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Next Generation Fiber Length Measurement

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ABSTRACT

The next generation fibre size analyser has been developed in Kajaani based on over 15 years experience in fibre measurement. This new FiberLab-analyser can measure fibre length both along the fibre centre line and as projected. The cross-sectional measurements of fibre are in principle similar to the earlier version FiberLab. Measured data are generally displayed in distributions. Some new calculations have been added, for example the fibres cross sectional area and fibre volume index both available as distributions as well.

The performance of the FiberLab measurement is verified against the manual microscopic testing. These tests show that the new image analysis-based measurement well matches with the manual methods.

1. Introduction

For nearly two decades, Kajaani has been in the forefront of development in the measurement of fibre properties. The FS-100, the first analyser for mill laboratories to measure fibre length distributions, was introduced in the early 1980s. Some years later the fully automatic analyser, FS-200, was developed, and for the rest of the past century this device was the workhorse of fibre length distribution measurement. A few years ago a further development was introduced: featuring fibre width and cell wall thickness, the Kajaani FiberLab was again the first to measure fibre width accurately enough. During the past year the development of FiberLab has resulted to a more accurate length measurement.

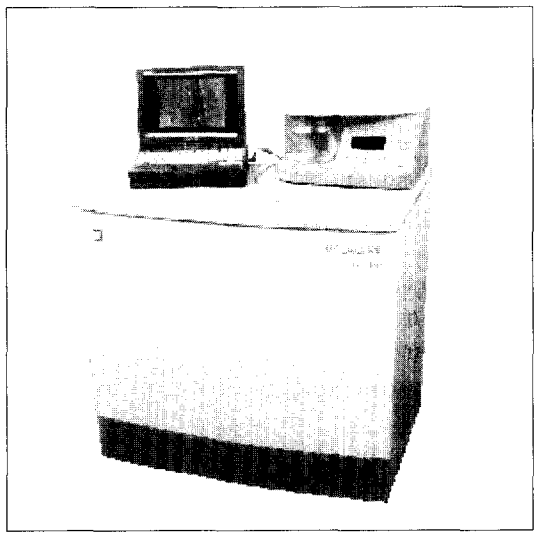

Fig. 1. Kajaaui FiverLab.

2. FiberlLab Platform

Over the years, the need for more accurate fibre length measurement has arisen, and for this purpose a new, more accurate device has been developed. This measure-

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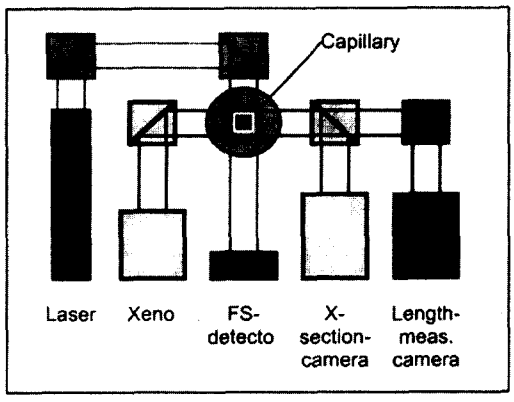

Fig. 2. The FiberLab measureneut platform.

ment uses the current FiberLab platform, platform (Fig. 1) but it also contains an essential change as regards the measurement: fibre length is measured by means of a 2-dimensional image analysis. In other respects the measurement principle is still similar to the earlier Kajaani analysers, measuring each fibre optically and individually. In the Fig. 2. there is the general layout of the measurement presented. Like in the previous versions of Kajaani Fibre size measurements the fibres are directed to and through a capillary, where the measurement takes place. The fibre concentration is so low that fibres go mainly one-by one through the measurement zone. The purpose of this device is to measure fibres and this requirement means that images should be taken on fibres, when they are in the proper place in the measurement zone. The polarisation effect of fibres is used to this purpose. When the detector of the fibre count indicates that a fibre is in the measurement zone of appr. 10 mm long, the xenon light is activated and images of the fibre are being registered into the memories of the CCD cameras. The new Fiberlab contains two CCD cameras. The one of those registers approximately the whole measurement area. The other camera has the optics for a 10 times higher magnification. With the two-camera arrangement the problem of measuring the fibre length and width will be solved. As in the previous version FiberLab all data processing takes place in commercial PC planted inside the FiberLab cabinet. In addition to this another PC can be used for the user interface functions, like results presentation for example.

3. FibreLab Features

The changes in the construction means that the new FiberLab gives both the fibre contour and projected fibre length as measurement results, in addition to the cross-sectional fibre dimensions also measured by the earlier model. All of these measurements can also be reported in the form of distributions. From these basic measurements various other values can be calculated. Fig. 3 shows a typical Fibre length distribution as measured with the FiberLab. As we proceed from the distributions down to more compact way of presenting the results we can look first more compact distributions of the length calculated to look like the old FS-200 distributions. The measured distributions will be reported as 0.05-mm resolution distributions, the old FS-200 distributions (and also the compacted distributions in the FiberLab) will be reported with 0.2-mm resolution. The results of Fig. 3 are presented in compact mode in Fig. 4.

