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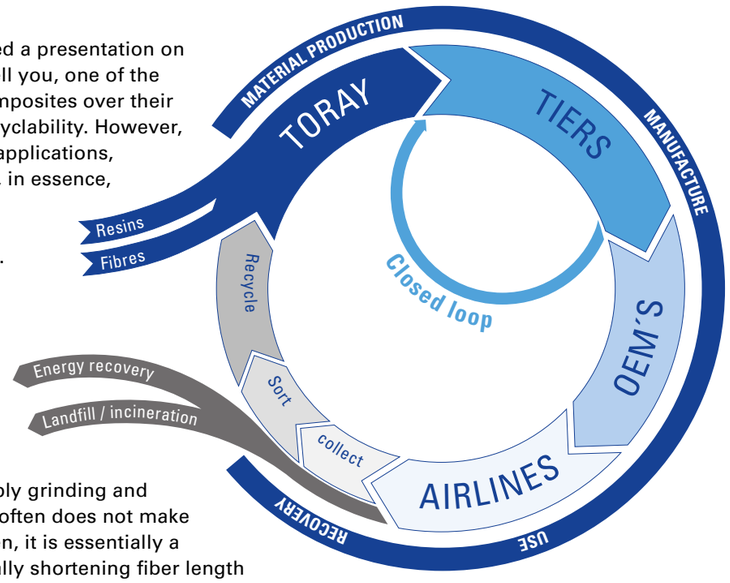
Recycling Thermoplastic Composites Beyond Grinding the Materials

TORAY

Toray Advanced Composites

Introduction

As anyone who has ever attended a presentation on thermoplastic composites can tell you, one of the advantages of thermoplastic composites over their thermoset counterparts is its recyclability. However, there are not a lot of real world applications, despite the fact that the process, in essence, is not difficult: grinding the materials down and applying heat and pressure to make parts. Toray is contributing to research efforts looking to maximize the recyclate's economic and technological value and thus its applicability in real-world applications.



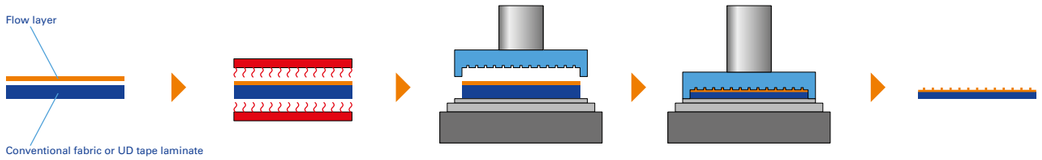
The mantra on recycling thermoplastic composites—simply grinding and remolding—although very true, often does not make a lot of sense economically. Often, it is essentially a form of downgrading: dramatically shortening fiber length and mechanical properties. Toray is participating and doing research in areas to solve these issues and make recycling of our materials available and useful to our customers. In this case, Toray focusses on closed-loop recycling with excess materials that are the result of the value chain as it exists today.

Toray chose to disseminate the knowledge that we have gathered with in-house projects to inspire the industry with the possibilities of thermoplastic materials. We would like to stimulate and encourage engineers to keep thinking creatively by providing the industry with ideas like this.

Flow Layer Enhanced Continuous Fiber Laminate

Toray Advanced Composites has developed a new format of reinforced thermoplastic laminate that incorporates recycled materials and offers processability and design advantages. This research was undertaken by Toray's internal Research & Product Development department, in collaboration with multiple graduate students who utilize this platform for their ongoing research projects.

This development is a new material format of continuous carbon fiber reinforced thermoplastic laminates that are enhanced with a flow layer of discontinuous fiber, either from virgin or recycled thermoplastic composites. This construction enables designers of composite components to add more complex features and benefit from the optimized material performance of continuous fiber reinforced laminates, maintaining a robust and cost-efficient stampforming process.



The enabled features encompass edge sealing and local strengthening or stiffening of the part, stiffening ribs, textures, and variable thicknesses are possible as well as local bosses to spread strains induced by fasteners.

Continuous fiber + recycled material core, to utilize properties when needed

Continuous fiber + recycled material core, to vary material thickness

Continuous fiber + recycled material surface, to add texture, stiffening ribs, etc...

With recycling excess material (e.g., nesting surplus and trimmings), and using this material as a flow layer in the end product, a balance is created between supply and demand of recyclate. Smart part design enables an engineer to near a 100% "buy to fly" ratio, and reduce the thickness of the base material laminate needed to achieve the desired performance. In this way, the blanks can be tailored to dramatically reduce the amount of material needed. The flow layer consists of high fiber volume fraction, long fiber reinforced Bulk Molding Compound, which can be supplied on the laminate or can be added locally prior to the stampforming process. The stampforming process itself is conventional: the laminate can be stampformed to shape in short ~5-minute thermoforming cycles.

