Reinforced Plastics • Volume xxx, Number xx • xxxx 2017 www.reinforcedplastics.com

The renaissance of flax fibers

Django Mathijsen

Once upon a time all materials were naturally sourced. Now that natural fibers have lost a lot of their traditional market shares to synthetic fibers, they are gearing up to conquer new markets: yarns and fabrics are being tailored to the reinforced plastics industry. Flax is a promising natural fiber. It is relatively stiff and strong. And because it stands out favorably in damping, environmental impact and 3D-capabilities, it is sure to carve out a niche in the composites industry.

"Flax has similar stiffness to glass fiber, but at only half the density," says Sophie de Rijk, manager automotive of Bcomp (http://www.bcomp.ch/en), an innovative natural fiber company in Fribourg, Switzerland (See Figure 1). De Rijk is a mechanical engineer, specialized in composite materials, and structure, fracture and fluid mechanics. "So, it is superior if you want to make something stiff and light. Carbon fiber is stiffer per weight than flax, but flax has much higher damping than glass or carbon fiber."

A vibration in a structure made from carbon or glass fiber reinforced polymers will take much longer to dampen out than in a structure made from flax reinforced polymers. So, an important application of flax fibers is to add damping to a structure made of carbon fiber reinforced plastics.

The strength of flax fibers is a bit lower than S-glass, and its price is higher. But as De Rijk explains, it has a lower environmental impact: "The carbon footprint of flax – the embodied energy to produce the raw material – is much lower than of carbon and glass fiber. Also, it does not interfere with food sourcing, but complements it, because flax is typically used as a shifting crop. If your field has to rest for a year, you plant flax. And you do not need water to extract the fibers."

Flax is harvested by pulling the plants out of the field (Figure 2). After the seeds are removed, the fibers have to be freed. Common practice is to spread the plants out over the field. Moisture and micro-organisms will then rot away the pectin that binds the fibers together. After a few days, the fibers can be collected from the field, crushed between cogwheels to remove the stalks, and combed to remove the short fibers. The resulting fluffy bundles of long fibers can then be spun into yarns.

The fact that flax does not tend to shed its fibers makes it especially friendly to parts manufacturers. "You do not need gloves," De Rijk says. "If you are working with glass fiber, you need gloves, otherwise you will get itchy. But flax is a textile and therefore safer and more pleasant to work with."

Started in a garage

Bcomp was started in a garage in 2003 with a few engineers trying to produce a better ski (Figure 3a,b). "They wanted to make light skies for off-piste freestyle skiers," De Rijk explains. "So, they used carbon fiber composites. But those skis were unpleasant because they vibrated a lot. That is why they turned to flax. Ski cores were our first product, and it is still the one we sell the most. It is a very light laminate of balsawood to take the compressive stresses, and flax fibers inside to take shear stresses." The damping properties of flax make the skis more stable to ride.

As flax fiber fabrics suitable for those ski cores were not on the market, they had to be specially developed, which eventually led to a full range of fabrics, optimized for various composites applications, from 120 g/m^2 to 350 g/m^2, now on the market as ampliTex®. There are non-crimp bi-axial and unidirectional fabrics, low-twist unidirectional and satin weaves, no-twist fabrics and braids.

De Rijk explains that the amount of twist in the yarns is a key issue in developing these materials: "The fibers extracted from a plant have different lengths: typically, 20 to 30 cm. So, if you want to make a continuous yarn, you have to do the same thing the grandmas with their spinning wheels used to do."

If you combine short strands and twist them, you end up with long yarns. In the textile industry they put a lot of twist in those

0034-3617/ https://doi.org/10.1016/j.repl.2017.11.020

Please cite this article in press as: D. Mathijsen, (2017), https://doi.org/10.1016/j.repl.2017.11.020

