FOREST PRODUCTS LABORATORY (Madison, Wis. 53705)
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Approved Technical Article

A Practical Method for Recycling Wax-Treated Corrugated

A method to reclaim wax-treated corrugated board using conventional equipment was developed at the Forest Products Laboratory of the Forest Service. U. S. Department of Agriculture, maintained at Madison, Wis., in cooperation with the University of Wisconsin. The following article by A. A. Mohaupt, chemical engineer, and J. W. Koning, Jr., forest products technologist, describes the method and presents test data on corrugating medium made from the reclaimed fibre and on corrugated board made from this medium.

**by A. A. Mohaupt
and
J. W. Koning, Jr.
Forest Products laboratory**

CORRUGATED board that has been coated or impregnated with wax blends has provided useful containers for many purposes. However, the wax treatments that improve container performance under humid conditions also present an obstacle to recycling.

Because wax blends are difficult to remove, virtually all used wax-treated corrugated board now is burned. buried or left to degrade at disposal sites.[1] Disposal of this material destroys a valuable resource, since most cormgated board contains good quality wood fibre that is desirable for recycling.

The use of wax-treated corrugated is increasing in the United States. Five years ago only 2 per cent of all corrugated containers contained wax.[2] Today's estimates are that wax-treated material is 6 to 7 per cent of the corrugated used and will account for as much as 10 per cent in the future. If these estimates are correct. projections of demand for paper and board[3] indicate that nearly 1 million tons of wax-treated corrugated board will be used annually in the United States.

Wax blends can be removed from waste corrugated by solvent extraction, but the necessary equipment is not available in most secondary fibre mills. Thus, we initiated a study at the Forest Products Laboratory to explore methods of removing the waxes with conventional equipment.

We found that hammermilling. disc refining. washing with hot water, and screening reduced wax content from 14 per cent to less than 1 per cent in pulp reclaimed from one lot of wax-treated corrugated container waste. Corrugating medium was made from the reclaimed fibre on a pilot plant paper machine, was subsequently converted to single-wall corrugated by bonding to commercial kraft linerboard. and was further converted into containers.

Compression test results of these containers were comparable to control containers made using commercial NSSC (neutral sulfite, semi-chemical) corrugating medium and commercial kraft linerboards. However, the combined board with reclaimed fibre medium had a lower flat crush strength. It may be possible to improve the flat crush strength with chemical additives or by blending the reclaimed fibre with virgin NSSC pulp.

Preliminary Tests

Waxes or was blends usually are the materials used to increase the moisture resistance of fibreboard. Since these wax blends generally soften at temperatures well below the boiling point of water, we first attempted to remove them with a hot water system. Tests were conducted with wax-coated and wax-saturated fibreboards containing about 14 and 55 per cent wax, respectively. Hot water alone was not adequate to remove the waxes, but hot water in conjunction with mechanical action, such as a blender, showed promise. A small hydropulper utilizing hot water was

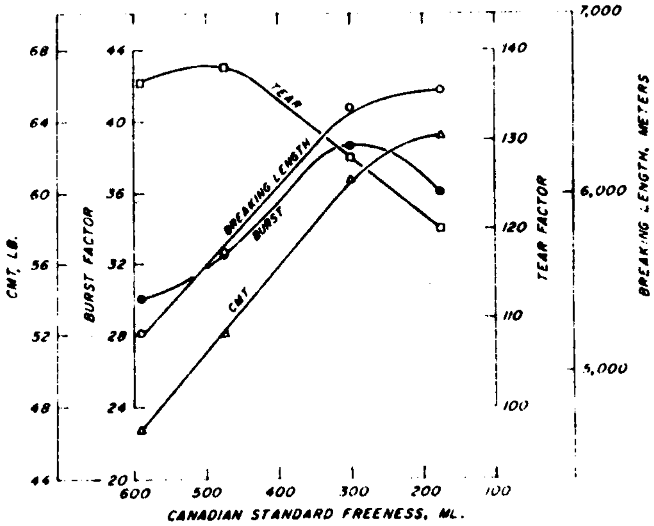


Fig. 1. Physical properties of 9-mil handsheets made from reclaimed pulp at several freeness levels.

