Greasy Wool Metrology

Historically, the processors and other users of wool, not the producers, have driven the development of objective measurement systems for various wool characteristics.

Measurement and specification of raw material characteristics is a fundamental component of modern manufacturing processes. It is central to maintaining product quality. The adoption of objective measurement of raw wool by wool processors has been driven by the same need.

1 Defining Quality Attributes of Greasy Wool and Wool Products

Put quite simply, metrology is the science of measurement. In broad terms metrologists are generally focussed upon developing and evaluating technologies and systems for objectively measuring the quality attributes of raw materials and manufactured products.

It is essential that raw materials and products meet the requirements of those who use them (Sommerville 1998). This **fitness for use** defines their quality. There are two general aspects of quality: **quality of design** and **quality of conformance**.

Raw materials and products are generally available in various grades or levels of quality. These variations are often intentional, and consequently the appropriate technical term in such instances is quality of design. For example, all wool suits serve the same basic function, but they are available in a range of designs, fabrics and prices, aimed at specific market segments.

On the other hand, quality of conformance is how well the product conforms to the specifications and tolerances required by the design. Quality of conformance is influenced by a number of factors. For example, for wool garments these may include the following:

- Variability of the greasy wool,
- Choice of the manufacturing processes,
- Operation of these processes,
- Training and supervision of the work force,
- Type of quality-assurance system (process controls, tests, inspection activities etc),
- Extent to which these quality assurance systems are followed, and
- Motivation of the workforce to achieve quality.

Every product, including wool, possesses a number of elements that jointly describe its fitness for use. These elements are often called **quality characteristics**. Quality characteristics may be of several types, for example:

- **Physical:** length, weight, fineness, yarn evenness.
- **Sensory:** handle, feel, appearance, colour.
- **Time Orientation:** reliability, durability, serviceability.

Generally it is difficult (and expensive) to provide customers with raw materials and products that have flawless quality characteristics. A major reason for this difficulty is **variability**. There is a certain amount of variability inherent in any raw material or product and consequently any two products can never be truly identical. Wool is an extremely variable material. It varies along the fibre, between fibres, between staples, between animals, between mobs, between bloodlines and between regions. If the wool industry wishes to improve quality and reduce overall cost it must find ways of restricting or controlling the impact of this inherent variability of the fibre on the quality of finished textile products. Wool metrologists have provided us with some of the means to do this.

Quality characteristics can be estimated subjectively using vision and touch, or they can be assigned a numerical value using objective measurements. Traditionally, the hand and the eye were the major tools used to determine the value and processing attributes of wool. Today however, at all levels of the industry, technology is increasingly replacing subjectivity.

2 A Brief History of Wool Metrology

The application of metrology in wool processing goes back more than two centuries. The first recorded attempt to objectively measure wool's most important characteristic, fibre fineness, was in 1777, when Daubenton measured the width of some wool fibres under a microscope by comparison with lines drawn on a piece of quartz (Sommerville, 1999). During the 19th century and the first half of the 20th century, the microscope became the favoured instrument for directly determining the fineness of wool tops. For various reasons this technology could not be readily applied to the same measurement in greasy wool.

However, the development of core testing in the USA after 1937, by the USDA, US Customs and the Boston Wool Trade Association, made the representative sampling of bales of greasy or scoured wool possible. In Australia in the 1950's and 60's CSIRO developed manual pressure core equipment. CSIRO and AWTA Ltd together with New Zealand Wool Testing Authority (NZWTA Ltd) designed improved machine core testing equipment suitable for large volume sampling. During the 1970's the Australian Objective Measurement Program (AOMP), as a prerequisite to "sale by sample", developed systems for representative grab sampling of full length wool from greasy or scoured wool lots.

These improved sampling technologies opened the way for the development of Standard Test Methods, which were able to provide more accurate and precise estimates of the most important value-determining characteristics of greasy wool in mill consignments, namely:

- Wool Base (Yield)
- Mean Fibre Diameter (Micron)
- Vegetable Matter Base
- Mean Staple Strength
- Mean Staple Length
- Colour

It is important to remember that these parameters are those previously subjectively assessed by wool buyers and by mill technicians before the advent of modern measurement technologies. Traditionally the industry has used these parameters to predict the value determining characteristics of wool tops such as:

- Mean Fibre Diameter (Micron)
- Hauteur
- Coefficient of Variation of Hauteur
- Colour

The major breakthrough in wool metrology occurred in the period 1945 to 1955 with the development of the Airflow instrument. This provided a relatively inexpensive indirect method for measuring the fineness of tops. By the late 1960's methods for preparing and measuring the fineness of greasy wool by Airflow had also been developed, and this instrument, despite its known limitations, became the primary technology for measuring the fineness of wool (Sommerville, 1999).

In the UK, WIRA and the British Wool Federation developed both yield and fineness test methods, but the USA and Europe established different processing and moisture tolerances to estimate commercial yields of fibre obtained from greasy wool.

