Original Research Article

Copy Paper from Recycled Egg Cartons – A 12-inch Paper Machine Development Study

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ABSTRACT

The presented research project describes the development of a copy paper product from recycled egg carton fiber material. The development included laboratory handsheet development and machine-made paper product produced on a 12-inch (304 mm) wide laboratory Fourdrinier paper machine which was operated at a speed of 6.4 ft/min (1.95 m/min).

The final machine-made paper had a recycled egg carton fiber content of 70% and 30% northern bleached softwood Kraft fiber as reinforcement fiber material to avoid sheet breaks and produce a continuous paper sheet with the laboratory Fourdrinier paper machine. The produced machine-made paper appeared to be visibly brighter to the eye with the addition of the northern bleached softwood Kraft pulp compared to paper without softwood fibers. Printing tests using a office type laser printer showed good results.

The produced machine-made paper had a basis weight of 81 g/m² and a solids content of 99.27%. After conditioning at a temperature of 23°C ± 1°C and a humidity of 50% the basis weight increased to 92.13 g/m², with a caliper of 186 µm. The tensile index and tear index was 93.20 Nm/g and 9.78 mN/gm² respectively, opacity measured 96.52%, and brightness measured at 37.09%.

It seems that REC pulp fiber material can absorbs more moisture during conditioning which leads to increased basis weight and thickness due to swelling of the fiber material.

Keywords: Copy paper, egg carton, paper, papermaking, paper machine, recycling

1. INTRODUCTION

When paper was invented by Cai Lun in ancient China during the Eastern Han dynasty (105 CE) [1-3], paper was made by hand from bamboo fibers. Today large paper machines which produce paper on a continuous basis. These machines are technological marvels with a length of over 600 m, producing a paper sheet that is over 11.5 meters wide at a speed at over 2000m/min., and with a daily production rate of over 4,500 metric tons [4,5].

Today, rising raw material, energy, water and additive cost increase production cost for paper and board products. In addition, tighter environmental regulations demand new solution of utilizing raw materials, reduction of energy consumption, and improvements to the production process itself, leading to a leaner paper production as well as increased sustainability, biodegradability and eco-efficiency by implementing new bio-based and recycled products in the manufacturing process [2,6].

Paper manufacturers are looking to produce paper products more sustainable and eco-efficient by adding sustainable additives, recycled fiber or partially sustainable fibers like straw and willow to produce sustainable and eco-friendly products [7-9]. However, the production process of fibers, regardless of if softwood (needle tree fibers) or hardwood (leaf

tree fibers) is the same. The most dominant commercial chemical extraction process for the cellulosic fiber material that used worldwide today is called Kraft pulping process and was invented by a German Scientist Carl Friedrich Dahl in 1879 and was used in 1895 in Sweden the first time [10-12].
Implementing recycled fiber materials do not need a chemical pulping process and recycled fiber materials have a more favorable environmental footprint.
One of these recycled aper containing materials are egg cartons. Recycled Egg Carton (REC) are produced from roadside recycled paper products. The recycled paper product is disintegrated and processed through a variety of processed to remove the unwanted components such as ink, sand, dirt, and unwanted organic components. The produced fiber slurry is den moulded into the distinctive egg carton shape. A drying process finalizes the shape and kills any bacteria that may have survived the production process [13].
The following manuscript describes the development and manufacturing of a copy like paper product from REC material at the State University of New York (SUNY), College of Environmental Science and Forestry (ESF), Chemical Engineering Departments Paper Engineering Program. The development included laboratory bench scale development and testing, and upscaling to a 12-inch (304 mm) wide laboratory paper machine.

http://www.eggpac.com/egg-packaging.html

2. MATERIALS AND METHODS

The following materials and methods were used for the egg carton copy paper grade development.
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2.1. Materials Used

For the development of a copy paper 60 lbs. (10.3 kg) Recycled Egg Carton (REG) were collected from households in the Syracuse, New York area was used as the selected fiber material.
Northern bleached softwood pulp with an 80% Black Spruce and 20% Jack Pine mixtures, having a ISO Brightness of 89.5% and an average fiber length of 2.26 mm, was used as a supplemental fiber material.
Unmodified corn starch was used as retention, sizing and strengthening agent [14,15].

