Repulping of Foil Decorated Paper

A Study Conducted by Georgia Tech's Renewable Bioproducts Institute and Commissioned by the Foil & Specialty Effects Association

A Message from the Foil & Specialty Effects Association

Executive Director Jeff Peterson

The Foil & Specialty Effects Association (FSEA) acknowledges the existence of misconceptions on sustainability issues as they pertain to the recyclability of metallic decorated paper and board. The association has been proactive in working to separate the decorated products that FSEA members provide (produced via hot foil, cold foil and digital foil transfer processes, as well as transfer metallization of board or paper), from the use of foil laminated paper and board, which can be a more difficult product to recycle or repulp.

FSEA has taken a strong position as to the recyclability of foil decorated paper and board. Ten years ago, the association published a study on the Recyclability and Repulpability of Foil Decorated Paper/Board in partnership with Pira International, a third-party research firm located in the United Kingdom. "The main conclusion," said the Pira International study, "is that both the hot and cold foil decorated samples tested in this work would cause no problems in repulping."

In 2020, as sustainability issues come to the forefront of the print decorating industry, the association commissioned a second study to be undertaken by the Georgia Tech Renewable Bioproducts Institute. The following study also demonstrates that foil decorated paper and board do not create problems in the recyclability/repulpability of paper and/or board in a common repulping process.

Repulping of Foil Decorated Paper

By Rallming Yang, Ph.D., Research Scientist II, Manager: Pulping and Chemical Analysis Lab
Renewable Bioproducts Institute

Study scope

A sample quantity of Coated-One-Side (C1S) 12 pt. card stock foil stamped with a gold metallic foil was supplied by the Foil & Specialty Effects Association (FSEA). Samples were supplied with different levels of foil coverage from 50% up to 100% coverage on each sheet. The foil stamped samples were sent to be evaluated for the feasibility of repulping. The received paper materials were repulped under the simulated industrial conditions. Rejects and screen yield were determined. Aluminum contents in starting paper materials and the accept fibers were assessed using inductively coupled plasma optical emission spectrometry (ICP-OES). Fiber morphology (fiber length, fines content, curl, kink and fiber width) was evaluated using a Fiber Quality Analyzer (FQA). Physical properties of the accept fibers also were accessed by the measurement of Canadian Standard Freeness (CSF), tensile strength, burst strength and tear strength. Results indicated that the repulping achieved 75% screened yield with 0.1% rejects. Aluminum content of accept fibers was 0.11 g /Kg, reducing from 1.06 g/Kg in the starting paper. Average fiber length (Arithmetic) was determined to be 0.937 mm. Physical strength properties generally were compactable with those of the recycled pulp fibers. It thus demonstrated that the decorative paper was feasible for recycling.

It was feasible to repulp the metallic foil decorated papers as it is done in common recycling settings.

Experimental

1. Repulping

200 g oven dry foil decorative papers were torn into 1x1 inch pieces and weighted into a plastic beaker. 1000 ml water was used to soak the torn paper material for 10 minutes. At the same time, temperature of a benchtop repulper was adjusted to 60 °C. After the paper was transferred into the repulper, additional water was added so that the final pulp slurry consistency was 5%. Sodium hydroxide and sodium silicate at 0.6% and 1.8% dosages were added and the mixture pH reached to 10.4. Repulping was running for 35 minutes at 555 rpm repulper speed. By the end of repulping, 1/4 of the repulped slurry was screened in a Somerville screen for 25 minutes.

Table 1. Repulping conditions

Exp #	Procedure	Rep. Aid	pH	Temp (deg C)
1	Bench Repulper	0.6% NaOH+1.8% sodium silicate	10.4	60
2	Bench Repulper	0.6% NaOH+1.8% sodium silicate	10.4	60

Other conditions: 5% repulping consistency, 4L total volume of slurry, 555 rpm repulper speed, 35 minutes repulping time.

2. Ashing

Ash content was measured by combustion of the sample in a furnace at 525 °C following Tappi standard T 211.

3. ICP analysis

Sample was converted into ash, shown in 2. The ash was leached with mixed acids (nitic acid, sulfuric acid and hydrochloric acid). Metallic materials were solubilized into the mixture. Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES Analysis) was used to determine aluminum content.

4. Canadian Standard Freeness

CSF was measured by following Tappi Standard T227 Freeness of Pulp.

5. Hand sheet forming

For each pulp stock prepared in 2, six hand sheets were formed following Tappi standard Tappi T-205.

6. Hand sheets test

The formed hand sheets were tested for physical strengths of tensile, tearing and burst in accordance with the corresponding Tappi standards.

7. Fiber morphology

Fiber morphology was evaluated using a Fiber Quality Analyzer.

Results

1. Paper composition evaluation

Because the decorative foil stamped areas on the paper stock were not uniformly distributed on the paper surface, it is difficult to sample the material for composition determination in a homogenous way. As a result, the mass balance determination of the starting paper sample was conducted as following: 200 g oven dry paper materials were repulping to yield a fiber slurry. After the total mass of the slurry was determined, a representative portion of the slurry was taken. Organics and inorganics were determined by ashing. The aluminum content in the starting paper sample was determined after acid leaching of the ash. Table 2 tabulated the composition of the materials.

Table 2. Composition of decorative paper

Test item	Value
Organics, %	85.7
Inorganics, %	14.3
Aluminum, g/kg paper	1.06

The organics in the paper sample include fibers, fines, coating materials and additives. The inorganics include fillers, coating materials and the decorative metallic foil. Data indicate that over 85.7% of the materials are organics; inorganics account for 14.3% of paper materials. Among those, aluminum content is 1.06 g/kg, roughly about 0.1% of the paper materials.

