TECHNICAL BOOK

Add-on release
What's new in 2014?

Flax and Hemp fibres: a natural solution for the composite industry

CELC

JEC COMPOSITES

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Flax and Hemp fibres: a natural solution for the composite industry

Prepared for

JEC GROUP

By

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Flax & hemp composites: European skills in synergy

The world's leading production basin for flax and hemp plant fibres is Europe, a region where all the stages of the natural-fibre-composite value chain are in favourably close proximity to one another. From applied research to entrepreneurial dynamics, the strategic development of flax and hemp composites there is secured both upstream and downstream by the synergy that exists between complementary skills and expertise. This in turn guarantees a constant dynamic process in the market.

Fibre traceability at every stage of production

Flax and hemp fibres are high-quality resources that are available in quantity. These plant-sourced raw materials can make sustainable industrial innovation economically competitive. Flax and hemp fibres are first-stage products from confirmed agricultural expertise and comply with homogenous fibre quality criteria – a key requirement in first-stage processing.
Relying on maximised product and raw material lineage, semi-finished product manufacturers are now delivering expanded lines of specific characterised preforms. The advantage is that composite manufacturers can use these preforms without having to make changes to their manufacturing processes. Thanks to this intra-European "high-performance proximity", flax and hemp are now compatible with mass production conditions and benefit from a short supply chain.

Better performance, better for health

As an alternative to fossil-based resources, flax and hemp provide the multi-sector industry with high-performance composites that are better for health, helping to minimise the environmental impacts of composites. The details of these specific advantages are given in this 2014 update to the 2012 edition, along with details on new products on the market. The two fibres provide practical, marketed solutions to end-of-life optimisation for components.

Flax & hemp for a down-to-earth future

Pragmatism also involves economic forecasting, which includes anticipating promising solutions, planning growth drivers, pooling research results, and more. The CELC pools the resources of its operators in order to address these issues, including upstream expertise, first-stage processors, technical centres and user manufacturers. As the leading international intermediary for technical flax and hemp applications in the composite industry, the CELC has a primary objective: to contribute an informed perspective on R&D advances in its subsector, endeavouring to foster the inherent links with industry.

The CELC Team
European Confederation of Flax and Hemp

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- I - Flax & hemp composites, what's new?

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Potential growth

The Lucintel study presented at the JEC EUROPE forum in 2012 predicted a strong (10% per year) growth of the use of natural fibres as reinforcement for composites. This expectation seems to be materialising now. According to the recently published study by the Nova Institute (WPC and NFC: European and Global Markets 2012 and Future Trends), natural fibre composites represented between 10 and 15% of the total European market in 2012. Two-thirds of it (about 260,000 metric tons) were wood fibre composites (WPC) used in extrusion and injection moulding, and hence using only short fibres. The remaining one-third (90,000 tonnes) consisted of composites reinforced with other types of natural fibres, like flax, hemp and kenaf; these are used in typical long-fibre composite processes (e.g. compression moulding, RTM) and short-fibre-based injection moulding and extrusion processes.

As will be explained in the "Flax and hemp composites applications" chapter of this booklet, natural fibre composites are entering many different application domains. The automotive sector, however, is one of the leading sectors, and the only one for which quantitative market data seem to be available. In the same Nova study, an analysis was made of the use of natural fibres in automotive applications in Europe (Fig. 1).

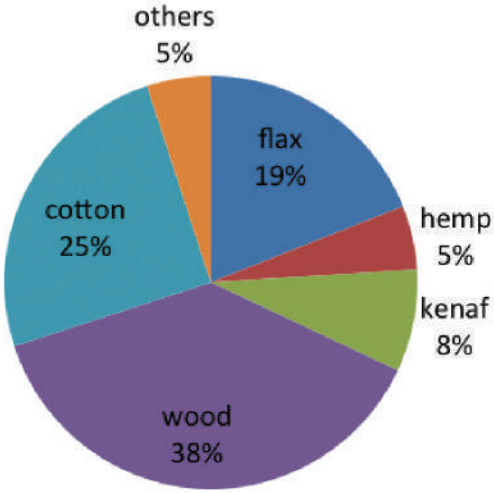


Fig.1 : Relative importance of all types of natural fibre composites in automotive applications in Europe (Nova Institute 2013)

A total volume of 80,000 metric tons (MT) of different wood and natural fibres was used in 150,000 MT of composites for the passenger cars and trucks produced in Europe in 2012 (hence, achieving an average weight fraction of 53% in such composites).
Wood fibre composites (60,000 MT of composites) were used mainly in rear shelves and trims for trunks and spare wheel shells, whereas the 90,000 MT of natural fibre composites mentioned further above were used mainly in trims for doors and dashboards in high-value cars. In the group of natural fibres, recycled cotton fibres (25%) were used mainly in truck driver cabins.
Of the remaining natural fibres (Fig.2), flax fibres represent 51% , or about 15,000 MT. **Together with the hemp fibres, these leading European natural fibres cover two-third of all natural fibre composites in the European automotive market.**

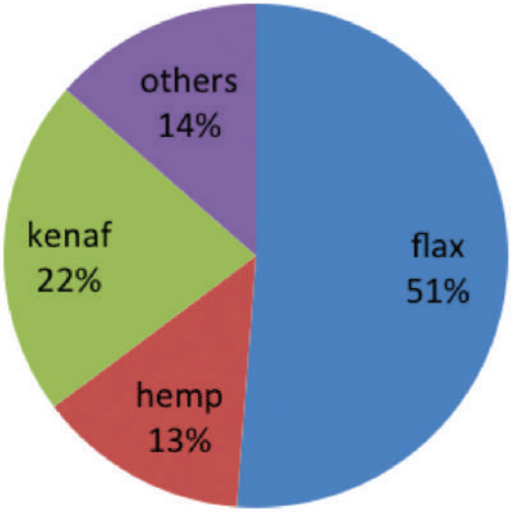


Fig. 2 : Use of natural fibres, excluding wood and cotton, in European automotive applications (based on data, published by Nova Institute 2013)

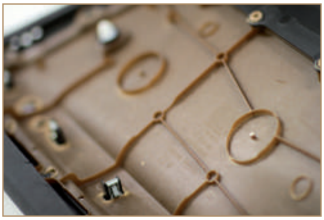
The growth potential, however, is big and promising. At this moment, the entire group of natural fibre composites (including wood and cotton) represents only an average of four kilograms of natural fibres per car. It has been shown that, in more advanced cars, a level of 20 kg per car can be easily achieved. Hence, we could reasonably expect a fivefold increase of the use of natural fibres in automotive applications. Due to their superior properties, it can be anticipated that flax and hemp fibres will achieve a similar increase, confirming the huge potential of these European fibres.
The potential growth in the automotive sector will certainly be followed by other application domains, e.g. aerospace, industrial, sports, or furniture, but statistical data are missing to quantify such growth.

Ongoing and expected developments

In order to achieve the expected growth, the European flax and hemp industry is developing new types of fibre preforms, the better to serve the composites industry and meet expectations there.

Three major development lines can be distinguished:

- **From non-structural to (semi) structural parts**: in the early development stage, natural fibres have been used in composites as random mats (mainly in compression moulding) or short fibre reinforcements (in injection moulding or extrusion). It is clear that if woven or UD-preforms are used, the composite mechanical properties will significantly increase, allowing for more semi-structural and even structural applications. The most recent developments of new preforms are presented in the next chapter. They are relevant for all application areas.



- The **challenge of automotive applications** is related not only to the achievable mechanical properties, but also to processing and market-volume aspects. Certainly in automotive, the large production volumes require preforms adapted to the specific manufacturing process (e.g. easy handling, good draping, high permeability), at affordable prices and with reliable, reproducible properties. Flax and hemp preform producers are taking these challenges seriously, as demonstrated by the many recently developed preforms presented in the next chapter.

- Such developments will certainly have **a positive spin-off to other application areas**. Development projects are already ongoing in the aerospace field, and sports applications have been a frontrunner in the use of flax fibre reinforced composites. The furniture market has also been discovering flax and hemp fibre composites.
In the chapter on applications, several exciting examples will be given of recently developed applications in these areas.

To meet all these challenges, the European flax and hemp industries are joining forces to speed up their composite-oriented developments. Several large European research projects are ongoing, at both the national and European scales. **Two focuses** are present in these projects:

- As mentioned above, specific **types of preforms** are being developed for composite applications. The combined involvement of flax and hemp fibre growers, preform producers and composite application designers and manufacturers is unique, and ensures that the developments achieved will meet the expectations of the composites industry.

