TECHNOLOGICAL PRACTICE CASE STUDY		MARCH 2009	
SOFT MATERIALS TECHNOLOGY	YEARS	7-10	11-13



SECURE COUTURE

Scientists at AgResearch have combined merino wool with synthetic fibres to produce a new stab-proof material that can be manufactured and worn as a normal garment.

FOCUS POINTS INCLUDE:

Outcome development and evaluation

- Ongoing research, experimentation, analysis, testing and evaluation against the specifications

Technological Products

- Properties of materials and their performance capability; formulation of new materials

ADDITIONAL SUPPORT MATERIAL

- www.agresearch.co.nz/textiles/docs/textile-processing.pdf
- www.agresearch.co.nz/publications/agresearch-textiles.pdf
- www.woolequities.co.nz/keratec.htm
- www.scionresearch.com/research/materials-and-energy/wood-and-fibre-technology
- www.sciencelearn.org.nz/contexts/just_elemental/people/professor_deliang_zhang
- www.sciencemediacentre.co.nz/2008/09/26/biomaterials-from-animal-blood-to-plastic

SECURE COUTURE

Think merino wool and images of romantic high country sheep stations and glamorous models strutting down catwalks in the latest designer outfits spring to mind. But a recent discovery has exposed new uses for merino that may shatter those preconceptions forever. Richard Worrall reports.

Merino wool is usually noted for its softness rather than its toughness. But that may change as merino gets ready to make a bold transition into the world of functional protective clothing and hopefully establish a lucrative new high-value niche export market.

By combining merino wool with certain synthetic fibres, scientists at AgResearch have developed an interesting new stab-proof material. That in itself is noteworthy, but what makes this material special is that it can also be manufactured and worn like a normal garment.

AgResearch even debuted a jacket made from the material at New Zealand Fashion Week last September [2008] and hopes to have the ground-breaking material ready for commercial release within 12 months.

AgResearch's Team Leader for Smart and Technical Textiles, Stewart Collie, says the material is a combination of fine merino wool, which forms a short-fibre outer surface, and a synthetic core made from a yarn called Vectran.

Vectran is a wholly-aromatic liquid-crystal-polymer-based fibre that was developed several years ago for applications such as cut resistant gloves for butchers and the aerospace industry. It is notable for its cut resistance, high strength and high modulus, with the end result being a very strong backing structure for the wool. "Cut and penetration resistance are not the traditional properties of wool so we use the composite material to compensate for that," says Mr Collie.

Form follows function

The origins of the stab-resistant fabric go back to 2002 when AgResearch purchased a Fibreknit machine to produce new research fabrics. The machine is capable of blending or knitting together two different types of material, effectively allowing a synthetic fibre to be knitted into a backing structure.

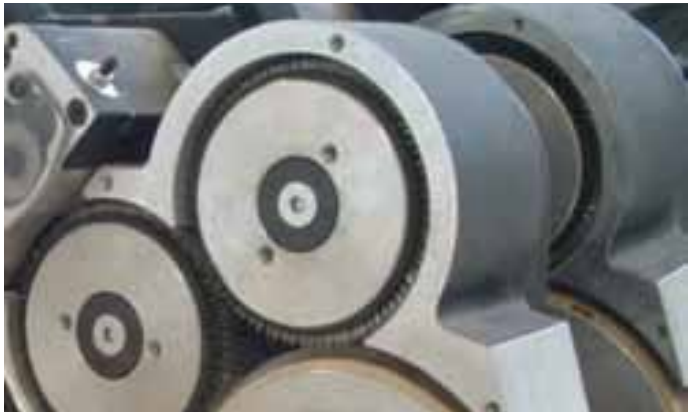
In 2004-05, AgResearch undertook initial work to use the machine to combine wool and Vectran into a stab-proof material, but the trials were shelved due to funding difficulties. It was not until the project was re-prioritised in late 2007 that the innovative work began. The new material's biggest breakthrough is that it looks and feels like regular fabric, meaning it can be incorporated into clothing. Although its protective capabilities are similar to conventional protective vests – such as the stab-resistant body armour used by the New Zealand Police – it does not look like a traditional protective vest.

It is far more comfortable to wear, less bulky, is able to breathe, and can be incorporated into standard jackets rather than just sleeveless vests. It can even form a separate garment to be worn under something else. For added versatility and to cope with some variation in levels of threat the wearer may face, Mr Collie says jackets can be made from multiple layers of the stab-proof material. Alternatively, jackets can be made with variable levels of protection according to the area of the garment. Between three and six layers of stab-proof material can be incorporated into jackets to protect vulnerable body organs in and around the torso or back, and lower levels of protection in less vulnerable areas, such as the arms.

