ANALYSIS OF THE COTTON COMBING PROCESS WITH NEW ON-LINE MEASURING SYSTEMS

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1 Introduction

Since two years the Institut für Textiltechnik der RWTH Aachen (ITA) develops a number of measuring systems to analyze the combing process. These systems support machinery developments as well as process optimization and help to gain knowledge concerning the influence of different machinery settings and material parameters. A detailed process analysis is an important tool to process critical fiber materials accurately, e.g. secondary fibers. In Germany the processing of secondary fibers to new products becomes increasingly more significant.

In detail, a special measurement system is developed and installed to determine forces acting in the nipper of a combing machine. Camera systems (High-Speed-Video and CCD) are used to visualise motion processes and fibre migration at the functional elements of combing machines, the nipper, the combing cylinder and the top comb. Moreover a doppler effect laser anemometer (DELA) is used to detect fiber slippage in the area of the nipper during combing by combing cylinder and at the feed rolls both, during the detaching and combing by the combing cylinder. For that purpose the DELA-system measures the difference of fiber velocities.

The complex adaptation of measurement instrumentation at the combing machine is challenging, due to the limited space at the machine. Furthermore the elementary working elements are moving with high velocity as well as acceleration due to the intermitting operation of the machine as well as the appearance of load peaks, e.g. by closing of the nipper. The adjusted measurement instrumentation has to stand heavy loads.

According to the sensitivity and the masses of the measuring optics it is of decisive importance to know the velocities and accelerations of the appropriate points of mounting in advanced. These are determined by a simulation of the nipper kinetics. The simulation calculates the loads on the measuring systems. Thus it becomes possible to decide whether and up to which production speed the systems can be used. In certain cases modifications of machinery are executed, in order to minimize the loads, which affect the measuring systems. So measurements are enabled at higher production speeds.

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The measuring techniques are adapted on a combing machine 1534/1 (fig. 1) of the company CSM (Chemnitzer Spinnereimaschinenbau GmbH).

2 Determination of Loads Acting in the Nipper

An even combing quality is realized by a homogeneous fiber wedging in the nipper. A measuring technique is developed and adapted to determine the initiated loads and their distribution over the width of the nipper.

The knowledge of the load distribution in the compression area is necessary, in order to judge whether a fiber wedging is ensured over the entire nipper width. Further it can be used in order to check the influence of different nipper geometries, i.e. top nipper profiles with and without application of plastic elements. Additionally the influence of different fiber materials or machine parameters on the load distribution in the compression area can be judged generally. As a result it is possible to develop optimized machine components and to find best machine settings concerning the load distribution.

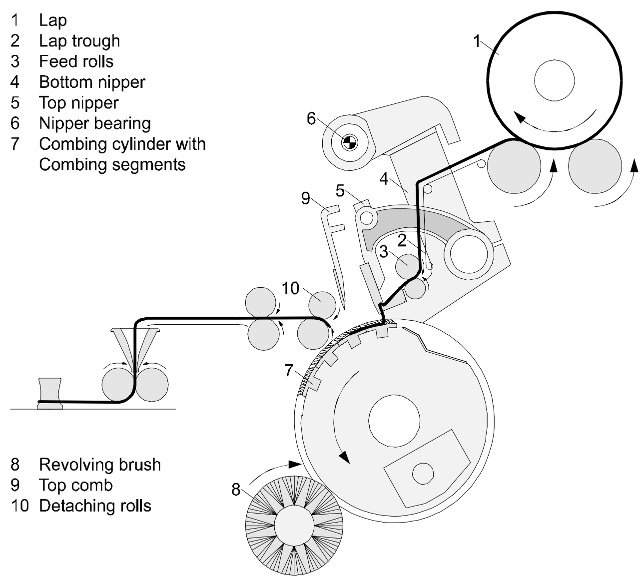

Figure 1. Operating principle of a combing machine

Figure 2 shows the complete load measuring system in the nipper area. The initiated load is measured by means of strain gauges. The load initiating rod is made of aluminum with low stiffness so that effects of the initiated loads on the extension and tossing behaviour can clearly be measured. Furthermore the rod is weakened at the measuring area of the strain gauges for the optimization of the measurements. The voltage produced by the strain gauges is transferred to an amplifier and recorded by the measurement system with a frequency of 500 Hz. A trigger signal is sent out by an approximation sensor, which takes its impulse from the shaft of the combing cylinder. The trigger signal is likewise recorded by the measurement system. By means of the trigger signal an accurate allocation of the measured loads to the appropriate machine positions is possible.

