Combining Mean Fibre Diameters and CVDs

Combining Mean Fibre Diameter (MFD) data for consignments is a routine procedure. The formulae to do this were derived in 1970 (see adjacent box), and were based on the assumption that the CVD data were also available.

The only means then available for determining MFD for raw wool, the Airflow instrument, did not provide estimates of CVD. Consequently the formula was simplified, to exclude the CVD.

This assumption presumed that the difference in MFD between component lots within a consignment is small.

All lots tested by AWTA Ltd are now tested for MFD using LASERSCAN. This instrument provides CVD as well as MFD so the correct combination formula is used.

The combination formulae are quite complex and do require some understanding of mathematics, and the symbols used by mathematicians. However, the basic calculation is really quite simple.

One of the key points to understand is the form of the CVD that is used in these equations. IWTO Certificates report CVD as a percentage.

The combination formulae use the Fractional Coefficient of Variation of Diameter (FCVD). This is simply the CVD divided by 100.

The data in the following table are used to provide an example of the calculation of MFD and CVD for a hypothetical consignment consisting of 5 sublots or components. Only data required for this calculation are included in this table.

Note the following definitions:

	Unit	Components				
		1	2	3	4	5
Nett	Kg	444	2767	2513	3031	2699
WB	%	64.71	55.33	57.97	55.83	57.49
MFD	microns	20.5	21.3	18.0	23.7	19.1
CVD	%	18.8	20.1	19.9	21.9	20.0

· Nett = the Nett Weight
· WB = the Wool Base
· MFD = the Mean Fibre Diameter
· CVD = Coefficient of Variation of Diameter

For the i^{th} lot in a consignment, where $i = 1, 2, 3 \ldots q$ and q is the total number of lots

$B_i =$ Wool Base (%)

$M_i =$ Nett Mass of the greasy wool (kilograms)

$D_i =$ Mean Fibre Diameter (microns)

$C_i =$ Fractional Coefficient of Variation of Diameter

$S_i =$ Estimated Standard Deviation of Diameter

$$C_i = \frac{S_i}{D_i} \qquad (1)$$

$$D = \frac{\sum_{i=1}^{q}\left(\frac{M_i B_i}{D_i\left(1 + C_i^2\right)}\right)}{\sum_{i=1}^{q}\left(\frac{M_i B_i}{D_i^2\left(1 + C_i^2\right)}\right)} \qquad (2)$$

$$C = \left[\frac{\sum_{i=1}^{q} M_i B_i}{D^2 \sum_{i=1}^{q}\left(\frac{M_i B_i}{D_i^2\left(1 + C_i^2\right)}\right)} - 1\right]^{\frac{1}{2}} \qquad (3)$$

where D is the Mean Fibre Diameter and C is the Fractional Coefficient of Diameter of the consignment.

If it is assumed that the range in Mean Fibre Diameter and Fractional Coefficient in Diameter between component lots of a consignment is small, then the equation for calculating the Mean Fibre Diameter of the consignment is greatly simplified.

$$D = \frac{MB}{\sum_{i=1}^{q}\left(\frac{M_i B_i}{D_i}\right)} \qquad (4)$$

Here, B is the Wool Base (%) and M is the Nett Mass (kilograms) of greasy wool for the consignment.

If these assumptions are not correct, then the accuracy of the prediction of combing performance will be reduced. Ensuring that the range in Mean Fibre Diameter is small is a simple exercise because the component lot details are known. However, prior to the introduction of LASERSCAN this was not possible since Coefficient of Variation in Diameter is unknown in Airflow testing. Variation in Coefficient of Diameter can cause errors in predicting the diameter of the top.

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The following table shows the results of each step in the calculation. The explanation of each step is provided in the subsequent paragraphs. All calculations should use floating point, rounding only when the final result is obtained.

