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Foundations and Metrology of the Almeter
Wool Fibre Length Measurement

By

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SUMMARY

This paper recalls how the Almeter instrument was introduced in the wool industry, as a successor to the comb sorters and in particular to the "Schlumberger Analyser", an automated comb sorter in use since 1950.

It also describes the methodology applied to ensure the conformity of the commercial instruments to a standard, and rectifies erroneous statements concerning the Almeter, contained in papers of Mark Brims to the Sliver Group.

BACKGROUND

It seems that the younger authors like Mark Brims and Andrew Peterson are not aware of some early parts of the evolution of wool fibre length measurement and as a consequence, are writing sometimes a few erroneous statements concerning not only the Almeter, but also wool fibre length in general.

The purpose of this short paper is thus to recall these parts of the early history which have a direct relation to the present work on fibre length in the Sliver Group, and to give the corresponding references.

1, Some important steps in the early history of wool fibre length

It is interesting to observe that an important part of the work on wool fibre length was reported to the Technical Committee.

In 1947, at the first post-war meeting of I.W.T.O., a very important paper, defining statistically the mean parameter measured by each different measurement method and making fundamental statements on the subject of wool fibre length, was presented by R.C. PALMER (WIRA, Leeds) [1]. One of these statements is expressed in this way in a following paper by R.C. PALMER [2], cited by F. Monfort in [3] :

"There is no such thing as a mean length of a wool; there is only a mean of a certain distribution of length of this wool".

The same point is stressed by F. Monfort, in his paper of 1950 [4] and in the chapter on fibre length of his book of 1960 [3], with the title "Les longueurs de la laine" (note the word "length" in the plural), pages 208-271.

The type of fibre length distribution, and thus the corresponding mean of that particular fibre length distribution, depends mainly on three factors :

1) the state of the fibre : extended under tension, relaxed or semi-relaxed, for instance.

2) the method of sampling in the formation of the test specimen, which can deliver for instance a “numerical” sample or a “length-biased” sample (see definition in [1] or [3]).

3) the measuring machine or instrument, including the measurement system itself and the calculation of the parameters of the distribution, from the data supplied by this system.

In function of these three factors, the different methods of measurement will thus give different types of fibre length distribution, and the corresponding means will be described by the nature of a possible bias (or by the absence of bias), by the state of the fibre, and by the instrument used. **But the variable l measured remains the fibre length in all cases.**

To represent the mean, the notations of R.C. Palmer (see [1] or [3]) use brackets containing two terms separated by a comma : the first term indicates the bias, the second the variable measured. In the absence of bias, the first term is put equal to 1.

In the second half of the 1940’s, the system of measurement the most used in the wool industry was the comb sorter, also called “array method” in the USA (ASTM). The preparation of the test specimen from the top produced a “numerical” (or unbiased) sample, in the form of an array of fibres with fibre heads aligned on a same origin line. From the weights of the different length classes, the calculations gave two types of distribution : biased by cross-sectional area a, and biased by weight w. The fibres were generally in a relaxed state (for some instruments semi-relaxed). If we call the corresponding relaxed length l_R, the comb sorter allowed to calculate the mean length biased by cross-section [a, l_R], and the mean length biased by weight [w, l_R].

An important step at the end of the 1940’s was the introduction of a partially automated comb sorter produced by Schlumberger. The weighing and the calculating operations were not included in this machine, but the controlled comb sorter improved the precision in a significant way. After some improvements, the final version called “Analyseur Schlumberger MAE” introduced in 1950 and described in [5] was produced in about 80 units installed in nearly all the main wool combing and spinning mills, mostly in Europe. The Technical Committee of I.W.T.O. thus organized interlaboratory trials in 1952 and 1953 [6] and an IWTO Standard for the measurement of wool fibre length on the Schlumberger comb sorter (appareil à peignes in French) was approved in 1959 [7]. In the operating manual of the instrument, Schlumberger had introduced the names : HAUTEUR for mean length biased by cross-section [a, l_R] and BARBE for mean length biased by weight [w, l_R].

