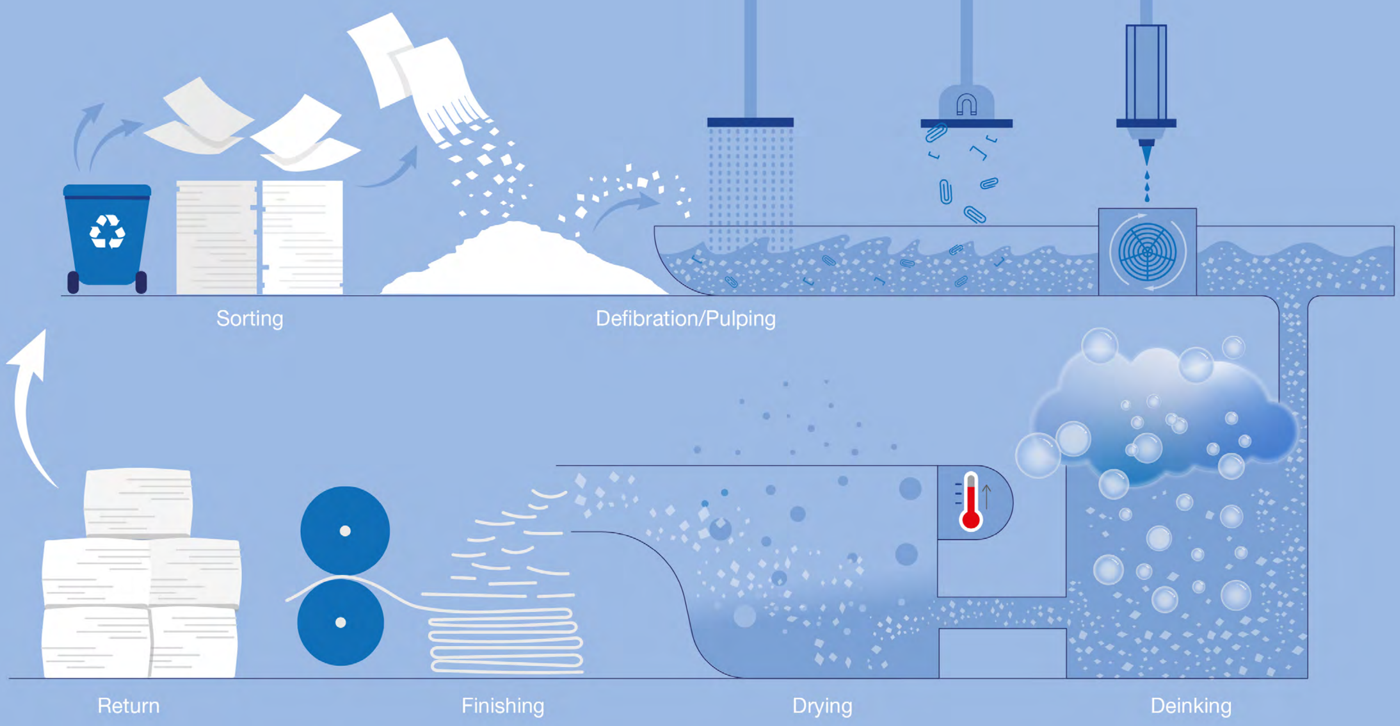


How transfer products influence the paper recycling process

Abstract

Recycling waste paper and cardboard is a complex and mechanical process. Reclaiming and returning waste paper to the recycling cycle protects nature and resources. For the last 10 years, the waste paper return rate within Germany has been continuously at around 75 % and illustrates the sustainable use of wood and paper as resources. Today, more and more products made from fiber-based materials – such as packaging, greeting cards, or magazines – are finished with transfer products by hot stamping, cold transfer, or digital transfer to meet visual requirements. The compatibility of refined paper materials in the transfer process within the recycling process of waste paper is examined below using representative examples.

