Determination of the Specific Fibre Weight of Pulp Fibres

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Abstract

Paper production is mainly based on fibrous raw material which may consist of primary or secondary fibres. Primary fibres are obtained directly from plant raw materials, mainly from wood and annual non-wood plants. Industrially, mostly thinnings and sawmill wastes are used.

Secondary fibres are produced from recovered paper. Rags are used only in very small amounts. Synthetic and mineral fibres do not play an important role.

Chemical pulp is produced by chemical pulping of vegetable raw materials such as not only hardwood and softwood, but also from straw from different kinds of cereals, bagasse, reed, or esparto grass, and from other annual non-wood plants. During chemical pulping, the most of the lignin is removed from the raw material.

The technological processes of the pulp and paper producing cause the change of the length and surface of the cellulose fibres with a different order of magnitude. Fibre length is a fundamental property of pulp. The determination of the fibre length and surface character of pulp fibres is important in papermaking technology and environmental protection as well. The mass and the strengths of the produced paper are characterized by those of the included single fibres.

New method has been elaborated for measuring the mass of cellulosic single fibres of different origin and of different pre-treatments. The number of single fibres in a known amount of pulp fibres has been measured in an aqueous suspension for this purpose. The measurement has been fulfilled in a Kajaani FS 100 fibre length analyser. This analyser is consisting of a capillary tube (0.2 mm) through which an aqueous suspension (density of suspension: 1 per thousand) of the fibres is passed.

The elaborated by us method for the determination of the average single fibre mass for cellulosic fibre of different origin could be successfully used for a wide range of cellulosic fibres.

Comparing the results of average fibre mass could be concluded that the unbleached never dried pine sulphate cellulose has the highest value and the bleached hardwood cellulose has the lowest one.

Introduction

The properties of papers are highly depended on the quality of the included cellulosic fibres.

Interfibrillar and intermolecular actions occur during the papermaking process.

The first interaction among the fibres is the felting occurring in the sieve section whereas the second one is the forming of hydrogen bonds among the cellulose molecules during drying. Such fibres are needed for the procedure in which the ratio between the length and the width of the fibre is 70:1.

The mass and the strengths of the produced paper are characterized by those of the included single fibres. Consequently new method has been elaborated by us for the measurement of the mass of the mentioned single fibres. The measurement has been fulfilled in a Kajaani FS 100 fibre length analyser. This analyser is consisting of a capillary tube (0.2 mm) through which an aqueous suspension (density of suspension: 1 per thousand) of the fibres is passed.

The pulp and paper industry started to use the Kajaani FS-100 in the 1980, this was the the first automated fiber analyser (Bichard and Scudamore, 1988) “and is an optical device accepted as method for laboratory fibre length measurements (Tappi T271) to measure fibre length and coarseness” (Copur and Makkonen, 2007). This tool is ready for quick and one simple measurement procedure (Piirainen, 1985). The main part of the device a capillary tube (0,2 mm) through which the thin suspension of the fibres is conducted. On the one side of the capillary is positioned a lamp and on the other, opposite side is a detector. When a fibre go through the capillary, the polarized picture of the single fibre is transmitted into the detector and from this we can calculate the length of

the fibre. “A low-pressure vacuum pump and chamber collect the analyzed fibres. The measurement range is between 0-6.79 mm, divided into 24 classes, of which the first 12 classes are resolved to 0.2 mm lengths and the last 12 have a resolution of 0.4 mm (for the 0-0.7 mm range)” (Jackson, 1988). The fibre counting is manually with a keyboard. The fibre suspension is diluted (0.0004% consistency).

Elaborated method

In our method for the establishing of the mass of cellulosic single fibres the following 4 steps should be fulfilled:

1. Determination of the dry matter content of the sample
2. Cellulose sample with 0.1-0.2 g absolute dry fibre content should be pulped in 1000 ml distilled water
3. 100 ml of the above mentioned suspension should be diluted to 1000 ml by distilled water.
4. 100 ml of the suspension should be filled into the Kajaani 100 fibre analyser to determine the ***average fibre length*** (**l_{af}**) and the ***total number of the included fibres*** **(tn)**.

