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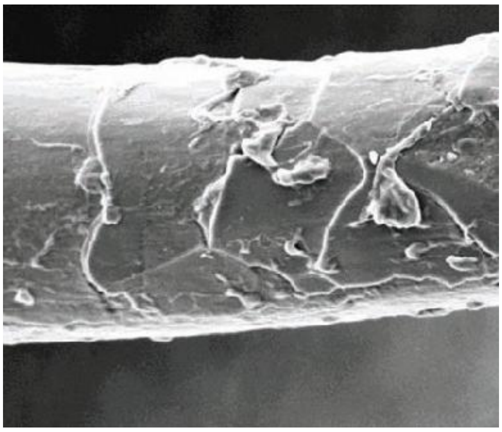
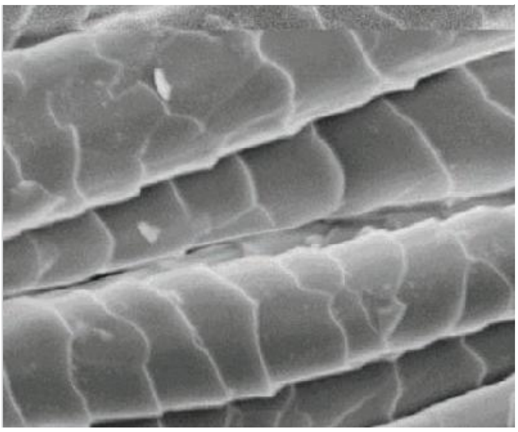
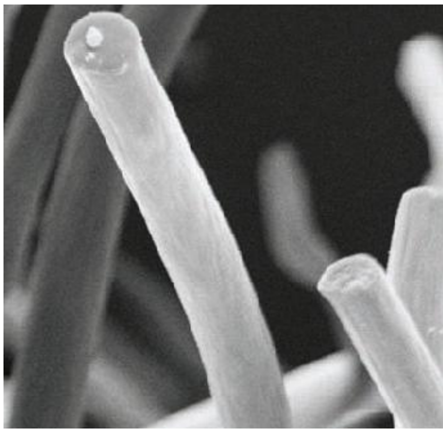


Merino wool before Multiplex Laser Surface Enhancement (MLSE) hydrophilic cleaning...



... the merino wool after the MLSE hydrophilic cleaning process has taken place



... after MLSE Nanostructure Si-Diamond treatment

Fruits of the loom

A centre in Huddersfield is seeking to revolutionise the modern use of textiles. Andrew Czyzewski reports

This year officially marks the bicentenary of the Luddite movement in the West Riding of Yorkshire. In 1812, the area around Huddersfield saw probably the worst violence, with pitched battles between skilled croppers, under threat from new mechanised technology and textile mill owners backed by government forces.

Although clearly a fraught period, industrialisation actually led to Huddersfield becoming globally renowned for its woollen cloth, bringing prosperity to the whole region.

Nothing lasts forever, though, and the last big mills shut down in the mid-20th century as bulk production moved to India and the Far East.

But in that continual spirit of rebirth, some of it survived. In a marketplace dominated by the new manufacturing superpowers, it was forced to adapt and carved out a niche producing the very highest-quality fabrics and pioneering new technologies in textile manufacture.

Recognising the growing potential in high-end products, West Yorkshire's textile bosses came together in 1999 to establish the Textile Centre of Excellence in Huddersfield, with a broad remit.

'We spent five years persuading our regional development agency that textile manufacture and processing wasn't yesterday's industry but tomorrow's, and that the technical textile market was growing fast, and with the right kind of support we could become leaders in adopting and implementing technologies,' said Bill Macbeth, managing director of the Textile Centre.

'We started looking around the world at areas we thought could be quite interesting — where there was an awful lot of academic research publication with very little evidence of real implementation and exploitation in the market.'

In the end, the Textile Centre secured £6m in funding from the now defunct Yorkshire Forward Regional Development Agency and the European Regional Development Fund for a 'Textile Innovation Programme' to run until the end of 2012, operating in three different areas: three-dimensional (3D) weaving of composite materials; plasma surface treatment of textiles for things such as flame retardancy; and anti-counterfeiting by weaving with signature DNA (see box-out).