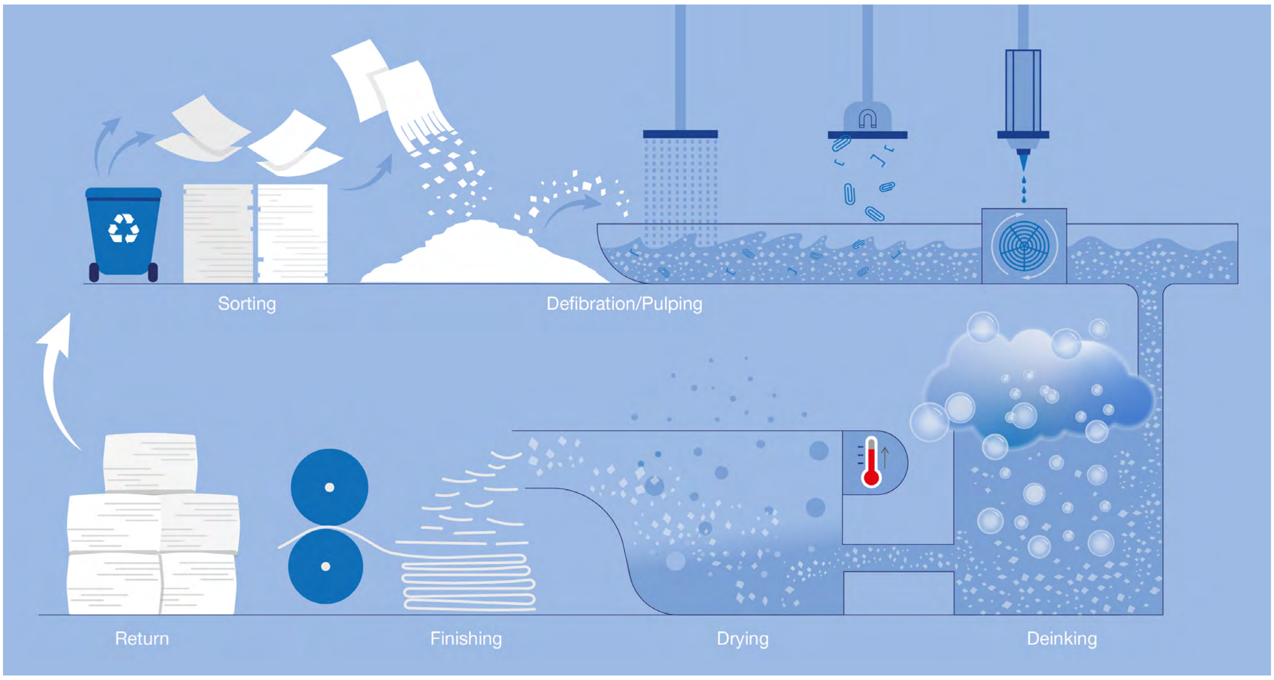


Fig. 1: Paper recycling process overview.

1. Sorting

Recycling fiber-based materials such as paper and cardboard begins with the pre-sorting of waste paper in every household. The waste paper is transported to a recycling center by waste disposal companies. There, waste paper is separated from cardboard and non-paper components in a sorting plant. Separating devices such as screening machines, feed bunkers, and conveyor chutes are initially used. Next, widespread near-infrared (NIR) spectroscopy is deployed. These NIR sorting systems sort different materials fully automatically based on their near-infrared spectrum and, accordingly, their material composition. The waste paper travels on a conveyor belt under an infrared light source. The light beams have a wavelength of 760 to 2,500 nm. Depending on the material composition, certain wavelength ranges are absorbed and reflected to varying degrees. The reflected rays are measured by the spectrometer and the material to be examined is assigned to a material class. This allows fiber-based materials to be separated from other materials such as plastic or metal.

The transfer product manufacturer LEONHARD KURZ has commissioned TOMRA to test the fully automatic sortability of paper/cardboard packaging that has been finished using hot stamping, cold transfer, or digital transfer. The degree of coverage of the samples with finishing was between 50 and 100%, with most samples being finished over their entire surface. It was investigated whether the coating layer applied by the finishing process has an influence on the sortability in an NIR sorting system. Static and dynamic tests were performed.

Fig. 2: Example of a folding box finished with transfer products.

Figure 2 shows an example of a folding box that has been finished with transfer products. Transfer products from the LUXOR®, LUMAFIN®, and SILVER LINE® product groups were used.

In TOMRA's static tests, the packaging samples were analyzed motionless or lying down using NIR detection, and the results were compared with a paper and a 2D film database.

Table 1: Static NIR detection results.

