

Latest development trends in controlling the mechanical groundwood process

A. Kärnä, H. Liimatainen, and H. Rusanen

Control of production rate is a good compromise between production and quality. Control of specific energy consumption can be considered when production is not critical.

Still the most widely used type of mechanical pulp, groundwood accounts for over 60% of all mechanical pulp produced. Until the 1960s, the main developments in mechanical pulping were in the grinding process. Then the proliferation of computers focused interest on groundwood mill control systems. In the 1970s, the emphasis again shifted away from control, because of the rapid spread in the use of TMP and the general belief that groundwood would disappear altogether.

Belief in the future of groundwood has now been restored, primarily because of the recognition of the special properties developed in pressurized groundwood. As the grinding process was gaining again in importance, microprocessor-based automation systems were undergoing rapid development. These new systems have made total groundwood mill control much easier to achieve and have spread quickly, especially in the Nordic countries. The objectives of groundwood control now range from the grinding process to integrated mill control systems.

Objectives of groundwood mill control

The planning of groundwood mill control systems starts from information about the process. This information can be divided into long-term, medium-term, and short-term factors (1). Long-term factors include:

- Types of grinding stone
- Patterns of sharpening
- Operations of sharpening
- Rates of stone dulling.

Medium-term factors include:

- Wood quality
- Volume and quality of white water
- "Illogical" shifts in the behavior of the stone.

Short-term factors are:

- Pocket differences
- Stroke differences
- Differences between the phases of grinding strokes.

Typical objectives of groundwood mill control are (2) the control of the pulp quality, the production rate, or the consumption of energy. To a certain extent, these objectives contradict each other. For example, increases in production rate are achieved at the expense of quality.

At one time, maximum production rate was regarded as the most important objective. However, this emphasis is now being superseded by quality considerations, particularly in Europe but also in North America. One example of more consistent quality control is the reduction of freeness variation, as depicted in Fig. 1. The overall freeness can be increased without the risk of exceeding the maximum allowable freeness. Increased freeness means that energy consumption can be decreased or that production can be increased. Because of less variation in freeness, it is also possible to reduce the amount of kraft pulp in the paper blend.

The objectives of groundwood mill control can be achieved (a) by control of an individual grinder, (b) by control of a group of grinders, and (c) the rest of the groundwood process, including screening and cleaning.