- As more and more semi-structural and structural applications are targeted, **application-specific properties** like fatigue behaviour, crash resistance, moisture influence, and recycling opportunities are being studied.

Through its Technical Section, CELC is continuously improving the flax and hemp value chain and its relation to the composites industry via a large number of targeted actions: participating in JEC Europe, organising technical workshops throughout Europe, or using communication tools such as technical publications about flax & hemp solutions. This last includes the introduction in 2014 of the first **standard datasheet template for flax and hemp preforms** as a reference for the entire industry.

- II - Semi-products with flax and hemp fibres

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*Since the edition of **"Flax and hemp fibres: a natural solution for the composite industry"** in 2012, the development of new and better preforms has not stopped. **New preforms** continue to come to market, not only improving on existing ones, but also realizing completely new concepts, providing many more possibilities for the users of these preforms.*

There are two types of preforms, dry and pre-impregnated. New preforms of both types will be presented.
Besides the preforms presented, there are also new types of weaves available, or compounds with other compositions, than those presented in the 2012 book.

Dry preforms

In the group of dry preforms, most innovations have been implemented. The new preforms contribute to a much better performance of flax fibres in composites.

In the group of weaves and non-crimp fabrics, very fine weaves have been developed using low twist yarns. In the group of non-crimp fabrics, products with very low areal weight (115 g/m²) are now available. They are also made with lower-twist yarns, and there is more flexibility in the orientation of the different layers.

© Bcomp

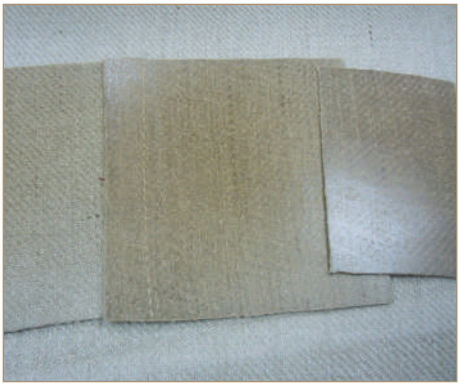
A braid with flax rovings is a completely new fibre architecture. These braids are available with different diameters, and are very useful for the production of hollow tubes. The mechanical properties are determined mainly by the braiding angle.

© Bcomp

UD preforms give the best mechanical properties because of the absence of twist and crimp. UD prepregs were already available, but now dry UD layers have also been developed and commercialised. They are produced with a patented process and no binder is added to the material. The flaxtape is available in different areal weights, from 50g/m² to 200g/m². The preforms can be used with both thermoset and thermoplastic matrices. The mechanical properties obtained show that the complete potential of the flax fibre is used. For a fibre volume fraction of 50%, a stiffness of 27 GPa in UD stacking or 15 GPa in cross-ply stacking is reached. The strength values are respectively 365 MPa and 185 MPa.

©Linéo

The combination of a technical fabric for the skins with a non-woven core layer is new. This sandwich textile can be used in standard composite manufacturing processes such as RTM and thermoforming. The pressure applied determines the final thickness of the end-product. By changing the structure of the textiles in the skins and the density of the core material, the user can adjust the physical properties (like thermal and acoustic insulation) and the mechanical performance. The fact that core and skin are made of the same material facilitates recycling.



©Groupe Depestele

The damping properties of natural fibres are well known. The product here completely optimized for applying the damping characteristics of flax to a composite, it can be used in any composite, particularly on flat plates and hollow tubes. This material consists of a woven (or UD) flax layer, to which very coarse yarns have been added. This greatly increases the structural stiffness of the product and the damping capability, while adding only a few percent in weight.

© Bcomp

Pre-impregnated preforms

©Ecotechnilin

Prepregs of non-woven mats in which the resin is also biobased are now available. For instance, furanic resins are made based on a waste product from sugar production. Prepregs of furanic resin with flax fibres can be transformed by compression moulding. Because of the furanic resin, the prepreg can easily be glued to a cardboard honeycomb. The fact that these prepregs are completely bio-based makes them very interesting from the ecological point of view.

Prepregs of a flax plain weave with PVC are now also available. These prepregs are prepared by dipping the weave into a PVC bath and then calendaring. The prepregs can be transformed into an actual part by compression moulding or thermoforming. The composites thus produced have a fibre volume fraction of 45% and a stiffness of 11,6 GPa.

©Solvin

This chapter completes Chapter V of the 2012 global publication "Flax and hemp fibres: a natural solution for the composite industry". Please refer to it for the complete range of semi-products with flax and hemp fibres.

Flax and hemp fibres, materials as key challengers for the composite market

It is a constant challenge to deliver to manufacturers of composite parts from many different sectors, complete, relevant and reliable material data, which have been measured using standardized methods. It is the explicit goal of the proposed ***"2014 Standard data sheet template for preforms - composites sector"*** *to enable this.*

The collective efforts of the industry's research and development activities of the Technical Section of the European Flax and Hemp Confederation (CELC) via its European Scientific Committee (CSE) are directed at consolidating the technical data that characterize flax and hemp preforms. This constitutes an essential starting point for an informed collaboration with manufacturers for large-scale utilization of these fibres.

Standard data sheet template for preforms

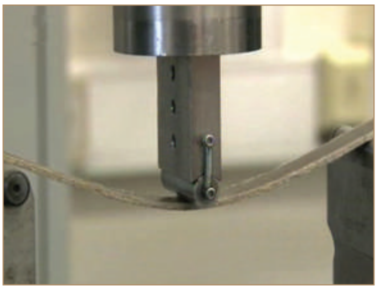
The flax and hemp industry is actively involved in a number of complementary organizational research projects, including Sinfoni, Lint and Fiabilin. The industry brings in cross-sector expertise from upstream players, primary processors, application manufacturers and technical centres. In support of these partnerships, the flax and hemp industry, is implementing a standard data sheet template. Standardizing the nomenclature has been the subject of consultation with industry and laboratories involved in ongoing research projects. The new standard data sheet template helps manufacturers ensure that flax and hemp preforms are compliant with application specifications, and also provides guidelines for all producers and users of preforms.

Currently, datasheet templates are available for 3 different types of preforms: random mats, weaves and non-crimp fabrics.

The format of the three datasheets is the same, each divided into four sections:

A. **Identification** of the preform
B. **Characterization** of the preform, meaning the areal density, type of yarns used, weave style, etc...
If a fibre treatment has been applied, then this should be included.
C. **Mechanical properties** of a composite produced with the preform: strength and stiffness in tension and bending
Plus the recommended storage and processing conditions.
D. The final section of the datasheet is **optional** and can be used to provide additional information about other relevant properties such as compressibility, drapeability, damping capacity etc.

All data sets are measured following international standards, in line with glass and carbon fibre benchmarks.
More information: technical@mastersoflinen.com



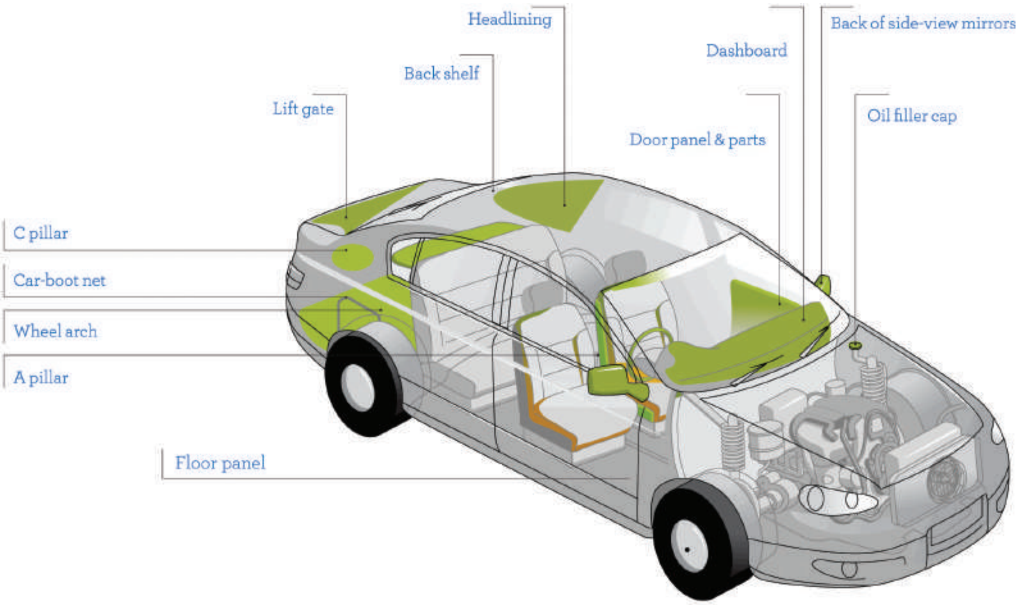
- III - Flax & hemp composite applications

