

CHIP QUALITY - ESSENTIALS AND IMPROVEMENTS

Tord Bergman
 Swedish Forest Products Research Laboratory, STFI
 Box 5604, S-114 86 Stockholm, Sweden

ABSTRACT

The importance of chip quality for the kraft pulping process is discussed. Chip quality includes many properties, such as mean size and size distribution, chip density, dryness, bark content and type of bark. Different ways of improving and controlling the chip size and chip size distribution are discussed.

The chipper should always produce a narrow chip size distribution, i.e. small amounts of thick chips and fines, even when the wood quality is changed e.g. when the dimension of the logs becomes smaller. A special problem is to obtain a good chip quality from very short logs, often produced in the barking drum.

Traditionally, different types of chip screening are used to achieve a better chip quality. For the new chip thickness screening systems, results based on our mill measurements show that high accuracy in the distances between the discs is important. In the case of fines screening, a two-stage system gives a high efficiency and a low loss of accept and pin chips.

Wood chips are a very heterogeneous material and a well designed handling and blending system is often a prerequisite for maintaining a uniform chip quality to the digester. Homogenization chip piles are therefore an important part of a modern chip handling system.

INTRODUCTION

The object of the operations in the wood yard and woodroom is to take the wood received from the forest and present it to the pulping department in the desired form and at a suitable rate. Different pulping processes have different requirements with regard to wood and chip quality. High quality wood and relatively pure species are more important in sulphite and mechanical processes than in kraft pulping. In all chemical processes, including kraft pulping, it is necessary for the chemicals to penetrate the wood completely and uniformly if pulping is to proceed in an efficient and economic manner (1). Any deviation from this ideal situation decreases the chemical usage efficiency as well as the yield and the uniformity and quality of the pulp.

The kraft pulping process is very versatile and can be adapted to make satisfactory pulp and paper grades from a variety of wood qualities and species. This has often led to the wrong conclusion that wood quality is unimportant in the kraft process, but the properties of the wood raw material always influence the resultant pulp properties. In addition, variations in wood and chip qualities influence the different stages in the pulping process, and this also leads to a reduction in pulp quality and uniformity.

Chip Quality

The quality of chips for pulping is usually determined only by the size distribution of the chips, which is determined in a laboratory screen which defines the different chip fractions according to Fig. 1 (2).

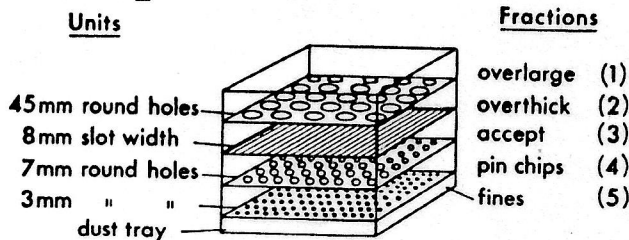


Fig. 1 Laboratory screen arrangement for evaluation of chip quality.

Chip quality also depends on other important properties as chip density, moisture content, bark content and wood species mix. Besides the chip size distribution, only the bark content is normally measured in a classification of sawmill chips.

BARK CONTENT

Bark in the chips has many negative effects on the pulping process and on the pulp quality. In the pulping process, bark in the wood raw material causes a lower yield and higher consumption of active alkali and bleaching chemicals. The quality of bleached pulp is reduced especially by some types of bark particles which decrease the cleanliness. Investigations at STFI have shown that stone cell aggregates from old birch bark and inner bark of spruce are very difficult to eliminate during the

