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Refiner systems: their inspection and maintenance

Scope

The purpose of this Technical Information Paper is to give guidance on methods of evaluating and maintaining a refining system to give optimum performance in terms of energy consumption and product performance. The guide is intended to be used by engineers who are new to the paper industry or to the subject of refining.

Safety precautions

Before commencing a study the following safety procedures should be followed:

- Always wear hearing protection, as the noise level in the vicinity of a refiner can be very high.
- Refiner motors are high voltage and the surroundings are usually wet. Stay away from electrical connection points and switchgear and wear non-slip insulated footwear.
- Wear safety glasses, as stock is hot and under pressure. Do not run the refiner with a closed circuit, or with the discharge valve tightly closed.
- Refiners should never be operated at excessive pressure or elevated stock temperatures due to potential for explosion or injury.

Background

In order to make full use of this guide, it is necessary to understand the importance of the refining process and the basics. Refining is the most influential of all of the papermaking processes. The old adage that “Paper is made in the beater (now refiner)” holds true for every paper product. In relation to the other processes involved in papermaking, only drying uses more energy, and no other process modifies the fiber properties or has more effect on the various aspects of the sheet.

Refiner mechanical condition and application greatly impact results in developing fiber and energy required. It is not necessary to purchase new equipment in order to optimize a refining system, there are a number of ways in which energy savings can be made or refined. Stock quality can be improved by means of good practice, (e.g. maintenance-refiner in good mechanical condition, correct capacity and filling design, optimal refining intensity, consistency, pH, etc.). However these opportunities are not always recognized and in many cases new systems are installed where, by changing operating practices and paying attention to the condition of equipment, similar performance or savings in energy could have been made at much lower capital cost.

It is not proposed to go into great detail on the fundamental aspects of the refining process. The current knowledge with respect to the fundamental changes in the fiber during beating or refining has been reviewed by a number of researchers. See the Reference section.

TIP Category: Automatically Periodically Reviewed (Seven-year review)

The primary effects of refining are:

- External fibrillation, the partial removal of the fiber wall, leaving it still attached to the fiber.
- Internal fibrillation and loosening of structure.
- Fiber cutting or shortening, measured optically or by increase in weight of short fiber fraction
- Fines production and the complete removal of parts of the fiber wall, creating debris in suspension

Some methods of evaluation to establish the type of treatment are:

Stock tests:

- Canadian Standard Freeness (CSF) or Schopper-Reigler Slowness ($^{\circ}$ SR)
- Fiber length analysis by optical analyzer or mesh classification (i.e. Clark, Bauer-McNett)

Handsheet tests:

- Tensile Index
- Tear Index
- Porosity
- Bulk
- Light Scattering Coefficient

The papermaker must define the fiber modifications desired by the refining process in terms of the finished product properties, and adjust any physical testing requirements accordingly. There are many process and handsheet tests available that provide insight into how the fiber is being modified in the refiner. This information can then be used to adjust the operating parameters of the refiner to enhance (or minimize) the desired sheet properties.

The next stage is to achieve the desired effect via refining and its control. Correct specifications must be defined. It must be recognized that papermaking is typically a compromise between desired effects, and it is not possible to optimize every property simultaneously. For example, tensile increases with refining whereas tear decreases. Conventionally, the correct balance of cutting and fibrillation has the most effect on the energy used to produce a given product by enabling the best balance of properties to be obtained.

Planning an evaluation program

The outline method to plan a refining evaluation study should be carried out in the following order:

Define the objectives – check to make sure that the present refining goals are well defined, especially if they are different from when the system was first installed. Possible objectives are: reduced energy, improved product quality or capacity optimization.

1. **Learn the system configuration** – study system drawings, refiner manuals, and most importantly, talk to the operators. Note any system piping or control changes that have been made since the system was first installed. See what limitations operators face that keep them from achieving their present goals.
2. **Inspect the equipment** – check the physical condition of the equipment and check maintenance records to see if extraordinary effort or expense is made to keep the system running. Talk to the maintenance department personnel responsible for the refiners to determine any on-going history of issues with any single refiner.
3. **Inspect refiner plates**—review refiner plate condition on removal, plate life, and refining performance over plate life cycle to determine how plate life cycle impact results—fiber development, energy, and capacity. Non-uniformity of wear, pluggage, and condition of plates removed are major indicators of refining conditions and issues.

4. **Survey the system** – collect the operating data from the system and compare it to the manufacturer's recommendations for power application and intensity. (See appendices for suggested databank of operating data needed to properly characterize the system.)
5. **Change operating variables** – design experimental tests that operate the refiners at different powers, sampling before and after each refiner (being sure to take samples outside any recirculation loops) and testing for relevant properties. Analyze the data and compare with current conditions to see if improvements have been made. Consult manufacturer's design recommendations when the system was commissioned and if appropriate, make adjustments to achieve the original design goals.

The best method of evaluating a system is by stock sampling, creation of handsheets and testing of the properties.

