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Press section monitoring

Scope

The use of instrumentation and other techniques for monitoring and troubleshooting paper machine press sections is widely accepted. High energy costs and the overall requirement to produce at a lower cost have emphasized the need for optimizing pressing efficiency. This TIP provides information on available instrumentation and procedures for monitoring wet press performance.

TIP 0404-62 “Index of Suppliers for Press Section Monitoring” lists trade names and manufacturers’ names related to press section monitoring.

Safety precautions

Paper machine press sections are complex machines that demand attention to personal safety. The following list contains only a part of the safety issues that should be addressed:

1. Mill safety procedures should be known before working on the machine.
2. Personal protective equipment, such as safety shoes and ear plugs, should be worn.
3. Make sure machine crews know what is being done and when.
4. Operators using instrumentation should be well trained.
5. Condition of the footwalks and ladders should be checked.
6. Make sure that any chemicals being applied to the press area are harmless before approaching or entering.
7. Measurements should not be taken immediately ahead of press nips.
8. Do not hang over in-going nips or climb precariously around framework, drive shafts, etc., and secure all cords, clothing and loose items.

Fabric characteristics

During pressing, the sheet is compressed between one or two fabrics and two rolls (or one roll and one shoe with rotating belt/cover) in the press nip. The main function of the press fabric is to provide a porous structure into which water can flow as it is squeezed out of the sheet, thus enabling water removal. However, the press fabric also performs several other important functions, such as sheet support and transfer, providing uniform pressure distribution, imparting a proper surface finish to the sheet, and driving the un-driven felt rolls. The fabric should also provide proper protection for the sheet; providing resistance to crushing, shadow marking and groove marking.

The design of a press fabric has to achieve a balance of several important characteristics in order to perform all of its functions well in operation. Such characteristics include strength and durability, void volume (space that is not occupied by yarns or fibers), water permeability (air permeability is often used as a substitute measure),

compressibility, compaction resistance, abrasion resistance, contaminant resistance, as well as heat and chemical resistance. Press fabric characteristics change during the operating life of a press fabric, hence the need for monitoring of press fabric condition. Some of these fabric characteristics may be monitored during operation, while others can only be properly measured by laboratory analysis following removal from the machine.

Fabric thickness

Fabric thickness (or caliper) indicates degree of wear and fabric compaction which influences specific void volume and permeability of the fabric, and can be useful in predicting operational characteristics. Fabric thickness continually changes during press section operation; the rate of change is strongly influenced by fabric design. Generally, fabric thickness decreases rapidly in the first few days after installation, tapers off, remains nearly uniform for a period of time, and finally reaches a point where the fabric is too thin to perform efficiently. Front side and back side measurements are taken while the fabric is in operation and an average value reported. Full cross-machine direction (CD) measurements may be made when the fabric is off the machine, before or after use. A history of thickness information on each fabric design is a useful indication of when to remove a fabric.

Caliper gauges for fabric monitoring are lightweight, hand-held instruments capable of measuring thickness a few inches in from the edge of the fabric. The basic instrument consists of a C-frame to which anvils are attached. A dial indicator reflects the separation of the anvils. Slits can be made across the fabric width to measure CD caliper after use before the fabric is removed from the machine. TIP 0404-28 "Method for Evaluating Thickness of Wet Press Fabrics" provides information using the caliper gauge, in both on machine and off machine cases.

Fabric basis weight

Total mass or basis weight measurements provide relatively accurate material balances around the fabric loop to predict the impact of fabric conditions on sheet dewatering. However, because sheet moisture can be effected by other factors, a full determination of fabric impact on dewatering requires measuring both fabric condition and sheet moisture. Cross direction total mass profiles of the fabric can indicate uniformity across the machine width. Variations caused by improper press roll crowns, malfunctions in press loading mechanisms, non-uniform showering and dewatering, and other sources frequently can be identified. Machine direction (MD) measurements are commonly used to detect roll bounce and MD fabric non-uniformities.

A common type of total mass gauge for fabric monitoring is a portable sensor using a gamma radioactive source in a backscatter mode. The measuring probe is about the size of a three-cell flashlight and weighs about 2 lb (0.9 kg). Since total mass is measured by backscatter, gamma gauges cannot be used with rolls or other background objects within 12 inches (30 cm) of the sensor. As with any backscatter sensor, total mass will vary with the distance of water or fabric from the sensing probe. The gauge can be packaged in a case with recorder. Since government regulatory agencies control the transport and use of radioactive sensors. This style total mass measurement device has been largely replaced by improved fabric and sheet moisture gauges.