The idea was for manufacturers to work with experts from universities and research organisations to create new high-value products. It was hoped that companies with textile experience and heritage might be able to bring something fresh to the table.

'Boeing for a long time — even before the Dreamliner — was talking about how you might weave a structure that can then be impregnated to give a stronger, lighter material, but very little understanding of how the weaving industry could actually relate and produce this kind of thing,' said Macbeth. 'We thought this must be an opportunity for us; we think we have some of the best technical weavers in the world.'

Composites such as carbon-fibre-reinforced polymer ('carbon fibre') are traditionally made by draping the fibre cloth over a mould, then injecting epoxy resin (if the cloth is not already pre-impregnated) and heating or air curing. That's essentially a two-dimensional weave, with a warp (y axis) and a weft (x axis). Companies have in the past attempted

to create '3D' composites by stacking epoxy-infused layers on top of each other, then cutting shapes out with a laser.

'It's extremely strong and extremely light; however, there is some residual weakness in there, in so far as the bottom sheet is not attached to the top sheet other than through the glue holding them all together,' said Craig Lawrence, technical manager for the Textile Centre.

The centre started working with loom manufacturer Griffith Textile Machines to build a prototype able to directly weave in three dimensions — so fibres or yarns are intertwined, interlaced and intermeshed (in the longitudinal x, cross y and vertical z directions, respectively).

'The idea is to weave the component shape you require, and that can then be put into a mould and infused with resin or additives. But because every layer is inherently tied together, there's no weakness; it's held together at many points,' said Lawrence.

Now, Lawrence acknowledges that there is some contention as to what constitutes true 3D weaving, centred around how you actually create that z axis. Carpets and velvets technically have a z axis in the vertical pile and companies have attempted composites that stop short of a true 3D weave by artificially creating a z axis that is not intermeshed.

It's also worth mentioning a video that was doing the rounds last year showing a 3D loom 'weaving' a pillar for a Lexus supercar. Impressive

> **We spent five years persuading our development agency that textile making wasn't yesterday's industry**
> Bill Macbeth, the Textile Centre

though it was, it wasn't actually weaving but rather braiding on an entirely custom-built tubular mandrel that produces extreme tension. It's a valid 3D technology in its own right, but astronomically expensive, essentially being commissioned for a single component.

The centre has now built its own unit. It comprises two high-speed rapier looms, one in the regular position and one floating above; novel sewing technology for end closure; enhanced tension modifications; and software for designing the weave and keeping it consistent. Before the machine actually went online, there was a feasibility study to semi-manually create a 3D-woven aerospace component. It is a kidney-shaped connector around 2.5in long with two raised projections that go through two holes in the turbine blades of a jet engine, holding them onto the spindle. Currently, the component is made from titanium, which after a time crystallises and reaches a failure point, shearing the projections.

'The component was woven in exactly the same shape — one part, no joints, no folds — where the tension was such that it kept every void between the fibres open and it could be infused with a ceramic to give a complete part that's a lot stronger and lighter than titanium,' Macbeth said. 'We have a machine now that can produce those components regularly, in a family of different shapes.'

The Textile Centre is working with the Advanced Manufacturing Research Centre (AMRC) in Rotherham and its main partner Boeing, ->

Research project: **setup for the plasma surface treatment of textiles (above left) and a three-dimensional loom under testing (above right)**

tagteam

Additive tag based on spliced plant DNA helps tackle the issue of counterfeiting

In December last year, a gang from Manchester was convicted of a Securicor cash robbery in London on the basis of a unique, synthetically created DNA sequence residue that was found on one suspect's mobile phone.

As soon as any cash van is compromised, a purple dye is sprayed on the notes, staining them. But criminals have learned that with a couple of delicate washes, they can get them perfectly clean (literally money laundering). Noting this, US company ADNAS came up with additive tag based on spliced plant DNA. The resulting sequence does not occur anywhere in nature and cannot be reverse engineered. Hence it can be traced with near-100 per cent certainty.

The Textile Centre for Excellence saw the potential in using it for protecting brands and cloths and set about a collaboration with ADNAS.

