DELIVERABLES REPORT

MultiHemp

Multipurpose hemp for industrial bioproducts and biomass

(Ref n. 311849)

6.3 Report on the realisation of a fibre preparation and feeding unit

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1. Background and objectives

Within this work package there is the need to gather all the partners and relative knowledge and analystical capacity to carry out fibre quality analysis on the samples generatated in WP1-WP3. Diverse measurements and inverstigations will be carried out on a great amount of hemp materials (stems, fibres and end uses), with two main topics: one is the quality integration along the production chains, and the other one is the quality evaluation of the raw material and as well as the end products. As an part of these analyses, testing of natural fibres is generally very time consuming because of the work to prepare the fibre samples and their scattering values. Based on this knowledge, it is necessay to develop, verify and implement a new (semi-)automated methodology and equipment for the sample preparation and the fibre characterization regarding the length and fineness of the hemp fibres/fibre bundles to evaluate the quality of the different genotypes (see Figure 1).

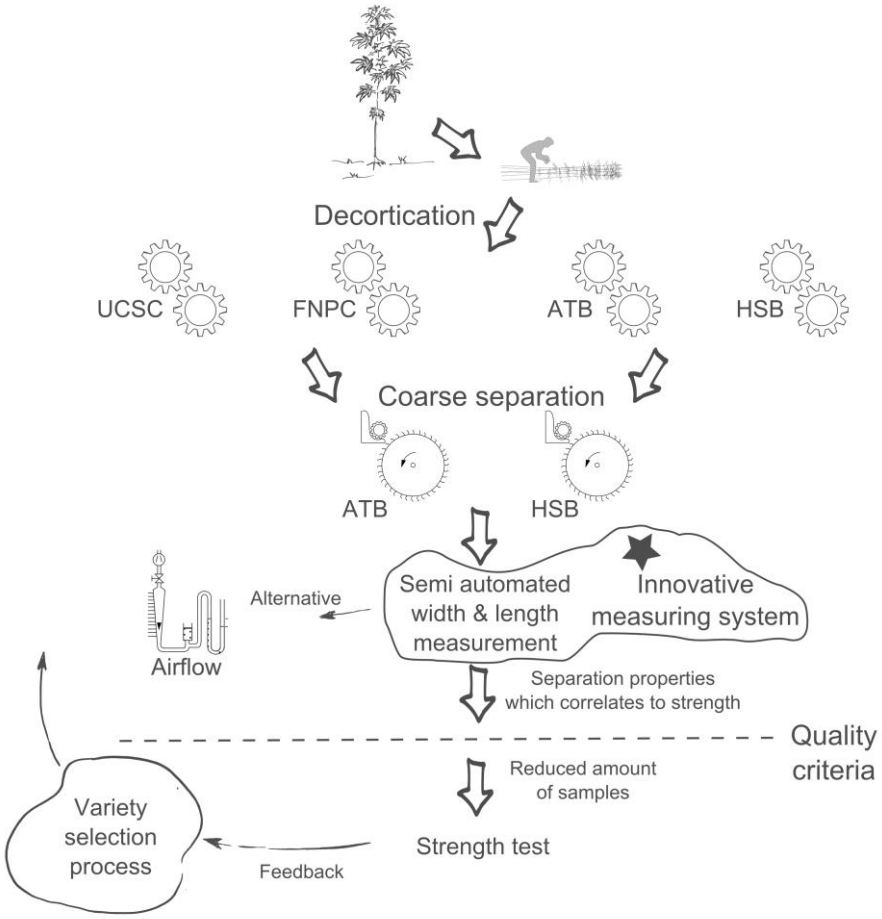

Figure 1: Integrated quality assessment concept from hemp stems through lab-scaled decortication/separation and fibre quality testing with a semi-automated width and length measurement.