In wool textile research, the comb sorters were also largely used during that period but the time requirements being less stringent, measurements on single fibres were also used. A simple method consisted in seizing the fibre between pliers in front of a ruler, and applying a tension just sufficient to rectify the fibre. At WIRA in Leeds, S.L. Anderson and R.C. Palmer developed the WIRA Single Fibre Length Machine, a partially automated instrument which applied a standardized tension to the fibres, used in IWTO-DTM 5-96 [8]. On a numerical sample of fibres, this machine measures the numerical mean length of fibres in an extended state or [1, l_E].

The next step, the introduction of the electronic instruments, is generally well known, and the IWTO Standards (IWTO-16 for the WIRA Fibre Diagram Machine and IWTO – 17-67, superseded by IWTO – 17-85, for the Almeter) give a list of references.

For the Almeter, the 14 references given in [9] cover nearly every domain, from the theory of the measurement and the description of the instrument to an analysis of the results and the experience obtained in using the instrument, in particular the large interlaboratory trials involving 32 participants (5 official testing or research laboratories and 27 mill laboratories).

The point which should be stressed here is the excellent correlation which was observed between the Hauteur and Barbe measured on the Almeter and the same parameters measured on the comb sorters, not only the Schlumberger Analyser but also the Suter used in the ASTM Method D519-68 (Measurement of wool fibre length by the Array Method). Considering the relatively wide and increasing acceptance of the Schlumberger Analyser, this result was one of the objectives we had agreed on in 1955 with Mr F. Monfort (Director of the “André Peltzer” laboratory of Centexbel), when the research for an electronic fibre length measuring instrument was started on his request.

The prototype of the Almeter was presented in operation at the Scheveningen meeting of IWTO in May 1961, but the first instruments were delivered in 1962. The first commercial company who acquired the Almeter, the combing and spinning mill Peltzer et Fils, after testing all the tops for a period of about 6 months on both Schlumberger and Almeter, established the excellent correlation between the two and went over to the sole use of the Almeter, followed immediately by a french combing and top merchant company. The first independent laboratory to establish the corresponding regression, the C.T.C.R.S. in Roubaix, published the Almeter/Schlumberger regression confirming this excellent correlation, in 1963 and 1965 (see ref [6] of the IWTO-17-85-Almeter Standard).

In this regression, it can be observed that the Almeter parameters (both Hauteur and Barbe) are a little longer than for the Schlumberger. This is due to the fact that in the Almeter, the tension given to the fibre "beards" when they are combed through the needles of the pinned fallers by the grip, is maintained even during the transfer in the sample holder to the electronic instrument, while in the Schlumberger Analyser the beards are left free of tension during some parts of the operation. The state of the fibre in the Almeter can thus be described as "semi-relaxed" and the measurement of Hauteur can be represented by [a, l_{SR}] and of Barbe by [w, l_{SR}].

An excellent correlation was also established with another comb sorter, the Suter, in an interlaboratory trial between 8 laboratories on 24 lots of wool tops measured on Almeter following IWTO 17-67 and Suter following the ASTM Method D519-68. The measured parameters were the weight biased mean length (Barbe), which gave a correlation coefficient of 99,7 % and the weight biased percentage of fibres shorter than 2 in, which gave a correlation coefficient of 97 %. Between the two instruments, on the weight biased mean length, the overall mean standard difference was only 0,036 in. The weight biased length measured by the Suter was thus on average about the same as the Almeter Barbe and could thus also be represented by [w, l_{SR}]. These results are cited in [10].

The foundations of the Almeter fibre length measurements are thus solid, as they correlate perfectly with the same parameters, cross-section biased mean length and weight-biased mean length, measured on two different comb sorters. As the Almeter instruments (about 400 analogue models and 400 digital models) are in use since 1962 and the comb-sorters since 1948, this corresponds now to 41 years experience on Almeter and 55 years experience on the parameters Hauteur and Barbe, accumulated in the wool industry, the wool trade and in the wool research and testing laboratories.

2. <u>A few erroneous statements concerning the Almeter and fibre length in general, contained in recent papers by Mark Brims</u>

The OFDA 4000 described in the reports SG02 to the Barcelona meeting, May 2002, and SG02 to the Buenos Aires meeting, May 2003, uses a sample preparation system which is very similar in principle to the Fibroliner (or Automatic Grip) of the Almeter. We can thus assume that a "numerical sample' is prepared. The parameter obtained by counting the number of fibres across the beard at 5 mm steps is thus probably an estimation (note that the Almeter measures at ¼ mm steps) of the "numerical mean length of the fibres in a semi-relaxed state", or [1, l_{SR}].