- Samples should be taken before and after each refiner, in this way the performance of each refiner in line can be compared and corrective action taken.
- Handsheets should be made of the samples using appropriate TAPPI methods.
- The handsheets can be tested for any properties, but the most useful are: tear, tensile, bulk and porosity. If desired, more relevant properties to the product's unique specification can be tested.
- Results can be presented in tabular or graphical form. In the latter case, properties can be plotted against energy or another property, as shown in Appendix A.

Implement changes, ensuring that operators are aware of the reasons for changes and are trained in any new operating techniques. Ensure that new practices are maintained and check by means of routine inspection.

Inspection

External

The first operation is to inspect the appearance of the refiner and its surroundings:

- Check the cleanliness of the refiner, if excessively dirty then this is a first indication of neglect.
Action: At the first opportunity, clean the refiner and surroundings that will enable you to more accurately assess the refiner's condition.
- Check for pulp and gland water leakage, as this is a good indicator of seal and gland packing wear.
Action: Replace seals and packing, following manufacturer's guidelines listed in the operating and maintenance manual. Check for worn shaft sleeves and replace if necessary.
- Check the refiner for excessive noise. Although refining can be a noisy process, certain abnormalities can be found by careful listening, for example, intermittent noise can mean that there is insufficient flow through the refiners resulting in cavitation and plate clash. A high-pitched "screaming" also indicates flow that is too low, but it also may mean that the refiner load is higher than what the fiber pad can support.
Action: Correction may involve fitting new fillings, a recirculation line to increase throughput, reducing the diameter of the refiner plates, or raising the refining consistency.
- Next, feel the refiner casing and bearing housings, checking for excessive heat. A high enough temperature may mean that there could be a problem with the bearings.
Action: Check for gland tightness and temperature of in going stock. If the bearing housing is too hot to touch comfortably, check the refiner manual for what the operating temperature should be before assuming that there is definitely a bearing problem.
- Check the mechanism for changing plate gap. Difficulty in movement denotes wear or damage of the shaft and quill assembly, galling of the spline assembly (if present) or excessive wear in the sliding surfaces.
Action: Check the adjusting motor to make sure that it is receiving the proper open or close signal from the controller, and for the proper time. Look at the mechanical condition of the gearmotor and check the shear pins. Observe the refiner in operation to see that too many signals are not received in too short a time period, indicating that the deadband on the controller is too tight. Lastly, open the refiner and check the shaft and sliding assemblies to see that the rotor is moving freely (if it is designed to do so) and the sliding head (or other stator parts) are moving as they are designed to do.

Internal

- Check plate installation sequence with the refiner handbook or installation guide provided by the plate supplier. If installed in the wrong sequence, the capacity and flow capabilities will be incorrect.
Action: Install the plates in the correct order. It may be necessary to fit new fillings if uneven wear is found.
- Check for plugging and debris in the grooves of the filling. Debris can cause damage to the plates, accelerate filling wear, and plug the grooves of the filling reducing hydraulic performance. Plugging of the grooves can occur if they are too narrow for the fiber that is being processed, process flow demand is too high, and/or contaminants are present.
Action: If debris is excessive, check the condition of the junk trap (if present), or consider installing a high density cleaner or other improvements to the stock cleaning system ahead of the refining plant.

Refiner fillings

When examining the fillings of a refiner, the following information should be recorded:

- The type of filling construction i.e. whether segmented, full, cast plates or machined.
- The plate angle (for a double disc refiner), which determines the flow capacity, should be checked. Confirm with the plate supplier that the proper angle is being used, as flows may have changed since the initial design and installation of the system.
- Note the metallurgy of the refiner filling. Some grades of stainless steel or Ni-hard are the most common, but there are many alloys available. Check with the plate supplier for details on the alloy you are using, and why that selection was made when the plates were last purchased.
- The fillings should be inspected for wear and damage. In a double disc refiner, the wear pattern is significant. If discs 1 and 2 (the ones on the motor end) are most worn, then the flow is too low or the feed pressure is too high, whereas if 3 and 4 (the ones on the adjustment end) are worn, then the flow can be too high for the filling or the rotor is not able to float properly.
Action: Seek advice from the relevant manufacturer on alloys and patterns that can help optimize the refining system. Most manufacturers have modeling software that can be used to select the patterns most likely to achieve the established goals of the refining system.

Reporting

Document observations from the inspection and present the recorded operating data. Identify items that can potentially explain the problems reported by the operators during the initial investigation.

Performance evaluation

The action of a refiner can be quantified using the equations of the Specific Edge Load theory (SEL) and Net Specific Energy (NSE), which gives terms for refining intensity and net energy used. Details of the Specific Edge Load theory are given in Appendix B. In order to be able to calculate intensity and energy usage, certain refiner and stock parameters must be measured. A suggested data sheet is shown in Appendix C.

Refiner parameters

The following motor parameters should be recorded and checked against manufacturers recommendations:

- Maximum power (Amperes, kW or HP)
- Rotational Speed (if there is a gearbox, note the gear reduction ratio and determine the speed of the output shaft)
- Voltage (AC or DC)
- Synchronous or induction