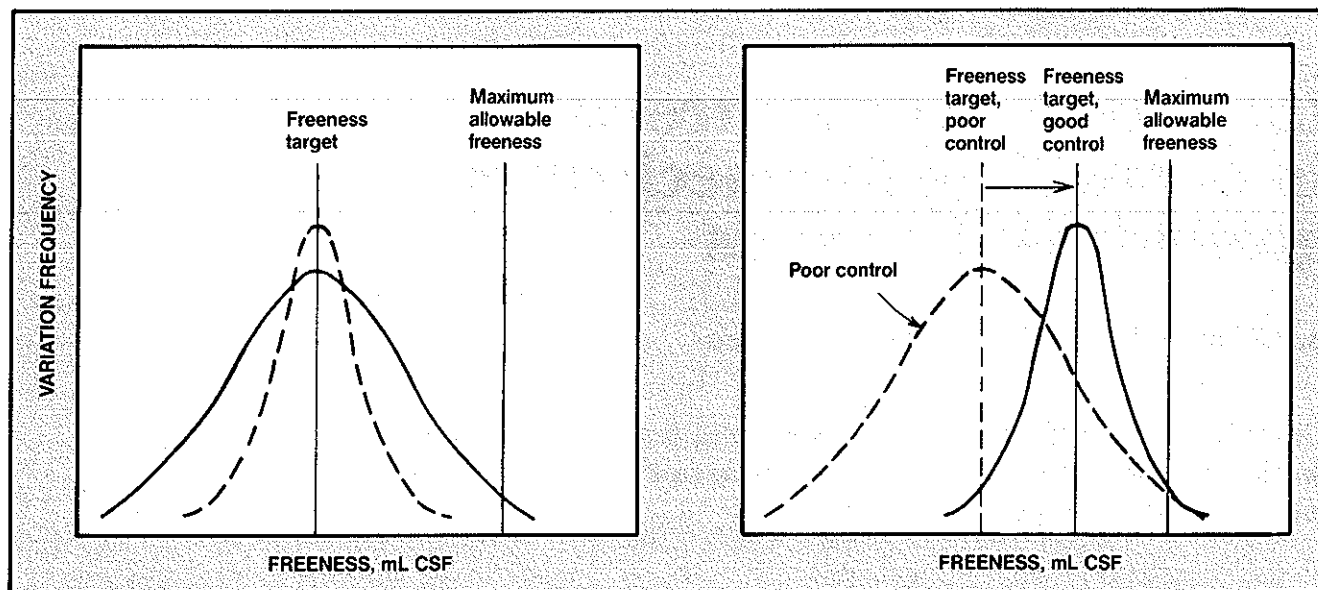
On-off grinder controls

The most important on-off grinder controls are for pocket charging systems. During the last few years, digital automation systems have become more and more common, and relay systems are gradually disappearing.

Digital systems have made pocket charging more reliable, which has increased production. Disturbances can be pinpointed quickly because of improved diagnos-

Kärnä is director of technology at Valmet Paper Machinery Inc., Paper Finishing Systems, Järvenpää, Finland. Liimatainen is research manager at Tampella Ltd., Inkeroinen, Finland. Rusanen is the head of the Automation Department at Tampella Ltd., Tampere, Finland.

1. The effect of an improved control system on the variation of freeness



tics, and certain fault conditions can be eliminated automatically. Log jams, for instance, can sometimes be eliminated this way.

Communication between the pocket charging system and other systems within the mill is vital, unless one single automation system covers the whole mill. The operators in the control room must always be able to know the conditions of each pocket.

Grinder control methods

The most important parameters for grinder control are:

- Peripheral speed of the stone
- Condition of the stone surface
- Dam position
- Shower water flow rate
- Shower water temperature
- Stock temperature
- Pressure in the grinder (for pressurized groundwood)
- Grinding (or hydraulic) pressure.

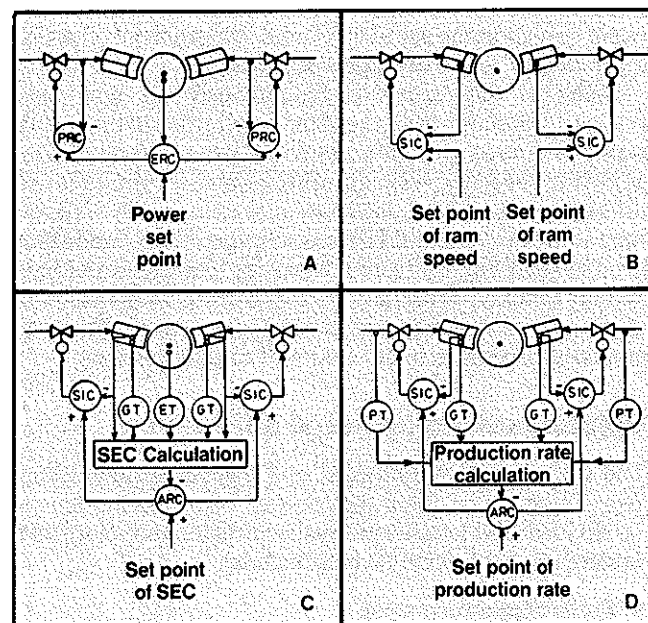
Peripheral stone speed cannot be economically used as an active control parameter. Stone preparation and maintenance is a possibility for control but one that is used only when necessary. Sharpening is normally undertaken at intervals of 7-15 days.

Dam position is of little importance and is seldom used as a control parameter. In fact, there has recently been an increase in pitless grinding, and the dam is no longer supplied with PGW grinders.

