixed waste paper was applied. It is visible that the bending strength was falling steadily with the growing quantity of waste paper particles. The usage of the MUF resin instead of UF one caused a considerable growth in bending strength (by about 10-15%).

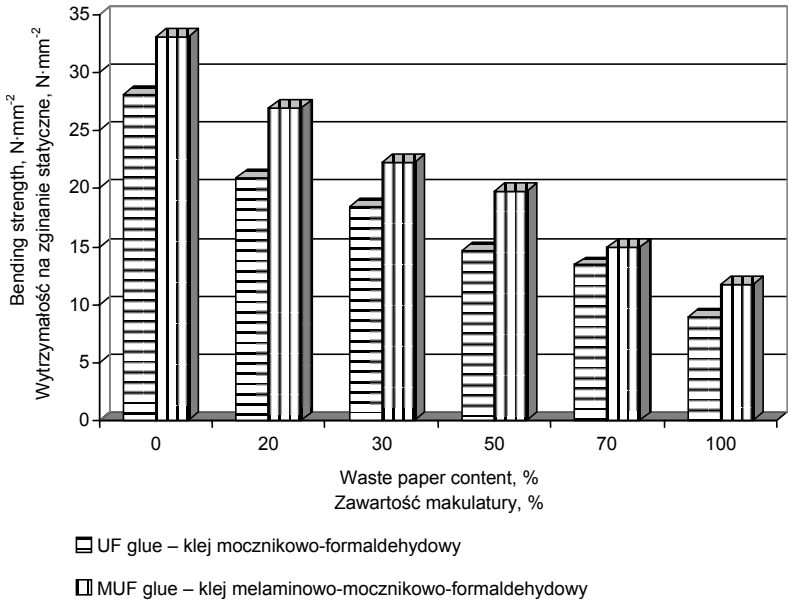

Fig. 1. The dependence of bending strength of boards on the content of particles of mixed waste paper
Rys. 1. Zależność wytrzymałości na zginanie statyczne płyt od zawartości cząstek makulatury mieszanej

From the point of view of standard requirements, sufficient strength was obtained by boards containing up to 30% of waste paper if the UF resin was applied. Boards produced with the MUF resin had a sufficient strength still at the waster paper content of 50%.

In Figure 2, the same relationship is presented, but referring to boards containing waste paper bags. The pattern of bending strength changes was in this case similar as previously, but all values were considerably higher.

The requirements of standards, like it was in the foregoing case, were satisfied by boards produced with the UF resin containing up to 30% of waste paper as well as by boards with a MUF resin and a 50% admixture of waste paper particles.

Figures 3 and 4 shows change in the modulus of elasticity of boards in relationship to waste paper content.

In the case of boards containing mixed waste paper (Fig. 3), the modulus of elasticity depended first of all on the proportion of the less rigid material (waste paper).

The greater was its share the lower value of the modulus. The influence of the kind of glue on the discussed property was negligible. The requirements of standards were satisfied by boards containing up to 20% of waste paper produced with the UF resin and produced with a 30% admixture of waste paper and the MUF resin.

The modulus of elasticity of boards produced with waste paper bags (Fig. 4) was falling, similarly as in the foregoing case, but from the waste paper content of 30%, the influence of the glue type on the discussed property became distinct.

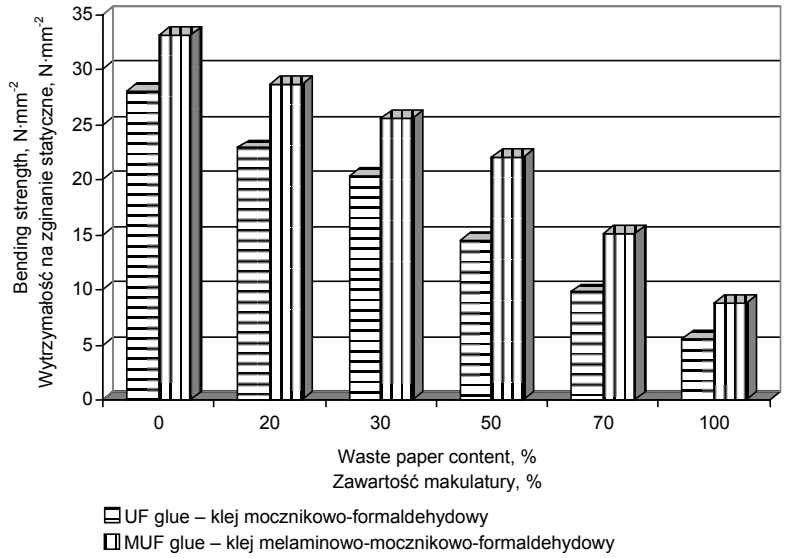

Fig. 2. The dependence of bending strength of boards on the content of particles of waste paper bags
Rys. 2. Zależność wytrzymałości na zginanie statyczne płyt od zawartości cząstek makulatury mocnej