TECHNICAL SECTION OF CELC

What's new in 2014?
This chapter completes the chap VIII of the 2012 global publication.
Please refer to it for the complete range of flax and hemp composite applications

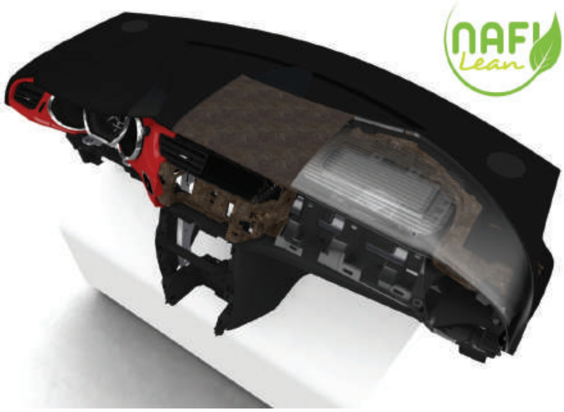
AUTOMOTIVE

In the automotive sector, the European 2000/53/EC directive on end-of-life vehicles sets an important industry objective for the year 2015: to achieve a 95% reuse/recovery rate for automotive components in terms of average weight per vehicle per year, with an 85% reuse/recycling rate.
Flax and hemp composites are offering a much more far-reaching approach than just addressing the recycling/reuse-issue, because they provide a more fundamental solution: a weight reduction (and hence less fuel consumption) and a renewable resource (and hence reduced life cycle impact)".
These renewably sourced composites can now be used in structural parts for car passenger compartments, with potentially far-reaching innovative structural design orientations affecting the entire life cycle. Selected for their damping performance and weight-reduction potential, flax and hemp fibres also have good mechanical properties and are exceptionally processable.

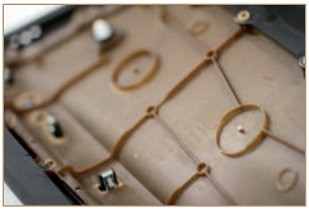


Dashboards: Hemp/NAFILean TP

Recyclability
Low weight



Faurecia's NAFILean project is an example of the teaming up of hemp fibre reinforcement with thermoplastics, which are more easily recyclable, more rapidly processed, and less harmful in terms of emissions. Replacing long glass fibre reinforced polyethylene (PE-LGF), the new-generation NAFILean material consists of a hemp fibre reinforced polypropylene matrix that is suitable for structural applications like dashboards. The advantages of a renewable resource and a 15-20% weight reduction compared to standard architectures are already benefitting the production of Peugeot 308 door panels.



© Faurecia

This new material has been validated for crucial interior applications (large parts that are subject to stringent safety requirements like head and knee impact or airbag deployment) based on long-term ageing estimates. This material enables complex shapes that can be processed on standard injection moulding machines at the same cost as PP-LGF. Another industrial advantage for large-scale use is the further reduction of the environmental impact, with the recycling capability in compliance with the standard for talc-filled PP. This constitutes a breakthrough, since landfill is the (unwanted) default alternative for materials reinforced with other fibres.

100% biosourced floor panels

© Jaguar

The first entirely biosourced floor panel is being used on the latest model of the Jaguar F-Type convertible. The 100% renewably sourced panel consists of a honeycomb paper core with skin layers of non-woven flax mats that are preimpregnated with a sugar-based thermoset resin. The panel is formed using a hot press process. It is 10-mm thick, with an areal weight of 2,500 gsm. As an alternative to glass fibres, flax fibres confer the mechanical strength and low weight needed to meet the specifications for this ultra-demanding sports car. The perspectives are good for the large-scale use of 100% bio-sourced panels and boot floors.

#PROJECT: flax/TP structural trim panels

Biosourced matrix
Low weight

PSA, Faurecia, Lineo, and the University of Reims have been partnering in the Flaxpreg project on structural trim panels, with three goals: a drastic weight reduction; the use of renewable resources; and processability of the composite with cycle times and material costs that are compatible with the constraints of automotive mass production. The material researched under the project is a semi-structural sandwich consisting of a paper honeycomb core with layers of long (80 cm) flax fibre mats and a thermoset resin to replace glass fibre/polyurethane composites. It complies with the Corporate Average Fuel Efficiency standards (CAFE China & Europe 2020). To guarantee the best possible environmental performance, both biosourced thermoset resins and polyamide thermoplastics are being examined. Due in particular to the excellent damping properties of flax, the focus over the medium term is on applications to replace metal, using flax in combination with glass and/or carbon fibre.

©PSA

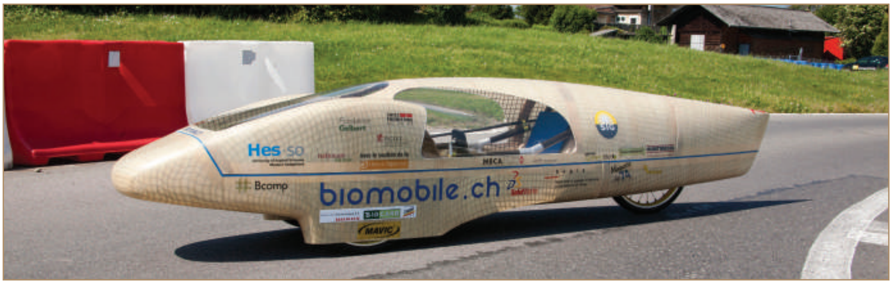
TRANSPORTATION & MOBILITY

Low weight

Due to the transformation of urban infrastructure and to increasing regulatory pressure on the recyclability and optimisation of energy consumption for vehicles, we must find innovative solutions for optimised passenger transportation. To navigate this mobility change, research is focusing on new types of vehicle. Flax and hemp composites can contribute structural solutions for prototypes that require strength and lower weight.

The BioMobile chassis prototype

The development of composite structural parts reinforced with natural fibres also applies to vehicle chassis. The “bio” objective of the BioMobile prototype, a vehicle with a heat engine powered by biofuel from organic waste, also involves revolutionising its structure. To replace as many metal parts as possible and offset the embodied energy required to manufacture the parts, this vehicle is designed with a lightweight tubular structure made of composite reinforced with UD flax fibre and a 100% flax grid for extra reinforcement. The extra-low weight ensures the BioMobile’s performance and staying power in competitive mode.



©Biomobile

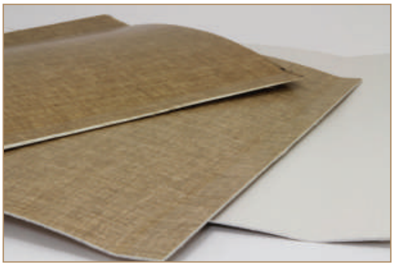
Human-powered vehicle

The CIEO project put together by ETH Zurich teams up a number of large European universities. The goal is to design and build the world's fastest human-powered vehicle (100km/h). The bold tandem bicycle concept combining aerodynamics and high-tech materials has been tested by high-level athletes. The half-monocoque body is reinforced with a flax grid in combination with specific composite manufacturing methods.
The thin-walled structure is reinforced with millimetre-scale stiffeners with defined thickness, orientation and density, giving the ultra-fast tandem a high-performance in terms of an optimal flexural strength to weight ratio. To increase the level of comfort and, as a result, boost the sports performance, the CIEO is pursuing further development on composites with combined biaxial-unidirectional flax reinforcement.