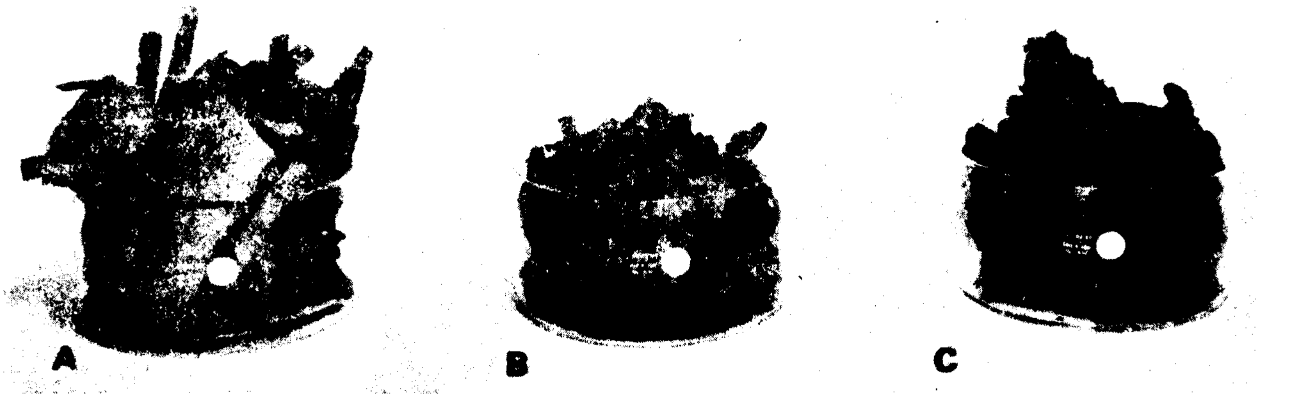
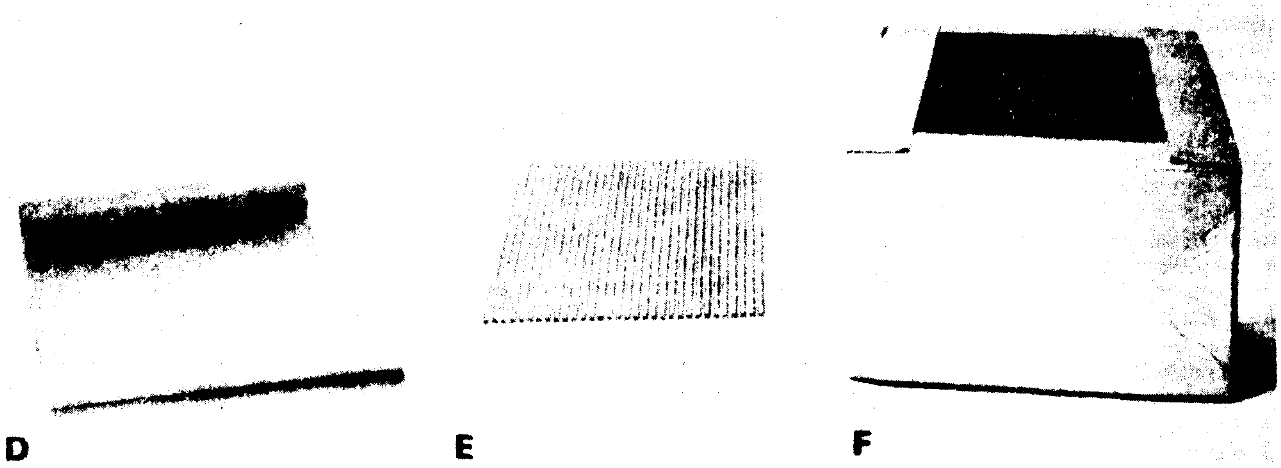