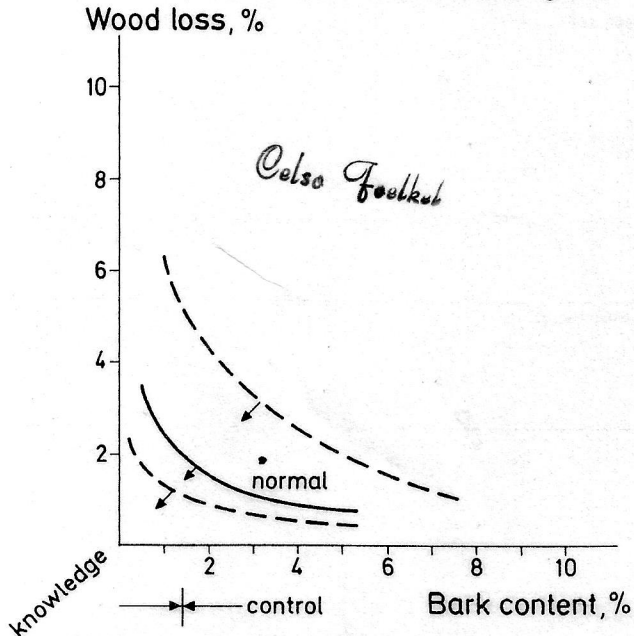


Fig. 2 The relationship between wood loss and bark content in chips for the drum barking operation. Increased knowledge, e.g. improved ability to run the barking process, decreases the wood loss at a given bark content.

bleaching (3). The bark content in the chips should therefore be as low as possible. The separation of bark from logs in a barking drum is not however an ideal operation.

Fig. 2 shows typical curves to characterize drum barking of Swedish softwood. Without any barking, the bark content in the chips is about 10%. When the bark is removed the wood losses also increase. The lower dotted curve shows the relationship when the bark is easily removed. The upper dotted curve is applicable to drum barking of dry wood or barking under winter conditions. In some cases we must accept bark in the chips if we still want to produce pulp from the wood instead of burning it together with the bark. Pretreatment of the logs, mechanically or thermally (warm water or steam) can improve the situation and the barking curve will move towards the origin. A better understanding of how the efficiency of the barking drum is affected when, for example, the rotation speed is changed makes it possible to control the barking operation. For complete control, sensors to measure the barking result are also needed. This type of sensor is however not available yet.

We must also remember the bark content in the sawmill chips. It is very important that the pulp mill makes clear to the sawmills the requirement of a low bark content. A system including a control of the chips and a cost reduction is normally a very efficient solution to this problem.

CHIP SIZE DISTRIBUTION

Chipping

A good control of the chipping equipment and of chips from sawmill residuals delivered to the mill

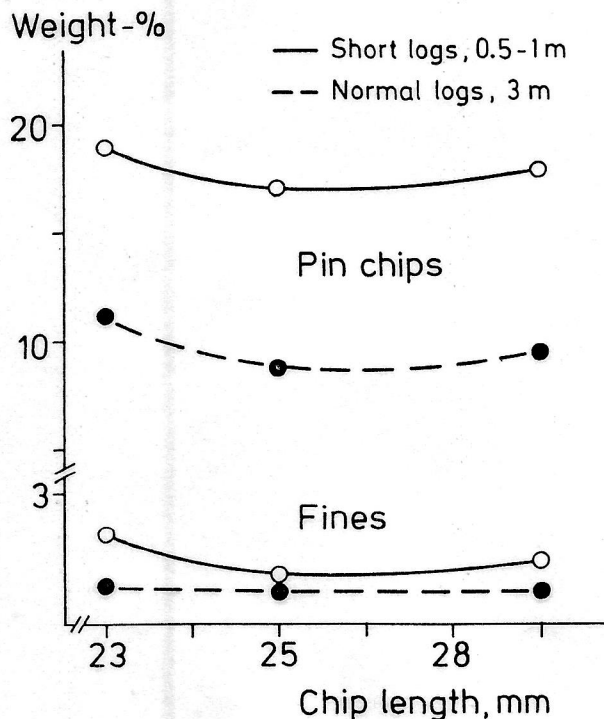


Fig. 3 Chipping of short logs in a conventional disc chipper gives a poor chip quality with high amounts of pin chips and fines.

is the first step in reaching a high chip quality. The chipping of whole logs in a properly maintained disc chipper normally gives a narrow size distribution with a relatively low content of over- and undersized material (4). When the dimensions of the logs decrease, it becomes more and more difficult to maintain good chip quality. A special problem is the breaking of small dimension logs in the barking drum, which results in short logs (0.5-1 m) in the infeed to the chipper. Under these conditions, the chipper produces very poor quality chips with high contents of pin chips and fines, as can be seen in Fig. 3. The production of the overlarge fraction is also high with these short logs.