© CIEO

AEROSPACE

#PROJECT: biosourced panels for aircraft interiors



Industrialising the production of biosourced panels for aircraft interiors is the objective that unites a European consortium of four partners *(Lineo, Invent GmbH, Boeing Research & Technology Europe, and Aimplas)* who are pooling a range of expertise that includes technical flax textile fabrication, the production of composite parts for the transportation industry, thermoplastic R&D, and composites. Since 2011, the consortium, called

Cayley, has been researching the industrialisation of sandwich panels made of different matrices reinforced with natural fibres. Perfecting the fire-containment treatment and optimising the dimensional stability are priority issues.
The Cayley project is prioritising research on systems with flax that is treated specifically for resistance to flames, smoke toxicity, and heat release. The reinforcements are combined with geopolymer, thermoplastic or biopolymer matrices to create the outer walls of the sandwich panels. The core material used for the panels is a thermoplastic foam designed for optimum fire resistance. The combination of these materials will help to considerably reduce the environmental impact of aircraft interior parts.
In addition to its advantages like vibration damping, better sound behaviour and lower cost, flax also reduces the environmental footprint of composite materials here. By its lower weight, it will lead to lower fuel consumption. The performance of these biosourced panels is adapted for aerospace requirements and can also meet the requirements for all types of transportation vehicles.

WIND ENERGY

PROJECT: ecodesigned wind turbines

© Univ. Nottingham

The design of composite wind turbine blades must comply not only with quality assurance, but also with the environmental regulations in effect, including for end-of-life (EOL) recycling. A two-year research project has achieved this objective, for a wind turbine blade made of flax-reinforced composite that is in compliance with British standards (IEC/British standard 61400). The blade prototype that was tested with success is adapted for an 11kW turbine, sufficient to provide five households with electric power.
A wind turbine's power depends mainly on the area swept by the rotating blades, so the goal of the research was to optimise the size of the blades and their strength, stability and vibration damping properties. Due to its good mechanical properties in terms of specific stiffness and strength, flax provided efficient solutions for all of these constraints. A vacuum infusion process was used to preserve the mechanical strength properties and reduce CO_2 emissions compared to traditional assembly processes.
The flax composite used for the blade has a polyester matrix reinforced with flax roving, and 300 g/m2 UD and 600g/m2 +/-45 biaxial preforms. The weight of the preforms used to make the blade decreased by half, resulting in more than 10% reduction of the blade's total weight of 23 kg (9 kg for the polyurethane foam core, 10 kg of resin, and 4 kg of flax fibre instead of 8 kg of glass fibre).
Based on fatigue tests, the service life of these ecodesigned blades is an estimated twenty years. The overall EOL balance for this new type of blade substantiates the economic advantage of flax over glass fibre; moreover, flax can also be incinerated, enabling energy recovery and carbon efficiency.

Vibration damping & lightweight

For this dynamic market, where the applicable standards are less stringent than in other sectors (e.g. aerospace), we can propose and rapidly commercialise new technologies. Whether it is for easier handling by a newcomer or to meet the requirements of experienced competitive players, low weight and vibration damping in the equipment are crucial advantages to ensure better performance. Flax has undeniable advantages for many disciplines in the sports sector.

Ping pong bats

This ping pong bat, which is designed for players who are training or competing, has a completely different feel and sound to it compared to standard bats. It is made of 7-ply laminated wood, including a balsa core with two flax-fibre plies. The vibration damping properties of the flax fibres makes for better play.

© Artengo

A cross-country ski with a recycled-PET foam/flax core

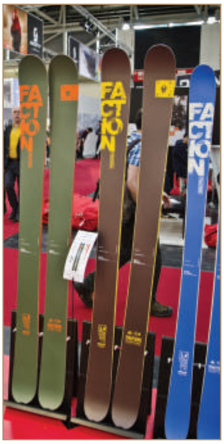
©Movement

The centre of a ski is traditionally made from a wood core, usually covered with a glass fibre reinforced composite. Now, there are alternatives that incorporate high-performance flax fibres. Wood may absorb impacts, but its weight needs to be optimised. By combining the core balsa with a recycled PET foam that incorporates a flax prepreg, one gets the additional advantage of high specific fatigue strength *(= fatigue strength divided by density)* due to the structural foam's low density and the flax fibre's high strength.

Moreover, during the machining of a standard wood plank, nearly half the material is lost to production waste through milling or grinding, and this slows down the machine time. The use of the flax composite in the core gives better results for cycle time and quantity of production waste.

This core, which can be machined like wood, is the lightest one on the market, yet with the "woody" feel to it that skiers expect.

Off-trail ski



©Faction

These high-performance skis dedicated to off-trail skiing are made with a balsa/flax core. This makes the ski lightweight, and with that comes more versatility. One can ski on longer skis for stability but still hit rails and spin with the same ease of shorter skis.
As with the cross-country ski, machining the core from a classic wood plank wastes about half of the material through milling or grinding. All this material needs to be evacuated during the machining process, which wastes machine time. When cores made from balsa and flax are used, the ski remains light, and less waste is produced because the manufacturing of such cores is more material efficient. Reducing the waste by 50% means a 50% lower environmental impact.

Ski poles

This ski pole is just as lightweight, stiff and strong as a carbon-fibre ski pole, with increased impact strength, thanks to flax's energy-absorbing properties. The pole is made with a flax braid and UD carbon/flax fibres. Twenty-two millimetres in diameter and up to 135 cm long, the pole has three times as much damping power as its synthetic equivalent, and therefore fewer vibrations with optimised comfort for the skier. The price of the finished product is equivalent to that of an aluminium or carbon pole, i.e. in the middle - to top-of-the-range segment. This new technology also is in pole position for ecodesign!


©Kang

Saddletree


©Sellerie Thomas Plfiger

To spare both the horse's and the rider's backs, the structure of a saddletree is crucial. The saddle core influences the steadiness of the bearing surface and needs to be adapted to the horse and the mechanics of its gaits. This implies a material that is flexible, yet able to absorb movement and return to its initial shape – unlike steel, which has a tendency to grind into the horse's back. The use of a flax fabric with a bonded wood laminate and multi-ply beech veneer reduces shock-wave vibration by 30%. The saddletrees are made to measure for a high-end segment, and guaranteed to resist repeated impacts from a rider weighing 100 kg, jumping over a 160-cm-high hedge.

Watersports/Kite surf

The advantages of natural fibres have been put to use in a new twin-tip kiteboard concept. This type of board is best adapted to beginners and its human engineering is similar to that of a snow-board. A PET/flax core with UD flax fibre lay-up guarantees lower weight for greater agility. At 1.9 kg, it weighs 25% less than standard kiteboards, with more comfortable vibration damping thanks to the flax properties, allowing the surfer to take on the choppiest waves.

© FFC

© VE Paddles

Watersports/Kayak paddle

A good paddle should make you forget it is there, whatever your kayaking experience. The blade quality should contribute to paddling comfort and relaxed, smooth strokes. This double-bladed paddle is made of UD flax fibre reinforced composite, guaranteeing a stiff, accurate blade that is more lightweight than a fibreglass one, yet designed to withstand more wear in wildwater sports.

BOATING

According to the French Federation of Boating Industries, the average age of the 546,000 active leisure craft is 23 years, while the service life of these boats is 30 years. The end-of-life (EOL) issues for these boats, which in general are made of rot-proof composite materials that are not particularly upgradable, will be problematic. Alternatives that are currently only at the prototype stage are heralding a new generation of more environment-friendly watercraft.

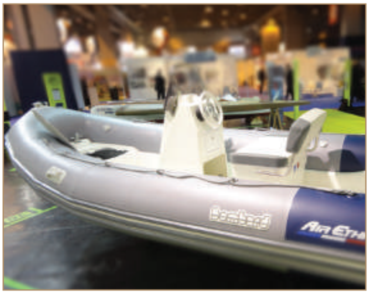
The *Gwalaz* is a 7-metre-long trimaran weighing 520 kg that cruises off the coast of Brittany, at speeds up to 16.4 knots. The boat incorporates bold ecodesign features, with flax fibre replacing glass fibre as reinforcement for the structural materials. The biocomposites used for the boat combine these natural fibres with mainly biosourced resins, e.g. those obtained from rapeseed-derived molecules. The *Gwalaz* is made up of 110 kilos of flax fibre, 33 kilos of balsa wood and cork, and 285 kilos of resin, 30% of which is biosourced. The infusion process used for the composite is in widespread use in boatbuilding, making it possible to assess performance against other materials. While the composites used in the Gwalaz are not yet recyclable, they can be incinerated *(with a minimum of remaining ashes which have to be landfilled)*, which facilitates EOL procedures.