2.2. Testing Methods

For this research project the following testing methods of the Technical Association of the Pulp and Paper Industry (TAPPI) and International Organization for Standardization (ISO) were used:
Beating of pulp (Valley beater method) in accordance to T 200 sp-06 “Laboratory beating of pulp (Valley beater method)” [16].
Handsheets were prepared according to TAPPI T 205 sp-12, “Forming handsheets for physical tests of pulp” [17]. Physical testing of handsheets was performed in accordance with T 220 sp-06, “Physical testing of pulp handsheets” [18]. Freeness of pulp was measured as Canadian Standard Freeness (CSF) according to TAPPI T 227 om-09 “Freeness of pulp (Canadian standard method)” [19]. Consistency of the pulp suspensions was measured with TAPPI T 240 om-07 “Consistency (concentration) of pulp suspensions” [20].
Conditioning of the paper samples was done according to T 402 sp-08, “Standard conditioning and testing atmospheres for paper, board, pulp handsheets, and related products” [21].

Basis weight was measured with TAPPI T 410 om-08. “Grammage of Paper and Paperboard (weight per unit area)” [22]. Thickness of the paper was measured with TAPPI T 411 om-10. “Thickness (caliper) of paper, paperboard, and combined board” [23].
Moisture content of pulp was determined by T412 om-06 “Moisture in pulp, paper and paperboard” [24].
The tear strength was done by following the T 414 om-12, “Internal tearing resistance of paper (Elmendorf-type method)” [25].
Tensile strength was evaluated using TAPPI method T 494 om-06 Tensile properties of paper and paperboard (using constant rate of elongation apparatus) [26].
Brightness was measured according to ISO 2470 “Paper, board and pulps - Measurement of diffuse blue reflectance factor – Part 1: Indoor daylight conditions (ISO Brightness) [27]. Opacity was determined according to ISO 2471:2008 Paper and Board: Determination of Opacity (Paper Backing) – Diffuse Reflectance Method [28].
Dryer can temperature of the 12-inch paper machine was controlled with build in temperature controllers.

2.3. Starch Preparation

Unmodified corn starch powder was prepared as sizing and retention agent using an automated jet cooking apparatus, which cooked the starch solution at 3.5% between 95°C and 98°C (203°F and 208°F) for ten minutes. After cooking the starch solution was diluted to a consistency of 3.0 % using deionized water at 20°C to eliminate bacterial growth. The resulting 9.6 gal (36.3 l) of 0.1 % starch solution was filled in to 5 gal pails and stored in a cold room at 41°F (5°C).

3. RESULTS AND DISCUSSION

All tests for this research and development project were performed in accordance to the in Section 2.2. referenced TAPPI and ISO methods. All results stayed in the precision statements for the referenced TAPPI and ISO methods.

3.1. Handsheet Development

The REC from household collections was torn in small pieces of an approximate size of between 1-ich and 2-inch (25 mm to 50 mm) square size and

3.1.1. Recycled Egg Carton Pulp Refining for Papermaking

Fibers used for papermaking might be refined to provide paper properties (strength) needed for the produced paper product. Laboratory refining for the handsheet development was done according to TAPPI T 200 sp-06 method [16] Based on past 12-inch Laboratory Fourdrinier Paper Machine (LFPM) data, it is suggested that the lowest freeness typically ran on the laboratory paper machine is in the 300 ml to 400 ml CSF area. No date on refining REC pulp is available, therefore, it was determined to develop a that the refining curve, shown in Figure 1., using a Valley beater as described in the T200 sp-06 testing method [16].
The developed refining curve shows that the starting freeness of the dispersed REC pulp suspension is 348.3 ml without any refining. With increased refining the lowest CSF value of 31 ml is reached after 60 minutes. After 80 minutes of refining the CSF value increased to 291.6 ml. This suggested that for the handsheet making and laboratory scale paper production on the LFPM only a good, dispersed pulp is used without applying refining to stay above the 300 ml CSF value. Any refining would decrease the CSF value and cause drainage issues on the LFPM fourdrinier section. In addition, refining would increase fines content and fiber shortening which would have a negative effect on paper properties. However, tensile strength could be increased with refining (decreased CSF value) [11].

