Reducing Energy Costs through Closed Loop Refiner Control

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Abstract

Energy costs are one of the key challenges facing the pulp and paper industry today. One area available to target energy reduction in the papermaking process is refiner optimization.

It is well understood that in order to reach and improve final paper quality, it is necessary to treat fibres by refining. Depending upon the paper type, refining can be a large energy consuming process. Successfully optimizing the refining process can help reduce papermaking costs, achieve the desired final paper quality and allow for increased production.

One method to improve the refining process is through closed-loop control; typically this is done by implementing “specific energy control”. This control strategy targets the specific refining energy based on production throughput and an energy set point. Good consistency control of the stock going into the refiners is paramount to achieve the desired results with this control strategy.

In addition to the traditional specific energy control approach, on-line freeness control can also be added into the control strategy which further enhances final results including energy savings. On-line freeness control adds the ability to account for incoming pulp furnish variations. With this approach, the final freeness after refining is measured on-line and is incorporated as a key control variable. The added freeness control requires a fast, accurate and reliable on-line measurement to get a meaningful freeness signal.

This paper discusses control loop design and what results can be achieved through specific energy and on-line freeness control around the refining process. Results are based on actual mill case studies. The paper reviews the papermaking benefits and return on investment implementing closed-loop refiner control. Specifically there are significant refining energy cost savings, enhanced drainage and production as a direct result of closed-loop refiner control and reduced freeness variability.

Introduction

There are many different strategies in the refining and stock approach system to adjust final paper quality. These would included fiber type and mix, refining load, refiner geometry and paper process conditions. Adjustments to each of these systems will generate different final pulp characteristics going to the paper machine and lead to ultimately different final paper characteristics. While there are various methods and techniques for specifying and measuring fiber properties, the measurement most favored by papermakers is Canadian Standard freeness or Shopper-Riegler.

Papermakers that have not implemented a control loop with freeness measurement around the refiner, find it very challenging to control fiber quality out the refining system. The mills that are not controlling the variability of fiber quality either through improved raw material or refining control will most likely see variations in final paper quality. Some mills try to counteract this problem by implementing other changes on the paper machine to rectify quality issues. Another solution is control of freeness using a real-time monitoring freeness analyzer with refiner load control and delivering a constant fiber quality out of the refiner operation. This strategy eliminates variable fiber entering the papermaking system and allows papermakers to focus on other parts of the papermaking process.

Results and Discussion

When fibers enter the refining stage there are certain properties which need to be modified in order to meet specific final paper / board properties.
The fiber-based variables below cannot be influenced by refining. Refiner-specific variables are selected once the refiner has been put in place. It is often done at the start-up of the machine, but is not typically continually optimized when raw material or paper quality changes.

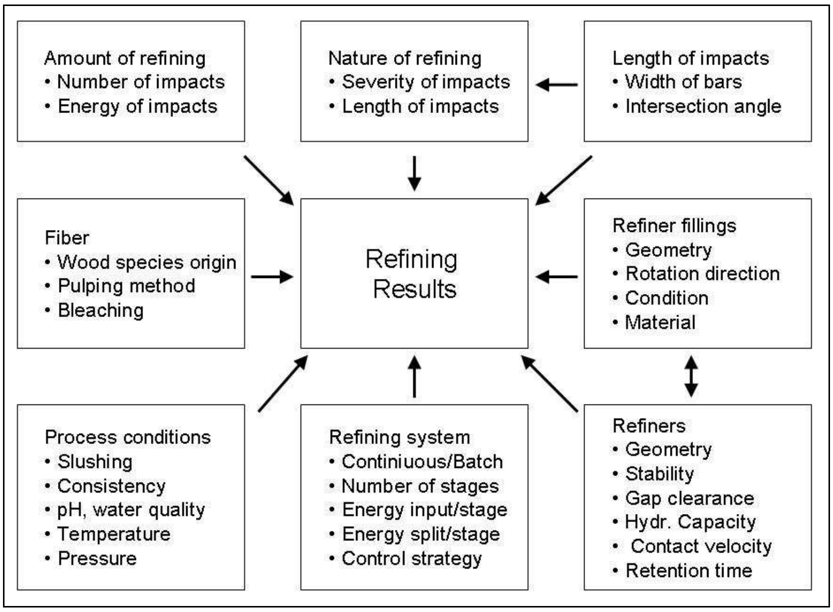


Fig. 1: Factors affecting refining result[1]

This paper will focus on variables that can be influenced during the operation of the refiner including:

- consistency
- pH
- temperature
- flow

To control these parameters there are preconditions for all types of refiner control.
There is no "correct" consistency, this is determined by the type of refiner and refiner plates, raw material, freeness target and flow. The importance here is that consistency needs to be controlled to get the best out of the refiner.