From the considerations in chapter 1 of this paper, this is a type of length distribution among the others, and <u>it is certainly not an "absolute" or "reference" value, which could be called "Mean Fibre Length" or "Wool Fibre Length".</u> Now this is exactly what the author Mark Brims tries to do in his two papers. In the Barcelona paper, the title on page 3 "Wool Fibre Length and Hauteur" already opposes Hauteur to Wool Fibre Length. In page 4, line 12, after a very approximate definition of the Almeter measurement signal, the matter becomes clear : "The Almeter does not measure fibre length". I will not comment on this sentence, every critical and intelligent reader will do it for himself.

Paragraph 4, page 4 of this paper starts wisely, but comes back immediately to the same objective : "The OFDA 4000 measures length by counting the number of fibres across the beard at 5 mm steps. It is recognised that this length may be known as "OFDA 4000 length", but for readability, the term length or OFDA 4 length will be used throughout the rest of this paper".

The word "length" is in fact frequently used, and already in the summary of the report in Buenos Aires, lines 7 and 8, the objective is attained: "Because the OFDA 4000 directly counts fibres within the drawn sample, another estimate of fibre length distribution can be determined (now called mean fibre length)".

This is exactly in contradiction with the statements of the statisticians R.C. Palmer and F. Monfort (cited in chapter 1 of this report).

In the report to Barcelona, page 4, the paragraph "Summarizing the length values from OFDA 4000" is not acceptable : "Length" should be "OFDA 4000 length" or another word created to describe $[1, l_{SR}]$; and the different definitions for Barbe and Almeter Barbe are not correct, as they have been proven by the numerous correlations established between Almeter and the comb sorters to be identical. They should thus be called "OFDA Barbe" or any other name created for the purpose.

In the last paragraph of page 4, report to Barcelona, the author over-estimates the influence of the variation of fibre diameter in <u>commercial</u> wool tops. This effect was examined since the beginning of the Almeter development and only a very small proportion of commercial tops, mainly in the very coarse range, was found to show a significant effect. A report on these lots was presented in 1962 to the Technical Committee. The author does not mention an important effect which reduces the effect of diameter variation : in a wool with "tapering" or diminishing diameter from root to end, about 50 % of the fibres will be in a reverse direction after scouring and carding, and the mean effect of diameter tends to be compensated.

As concerns the differences in short fibre content observed in the paper to Buenos Aires, a difference of that importance has never been observed on commercial tops.

During several research projects, more than 300 tops in total have been measured at Centexbel-Verviers on Almeter and on the WIRA Single Fibre Machine (average for each top determined on 1002 fibres divided between 3 operators) for the calculation of $[1, l_E]$. We have never found such a difference; a suggestion would be to send a large sample of that particular lot for a detailed analysis to a research laboratory, Centexbel-Verviers for instance.

3. <u>Metrolology of the serial production of the Almeter instruments</u>

For about 40 years, the measurements of Hauteur and Barbe on the analogue and digital Almeter instruments have been kept stable and conform to a standard, thanks to a particular metrology system for the electronic instrument and thanks to Interwoollabs or a central testing laboratory, who were able to detect the existence of malfunctions in the manual or automatic grip (Fibroliner).

The metrolology system was developed in collaboration between the constructor of the analogue Almeter M.B.L.E.-PHILIPS Belgium (Y. Hecq – G. Marechal) who had the experience of the manufacture of other electronic measuring instruments, and Centexbel (J. Grignet). The basis was a set of 7 plexiglass calibration trapeziums; this form simulated the signal produced by a wool sample, including the fall of the signal on the origin line.

A first group of 10 sets of these 7 standards were machined to very close tolerances and called "primary standards"; a second similar group was produced for Centexbel.

A "standard instrument" at the research laboratory of MBLE was thoroughly checked for the conformity of electric voltages and currents at every critical point; the values of the 10 units of the 7 primary standards were then averaged. This measurement was repeated at regular and close intervals and if a very small drift was detected on the average of at least one of the seven different standards, the process of checking every voltage was started again.