Name of sample	Paper database	2D film database
olia	Predominantly coated cardboard	Paper
l'oreal casting	Predominantly coated cardboard	Paper
aramis	Predominantly coated cardboard	Paper
brand	Predominantly coated cardboard	Paper
brand white	Predominantly coated cardboard	Paper
toothpaste blue	Partially coated cardboard	Paper
toothpaste white	Predominantly coated cardboard	Paper
chocolate sbm	Magazine / coated carton	Paper
champagne	Other polymer	PP film
tafelzier	Predominantly coated cardboard	Paper

Table 1 shows the static sorting test results. Nine out of ten samples were correctly identified as paper/cardboard in comparison with both databases. Only one sample was incorrectly assigned to a polymer or PP film material due to the finishing.

For the dynamic analysis, KURZ had the packaging samples sorted in TOMRA's NIR sorting system. The samples were mixed into two-dimensional packaging waste, which served as background material, to simulate a sorting process in a packaging waste sorting plant.

Fig. 3: Schematic representation of an NIR sorting system.

Figure 3 schematically illustrates the sorting process using NIR spectroscopy. The sorting takes place in two steps:

1) Ejection of plastic, metal, and Tetra Paks so that only fiberbased materials remain in the stream

2) Ejection of cardboard to separate paper from cardboard so that the output stream consists exclusively of paper as far as possible

The recovery rate of cardboard is 86.0 % in the dynamic sorting test performed and the recovery rate of paper is 84.7 %.

2. Pulping

After the sorting process, the waste paper is shredded, crushed in a pulper or refiner, and foreign materials are separated. Pulping can be done from both waste paper and wood chips as raw material. At the end of the process, a fiber pulp is produced, which is a suspension of fibers in water.

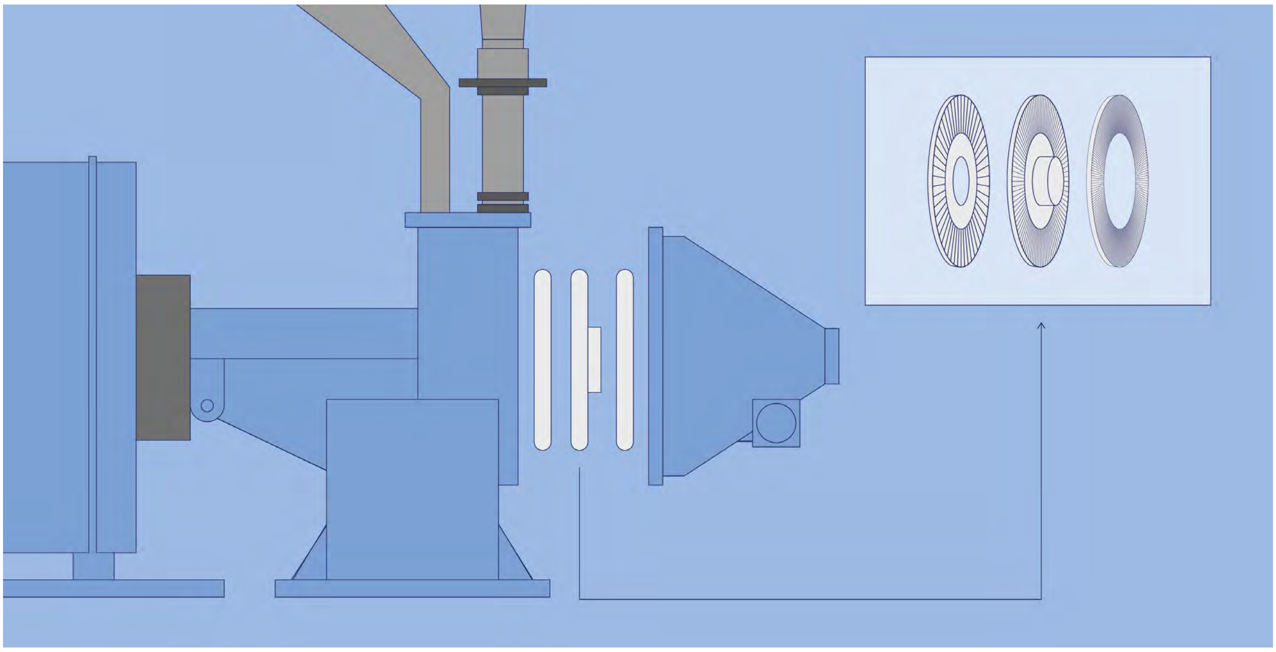


Fig. 4: Refiner.

Refiners produce wood materials by shredding wood chips or waste paper and grinding the fibers. When defibering waste paper, only the long fibers are usually processed and separated from the short fibers.