©Kairos

The Aretē is a 4.60-metre-long monohull prototype that is testing the strength of its innovative composite material In real-life racing conditions. Its UD flax/thermoset hull weighs 65 kg, and the natural fibres account for 70% of that. This greener, lighter material advantage has made the boat a three-time winner in regatta mode.
Prototypes like these serve to test fabrication techniques, biomaterial performance at the boat scale, and the behaviour in real conditions, boosting progress significantly towards 100% biocomposite boats.

Semi-rigid boats

The semi-rigid boats in the AirEthic project are built by assembly of a rigid composite hull and an inflatable float. Both boats, winners of the 2013 JEC Innovation Award in the Sports & Leisure category, were designed according to the same ecodesign principle. The AirEthic is now produced in series, while the Z-Concept is a concept boat that incorporates all aspects of eco-impact reduction, including recyclable thermoplastic materials, biosourced materials, clean processes and electric motor.



© Zodiac

To reduce the composite hull's environmental footprint, the RTM process was chosen, with flax fibre reinforcement for moulding the AirEthic's bottom and deck. Both these AirEthic parts are moulded in separate tooling, while the Z-Concept is designed for one-step assembly of the entire hull, with flax reinforcement on the deck side. The environmental impact of the composites used so far in semi-rigid boats has improved ever since it has been shown that some of the glass-fibre reinforcement can be replaced by the flax reinforcement material.

Flax's low density and vibration damping capability are serving in new applications to produce or retransmit music according to high acoustic standards.

Ukulele

This ukulele is the first concert-level instrument made in natural fibre reinforced composite, and combines two innovations. This new instrument has a sound like vintage wood, and peerless acoustic quality. It is also lightweight and strong, which facilitates transport. The ukulele back incorporates a multiaxial flax prepreg (with cashew-oil-derived resin) and the front, a flaxtape. As a commercialised ecomaterial innovation, this could herald the development of other high-tech instruments.

© Blackbird

Speaker diaphragm

© Focal

In the field of home and in-vehicle audio systems, five years of research has led to a new generation of speaker diaphragms in a new version of the glass/glass sandwich structures that has been very successful in high-end models.

The diaphragm quality is crucial for the transducer interface: the diaphragm, or membrane, captures the vibrations from the air in movement, and the transmitting fidelity depends on the intrinsic properties of the material used for the membrane. Ideally, the membrane should meet three main, somewhat contradictory criteria: it must be lightweight to optimise the rate of acceleration; it must be stiff enough to act as a piston; and it must be damped to avoid affecting the sound.

Flax has low density, a high Young's modulus, and good vibration-damping capability. For this new-generation diaphragm, the flax is used in combination with other composite materials. A multiaxial flax fabric is placed between two sheets of glass fibre to form a sandwich structure with very low density, high stiffness, and favoured straight cones as they deliver tighter bass. Another advantage is that the fabrication process can be mechanised and automated to enable the production of reasonably priced speakers.

PERSONAL EQUIPMENT

Aesthetics

Given that the aesthetic aspect of flax composites sometimes appeals to manufacturers, in particular in the field of sports, it goes to say that "naturalness" as a feature is also giving rise to new creations in the field of personal equipment, where the combination of form and functionality is on display.

Glasses frame

Six plies of 100% flax impregnated with a biodegradable resin make for an ultra-light pair of glasses. Awarded for its technological innovation at the 2012 Silmo d'Or optics/eyewear tradefair, this frame is marketed with an adjustable nosepiece for a perfect fit and a patented In & Out system for mounting the lenses. Flax's impact and vibration resistance guarantees a tough frame weighing only 10 grams. Upcoming design developments will likely include vibrant new colours, thanks to flax's great compatibility with dyes.

© Custom 6

Leather goods

The design of this overnight suitcase is both aesthetic and technical, featuring a 50%-flax/thermoplastic-polyamide-resin composite. Aiming for low weight and robustness, this limited-series article showcases the refined natural qualities of the materials, a combination of flax and calf skin.

© Delsey

Case for reader or touch-screen tablet

This attractive case not only protects portable electronic devices on a day-to-day basis, it incorporates functional features. The needle-punched flax mat/recycled polypropylene exterior is glued and sewn to an inner spunlace-mat/polyester layer to protect readers or tablets from vibrations and temperature fluctuations. Another advantage is the possibility to write comfortably on the notepad.

© Tapegear

Roof exhauster

Installed at the top of an air duct, this exhauster considerably improves the natural evacuation of vitiated air from inside rooms, using the force of the wind that blows over it. Its aerodynamic design ensures protection of the duct and the ventilation system from the outside air and rainwater.
Because it is subject to temperature variations and weather conditions, this exhauster designed in thermoset composite combines stiffness and long-term durability. With 30% flax fibre mat reinforcement, it offers an alternative to the standard use of glass fibre, reducing the environmental impact and improving the product's end-of-life management.

© Mastermodel/Uniwersal

Lighting

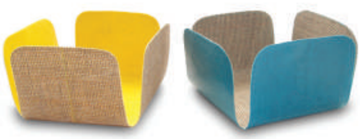
This creative lamp is made of semi-transparent tinted composite in a carefully designed complex shape, using a new material. Combining a pearly inside layer with a multiaxial flax composite and available in blue, green, yellow or red, the lamp "sheds a new light" on the finishing possibilities for flax composites.

© AIM Studio

Colour!

Home accessories

This stackable tidy is made using a commingled flax fabric with polylactic acid (PLA). This home accessory is an example of an attractive, practical ecodesigned application that is entirely biodegradable and recyclable. It also demonstrates the great compatibility of flax composites with dyes, opening up a generation of beautiful, colourful biomaterials.



© M Design

Ecological

© davidderksen
Styling and photography by Camille Cortet

Table top

Designed for office spaces, this lightweight table on aluminium trestles is based on a «cradle to cradle» (regenerative design) concept. The flax/hemp reinforced bioresin composite table top meets this environmental requirement, since it can be composted at end of life. The material is as soft to the touch as it is easy on the eyes. Its low weight also makes it more practical and accentuates its elegant minimalist lines.

Cantilever chair

Form, function and ecodesign: this threesome stimulates the creativity of designers who have embraced the use of 100% recyclable natural materials that are still aesthetically suitable and functionally efficient. Carefully designed for cantilever comfort, Flaxx consists of a metal frame that is stabilised on four feet, with a flax composite shell. For the requirements of this precariously balanced structure, the shell must have flawless strength. The flax mat/polypropylene (PP) seat provides optimum flexibility for comfort and lasting resistance in terms of durability and weatherability. Flaxx is designed for both indoor and outdoor use, and comes in green, black, beige and white.

©Flaxx

©Magis by Philippe Starck, Zartan Eco

Chair shell

A feat of ecodesign with fluid lines: this chair is made from recycled, recyclable, and biodegradable materials. Designer Philippe Starck used a recycled PP for the underframe and a choice of flax mat/PP or hemp mat/PP composite for the seat. The shell shape entails absolute control over the compression moulding process, and the result is a comfortable chair with pure lines.

One-piece chair

An injection moulded hemp composite solution has been developed to meet the specifications for chairs destined for community use: ecodesigned, stackable, and lightweight yet stable and strong. The complex grooves moulded into the structure of these one-piece seats are not just there for the aesthetics, they also contribute to the chair's sturdiness and overall stiffness. These Geometric chairs from Finnish design studio Ko-Ho can be incinerated at end of life without harmful emissions. They come in several different colours.

© Ko-Ho

© Youkaïdi

Pin-stripe armchair

In a play on the visual codes of a fabric, Alice is an armchair with a shell that incorporates a biaxial flax composite and a patterned linen fabric. The material not only has the suitable structural properties to one-piece mould an armchair, it also allows novel graphic finishing touches: beneath the transparent surface, the lines and natural colour of the flax composite show up in a nice optical effect against the blue striped veneer.

URBAN FURNITURE

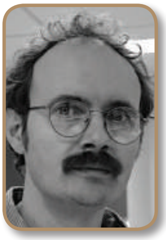
Eco-intelligent outdoor lighting

© Saint Luc Edition

Already in use as urban furniture in Norway, Shrooms are ecodesigned light fixtures made of flax composite. They are lighting up the village of Falger, and also decreasing its energy consumption by 75%, via a system of Leds controlled by an ambient light sensor and a smart presence-detection radar. Besides this ecobenefit, the ecoprocess involves the use of renewably sourced materials: flax fibres are used to replace the glass fibres usually used for this type of application, consuming only one-tenth as much energy as glass during the production phase. The composite used for the shrooms is reinforced with multiaxial flax, combining low weight and a toughness capable of withstanding the outdoor weather conditions.

