WHAT ARE THE LIMITS TO WOOL FIBRE FINENESS MEASUREMENT?

Programs attempting to breed commercial sheep flocks averaging 14 microns are now under way (see News). If these are successful the limitations of existing measurement technologies in measuring wool fibres around 10 microns and less may become an important issue. Both LASERSCAN and OFDA 100 are each capable of measuring the fineness distribution characteristics of such wools. However, it is well known that while both instruments can produce fibre diameter distributions, which include measurements less than 10 microns, for the same sample the OFDA 100 generally "sees" more of these fibres than LASERSCAN (see Figure 1). The reason for this has been a matter of conjecture for many years. Furthermore, while both instruments detect a small number of fibres as fine as 5 microns, doubt has been expressed as to whether or not these readings represent real fibres.

A paper presented to the Shanghai Conference of IWTO in May 2001, has attempted to address these issues **(Technical note: 5 micron fibres found in an ultrafine grower lot - implications for diameter distribution measurement, B.P. Baxter, Technology & Standards Committee - Raw Wool Group, Report RWG-02, IWTO Congress, Shanghai, May 2001)**. The paper reports the results of Scanning Electron Microscope (SEM) measurements of some very fine fibres from an ultrafine (13 microns) farm lot produced in New Zealand.

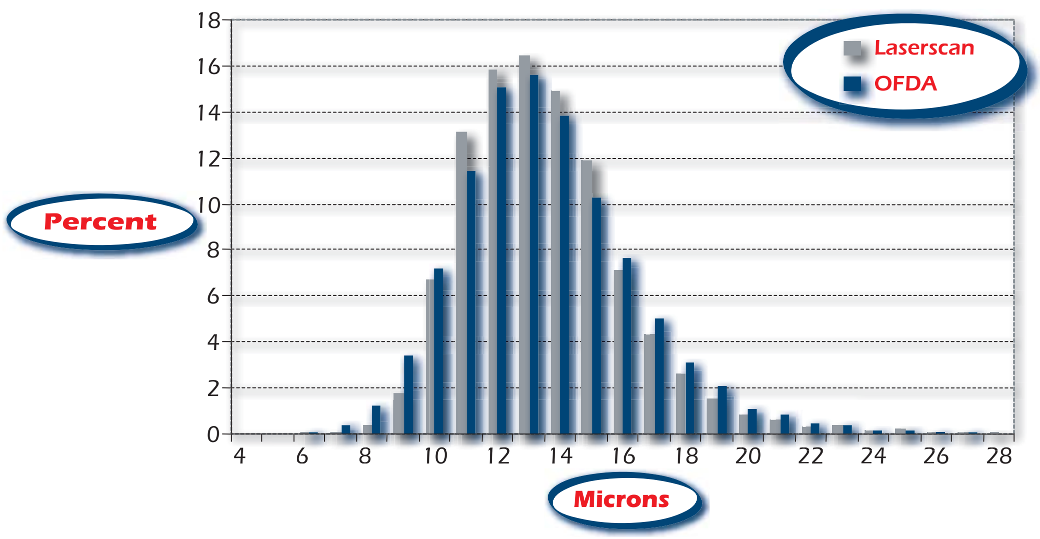
Two independent laboratories provided SEM images of a small number of very fine fibres, from this farm lot.

Scanning Electron Microscopy is often utilised by fibre technologists where much greater magnification and better image resolution than conventional optical microscopes provide, is required. The technique is not readily adaptable to commercial wool testing, being very expensive and very slow.

In the original paper several such images are shown, two of which are reproduced here (Figure 2). Note that these reproductions have been electronically enhanced. Also, because the two laboratories used different magnifications (1500X and 1000X respectively) these examples have been manipulated electronically to ensure the scale is the same. Segments from the separate fibres, which have almost the same nominal diameter (5.7 and 5.9 microns respectively), have been manipulated to show that the correspondence between the two laboratories is very close. The vertical fibre segments on the right hand of the Laboratory 1 image demonstrate this. These segments have been electronically cut from the images and rotated so that they are both vertical. The vertical yellow lines are drawn tangential to the ends of the transects where each fibre was measured.