Fig. 2. Conversion of wax-treated corrugated fibreboard waste into corrugating medium: A—wax-treatedwaste, 9—hammer-milled waste. C-disc milled and washed pulp, D—fourdrinier-made corrugating medium. E—singlefaceboard showing corrugated medium. F—testcontainer utilizing corrugated medium made from reclaimed fibre.



tried, but its action was not severe enough to completely fiberize the treated board. Small pieces of board were still intact after more than 30 min. of action.

However, we did obtain good fibre dispersion by feeding small (up to 2 sq. in.) pieces of wax-treated fibreboards into a small disc mill with 190 deg. F. water. An analysis of the fibre indicated that all but about 3 per cent of the wax was removed. The fibre stock was then washed with hot water and screened, reducing the wax content to less than 1 per cent. Recovery of the wax in the effluent from the processing operations was not investigated in this study.

The pulp procured by this process from the wax-coated fibreboard had a Canadian Standard freeness of about 600 milliliters. This high freeness was attributed partially to the remaining wax coating on the fibres and partially to the loss of fines. The pulp was refined further to obtain the optimal combination of physical properties. These properties were based on the evaluation of 9-mil handsheets that were made from pulp refined to various levels of freeness. Resulting changes in the physical properties are presented in Fig. 1. From this information, we concluded that pulp from such waste for use as corrugating medium should be refined to a freeness of about 300 milliliters.

Producing Corrugating Medium

Once the general procedure had been established, 200 lb. of wax-treated corrugated waste containing about 14 per cent wax (based on dry fibre weight) were processed for a machine run to make a 26-lb. per 1,000 sq. ft. corrugating medium. The waste as received from a commercial manufacturer (Fig. 2: A) was passed over a $^{3}/_{8}$-in. mesh screen to remove dirt, small staples and other loose foreign materials. It was then hammermilled, reducing the particle size (Fig. 2: B) so that it would be processed satisfactorily in the screw feed of our 36-in. double rotating disc mill with plate clearance of 0.010 in. Water at a temperature of about 190 deg. F. (88 deg. C.) was fed into the mill and hot water showers were used around the outside of the plates.

The pulp corning from the disc mill had a wax content of approximately 3 per cent. A sidehill screen with 75-mesh wire was constructed under the mill so that the fibre was separated from the effluent containing the major portion of the wax. Further washing and screening with hot water reduced the wax content in the pulp to less than 1 per cent. The pulp was then refined to Canadian Standard freeness of 300 milliliters.

No difficulties were encountered in making corrugating medium (Fig. 2: D) from this furnish (Fig. 2: C) on a 13-in. fourdrinier paper machine. Results of tests comparing the experimental corrugating medium made from the wax-treated waste and a commercial corrugating medium made from substantially NSSC pulp as a control are summarized in Table 1. A hot solvent extraction with the experimental medium showed that the residual wax content was about 0.5 per cent.

Although the CMT strength was

Property (TAPPI Standards tests)	Corrugating medium	
	NSSC control	Wax-treated waste
Weight (lb./1,000 sq. ft.)	26.4	26.0
Thickness (in.)	0.0098	0.0092
Apparent density (g./cc.)	0.52	0.55
CMT (lb.)	67.4	55.0
Burst (pt.)	32	39
Tear (g.)	86	122
Folds (MIT)	24	95
Ring crush: MD* (lb.)	72.3	52.1
CD* (lb.)	48.9	36.4
Tension**		
Stress: MD (psi.)	5,440	4,460
CD (psi.)	1 970	1,960
Modulus of elasticity: MD (psi.)	884,000	645,000
CD (psi.)	276,000	227,000
Strain-to-failure: MD (pct.)	0.91	1.49
CD (pct.)	1.90	4.27

*MD: machine direction; CD: cross machine direction.
**Test developed at Forest Products Laboratory.