2. Approachs of the fibre preparation

After the decortication and separation processes the fibre samples will be prepared according to the different analyses to be performed afterwards. The quality of the fibre preparation affects directly not noly the subsequent analyzing actions, but also the analyzing results. What is more, the efficiency of the preparation works decides mainly the effecency of the whole fibre analyzing process. For analyzing the fibre length or / and fineness, the image analyzing methods are often used, where fibre samples - parallelized at one end - must be prepared firstly, before images of the fibre samples are made. As for this, different approachs have been tried and compared.

2.1 Manually fibre preparation

As the conventional and aiding method, manual fibre preparations are always needed, to provide the fibre bundles with better quality, especially by the situations, in which there are no other suitable tools and facillities available. At HSB, one process for the manual preparation of the fibre bundles, which are parallelized and aligned at one end, has been developed, tested and standardized [1]. The measuring instruction is attatched to this report. With this normalized process the efficiency of the manuall fibre preparations is increased, and the quality of the prepared fibre bundle samples can be guaranteed. One trained operator needs only about 30 minutes to prepare one sample.

2.2 Tools and aid devices

Some tools and devices can also be usefull to optimised and speed up the manual fibre preparation process. Figure 2 shows one tool at HSB from Shirley Developments Limited (Stockport, SK1 3JW, England), coarsely parallelized fibre bundles can be obtained in a first preparation step by using this tool before the manual fibre Preparations.

Figure 2: Fibre prepartion tool (Shirley Developments Limited) at HSB

2.3 (Semi-)automatic feeding unit

In spite of the achieved improvement on the efficiency of the fibre preparation and as well on the quality of the prepared samples, the manual fibre preparations are still time-consuming on one hand, on the other hand the operator has to be trained to fufill this task. Thus, it is necessary to develop a new (semi)-automated methodology and equipment for the fibre sample preparation. And also the fibre characterization regarding the length and fineness of the hemp fibres/fibre bundles, to quickly evaluate the quality of the different genotypes from WP1-WP3. For these purposes, efforts have been made to invent one (semi-) automatic feeding unit, the concept has been developed.

3. New conception to develop the (semi-)automated feeding unit

3.1 State of the art

To automatically prepare the natual fibre samples, attempts and inverstigations have been untertaken by some companies and orgnisations, and commercial devices are also available on the markt. But most of these technogies and the developed devices focused on short natural fibres, mainly for cotton and wool. Because within this project we mainly inverstigate the long fibre bundles on one hand, and on the other hand the hemp fibres have different morphological properties compared to cotton and wool, these devices available on the markt are not suitable for our applications.

In 1989, Siegfried Payer AG (Wollerau, Schwitzerland) presented one concept and an automated device [2] to prepare the long fibre bundles for the length measurement. A device working on the same principle is located at ATB (Figure 3), named *Fibroliner*. This device together with an image analyzing software (FibreScanner, see report 6.2) is used for the fibre length measurement. Firstly, the fibres will be prepared to parallelize fibre bundles, which are then scanned with a suitable image resolution. The software FibreScanner analyses these images to gain the fibre length information.

