Consumer demands create technical challenges along the supply chain, including spinning. Spinning is one of the intermediate steps along the supply chain between the farm gate and the final product in the consumer's wardrobe. Consumer demands impact the supply chain imposing technical challenges and limitations for each of the different processes, including spinning.

Contrasting two familiar cotton garments, a pair of jeans and a light weight summer shirt illustrates this point. Leaving aside the important but somewhat fickle issues of price, colour and fashion, what technical performance do we expect from these two different garments?

A key feature of jeans is durability, strength and abrasion resistance. As a result denim fabric for jeans is relatively thick and heavy. By comparison, for summer shirts, comfort and 'breathability' are paramount and so the fabric is much lighter. These examples illustrate the general point that within the textile industry, fabric mass is an important technical specification. Garment manufacturers will specify to the fabric manufacturer what a fabric must weigh in terms of mass per unit area.

A typical value for a denim/jeans fabric is 400 grams per square metre (gsm), with a light to heavy range from 340 to 500 gsm, whereas light summer shirting fabric has a range from 70 to 140 gsm.

In our example, the denim jeans fabric is woven using relatively thick yarn (thread) and the summer shirting fabric requires a much finer yarn. Actual yarn thickness is a little awkward to measure accurately and so the textile industry routinely measures and refers to the mass per unit length of a yarn, called the yarn linear density or yarn count.

Table 1 lists typical yarn values corresponding to our example of two different garments/fabrics. A small complication is that yarn count can be measured using two different methods.

---

**ENGINEERING/AGRICULTURAL TECHNICIAN**

Due to increasing workload Aquatech Consulting is looking for a full-time engineering or agricultural technician for its practice based in Narrabri NSW.

You must possess a current drivers’ licence, good verbal and written communication skills and be able to work as part of a small team directly with irrigators and other consultants. An associate diploma or equivalent in engineering or agricultural science would be an advantage. This position would be ideally suited to applicants from a farming or small country town background. Students currently enrolled or wishing to enrol in suitable courses will be considered.

Above award pay and a rewarding and challenging position awaits the right applicant.

Applications close 24/04/08
For further information please contact:
Mr Jim Purcell
Aquatech Consulting Pty Ltd
PO Box 443
NARRABRI NSW 2390
Ph: 02 6792 1265 or 0429 902 584

---

**MORRE REAL ESTATE**

Specialists in the Sale and Valuation of Rural Properties

- Rural Properties
- Cargill Cotton Agents
- Town Sales
- Registered Valuers
- Property Management
- Auctions
- Clearing Sales

**www.moreerealestate.com.au**

Phone: 02 7651 1100
Fax: 02 6751 1766

After Hours:
Paul Kelly 0428 281 428
Cliff Brown 02 6752 3970
Allan Gobbert 0428 523 375

---

**MORRE REAL ESTATE**
different systems – hence the two sets of numbers in the Table.

In scientific circles, the yarn linear density is expressed as the mass in grams of one kilometre of yarn, with the units being called tex. In this system, as the tex value increases so does the yarn actual thickness.

So in our example, from Table 1, a one kilometre length of yarn extracted from a pair of jeans will have a mass of 100 grams whereas the same length of yarn extracted from a summer shirt will have a mass of only 15 grams.

**TABLE 1: Typical fabric mass and yarn requirements to manufacture specific garments**

<table>
<thead>
<tr>
<th>Garment</th>
<th>Fabric mass (gsm)</th>
<th>Yarn linear density or count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeans</td>
<td>400</td>
<td>100 6</td>
</tr>
<tr>
<td>Summer woven shirt</td>
<td>80</td>
<td>15 40</td>
</tr>
</tbody>
</table>

The second system of measurement, called the English Cotton count (or simply Ne) is commonly used by the cotton spinning industry. This system measures the number of hanks, each of which are 840 yards long and weigh one English pound. In this system a big number implies a fine yarn and a small number implies a coarse yarn. This is the reverse of the tex system.

There is a simple conversion between Ne and tex, as follows:

Yarn linear density in tex = $590.5 \div (yarn\ count\ in\ Ne)$ and
Yarn count in Ne = $590.5 \div (yarn\ linear\ density\ in\ tex)$.

So we have the garment, which determines the fabric mass per unit area that the weaver must produce, which in turn determines the mass per unit length of the yarn (ie yarn count) that the spinner must produce.

**The concept of fibre linear density or fibre fineness**

Just as yarn is measured in terms of mass per unit length, it is possible to characterise fibres in a similar way. As fibres are much finer than yarns, mass per unit length of a fibre is normally expressed in terms of the mass in milligrams of one kilometre length of a fibre. The unit is called milli-tex or mtex. A typical value for cotton fibre is about 200 mtex – that is, a cotton fibre hypothetically one kilometre long would weigh 200 milligrams.

In the cotton industry, the fibre linear density is often called the fibre fineness. But cotton fibres have an irregular cross-sectional shape as shown in Figure 1, and the mtex value is not a measure of the actual physical dimensions of the fibre and so fibre fineness is perhaps a misleading name.

It is interesting to note fibre linear density is in common usage by the synthetic industry and is routinely used as a key part of fibre specification in commercial trading. In the wool industry, the other important natural...
Australian textile fibre, as the fibres are approximately circular in cross-section, fibre diameter (the micron value) is commonly used rather than fibre linear density.

**The spinning process**

Let us now turn to the technical challenges facing spinning to understand the importance of fibre linear density/fibre fineness.

Imagine the task of spinning a 15 tex yarn (15 grams per kilometre) using cotton fibre with a linear density of 200mtex (200 milligrams or 0.2 grams per kilometre). These numbers are not atypical for Australian cotton and its usage.