2. Repulping

Table 3 listed the repulping results of the duplicate runs. pH of the slurry after the additions of chemicals was about 10.4, and the value changed little during the entire repulping period.

Table 3. Repulping of Kleenex paper towel

Experiment	Initial pH	End pH	Energy input kwh	Screen yield %	Rejects %
Run 1	10.4	10.4	0.227	75.48	0.05
Run 2	10.4	10.4	0.227	75.20	0.07
Average	10.4	10.4	0.227	75.34	0.06

The duplicate runs of repulping produced identical screen yield at around 75%. The rejects are less than 0.1%. Comparing data in Table 2 and Table 3, it is clear that significant portion of the organics in the starting paper sample were washed away during the screening. The lost portion of organics may include fines and coating substances. The rejects collected from screening are mainly polymers that may be the components of the coatings.

3. The fate of aluminum

The main challenge in the recycle of the foil stamped decorative paper is to remove the aluminum foil so that the metal will not affect the paper properties of the reclaimed fibers. To determine the fate of the aluminum during the repulping, content of the metal in accepted fibers and in the filtrate was determined. Table 4 listed the analyzed results.

Table 4. Aluminum content in accept fibers and filtrate

Matrix	Aluminum
Accepted fibers, g/kg fiber	0.11
Filtrate, g/kg solids	5.65

It is obvious that the majority of aluminum was turned into fine particles and stayed in filtrate during repulping. The particles can be washed away from the fibers during the screening process.

4. Properties of reclaimed fibers

The properties of reclaimed fibers were accessed in terms of fiber morphology, freeness and physical strength properties.

Table 5 tabulated FQA analysis results. The morphology data generally are comparable with those of the typical softwood pulp fibers. The average fiber length is 0.937 mm.

Table 5. Fiber quality

Test	Percentage fines, %		Mean Length, mm			Mean Curl		Mean kink, 1/mm			Fiber Wid. µm
	Arith.	L.W	Arith	L.W	W. W	Arith.	L.W	Kink index	Kink angle	Kink	
1	2.40	0.20	0.939	1.415	2.090	0.16	0.17	2.18	44.31	1.02	20
2	2.60	0.20	0.934	1.395	2.043	0.16	0.17	2.19	44.04	1.01	20
Aver.	2.50	0.20	0.937	1.405	2.067	0.16	0.17	2.18	44.17	1.02	20

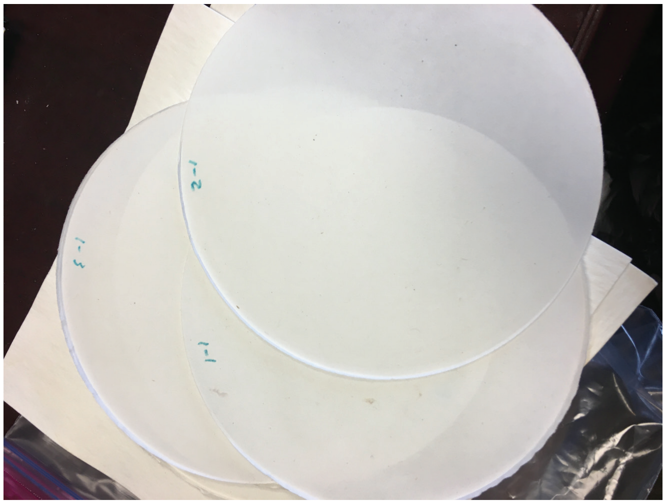

Image 1. Hand sheets from reclaimed decorative papers.

The freeness of the pulp fibers is determined to be 680 ml, at the high level of the recycled pulp fibers. The low content in fines also may have contributed to the high freeness value.

The reclaimed fibers were prepared into hand sheets for physical strength tests. Image 1 displayed the hand sheets that were used for the tests. Table 6 listed the physical test results. As indicated, the physical strengths of the reclaimed fibers generally are compactable with those of the reference recycled fibers from paper towel. The slight low in burst strength and tear strength can be attributed to the high freeness of the reclaimed fibers.

…aluminum content was reduced from 1.06g/kg in the starting paper to 0.11 g/kg in the reclaimed fibers.

Table 6. Physical strength properties of the reclaimed fibers.

Tests	CSF, ml	Tensile strength kN/m	Tensile index N m/g	Burst Strength kPa	Burst index kPa m²/g	Tear strength mN	Tear Index mN m²/g
Value	650	1.41	21.22	70.69	1.06	382.1	5.73
Reference[1]	580	1.28	19.66	85.71	1.32	445.9	6.87

1. Reference pulp is reclaimed from a paper towel sample.

Conclusion

1. The foil stamped paper stock could be repulped to yield 75% fibers with very low rejects.
2. The aluminum in the foil stamped papers could be broken down to small particles and were removed from fibers during screening. As a result, aluminum content was reduced from 1.06g/kg in the starting paper to 0.11 g/kg in the reclaimed fibers.
3. The average fiber length of the reclaimed fibers was 0.937, which was typical value for the softwood pulp fibers.
4. The hand sheet prepared from the reclaimed fibers demonstrated similar physical strengths to the recycled paper towel fibers.
5. It was feasible to repulp the metallic foil decorated papers as it is done in common recycling settings. ◆

Rallming Yang, Ph.D. is the manager of the Pulping and Chemical Analysis Lab at Georgia Tech's Renewable Bioproducts Institute. In May 2000, Dr. Yang earned his doctorate degree in environmental and resource engineering from the college of environmental science and forestry, State University of New York. He also held M.S. degree and B.Sc. degree in pulping and paper. With strong educational background in wood chemistry, coupled with the acquired skills and experience in chemical analysis, Dr. Yang's main area of interest is utilizations of natural resources, especially biomass, in a sustainable way.