Next step is to form fractions from the distributions. Fractions can be calculated from the length distributions so far. The user can select the length areas of these 6 fractions. Fig. 5 shows one set of fractions from the data of the Fig. 3.

The last step is to calculate the averages. These will be calculated from all measured distributions.

In addition to the values related directly to the measured distributions, the new

Table. 1. List of printed results

Variables	Distribution	Fractions	Averages & Sums	Note
Population fibre length	Yes	6	Yes	Fines
Length-weighted fibre length	Yes	6	Yes	Fines
Weight weighted fibre length	Yes	6	Yes	
Population projection length	Yes	6	Yes	Fines
Length-weighted projection length	Yes	6	Yes	Fines
Weight-weighted projection length	Yes	6	Yes	
Fibre curl	Yes		Yes	
Fibre width	Yes		Yes	
Fibre cell wall thickness	Yes		Yes	
Fibre cross sectional area	Yes		Yes	
Fibre volume index	Yes		Yes	
Coarseness			Yes	
Fibres per mg			Yes	
Wood species calculation			2 or 3 components	
Custom results			3 values	
Fibre counted & imaged			Yes	
Ranges in averages			Yes	
Fibre sieve according to length, width and cwt.		6		

FiberLab calculates also some values where results from several distributions will be connected. A new such variable is the fibre cross section area. This value is calculated from the fibre width and fibre cell wall thickness values. As the calculation takes place immediately after measurement of these values a distribution will be obtained. Because the measurement is actually 2-dimensional we have adopted such a practise that fibres are thought to be round in cross section and accordingly the formula related to the area of a circle is being used here. While the fibres will be measured in very dilute suspension, and they have time to reform this assumption may be rather correct. As we know also the length of the fibre a volume of the cylinder to contain the fibre

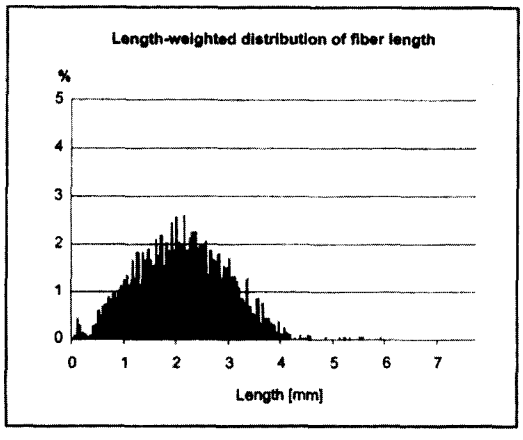

Fig. 3. Fibre leugth distribution as measured by the FoberLab.

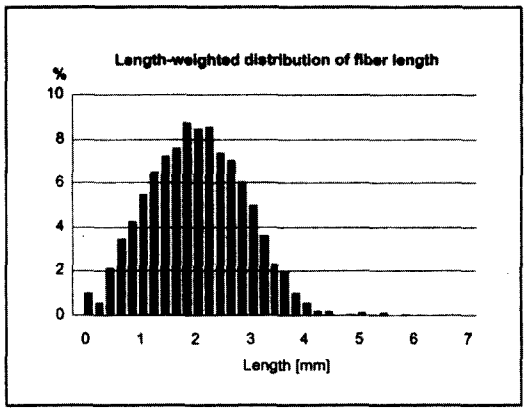

Fig. 4. Condensed Fibre length distributions. Same data as in Fig. 3.

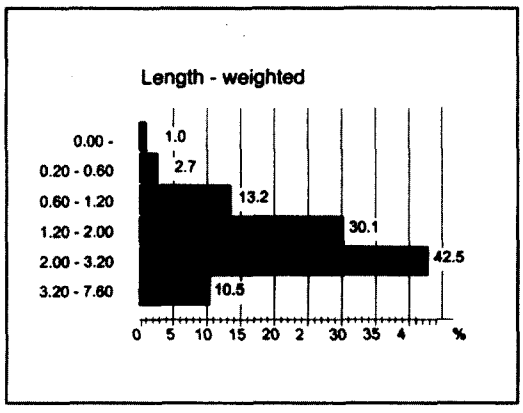

Fig. 5. Fibre length fractions. Same data as in Fig. 3.

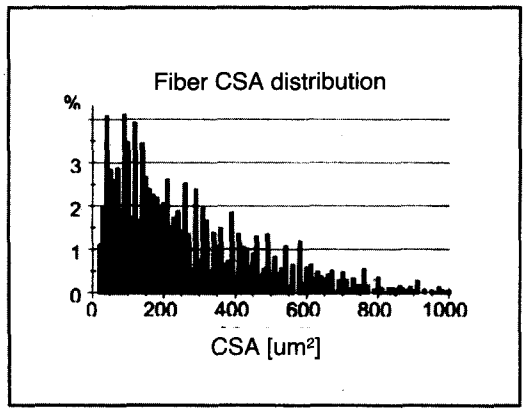

Fig. 6. Distribution of fibre cross-sectional area.

can be calculated. The first of these two new variables has been used to indicate fibre coarseness without actually weighing the sample. An example of this distribution is in Fig. 6. How the fibre volume index can be used is not yet studied. There are some ideas to use this for the more accurate wood species determination.

