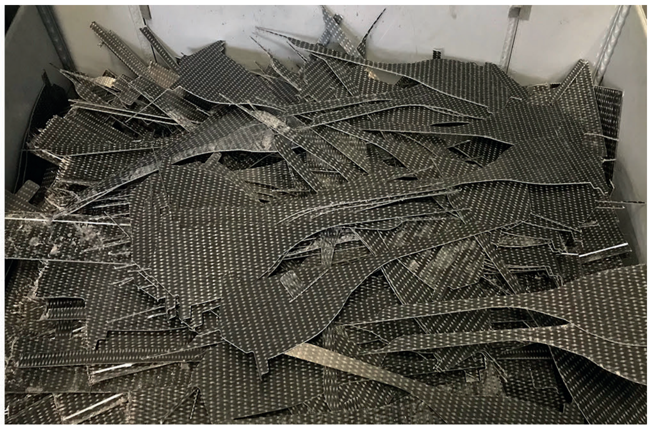
Organo Sheet Recycling

Feeding Mechanically Recycled Fiber-Reinforced Thermoplastics Back to Production

Organo sheets have become established in several industrial sectors for the series production of highly stressed lightweight components. Hereby, waste material accumulates during production, which cannot be fed back directly to the manufacturing process. Therefore, the utilization of this scrap material is a promising recycling approach.



Even with a highly optimized production of organo sheets, considerable amounts of scrap occur © Lanxess

Continuous fiber-reinforced thermoplastics exhibit very good technical properties that permit their use in numerous application areas – from sports shoes to housings for electronic equipment through to safety-relevant automotive components such as brake pedals or A-pillar reinforcements. For more than 20 years, Bond-Laminates GmbH, an affiliate of Lanxess, has been producing such fiber composite materials under the brand name "Tepex" in their Brilon/Germany site. Meanwhile, these organo sheets have become established in many mass-produced products.

Process parameters	Recommendation
Shredding device	Single-shaft shredder
Shear roller speed	100 rpm
Shear blade geometry	Square
Cutting gap	≤1.0 mm
Cutting angle	<10°
Screen size (for regrind size 8-15 mm)	15-20 mm
Feed width	≥1300 mm

Table 1. Recommended process parameters for shredding organo sheet trim waste Source: Lanxess

Tepex organo sheets are manufactured in a continuous process, and are customized for the respective processor. In particular for the automotive industry, where the semi-finished Tepex items are further processed in fully automated manufacturing cells, the inlays are supplied as two-dimensional pre-cuts. In order to minimize the scrap produced when trimming these inlays, the corresponding geometries are interleaved in the semi-finished item – taking the necessary fiber orientation into account – so that an optimum material yield is possible. This procedure is also known as "nesting".

However, with strongly curved geometries that make interleaving highly problematic, systematic trim waste is unavoidable (**Title figure**). Under mass-production conditions, a waste proportion of just 5 to 10% results in huge amounts of residual material, which cannot be returned directly to the production process. In order to re-use the material, it must first be recycled.

Suitable Recycling Process for Organo Sheets

Because Tepex and comparable organo sheets are based on a thermoplastic plastic matrix, recycling is possible with material utilization by means of mechanical rework as well as by means of chemical raw material utilization, i.e. splitting up into individual components by means of hydration, hydrolysis, and pyrolysis. Recycling of residual and waste material offers the greatest economic benefits. Hereby, the Tepex waste must first be ground to a defined particle size.

Conventional rotary cutter granulators are able to shred all types of organo sheet. However, the high cutting speeds normally used for this technique result in a very high wear rate of the cutter blades. Moreover, the regrind has a high dust content and a relatively low medium particle size. In general, the resulting low bulk density of the regrind is unsuitable for conventional processing operations such as regranulation or direct injection molding.

A reduction of cutting speed with uniform shredding performance can be achieved with classical shaft shredders. However, a low speed should be selected for the shear roller. In particular, single-shaft shredders with automatic hydraulic feed are well suited to produce a homogeneous regrind (**Fig. 1**) [1]. Hereby, large lamellar particles – as can occur with other shredding methods – are avoided. This also applies for thicker materials or particularly brittle carbon fiber-reinforced variants.