Fig. 1. Refining Curve of Recycled Egg Carton Fiber Material

3.1.2 Handsheet Making from Recycled Egg Carton Pulp

Handsheet forming was done according to TAPPI method T-205 sp-12 [17] with a variation that matched the unique REC copy paper process. In the T 205 method the handsheet basis weight is 60 g/m², requiring a OD fiber weight in the fiber suspension used to make the handsheet of 1.2 g. The REC copy paper required a higher basis weight, therefore handsheets were made with 1.6 g of OD fibers in the suspension representing a basis weight of 80 g/m² were made to represent the target grammage for the later 12-inch LFPM production run.

The pulp for handsheet making was produced by tearing the REC into square pieces of approximately 1-inch (25 mm x 25 mm) followed by soaking in tap water with a temperature of 68°F (20°C) for 4 hours, followed by beating according to TAPPI method T 200 sp-06 [16].

3.1 Hansheet Properties made from Recycled Egg Carton

Table 1. shows the paper properties selected for the REC copy paper. Handsheets for the REC copy paper development was produced with basis weight of 60 g/m² and 80 g/m² according to TAPPI standard T205 sp-06 [17].

Paper testing was performed as required by TAPPI T 402 sp-08 [21] at a temperature of 23°C ± 1°C and a humidity of 50% ± 2%.

The handsheet basis weight achieved for the 60 g/m² and 80 g/m² targeted basis weight was measured with the TAPPI T 410 om-08 method [22] and. Handsheets had a basis weight of 58.72 g/m² and 79.60 g/m² respectively.

The thicknees of the manufactured REC handsheets was measured with TAPPI method T 411 om-10 [23]. The thickness was 139.40 µm for the 60 g/m² and 183.90 µm for the 80 g/m² targeted bases weight.

The tensile index and tear index according to TAPPI method T 414 om-12 [25] and T 494 om-06 [26] resulted in a tensile and tear index of 17.44 Nm/g and 7.82 mN/gm² for the 60 g/m² and 18.14 Nm/g and 8.48 mN/gm² for the 80 g/m² REC handsheets respectively.

Opacity and brightness values for the handsheets, meassured according to ISO 2470 [27] and ISO 2471:2008 [28] method, resulted in a opacity and brightness of 99.54% and 38.32% and 99.70% and 39.35% for the 60 g/m² and 80 g/m² respectively.

Table 1. Recycled Egg Carton Handsheet Properties

Measurement	Value	
Target Basis weight OD [g/m²]	**60**	**80**
Basis weight Cond [g/m²]	58.72	79.60
Thickness [µm]	139.40	183.90
Tensile Index [Nm/g]	17.44	18.14
Tear Index [mN/gm²]	7.82	8.48
Opacity [%]	99.54	99.70
Brightness [%]	38.32	39.35

According to these results the target basis weights were reached for both the 60 g/m² and 80 g/m² handsheets. It is observed that the measured mechanical paper properties increased with higher basis weight due to the increased fiber content and increased interfiber bonding of the fibers. The measured optical properties (opacity and brightness) were nearly the same. However, the measured thickness is above conventional copy paper thickness of approximately 100 µm, because TAPPI handsheet making does not allow a

pressing/compressing. This meant that for the LFPM production run calandering would be necessary.
The gray-isch color of the handsheets resulted also detracts from the brightness of the paper at about 40%. This issue could be improved by adding some bleached virgin fiber pulp to the paper, brightening agents, or by removing inks and dyes prior to papermaking using flotation/deinking and bleaching processes. However, the later was out of the scope of this project due to the availability of suitable laboratory scale processes for deinking and bleaching.