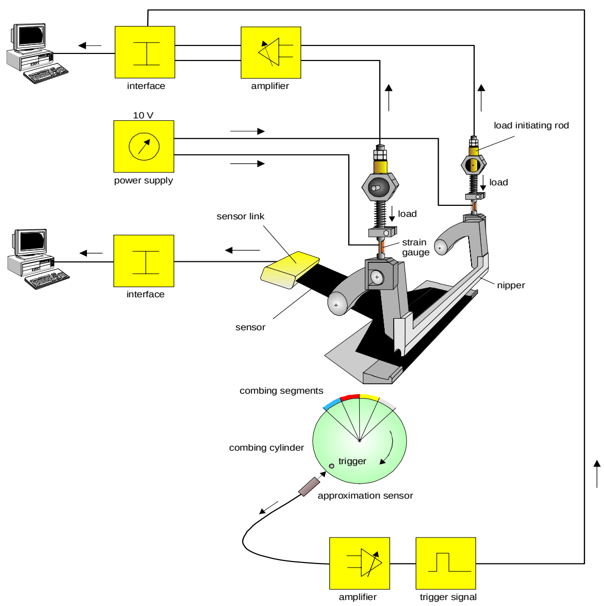

Figure 2. Load measuring system for the nipper

The distribution of the load in the compression area is determined with a Tekscan-compression-sensor-system of the company Tekscan, Inc., Boston. The system consists of sensor, sensor link, operational software, data acquisition card and PC. The foil sensors consist of conductive and semiconducting ink which are positioned in an array of rows and columns. The intersections of conductive rows and columns form the measuring positions. 11 rows and 44 columns are activated in the nipper compression area during the measurements.

The figures 3 up to 5 represent some results of the measurements. Figure 3 shows the measurement of the initiated load. The maximum load occurs during the operation of the combing cylinder and increases with more aggressively intervening of the combing cylinder. A sudden reduction of the load down to 0 N follows the opening of the nipper. Furthermore an identical progression of the nipper load for both load initiating rods is visible.