The material's unobtrusiveness also works to the wearer's advantage if they are involved in night-time security work, for example at a nightclub or during a concert, or for prison guards. Security staff are perceived as less threatening if they do not wear garments that seem confrontational or suggest trouble is likely to erupt.

As well as resistant to sharp objects, the material is also highly flame resistant, an ability it inherits from the natural properties of wool, but greatly enhanced by the Vectran backing. The flame retardant

properties are so effective it can withstand a blowtorch for 60 seconds before a hole is eventually burnt through the fabric. The secret to this flame resistance is what happens to the fibre when heat is applied. Wool, a natural protein fibre, does not ignite when exposed to severe heat, instead it chars into a thick layer of carbon. This carbon then forms a protective barrier against further heat. The Vectran yarn holds the carbon in place, making the fabric capable of withstanding a severe temperature "flashover" without causing serious injury to the wearer or undue damage to the fabric's integrity.



Production expectation

Turning merino wool into a functional safety fabric begins with wool preparation. This involves subjecting the fibre to a number of processes. Firstly, scouring cleans the wool to remove impurities such as foreign plant or vegetable matter and dirt, then carding breaks up the clumps of fibres to ensure they are uniform. Once these processes are complete, the wool is consolidated into a sliver or loose rope of wool.

The sliver is fed into the knitting machine at the same time as the synthetic Vectran fibre and the two components are fused together with latch needles. The machine has several hundred of these which rise and fall as the knitting machine rotates. Eventually the fabric emerges as a big tube or sock with a 1.5-metre circumference.

At this point the fabric is subject to a finishing process. The exact details are commercially sensitive, but the process helps to stabilise the fabric and give it the final dimensions and surface characteristics that are crucial to its stab-proof properties.

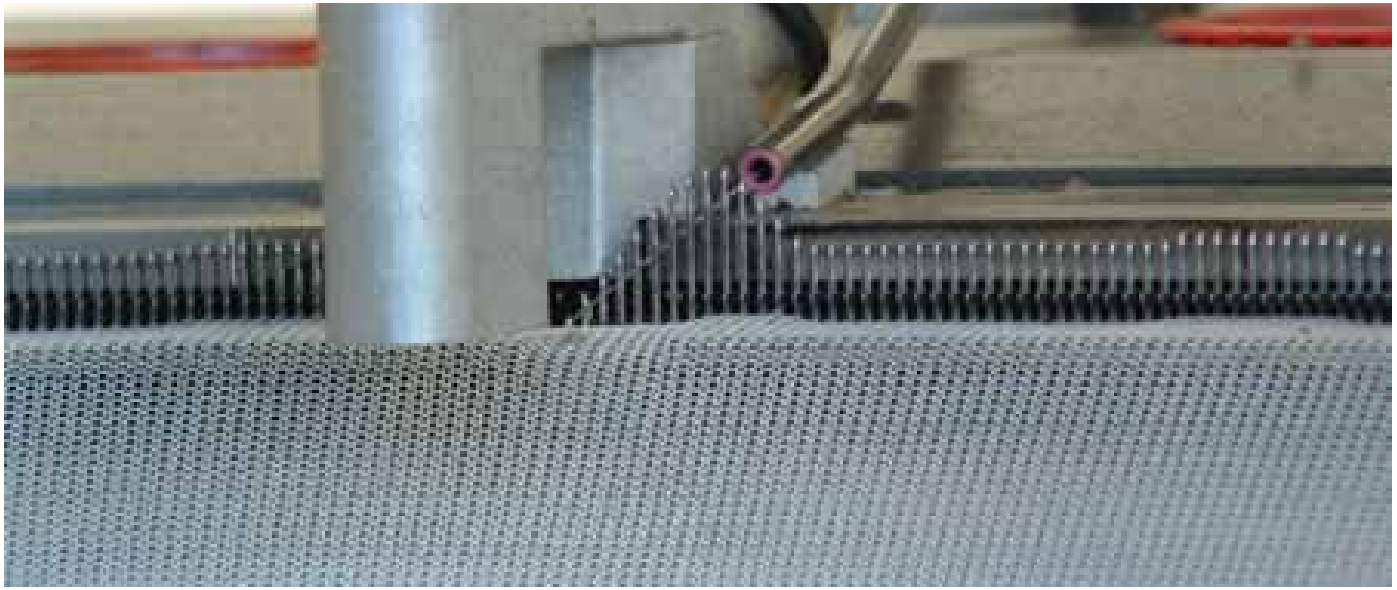
"The finishing process changes the fabric's structure to improve its strength and secures the fibres so they are less likely to come apart if it is attacked," says Mr Collie.