- IV - Minimising environmental impacts over the entire life cycle

FURTHER INSIGHTS INTO LCA FOR BIOCOMPOSITE MECHANICAL RECYCLING OF BIOCOMPOSITES



Christophe Baley,
Professor at the University of Bretagne Sud,
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Assisted by Antoine Le Duigou, Associate professor
at the University of Bretagne Sud,
LIMATB (laboratory of engineering of materials of Bretagne), France

Previous works mentioned in Chapter IX of the previous co-published book have focused on eco-design, life cycle analysis (LCA) and recycling. The present update leaflet focuses more specifically on the use of an LCA approach in the recycling of biocomposites.

1. Why is recycling necessary?

Recycling can involve thermal, chemical, biological or mechanical means. This article focuses on mechanical recycling, which includes waste collection, grinding and forming. From an ecosystem point of view (the earth), humans are facing issues like the dwindling of accessible non-renewable resources and the rising production of waste. Recycling, which recovers waste material and re-introduces it into the production cycle, is one solution to control human pressure on environmental resources, especially given population growth.
In a solution using biobased material, photosynthesis enables plant growth (flax or hemp fibres for example) by storing carbon dioxide from the atmosphere and converting it into carbon (the plant skeleton). If you go on to recycle that biobased material, even more carbon will be stored (1).




2. Life cycle analysis

Basically, life cycle analysis is performed following ISO 14044 standards (2) in a typical cradle-to-grave approach. Life cycle boundary becomes more complex when recycling or the use of recycled material is taken into account, enabling a “cradle to cradle” approach.

We need to distinguish between closed-loop and open-loop recycling. Closed-loop recycling is a process that recovers materials without any quality degradation, while the open-loop process deals with materials for which the properties deteriorate when the material is recycled. Thus, one will have to use specific allocation rules in order to “share out” the environmental impact between the different processes (3), e.g. when plastic bottles are recycled into plastic garbage bags. Hence, recycling avoids various inputs for plastic garbage-bag production but without plastic bottles as input, recycling process has no-sense.

According to the methodology developed in BPX 30 323 2-0, both the producer using the recycled material and the other players producing recyclable materials must be factored into the environmental impact of recycling the material. Other parameters to be taken into account include the:

- amount of recycled material
- recycling rate
- impact of virgin material
- impact of recycling process (collection + grinding)
- impact of elimination (incineration, landfill...)
- loss of functional properties.

3. Example with PLA/flax biocomposite

The work of Le Duigou et al. (4) has shown almost no variation of Young’s Modulus for PLLA/flax biocomposites when they are recycled. Therefore, for the stiffness criterion, no loss of biocomposite properties has to be accounted for. Figure 1 compares the impacts of three different uses of an end-of-life PLA/flax biocomposite. More information (design criteria, functional unit, boundary, etc.) is available on reference (5).

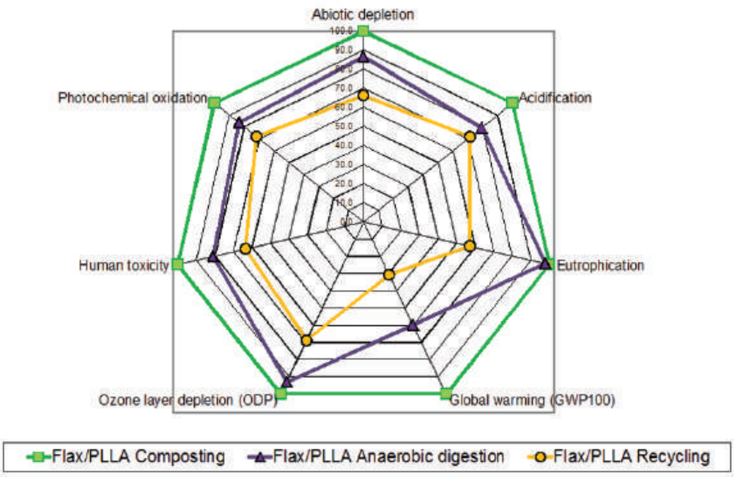

Fig 1: Comparaison of environmental impacts for the life cycle of flax/PLLA biocomposites: composting, anaerobic digestion and recycling

Analysis of the results indicates that all three scenarios result in globally lower environmental impacts than those for the glass-mat/polyester composites typically used for marine applications.

The recycling option should be favoured, as it significantly reduces all the indicators compared to the other methods (composting and anaerobic digestion). Both raw material consumption and waste are reduced when a hypothesis that includes 50/50 sharing of the impacts between upstream and downstream life cycles (1) is adopted for biocomposite recycling. However, recycling implies a relatively high non-renewable energy consumption compared to the scenarios with energy recovery, due to the sorting and grinding steps. The evaluation of the environmental impact of recycling is complex, and a number of hypotheses (6) are not universally accepted. It should also be borne in mind that recycling is more of an end-of-use treatment rather than an end-of-life treatment such as composting.

Anaerobic digestion is an appropriate solution for biocomposites, as it allows methane production (biogas). The methane can be exploited for energy, thus reducing global energy consumption. Aerobic composting consumes non-renewable energy in a similar way to landfilling and results in globally higher impacts than the other end-of-life scenarios. In addition, leachates can be produced, which can increase eutrophication The advantage of both aerobic and anaerobic composting lies in the production of biomass, which can improve fertility of the soil. This is not taken into account in our analysis.

Given the importance of the end-of-life treatment, it is essential to set up the appropriate facilities as soon as these biocomposite materials are developed commercially (e.g. in the automotive, railway, or marine sectors) in order to optimise their environmental impact.

4. Conclusion

Recycling is an end-of-use treatment that enables re-introducing material into the production cycle. A specific LCA methodology is being developed to take the relation between the different life cycles into account.

The recycling option should be favoured for flax/PLLA biocomposites, as it significantly reduces all the indicators compared to other methods such as composting and anaerobic digestion.

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Recovering end-of-life biosourced materials and identifying waste stocks

ADEME, the French Environment and Energy Management Agency, is partnering with industrial players to sponsor a nationwide study to identify the current waste stocks of end-of-life (EOL) biosourced (1) materials in the transportation, packaging and building sectors.

The study will help to
1) assess the evolution of such stocks and the corresponding dynamics for change through to 2020 and 2030;
2) assess the compatibility of existing stocks with current recovery streams;
and 3) determine how relevant it would be to develop specific streams.

The study results will be published in Spring 2014.

Biosourced material production has greatly increased over the past few years. Renewable resources have become a reliable alternative to fossil-based materials, given that the performance of natural materials can be as high or even higher than standard materials. The transportation, building and packaging industries are particularly interested in these materials.

To smooth the introduction of biosourced materials into these markets, it is important to assess their impact over the entire life cycle. This also includes end of life, because regulations require the recycling of these materials and recycling objectives are sector specific.
Current waste stocks for EOL biosourced materials with innovative polymer structures are small in comparison to those for standard materials, but have not yet been properly identified. This makes it difficult to set up effective recovery solutions. Even in the current context, however, the market share of biosourced materials will certainly increase.

To accurately predict how future waste stocks will develop and to anticipate the associated recovery potential, we need to come up with a forward-looking vision that fosters the active participation of the manufacturers involved, and thus also helps to develop the subsector for biosourced products.

Europe is the leading production and processing basin for flax and hemp fibres, providing a regional supply for the production of biosourced composites.

Reference:
ADEME, Agence de l'Environnement et de la Maîtrise de l'Energie/French Environment and Energy Management Agency

(1) For the purposes of the study:
Biosourced composite: a combination of non-miscible materials, part of which are derived from plant resources
Fibres only or mixed with additives

- V - Flax & hemp composites, on going developments

ABOUT WATER/DURABILITY

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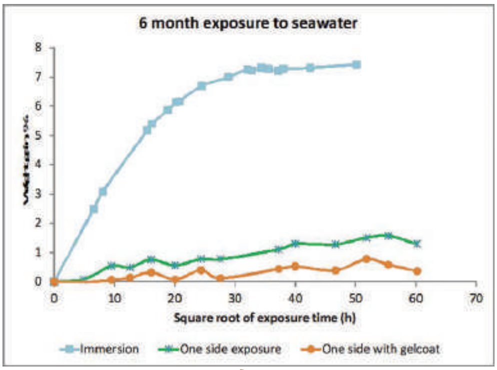
There has been some concern expressed over the durability of flax and hemp based composites in wet environments. This is understandable, cellulose based fibres are sensitive to moisture, though it should be remembered that many wooden sailing ships have been in service for decades. Nevertheless the durability of biocomposites in a wet environment is an ongoing research topic and various studies have been published the last couple of years. Two aspects should be underlined:

First, all natural fibres contain water, typically up to 10% by weight. This water is essential to obtain the attractive properties of these fibres. Drying will result in lower failure properties [1] and this must be considered when defining a manufacturing process.