Fig. 1. Shredded Tepex: during shredding, the type of machine used is decisive. Single-shaft shredders in particular are able to produce a homogeneous regrind © Lanxess

Shredding Parameters

Due to the high rigidity, strength, and impact resistance of Tepex materials, a suitable set-up is necessary for efficient shredding. Apart from the smallest possible positive cutting angle, other parameters should be ensured (**Table 1**) [2]. In addition, a suitable extraction system should always be provided due to the high dust generation.

Reground material produced by shredding can be used directly for typical plastics processing methods such as injection molding or extrusion. In order to ensure smooth production in standard machines without modified feed zones, a medium particle size of 8 to 15 mm is recommended. Such regrinds have a bulk density of about 200 kg/m^3 (±20 kg/m^3). If conventional granulate (re-granulates or virgin material) is added to the regrind in an amount ≤20%, the bridging tendency will be reduced so far that normal feed hoppers without forced feeding – i.e. standard versions – can be used. This is confirmed by investigations at Kunststofftechnik Paderborn, a research facility of the Paderborn University, Germany.

Suitable Screw for 100 Percent Regrind

Figure 2 shows an automatic process in which a mix of 80% granulate and 20% organo sheet regrind was injection molded using a standard 25-mm diameter screw without additional pe- »

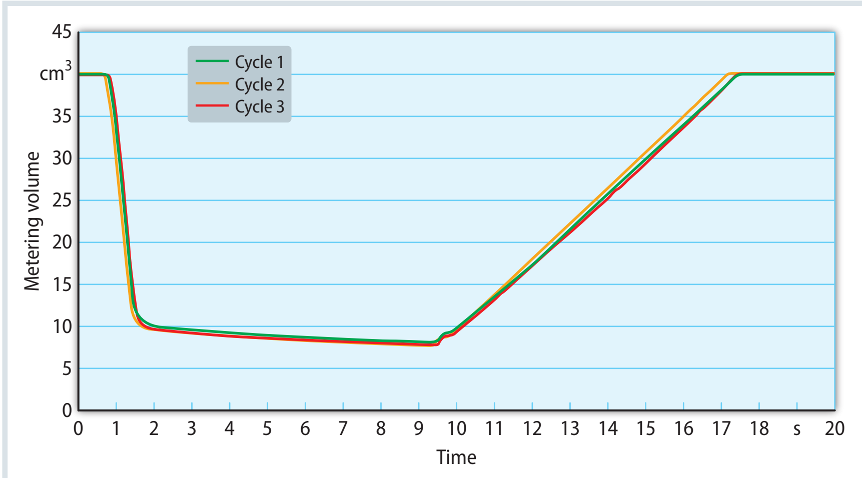


Fig. 2. Processing a mix of 80% granulate and 20% organo sheet regrind with a standard 3-zone screw: reproducible metering in every cycle is possible during processing Source: Lanxess; graphic: © Hanser

ripherals. Higher amounts of regrind, sometimes even up to 100%, can also be processed with standard machines, provided that a suitable forced feed for the regrind is used, e.g. a compression screw with high channel depth. For maximizing the mechanical properties in the component, screw geometries with high channel depths in the feed zone that are gentle to the fibers can be used. But usually they are not essential. Tepex regrind with the recommended medium particle size can be processed without problems using standard, unmodified three-zone screws.

For the injection molding process, and depending on the component to be produced, low metering speeds and back pressures are recommended. Normally, the optimum operating point is determined by the machine type used and the component's design.

The addition of short fiber-reinforced or non-reinforced virgin material permits the component's fiber content to be adjusted precisely. With Tepex based on polypropylene (PP), a reduction of the regrind to a fiber weight content of 30% is expedient, because short fiber-reinforced PP-GF compounds with a higher fiber content are hardly available on the market. Due to the non-polarity of PP, an improvement of the mechanical properties by a further increase of the fiber weight content is not a trivial matter, and can usually only be achieved with special long-fiber granulates. Other Tepex types can also be processed without additives, or short fiber-reinforced virgin material with comparable fiber weight content can be admixed.