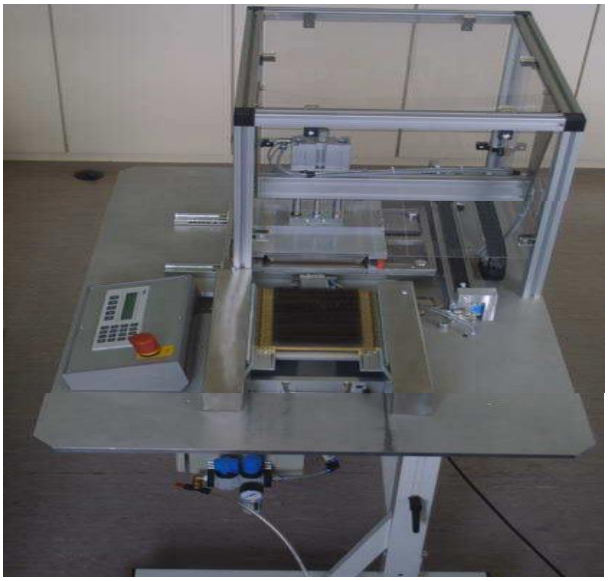

Figure 3: Overview of the Fibroliner

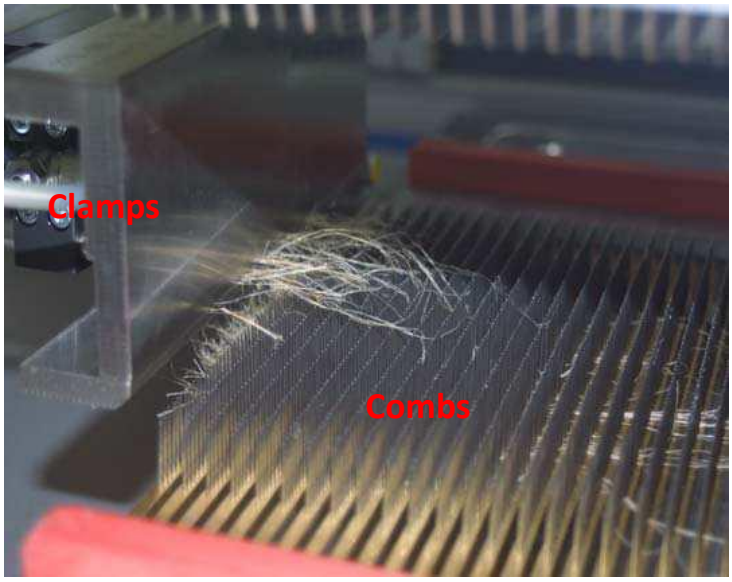

Figure 4: Clamps system and combs system of the Fibroliner

As an automated fibre preparation unit the Fibroliner works in the following way:

Firstly, the manually parallelized fibres will be pressed on the base plate of the combs, then the clamps run to the base plate and stop very close in front of the first comb to fetch the fibres, the ends of which are out of the base plate, after that the clamps with the fibres run back and put down the parallelized fibres on the sample plate. After this treatment the fibre bundle sample is ready for analysing (scanning and image analysis).

For the preparation of the hemp fibres samples the device has the following disadvantages:

1) Not very suitable for the preparation of the hemp samples.

2) Subsequent fiber analysis (FibreScanner) takes additional time.

3) The obtained fibre bundle samples are only used for the fibre length analysis.

The first mentioned aspect is due to the different biological properities of the hemp fibres compared to cotton and wool, for which the device originally was designed. Because of their internal stress, the hemp fibres can not keep staight enough within the graping process to easily obtain the parallelized samples, and some fibres held by the clamps are even skewed to the clamps. Thus, pre- and post-treatments are needed to obtain better parallelized hemp fibre bundle samples, for it more time should be given, and more attention should be paied. As for the second disadvantage, the prepared fibre samples must be scanned afterwards and then analysed by the image analysing method, such as FibreScanner. Additional time is needed. With the obtained fibre sampls only measurements of the fibre length can be untertaken, the measurement of the fibre fineness requires additional preparation work and analysis.

3.2 Conception for developing the automated feeding unit

Based on the technogies nowadays and in the case of the difficulties mentioned above, efforts have been made to develop a concept for a new device, which is more suitable for the preparation of the long hemp fibre bundles.

Figure 5 shows the concept to develop the new automated feeding unit. With consideration of the project plan and the development period, on this new feeding unit the same technique by Fibroliner will be adopted for the fibre graping process. The clamp system (Figure 6) has to be equipped with the nozzles and other needed facilities to provide the compressed air during drawing back the fibres towards the sample plate. Within the optimized air stream the fibres could be straightened and keep also perpendicular to the clamps, for gaining the parallelized hemp fibre bundles. A pair of the lock-in-combs (or lock-in-brushes) (Figure 7) straighten the fibres further and fix them, furthermore, it offers an access to equip the feeding unit with an imaging system for the fibre length and fineness online-analyzing.