3.2. Laboratory Fourdrinier Paper Machine Run

For upscaling the laboratory straw art paper handsheets into a continuous production scale a 12-inch (304 mm) wide Laboratory Fourdrinier Paper Machine (LFPM) located at the pilot plant of the Chemical Engineering Department at SUNY-ESF is used. The description of the paper production system follows to produce from previous publications from Dölle & Rainville [29], with the set-up of the LFPM system described as follow:

3.2.1. Stock Preparation of Recycled Egg Carton

For the stock preparation of the REC material a system arrangement, as shown in Figure 2. was used.
A total of 50.0 lbs. (22.67 kg) OD REC was pulped in the 35 gal (132.5 l) low consistency laboratory pulper for 15 minutes at 20°C in five batches at 5% consistency using 10.0 lbs. (4.54 kg) of the REC material and 22.8 gal (86.26 l) of water. Each pulping batch of 23.98 gal. (90.8 l) took approximately 30 minutes to complete.
After each pulping batch the 5% REC suspension was pumped with a 3 hp (2.24 kW) transfer pump into two 240 gal. (908.5 l) storage chests, that is agitated each with a 1.5 hp (1.12 kW) propeller agitator. The storage chests were filled equally each with 59.97 gal. (227 l) of the 5% REC suspension After pulping the 5% REC suspension in the storage chests was diluted to a refining suspension of 3 % by adding 39.85 gal. (150.83 l) of water. This resulted in 99.8 gal (377.8 l) of REC pulp suspension in both storage chests available for refining. After dilution a CSF measurement, according to T 227 om-09 [27] of the REC pulp suspension was taken. The resulting CSF was 205 ml. It was decided to not perform a refining step with the 10 hp (7.46 kW) low consistency conical Jordan refiner, because a lower freeness level of the REC pulp suspension will have a significantly impact on the dewatering process during papermaking on the LFPM fourdrinier section. Normally a CSF value of 300 ml is targeted for paper making operation at the LFPM to achieve optimum dewatering and sheet forming. After the CSF measurement the REC pulp suspension in both storage chests was diluted to a machine chest consistency of 1.5% by adding 99.8 gal (377.8 l) of water at 20°C to the REC pulp suspension. This resulted in 199.7 gal (756.6 l) of REC pulp suspension in both storage chests available for paper production.

Fig. 2. Laboratory stock preparation system [29].

3.2.2. 12-inch Laboratory Fourdrinier Paper Machine Run

For upscaling the REC handsheet study to continuous machine-made REC copy paper product a 12-inch LFPM system was used that is comprised of (i) the LFPM wet End system shown in Figure 4., and (ii) the LFPM itself shown on Figure 5., for producing the REC copy paper product.
The LFPM features a 70 inch (1778 mm) long Fourdrinier section followed by a 2-nip press section. After the press section, there is a dryer section with a Yankee dryer (J1), followed by a 1st and 2nd dryer section with 10 (D1-D10) and 8 (D12-D18) electric heated dryer drums. Each dryer drum can be heated to up to 343°C (650°F). Between the 1st and 2nd dryer section a size press is located. A 6-roll vertical calendar stack, of which on roll (C2) can be heated is located after the dryer section followed by the reel. The LFPM wet end has an total

installed electrical power of 4 hp (3.0 kW) and the LFPM has a total installed power of 30 hp (22.5 kW). The LFPM can produce a finished paper product with a basis weight between 20 g/m² and 750 g/m² at a speed of up to 8.0 m/min.

The wet end of the LFPM, as shown in Fig. 4. consists of the two storage chests that serve as the LFPM machine chests with a usable volume of 240 gal. (908.5 l) each. The storage chests have been used during stock preparation and hold the produced 199.7 gal (756.6 l) of REC pulp suspension at a consistency of 1.5%. The REC pulp suspension is agitated continuously in each chest with a 1.5 hp (1.12 kW) propeller agitator. Additives can be added at the machine chest as needed. For the REC copy paper production, no additives were added to the machine chests prior to papermaking. Based on previous experience the REC pulp fiber slurry should be sufficient to operate the LFPM for up to 6 hours, allowing all necessary operational adjustments till the desired REC copy paper specifications are met.

Prior to the LFPM run, 4 lbs. (1.81 kg) of oven dry unmodified corn starch were prepared as described in Section 2.3, using a jet cooking apparatus. During the LFPM run the 3.0 % starch solution was added with a peristaltic pump first to the LFPM size press and later as mass sizing to the mixing chest for surface sizing and retention aid.

