On-line measurement of wood chip size

Anders Petterson, Lars Olsson, and Sven-Olof Lundqvist

STFI has developed an optical, on-line system to obtain new values of the size distribution of chips every 5 minutes.

In Scandinavia and elsewhere, improvements in wood handling and chip production have become attractive because wood costs have been increasing while wood quality has been declining and becoming more varied. This need for improvements also extends to measurement and control. Measurement and control techniques have not been as well developed in the woodroom and woodyard as in other parts of the pulp and paper mill. Only recently has it become possible to measure important properties of the wood chips on-line.

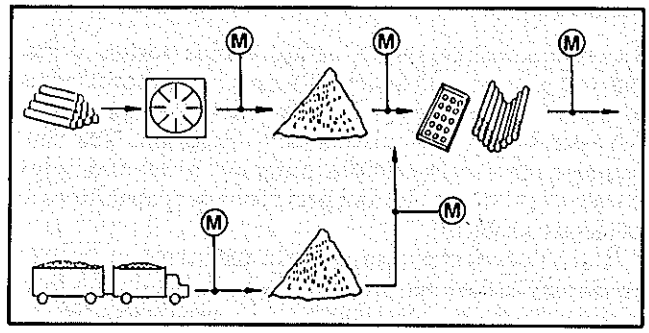
The size distribution of wood chips is an important chip property for both chemical and mechanical pulping. The chip size distribution may affect both the product quality and the production efficiency. Until recently, only off-line analysis of particle size has been possible. This analysis is normally performed on small chip samples using sets of mechanical screens, which can be time-consuming and cumbersome. Automated chip size classifiers are commercially available, but no on-line classifiers have been reported. Thus, chip size distributions have often been determined with frequencies too low and on samples too small to give a true picture of the real variations. In answer to the growing interest in efficient production of high-quality chips, STFI has developed a new optical system to measure the chip size distribution on-line.

On-line chip size measurement

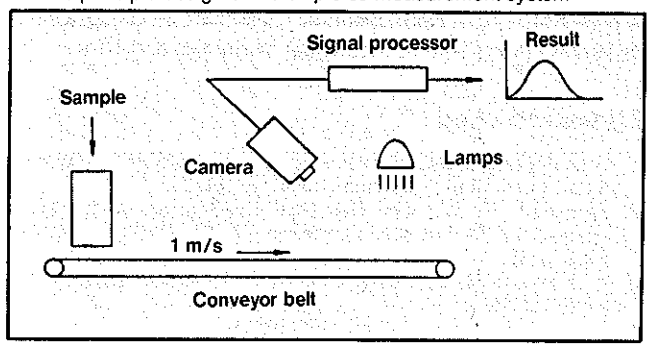
The new optical system for measuring chip size distribution opens up new possibilities for control. The system can be installed on-line, giving continuous measurements on a "sample stream" of the chip flow. It may be used in several positions, as shown in **Fig. 1**, for control and information purposes:

- After chippers to monitor knife condition and adjustments of chipper tolerances
- At chip screens to control feed rate and screen performance

1. Measurement positions where the system can be used to give valuable information



2. The principle design of the chip size measurement system



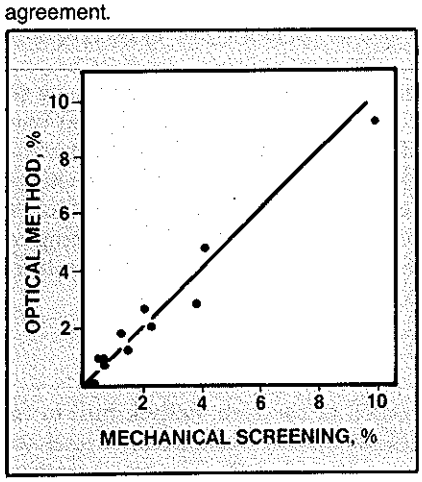
- At chip blending to control the ratios of different types of chips or chip fractions to achieve a specified mixture
- Before digesters and refiners to give operators and staff information on chip quality and to allow the process to be adjusted accordingly.

