Measuring Fibre Curvature: Key Issues.

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Summary

The capability of instruments such as SIROLAN-LASERSCAN™ (LASERSCAN) and OFDA100 to provide measurements of fibre curvature has resulted in increased interest, within Australia among wool producers and exporters, and among overseas top-makers and spinners. However, the metrology of fibre curvature measurement by these instruments is poorly understood. Standardised conditions for preparation, and measurement procedures that stabilise the curvature of the wool fibres prior to measurement by either instrument, are yet to be defined.

Based on its strong association with crimp frequency, wool fibre curvature measurement holds promise as a specification, which can be used to add value to wool in production, trading and processing. However, wool fibre shape (or curvature) is relatively unstable compared to other raw wool parameters such as mean fibre diameter, adding emphasis to the importance of defining standardised preparation procedures.

The stability of the fibre curvature measurement is affected by the sample preparation procedures currently used for both LASERSCAN and OFDA100. Preliminary results show that Shirley Analysing influences fibre curvature, as can the particular design of the OFDA100 spreader. The simple process of minicoring also increases measured fibre curvature. Results are presented highlighting the relationship between fibre curvature measurements by LASERSCAN and OFDA100. The need for a calibration system for these instruments for fibre curvature measurement is foreshadowed.

While it is encouraging to see breeders adopting new technologies, research is showing that breeders should be careful when using fibre curvature measurements in the implementation of their breeding plans. Breeders need to be aware of the limitations of the measurement of fibre curvature, and remember that the measurement should not be treated with the same level of confidence as that given to mean fibre diameter.

Introduction

There has been much debate throughout the wool industry regarding the measurement of wool Mean Fibre Curvature (MFC), but the question of greatest interest to wool producers and breeders is, "What benefits are there for me for investing in MFC measurements?". The industry has no simple answer to this question, and each interested party needs to assess the benefits for themselves. This paper attempts to provide wool producers with the knowledge to assist them in their assessment of potential benefits or otherwise. The main issue to be addressed in this paper is the repeatability of the measurements themselves.

Previous reports (Wuliji *et* al 1995, Stevens and Mahar 1995) have shown that there are potential benefits to processors by specifying MFC for consignments of differing end-use. However, processors should be aware that MFC is a fledgling measurement and should not be afforded the same level of dependability as Mean Fibre Diameter (MFD). Today, sale lots are primarily assembled using MFD. There are very few, if any, sale lots that are assembled using MFC measurements. Therefore it is difficult for a processor to assemble a consignment of a particular MFC.

Relationship between MFC and Crimp Frequency

Fibre curvature is only one way to describe the shape of a wool fibre. Previously, shape descriptors such as crimp frequency and crimp definition have been used to describe the shape of a fibre in the greasy state. Crimp frequency is traditionally measured on a greasy staple of wool using a crimp gauge. The benefit of the MFC measurement is that MFC is measured in conjunction with MFD and Standard Deviation of Diameter (SDD) on both of the instruments available for commercial fibre testing.

Single fibre crimp frequency has been found to relate directly to single fibre curvature (Kurdo, 1985), however the relationship between staple crimp frequency and MFC is not as simple (Hansford & Humphries, 1997), with a correlation coefficient (r^2) of 0.68 (Fish *et al* 2000b) for one trial as measured on LASERSCAN (Figure 1). A similar relationship ($r^2 = 0.62$) exists between staple crimp frequency and MFC on OFDA100 (Fish *et al* 2000b).