Average single fibre mass (**m_{asf}**) can be calculated by dividing the included ***mass of the fibres*** (**m_f**) by their above gained number (tn):

$$m_{asf}\,(g) = m_{af}\,(g) / tn \qquad (1)$$

The above discussed data enable the calculation of the ***specific mass*** **(m_{spec})** in g/mm of the single fibre:

$$m_{spec}\,(g/mm) = m_{asf}\,(g) / l_{af}\,(mm) \qquad (2)$$

Experiments

Our above discussed experimental method has been applied for the following studied fibres:

Different ECF bleached pine fibres

Different pine sulphate celluloses

Semi-chemical-pulp – cellulose fibres (mixed hardwood)

Chemical Thermo Mechanical Pulp (CTMP, pine)

1. Initially the impact of the grinding of different ECF bleached pine fibres in Jokro mill has been determined on the mass of the single fibre. 5 samples of different freeness (12, 18, 24, 32, 60 °SR) have been produced by grinding in Jokro mill. 5 Bauer McNett fractions have been separated (mesh: 14, 30, 50, 100, 200) from each mentioned samples of different freeness respectively. The average mass and length of single fibre of mentioned samples have been determined and compared with each other.

2. The average mass and length of single fibres of dried and never dried pine sulphate celluloses respectively after grinding in PFI mill have been determined and compared with each other thereafter.

3. Further experiments have been performed with Chemical Thermo Mechanical Pulp (CTMP) single fibres.

4. Finally the average mass and length of single fibre of 9 different cellulosic fibres of the same freeness have also been studied.

Results and discussion

Obtained data in the 1. set of experiments are summarised in Table 1. and in Figure 1.

Finnish bleached pine fibres of different freeness ground in a Jokro mill			
Bauer McNett fractions	Freeness	Fibre length	Fibre weiht
	°SR	mm	µg
14	12	2,7	1,8
30		1,92	0,95
50		1,1	0,797
100		0,65	0,742
200		0,52	0,741
14	18	2,7	0,8
30		1,94	0,6
50		1,16	0,5
100		0,67	0,4
200		0,43	0,259
14	24	2,59	0,2
30		1,86	0,1
50		1,09	0,052
100		0,61	0,034
200		0,33	0,032
14	32	2,54	0,795
30		1,87	0,325
50		1,05	0,132
100		0,58	0,145
200		0,31	0,1
14	60	2,59	0,889
30		1,89	0,592
50		1,01	0,291
100		0,56	0,266
200		0,34	0,26

Table 1: Average fibre length and mass of ECF bleached pine fibres of 5 different freeness (after grinding in Jokro mill) and 5 Bauer McNett fractions of each freeness.

The first observation from the obtained data is that the grinding practically does not decrease the average length of single fibres but it is significantly decreases their mass.