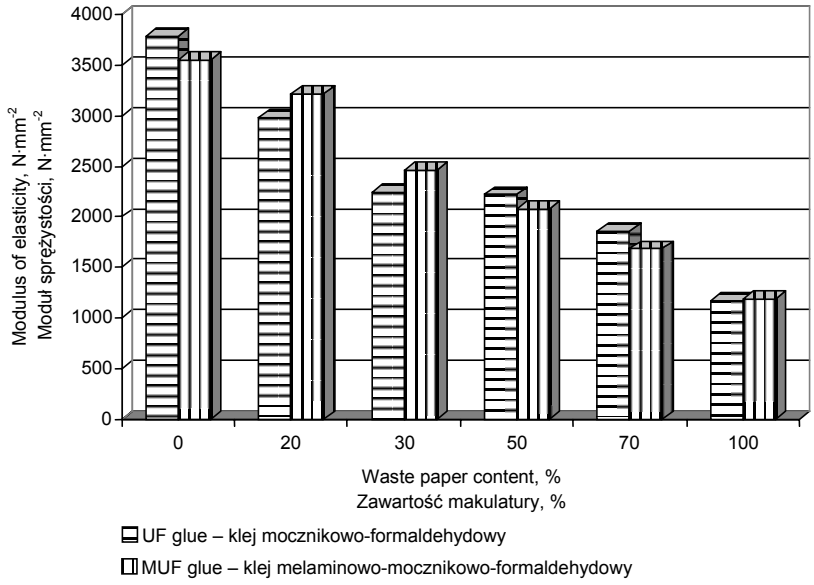

Fig. 3. Changes in the modulus of elasticity of boards in relationship to content of particles of mixed waste paper
Rys. 3. Zmiany modułu sprężystości płyt w zależności od zawartości cząstek makulatury mieszanej

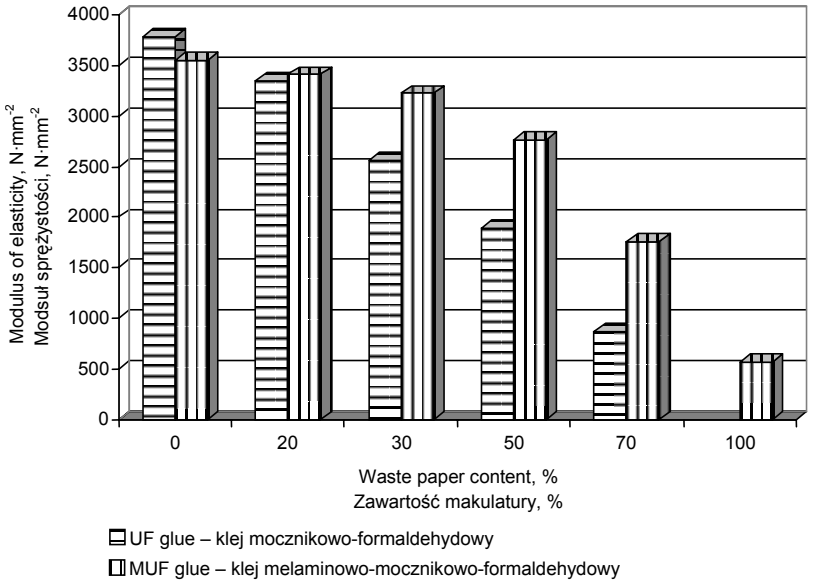

Fig. 4. Changes in the modulus of elasticity of boards in relationship to content of particles of waste paper bags
Rys. 4. Zmiany modułu sprężystości płyt w zależności od zawartości cząstek makulatury mocnej

Boards produced with the MUF resin had considerably higher modulus of elasticity than those with the UF resin. The requirements of standards were satisfied by boards containing up to 30% of waste paper and the UF resin and boards with a 50% admixture of waste paper and the MUF resin.

Perpendicular tensile strength in the case of application of mixed waste paper (Fig. 5) and waste paper bags (Fig. 6) was falling similarly as the bending strength. Values acceptable by standards were reached by boards containing up to 30% of waste paper, regardless of the type of glue.

Thickness swelling of the examined boards depended on the content of waste paper as well. It was distinctly growing with the increase in this content. Boards produced with the UF resin and mixed waste paper (Fig. 7) did not meet the standard requirements related to thickness swelling at all.