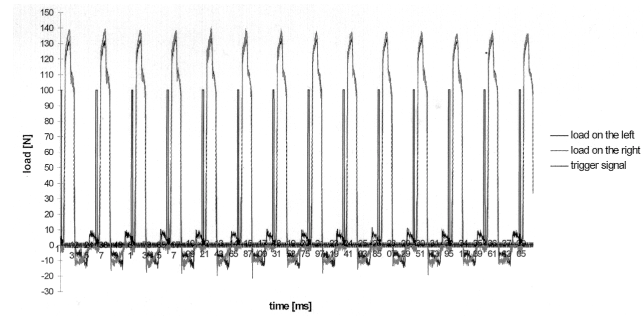

Figure 3. Initiated load for 14 combing cycles

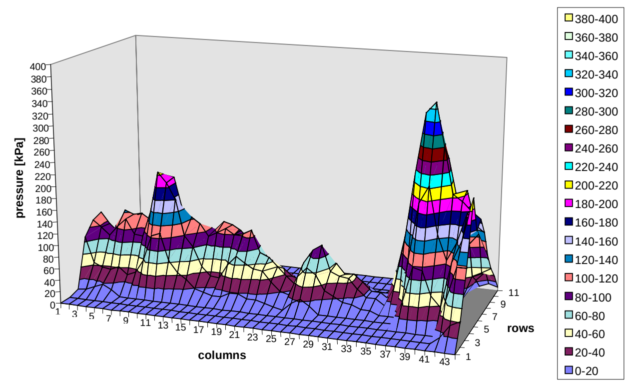

Figure 4. Pure metal top nipper

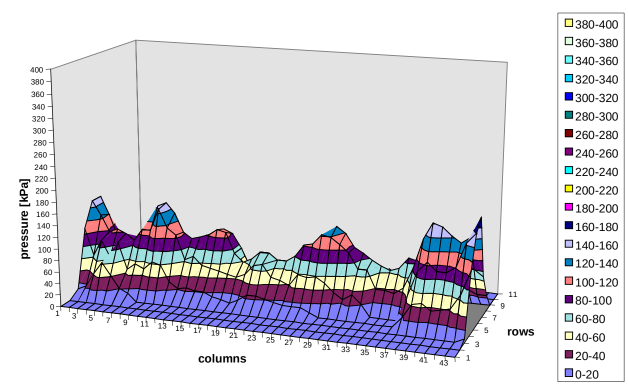

Figure 5. Metal top nipper with an inserted plastic element

Figures 4 and 5 illustrate the influence of different types of top nipper on the load distribution in the compression area. The measurements are performed with a frequency of 100 Hz. Two types of top nipper are used, one pure metal (fig. 4) and one with an inserted plastic element (fig. 5). On the one hand the pictures illustrate the good load distribution caused by the plastic insert. Here the force level over the nipper width varies between 100 and 180 N. In the nipper center there is a load of 100 N. On the other hand the pure metal top nipper shows clamping zones which are hardly or not at all loaded. The extreme load peaks up to 320 and 360 N point to defects of the surfaces of the nipper. A increasing danger of the fiber damage exists in these places.

The influence of different machine parameters, different fiber materials and the effect of these influences for different sizes of initiated loads are examined with regard to load distribution.

3 Visualization of Fiber Movement and Migration

The analytical measurements are performed at the functional elements of the combing machine, the nipper, the combing cylinder and the top comb. The aim of this analysis is the visualization of fiber movement and migration to qualify the combing process. Furthermore optimized combing parameters have to be found.

The material behaviour during combing of secondary fibers shall be analyzed. The elimination of impurities, nops and thread remainders by the combing process is particularly important during the processing of tearing fibers. It has to be examined whether e.g. a thread is resolved by the combing cylinder, carried forward by it and separated as noil or whether it arrives into the combed sliver.

The selection of best machine parameters for secondary fibers is very difficult. They have to be found with help of visualization. For example the choice of the correct number of needles/cm of the top comb and the combing cylinder is difficult. This problem arises from extreme variety of fiber fineness of the different fiber types in secondary fibers. Furthermore it must be tested if there is any fiber slippage, e.g. at the nipper and how particles like threads can influence the combing behaviour, i.e. if they disable the fibers to pass the top comb.

A high-speed-video camera is used for the investigations. The following picture (fig. 6) illustrates the high-speed-video measuring system, conceived for the analyses of the material behaviour at the combing cylinder and at the nipper. Up to 40500 images/s can digitally be recorded with the high-speed-video camera. For the lighting a cold-light-lamp is used which operates with a frequency of 70 kHz. The lamp is attached near to the measuring field without heat problems. The system is triggered in order to allocate pictures to machine positions. The trigger signal is produced by an approximation sensor, which takes its impulse of the shaft of the combing cylinder.

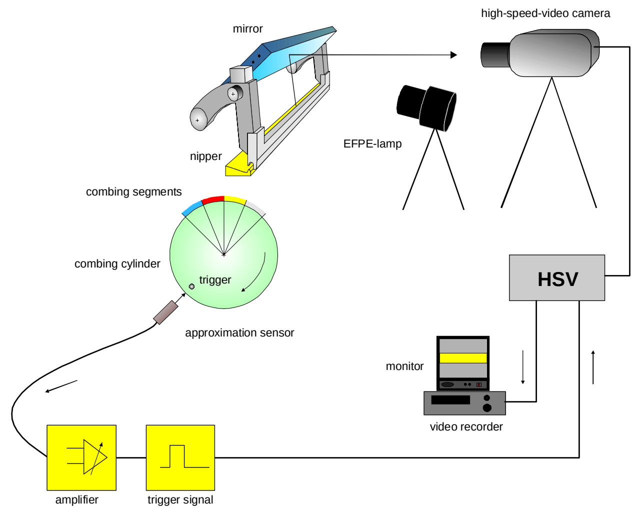

Figure 6. High-speed-video measuring system

The camera cannot be mounted at the nipper due to its weight. The accelerations on the camera would be to high. Therefore the camera is stationarily installed. The nipper movement is followed by a mirror system fastened at the nipper. So a view is enabled perpendicularly on the measuring field with the installed camera.

Figure 7 shows six of the images taken during a combing cycle. The images show the combing segments with increasing fineness of the needles/cm and their influence on a thread. In this case the end of the thread was not resolved by the combing cylinder. During combing no fiber slippage can be proven at the combing cylinder for all analyzed fiber materials. Thus the fiber wedging represents no difficulty for the processing of tearing fibers on combing machines.