It is important to note that SEM measurements are conducted in a vacuum, so the moisture in the fibres will be very low. Wool fibres readily absorb moisture and, depending upon the diameter, can swell by as much as 2 microns when they do so. All the technologies used commercially for estimating wool fibre diameter require the fibres to be in equilibrium with a standard atmosphere of 20^{0}C and a relative humidity of 65%. In other words the fibres are in a "swollen" state. An adjustment to the dimensions shown on the SEM images was made to take account of this effect. The adjustment used needs to be verified to confirm its accuracy when applied to individual wool fibres of low diameter. Any error in the adjustment will introduce an error in the reported values. Until the adjustment has been verified all reported values can only be considered as indicative. In addition because the fibres are not in the same state, direct comparison of these dimensions with

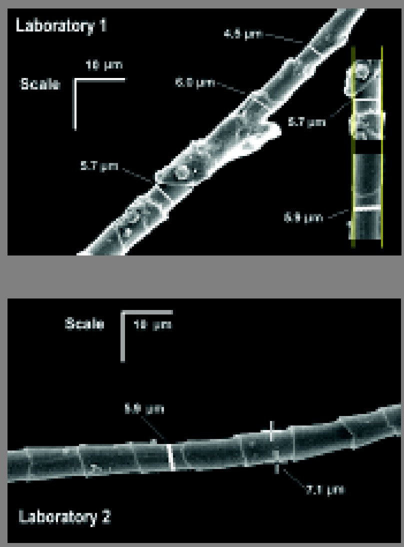
Figure 1: Histogram comparison - Ultrafine grower lot



measurements made by OFDA 100 and LASERSCAN must viewed with considerable caution.

It is also important to note that these dimensions represent the width of these fibres at a point along their length. **They do not represent the average diameter of the individual fibres.** At a particular point along a fibre the diameter may be 5 microns, but that does not mean that the **average** diameter of the fibre is 5 microns. Of the examples shown in the paper, none of the fibres could be said to average 5 microns. Based on the indicated dimensions, each of these short (60 micron to 80 micron) segments of fibre could be said to be within a range of 6-10 microns in diameter. It is reasonably safe to assume therefore that fibres with mean diameters within this range do exist, and both OFDA 100 and LASERSCAN do "see" them.

FIGURE 2



However, when examining fibre diameter distributions produced by either LASERSCAN or OFDA 100, one must not assume that the measurements allocated to a particular micron bin actually represent average fibre diameters of individual fibres. They do not. They represent readings taken by the instruments based on short segments of many individual fibre snippets. In the case of LASERSCAN the length of this segment is approximately 200 microns, and in the case of OFDA 100 it is approximately 4 microns.

The variation exhibited in these distribution histograms arises from variation along the snippets and between the snippets. Because the OFDA 100 measurements are derived from much shorter fibre segments it is entirely conceivable that the contribution from along the fibre variation to a distribution produced by this instrument will be higher than the equivalent contribution to a LASERSCAN distribution. If this is the case then for the same wool the Standard Deviation calculated from an OFDA 100 distribution should be higher than the Standard Deviation (SD) derived from a LASERSCAN distribution. There is a considerable body of evidence to support the observation that for very fine wools and for very coarse wools this is indeed the case, but unfortunately for a range of wools in between the opposite is true.

Equally, one would expect that the SD produced by OFDA 100 would more closely emulate the SD produced by the Projection Microscope, since this instrument measures similarly short fibre segments. In fact this is not the case - the LASERSCAN SD is generally closer to the Projection Microscope SD, at least for wool tops.

Obviously, other factors must also be involved.

We should not lose sight of the reason why the industry measures fibre diameter in the first place. Mean Fibre Diameter is of fundamental importance to spinners and weavers, as it is a primary determinant of yarn and fabric quality, including product fineness (linear and areal density) and flexibility. Variation in fibre diameter and average fibre length also directly affect yarn and fabric quality, but to lessor extents than does Mean Fibre Diameter. One could conjecture that the between fibre variation in diameter in a top is probably a much more important determinant of yarn and fabric quality than is the along fibre variation. In part this may be due to the fact that fibre breakages during top making tend to occur at the thin points in the fibre and the resulting fibre ends contribute less to yarn quality than does the body of the fibre.

At the moment, whether or not fibres less than 10 microns exist and can be measured has no commercial significance. However, a significant increase in production of wool with an average diameter less than 13 -14 microns is bound to increase interest in the population of fibres at the fine end of the distribution in diameters associated with these wools. Reliable measurement systems will then be required. OFDA 100 and LASERSCAN are both calibrated instruments, but the lowest calibration standard is about 17 microns. Consequently, both instruments are operating in an extrapolated area of their calibration functions when measuring ultrafine wools. Furthermore, for fibre diameters around 5 - 6 microns, both technologies are approaching the limit of their performance. Clearly, more fundamental information about the performance of both instruments in measuring very fine fibres, rather than speculation, will be required.

To this end AWTA Ltd, the University of New South Wales, and the Australian Research Council are sponsoring a PhD student, working at AWTA Ltd's Research & Development Division under the supervision of Dr Trevor Mahar and Professor Ron Postle, to conduct some fundamental research examining the limits of detection of both instruments. This work is expected to provide a better understanding of reasons for the observed differences between the technologies and of their limitations.