Steps	Parameter	Unit	Component					Combined
			1	2	3	4	5	
	Nett	Kg	444	2767	2513	3031	2699	
	WB	%	64.71	55.33	57.97	55.83	57.49	
	MFD	micron	20.5	21.3	18.00	23.7	19.1	
	CVD	%	18.8	20.1	19.9	21.9	20.0	
Step 1	FCVD		0.188	0.201	0.199	0.219	0.200	
Step 2	$FCVD^2$		0.035344	0.040401	0.039601	0.047961	0.040000	
Step 3	$(1+FCVD^2)$		1.035344	1.040401	1.039601	1.047961	1.040000	
Step 4	Nett x WB		28731.24	153098.11	145678.61	169220.73	155165.51	651894.20
Step 5	$MFD^*(1+FCVD^2)$		21.225	22.161	18.713	24.837	19.864	
Step 6	$MFD^{2*}(1+FCVD^2)$		435.103	472.020	336.831	588.629	379.402	
Step 7	Nett x $WB/(MFD^*(1+FCVD^2))$		1353.679	6908.591	7784.964	6813.341	7811.393	30671.967
Step 8	Nett x $WB/(MFD^{2*}(1+FCVD^2))$		66.033	324.347	432.498	287.483	408.973	1519.334
Step 9	Combined MFD(unrounded)	micron						20.1877675
Step 10	Combined MFD (rounded)	micron						20.2
Step 11	Combined MFD^2							407.545958
Step 12	Combined FCVD							0.230
	Combined CVD	%						23.0

Mean Fibre Diameter

Step 1: Calculate the FCVD for each component by dividing the CVD by 100.

Step 2: Square the values obtained from step 1 (i.e. multiply each FCVD by itself)

Step 3: Add 1 to each of the values obtained in Step 2.

Step 4: Multiply the WB for each component by the corresponding Nett. Calculate the sum of all the results so obtained. In the table, this sum is recorded in the extreme right hand column.

Step 5: Multiply the MFD for each component by the corresponding values obtained from Step 3.

Step 6: Multiply the MFD for each component by the corresponding values obtained from Step 5

Step 7: For each component lot, divide the values obtained in Step 4 by those obtained in Step 5. Calculate the sum of all the results so obtained. In the table, this sum is recorded in the extreme right hand column.

Note 1: In the table only 3 decimal places are displayed simply for convenience of presentation. The following calculations that use these values use the unrounded results.

Step 8: For each component lot, divide the values obtained in Step 4 by those obtained in Step 6. Calculate the sum of all the results so obtained. In the table this sum is recorded in the extreme right hand column.

Note 2: In the table only 3 decimal places are displayed simply for convenience of presentation. The following calculations that use these values use the unrounded results.

Step 9: Calculate the MFD by dividing the summation obtained in Step 7 by the summation in Step 8. Store the unrounded result of this calculation.

Note 3: The value so obtained in the table is calculated using the unrounded values obtained from Step 7 and Step 8. Using the exact numbers displayed for Step 7 and Step 8 will provide a slightly different value from the value shown because not all decimal places for these data are shown (see Notes 1 & 2).

Step 10: Round the value obtained by Step 9 to one (1) decimal place. This is the Combined Mean Fibre Diameter for the consignment.

Coefficient of Variation of Diameter

Step 11: Square the unrounded value of the combined MFD obtained in Step 9 (i.e. multiply the unrounded combined MFD by itself).

Note 4: In this case also Note 3 applies. Any differences between the value in the table are due to the same factors.

Step 12: Calculate the Combined FCVD. This calculation uses the summations in the extreme right hand column of the above table. Firstly, divide the summation obtained at Step 4 by the product of Step 11 and the summation obtained in Step 8. Subtract 1 from the result and then calculate the square root. The result of this calculation may be rounded to 3 decimal places.

Step 13: Multiply the result of Step 12 by 100. This is the combined CVD, expressed as a percentage. For the particular lots involved in this example, had the combination been conducted using the formula now in use for Airflow, the result for the Mean Fibre Diameter would have been 20.4 microns, compared with 20.2 microns using the correct formula. The difference is solely due to the effect of the CVD.

LASERSCAN offers the potential of more accurate prediction of processing performance, particularly where the range of the MFDs of the component lots is large, or where the CVDs of the component lots are significantly different from the norm for the MFDs involved.

Equations have also been developed which enable the combination of the individual fibre diameter distributions of the component lots to obtain an overall distribution for the consignment.

This calculation is considerably more complex and, at this stage, is probably of little commercial interest.

FURTHER INFORMATION

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