NEWCOMERS: NATURAL FIBER WELDING

Illinois-based Natural Fiber Welding has developed a method to regenerate and reconstruct yarns. This process can endow a natural fibre with properties akin to those of a synthetic yarn and could also expand the possibilities of textile-to-textile recycling.

Strong bonds

The company is called Natural Fiber Welding (NFW), and, as its name implies, it has devised a method that 'welds' cellulose-based fibres into filaments and can also make materials that are similar to non-wovens. Based in Peoria, Illinois and founded in 2015, its process fuses fibres together to make what it calls a "composite" yarn requiring neither glue nor any other adhesive. It relies instead on chemistry to modify the physical nature of a textile yarn at molecular level.

The chemistry it uses is based on ionic liquids. These, according to company CEO and co-founder Luke Haverhals, a chemist, are salts that melt at under 100°C. They are commonly used in the denim industry for indigo dyeing. The salts' liquid form makes them soluble in water.

Ionic liquids are also used in the textile industry to make lyocell, a regenerated cellulose, but NFW says its process is different. "In lyocell manufacturing, the cellulosic material is fully dissolved, and once this has happened, it is no longer possible to reorder the molecular structure of the fibre afterwards," he says.

During the 'welding' process developed by the company, ionic liquids make cellulosic fibres bond together, an operation that Dr Haverhals says takes just a few seconds. It also operates in a closed loop: water and salts are separated after the operation and can be reused. "Our technology generates no waste, the salts can be reused and this makes it more cost-effective," he explains.

The resulting 'welded' filaments are said to have a high tenacity and a smooth surface, two properties that give them characteristics similar to synthetic yarns. One composite yarn fabric sample was subjected to a Martindale abrasion resistance test and outperformed a textile made in virgin cotton, the company claims.

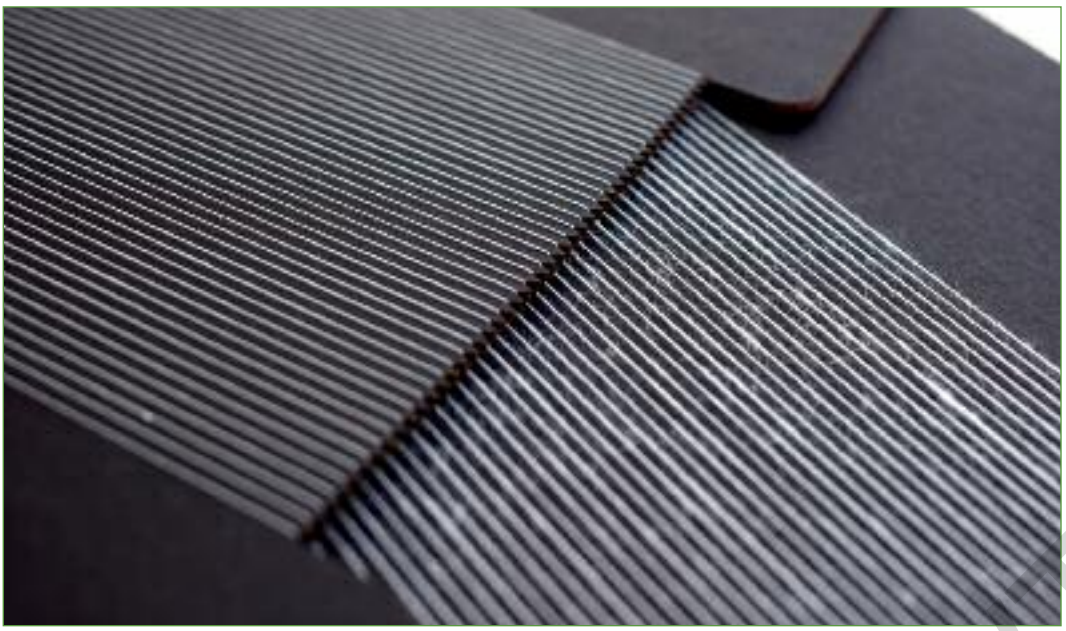
Natural Fiber Welding rebuilds the "intermolecular connection between cellulose fibres," as Dr Haverhals tells *WSA*. As the bond is being made at molecular level, it only needs a very small contact surface area to make the connection. In addition, the company's patented process can be "tuned" to obtain certain specific end results. 'Process variables that control natural fibre welding: time, temperature, and amount of ionic liquid' is the title of an article published in Cellulose, in February 2012 in which Dr Luke Haverhals is the lead author.



NFW's fibre-welding techniques could offer a solution for textile-to-textile recycling.

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The 'welded' cotton threads (on the left) are visibly smoother than traditional spun cotton yarns (on the right).

Natural Fiber Welding, Inc.

Improving on nature

If NFW can engineer the molecular structure of cellulose, it suggests that it can produce the material in formats not previously possible. Among the new conceivable options, Dr Haverhals says it can be used to make a recycled cotton that will not pill, a cotton fibre that will wick moisture faster or even a cotton thread that could be engineered to store electricity.

In addition to refining or upgrading cotton, NFW says its treatment can be applied to other fibres including silk, wool, jute, chitin, lignocellulosic materials and even synthetics. The state of Illinois has recently passed an Industrial Hemp Act, signed into law in August 2018, allowing the farming of hemp for industrial uses. This new, local resource could be 'welded' into new forms says NFW. Composite materials for use in vehicles may be a possible future development for the company, and packaging applications are also under consideration.