In addition to these also conventional pulp coarseness with sample weight will be calculated as well as the curl index based on the measurements of projected and contour length of fibres. The list of printed results are presented in the Table 1.

4. Comparison with the Manual Measurement

The measurement is calibrated against the manually measured results. First step is to set the length -pixel ration correct by tuning the system with artificial (rayon) fibres of known fibre length distribution. The reference measurement of the artificial fibre is made by manual means in the Finnish Pulp and Paper Research Institute. The length ratio is set such a way that the measurement results will have good match with the manual results. In Fig. 7 there are results of this measurement. We have also another tested material to use in tuning the instrument.

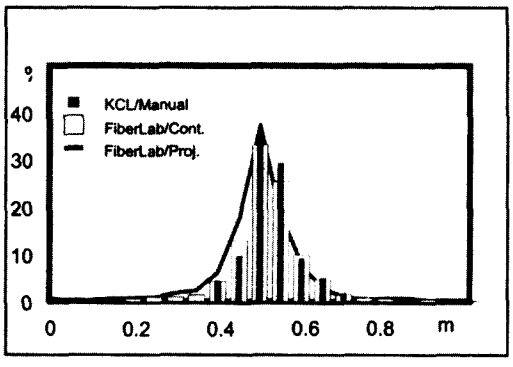

Fig. 7. Distributions of the test rayon.

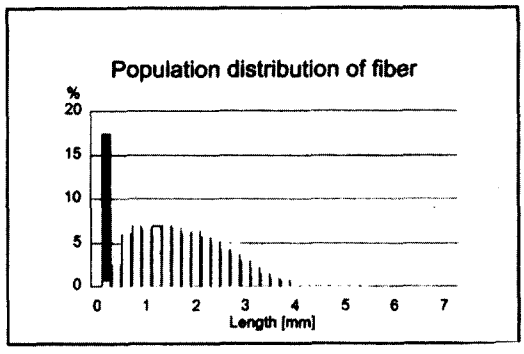

Fig. 8. Distributions of the test softwood.

This is natural softwood pulp, which has been tested manually similarly as the artificial fibre. Fig. 8 shows results of the softwood testing. The only real difference is in the amount of fines observed. In the manual measurement the focus is in the fibres and the fines are not included in the analysis. When the measurement of fines in the FiberLab is limited the resulting distributions will match remarkably well.

5. Comparsion with the FS-200 Method

Generally speaking, IA-based measurements tend to differ from the FS-200 results. In some cases the IA-procedures reject the fines and thus show higher averages than the FS-200. Deviations to the opposite direction have also been observed, possibly resulting from the difficulties associated with correctly interpreting fibre network images taken for the analysis.

One of the leading principles in the development work has been to maintain similarity of measurement as far as possible as compared to the FS-200. For this reason the FiberLab performs the analysis from individual fibres and has the measurement range same as the FS-200.

Because of different type of detection it is not, however, possible to get the exactly matching results. In the new method the position of fibre during the measurement has lesser effect to the result as in the earlier FS-200 method. Therefore the average fibre lengths tend to be a bit longer with the new FiberLab method.

On the other hand the FS-method cannot make difference between two immediately following fibres, which leads to the detection of some over-long, actually non-existing fibres in the FS-method. This is visible in the area of 5 to 7 mm for normal softwoods. As this was noted, the reference analysis of the softwood pulp, as already mentioned above, was ordered from the Finnish Pulp and Paper Research Institute to obtain clarity which test, FS-method or Image analysis, show better results. Although it is again difficult to compare results with totally different methods, these test results show that we now have a more accurate and versatile fibre size analyser available.

6. Further Development

The development of fibre characterisation has been very much the development of fibre size measurement. The fibre properties can be divided into four categories: fibre size properties, fibre shape properties, fibre cell wall structure and fibre surface. Current development has solved most of the problems related to the fibre size measurement. Some measurements to characterise fibre shape exist and development seems to look possibilities to measure fibre cell wall properties more easily. These are, I believe, the tasks of the analysers to come.

7. Summary

The next generation fibre size analyser has been developed in Kajaani based on over 15 years experience in fibre measurement. This new FiberLab-analyser can measure fibre length both along the fibre centre line and as projected. The cross-sectional measurements of fibre are in principle similar to the earlier version FiberLab. Measured data are generally displayed in distributions. Some new calculations have been added, for example the fibres cross sectional area and fibre volume index both available as distributions as

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