The mechanical performance of such tailored parts can be drastically improved while decreasing part weight. The flow layer allows for the design of stiffening ribs in corners and in the flanges, bearing strength by the addition of bosses around the drilled holes and thickness variations in the base laminates. The mechanical performance is optimized due to the inherently good interface between the laminate and reinforcing features.

Apart from the obvious advantage of using less material to produce a part and decrease weight, this innovative way of production makes it possible to use recyclate directly at the source where it is created. This creates a balance between the supply and demand of recyclable materials and limits the carbon footprint of the recyclate by eliminating scrap transportation. Furthermore, it gives a means to a tightly regulated industry, such as the aircraft industry, to keep on top of material traceability.

Advantages of Recycled Flow Layer Enhanced Laminates

- Offering better performance to cost ratio
- Improving performance to weight ratio
- Allowing complex composite geometries
- High potential for improving buy to fly ratio
- Balanced usage of recycled materials

Conclusion

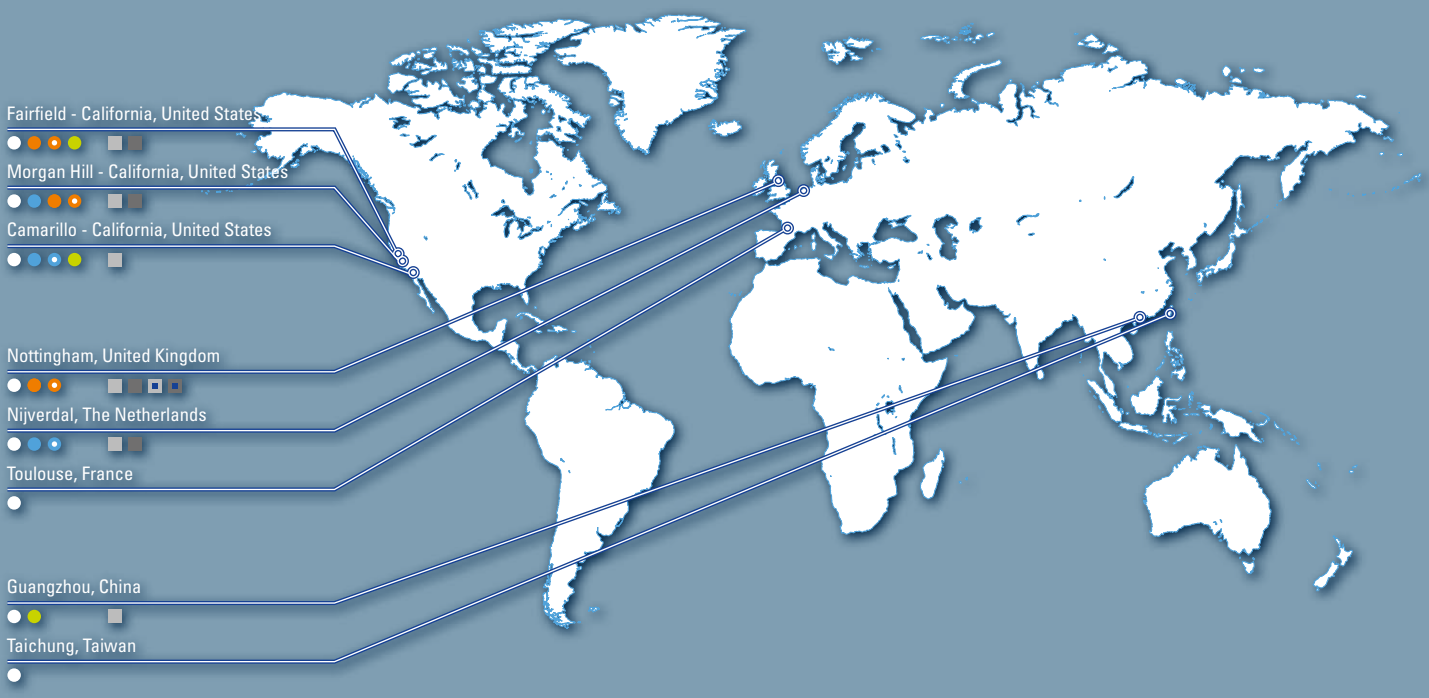
This technique combines the unmatched performance of continuous fiber products, either fabric or UD tape reinforced with the superb mechanical properties and design freedom of long fiber reinforced bulk molding compound. Tailoring local stiffening, strengthening, and functional features can reduce the average laminate thickness and thus component weight.
Recycling excess material from previous processes in the part as the flow layer potentially increases the degree of utilization of purchased material, the so-called "buy to fly" ratio up to nearly 100%.

The fast, robust, and cost-effective conventional stampforming process can be used for part manufacture, therefore, no expensive tooling or equipment investment is needed and short cycle times can be maintained.

Locations and Capabilities

SOLUTIONS
- Thermoplastic composites
- Thermoplastic laminates
- Thermoset composites
- Carbon-free manufacturing
- Parts manufacture
- Sales office

CERTIFICATIONS
- ISO 9001:2015
- AS9100D
- ISO 14001:2015
- ISO 45001:2018



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