'Counterfeiting is a huge and booming problem that we have in the textile industry and certainly the apparel and accessory industry. It's tremendously important with the emerging BRIC markets, where people will pay for top-quality products as long as the provenance is assured,' said Bill Macbeth, managing director of the centre.

This is particularly important for the Yorkshire region, which produces some of the most high-end clothes in the world.

Indeed, the world's most expensive suit, at £70,000 a pop, was made from fabric carefully woven in Huddersfield, using the underbelly hair of an arctic musk ox, which only sprouts every three years.

Ultimately, Macbeth believes they can put a unique Yorkshire signature into fabric at around 20 pence per metre, which would make it highly attractive to manufacturers for protecting their brands.

The tough thing is to get the DNA to stick. With cash applications, if the signature spreads, it can actually be an advantage, as with the mobile phone conviction. But with the fabric, it has to be inexorably linked with the underlying assets. Again, the team is using its deep knowledge of textile processes to modify the surface with the use of binders that adhere to the DNA.

The other problem is that businesses using a signature would then have to send off a legally disputed product for verification to a costly forensics lab — although sequencing technology is getting cheaper all the time.

as well as maintaining close academic links with Carl Lawrence, who is professor of textile engineering at Leeds University.

They will be working with clients to produce small prototype components in a number of fibre types including carbon, glass, aluminium and silicon carbide. A Technology Strategy Board (TSB) project currently under way is investigating the potential of weaving prototype suspension struts and suspension connectors using aluminium oxide yarn infused with aluminium.

The Aluminium Matrix Composite Materials for Vehicle Weight Reduction (AluMatCom) project brings together leading players in weaving (Antich & Sons and the Textile Centre), casting (Composite Metal Technology) and automotive (Jaguar Land Rover).

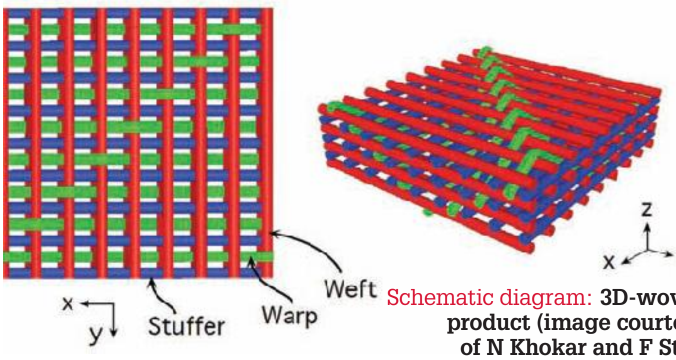
Although it's all still at an early stage, it's difficult not to be impressed by what's being attempted at the centre. You basically have a collection of weavers who, for most of their existence, have focused solely on the textile industry, now tackling difficult technologies and getting the attention of the big boys in the automotive and aerospace sectors.

That said, it's an awfully long road to implementation and those industries are famously conservative when it comes to actually adopting new technologies.

Perhaps the facet of the Innovation Programme with the greatest potential for near-term payback is rather closer to home with Multiplex Laser Surface Enhancement (MLSE) for textiles.

The technology originated in metallurgy as way of manufacturing cutting tools with polycrystalline diamond films — not by external coating but using the endogenous carbon already there in the tool.

Developed by Dr Pravin Mistry, now at Turchan Technology in Detroit, the technique first uses a laser to vaporise and mobilise carbon contained within the substrate. Additional atmospheric carbon can be supplemented into that plasma, which is then compacted by another, differently specified laser to create the diamond surface.



Schematic diagram: **3D-woven product (image courtesy of N Khokar and F Stig)**

The Textile Centre contacted the inventor with the aim of adapting the process to textiles to imbue certain properties such as hydrophobicity, hydrophilicity and fire retardancy, as Craig Lawrence explained. 'If you're trying to make something fire retardant, at the moment you have to send the fabric over to Germany to go through a chemical bath [where it is] neutralised, washed and rinsed; then it comes to Lancashire for more treatment and eventually gets back to the company that wove the fabric in the first place. That process can be extremely expensive, anything up to £15 per metre — a lot of money, especially if your fabric only cost 15 pence to make in the first place; then you've got to sell it on and put your profit margin on. So we asked: "Can we make the fabric fire retardant using purely laser power and gases, and maybe a very diluted chemical through a spray system?"'