Manual control

Manual control means that the gap between the refiner plates is controlled by hand by a gap control device that is turned manually or uses a push button. Flow and consistency variations have a direct influence on the refining load, hence the freeness. When the gap is kept constant, decreased flow or consistency reduces the thickness of fiber flocks between the plates and thus decreases the refiner load.
Consistency and flow both need to be measured and controlled to avoid quality problems.

Power control

With power control the refiner motor load is kept constant on a set value. As flow and consistency vary, net refining varies directly with stock mass flow variations. Such a control loop can have more negative than positive effects.

Specific refining energy control

Flow and consistency are measured and controlled before the refiner. The goal is to supply the optimum consistency to the refiner. Three input signals (power, flow and consistency) are used to calculate the amount of work done in the refiner on each unit weight of solids in the stock.

The calculated specific energy (kWh/ton) is compared to a set point and the refining power (kW) is changed as needed. Since specific energy control reflects changes in both the stock flow and the consistency, the degree of refining responds to changes in process conditions. It is not possible to specify a certain specific energy needed for a certain pulp or freeness. This has to be developed on-site as too many parameters influence the outcome as shown in figure Fig 1
The disadvantage to specific energy control is that it has no input that reflects changes in incoming furnish.

To reach furnish responsiveness, freeness control is necessary.

Freeness control

The first step is to add a freeness measurement after the last refiner in the loop. Some mills go even further and install one instrument after each refiner as they sometimes use refiners number 1 and 2 and at other times number 2 and 3.

A freeness transmitter measures the dewatering speed of a fixed amount of fibers, generating a value which most mills then use to control the refiner load and adjust the fiber properties.

The complete freeness control scheme is shown below.