No additional chemicals were added to the REC paper pulp suspension during the LFPM run.

After all preparations were made, the final production run of the LFPM paper machine was executed.

The LFPM was started up and the REC pulp suspension at a headbox consistency of 1.0% was sent to the paper machine. However, it was not possible to get a sheet formed that made it through the press section. The formed paper sheet broke continuously after the wet end section. In addition the stock seem to clogging the delivery lines in the stock delivering system.

It was decided that the REC pulp suspension is to weak to form a aper sheet ant the LFPM and a reinforcement pulp is needed. It was decided to use northern bleached softwood pulp as the reinforcement pulp, because it was available and in the storage. From the original prepared REC pulp 25% of the volume had already been used. Based on prior operation al experience of the LFPM it was decided to add the softwood pulp at a ratio of 70/30. Therefore 8.5 lbs. (3.85 kg) OD of northern softwood was pulp in the 35-gal (132.5 l) low consistency laboratory pulper for 15 minutes at 20°C at 5% consistency using 8.5 lbs. (3.85 kg) OD and 19.4 gal. (73.15 l) of water. After pulping the northern bleaches softwood pulp was diluted to 3% consistency in the pulper by adding gal. (l) of water. The 3% NBSK pulp suspension had a final volume of gal. (128.3 l) in the low consistency pulper. The NBSK pulp suspension was then transferred in the 240 gal. (908.5 l) storage chest empty storage chest with a 3 hp (2.24 kW) transfer pump for refining.

The NBSK pulp slurry was then refined from a 700 ml CSF value to 500 ml with the 10 hp (7.46 kW) low consistency conical Jorda under a 1.5 Amp net load and 19.5 minutes total refining time. The CSF value was carefully monitored according to TAPPI test method T 227 om-09 [19]. After refining the NBSK fiber slurry was diluted to a machine chest consistency of 1.5% by adding 84.7 gal. (320.0 l) of water at 20°C. This resulted in 68.3 gal (256.6.0 l) of NBSK pulp fiber mixture ready to be mixed with the remaining REC pulp suspension.

159.2 gal. (l) of REC pulp suspension from the 2nd machine chest were pumped into the 1st machine chest that contains the NBSK pulp suspension to achieve a 70/30 split of REC/NBSK pulp. The final volume available for papermaking was 227.5 gal. (855.3.0 l) containing 28.32 lbs. (12.83 kg) of REC and NBSK pulp fiber mixture, enough to run the LFPM for 4.5 hours.

The LFPM was started up again. With the new REC/NBSK pulp mixture no sheet breaks occurred after the forming section. After LFPM ran satisfactory and a 79 g/m² basis weight was reached the size press operation was added by supplying the prepared starch solution for surface sizing with the prepared 3% starch suspension. Basis weight measurements increased to 81 g/m² indicated that the basis weight increased by 2.53%.

After all operational parameters were satisfactory a snapshot was conducted to analyses the moisture profile of the LFPM. The LFPM operational parameters for the snapshot were as follows:

a) 6.4 ft/min (1.95 m/min) was the operational speed of the LFPM for the REC/NBSK copy paper production run.

b) Vacuum levels for the fourdrinier table were set at 0 for the 1^{st}, 27579 Pa for the second vacuum section, 0 for the 3^{rd} to 6^{th}, 13789 Pa for the 7^{th}, 27579 Pa for the 8^{th}, 48263 Pa for the 9^{th}, and 0 for the 10^{th} vacuum section.

c) The final fiber flow to the headbox at a consistency of 1% was set at approximately 1.27 gal/min (4.75 l/min) to achieve the desired basis weight of 80 g/m² for the REC copy paper product. The

d) The 1^{st} and 2^{nd} press was operated at 30 psi (20,6842 Pa) and 40 psi (27,579 Pa) for all adjustment of the art grade.