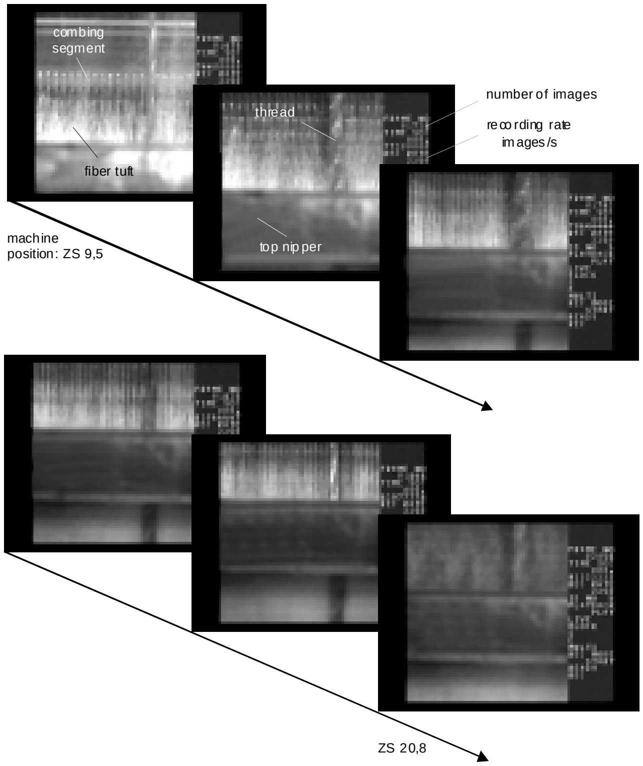

Figure 7. Influence of the combing cylinder on a thread

The top comb intervention is examined with the processing of different tearing fiber materials and primary cotton. The needle densities and the stitching depths of the top comb were varied depending upon material conditions. A fiber blockage is detected in front of the top comb during the detaching for some fiber materials although the lowest needle density is used. In order to implement a process without interruptions special needles would have to be manufactured for these materials.

4 Analysis of Material Behaviour by Velocity Measurements

Apart from the visualization the material behaviour can be analyzed by a determination and/or a comparison of fiber velocities. Fiber slippage can occur in the nipper and between the feed rolls during combing by the combing cylinder. Furthermore it can occur during detaching between the feed rolls, which in that combing phase are the only clamp areas. Threads positioned in the clamp area are one reason for the occurrance of fiber slippage.

One aim of the investigations is the analysis of the material behaviour at the nipper during the combing by the combing cylinder which represent a supplement to the results of measurement by visualization. If fiber wedging without slippage is present, the velocity of the fibers behind the nipper is zero during this work procedure.

Another aim of the investigations is the analysis of the material behaviour at the feed rolls during the detaching process. The analysis by means of velocity measurements in this area is the only possibility to prove e.g. fiber slippage. This is due to the necessity to measure the difference between feed and existing fiber velocity which may be different from the feed velocity as a result of an additional velocity caused by fiber slippage. These relative velocities cannot be detected by visual systems.

A suitable system for the determination of fiber velocities is the doppler effect laser anemometer (DELA). The dynamics of working organs and thus loads working on the DELA-sensor have to be considered using this measuring principle. So the sensor has to be moved according to the working elements for accurate measurements. Other solutions, e.g. mirror systems comparable to the visualization measurement system, cannot be used. In this case the distance between sensor and the measuring point varies. As a result the laser cannot be focussed.

Therefore a measuring system was developed, which determines the maximum accelerations based on the DELA-sensor. Two periodically occurring maxima of accelerations are caused per combing cycle by closing and opening of the nipper. The maximum accelerations have been minimized by appropriate machine modifications. As a result the DELA-measurements at the nipper can be performed up to 240 combing cycles per minute and up to 360 combing cycles per minute for measurements at the feed rolls.

The attachments of the DELA-sensor at the nipper and at the feed rolls are designed in such a way, that the sensor can be moved over the width of the fiber fleece and that it guarantees measurement free of vibration. Furthermore a variable adjustment of the laser focus is possible, e.g. to focus on the fiber material or at the nipper. The sensor attachment at the nipper as well as the structure of the DELA-measuring system are shown in figure 8.