The knitting machine can also vary the knit structure by changing the simple base loop to alter the materials extensibility and the ease with which it deforms. As a result, the structure can be tightened to improve penetration resistance.

The biggest production challenge is the strength of the material. The yarns are so strong they can break the steel knitting needles. To overcome this, the yarns have to be knitted at as low a tension as possible.

The finishing process also acts as a general tidy up of the fabric surface, which may appear irregular, and eliminates any dirt that the fabric may have picked up from the processing equipment. Once the fabric has been manufactured, garments are cut to shape using special tools designed to cope with fabrics made not to be cut.

Initial plans are to produce 20-metre trial lengths of the material with production funded internally, but AgResearch is looking for a commercial partner to step production up to higher volumes. It is hoped the first phase of commercial production will remain in New Zealand, with AgResearch having the only knitting machine of its type in Australasia, which is capable of producing 20-30 metres of material per hour.



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Test performance

While the anecdotal performance has been very encouraging, AgResearch will also undertake scientific standardised tests to prove its claims for the material. This will be crucial in gaining commercial customers.

Stab resistance is generally tested by dropping a standard pointed knife into the composite material from a range of set heights after which the size and nature of the cut is examined to assess the level of damage. Knowing the geometry and length of the blade, it is then possible to calculate the level of penetration. Other tests measure cut resistance by drawing a standard blade over the fabric with a certain force applied. A range of other tests will also be carried out to simulate an attack with improvised weapons such as screwdrivers or a broken piece of glass.

Fire resistance is measured using standard tests covering ignition time and heat transfer.

Basic fabric tests have also been undertaken covering factors such as pilling, abrasion resistance and washability.

If successful in New Zealand, Mr Collie says the material could also be produced offshore under licence.

"There has been quite a lot of interest in the fabric from people involved in different parts of the wool processing supply chain – from garment manufacturers through to suppliers of wool processing equipment."

Whatever happens long-term with the manufacture, he says ongoing research and development will continue to be based in New Zealand to ensure the intellectual property stays in local hands. It is difficult to say how much individual garments will sell for at this stage, although it may be several hundred dollars depending on the style of garment and how many layers of stab-resistant materials are incorporated into a particular item of clothing.

With the fabric being stab resistant rather than bulletproof, Mr Collie anticipates the major markets will be regions where gun use is less prevalent, such as Western Europe. Aside from security guards and prison officers, other possible customers could include retail employees exposed to high threat levels or social service agencies where staff sometimes deal with volatile members of the public. Perhaps a sign of the times, Mr Collie says the garments may even be bought by the general public, particularly by people who have a heightened risk of being attacked in the street.

Richard Worrall is a Christchurch-based freelance journalist.

Additional links for follow-up activity

Areas: Textiles; Materials; Production technology
Level: Senior

VECTRAN™ is a manufactured fibre, spun from a created liquid crystal polymer by Celanese Acetate LLC and now manufactured by Kuraray Co, Ltd. Chemically it is an aromatic polyester. See en.wikipedia.org/wiki/Vectran.

Vectran exhibits exceptional strength and rigidity – weight-for-weight it is five times stronger than steel and ten times stronger than aluminum: www.vectranfiber.com/engineering_introduction.asp

The first use of Vectran™ was for demanding and specialised military applications. The unique properties of the high-performance fibre satisfy many of the military and aerospace needs of today – airbags made with Vectran fiber successfully cushioned the 1997 Mars Pathfinder landing on the surface of Mars. www.vectranfiber.com/applications.asp#

A copy of the *Dictionary of Fiber and Textile Technology* can be downloaded from the site. It provides an up-to-date glossary of terms encountered in the manufactured fibre and textile trades including recent developments in fibre forming polymers, new commercially manufactured fibre, textile equipment advancesand new applications for textile materials such as geotextiles and advanced composites. www.vectranfiber.com/pdf/vectran_fiber_2.pdf

AGRESEARCH is the largest of New Zealand's Crown Research Institutes with research centres at Ruakura, Grasslands, Wallaceville, Lincoln and Invermay.

The Textiles division at AgResearch was formed out of Canesis Network, originally the Wool Research Organisation of New Zealand (WRONZ). Agresearch Textiles is now a world leader in applying science and engineering to the domain of textiles for industrial and fashion applications.

The AgResearch Textile processing plant offers a comprehensive range of equipment and facilities for processing product development and research, specialising in the processing of wool, mohair, alpaca, llama, opossum or syntheytic fibres www.agresearch.co.nz/textiles/docs/textile-processing.pdf

TEXTILES: From farm to finished product is one of a range of AgResearch publications . It details recent innovations in textile technology including ways in which nanotechnology can be used to create better textile products. www.agresearch.co.nz/publications/agresearch-textiles.pdf

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