e) the heat for the three electrical heated dryer sections was set for the Yankee-Dryer (J1) and each dryer can pair by an electronic heating module to: (i) 160.0°C (425°F) for the Yankee-Dryer (J1), (ii) dryers in dryer section 2 were heated at 165.6°C (524°F) for the 1^{st} to the 10^{th} dryer (D1-D10), (iii) dryers in dryer section 3 were kept at 15.0°C (410°F). For the 10^{1h} and 12^{th} (D11 &D12) dryer, 182.2°C (425°F) for the 13^{th} to the 16^{th} (D13 to D16) dryer, and at 182.2°C (425°F) for dryers 18^{th} and 19^{th} (D18 & D19), the heat was set to 182.2°C (430°F).

f) The calendar section operated without pressure and heat at first and then was set to an operational pressure of 20 psi (275,790 Pa) using 2 nips.

g) After the calendaring section the REC copy paper was rolled up and the paper rolls were conditioned according to TAPPI Test method T402 before cut in size for testing and print evaluation.

The moisture and associated solids profile in % is shown in Figure 3. of the snapshot, representing the paper at each stage of production in the LFPM. Figure 3., shows that the pulp suspension entering the headbox had a moisture content/ water content of 99.39% representing a solids content of 0.67% based on OD fibers. At the real the water content was reduced to 0.73% representing a 99.27% solids content based on OD fibers..

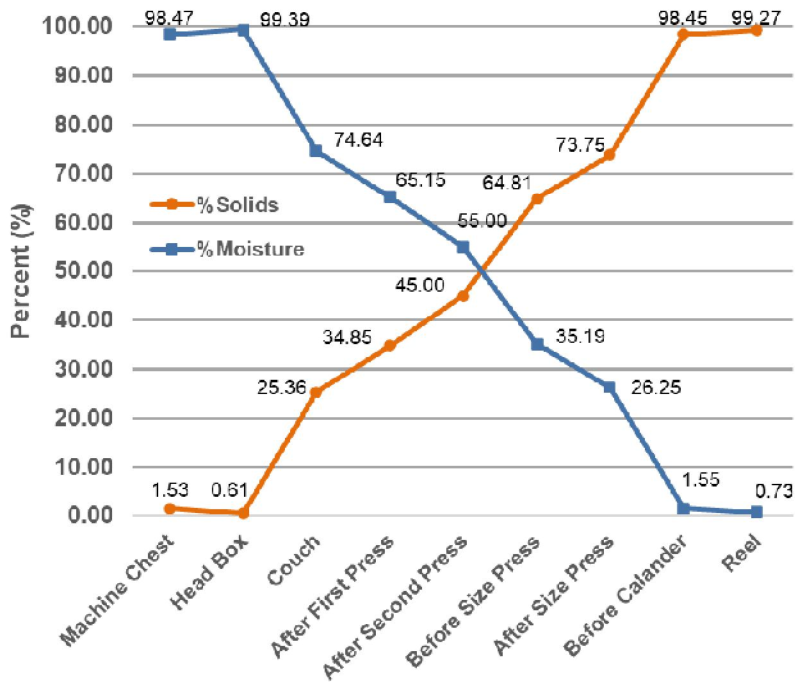

Fig. 3. Moisture and Solids Profile of Fourdrinier Laboratory Paper Machine

Fig. 4. Wet End of the 12" laboratory Fourdrinier paper machine [29].

Fig. 5. Laboratory Fourdrinier paper machine [29].

3.2.3. 12-inch Laboratory Fourdrinier Paper Machine Paper Testing Results

Paper testing during the LFPM run was conducted immediately following the paper product reaching the reel at a temperature of 23°C and a relative humidity of 30%.

Lab testing of the produced copy paper containing REC and NBSK fibers was conducted after the selected paper specimens were conditioned for several days at a temperature of 23°C and a relative humidity of 50% according to T402 [21]. Table 2. Shows in comparison the Machine-Made (MM) paper to the 80 g/m² produced Handsheet (HS) paper.

Paper testing was performed as required by TAPPI T 402 sp-08 [21] at a temperature of 23°C ± 1°C and a humidity of 50% ± 2%.

The final moisture content of the unconditioned and conditioned paper was 99.27% and 91.00% measured according to TAPPI T412 om-06 [24].

The handsheet basis weight achieved for the machine-made paper was 92.13 g/m² measured according to the TAPPI T 410 om-08 method [22.]