Second, it is the matrix resin in a biocomposite which protects the fibres, just as in a traditional composite the matrix protects glass fibres (which are also sensitive to water). However, the standard practice used to examine wet aging is to place small composite coupons with cut edges in water and measure weight gain, and this is very severe on biocomposites as water wicks along the fibres and this may result in high weight gains, 10% or more. This is not representative of most applications, in which only the sample face is exposed to water; when tests are performed under these conditions weight gains are low, similar to those of traditional composites with the same matrix resin, Figure 1 [2].

a)



b)

Figure 1: a) Water bath with external samples to examine water entry through sample face, b) example of weight gain plots for complete immersion and single face exposure.

Another aspect of durability resistance to weathering, and in particular to sunlight and ultra-violet (UV) aging. Again this is an ongoing research topic but the first barrier to UV degradation is the matrix resin, not the fibres. The choice of matrix is therefore critical and this is common to all composites. The cellulose fibres will degrade if exposed, but this is not a new problem and there is extensive knowledge of the weathering of wooden structures. A recent overview of published work in this area was provided by Azwa et al [3].

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FATIGUE BEHAVIOUR OF FLAX REINFORCED COMPOSITES

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The use of flax-fibre textiles as replacement for synthetic textiles is on the increase. While these fibres have been used for millennia, not much is known about their fatigue behaviour in a composite. This has limited their use in high-performance applications like aerospace components. Only a few studies from Shah et al. on flax/epoxy and Gassan et al. on flax and jute reinforced epoxy talk about this performance. The purpose of the present work is to systematically study the tension-tension fatigue behaviour of flax-fibre composites and of several different textile architectures and laminate configurations used in a wide range of applications.
The assessment showed that textile architecture has a strong effect on the fatigue behaviour, as seen from S/N curves in Figure 1a (1). We observed that flax/epoxy composites with higher strength and modulus properties exhibited delayed damage initiation, increased failure loads, and slower damage propagation rates. We also observed that the flax composites exhibit slow stiffness degradation due to their largely fibre-dominated properties (see Figure 1b (2)). Furthermore, unidirectional composites were less sensitive to fatigue-induced damage than woven or random mat. The wide hysteresis loop may also be a sign of high damage activity during the initial phase of fatigue loading, indicating greater energy dissipation at the fibre–matrix interface. This damage does not appear to have big influence from then on, up to the test piece's failure. This behaviour indicates a high dynamic modulus due to the potential reorientation of the flax microfibrils present in the elementary fibres, from 10° to 0° (3) .

a)

b)

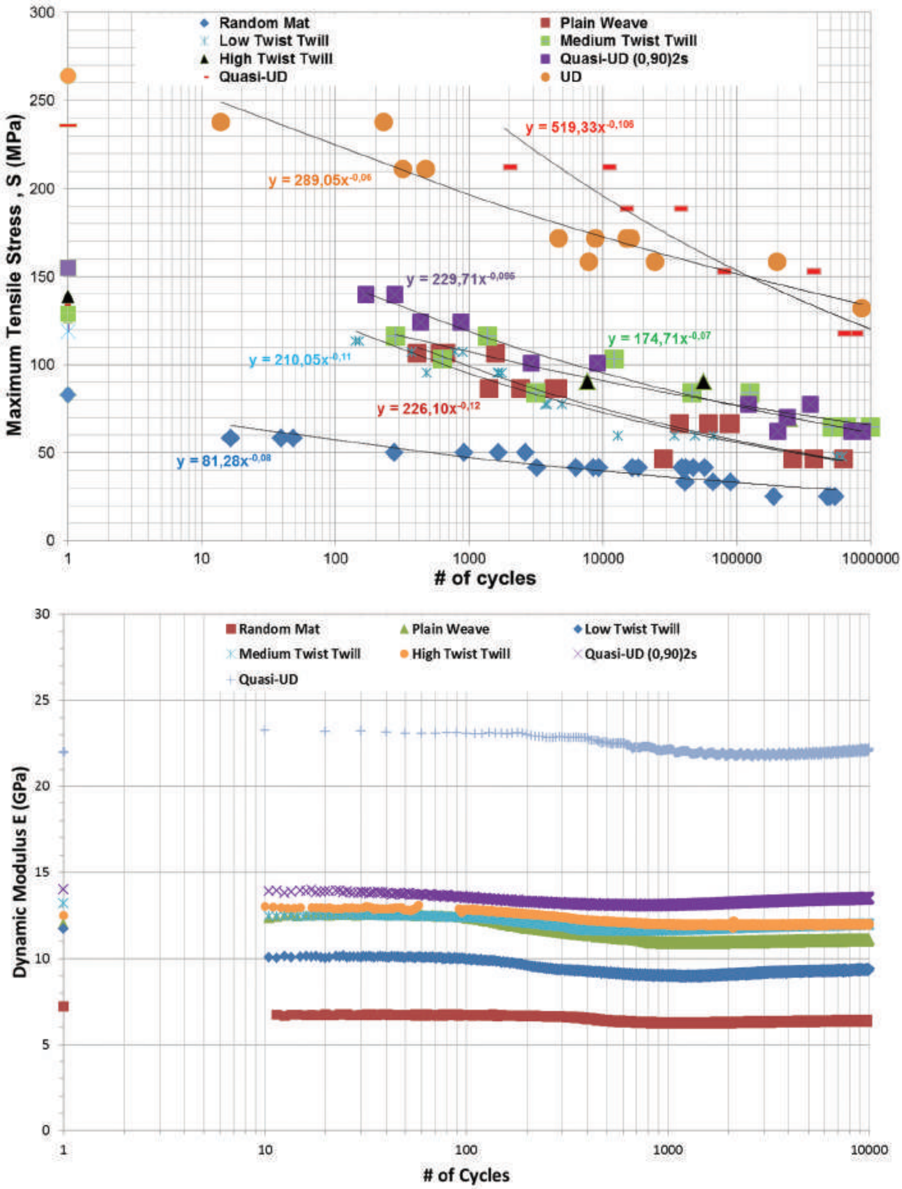

Figure 1: a) S/N Curves and b) stiffness degradation of various flax-epoxy composites.

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Simulation of bio-based composites – NFC-Simulation

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Professor at University of Applied Sciences
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To give natural-fibre-reinforced plastics the same status as established conventional plastics, all components must be predictable and the data must be considered in the material selection process. In this context, material selection is an important activity in the component development process. The aim of the NFC-Simulation project (M-Base, 2013) is to generate a complete, integrated solution for the simulation of injection-mouldable, natural-fibre-reinforced parts, from material selection to processing, to the crash simulation of a Ford B-Max instrument panel. The following tasks are necessary to achieve these objectives (M-Base, 2013 & Anonymous, 2014):

1. Establishing the pre- and post-processing micro-mechanical characteristics of natural fibres (Albrecht & Müssig, 2013 & 2014).
2. Deriving a suitable fibre orientation model (Franzen et al., 2013).
3. Modelling typical side-effects when using natural-fibre-reinforced plastics, for example, fibre damage or separation (Franzen et al., 2013).
4. Compounding and processing of natural-fibre-reinforced plastics (Neudecker & Endres, 2013).
5. Comprehensive characterisation of the rheological and thermal characteristics of the natural-fibre-reinforced compounds (Steuernagel, 2013).
6. Determining quasi-static and dynamic mechanical characteristics.
7. Integrating the fibre orientation model using commercial flow simulation software (Franzen et al., 2013).
8. Scaling up compound production to near-series level.
9. Integrating material models using commercial CAE software, especially for processing and crash simulation purposes (Franzen et al., 2013).
10. Simulating a series component (process and crash).
11. Series component production and extensive mechanical testing, including high dynamic response in crash impact tests.