A special line with a smaller chipper makes it possible to produce a fairly good chip quality even from these short logs. The need for a separate chipping line has increased as a result of the use of whole trees which means both debranching and debarking of small dimension logs in the barking drum.

Chip Screening

The pulping processes often demand a more narrow chip size distribution and the chips therefore have to be screened to remove the oversized and undersized fractions. The aim of the screening system is a high efficiency of removal of unwanted material without loss of acceptable chips.

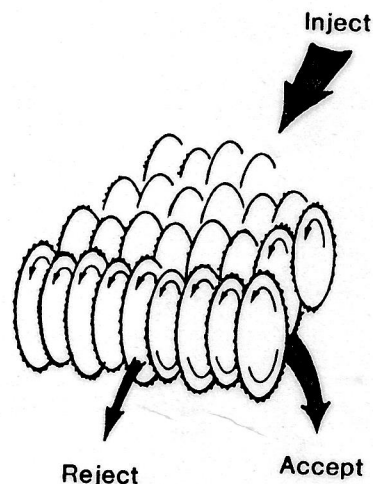


Fig. 4 Disc screen for chip thickness screening.

Thickness Screening. Conventional hole-screens separate only the overlarge fraction (fraction 1 in Fig. 1). Many studies on a laboratory scale have shown the importance of chip thickness for kraft pulping (5, 6, 7). In the late seventies, Black Clawson developed a thickness screening system containing a disc screen as shown in Fig. 4 and a chip slicer. The screen was flat and the distance between the discs was 7.5 mm. Results from a pilot plant test have been presented in the literature (8). Rader International developed a "V"-shaped disc screen and a slicer and later Winbergs, a Swedish company, constructed a chip thickness screening system with a flat disc screen. The efficiency for rejecting overlarge and overthick chips (> 8 mm) in these screens is shown in Fig. 5. The results are

presented in the same way as for screening of pulp and they are based on large-scale mill measurements.

Efficiency, % Overthick chips

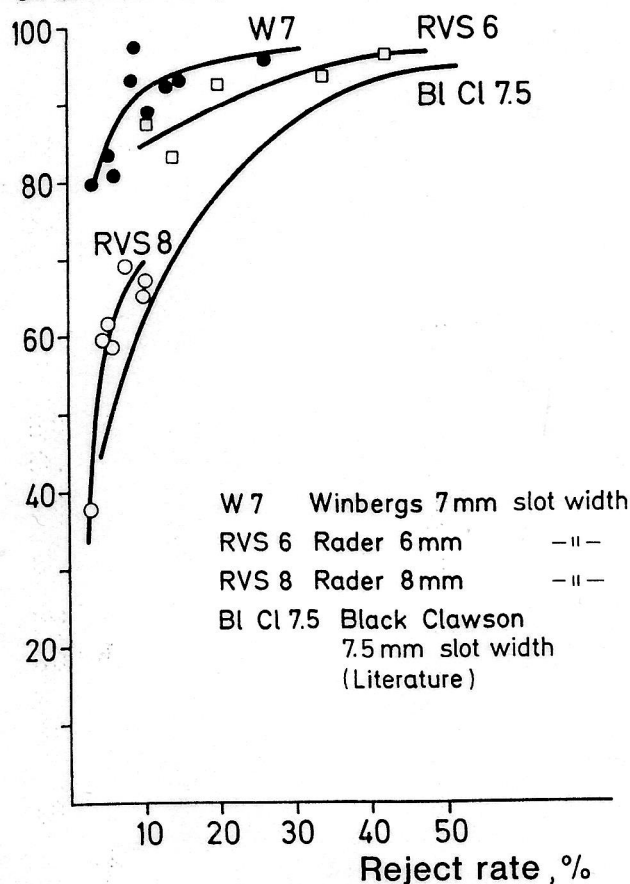


Fig. 5 Removal efficiency for overthick chips (> 8 mm) in different disc screens.