The velocity measurements are linearly executed (1st channel). The second DELA-channel is used for recording the trigger signal. The trigger signal can be converted in such a way, that an interpretation by the DELA-system is possible by means of a burst generator. By selections of both channels the indication of certain machine positions in the time-velocity-curves becomes possible.

The recording rate is set to 3000 measuring points. The measuring time results from the particle density in the measuring volume, respectively is set to upper limit of 5 seconds. The laser focus is fixed in such a way that the measuring volume is situated 1 mm behind the clamping line of the nipper or the feed rolls. A negative velocity amount means a relative motion in feed direction of the fiber material. During the measurements the machine parameters and the fiber material are varied.

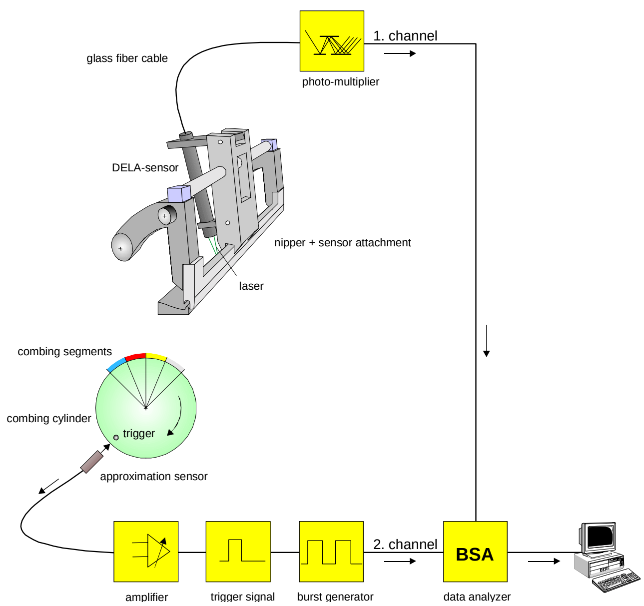

Figure 8. DELA-measuring system

In figure 9 a DELA-measuring result is presented, taken behind the nipper. The measurement is preformed with standard adjustments for primary cotton (medium staple). The used material was primary cotton.

The focus possibilities of the two laser beams are sufficient to supply a high measuring rate in case of a closed nipper. The average from the measured values taken in the marked combing area of the combing cylinder (1) tends to zero. Thus the relative velocity between the DELA-sensor and the fiber material is zero. The first peak (2) shows the closing process of the nipper. When closing the top nipper the sensor, which is fastened to it, moves backward relative to the fiber material lying on the bottom nipper. This is interpreted by the measuring system as a movement in feed direction. The second peak (3) shows the process during opening the top nipper. Here the opposite of the effect of the nipper closing takes place. In the second half of the combing cycle (4) the laser gets out of focus by the nipper movement.

Different fiber materials are analyzed according to the presented measuring results. Furthermore the influence of different machine parameters, e.g. the top nipper is investigated. For all materials a fiber wedging and feeding without slippage are detected. Therefore a accurate process can be expected.

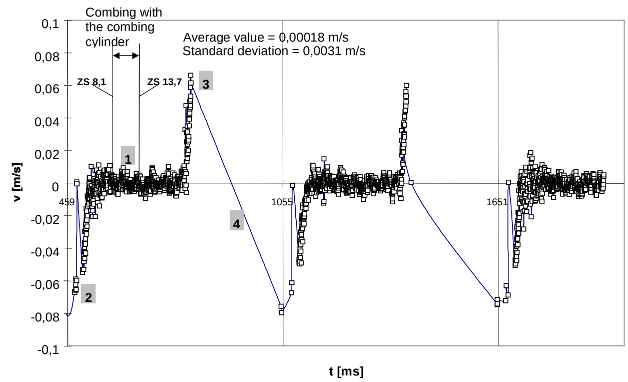

Figure 9. DELA-measurement behind the clamping line of the nipper

5 Summary and Outlook

Different on-line measuring systems for the analysis of the combing process are developed. One system detects the forces acting between the nipper. A camera system visualizes the fiber movement and migration during combing by combing cylinder and top comb. A DELA-sensor system determines the material behaviour by velocity measurements.

The measuring systems are used for optimization of the machine and the process beside the pure investigations of the influence of different machine settings and fiber material parameters on the combing process. With some modifications the measuring systems may also be used for investigation of other functional elements of the combing machine. So the whole combing process can be analyzed and optimized by means of the presented on-line measuring systems.

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