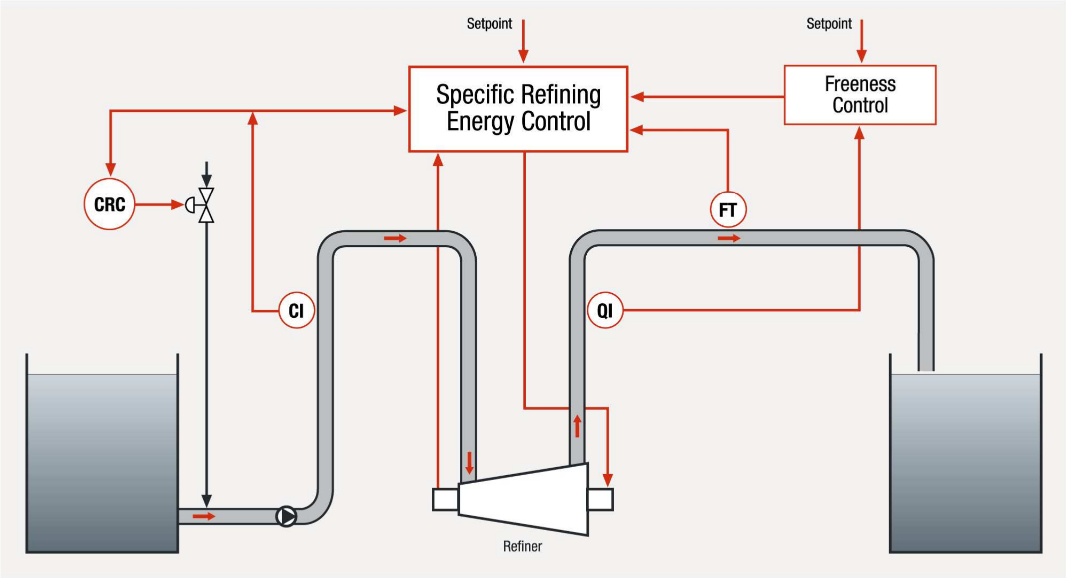


Fig 2: Freeness control loop

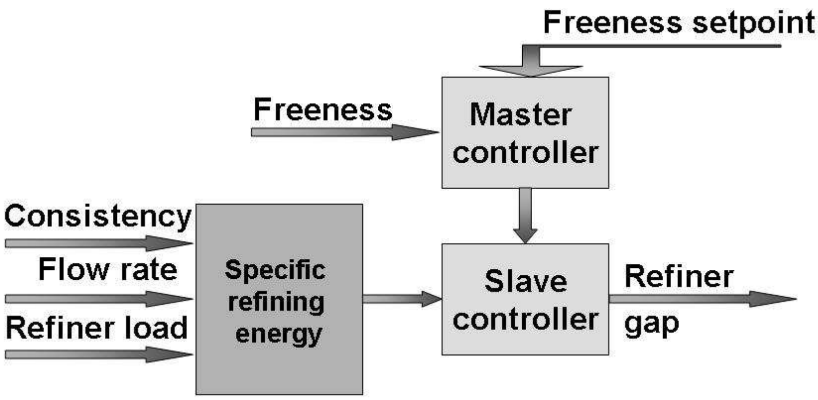


Fig 3: Flow chart freeness control

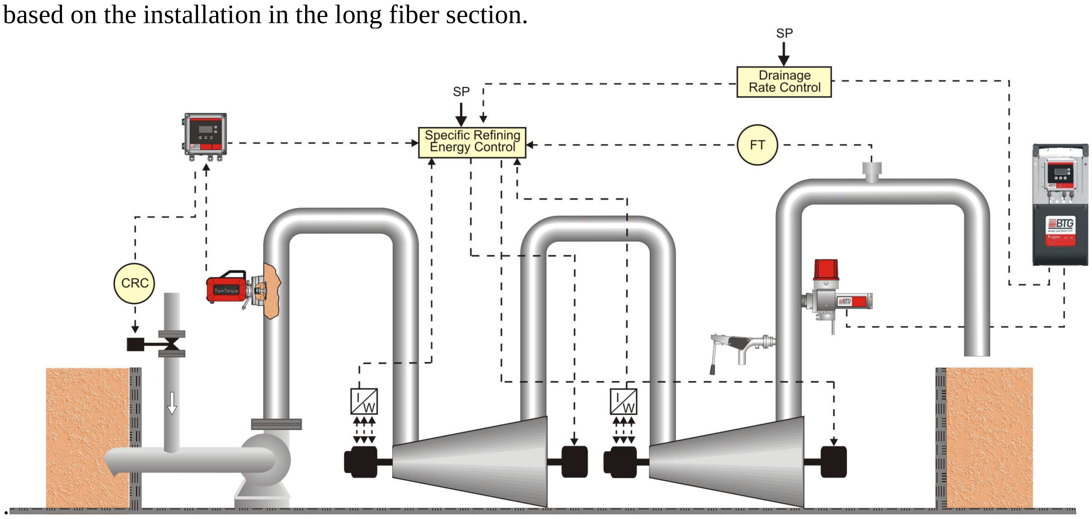
The control of the specific refining energy is done with a slave controller. The actual value of the specific refining energy is calculated in a separate central processing unit. In the slave controller this value is compared with the output of the master controller. Based on the comparison the controller reacts and adjusts the refiner gap according to the control difference. From the freeness measurement the master controller gets an actual value, which is compared with the adjusted set point. According to the control parameters, the system deviation will give an external set point to the slave controller. Then, the slave controller will compare again and the refiner gap is adjusted until the control deviation reaches zero.

Mill case

Implementing a refiner control loop has proven benefits in terms of savings of money and energy.
The example illustrated below shows a machine running at a speed of 1,000 m/min and producing 33 t/h of coated paper. It receives its raw material from separate hardwood and softwood fiber lines; the variation in form and structure of the different fibers is the reason for separate refining lines. Implementing freeness in

combination with specific energy control helps achieve stable refining results, independent of variations in fiber grades.

In the thick stock area after the refiner, a BTG DRT-5500 Freeness Inline transmitter has been installed to implement freeness in combination with specific energy control. The return on investment (ROI) calculation is based on the installation in the long fiber section.



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The specific energy for this stage is 160 kWh/t. A calculation based on a 1-year period at 93% capacity usage gives a total energy consumption of 7,680 MWh/year. Taking into account an energy cost of $ 70.7MWh, this translates into a yearly cost of $542,976. With a reduced freeness variation of ±1°SR instead of ±3°SR, the energy costs can be reduced by $135,744 a year – a very welcome saving for most mills. Based on this situation a projected return on investment is well under six months.
Some years ago, when the importance of saving energy was not high on the agenda, mills generally implemented freeness control to take advantage of other benefits – e.g. improved drainage on the paper machine and improved sheet properties, such as formation and strength. Final paper bulk is an important factor and good drainage properties decrease line pressure before the drying section, which in turn reduces specific steam consumption. Improved drainage also allows potentially increased machine speed.

These benefits are undoubtedly still important. But in a highly competitive, environmentally-sensitive market, the added benefit of reducing costs and cutting energy demand (and hence emissions) in paper and board production is a compelling bonus that is persuading most of the world’s leading mills to make freeness control loops part of their production process.

Conclusions

Freeness control is an opportunity to reduce energy costs to a much greater extend as in other areas of the paper making process. Beside this cost reduction, quality parameters can be maintained and lead to satisfied customers. Something where it is hardly to put money on.

References

1. Hannu Paulapuro, “Papermaking Part 1, Stock Preparation and Wet End”, Papermaking Science and Technology, Book 8, Page 90