The Rader disc screen evaluated, with a slot width of 8 mm, eliminated 65-70 % of the overthick chips at 10 % reject rate. (Normal chip quality and loading.) When the slot width was reduced to 6 mm, the efficiency increased to about 90 % at a reject rate of 20 %. A 20 % reject rate means that the capacity of the slicer must be high and that the production of pin chips and fines in the slicer can be noticeable. The best result was obtained with the Winbergs disc screen which eliminated more than 90 % of the overthick chips at a moderate reject rate. The higher efficiency does not depend on the different shapes of the screens, but on the accuracy in slot width between the discs.

The function of the slicer is extremely important for the result of the total chip thickness screening system. If the slicer does not perform satisfactorily, it does not matter how efficient the chip screening operation is. We have found that the slicers normally produce a good chip quality.

A mill trial was performed over a period of two weeks to evaluate the effect of chip thickness screening on the kraft pulp process. The mill

measurements were made in Fiskeby AB's sulphate mill in Skärblacksa with two production lines (9). One line is equipped with a continuous Kamyrdigester for production of pulp for sack paper. The other line produces bleached pulp and is equipped with batch digesters. The first week was a reference week with no chip screening and during the second week the digesters were supplied with screened chips from two Rader "V"-screens (RVS 8). Fig. 6 shows the reduction in shives content in unscreened pulp from the continuous digester. In the batch low-kappa line (kappa number 33) the shives content in unscreened pulp decreased from 2.5 % to 1.4 % when thickness-screened chips were used.

The chip-thickness screening also gave an improvement in the reject handling system of the continuous line. The total rejected pulp flow, the shives content in the rejected pulp and the power consumption in the reject refiner were decreased by 30 to 50 %. If the shives content in the pulp is a limiting factor, the results indicate that chip-thickness screening can make it possible to achieve a better production economy by increasing the kappa number by about five units.

Shives content, Somerville ϕ 0.15 mm weight -%

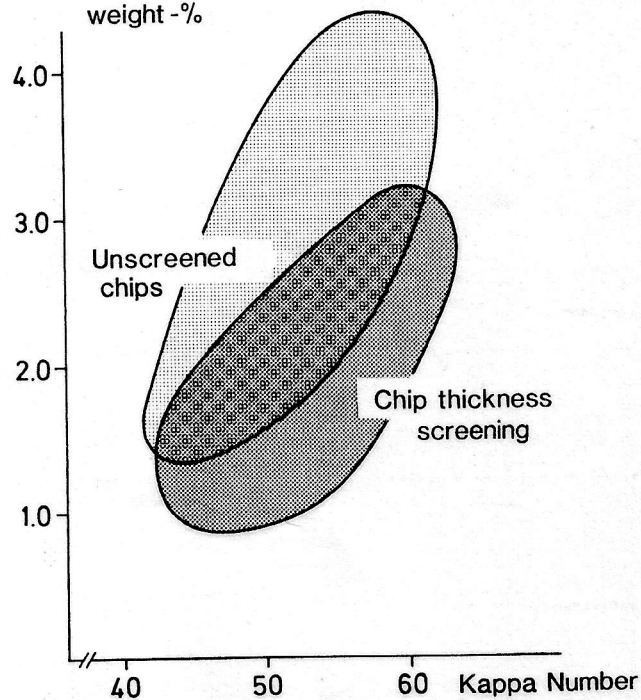


Fig. 6 Relationship between shives content and kappa number. Unscreened pulp after in-line refining.

Screening of Fines. At the other end of the chip size distribution curve we find the undersized material, fines and pin chips. Different pulping processes and different pulping equipments have different tolerances towards undersized fractions of the chips. Some principle screening systems for fines are shown in Fig. 7.