According to general wisdom, we could achieve more controlled grinding if we could minimize the variations in the shower water flow. But how does this translate into practice?

Pulp properties are influenced by grinder pressure and shower water temperature. The best strength properties are generally achieved when both are set at their maximum values. However, this prevents their use as

2. Principles of different types of grinder control A: Power control. B: Ram speed control. C: Specific energy control (SEC). D: Production rate control. PRC = pressure controller. ERC = power controller. SIC = speed controller. GT = position transmitter. ET = power transmitter. PT = pressure transmitter. ARC = controller, SEC or production.

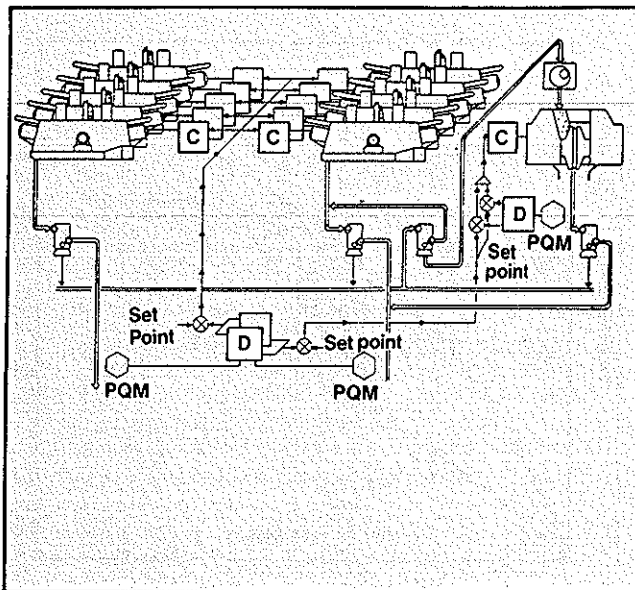


active control parameters. Furthermore, the use of stock temperature as a parameter is questionable because it is achieved by so many different factors.

Therefore, hydraulic pressure will be the only active control parameter generally used. It can be influenced by the following control methods:

- Pressure control
- Power control
- Control of ram speed
- Control of production rate

3. Principle schematic of the SCS control system. C = local computer control. D = drainage, fractions, and shives.



- Control of specific energy consumption.

Pressure control

Applying pressure control to a particular pocket involves adjusting the pressure of water to the constant value. This method is seldom used by itself. It has the disadvantages of causing large variations in quality and production.

Power control

Power control is probably still the most commonly used control method. It usually involves direct control of the hydraulic pressure valve. Normally, pressure control or speed control is used as a subsidiary control method (Fig. 2). If the grinders are operated in series (one motor coupled to two grinders), the power of each grinder can be measured by comparing the total power with the power measured by a torductor between the grinders. The torductor measures the torque of the second grinder.

Power control has the advantages of even power and high production rates. However, it also causes (a) large variations in quality, (b) coarse pulp because of the rapid movement of the ram, or shoe, pressing the logs against the pulpstone after pocket charging, and (c) high energy consumption per ton of stock as a result of arching, where the speed of the ram falls too low.

When ram speed control is used as a subsidiary to power control instead of pressure control, the disadvantages of coarse pulp and high energy consumption can be decreased.

Speed control

Speed control involves measuring the speed of the ram or pressure shoe and stabilizing it by directly adjusting the high-pressure water valve with the speed difference (Fig. 2). Power is also continuously monitored, and if it exceeds a maximum value, the system changes to power control automatically.

In this method, pulp quality is more consistent than with power control. There is no rapid ram movement after

I. Comparison of different control methods

	Control method			
	Power	Speed	Production rate	SEC
Quality variations	•	••	•••	••••
Production rate	••••	••	•••	•
Power variations	••••	••	•••	•
SEC variations	•	••	•••	••••

SEC = specific energy consumption.
Poor = •. Good = ••••.

pocket charging, and there is less arching. However, compared to power control, speed control has the disadvantages of (a) yielding power that is more uneven and (b) a lower production rate.