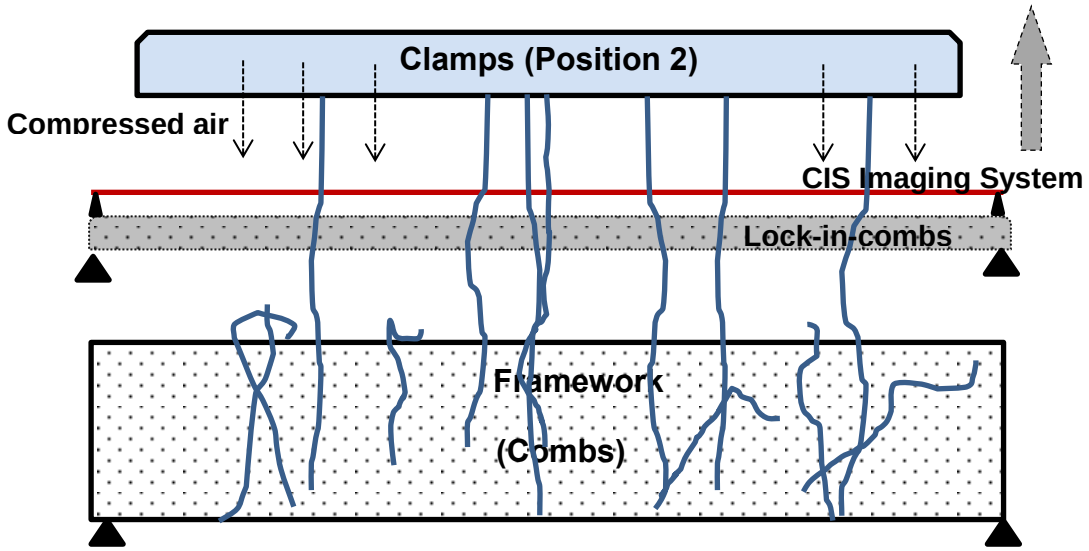

Figure 5: Setup of the automated fibre feeding unit with an image measuring system

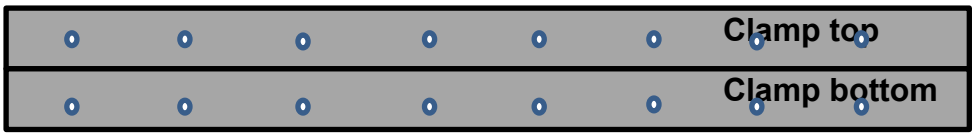

Figure 6: Conception of the clamps system

Figure 7: Conception of the Lock-in_combs system

3.3 Conception to develop one scanning system based on the feeding unit

An imaging system can easily be installed on this new fibre feeding unit, to realise the online analysis for the fibre fineness and length. After a detailed investigation the CIS system is chosen as the imaging system because its advantages for our case (see Table 1). Figure 8 shows the conception to develop the automated feeding unit equipped with the image online-analysing system. Table 1 sums up the needed devices and components to realise these functions.