Boards with the MUF resin and the waste paper content of up to 20% showed a swelling at the limit of standard requirements (Fig. 8). Similar was the swelling pattern of boards produced with an admixture of waste paper bags. It should be however, emphasised here that the tested boards had been produced without an admixture of any hydrophobic agent. This was done intentionally so that there would not be additional factors. The hydrophobic substances have an influence not only on water resistance but also on the mechanical properties of boards. In the ensuring steps of the research the boards will be made with paraffin emulsion, as in standard technology of particleboards.

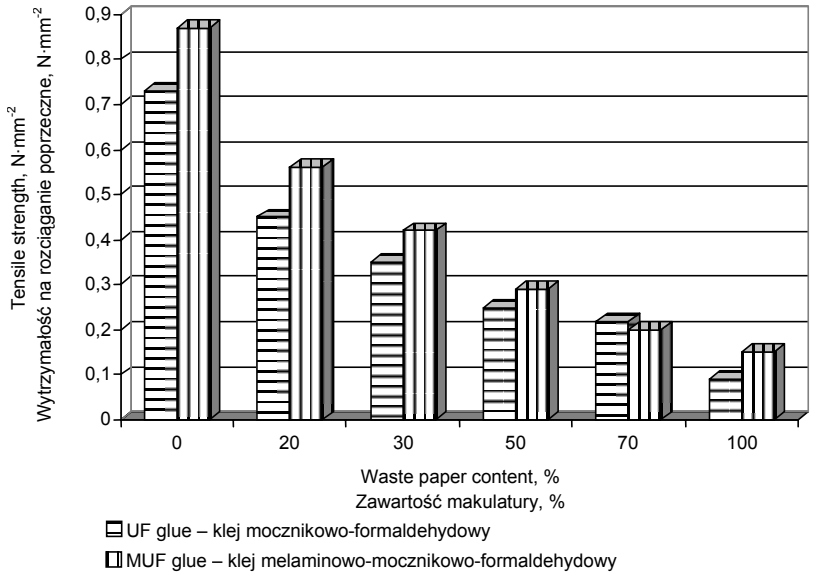

Fig. 5. Changes in the tensile strength of boards in relationship to content of particles of mixed waste paper
Rys. 5. Zmiany wytrzymałości na rozciąganie poprzeczne w zależności od zawartości cząstek makulatury mieszanej

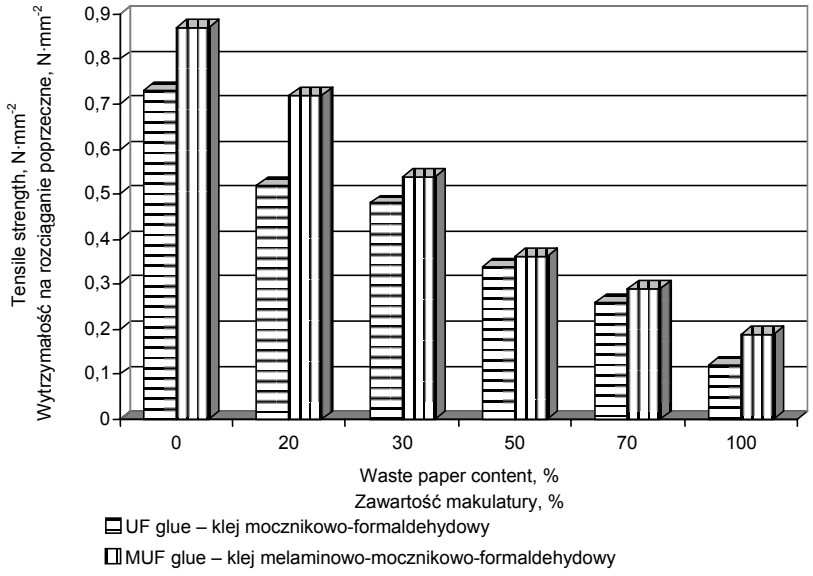

Fig. 6. Changes in the tensile strength of boards in relationship to content of particles of waste paper bags
Rys. 6. Zmiany wytrzymałości na rozciąganie poprzeczne w zależności od zawartości cząstek makulatury mocnej