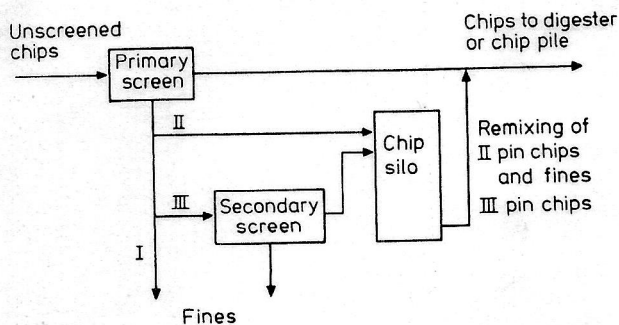


Fig. 7 Three principle screening systems for fines removal (to be burned) or control of the undersize fractions.

Alternative I is the normal type of screening in one step. System II is used to eliminate variations in undersized material, not to separate it. Alternative III is the most complicated system with both primary and secondary screening. In the secondary screen, the pin chips are separated from the fines and can be mixed with the accept fraction under controlled conditions. Results from mill trials have shown that only a two-step screening system can combine a high removal efficiency for fines with a low loss of acceptable chips.

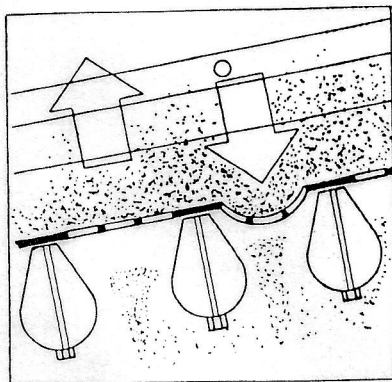


Fig. 8 The principle of the Liwell screen is alternate stretching and slackening of flexible mats.

A new development for chip screening, designed to meet the mining industry's screening needs, is the Liwell screen. The principle of the Liwell screen is alternate stretching and slackening of flexible mats, Fig. 8. This prevents accretion and plugging of the screen even under winter conditions (10).

Fig. 9 shows the efficiency for fines and pin chips removal in a Liwell screen and in a conventional shaking screen. The Liwell screen rejects about 90% of the fines and the total reject rate is twice as high as for the conventional screen. In both cases there is a need of a secondary screen to separate the pin chips from the fines. Results achieved with a Liwell screen (square 6 mm) in the secondary position also show about 90% removal efficiency for fines.

Efficiency, %

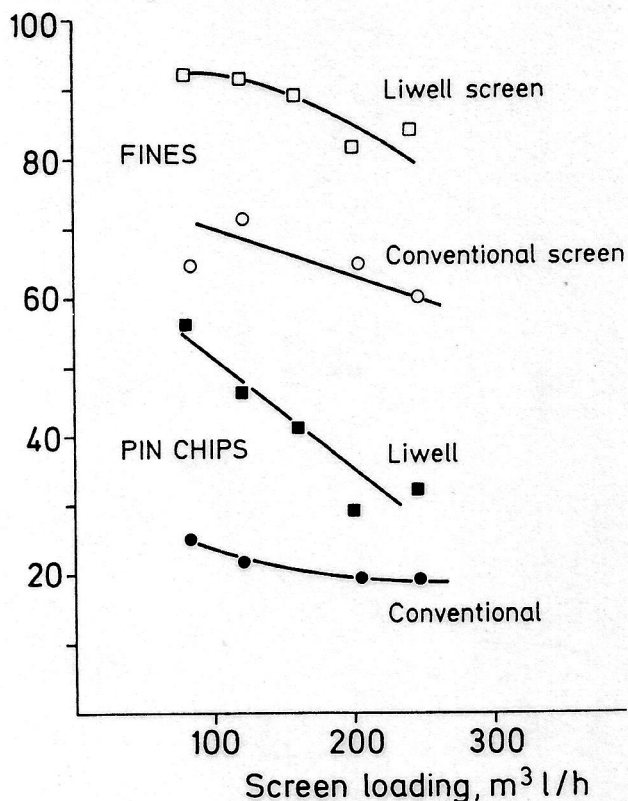


Fig. 9 Removal efficiencies for fines and pin chips in a Liwell screen (square 10 mm) and a conventional hole screen (diam. 10 mm).