Control of production rate

This method controls the set value of the speed controller for each pocket as a function of pressure shoe movement. Therefore, the amount of stock produced is stabilized (Fig. 2). This method is also known as "programmed speed control" in a two-pocket grinder, since it is a more sophisticated version of speed control.

Variations in quality with control of production rate are between those obtained with speed control and control of specific energy consumption. This method has the advantages over speed control of higher average power and higher production.

Control of specific energy consumption

By controlling the specific energy consumption, the energy consumption per ton of pulp is stabilized. The method relies on the relationship between energy consumption and pulp freeness. Specific energy consumption and freeness are stabilized simultaneously.

For this method, the production rate per grinder must be continuously calculated. The components of the calculation are the speed and position information on the pressure shoe, the wood density packing factor, and the cross-sectional areas of the pocket. The wood density changes during any pocket grinding, and this change must also be taken into account.

Summary of control methods

Table I compares the main characteristics of the four most common control methods, based on numerous experiments undertaken by Tampella.

In the future, power control should be used only when quality can be sacrificed to achieve the maximum production. Control of production rate is a compromise

between power control and control of specific energy consumption and may be used more and more. Control of specific energy consumption can be used only when production rate is not a critical factor.

Digital microprocessor-based automation systems offer many opportunities for even more sophisticated control. One example would be self-tuning controllers that determine their own parameters.

Integrated groundwood mill control

The general objective of integrated control is to stabilize a particular parameter of the finished pulp, whether it is freeness, burst strength, or tear strength. Simulations have proven that it is possible to stabilize only one parameter at a time, since attempts at stabilizing several parameters result in no additional advantages (5). Integrated systems in use today include the Camel, the Agmo, the SCS, and the Kajaani-4000/Tampella.

Camel

This system was first developed at the end of the 1960s in Canada, and it was among the first computerized grinder control systems based on mathematical models.

The system inputs are shower water flow and temperature, motor load, log feeding speed, groundwood temperature, and total mill power. On the basis of this information, set points for shower water flow and grinding pressure are calculated by means of models.

The Camel system was expected to satisfy extremely demanding objectives: quality improvement, increased production, decreased energy consumption, and labor. As far as we know, Camel has been used only on one grinder, which indicates this system's commercial success.

Agmo

Agmo was developed in Finland at the beginning of the 1970s and is based primarily on the following mathematical models. For the stone sharpness model:

$$m = SP^{\alpha} \quad (1)$$

For the quality model:

$$Q_j = K_j S^{a_j} P^{b_j} \quad (2)$$

For the mixing model:

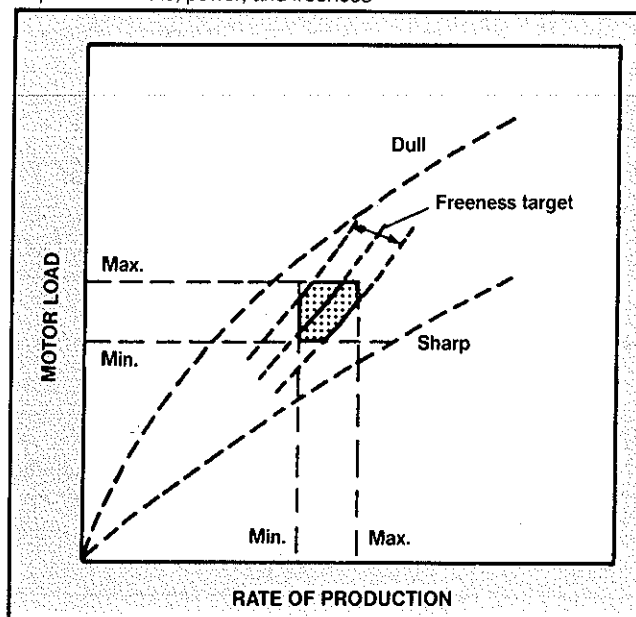
$$\log F = \sum_{i=1}^n c_i \log F_i \quad (3)$$

where

- m = production rate
- S = sharpness
- P = motor load
- Q_j = groundwood property j
- F = groundwood freeness
- F_i = freeness of fraction i
- c_i = proportion of fraction i
- K_j, a_j, b_j = constants.