Table 1. Properties of corrugating mediums made from NSSC (control) and wax-treated waste board.

Property	Corrugated fibreboard	
	NSSC medium	Experimental medium
Singleface thickness (in.)	0.195	0.200
Flat crush (psi.)	29.4	17.6
Box compression:		
Strength (lb.)	922	882
Coefficient of variation (pct.)	5.24	5.58
Deflection (in.)	0.74	0.57
Moisture content (pct.)*	7.8	8.0

*Moisture content based on ovendry weight.

Table 2. Properties of corrugated fibreboard made with NSSC (control) and experimental corrugating mediums.

lower for the experimental medium than for the NSSC control medium, it still fell within the range of values obtained for commercial mediums.[5] Burst, tear and fold values for the experimental medium were greater than those obtained with the NSSC control.

Converting

Following the successful manufacture of corrugating medium on the paper machine, the material was evaluated on a pilot plant singlefacer for runability in terms of flute fracture and high-low flute characteristics. During the flute fracture portion of the runability operation the experimental medium was corrupted, but it was not glued to a linerboard. It was run at a speed of more than 900 ft. per min. without fracturing when minimum tension was applied to the web.

The high-low characteristics, or the average difference between adjacent flute heights, were determined by dial gauge measurements of more than 200 adjacent flutes on single-face board. The experimental medium averaged 0.8 mil between flute heights, whereas the NSSC control medium averaged 1.6 mil. indicating better flute uniformity for the experimental medium.

The experimental medium was bonded successfully to a nominal 42-lb. linerboard at a speed of 200 ft. per min. with commercial starch adhesive, full wrap on the corrugating medium preheater, one-half wrap on the linerboard preheater, 12 psig. steam to the medium presteamer, and 245 lb. per in. of width of roll pressure (Fig. 2: E). At a speed of 280 ft. per min. the bond was not adequate. However, when the linerboard wrap was increased from one half to full on the preheater and the roll pressures increased to 335 lb. per in. of width, a satisfactory bond was obtained at 500 ft. per min. No difficulties were encountered in doublebacking the singleface material using a pilot plant doublebacker.

A control board was also made using commercial NSSC corrugating medium and the same 42 lb. linerboard used to face the experimental corrugating medium.

The average top-to-bottom compressive strength was determined for 10 boxes $18\frac{9}{16}$ x $12\frac{3}{8}$ x 8 in. with 2-in. flaps (Fig. 2: F) using TAPPI Standard T 804, and the test results are presented in Table 2. The boxes were made with 2-in. flaps because of the limited width of the experimental corrugating medium. The compressive strength of the experimental corrugated fibreboard boxes was only 4 per cent lower than the compressive strength of the control corrugated boxes. A statistical analysis of the data showed that the difference in results was not significant at the 5 per cent level.

The flat crush strength of the combined boards was determined according to TAPPI Standard T 808, and the results are given in Table 2. The flat crush strength for the experimental board was approximately 60 per cent as strong as the control board (17.6 versus 29.4 lb.). However, this was improved to 72 per cent (21.2 versiis 29.4 lb.) by running the singlefacer at high roll pressures, full wrap on the linerboard preheater, and 300 plus ft. per min. Two possible ways to further improve the flat crush strength would be to blend the reclaimed fibre with virgin NSSC stock or to add a strengthening agent, such as starch or gum, to the reclaimed fibre.

Conclusions

Results of this study indicate that presently used wax blends found in treated corrugated board can be removed with existing mill equipment. The reclaimed fibre has a potential use in the corrugating medium. Because the flat crush strength of the corrugated board made with a corrugating medium containing 100 per cent of the reclaimed fibre was lower than that considered necessary for some applications, it is recommended that the reclaimed fibre be blended with other fibre stock. ■

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