A distinction is made between three types of refined wood materials process:

1) Refined Mechanical Pulp (RMP) process: Mechanical fragmentation of wood in a refiner at ambient pressure

2) Thermo-Mechanical Pulp (TMP) process: The temperature in the mill is increased, resulting in a higher proportion of long fibers

3) Chemi-Thermo-Mechanical Pulp (CTMP) process: Corresponds to the TMP process, extended by an additional chemical pretreatment of the wood chips

The RMP process is the simplest refiner wood material process, but the TMP process is the most widespread, as it results in a higher yield of long fibers.

There are two different types of refiners:

1) Disk refiners (disk mill) and

2) Cone refiners (cone mill). Within these types, refiners are differentiated according to their carrier bodies on which the grinding plates are located, e.g., single-disk, double-disk, flat-cone refiner.

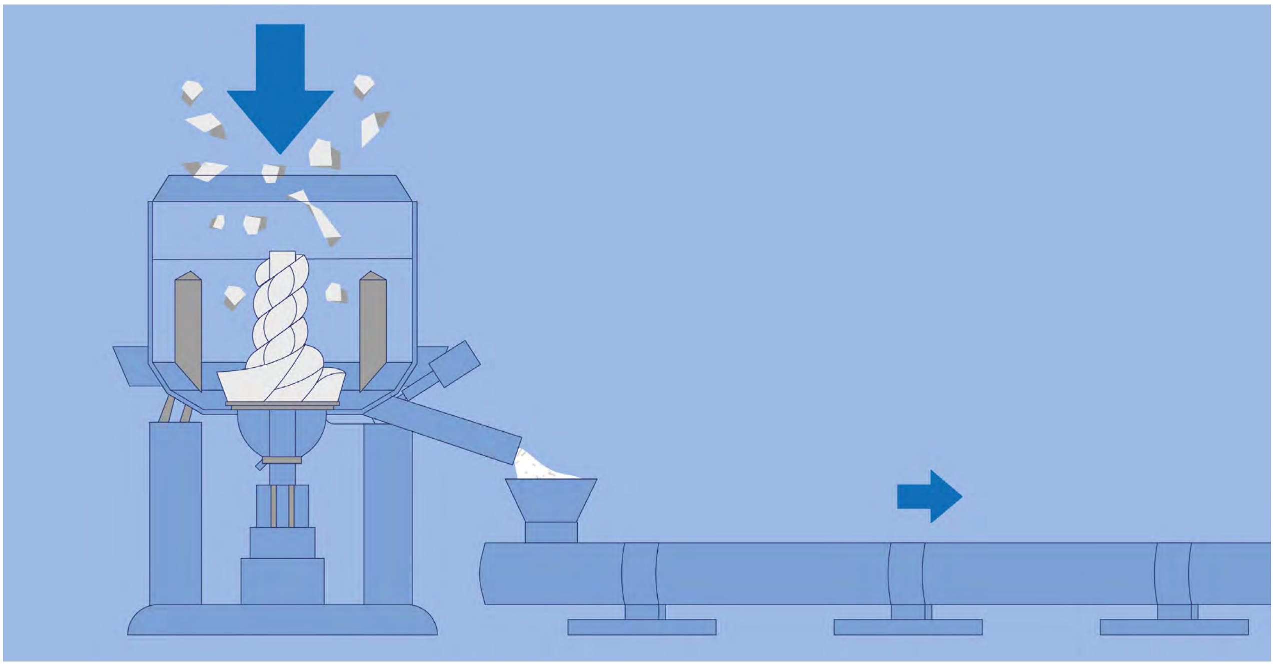
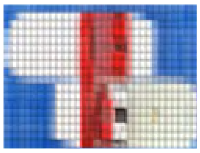


Fig. 5: Pulper.

The pulping process in a pulper produces a pumpable medium from the solid waste paper. Interfering materials such as staples and ink should be minimally or not at all shredded so that they can be separated from the shredded fibers in later separation processes as larger particles. A pulper (see Figure 5) contains a rotor, several fixed elements (impact edges, bars), and a sieve. Defibration occurs due to internal and external shear forces. In waste paper plants, two pulpers are often connected in series to achieve a higher throughput.