The initial data for Agmo are stone sharpnesses, stock

4. The target area of grinder control, formed by the tolerance limits of production rate, power, and freeness



level in the chests, energy price, daily production, and target freeness. On this basis, the system allocates groundwood mill production demand between the grinders in the most effective way.

Agmo was designed to achieve the following:

- Groundwood quality (freeness) to be controlled as required
- Requested production to be obtained
- Production costs to be minimized
- Stones to be used evenly with sharpening carried out at optimal intervals.

In Agmo, the quality properties of the groundwood are kept within the target range, and grinder production is maximized. Stones are sharpened at suitable times. Achieving the other goals involves a presimulation program that calculates every possible combination of the grinders, from which the four best are selected.

This system did effectively compensate for long-term variations in quality. One disadvantage of the operation was that it was complex and time-consuming, partly as a result of the inefficient computers that were in use during the 1970s.

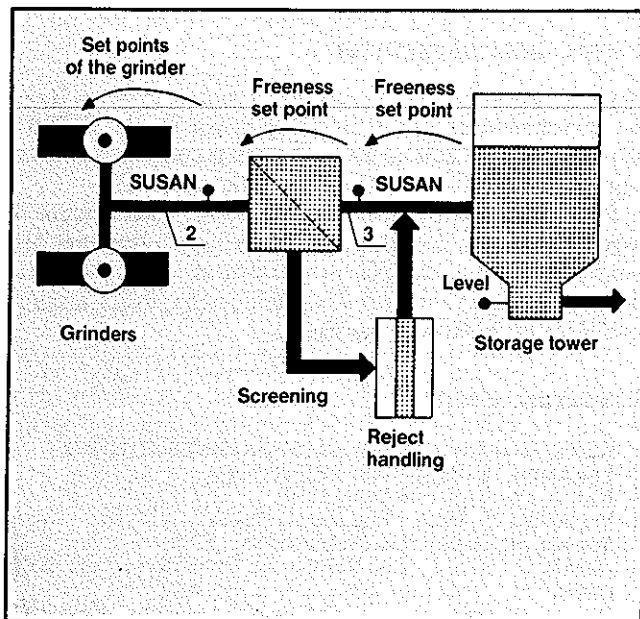
SCS

Developed in Sweden, this system is also based largely on the use of models (6, 7). It controls not only grinders but also the screening operation (Fig. 3).

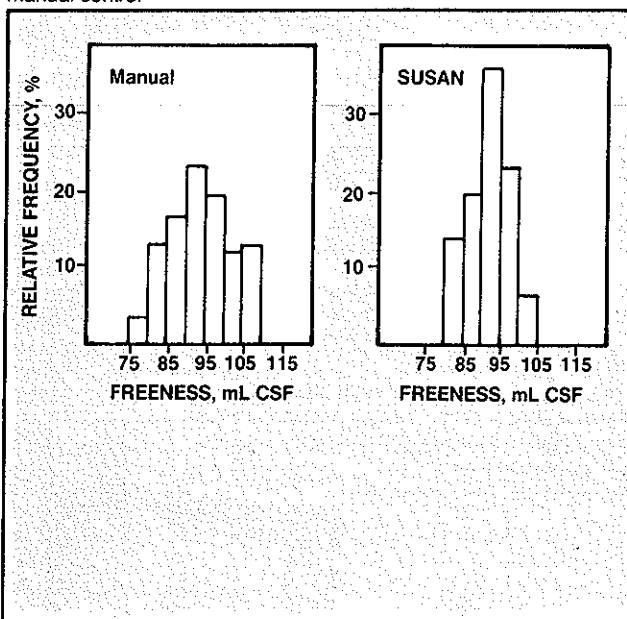
The grinders are controlled to stabilize the average consumption of specific energy by means of speed control. An on-line pulp tester, the pulp quality monitor is used to monitor the freeness of combined stock. The same device also provides information on fiber fraction, shive content, and consistency, which is used in screening control. Screening is controlled through the reject ratio.