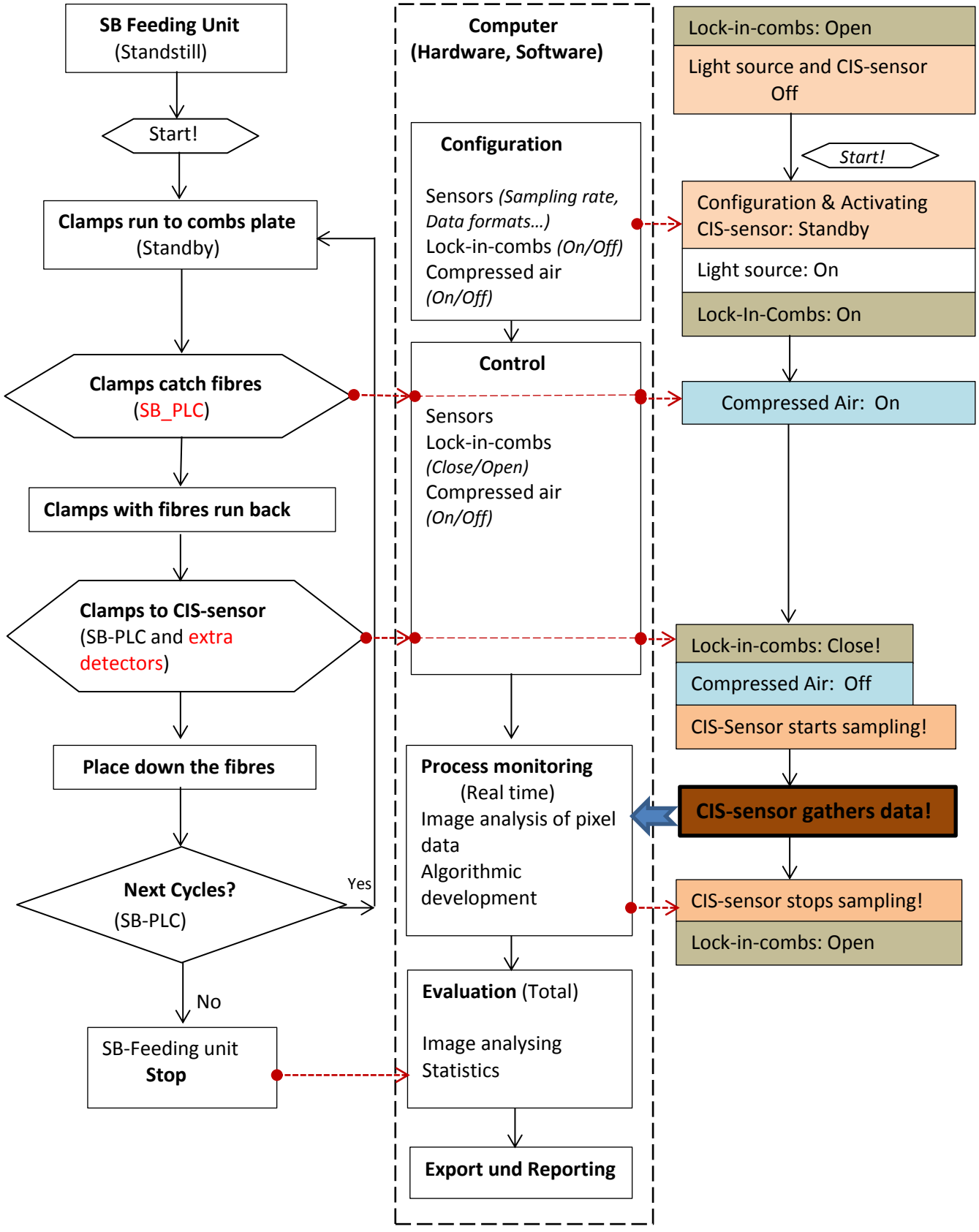

Figure 8: Integration of the image analysing system into the automated fibre feeding unit.

Function	Needed devices	Comments
Imaging system	CCD-sensor: Light source (LED-Array), other optical elements	High resolution, high cost, the complex optical arrangement and higher requirement for hardware and software
	CIS system	Advantage: small dimension without the complex optics, lower cost; Disadvantage: relative low resolution and small depth of field
Compressed air	automated valve	Control the valve of the compressed air
Lock-in-combs	Step motor	For opening and closing the Lock-in-combs
Clamp system	Position register	Detection of the clamps position
Hardware & Software	Data processing in real time**!!!**	Configure and control the other units, process control, image analysis and data analysis

Table 1: The needed devices for the different functions in the new automated fibre feeding unit