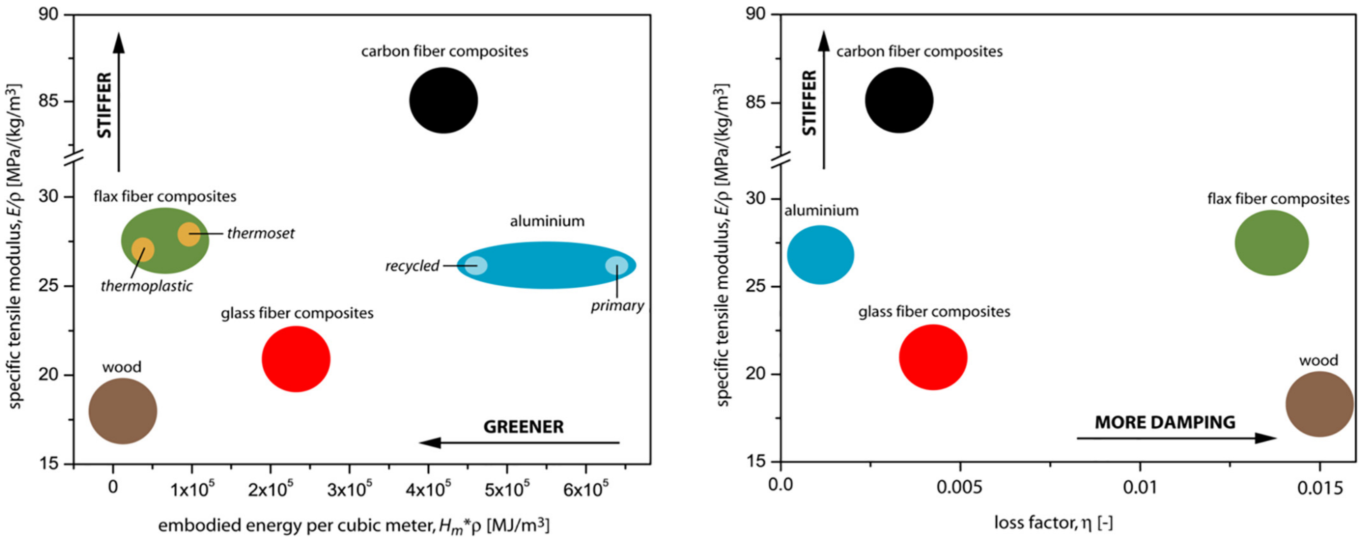

FIGURE 1
Flax fiber composites stand out favorably in damping, stiffness and embodied energy (Image courtesy Bcomp).

FIGURE 2
Flax is harvested by pulling out the plants. The fibers are then freed by spreading the plants out over the field, so the pectin that binds the fibers can rot away (Image courtesy Bcomp).

yarns, because they have to be processed and used in a dry state. It is the amount of twist that keeps the yarns together for their entire life.

But when you use yarns in composites, that twist will cause the fibers to no longer be loaded perfectly longitudinally, the direction in which they are the stiffest. Twist causes sideways loading on the fibers and thus lower stiffness of the composite. "You want to limit the twist in the yarns as much as possible to achieve the highest stiffness," De Rijk says. "But low twist makes the yarns more complicated to handle when they are still in their dry state." So Bcomp spends a lot of time with their suppliers, optimizing the amount of twist in the yarns to get the right compromise between ease of processing and stiffness of the finished composite.

AmpliTex is used in many applications in the sports and leisure industry, surfing for example (Figure 4). But it is also used in musical instruments.

3D reinforcements

An interesting intermediate product Bcomp offers is powerRibs®. This was developed to make full use of the special 3D capabilities of flax.

PowerRibs are a net of flax which can be laminated onto (usually the invisible side of) the surface of a product. It is a convenient way of adding ribs to give a surface a higher bending stiffness (Figures 5 and 6). "Flax is much more effective in creating a 3D rib structure on the back of thin components than glass or carbon fiber," De Rijk says. "We make powerRibs out of very thick flax yarns, which are nice and round. When you manufacture a composite part, you will always apply some kind of pressure: in an autoclave, in the form of a vacuum bag pressing down on the layup, in the form of compression molding... With flax yarns, even if you apply pressure, the yarn will stay round, preserving the 3D effect. The whole point of using powerRibs is to create this thick 3D rib structure. If you would try to do the same with glass or carbon fiber, the yarns would just flatten out the moment you start applying pressure, resulting in a 2D reinforcement instead of a 3D one." The amount of twist in the yarns was again crucial in developing this material: it must be high enough so that the yarns stay round when pressure is put on them during processing, and low enough not to lose too much longitudinal stiffness.

The founders of Bcomp came up with the idea for the powerRibs while running in the forest, discussing possibilities of reinforcing poles. "The very first powerRibs were actually plus and minus 45 degrees," De Rijk says. "Now, we have a zero and ninety degrees net. And it is not woven, but stitched together with thin polyester yarn. That way, the yarns slide easily with respect to each other, which is why we can do very complex 3D geometries with compression molding: the raw material just slides into shape."

Please cite this article in press as: D. Mathijsen, (2017), https://doi.org/10.1016/j.repl.2017.11.020