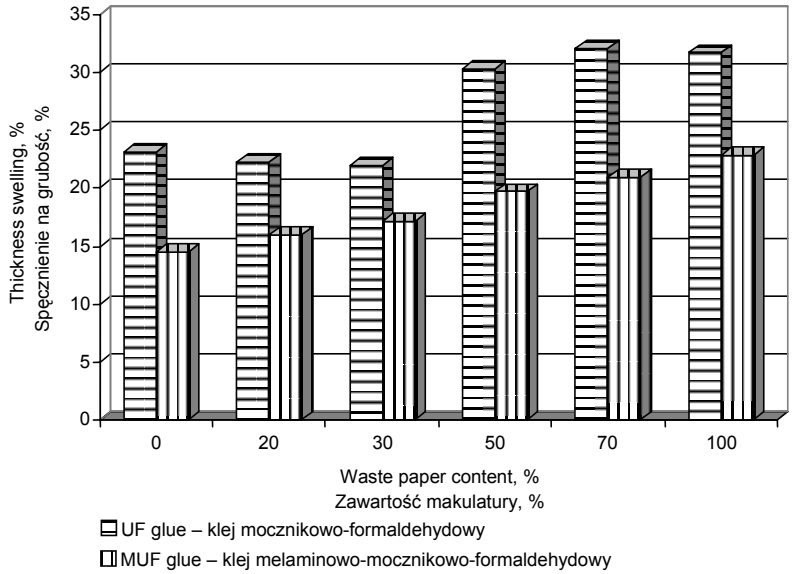

Fig. 7. Changes in the thickness swelling of boards in relationship to content of particles of mixed waste paper
Rys. 7. Zmiany spęcznienia płyt w zależności od zawartości cząstek makulatury mieszanej

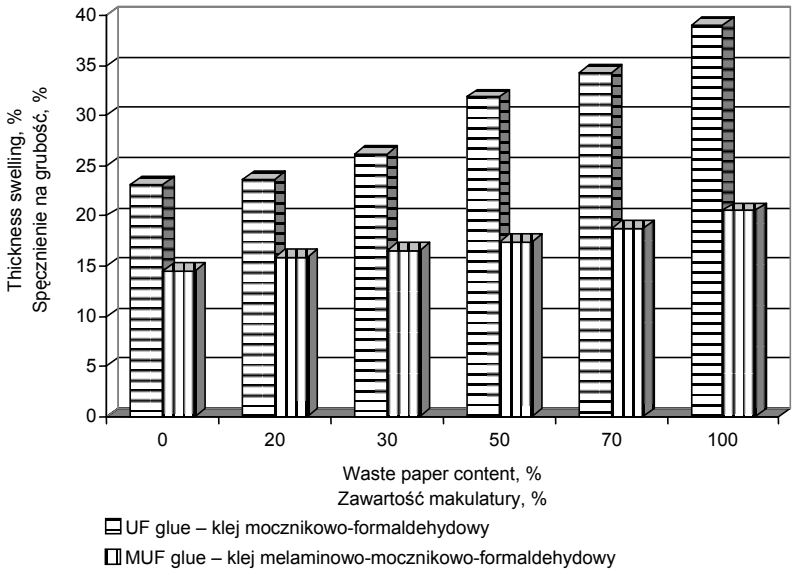

Fig. 8. Changes in the thickness swelling of boards in relationship to content of particles of waste paper bags
Rys. 8. Zmiany spęcznienia płyt w zależności od zawartości cząstek makulatury mocnej

CONCLUSIONS

1. Waste paper can be a supplementary addition in the production of particleboards.
2. Both mixed waste paper and waste paper bags can be applied to this purpose.
3. Maximum content of waste paper in boards should not exceed 50% if the MUF resin is applied to the production and 30% if boards are produced with the UF resin.
4. Waste-paper – wood-particle boards should be produced with an addition of hydrophobic agents.

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ZASTOSOWANIE MAKULATURY W PRODUKCJI PŁYT WIÓROWYCH

Streszczenie. Wytworzono jednowarstwowe płyty wiórowe z dodatkiem cząstek z makulatury. Do wytwarzania płyt użyto dwóch rodzajów makulatury (mieszaną i mocną) oraz dwóch klejów (mocznikowo-formaldehydowego – UF i melaminowo-mocznikowo-formaldehydowego – MUF). Zbadano właściwości płyt (wytrzymałość na zginanie, moduł sprężystości, wytrzymałość na rozciąganie prostopadłe do powierzchni i spęcznienie na grubość po 24 h moczenia w wodzie). Stwierdzono, że makulatura może być stosowana jako uzupełniający dodatek w produkcji płyt wiórowych. Płyty miały wystarczające właściwości, jeśli maksymalna zawartość makulatury nie przekraczała 50% (z klejem MUF) oraz 30% (z klejem UF).

Słowa kluczowe: płyty wiórowe, makulatura, recykling

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