4. Discussion and outlook

Within this project we investigate a great amount of fibre samples regarding their fineness and length. The efficiency of the fibre samples preparation directly affects the efficiency of the whole fibre analyzing work, and furthermore, the quality of the prepared fibre samples influences the analyzing results dramatically. Based on the technogies nowadays and in the case of the difficulties to prepare the long hemp fibre bundles, we have invented a concept to develop a new device. In order to realise this development some further steps are under process:

1) Choice of the suitable imaging sensor system

2) Development of the software of the imaging analysis (with Matlab)

3) Modification of the device on hand and development of an automated fibre preparation system

4) Integration of the imaging system (software and hardware)

References:

1. B. Uhrlaub, Sh. Wang, J. Müssig, H. Gusovius, C. Lühr, Bremen, Germany, August 2013: MEASURING INSTRUCTION: Sample preparation for lengths measurement of hemp fibre bundles

2. Ernste Völlm, Horgen, Siegfried Payer AG (Wollerau, Schwitzerland), US4827781, 09.05.1989: Method and apparatus for the end alignment of fibers for fiber length measurement

Sample preparation for lengths measurement of hemp fibre bundles

M E A S U R I N G I N S T R U C T I O N

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Material and methods

1. Separate ca. 0,6g sample material
2. Manual separation of shives and meshes and put them in little Petri dishes (see Figure 6)

Workplace

Work plate:

- Size: ca. 40x60cm
- Surface: smooth, beamless, dark, straight edges
- Material: Stone (such as a tile)

Figure 1: Work plate

Preparation of the hemp staples

3. Stick a ca. 17 cm double-faced adhesive tape (the tape has to be clear-transparent *Tesa photo*) straight on the right edge and let it overlap about 1 cm.

4. Align the ends of the fibres: use the left side of the plate to pull out single fibre bundles (do it over the plate to collect the dust and the very fine fibres) and uncurl them. Now stick one end of each fibre bundle exactly on the edge without protruding the fibre bundles from it (see Figure 2&5).

Figure 2: Hemp fibre bundles aligned at one end (fibre bundle collective)

5. The fibre bundle collective should be about 15 cm wide. If there are many fibres on one spot or they are too curly, spray on a bit distilled H_2O and protect the tape-film during this. Heckle the fibres with the fingers and a wide-toothed comb (wood or horn, 1 tooth/cm).

Figure 3

6. The extracted fibre bundles should get stuck on the tape again, including the fine and short ones.
   Up until now the whole procedure should have lasted about 30 minutes.

7. Ensure the prepared fibre bundle collective with an adhesive tape.
   Cover it completely with a transparency (Herlitz Prospekthülle A4) and roll smoothly over it with a roll (ABIG-Abdrückwalze 150mm x 30mm).

Figure 4: rolling the prepared fibre bundle

Figure 5: begin and ending of aligning the fibre bundles at the end

8. Collect and weigh the hand sorted very fine fibre bundles, which constantly got separated from the staple (see Figure 6).
   We have to discuss how to analyse this.
   Also collect the dust, brush it in a Petri- dish and weigh it.

9. Detach the prepared fibre bundle collective carefully and cut the tape-endings.

10. Scan the fibre bundle collective with 300dpi between glass plates and save it as tif format. The sample gets archived in a Din A4 transparency.

Figure 6: Fractions of the hemp samples after manual separation
A: fibre and fibre bundles < mm, B: fibre bundles for preparation, C: shives

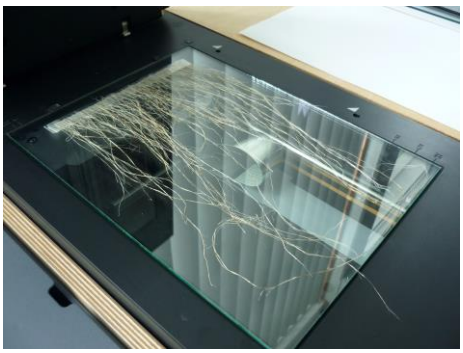

Figure 7: Prepared sample (fibre bundle collective) on the scanner