Mechanical Properties like Conventional Short Fiber-Reinforced Plastics

Strength, rigidity, and toughness of the recyclate are comparable with those of conventional short fiber-reinforced plastics with corresponding fiber contents. In order to validate this claim, Tepex re-

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References & Digital Version

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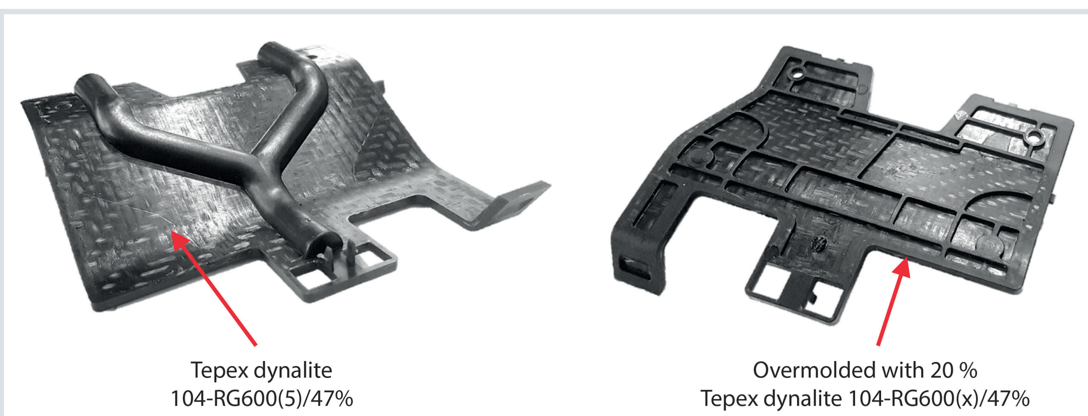

Fig. 4. A demonstrator shows that the regrind is suitable for injection molding plastic components. The overmolding material of the demonstrator is a mix of 80% virgin material and 20% Tepex regrind © Lanxess

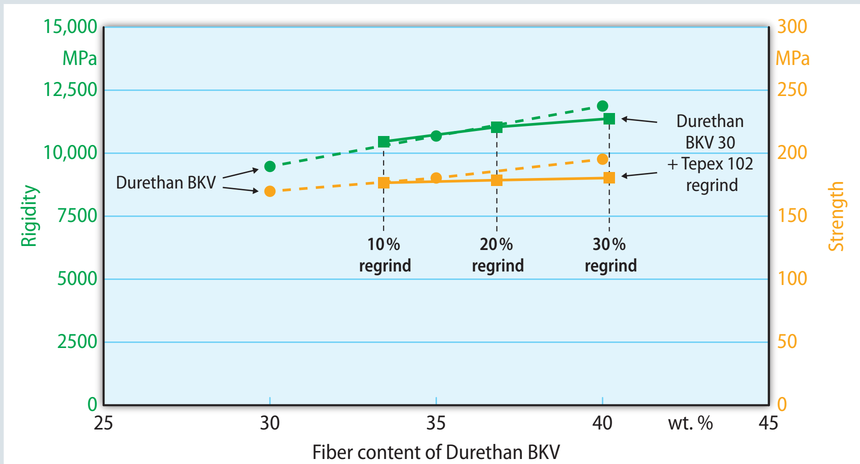

Fig. 3. Comparison of rigidity and strength between PA6 Durethan BKV30, BKV35, and BKV40, as well as PA6 Durethan BKV30 with additions of 10, 20, and 30 % Tepex 102 regrind: the values are comparable in spite of the addition of regrind Source: Lanxess; graphic: © Hanser

grind (source material: Tepex dynalite 102-RG600(x)/47 %; fiber weight content: 66 %) was mixed with different amounts of a short glass fiber-reinforced Durethan BKV30 (polyamide 6 (PA6), fiber weight content: 30 %), and processed directly in an injection molder. Hereby, the resulting mechanical values for flexural modulus and tensile strength are the same as for Durethan types with comparable fiber weight content (Fig. 3) [3]. The results were confirmed in various investigations – also with other polymers and fiber materials. [1, 4]

For the purpose of verification, a demonstrator component (**Fig. 4**) was produced in cooperation with Kunststofftechnik Paderborn. The component is used for research work, and originally served for investigating different aspects of the special injection molding process GITBlow [5]. The geometry is similar to components that are already being mass-produced for the automotive industry [6].

The overmolding material consists entirely of a mix of 80 % virgin material and 20 % regrind. The demonstrator shows that thick-walled regions with negligible shrinkage as well as thin-walled regions with long flow paths can be produced completely and without visible shrinkage effects, provided that normal injection conditions are observed.

Without additional investments, recycled trim wastes can be used in planned or even in ongoing series products. Consequently, the process represents an important step towards a comprehensive circular economy for continuous fiber-reinforced thermoplastics. ■