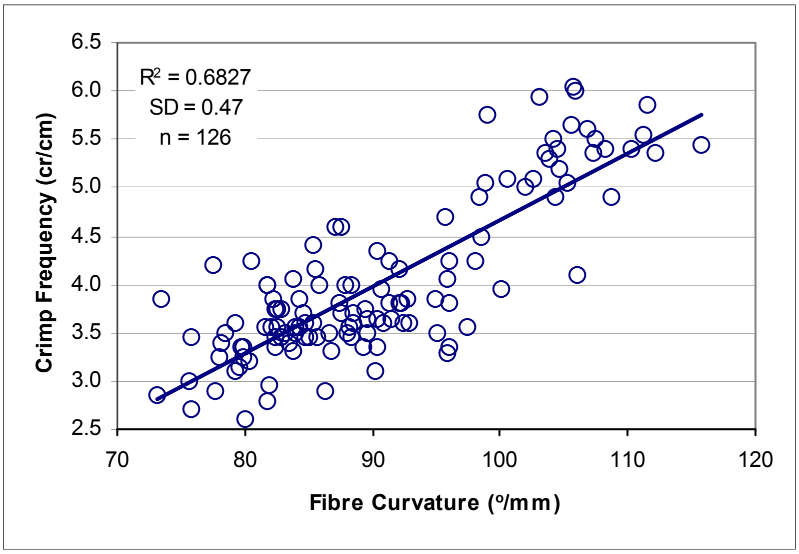

Figure 1: The relationship between manually measured fibre crimp frequency, and mean fibre curvature as measured on LASERSCAN, with Correlation Coefficient (r^2) =0.68 (taken from Fish *et al* 2000).

Relationship between MFC and MFD

Fish *et al* (1999), Fish (2002a) and Stanton and Curtis (2002) have shown that there is a relationship between MFD and MFC for sale-lots of Australian wool, however this relationship is dependent on the source and type of the wool. While the relationship exists, there is no “right” or “wrong” relationship for MFC and MFD. Swan (1998) used a bareme, entitled “True-to-Type”, to demonstrate the relationship between wool of similar MFD but differing MFC. The True-to-Type bareme was used to demonstrate the differences between wool of differing types, namely “traditional” and “elite” types. This bareme does not imply that there are “right” or “wrong” types of wool, rather it acknowledges that there are differences in physical characteristics between wool of varying types, which have differing processing potential.

Limitations to the Use of MFC in Specification

The use of MFC measurement for the specification of raw wool for the textile industry is potentially limited by a number of factors: the relative instability of the measurement in comparison with the measurement of MFD, the need for standardised MFC measurement, and industry acceptance of the measurement. While it is impossible to control the acceptance of the measurement by the international industry, it is potentially possible to control the measurement’s instability through calibration, standardisation and an understanding of the processes involved in the measurement.

Limitations in the Measurement of Mean Fibre Curvature

Calibration

In the context of MFC, calibration is defined as the correction of raw instrument values to a standard measurement of fibre curvature. MFD is calibrated using the Interwoollabs Standard IH Tops, which are a set of eight tops of known MFD. Fibre Curvature is an un-calibrated measurement because no standard or point of reference exists for its measurement. As a result, fibre curvature measurements are generated worldwide, with no means of comparing the accuracy with a universally defined and agreed benchmark. With no calibration material available to account for different sample preparation routes, there is no means of harmonising the response of individual instruments. There is evidence of between instrument differences for both LASERSCAN and OFDA100 (Fish 2002a).

Baxter (2002) queries whether a confidence interval of ±7°/mm (based on a round trial of 40 OFDA100 instruments) is adequate for industry needs. This trial standardised measurement by using a photographed graticule to remove sample variance for the estimation of the confidence limit. If the industry wishes to trade on MFC, then a more robust calibration maybe required to provide adequate discrimination between different wool. This would require a level of standardisation in the measurement system as a means of accounting for differences arising from sample preparation procedures.

Standardisation

Standardisation refers to the control of procedures and techniques associated with the measurement of MFC in order to reduce the variance associated with a measurement procedure. It has been shown (Fish *et al* 1999, Ranford 1999, Fish 2002a) that the preparation techniques (such as scouring, minicoring and any technique that can exert a force on the fibre) used prior to measurement can affect the measurement of MFC by varying degrees. Standardisation of MFC measurement is important because external forces influence the intrinsic shape of wool fibres, an influence that is compounded by the visco-elastic properties of the wool fibres themselves (Fish *et al* 1999). Therefore it is important to limit the range of possible influences by standardizing the measurement technique.

The Fibre Curvature Working Group of TX12 devised an IWTO Draft Test Method for Fibre Curvature (Ranford 1999) based on IWTO-12 and IWTO-47, however the Draft Test Method is yet to be adopted by the industry as a Working Draft Test Method.