On a broader level, NFW would like to favour natural fibres over raw materials made from fossil fuels for industrial end-uses. "One tonne of polyester uses around 160 litres of oil," the company founder points out. He goes on to say that one tonne of cotton has 440 kilos of carbon sequestered within it. "Plants are carbon recycling machines," Dr Haverhals says. "Photosynthesis converts sunlight, water, and carbon dioxide into sugars, the basic building blocks of cotton fibre. All of the carbon in the sugar was originally atmospheric CO2 that has been sequestered by the plant." Taking into account the molar mass of carbon, the number of carbon atoms in one unit of sugars such as cellulose and the number of units in one tonne of cotton allows him to present the figure of 440 kilos as his conclusion.



NFW believes it can re-engineer any conventional natural fibre to make "composite" yarns.

Natural Fiber Welding, Inc.

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The process invented by NFW can make materials for shoes and accessories. It claims that these 100% plant-based, biodegradable textiles perform like plastics.

Natural Fiber Welding, Inc.

A solution for recycling

But why use virgin cotton, when there is an abundance of used clothing made in cotton? This is a key focus for the US start-up that believes it can turn low-value recycled cotton into high-tech materials.

The business of recycling used textiles into new yarns faces many challenges (see Closing the Clothing Loop, *WSA* March/April 2019). Among these, the state of fibres retrieved after the cutting up and shredding of used garments is a major issue. Mechanical recycling is a violent process, and cotton is a fragile fibre. This is where NFW may provide a practical solution. When a garment is broken down into a fibrous mass, the individual strands are often too short for spinning on high-speed industrial machinery. The minimum accepted length for open-end spinning is said to be 20 mm. Welding short-staple strands into longer ones would increase their market value. This prospect is one reason why the start-up received funding from Dutch textile incubator Fashion For Good.

NFW has tested its process with a recycled cotton textile manufacturer based in southern California. The welded fibres were used to make a knit fabric with 30% recycled cotton content that Dr Haverhals says displayed a higher pill performance than a virgin Pima cotton knit. The company is now working on creating finer-count yarns that could contain up to 50% recycled content.

Proof of concept

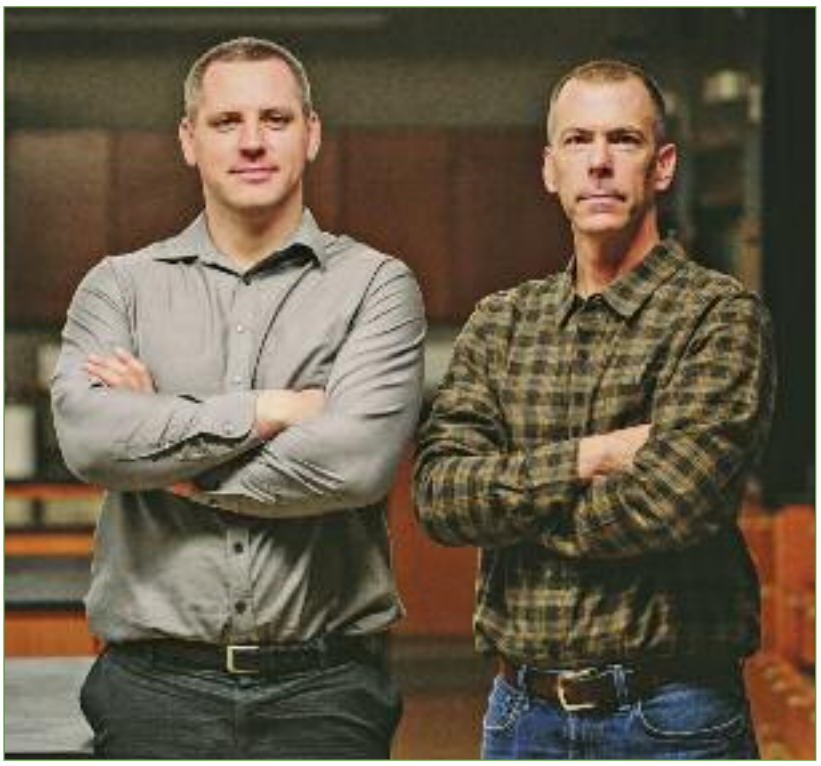
The start-up company also made a table top from recycled jeans in a partnership with Steelcase, which it sees as a major breakthrough and proof of concept. The company was then able to raise more funds and start work on an expansion of its demo plant, which could be operational later this year. This extension will enable the company to begin treating used jeans and hemp fibres. A longer-term goal is to turn staple fibre cotton into high-strength filaments.

The business model the company is considering further down the line is to license its technology and commercialise the machinery.

If the solution developed by Natural Fiber Welding can tweak the mechanical properties of a fibre, whether new or recycled, in a fast, efficient and cost-effective way, as Dr Haverhals believes, this could be a game-changing technology for the textile industry. In addition to providing a solution for textile-to-textile recycling, it could also bind (or weld), rather than bridge, the gap between natural and synthetic polymers.

Dr Luke Haverhals, founder and CEO of Natural Fiber Welding with Steve Zika, company COO.

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