The Fachverband Faltschachtel-Industrie e. V. (FFI) commissioned the Papiertechnische Stiftung (PTS) with a study on the ‘recyclability of folding boxes and material combinations.‘ The test results of an example of paper packaging finished with cold foil transfer can be seen in Table 2.

Table 2: PTS examination results.

Sample		**Exterior coating** FFI2020-BA14	
			
Folding box		GC2 290 g/m^2	
Pressure	Varnish	UV 1,99 g/m^2 54 % surface area	UV 1,2 µm 85 % surface area
Coating		Alu 2 µm, 65 % surface with cold film transfer Dispersion adhesive	
Fiber yield		88 %	
Recycling Separate Collection PPK		Recyclable	
Adhesive impurities		Existing and slightly damaging → fiber tears	
Visual impurities		Present and disruptive → Some metal particles	
Polymer substances [mm^2/kg]		Total stock	Good stock
		1.103.115	5.288

PTS came to the conclusion that packaging finished with KURZ transfer products can be recycled in a mixture such as household collection goods. However, visual impurities are still present in the processed material and visually disturbing.

3. Deinking

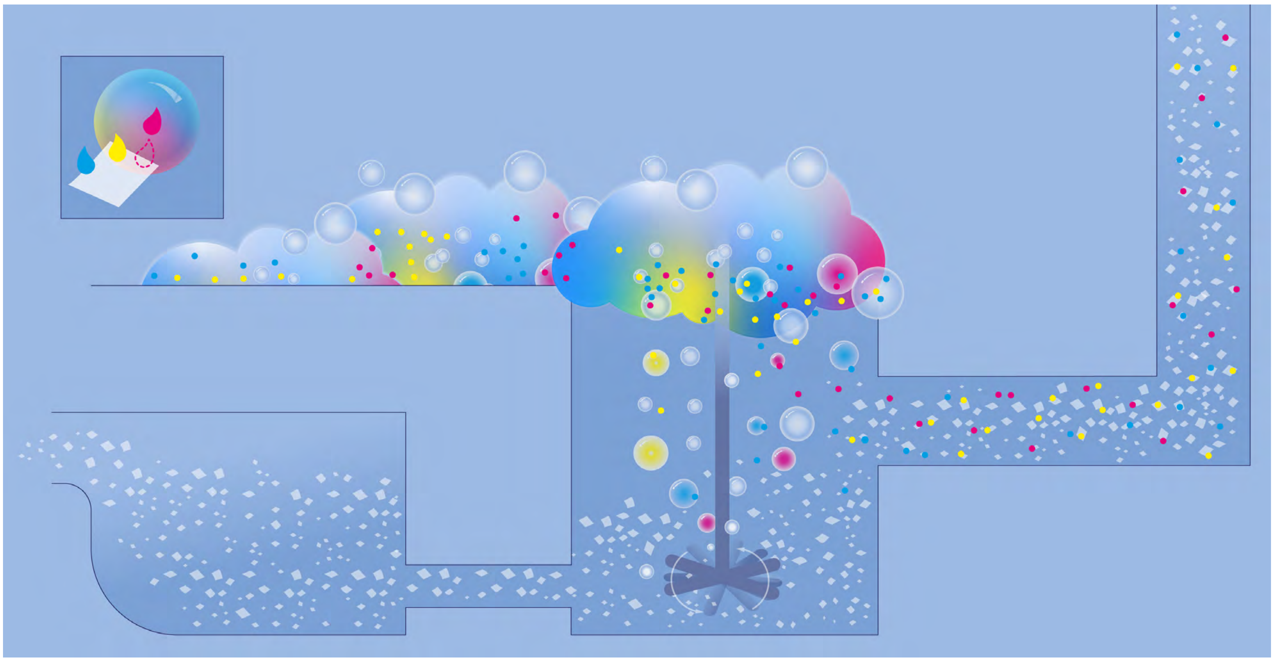


Fig. 6: Deinking process.

Deinking refers to the removal of ink during paper recycling. Figure 6 shows the deinking process schematically. In the deinking process, the paper is first crushed and water added. In the resulting pulp suspension, the paper fibers absorb the water and swell. This process loosens the bond between dye particles and pulp fibers. In subsequent filtering and cleaning stages, contamination such as staples and glue residues are removed and the suspension is prepared. Glue residues are removed by means of a centrifuge and staples and paper clips through magnetic separators. The fiber pulp is cleaned with sodium hydroxide and surfactants, among other things. The inks are removed by air flotation or foam flotation. Air is blown into the suspension tank, which creates foam. The ink particles stick to the foam bubbles and are transported to the water surface. The foam with dye particles collects on the surface of the water while the cellulose fibers sink to the bottom of the container. The contaminated foam is removed mechanically. This entire process is repeated several times until the desired cleanliness of the fibers is achieved.