The international adoption of common sampling and testing procedures became possible through the International Wool Textile Organisation (IWTO), established in 1930. IWTO set up technical and commercial committees to oversee the development of standards, thereby enabling common sampling and measurement processes to be adopted by all wool growing and wool processing countries. Nevertheless, it was not until 1965 that technical and commercial delegates at IWTO were able to agree on standardised sampling and testing processes for Wool Base and Vegetable Matter Base. The industry waited until the early 1980's for development of standardised systems for determining Staple Length & Strength and Position of Break based on subsamples drawn from grab samples

Once wool metrologists had developed the sampling and testing technologies and Standard Test Methods became available, the impetus for the growth in objective measurement, initially for mill consignments and then for presale farm lots was driven by the users of wool, to assist them in ensuring the quality of conformance of the yarns, fabrics and garments they produced. In Australia wool producers were initially reluctant to adopt objective measurement and sale by sample of auction lots, but adoption accelerated throughout the 1970's, 80's and 90's as price differentials between untested and tested lots became evident.

During the 1990's new technologies (Sirolan Laserscan, OFDA100) emerged for measurement of the fineness distribution characteristics of greasy wool as well as the mean diameter. By 2000 these technologies had effectively replaced the Airflow.

3 Technical and Commercial Requirements of Wool Testing Systems

Objective determination of defined characteristics of materials usually involves measurements based on a small proportion of the material of interest. Where materials are **homogeneous**, obtaining a representative sub-sample of the whole is a relatively simple problem. Where there is **heterogeneity** obtaining a sub-sample that is representative of the whole is a much more difficult task.

There are a several factors that bear on the technical and commercial application of objective measurement systems (Sommerville 1998; Sommerville 2001, Douglas 2000). We will consider only the four most important of these here.

3.1 Sampling

Wool is a **heterogeneous material**, both in the bulk or when still on the sheep's back. The sampling procedures for sale lots or consignments of wool have been carefully developed to ensure that the sample represents the bulk with a predictable degree of error. The requirements for sampling the bulk also extend to further sub-sampling of the sample itself, in order to measure a specific characteristic. The theory and practice of these sampling regimes will not be considered here. Suffice to say **sampling is the first and most important step in any wool testing system**.

3.2 Precision

Precision describes the reproducibility of results – that is the agreement between numerical values of two or more measurements determined using the same measurement systems. Common components of all measurement systems are:

- sampling (both from the bulk and further sampling of samples obtained from the bulk),
- instruments or machines,
- laboratories, and
- people.

Each of these components introduces errors and the errors are additive. The precision of a measurement of any particular characteristic is therefore determined by the sum of the errors in each of these components of the measurement system.

3.3 Bias

Wool metrologists are concerned with two types of errors:

- random or indeterminate errors; and
- systematic or determinate errors.

The error in the mean of a number of replicate measurements is equal to the sum of these two errors.

Random or indeterminate errors impact upon precision. Bias may have little or no effect on precision, but it has a significant effect upon accuracy i.e. how close the measurement is to the "true" result.

Bias is a result of systematic or determinate errors. Systematic errors always act in one direction, resulting in a consistently larger or a consistently smaller result than the "true" result. Bias can result from several causes, and generally, these can be classified into one of six groups:

- sampling;
- differences in fundamental assumptions;
- personal errors;
- instrumental errors;
- method errors; or
- interferences.

Bias may be constant over the range of variation of the characteristic being measured, or it may vary over this range. One of the objectives of standardising wool testing systems is the elimination or at least the minimisation of bias. Where bias cannot be eliminated, provided it is not level dependent, a measurement technology may still be useful.

3.4 Cost

Industry adoption of any objective measurements is wholly influenced by the cost versus the benefit. Therefore, in establishing an objective measurement system, factors such as sampling, precision and bias must be balanced against the costs and the potential benefits. As a general rule, metrologists try to balance the demands of sampling, precision and bias to provide a measurement at an acceptable cost. This inevitably means that some compromises must be made.

4 Information Provided by Greasy Wool Measurements

Certified Parameters	Predictive Application	Test Method(s)
Mean Fibre Diameter	Top Diameter	IWTO-28 IWTO-12 IWTO-47
Wool Base Vegetable Matter Base	Schlumberger Dry Top & Noil Yield IWTO Clean Scoured Yield Japanese Clean Scoured Yield Australian Carbonising Yield	IWTO-19
Staple Length Staple Strength Position of Break	TEAM Formulae for: • Hauteur • Coefficient of Variation of Hauteur • Romaine	IWTO-30
Colour	Whiteness of Top Brightness of Top	IWTO-56

Note 1: The TEAM formulae also include terms for Mean Fibre Diameter & Vegetable Matter base. A new TEAM formula arising out of the TEAM-3 Trial adds terms including Coefficient of Variation of Diameter and Coefficient of variation of Staple Length.