Fish (2002a) has shown that a number of factors can contribute to differences in MFC prior to measurement. These include Shirley Analysing, the use of blunt minicoring tubes and repeated minicoring of test samples have all been shown to increase the MFC of samples. These factors must be considered in any attempt to standardise the measurement of MFC.

Precision

MFC has been shown to vary over the fleeces of sheep (Fish *et al* 2002; Fish 2002a; Marler *et al* 2002; Sumner & Upsdell 2000). The trend in MFC over the fleece does not relate directly to the observed trends in MFD and SDD. The implications that can be drawn from sampling a fleece need to be related to the trends expressed over the entirety of the fleece, and the expression of MFC amongst the flock of animals investigated (Fish 2002a, Marler 2001). Therefore the selection of the sampling site is an issue that needs to be addressed if individual sheep are to be compared.

OFDA100-LASERSCAN Differences

MFC is an additional measurement provided when MFD is tested in accordance with IWTO-12-01 (LASERSCAN) and IWTO-47-01 (OFDA100). OFDA100 collects MFC data in much smaller increments than LASERSCAN, but despite this, there is good agreement between the instruments (r^2=0.74)(Figure 2, taken from Fish *et al* 2000).

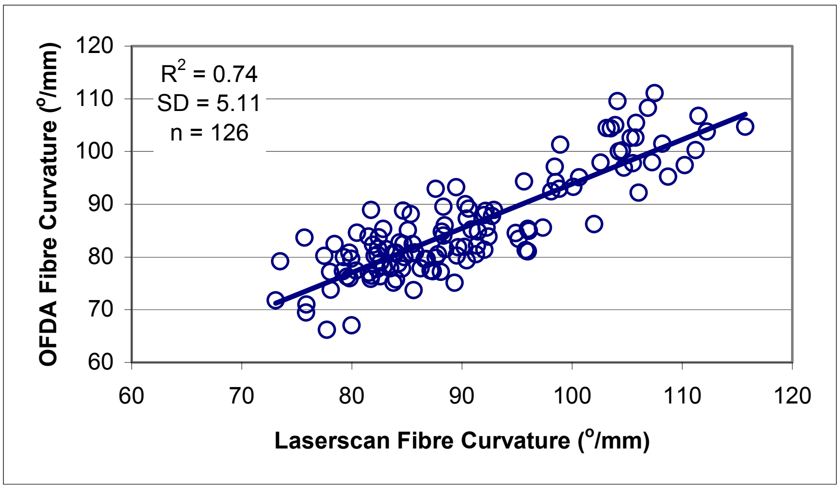

Figure 2: Comparison of Mean Fibre Curvature data generated using one LASERSCAN and one OFDA100 (taken from Fish *et al* 2000)

To calculate MFC, OFDA100 uses a similar method as that used for the calculation of MFD. A histogram is compiled from the individual fibre curvature measurements and allocated to 8 deg/mm class intervals. In contrast, LASERSCAN calculates MFC by allocating fibres to one of 8 class intervals (AWTA Ltd 2002). It has been shown that there is a negligible difference (<1deg/mm) between the two methods of allocation (Fish 2002b), and that this does not solely explain the instrument differences.

Concluding Remarks

MFC measurement is potentially very useful for both wool producers and wool processors. However, the development of this measurement into a beneficial industry tool needs to progress in a sensible manner. MFC measurement does not have the same level of repeatability as MFD, and as a result, conclusions cannot be made from MFC results with the same level of confidence.

Standardisation of the MFC measurement technique is of major importance for the long-term viability of the measurement. Standardising a test procedure for both LASERSCAN and OFDA100 will help reduce the level of measurement variance contributing to differences in the measurement of MFC. The standardisation of the procedures will then enable the assessment of the true value of a MFC calibration.

While the potential benefits of MFC measurement to the wool industry in general are yet to be fully realised, it is important for the industry to be aware of the limitations of MFC. This is especially true when interpreting data for comparisons of sheep and sale lots. Comparisons should only be made between the same instrument type, using the same preparation and measurement procedures. This implies measurements from the same test-house, and even then strict internal quality control is important for the repeatability of MFC.

Further work is required on the standardisation of measurement procedures, which will benefit the industry's understanding and knowledge of this fibre measurement.

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