KURZ has had the deinkability of finished products tested and certified by INGEDE (International Association of the Deinking Industry). The samples were tested according to INGEDE method 11, and the assessment was carried out according to the “Assessment of Printed Product Recyclability—Deinkability Score” (EPRC 2017).

Table 3: Results of INGEDE's deinkability studies.

Process	Product	Quality	Color	KURZ color code	Gloss level	Overall score	Deinkability
Cold transfer	LUXOR®/ ALUFIN®	KPS	Silver	150	Glossy	100	Good
		KTM	Silver	150	Glossy	100	Good
Hot stamping	LUXOR®/ ALUFIN®	MHC	Red	307	Satin Gloss	100	Good
		MSU	Matt Antique Gold	420	Satin Gloss	100	Good
			Supermatt Gold	429	Supermatt	100	Good
		MTC	Gold	220	Glossy	100	Good
		MTH	Gold	220	Glossy	100	Good
		MTS	Silver	150	Glossy	100	Good
			Red	307	Satin Gloss	97	Good
			Deep Black	362	Satin Gloss	96	Good
		MTS-F	Silver	150	Glossy	100	Good
			Gold	220	Glossy	100	Good
			Navy	302	Satin Gloss	100	Good
		MTS-OP	Silver	150	Glossy	100	Good
			Gold	220	Glossy	100	Good
	LUMAFIN®	MS	Met. Bronze	701	Glossy	83	Good
			Green	730	Glossy	83	Good
	COLORIT®	PEARL	Pearl White	99015	Glossy	93	Good
		Trans	Black	812	Glossy	100	Good
		V	Dark Blue	917	Matt	100	Good
		VB	Black	912	Matt	100	Good
	LIGHT LINE®	XL	Silver	150	Glossy	100	Good

Table 3 shows the transfer products examined. All 22 tested transfer products from the LUXOR®/ALUFIN®, LUMAFIN®, COLORIT®, and LIGHT LINE® product groups received the top rating 'good', confirming the deinkability of a product finished with the tested transfer products. The transfer products examined were tested representatively for all transfer products offered by KURZ. The formulations for each product quality are distinguished mainly by the dyes used.

Within a product quality, the structure of layers of the transfer products in the recycling process can be assumed to be largely identical. A representative selection of product qualities with as different a layer structure and color strength as possible was chosen and examined more closely. Deinkability has been tested for various parameters, including color (light/dark), metallization/pigmentation, matting agent, adhesive (UV adhesive, various adhesive layers).

4. Drying

Deinking is followed by the pressing and drying process. For pressing, the deinked fiber pulp flows over a sieve and is pressed together between two felt rollers. This already reduces the water content to 45 to 50%. To further reduce the water content to 5%, the pressed paper is dried between heated cylinders at approx. 70°C.

5. Finishing for further processing

To make the recycled paper writable and printable, it needs to be finished. This can be done by surface sizing, laminating, or coating.

- Surface sizing: Applying a thin layer of starch
- Laminating: Surface bonding of several sheets of paper
- Coating: Application of a ‘coating color‘, consisting of binder, pigments, and other additives

These finishes compensate for unevenness in the raw paper and ensure a connected surface. This gives the paper a gloss, a special haptic effect, or high grammages, for example. After finishing, the paper is smoothed and wound by heated rollers. The paper is now ready for further processing and can be cut to the desired format.

Waste paper can be recycled five to six times, after which the fibers become too short for the recycling process. Therefore, fresh fibers (primary fibers) must be added to the waste paper recycling process.

If a product refined with KURZ transfer products ends up in nature instead of in the recycling cycle, it is ensured that KURZ transfer products do not interfere with the composting process. KURZ had DIN CERTO (Society for Conformity Assessment mbH) certify this according to DIN EN 13432:2000–12 through a certification program for the composting process of harmless additives (2018–03).

Conclusion

In summary, the results of the study suggest that fiber-based products that have been finished with KURZ transfer products are recyclable in household collectibles. Finishing with a wide range of products is harmless to the recycling process and, in most cases, has no disruptive effect.

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