On this "standard instrument", the "secondary standard trapeziums", which would accompany each serial instrument, were measured and the observed values recorded in a document in the "calibration box" containing the trapeziums. These "secondary standard" were then used to calibrate the serial instrument (by adjustment of small potentiometers on every range) which would be associated to this calibration box (5 measurements were averaged for this calibration).

A rectangular plexiglass calibre was used to fix the high-frequency gain, which was kept between two limits during the instrument use. The range of 7 standards covering the wool fibre length range in Hauteur and Barbe was necessary for the analogue instrument, where the adjustment was made on 2 or 3 points in each of the 4 ranges. Where the user of the instrument detected a prescribed small difference on the nominal values of the trapeziums, the same procedure of adjustment could be followed.

With the introduction of the digital Almeter with microprocessor and integrated circuits in 1978-1979, (first serial instrument delivered by Peyer to an English combing mill), the drift of the components being much smaller, the number of trapezium's was much reduced but the same procedure was still followed.

CONCLUSIONS

1) The foundations of the Almeter fibre length measurements are solid, both theoretically and experimentally, and they correlate perfectly with the same distributions of Hauteur and Barbe measured previously by the comb sorters: semi-automated Schlumberger (IWTO 1-59) and Suter (ASTM D519-68)

2) The so-called "OFDA 4000 length" is a type of length distribution among the others, and certainly not an "absolute" or "reference value", which could be called "mean fibre length" or "wool fibre length"

3) Differences of short fibres content as important as observed on one top by Brims between Almeter and another length measuring method have never been observed on commercial tops by Centexbel and this particular top should be analysed in detail by a research laboratory, Centexbel-Verviers for instance.

4) The metrology system (together with the Interwoollabs or central testing laboratory checks) used for ensuring the conformity of the serial instruments to a standard instrument, has succeeded in keeping the measurements of Hauteur and Barbe stable and conform to a standard, for 800 Almeters over 40 years.

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Comments on Sliver Group Report 2: "Foundations and Metrology of the Almeter Wool Fibre Length Measurement."

I disagree that I have made erroneous statements concerning fibre length.

In neither of the papers have I referred to OFDA4000 fibre length as an absolute or reference length. I have found by experiment and had pointed out by numerous people that length depends on the state of tension on the fibre, this is made clear on page 3 of "Introducing OFDA4000…".

I stand by the statement that Almeter does not measure fibre length, although perhaps I should have qualified that by saying it measures "length biased by cross section". The Almeter test method IWTO-17 clearly supports this since it always mentions Almeter measured length with the qualification "biased by cross section"(except in the heading), or uses the term hauteur. In the special case where there is no change in fibre diameter along the beard then Almeter hauteur should equal the length. The capacitance method will fail to produce the correct hauteur on samples of blended fibres of different dielectric constant, such as blends of wool and synthetic fibres.

The main confusion that may arise in the future is the use of the term length by the Almeter. The recent Almeter advertising literature uses the term length, when it should be using the term hauteur. The term length should be reserved for instruments that measure it directly, without cross section bias.

I reject the requirement for OFDA4000 length measurement to be called "OFDA4000 length", especially when Almeter is incorrectly using the term length interchangeably with hauteur. At the very least it is premature, and if to be applied fairly leads to all measurements that can be performed by 2 or more instruments to be named after the instrument, eg Laserscan diameter, Laserscan comfort factor etc.

I agree that it is unexpected to see significant diameter profiles in many commercial tops, however this is also reported by CSIRO as the basis for its fine ends test method (DTM-60). This test uses snippets guillotined from the end of the fibroliner beard, and if there was no beard diameter profile then there would be no need for this test. Simple maths shows that a reduction from 20um to 19um at the end of the beard reduces the average fibre cross section by over 10%, there is 10% less wool NOT 10% fewer fibres at the beard end.

I will be selecting several of the most extreme cases of difference in short fibre content, as measured by length and by hauteur on OFDA4000, and sending these tops to Centexbel and others for measurement. Any suggestions of suitable testing institutes with experience in measuring fibre length would be appreciated.

Several trials are underway at present comparing Almeter to OFDA4000, including the trial for the IWTO DTM. It is planned to report these results at the IWTO meeting in May 2004.

Sincerely,

Mark Brims