Note 2: Measurement of Colour in Greasy Wool has not achieved a significant level of adoption in Australia, in part due to the fact that Australian Merino Wool is renowned for its whiteness and brightness. However, some lines of wool, such as crutchings, skirtings and bellies are often significantly more coloured than fleece wools. There have also been seasons, when conditions have been wet and humid where significant discoloration of fleece wools has occurred. In New Zealand, where cross bred wool predominates, sale lots are routinely measured for Colour. Research has shown that there is a strong relationship between the clean colour of greasy wool and the clean colour of the resultant top.

5 Using Greasy Wool Measurements

The inherent value of any greasy wool measurement is in its usefulness in ensuring quality of conformance to a specified design. This usefulness is dictated by the extent to which the conversion of greasy wool into product itself modifies the physical characteristics of the wool, and to the extent to which these modifications can be predicted from the greasy wool measurements.

We know that during the primary processing steps,

- scouring:
- carding, and
- combing,

fibres are lost or removed, fibres are broken and fibres can be discoloured. Hence any measurements made on greasy wool will not be replicated when repeated on the tops produced from this greasy wool. Systematic differences are to be expected and do occur.

Fortunately, the most important characteristic of greasy wool, Mean Fibre Diameter, is usually only marginally changed during processing, with the average value in the top increasing by 0.2-0.4 microns. Hence the greasy wool measurements can, in most instances, be used to predict this with a high degree of precision.

Top Yield on the other hand is more dependent on the mill.. Predicting Top Yield from the greasy wool characteristics such as Yield and Vegetable Matter Base requires adjustment for mill effects. Some generalised adjustments are included in the Schlumberger Dry Top & Noil Yield calculation but allowances still need to be made for individual mill effects.

Likewise, prediction of fibre length distribution characteristics such as Hauteur and Coefficient of Variation of Hauteur is not simple, due to the fibre breakage that always occurs during processing. For these parameters the processing outcome is very highly mill dependent. However, the TEAM trials developed general formulae, based on Staple Length, Staple Strength, Vegetable Matter Base, Mean Fibre Diameter, Position of Break, Coefficient of Variation of Diameter and Coefficient of Variation of Staple Length that can be used to predict Hauteur, Coefficient of Variation of Hauteur and Romaine. Nevertheless, for this to be useful, each mill must derive a “mill factor” to add to the formulae. The “mill factor” is specific to every mill, and corrects the TEAM formulae predictions so that they more accurately reflect the performance of the mill.

6 Conclusion

Wool metrology has provided technologies and systems that objectively measure most of the value determining characteristics of greasy wool. This in turn enables wool processors to more accurately specify raw wool characteristics that will ensure that when this wool is processed into top the product will have the characteristics required by the spinner (Douglas & Couchman 1997, Douglas 2000).

Through IWTO the industry has developed commercial regulations that apply to the respective Test Methods that among other things set out requirements for guarantees, check tests and retests. These regulations are supported by an Arbitration Agreement that provides a mechanism for settling disputes between buyers and sellers (IWTO Blue Book). These publications, as well as copies of the Test Methods, can be purchased from IWTO.

7 Useful References

Douglas, SAS & Couchman. R C, *Industry View of the TEAM Prediction Formulae*,Report to: IWTO Woolgrower's, Traders and Early Processors Committee, Nice, December, 1997

Douglas S.A.S. *Wool Trading Requirements & Technical Limitations of IWTO Test Methods*, AWTA Ltd, Melbourne, 2000

Sommerville, P.J., *Objective Measurements – More than Pretty Numbers*, AWTA Ltd, Melbourne, 1998

Sommerville, P.J., Technology & Standards Committee, Raw Wool Group, *Report RWG03S*, IWTO, Florence. 1999

Sommerville ,P.J. *Technical & Commercial Requirements of Wool Testing Systems*, , AWTA Ltd Newsletter, September 2001

TEAM Final Report 1985

Report on Trials Evaluating Additional Measurements 1981-1988

TEAM-3 Final Report

7.1 *Additional Reference Material*

Testing the WoolClip, AWTA Ltd

Glossary of Terms, Testing the WoolClip, AWTA Ltd

Publications, AWTA Ltd

8 Test Specifications for Greasy Wool

IWTO-12	Measurement of the Mean and Distribution of Fibre Diameter Using the SIROLAN_LASERSCAN Fibred Diameter Analyser
IWTO-19	Determination of Wool Base and Vegetable Matter Base of Core Samples of Raw Wool
IWTO-28	Determination by the Airflow Method of the Mean Fibre Diameter of Core Samples of Raw Wool
IWTO-30	Determination of Staple Length and Staple Strength
IWTO-31	Calculation of IWTO Combined Certificates for Deliveries of Raw Wool
IWTO-38	Method for Grab Sampling Greasy Wool from Bales
IWTO-47	Measurement of the Mean and Distribution of Fibre Diameter of Wool Using and Optical Fibre Diameter Analyser (OFDA).
IWTO-56	Method for the Measurement of Colour of Raw Wool

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