CHIP DENSITY AND MOISTURE CONTENT

The feed of wood to the digester, whether continuous or batchwise, is on a volume basis, whereas the charge of cooking chemicals is on a weight basis. The chip density is therefore a critical factor for the cooking result and the possibility of keeping the kappa number at the desired level.

In a mill trial we measured the variation in chip density directly after a chip pile. This trial was performed during a week in a pulp mill with a traditional chip handling system, which means a rather poor blending of the chips in the chip pile and an uncontrolled amount of sawmill chips in the feed to the digester. The variation in loose-chip packing density during this period is illustrated in Fig. 10 and the extreme values are $\pm 10\%$.

Chip density is related to the wood density and to the packing of the chips, i.e. to the ratio of the solid to the loose bulk volume of the chips. Variations in wood species mix, sawmill chip content, chip size distribution and dryness therefore directly influence the chip density and the feed of wood to the digester.

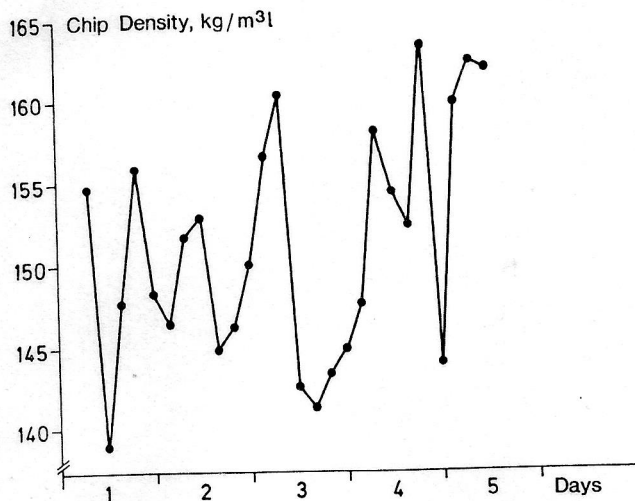


Fig. 10 Variation in chip density (kg od/m³) over a period of five days. The chip samples were selected directly after a conventional chip pile.

Moisture content is another important chip property. A variation in wood moisture content influences the ratio of liquor to wood in the digester. The chip dryness measured during the same period ranged between 51 and 59 %.

One interesting question relates to the connection between variations in chip quality and deviations in the kappa number of the pulp. We have tried to estimate the effect on the kappa number of the observed chip quality variations. In our calculations we assume that both the cooking temperature and the alkaline charge are constant. The result is shown in Table 1. When the chip density changes by 10 %, here 15 kg od/m³, the kappa number changes as much as 5 units. The measured changes in chip dryness influence the kappa number in a more moderate way, about one unit.

Table 1. Relationship between variations in chip properties and the deviations in kappa number of the pulp.

Chip property	Normal value	Variation	Changes in kappa number
Density, kg od/m^3	150	15	5 units
Moisture content, %	50	5	1 units
Pin chips and fines, %	10	+10	> 10 units

The chip size distribution can also be an important property for controlling the kappa number. The continuous digester in particular can have a rather low tolerance level for undersized material. In the chip handling system described above, we found that the content of pin chips and fines could vary widely. If it increases from the normal 10 % up to 20 %, there can be problems in the continuous digester. If the digester has to be stopped the

kappa number decreases. In this mill measurement, a two-hour stop resulted in a decrease in kappa number by 10-20 units for the pulp in the cooking zone, Table 1.

CHIP HANDLING SYSTEM

The goal of a low bark content can be reached through a better control of the barking result in the barking drum and of the bark content in the sawmill chips. Small undersize and oversize chip fractions can be obtained through a proper adjustment of the chipper and a correct choice of screening equipment. But there are still variations in wood and chip density, moisture content and wood species mix. At the end of the chip handling system we therefore need a blending operation for the homogenization of different chip types.