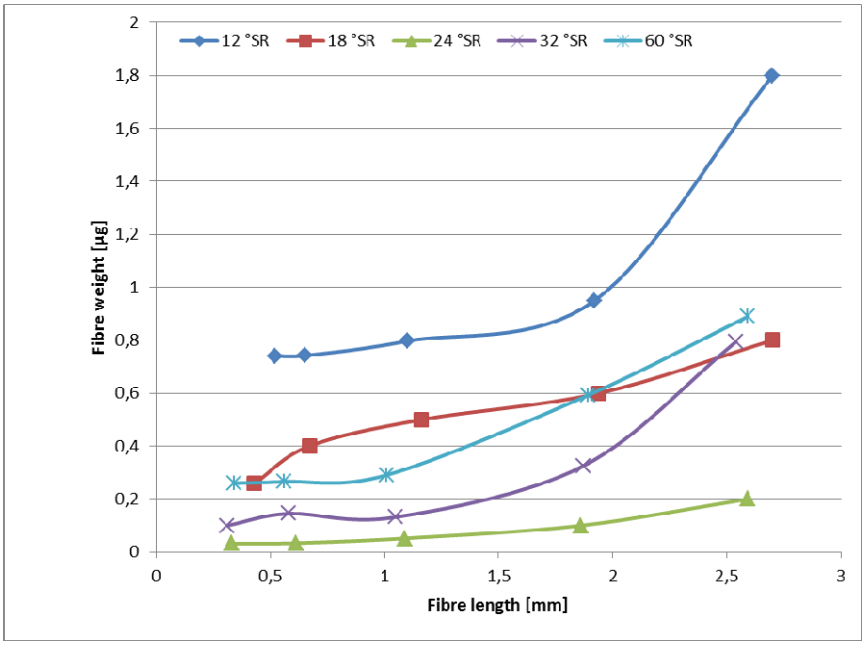

Figure 1. Average fibre length and mass of ECF bleached pine fibres of 5 different freeness and 5 Bauer McNett fractions of each freeness.

From this might be concluded that the grinding keeps the lengths of the fibre practically unchanged but it is sensitively decreasing its cross section. Final conclusion is that in the length acting binding forces are strong primary ones whereas in the cross sections acting ones are much weaker secondary forces.

Obtained data in the 2. set of experiments are summarised in Tables 2 an 3.

Bleached never dried sulphate pine ground in a PFI mill			
Freeness	Fibre length	Fibre weight	Specific fibre weight
SR°	mm	µg	µg/mm
13	2,27	0,303	0,133
22	2,26	0,298	0,131
33	2,23	0,295	0,132
47	2,21	0,295	0,133
57	2,19	0,289	0,131

Table 2. Changes in average fibre mass, average fibre length and specific fibre mass of never dried pine sulphate cellulose single fibre in the function of freeness after grinding in PFI mill.

Bleached dried sulphate pine ground in a PFI mill			
Freeness	Fibre length	Fibre mass	Specific fibre mass
SR°	mm	µg	µg/mm
13	2,3	0,381	0,165
20	2,27	0,314	0,138
32	2,25	0,283	0,125
45	2,08	0,273	0,131
54	2,04	0,268	0,131

Table 3. Changes in the average fibre mass, average fibre length and in then specific fibre mass of dried pine sulphate cellulose single fibre in the function of freeness after grinding in PFI mill.

Concerning changes in fibre length and fibre mass after grinding leading to freeness form 13 °SR to 57 °SR enabled the conclusion that small loss occurred in them as well of dried (Table 2.) as of never dried samples (table 3.) The changes in specific fibre mass are nearly neglectable in both samples because the loss in fibre length and fibre mass are proportional.

Obtained data in the 3. set of experiments are summarised in Tables 4 and 5.

Never dried Chemical Thermo Mechanical Pulp (CTMP) ground in a PFI mill			
Freeness	Fibre length	Fibre weight	Specific fibre weight
SR°	mm	µg	µg/mm
26	2,2	0,628	0,285
35	1,81	0,537	0,296
40	1,73	0,401	0,231
54	1,44	0,366	0,254

Table 4. Changes in average fibre mass, average fibre length and specific fibre mass of never dried Chemical Thermo Mechanical Pulp (CTMP) single fibre in the function of freeness after grinding in PFI mill.

Dried Chemical Thermo Mechanical Pulp (CTMP) ground in a PFI mill			
Freeness	Fibre length	Fibre weight	Specific fibre weight
SR°	mm	µg	µg/mm
23	2,31	0,607	0,262
30	1,96	0,342	0,174
42	1,71	0,299	0,174
52	1,36	0,246	0,180

Table 5. Changes in average fibre mass, average fibre length and specific fibre mass of dried Chemical Thermo Mechanical Pulp (CTMP) single fibre in the function of freeness after grinding in PFI mill.

Both the length and the mass of CTMP single fibres decreased in the function of the increased freeness as well for dried as for never dried samples. No such tendency could be concluded in case of specific fibre mass data.

Obtained data in the 4. set of experiments are summarised in Figures 2 and 3.

