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Fundamental Principles of Fibre Fineness Measurement

Part 10

Conductometry



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CONDUCTOMETRY



The Coulter Counter

Principle

Conductometry is a general term encompassing a range of measurement systems that utilise the phenomenon of the electrical conductivity of solids and liquids. It is a widely used technique in the science of analytical chemistry.

Application of the technique to the measurement of the fineness of wool has been limited. However the Coulter Counter, an instrument designed to measure particle sizes and particle size distributions has been applied to the measurement of fineness of wool tops and core samples from greasy wool.

Berg (1958) has described the Coulter Counter. A suspension of particles, suspended in a conducting liquid, which is inert with respect to the particles, is metered through a small orifice. Electrodes are located on each side of the opening, and the electrical resistance of the path from one electrode to the other varies proportionally to the volume of the particle passing through the orifice. More exactly the resistance changes proportionally to volume of conducting liquid displaced by the particle while it is passing through the resistance path. The electronics of the instrument is designed to produce a voltage pulse with the passage of each particle. The size of the pulse is the measured variable, and by calibration with particles of known dimensions the equivalent

volume of unknown particles can be determined. If the calibrating particles and the measured particles have the same dimensional characteristics in at least two dimensions then the third dimension of an unknown can be inferred. In the case of roughly cylindrical particles, such as snippets of wool fibres the calibration simply relies upon ensuring that the fibre snippets of the calibrating material and the measured material are approximately the same.

Development

O'Connell and Martsch (1962) described an application of the Coulter Counter to the measurement of the fineness of wool top. The data reported by these authors is shown in the following table. The Projection Microscope measurements on the comparative tops were based on round trials between a large number of laboratories using the ASTM method.

O'Connell and Martsch concluded that the average fineness of wool tops could be measured with the Coulter Counter with a reproducibility equivalent to or better than estimates made by expert operators using the microscope. Under a set of standard conditions, they expected that the Coulter Counter would produce a higher degree of reproducibility among operators or laboratories than the projector method because operator judgement would not be a source of error.



Comparison of the Coulter Counter with Projection Microscope

Top	ASTM Projector		Coulter Counter		Differences	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
57-1	20.44	4.46	20.15	4.84	-0.29	0.38
57-3	21.69	4.84	21.44	5.33	-0.25	0.49
57-4	23.60	5.78	23.13	5.94	-0.47	0.16
259-P	24.43	5.05	23.96	5.48	-0.47	0.43
57-5	26.25	6.29	26.26	6.70	0.01	0.41
233-P	26.55	6.92	27.03	7.14	0.48	0.22
57-2	27.71	6.60	27.72	6.51	0.01	-0.09
57-6	29.84	7.72	29.37	7.37	-0.47	-0.35
57-7	31.52	7.48	31.00	7.47	-0.52	-0.01
53-11	32.68	9.10	31.35	8.57	-1.33	-0.53
239-P	32.85	8.82	32.27	8.67	-0.58	-0.15
57-8	34.36	8.55	33.47	8.29	-0.89	-0.26
51-119	37.98	9.31	38.02	9.54	0.04	0.23
58-27	21.49	5.00	21.63	5.32	0.14	0.32
Lot F	30.08	8.08	29.96	8.08	-0.12	0.00
Mean	28.10	6.93	27.78	7.02	-0.31	0.08

Bloch and Gusack (1963) described the performance of the instrument in measuring denier distributions in synthetic fibres. They summarised the advantages and disadvantages of the instrument as follows:

Advantages

Measures a large sample size (approximately 1000 fibres).

Independence of measurements from particle shape.

Efficient and relatively rapid procedure.

Suitability of data for automatic processing.

Minimising of operator fatigue and bias.

Disadvantages

Accuracy of the results depends on the accuracy of the fibre density or alternatively on constant density.

Accuracy depends on the length uniformity of the sectioned fibres.

Buras and Penoyer (1968) described an investigation into methods for rapidly preparing snippets from wool top and greasy wool cores for measurement in the Coulter Counter. They developed a system that involved shrink-wrapping the fibre bundle, and wetting the bundle to encourage the fibres to swell and provide increased support for each other. The bundle was then placed in a restraining mechanism and advanced with a precision micrometer, while the sections were taken by cutting with a double-edged razor blade. Approximately 20 minutes was required to prepare each sample.

A novel application of the Coulter Counter was reported by Andrews and Irvine (1969). This involved using the Coulter Counter simply as a counting device in an improved gravimetric method.

The novelty of the method was that the fibres were cut into snippets short enough to be easily specified. Since the number of length measurements required for a test then became too large to be practicable, an estimate is obtained of the total length of snippets in the weighed sample. Firstly the total number of snippets, N , was counted using a Coulter Counter. Secondly, the individual lengths in another, much smaller, sample of the snippets were measured with a Projection Microscope and averaged. The product of N and the average snippet length is an estimate of the total length of fibre in the sample. In such a numerical sample of snippets, cut from the original sliver or assembly, the total length of snippets in each



small interval of diameter must be proportional to the total length of fibres in the same diameter interval in the original assembly. Each fibre is therefore represented in proportion to its length, as is the case with the intact fibre gravimetric method. The precision for the method was better than 0.2 μm .

Technical Issues

Many of the technical issues that must be considered for other measurement systems must also be considered with the Coulter Counter. Obviously, because the instrument measures a volume from which fineness must be inferred, it is sensitive to the preparative systems. Uniformity in the length of the snippets is important, much more important than in other systems that are based on an estimate of the dimensions of snippets. For the same reason the density is also important. The technique has not been adequately developed to assess the effects of conditioning, but the same importance this assumes in other systems will apply.

Commercial Issues

Interest in the Coulter Counter for estimation of wool fibre fineness has not been substantial, and the instrument has remained a tool for researchers rather than a commercially used instrument.

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