Reportedly, one SCS installation achieved a 10-mL increase in freeness through reduced variation, a decrease

5. The principle of the preliminary control system based on SUSAN



6. Results of the SUSAN control system compared with results of manual control



in specific energy consumption of 80 kW·h/ton, and an 8% increase in production.

Kajaani-4000/Tampella

This system was jointly developed with Kajaani Electronics and Tampella in the early 1980s and is based on target area control. The system attempts to keep the control parameters within given limits. The target area is formed by the tolerance limits of production rate, power, and freeness, within which the grinders should operate (Fig. 4).

The control system proper is divided into three sections: control of final freeness, control of the stone group, and control of individual stones. The individual grinder is controlled by production rate or specific energy consumption control as developed by Tampella. Grinder group control loads the stone producing the best quality of pulp as heavily as possible, with the worst stone being loaded as lightly as possible. Disturbances in screening and reject handling are compensated for by measured freeness control, which attempts to maintain a constant freeness by controlling the calculated freeness set value of the stone group.

There were some initial difficulties when this system was started up in 1982. These included the difficulty of measuring freeness in a reliable way. The problem was solved through an extensive updating system that corrects the measured freeness values through laboratory calibrations made every 2 h. This system has been in almost continuous use at Tampella's Anjala mill, with production of about 1000 tons of pressure groundwood per day. Compared with manual control, this system gives a 20–40% reduction in freeness variation of screened, accepted stock.

Control based on direct measurements

Toady's integrated control systems are largely based on

mathematical models. Our experience shows that laboratory values may differ by more than 20% from the values of the models. Furthermore, systems based on models use a freeness measurement obtained from the finished pulp, which might involve a delay of up to 30 min between the grinder and the measurement. There is a long delay before a disturbance in the grinder shows up in the finished pulp. Thus, control based on direct measurements would be a better alternative.

This idea forms the basis of a device called "SUSAN," which is an analyzer for measuring freeness and consistency developed by Tampella. Using this device, measurements of freeness and production rate can be taken (a) from pit stock, (b) before and after screening, (c) from refined reject pulp, and (d) from finished pulp.

A simple control system based on the SUSAN analyzer was tested at the Anjala mill and is shown in Fig. 5.

Briefly, the principle of the system is as follows. First, the set point of freeness in Position 3 is determined by the operator, to 100 mL (± 5 mL) for example.

Second, the set point of pulp freeness in Position 2 was calculated by the freeness as measured in Position 3. Limits were also set for this set point (such as 150 ± 15 mL).

Third, the set point of stone group production rate was calculated from the freeness as measured in Position 2. The load was divided among the stones so that the duller stone was most heavily loaded.

Fourth, the set point of production rate for each stone was transmitted to the production rate controller.

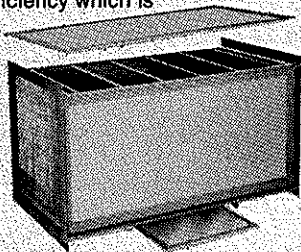
The results are shown in Fig. 6. There was a 33% reduction in freeness variation as opposed to operation under manual control. After this initial trial, the system was further developed using freeness and consistency measurements taken under each stone.

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Future control systems

We will probably see an increase in control systems based on direct measurement. Systems based on the SUSAN type of analyzer can be designed using simpler computer equipment than is possible with model systems.

Here, we have not attempted to deal with control of screening, reject handling, or bleaching. In the next few years, screening control in particular is expected to develop rapidly. Commercial control packages are already available for bleaching control.

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