Fabric density

The press fabric density is a frequently used general indicator of press fabric condition and potential life remaining. The value of press fabric density is determined by a simple calculation of fabric basis weight divided by fabric caliper (thickness). Since any change in the fabric basis weight reflects the net effects of both fabric wear (weight loss) and fabric filling (weight increase), while a reduction in fabric caliper indicates the net effects of fabric weight loss (wear) and fabric compaction, the density value thus encompasses all of these effects into one number. By virtue of being a calculated value, there is no instrument to directly measure the density of a press fabric, however it is frequently included in used press fabric analysis reports. The density of a press fabric will normally increase through life as the fabric compacts and fills up with contaminants, although this increase may be partially offset by effective cleaning and wear.

Fabric water content

Fabric water content can be an important variable in some press systems, although numerous studies indicate low correlation between fabric moisture and existing sheet dryness in many commercial fabric/roll systems. High water loads in the fabric increase hydraulic flow resistance of the fabric in the press nip. This increases inertial

forces that have to be overcome for water to flow out of the fabric and the nip system, this may increase sheet rewetting. Conversely fabrics that have been over dried may not pick up as much water and increase energy usage (vacuum energy and machine drag).

Usually, CD measurements are performed before and after each press nip (if safely possible) and before and after the fabric suction boxes. The measurements are best made on the same side of the fabric because some measuring devices preferentially detect surface water. Machine direction measurements usually are made prior to the uhle boxes, where the effect of nip bounce may be more easily detected.

As with total mass sensors, measurements on press fabrics provide water balances around the fabric loop and identify the source of CD profile variation. Most of the sensors available for water content measurements have fast response times so that short-term MD moisture variations can be monitored.

The most successful fabric measurements have been obtained using instruments based on microwave and radio frequency (RF) principles, but infrared principles can also be used. These sensors make use of the fact that water responds to these electrical frequencies differently from other materials normally present in the press section. Most of the instruments are small, very portable, and can be used at many different positions on the fabric run, depending on press configuration. Fixed continuous measurement installations are also possible.

Although all of these sensors respond to the water content in press fabrics, absolute calibration on a wide range of fabrics can be difficult. The sensors generally are sensitive to distance between the sensing head and the water in the fabric, which in turn varies with fabric compaction and fabric design. The measurements can also be sensitive to operator use and to location on the machine, which may affect the repeatability of the results. If possible, all measurements should be performed on the same side of the fabric. The RF sensor is sensitive to water conductivity; a conductivity cell is supplied with the sensing head to permit measurement of and compensation for conductivity on the instrument calibration. Further development of these moisture sensors may make it possible to generate good calibration data on different fabric designs.

For additional information on procedures and portable equipment options used to accomplish water balance in the press section, the reader is referred to TAPPI TIP 0502-18 "Press Section Water Balance Using Portable Sensors."

Degree of fabric filling/openness (porosity/permeability)

Degree of fabric openess is an important factor in the hydraulic flow resistance in the press nip. A filled fabric restricts water migration in the nip and reduces water removal efficiency. Measurement of fabric air flow properties during operation are useful in predicting performance, monitoring fabric cleaning, and scheduling clothing changes. The measurements are made at intervals across the fabric width to indicate areas of wear, filling, and other problems.

The instruments that monitor fabric permeability are based on flow of air or water through the fabric. One instrument uses a portable suction box calibrated to yield an openess figure. The instrument is connected to a mill vacuum supply and held in contact with a running fabric. Resistance to air flow is measured in inches of mercury. TAPPI TIP 0404-29 "Porosity Measurement of Press Fabrics on the Paper Machine (HSPT)" describes use of one device.

Laboratory air permeability testers measure the cubic feet per minute ($1.699 \text{ m}^3/\text{h}$) of air passing through a square foot (0.0929 m^2) of fabric under an applied pressure drop of 0.5 inch (1.3 cm) of water. TAPPI Classical Test Method (T 251 "Air Permeability of Porous Papers, Fabrics, and Pulp Handsheets") is for press fabrics. Most fabric manufacturers and some chemical suppliers are equipped to measure and report Frazier test results on the dry fabrics they supply as well as provide a testing service on returned fabric samples.