This yarn will need 75 of the 200mtex fibres side by side to build up the required yarn mass (ie 15 divided by 0.2). So conceptually the spinner needs to construct the yarn with 75 fibres side by side, while building up the length of the yarn by putting new fibres exactly at the point where the previous fibre ends.

Figure 2(a) schematically shows a section of this idealised yarn. For simplicity, in Figure 2, only six rows of fibres are shown rather than the 75 required for the yarn. This structure is then twisted together to form a yarn by spinning. (See the insert box to understand the magic of forming a strong yarn from such an array of discontinuous fibres.)

Unfortunately, in the actual spinning process, there is no mechanism for placing the fibres precisely end to end as in Figure 2(a) (idealised yarn). Figure 2(b) (real yarn) is a more realistic representation of a yarn cross section.

Figures 2(a) and (b), both have on average six rows of fibres. But in Figure 2(b) the starting point of each fibre along the length of the yarn is random. Consequently, the actual number of fibres across the width of the yarn varies along its length.

This can be seen by counting the number of fibres crossing the vertical red line in Figure 2(b) and at other points along the yarn. While on average there are six fibres in the cross-section, at the vertical marker there are only four fibres and further along the yarn there are some short regions where there are seven or eight fibres in the cross-section.

In summary, real yarns naturally/always have thicker spots and thinner spots along their length. This effect can sometimes be observed in light weight tee shirts or vests where close examination highlights a slightly uneven appearance of the knit structure. This uneven appearance is caused by naturally occurring short lengths of yarn that are either particularly thin or thick.

Figure 3 shows a real example of the cross-section of a cotton yarn showing the packing of individual cotton fibres within the structure. In this yarn cross-section, 78 individual fibres are distinguishable.

**The impact of fibre linear density or fineness to the spinner**

A thin place in a yarn is a weak place, which has potential to break during either the spinning process itself or later during fabric manufacture. This can have a significant impact on the efficiency of the processes, so there is considerable pressure on the spinner to ensure that the yarn manufactured and supplied is as even as possible so breakages do not occur. The linear density or fineness of the raw cotton fibre used to manufacture the yarn can have a big impact on yarn evenness, as illustrated below.

In our example, illustrated in Figures 2(a) and (b), imagine if the spinner chose to make the same yarn from a coarser cotton fibre with a linear density of say 250mtex rather than 200mtex. In this case, fewer rows of the heavier fibres are required to make up the required mass for the yarn. ...
as shown schematically in Figure 2(c). It is now clear that the natural variation in the number of fibres in the yarn cross-section is now more exaggerated with the ‘thin’ place identified with the vertical line in Figure 2(c) being much more exaggerated.

Figure 4(a) illustrates the effect of making the same yarn from cottons with different fibre linear density/fineness values. As the cotton becomes coarser, its linear density/fineness increases, the average number of fibres in the yarn cross-section reduces (the peak of the curve in Figure 4 moves to the left). It is important that the yarn is strong enough at all points along its length so that it does not break during spinning or fabric manufacture.

Figure 4(b) plots the relative number of particularly thin places along the yarn (each with less than half the average number of fibres in the yarn cross-section. It shows that increasing the linear density (fineness) by a relatively small amount can have a relatively big effect on the ability to spin the yarn. For example, increasing the fibre linear density by only 10 per cent from 160mtex to 180mtex increases the number of critical thin spots by a factor of 300 per cent.

The 160 or 180mtex fibre might easily spin and produce a commercially acceptable yarn. But the spinner might not be able to spin the same yarn from the 200mtex fibre due to the very large number of breakages and yarn unevenness.

These effects are well known to the spinner and so he chooses the input fibre quality with some care. As noted above, the linear density of synthetic fibres is routinely available and fibre diameter (micron) is used by the wool industry.

Spinners carefully use this data to choose appropriate raw materials for spinning either synthetic or wool yarns. In the case of cotton, unfortunately, fibre linear density or fineness is not available to the trade, which instead relies on the micronaire value as a proxy for fibre linear density (fineness).

The industry discount for high micronaire is indeed a direct manifestation of the problems highlighted in the example above of trying to spin a yarn if the fibre is too coarse.

The limitations of micronaire

As noted in Part 1 of this series (van der Sluijs et al, 2008) micronaire is a mixture of both fibre linear density (fineness) and also fibre maturity. Figure 5 shows the relationship between these three parameters. Note that it is not possible to accurately estimate fibre linear density (fineness) from the micronaire value alone.

For example as shown in the Figure, a micronaire value of 4.1 can be obtained from cottons with fibre linear density values over the range 160 to 200 mtex for fibre maturity values in the range 0.95 down to 0.75. While a thorough study of range of fibre maturity for Australian cotton has not been undertaken, this is likely to be a representative range.

Note that the range of fibre fineness values (ie 160 to 200 mtex) in this example can give rise to quite different behaviour in spinning as illustrated in Figure 4. It is thus not surprising those spinners of fine yarns who are largely the customers for Australian cotton adopt a risk management strategy of discounting high micronaire cotton.

It would therefore be useful to have a technique to routinely measure cotton fibre linear density or fineness directly as part of the determination of the quality and value of a cotton. The Cottonscan instrument under development at CSIRO and supported financially by the Australian cotton industry through research funding from the CRDC is designed to undertake this task.

CONCLUSION

Fibre linear density (sometimes called fibre fineness) is a key parameter that can significantly impact on the spinner’s ability to manufacture fine yarns suitable for high value-added fabrics, the desired market for Australian cotton.

The ambiguity in interpreting the fibre linear density or fineness of a sample of cotton from the micronaire value leads to potential major impacts on spinning efficiency and yarn quality. So it would be useful if the industry were able to directly measure fibre linear density or fineness of cotton samples.