Real-time image analysis

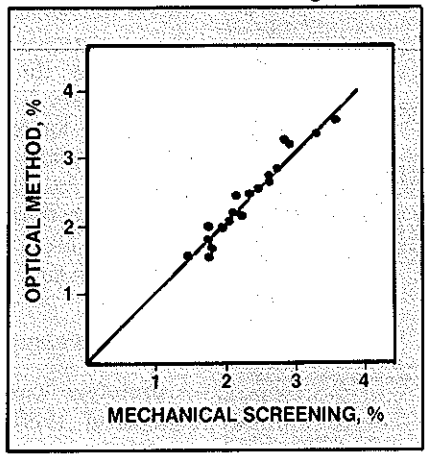
The new chip measurement system is based on the use of real-time image analysis. A sample stream of chips is diverted to the system, and the chips are distributed on the surface of a conveyor belt moving at a speed of 1 m/s, as illustrated in **Fig. 2**. A linear array camera scans the belt, with a resolution of 0.5 mm below two lamps. As the conveyor belt moves, the signal from the camera

Petterson is a project leader, Olsson is a project leader, and Lundqvist is manager of fiber-line measurement and control at STFI (Swedish Pulp and Paper Research Institute), Box 5604, S-114 86 Stockholm, Sweden.

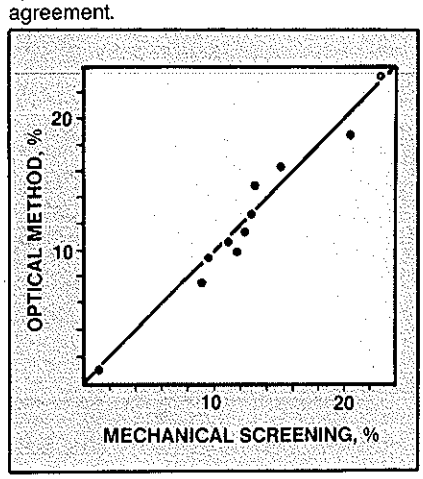
3. On samples from a variety of chip types, the fines content as determined by the optical and the mechanical methods are in agreement.



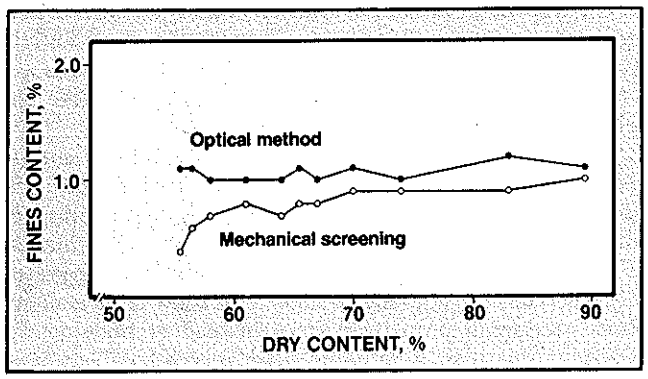
4. On chips from sampling positions on the feed and accept flows of a chip screen, the fines content as determined by the optical and the mechanical methods are in agreement.



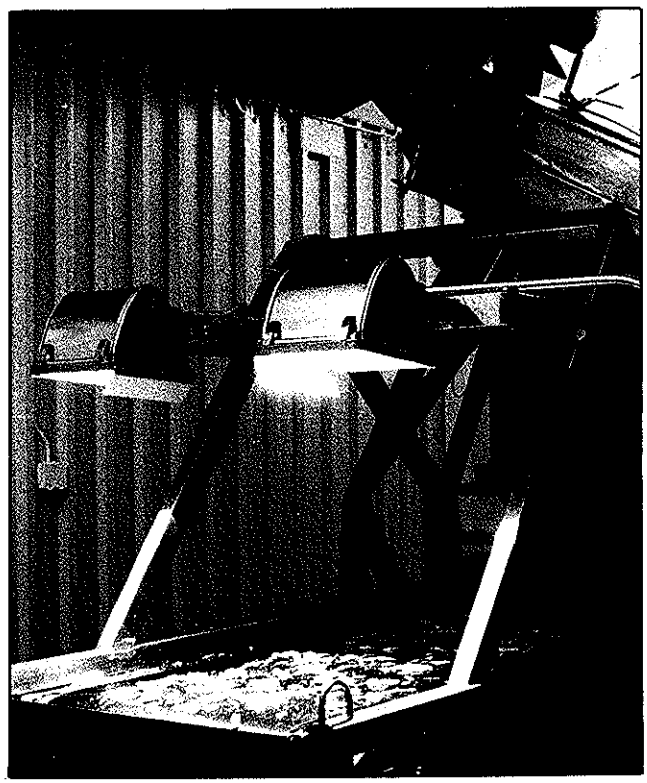
5. On samples from a variety of chip types, the pin chips content as determined by the optical and the mechanical methods are in agreement.