The thickness of the manufactured REC paper was measured with TAPPI method T 411 om-10 [23]. The thickness was 186.20 µm for the 92.12 g/m² paper basis weight.

The tensile index and tear index according to TAPPI method T 414 om-12 [25] and T 494 om-06 [26] resulted in a tensile and tear index of 93.20 Nm/g and 9.78 mN/gm² produced machine made paper respectively.

Opacity and brightness values for the machine-made paper, measured according to ISO 2470 [27] and ISO 2471:2008 [28] method, resulted in a opacity and brightness of 96.52% and 37.09% respectively.

Table 2. Machine Made Recycled Egg Carton Paper Properties

Measurement	**Value**	
Basis weight OD [g/m²]	**HS**	**MM**
Moisture Content Uncond. [%}	N/A	0.73
Moisture Content Cond. [%]	7.00	.00
Basis Weight Uncond. [g/m²]	77.00	81.00
Basis Weight Cond. [g/m²]	79.60	92.13
Thickness [µm]	183.90	186.20
Tensile Index [Nm/g]	18.14	93.20
Tear Index [mN/gm²]	8.48	9.78
Opacity [%]	99.70	96.52
Brightness [%]	39.35	37.09

Overall, the LFPM run was a success in producing a copy paper product that contained REC fiber material. However due to run ability issues of the LFPM it was necessary to add 30% NBSK pulp fiber material. The produced machine-made paper appeared to be visibly brighter to the eye with the addition of the NBSK pulp, however the brightness measurements showed a difference of 6.09% compared to the HS made paper product. The produced MM copy paper printed nicely on a office type laser printer.

Paper testing data shows that the tensile index and tear index of the MM copy paper increased 513.78% and 15.33% respectively compared to the HS. This can be linked to the addition of the virgin NBSK pulp fibers. It is well known in the industry that softwood fiber has higher tensile properties than hardwood and recycled fibers and can be used as reinforcement fiber material [6, 11].
The basis weight of 81 g/m² of the MM paper had a high solids content of 99.27% with only 0.73% moisture in the paper product. During conditioning at 23°C ± 1°C and a humidity of 50% ± 2% the MM paper product absorbed moisture increasing its basis weight to a much higher level as usual. This led to an higher than expected basis weight of 92.13 g/m².
This may also be the reason why the thickness with 186 µm of the MM paper product was higher. As the paper absorbed moisture the fibers began to swell which is the most likely cause for the thicker paper. The reason for this might be, that the REC fiber material can absorb a higher amount of moisture than regular pulp fibers. A Reports by Nethercote et. al. [44] shows that egg cartons produced from recycled fiber can contain over 10% of moisture at a temperature of 18.3°C and a humidity of 52%, and over 15% moisture at a temperature of 21.1°C and a humidity of 80%
Future research effort should focus on the moisture absorbing potential of REC fibers, improving the preparation of the REC pulp fiber in regard to optimizing refining, deinking/flotation of the REC pulp fibers and additives that might improve brightness and strength of the REC fibers.

4. CONCLUSION

The presented research project describes the development of a copy paper product from REC based fiber material. The development included laboratory handsheet development and machine-made paper product produced on a 12-inch (304 mm) wide LFPM operated at a speed of 6.4 ft/min (1.95 m/min).
The final MM paper had a REC fiber content of 70%. 30% NBSK fiber had to be added in order to avoid sheet breaks and produce a continuous paper sheet with the LFPM. The produced machine-made paper appeared to be visibly brighter to the eye with the addition of the NBSK pulp and printing tests using a office type laser printer showed good results.
The produced MM paper had a basis weight of 81 g/m² of the MM paper had a high solids content of 99.27% with only 0.73% moisture in the paper product. After conditioning at a temperature of 23°C ± 1°C and a humidity of 50% the basis weight increased to 92.13 g/m², with a caliper of 186 µm. The tensile index and tear index was 93.20 Nm/g and 9.78 mN/gm² respectively, opacity measured 96.52%, and brightness measured at 37.09%.
It seems that REC pulp fiber material can absorbs more moisture during conditioning which leads to increased basis weight and thickness due to swelling of the fiber material.

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