Chip homogenization piles

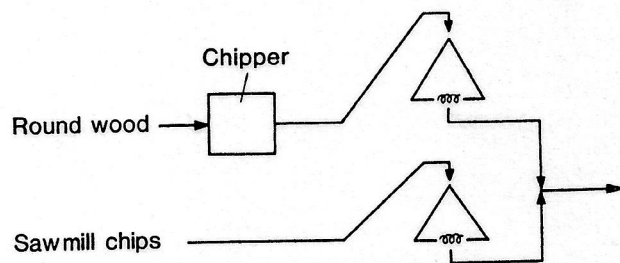


Fig. 11 Chip handling system with homogenization piles for roundwood chips and sawmill chips.

Fig. 11 shows a system where the two wood grades, roundwood chips and sawmill chips, are stored in separate chip piles. The chip piles are of the homogenization type with a traversing infeed on the top of the pile. The blending effect is achieved by the discharge through moving screws at the bottom. The arrangement with two separate chip piles enables the proportion of the more inhomogeneous sawmill chips to be controlled.

Measurements on homogenization chip piles, using radioactive-marked chips, have shown that the blending effect differs slightly from the theoretical ideal situation, although the function is still very good. Our own measurements on chip samples taken directly after a homogenization pile have also shown that the deviations in the different chip properties are much smaller than in the traditional chip handling systems.

SUMMARY

- Mechanical or thermal pretreatment of dry or frozen logs improves the efficiency of the barking drum. A better knowledge of the barking operation and sensors to measure the barking result are pre-conditions for a complete control system for drum barking.
- A good chip quality can be achieved from very short logs, which are often produced in the barking drum, by using a separate chipping line with a smaller chipper.

- 80-90 % of the overthick chips can be eliminated in screening systems having a high accuracy in the distances between the discs.
- A two-stage system for fines screening gives a high efficiency and a low loss of accept and pin chips. New screening equipment shows a higher efficiency and a better availability than traditional screening systems.
- A well designed chip handling and blending system is a prerequisite for supplying a uniform chip quality to the digester. Homogenization chip piles are therefore an important part of a modern chip handling system.

ACKNOWLEDGEMENTS

The author thanks Dr. Ants Teder for helpful suggestions and for criticism of this manuscript. Thanks are also due to Dr. Anthony Bristow for linguistic revision of the manuscript.

REFERENCES

1. Barnes, E.T., Pulp and Paper Technology Series, No. 5, Chip Quality Monograph, (J.V. Hatton, Ed.), Joint Textbook Committee of Paper Industry, Atlanta, 1979, p. 71.
2. Edberg, U., Engström, L. and Hartler, N., Standard method for screening of market chips. (Swedish, Eng. sum) Svensk Papperstidning, 74(19):617 (1971).
3. Axegård, P., Particles difficult to bleach in softwood kraft pulp. Svensk Papperstidning, 81(14):449 (1978).
4. Hatton, J.V., Mill testing of W.F.P.L. chip quality procedure. Can. For. Serv., West. For. Prod. Lab., Inf. REP. VP-X-139, Vancouver, B.C. (1975).
5. Hartler, N. and Onisko, W., The interdependence of chip thickness, cooking temperature and screenings in kraft cooking of pine. (Swedish, Eng. sum.) Svensk Papperstidning, 65(22):905 (1962).
6. Colombo, P., Corbetta, D., Pirotta, A. and Rufinni, G., The influence of thickness of chips on pulp properties in kraft cooking. Svensk Papperstidning, 67(12):505 (1964).
7. Akhtaruzzaman, A.F.M. and Virkola, N-E., Influence of chip dimensions in kraft pulping, Part I. Mechanism of movement of chemicals into chips. Paperi ja Puu, 61(9):578 (1979).
8. Steffes, F.S., Commercial screening for overthick chip removal. Tappi, 61(11):63 (1978).
9. Eklund, L., Chip screening - a pulping process at Fiskeby mill. Proceedings of SPCI Conference 1984, Stockholm, p. 31.
10. Stade, Y., Chip screening operations on Liwell screens. Proceedings of SPCI Conference 1984, Stockholm, p. 27.