Although still under validation, the process first injects carrier gases, including helium, argon and nitrogen, alongside reactor gases, mainly carbon dioxide and oxygen, into a chamber above the fabric at atmospheric pressure. An electrical current ionises the mixture, creating a plasma that partially ablates the surface of the textile — in the case of the wool, freeing up more carbon. That plasma is then targeted with UV laser to pressurise it and deposit a nano film of carbon over each fibre of the textile.

'Initially we're working with wool, but ultimately we want to make silk fire retardant,' Lawrence added. 'We know if we can make silk fire retardant, Mark and Spencer's have got four million garments they want to make for ladies' nightwear that are currently made out of polyester.'

The centre said the MLSE system has potential to create hydrophilic wool, allowing low-temperature dying. Presently, the process for dying wool requires a water bath at 120˚C for four hours with very acidic dyes. 'That's extremely expensive, especially if you think one company around here actually dyes six million metres a year, so you can imagine what the energy costs are,' said Lawrence.

The surface modification that occurs basically cleans the wool at the nanoscale, rearranging the tiny scales that make up each fibre so they more easily wick in water. Wool that undergoes this process can be dyed at a temperature of 70°C for three hours, using less aggressive chemical dyes, the researchers claim.

Like any research and development project, the MLSE system has encountered some technical challenges, more to do with the second-hand laser it was using (soon to be replaced) than anything else. Production is due to restart this week with a new German-built laser. But the impressive thing is the scale it can operate at. Plasma has been used on textiles before at the lab scale, but the centre has the materials-handling equipment and know-how to treat 25 linear metres per minute on a fabric up to 2m wide, straight from being woven, roll to roll.

During a recent open day at the Textile Centre for interested parties and potential clients, there was a telling moment where someone representing a university asked if they hadn't considered doing the MLSE at a smaller lab scale first. There were a few confused expressions. 'No,' said Lawrence. 'We only had three years and we're here to create the industry new technologies to move forward and to develop the industry — bring it kicking and screaming out of the 19th century.'

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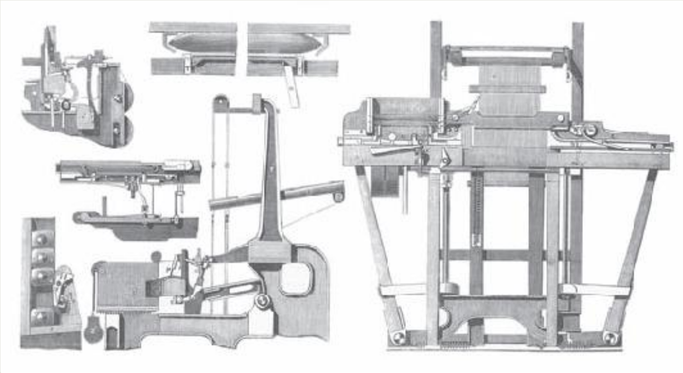
inthearchive

Loom patent from 1868 attempts to deal with the problem of weft breaks



The Engineer archive contains quite a comprehensive history of the development of higher levels of automation in loom operation.

The 4 December 1868 issue covers a patent for a perpetual motion loom by John Bullough from Accrington.

'Notwithstanding the state of perfection we have been in the habit of thinking the power loom has been brought to by the invention of the weft fork, the loose reed, the stop rod and the self-acting temple, it is none the less a fact that one third to one sixth of the times of every calico loom is lost owing to two prominent defects, while the cry has been constantly for more and more speed, until looms are now run at what many in the old school call "mad speeds" this fact of so much time being lost in stoppages seems to have been overlooked.

'Of the large number of patents taken out almost weekly for improvements in looms, very few attempt to cope with the conspicuous defect of the loom having to stop every time the weft breaks — on average every three minutes during the day — while not a single attempt has hitherto been made to remedy the still greater defect of being compelled to stop the loom to piece and draw in warp threads that break.

'The loom that we illustrate above professes to overcome both these defects.'