6. The result of the mechanical classification method for fines content is dependent on the chip dry content, while the optical method does not show such a dependence.



7. One of the installations of the on-line system for chip size measurement



is analyzed by an image processor. Finally, a computer calculates and presents the chip size distribution.

The image processor, with a special algorithm, was developed to match the need for high capacity in the system. Data are processed in real time. About 2 million values are processed every second, and the algorithm accounts for a certain amount of overlapping chips.

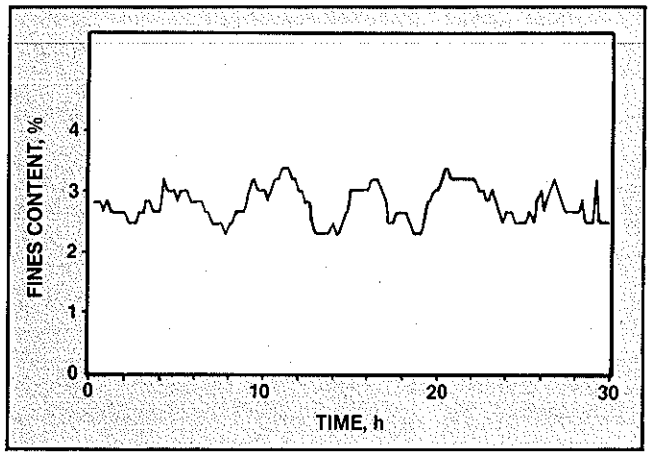
The optical method has been evaluated in relation to the standardized mechanical classification method called the "STFI pin-chip method."* **Figure 3** shows the agreement between the optical and the mechanical methods for the fines fraction of a variety of different chip types. **Figure 4** shows the corresponding agreement for the fines fraction from sampling positions on the feed and accept flows of a chip screen in a mill. **Figure 5** shows the agreement between the two methods for the pin chips fraction of various chip types.

Other factors to consider in comparing mechanical and optical methods include the deficiencies in the mechanical screening method such as effects of heavy screen loads, dry content, and lack of precision in the screens. The mechanical method is more sensitive to variations in the dry content of the chips than the optical method, as **Fig. 6** illustrates.

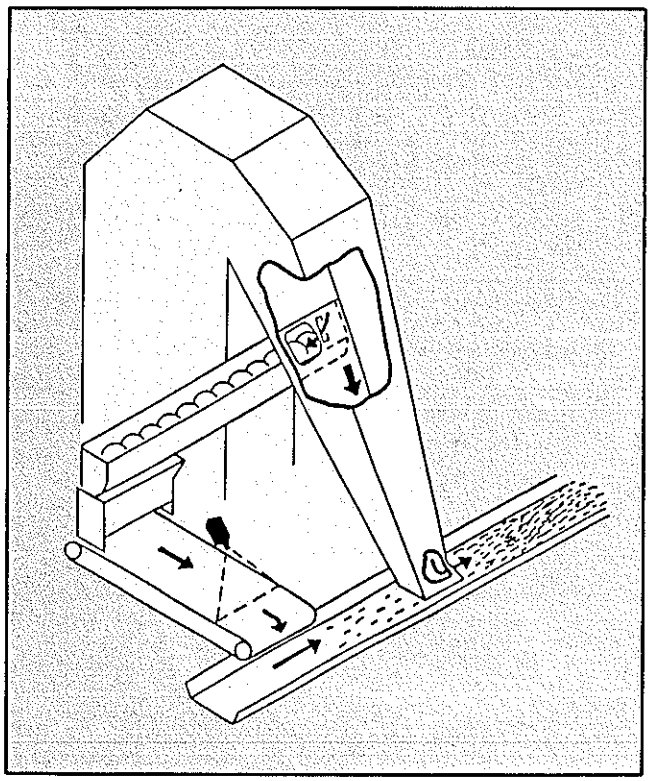
This figure shows results from two samples taken from the same population of chips. The samples were dried and tested at successively lower moisture contents. The mechanical method shows a trend toward higher fines content at higher dry content, while the optical method does not. The situation is similar for the pin chip fraction, but it is the opposite for the accepts fraction.