Implementation of the above tasks 2, 3 and 7 is shown schematically in Figure 1 for an injection-moulded plate. The micromechanical model for simulating fibre breakage during processing is under development in the Polymer Engineering Centre at the University of Wisconsin-Madison (Madison, Wisconsin, USA). Injection moulding is known to cause significant fibre damage. Loken et al. (2013) give a nice overview of which processing factors most significantly impact fibre damage or fibre length attrition.

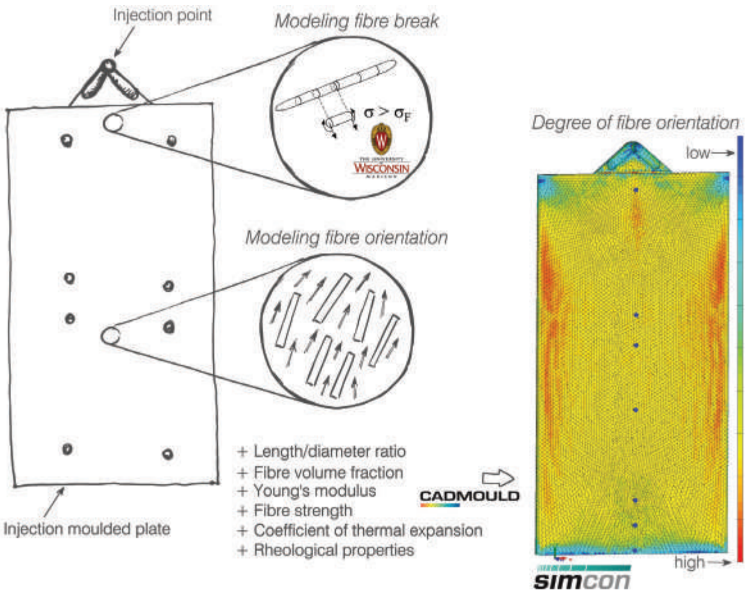

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Figure 1: Concept for a suitable fibre-orientation model and a concept for modelling fibre break during processing, for an injection-moulded plate (300x160x3 mm³) to be integrated into Cadmould software.

Within the framework of the NFC-Simulation project, the Simcon company achieved the first successful results in simulating the fibre orientation of injection-moulded, natural-fibre-reinforced parts using Cadmould software (Franzen et al., 2013).

A general idea of the implementation of task 9 above is illustrated in Figure 2. More details about the material models (MFGenYld & CrachFEM) can be found in Franzen et al. (2013).

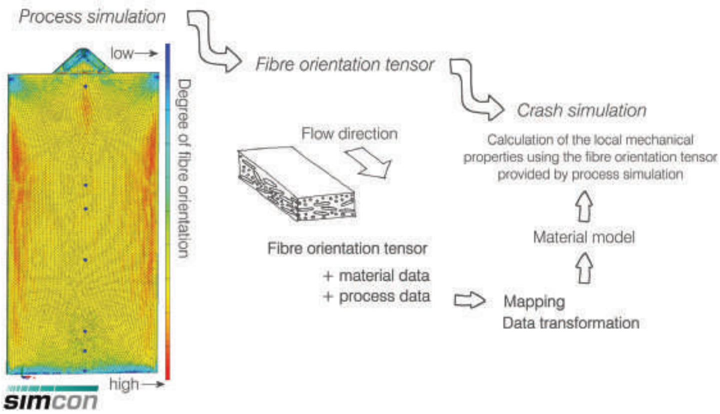

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Figure 2: Integrating material models with commercial CAE software, especially for processing and crash simulation purposes.

Within the NFC-Simulation project for a series component (instrument panel for the Ford B-Max) made of natural-fibre-reinforced plastic, the relevant data are being generated and CAE methods are under development to allow a full process/crash simulation of an injection-moulded NFRC part. The project consortium expects that once the work is completed, it will help to further acceptance of bio-based materials and pave the way for natural-fibre-reinforced compounds into mass production – and not just in the automotive industry (M-Base, 2013 & Anonymous, 2014).

Acknowledgement

The author thanks Ms. Kathina Müssig for her creative work in preparing the illustrations.

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The CELC Technical Section

Created in 2005, the CELC's Technical Section is a leading platform in the field of new technical applications for flax & hemp fibres in composites and eco-building.

The Section brings together fibre and semi-finished product suppliers, preparers and processors, serving as a bridge between the requirements of the multi-segment industry and the value chain's industrialisation capacity for technical flax and hemp applications.

Its goals:
- Organise a European skills network that includes companies, universities and research centres
- Stimulate research capabilities towards the development of flax and hemp fibres in the technical sectors.
- Promote R&D knowledge and applications to industrial users

With its European Scientific Committee, the CELC guides its members towards the future to discover new technical opportunities.

The Linen Dream Lab is a showroom dedicated to textile and technical innovations. It offers services to innovators in the fashion, art of living and design industries: support for creation and sourcing. It has material, yarn, and fabric libraries.

The European Confederation of Flax and Hemp (CELC) is the only European agro-industrial organization that encompasses all production and processing stages for flax & hemp. It was created in 1951 and includes 10,000 member companies in 14 different countries. In collaboration with specialised partners and European professional organisations, the CELC works to create an environment encouraging competition between industrial companies in an international context.

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Contributors,
CELC European Scientific Committee Members

In 2009, to further their strategic foresight plan for technical uses, the CELC's Technical Section created a European Scientific Committee dedicated to flax and hemp fibres used as composite reinforcement.

Under the Open Innovation initiative, 10 experts from five different countries are sharing their knowledge of analytical and characterisation techniques to define innovations, in anticipation of industrial requirements.

Through the publication "*Flax and hemp fibres: a natural solution for the composite industry*" and this additionnal leaflet, the European Scientific Committee is transferring its knowledge to the whole composite industry value chain.

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The general objective is to support the flax and hemp industry by drawing on the operational advice of these experts to increase expertise in:
- standards and ranking
- training
- publication of reference works
- information sharing

They pool their knowledge of analytical and characterisation techniques to:
- establish an inventory of existing scientific resources and techniques
- consider possibilities for development and new research in correlation with the industry's strategy
- give priority to open-ended innovation and facilitate the transfer of technical skills.

JEC Group

JEC is an industry organization dedicated to promoting composite materials internationally. It originates from a non-profit association called CPC. The company's policy is to reinvest all income into developing new products and services for its customers and for the composite
Industry.

JEC supports the development of composite materials by fostering knowledge transfer and exchanges between suppliers and users.

To date, the JEC network connects more than 250,000 professionals from a hundred countries. A strongly user-oriented strategy JEC informs composite professionals about major events, economic, technical and technological developments, new products and applications.

JEC's mission is to organize exchanges and to facilitate connections among all involved players – raw material producers, processors, distributors, machine and software manufacturers, institutions, academics, researchers and users (aeronautics, automotive, marine, land transportation, construction, energy, sports & leisure, EEE, etc).

Six major fields of expertise
Information, Learning, Intelligence, Publications, Innovation, Connecting

International activity
JEC's offer is directed at the 550,000 composite industry professionals around the world, JEC's broad range of products/services and its many promotional activities facilitate the development of business-to-business know-how and connections within the composite industry. Well known for its expertise, the Group is now an acknowledged leader in Europe and worldwide. Its upstream and downstream connections allow JEC to represent the entire industry, from hightech to consumer products. JEC organizes "cross-pollination" among the different segments so that all might benefit from the accumulated experience. Many such transfers take place each year at the JEC Composites Shows and Conferences and other meeting platforms of the Company.

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In response to the industry sectors' ecodesign initiative, the European Flax and Hemp confederation CELC's Technical Section has been working in cooperation with its European Scientific Committee - CSE on this additional leaflet following the first technical and scientific publication on renewable natural fibre based composite solutions, **"Flax and Hemp, a natural solution for the composite industry"**. Published with the JEC Group, which is a reference in the composite sector, this work is the result of well-supported R&D, a well-organised production chain, and thorough research. It emphasises the interest of an open innovation approach to meet industry needs.

CSE's ten experts, including CSE President Ignaas Verpoest address the new on going developments of flax and hemp as used in polymer reinforcement.

Joris Baets, Christophe Baley, Peter Davies, Moussa Gomina, Mark Hughes, Hans Lilholt, Jörg Müssig, Joris Van Acker, Ignaas Verpoest, Gerhard Ziegmann.

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