Preparing the mind

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The invention, development and commercialisation of Siroclear and Solospun

Siroclear

Discussion with industry revealed that even after carding and combing, vegetable matter (VM) particles still required removal from worsted fabrics. These particles were generally fine, fibrillated pieces of VM that behave much like fibres and hence are difficult to remove by traditional methods. The cost of fabric mending was increasing, so the question was whether anything could be done to remove these few remaining VM particles in a cost-effective manner.

After reviewing the worsted yarn processing steps, it became evident that an opportunity existed to detect and remove VM particles during the winding and clearing operation conducted after spinning. Clearing faults (thick and thin places) and rejoining the yarn had become a sophisticated, automated process. In particular, the CSIRO development of the Thermosplicer had resulted in the ability to produce robust, nearly invisible splices when joining worsted yarns. Could we develop another sensor that could be fitted to the winder to specifically detect VM particles? To detect VM particles, the sensor would need to be an optical device. At that stage the commercial yarn clearing sensors were designed to detect only changes in yarn mass or diameter and the majority were capacitive sensors. Optical sensors were available, but these were not capable of detecting VM particles because VM particles and other coloured faults did not necessarily coincide with a large or detectable increase in yarn diameter.

The optical sensors available at the time relied on a shadow technique (that is, light source on one side, detector on the other with the yarn passing between). Rather than viewing a shadow we needed a way to ‘see into’ the yarn to detect the VM particles. It was known, and experience had shown, that it was possible to make wool fibres nearly invisible in a liquid that has a similar light refractive index as wool – salicylic acid and benzyl alcohol are two examples of such a liquid. At CSIRO salicylic acid had been used in fibre orientation studies. Coloured wool fibres seeded into undyed (ecru) wool slivers became visible as the undyed fibres ‘disappeared’, thus allowing their position and orientation to be measured. But it was not practical to immerse yarn into a liquid on the winder – it would be rather messy and would of course result in wet yarn. So, another method had to be found to make the undyed yarn invisible to highlight VM and other coloured faults.

A literature review showed that across a broad spectrum of visible light, the light reflectance between ecru wool and VM was quite distinct and that around about the 500 nm wavelength mark, the difference was possibly at its greatest. This wavelength was close to green light. But how do you ensure you have the optimum wavelength conditions? Unfortunately, the photo detectors at the time operated more efficiently in red light, but they were still able to operate, albeit not as efficiently, with green light. Green LEDs came later, so we initially opted for a halogen lamp and a BG38 (or green) filter. So what we essentially ended up with was a spotlight illuminating the yarn with a photo detector looking down on the scene and a green filter screening the light entering the detector.

But how do we hide the yarn? A number of different backgrounds were tried, including wool, to hide the yarn, but all the photo detector could see was the yarn – still acting as a thin and thick place detector. At the time, we were also developing core spinning with Sirospun yarns. To ensure that the filament core was central to the two outer wool strands during spinning, a slot was cut in the middle arm of the front zone condensers. When the front zone condenser was illuminated with the spotlight and an ecru yarn dragged through no signal was observed coming from the photo detector. After confirming that the photo detector was still operational, a black mark was placed on the ecru yarn. All that was detected was the black mark. Making up yarn lengths with thick and thin faults and VM particles passing them through this crude set-up demonstrated that virtually no signal was generated by the photo detector for ecru yarn; only a small signal was generated when thick place faults were dragged through the slot, but much larger signals were generated for VM particles. We had made the yarn 'invisible' – but how?

When the spotlight was illuminating the front zone condenser, the reflectance within was causing uniform light conditions around the slot and the yarn. Experiments showed that if yarn was illuminated from the same direction as the photo detector, the yarn was highlighted. We knew, of course, that when it was illuminated from the opposite side of the detector, the yarn was in shadow. However, when we 'balanced' the illumination from the same and opposite directions to the detector, we could make the yarn invisible, and Siroclear was born.

The principle was now understood, but the spotlight and a front zone condenser system had to be miniaturised to fit onto a winder. A lot of work went into the development of the sensor using green LEDs to illuminate the yarn from the same and opposite directions to the detector while the ecru yarn passed through a translucent ceramic guide. Software also had to be developed to monitor the photo detector signal and provide an indication when a VM or coloured contaminant was detected. The prototype developed at CSIRO was demonstrated under textile mill conditions to representatives from a Swiss optical clearer manufacture, Loepfe. The representatives were clearly impressed by its performance and after some further development by Loepfe, the Siroclear technology was incorporated into Loepfe's Yarnmaster optical sensor range.

Audience participation: What were the circumstances and background that led to the invention of Siroclear?