Another portable device uses a turbine air flow meter that is placed over the top of the fabric suction box. The volume of air flowing through the fabric and the vacuum level are usually reported. Because very few machines have identical vacuum capacity, this measurement cannot be used to compare machines.

A third portable device is based on water flow rate through the fabric. The instrument is placed over the fabric and a jet of water is passed through the fabric. Water flow rate is reported along with the water pressure used for the test. Complete information on operation and analysis of results may be found in TAPPI TIP 0404-43 "Water Permeability of Fabrics."

Some mills use uhle box vacuum as an indicator of the degree of fabric openess. When a liquid ring pump is used to generate vacuum, the vacuum on the uhle box will increase as the fabric becomes filled. Information can be misleading if several vacuum elements are supplied by the same vacuum pump.

The various permeability tests can quantify the severity of a filling problem but cannot identify the cause. Some chemical and fabric suppliers can perform analyses on returned fabric samples to identify the chemical nature of the contaminants which are filling the fabric. TIP 0404-51 “Paper Machine Clothing Cleaning and Conditioning for Recycled Fiber Use” provides information specific to fabrics used with recycled fibers, these fabrics can have increased problems with filling.

A database of these records can help track process changes and offer solutions to fabric filling problems. TIP 0404-21 “Press Fabric Record Book” provides a format for recording data on press fabrics. TIP 0404-26 “Paper Machine Clothing Performance Analysis” provides additional information on monitoring and analyzing press felt performance.

Fabric fiber shedding

Batt fiber that sheds from press fabrics during use can seriously affect dewatering capability and product quality. Techniques used to vacuum the sheet of finished paper on-line quantify the amount of batt fiber leaving the machine with the sheet. Either side of the web can be measured if proper precautions are taken. An apparatus consisting of a narrow slotted metering head (24 inches wide) (0.6m), a vacuum hose, and a removable fine wire mesh filter has been used to measure batt fiber shedding. This device connects to a vacuum source and the sheet is vacuumed for a set period of time. The debris caught by the filter is examined under magnification. Batt fiber is separated from wood and other debris, and a fiber count per unit time is produced. Particles can be tested with a drop of a concentrated formic acid (use proper safety precautions) to determine their source. Nylon batt fibers will be immediately dissolved by the acid, while wood fiber will be wetted and will not dissolve.

Running fabric length

Press fabric running length must be within a specific size range to properly fit each press section. Woven fabrics were designed to run at a specific length for optimum performance relative to width, drainage, and tension. Modern fabrics are designed to operate in a specific tension range for best performance.

Running fabric length is usually determined with a fabric measuring wheel that consists of a rotating element (usually 1 foot [0.305 m] in circumference) connected mechanically with a footage meter. Buttons are incorporated to start, stop, and zero the counter. Some press sections have permanent position indicators mounted on the jack-roll take-up mechanism to allow for direct reading of running fabric length.

A less accurate method is to compare fabric revolutions per minute (rpm) to press speed.

Many mills use position of the stretch roll to chart running length versus time. This method can be used on fabrics running at constant tension and provide a good indication of fabric life.

Fabric tension

Uniform fabric tension is necessary for good drainage, optimum fabric life, and consistently good runnability. Every fabric is designed to operate in a specific tension range. Proper fabric tension generally will be obtained if the fabric is run to the desired length. Difference in fabric stiffness may require different operating tension targets for varying fabric designs.

Many machines now have pneumatic indicators or load cells to monitor and automatically control tension. Portable instruments capable of measuring paper machine fabric operating tension consist of a frame with two feet, a movable weighted arm and foot, a deflection gauge to measure position of the movable foot, and a handle to permit movement of the instrument on a fabric. The movable foot is positioned between stationary feet and it seeks a level depending on fabric tension. The deflection gauge is calibrated to convert the change in foot position to the change in fabric tension. Application is limited to press positions with an accessible, horizontal ($\pm 15^\circ$) fabric run. Gauges based on load cells and dial indicators are available from various instrument suppliers.

Tradeline distortion

Tradeline or weave distortion is a common phenomenon on paper machines. The tradelines are on the fabric to show the position of the filling (CD) yarn in relation to the warp (MD) yarn. Any distortion of the tradeline means a similar distortion in the weave which can cause the fabric to close up non-uniformly. A small amount of tradeline distortion is not significant if the distortion is uniform, but a tradeline that is off 1 foot (0.305 m) or more