*Edberg, U., Engstrom, L., and Hartler, N., Svensk Papperstid. 74(19): 617(1971).

8. The variations of fines content during 30 h in the Ncb Vallvik mill, showing that during this period, the screening of fines was not needed



9. The sampling system and the position of the STFI chip size measurement system in the Ncb Vallvik mill. In the vertical chute at the back, the chips are elevated from the chip screen room. The lower conveyor belt transports the chips to the digester.



High capacity means better data

The measurement system can measure about 1 m^3 of chips per hour, which is about a thousand times more than the amount analyzed manually in most mills. Data from the camera are processed continuously, and a new set of data for the chip size distribution is given after a specified integration time. A longer integration time corresponds to a larger chip sample and means more reliable data. Long integration time also makes it impossible to monitor quick changes.

Three integration times may be used simultaneously. The mill personnel may set these integration times, depending on the degree of variability and the ability to adjust the operation to that variability or to receive shift or day overages.

Typically, the measurement system presents a new set of data every 5 min to detect quick changes in the fines content. A longer integration time may be used to get a more accurate reading for the larger chip fractions. Otherwise, a relatively small number of oversized chips may pass by the camera during the 5-min period, bringing a less representative reading for this fraction. The third integration time may be used for shift averages.

Mill experience

A prototype was installed at the Ncb Vallvik mill in the spring of 1985. The trial was satisfactory, and the prototype was acquired by the mill. The measurement system has since been further developed, based on the prototype experiences. A mill installation of an industrially designed version of the system is shown in **Fig. 7**.

Since August 1986, four such on-line systems have been installed in Swedish mills, one producing thermomechanical pulp, one producing a high-yield pulp for linerboard, and two producing bleached kraft pulp. (The Ncb Vallvik mill is one of the bleached kraft mills.) The systems are installed at various positions, from directly after the chipper to immediately before the digester.

The experiences of the mills using the optical sensors have been good. For example, in Ncb Vallvik, the mill personnel have gained valuable insights as to the influence of the chip size distribution on digester performance. Furthermore, the operators have been able to by-pass the fines screens during long periods with a low fines content, thus producing pulp from fines instead of burning the fines. In this way, a valuable fiber source has been used to increase production without inducing disturbances in the mill. **Figure 8** illustrates the variations during a period of low fines content, when screening of fines was not needed. In an evaluation made by Ncb Vallvik, the system has shown a short pay-back time.

Two of the four industrially designed systems were installed after chippers to monitor chipper performance. The other two systems are used to control the blending of chips with different chip size distributions. The reliability of all installations has been high, at close to 100% functional availability for the measurement system itself. Some problems occurred initially with the sampling equipment however.

Chip sampling—difficult but possible

It is not easy to remove representative samples from a stream of wood chips. It is sometimes even difficult to find a position where it is physically possible to install an automatic sampling device. The most effective location is a transfer point between two chip conveyors or a similar location where a sampling screw conveyor may be inserted into a stream of falling chips.

Figure 9 shows the sampling system in the Ncb Vallvik prototype installation, based on another principle. Here, the chips slide down a plate. The sample is taken through

a slot in the plate and transported to the system by a screw conveyor. By adjusting the size of the slot and the speed of the screw, it has been possible to obtain representative samples.

Summary

At STFI, an optical measurement system to determine the chip size distribution on-line has been developed. It is now installed in four Swedish mills. The measurement system has given important information about digester and chipper operation and has been used for the control of chip screening and chip blending. Other applications are also possible. The measurement system has been reported to be functionally available with good reliability.

STFI is now very active in the development of measurement and control techniques for the woodyard and woodroom. The optical chip size measurement system is one result from these activities. Our belief is that we will be able to contribute further to efficient production of high-quality chips.

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