The circumstances that led to the invention of Siroclear, experience, opportunity and curiosity were the keys to preparing the mind. Experience had been gained in making ecru wool fibres invisible by immersing them in a liquid with a similar light refractive index. Knowing where Siroclear would be most effective in detecting and removing foreign faults came from our splice development work; that is, the Thermosplicer technology. Acknowledgement of the impractically of immersing a moving yarn in a liquid led to the realisation that an optical system would be the most practical. Opportunity and curiosity came into play when searching for a method that would assist in making ecru yarn 'invisible'. While experimenting with ways to ensure a filament could be aligned with the centre of a Sirospun yarn during spinning, it was observed the filament was difficult to see when running through the slot cut into the back of the front zone condenser. The plastic used in the construction of the front zone condenser was translucent, so curiosity was tweaked whether under the right lighting conditions, would an ecru yarn also be difficult to see. It was, in fact it was practically invisible.

The principle of the Siroclear technology also led to the development of a Dark Lot Sorter. This system used balanced light conditions to look for dark fibres clumps in scoured wool. The Dark Lot Sorter was also licensed to and commercialised by Loepfe and later the Loptex Company.

Solospun

Without the experience gained in the development of the earlier weavable singles yarn development, Sirospun, the current Solospun technology may not have eventuated. When spinning a singles yarn, one strand of roving is used to spin one yarn. To reduce the yarn hairiness for weaving, two singles yarns are spun with the resulting structure trapping the protruding fibre ends within the resulting two-fold yarn. Sirospun worked on the principle that when two strands of wool fibre, separated by a set distance during the drafting stage in spinning, were allowed to combine in the twisting zone, fibre ends were naturally trapped within the resulting yarn, creating a yarn with low yarn hairiness suitable for weaving directly from the spinning frame. For the same fibre diameter, Sirospun technology allowed the production of weaving yarns that were lighter than could economically be spun using the conventional singles and two-fold yarn route.

Sirospun underpinned the successful Cool Wool program. The Woolmark Company promoted Cool Wool as a lightweight worsted fabric with a soft or dry handle, supple drape, clean finish and ‘hard’ twist yarns, ideal for a wide range of climates and temperatures.

Although quite successful, and still used today, Sirospun required twice as many roving packages on the spinning frame, special roving guides for the drafting zone and a detector to break the yarn if for some reason only a single fibre strand was spinning. The demand for even lighter weight fabrics continued, so the challenge was to produce an even lighter weight weavable singles yarn on the spinning frame. Would it be possible to produce a weavable singles yarn from a single roving?

There was a lot of discussion among colleagues, who pondered the problem and likely solutions. While playing with ways to ‘mop up’ the outer fibres in the drafted fibre strand so they might be incorporated within the yarn structure using a small roller placed at the exit of the draft zone, by accident the emerging strand split into two when half the fibres ‘fell’ over the edge of the roller. The fibre strand that remained on the surface of the roller and the strand that was moving down the side of the roller recombined and were twisted together to form a yarn – Sirospun in miniature. The part of the fibre strand that moved down the side of the roller was susceptible to breakage, so various roller designs aimed at splitting the strand in two were tried, including a range of cam-type profiles. A yarn from a single roving having low yarn hairiness could be produced. However, this design relied on the splitting roller to be always accurately aligned with roving strand – not possible under commercial spinning conditions. To minimise wear on the rubber draft rollers, the rovings are slowly traversed from side-to-side. So how do we maintain alignment under these conditions? The solution: design a roller with fine slots across its width so that no matter where the roving was in its back and forth traverse, it would always be split into two or more strands.

Once the principle was established, the technology had to be implemented. The Solospun rollers were best driven from the bottom front metal rollers, but rubber was not a suitable material as it was difficult to manufacture with slots and tended to wear down very quickly. Metal or hard wearing plastic tended to slip and when fitted with a rubber tyre attracted fibre and required constant cleaning. A compromise with plastic hardness was the best solution and the addition of carbon prevented static charge build-up and so minimised fibres adhering to the roller. The knowledge and experience of plastics experts was invaluable at this stage. Finally, the work of many resulted in a simple attachment mechanism that eliminated the need to make any modifications to the spinning frame, resulting in a simple clip-on attachment to produce weavable singles yarns – Solospun.

Commercialisation was fairly straightforward with two of the project partners, Canesis and the Woolmark Company, currently marketing the technology with the rollers, and clip-on attachments being manufactured in Australia by Warren & Brown in Melbourne.

For the development of Solospun, the mind had been prepared through the experience gained during the development and implementation of the previous Sirospun spinning technology. Making the connection with the in-miniature strand splitting created by the small roller placed at the exit of the drafting zone on the spinning frame and Sirospun was the key.

The Disney Corporation has an Innovations Department staffed by a group of people known as Imagineers. Disney created a playful character called Figment (an idea is in reality a figment of your imagination). The message is that creativity can be fun and can be developed by maintaining the curiosity about the world that one had as a child. So the message we hope you take away from this session is that a prepared mind is a playful mind that expects the unexpected.

References

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Questions

Think about a successful problem-solving exercise in which you have been involved. Write down the experiences you and/or your team members drew upon to solve the problem.