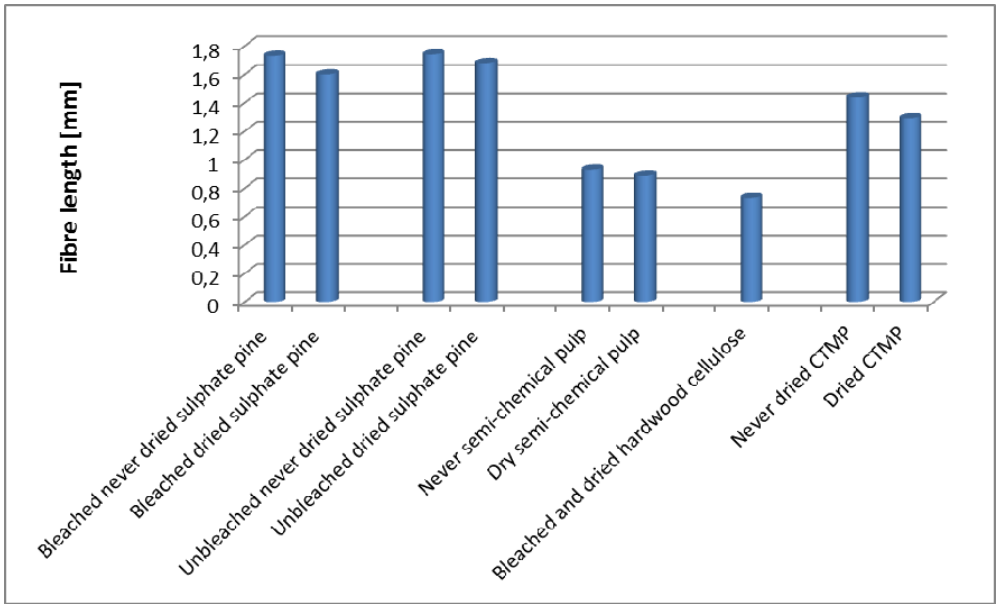

Figure 2. Changes in the average fibre length of cellulose single fibre of different prehistory at the same freeness (50 °SR).

Comparing the average fibre length could be concluded that the unbleached never dried pine sulphate cellulose has the highest value and the bleached hardwood cellulose has the lowest one.

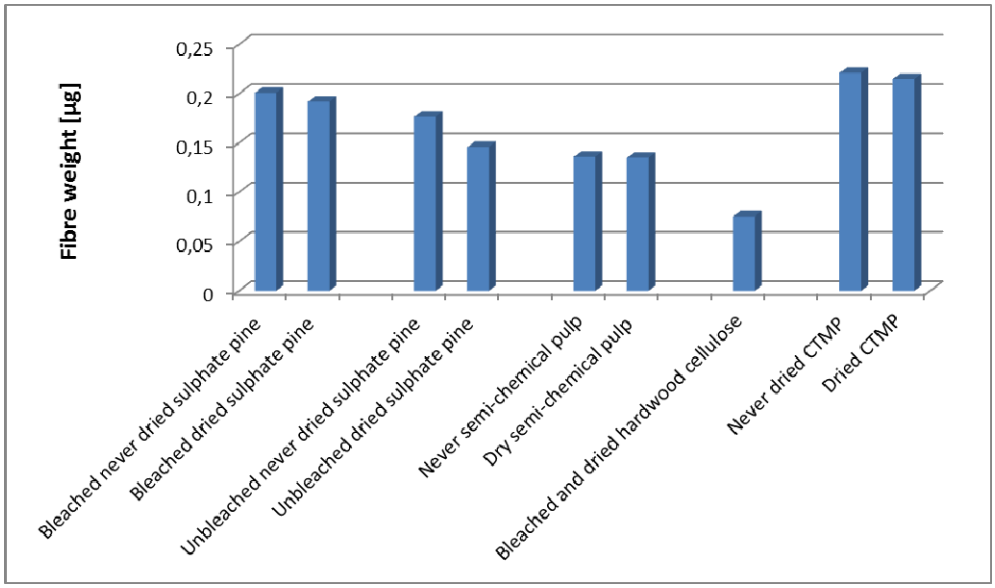

Figure 3. Changes in the average fibre mass of cellulose single fibre of different prehistory at the same freeness (50 °SR).

Comparing the average fibre mass could be concluded that the unbleached never dried pine sulphate cellulose has the highest value and the bleached hardwood cellulose has the lowest one.

Conclusions

The elaborated by us method for the determination of the average single fibre mass for cellulosic fibre of different origin could be successfully used for a wide range of cellulosic fibres.

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