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Techniques for nip impressions

Scope

Paper machine technology has resulted in faster running paper machines with ever increasing operating pressures in the press and other sections of the paper machine. It is now more important than ever that the operating pressure between two or more rolls be evenly distributed across the face of the nipped rolls to insure product quality and roll cover integrity. One way to ascertain if a uniform pressure distribution is being applied is to take nip impressions. This Technical Information Paper reviews the need for nip impressions, the various media available to perform the work and general instructions for taking the impressions. In addition, measurement analysis is addressed and a crown correction equation based on nip impression measurements is discussed.

Definitions

A nip impression is the footprint of two mating rolls taken under controlled conditions. To be of maximum use, it should be continuous across the face of the rolls forming the nip. It should also be made with materials that are capable of showing a reasonably sharp transition between the loaded and unloaded areas on the paper, film, foil, or electronic nip profile sensor being used to obtain the impression. There are four major commercially available products used to acquire nip impressions.

1. A traditional method uses paper and carbon paper which are used together so that the carbon paper produces a copy of the pressurized area on the plain white paper. It must be used in a dry environment or protected with a waterproof envelope of some type if in the environment is wet.
2. Embossed metallic foil (usually aluminum) is another used medium. It has the advantage of being able to be used under wet and very hot conditions. It is somewhat more difficult to measure than the carbon paper and does not store as well. It has a tendency to wrinkle, which makes reading the results difficult.
3. The third material consists of two plastic films, one of which is coated with micro capsules with graduated resistance to rupture under pressure. The other film is coated with a material that reacts with the contents of the ruptured micro capsules to generate a color of varying intensity. This material can be used statically as is done with carbon paper and foil or it can be rolled through a nip between slowly rotating rolls. To take full advantage of the potential of this method, it is necessary to use an instrument capable of measuring color intensity differences. A distinct advantage of this method is that it can be used to take both slow rolling and static nip impressions with the felt(s) in place.
4. The fourth medium is electronic nip impression sensors, which provide nip width readings, pressure readings, or both. The sensors are placed in the nip as with the previous methods, but are connected to a computer for real-time output display. The sensors are usually encapsulated in a film, so they may be used in wet conditions. The sensors, however, are limited to temperatures less than 350 F. The distinct advantage of this method is the ability to take multiple nip impressions using numerous load profiles without changing the sensor medium in the nip.

Safety precautions

Anytime people are working with heated or steam pressurized rolls, extreme care is required. Whenever working around roll nips, extreme care must be observed. Lock out/tag out rules must be followed when applicable while completing nip impressions. Any drive or loading control jumpers required must be returned to operational state once measurements are completed. Use proper fall arrest attire or equipment as required while completing measurements.

Background

There are many variables at work during the operation of a paper machine. These variables make it difficult, if not impossible, to judge the condition of an individual nip simply from entering or exiting sheet characteristics. This means that the moisture profile of the sheet or a felt in a press section does not necessarily give a good indication of the uniformity of the nip pressure. Why then should the papermaker be concerned about the nip if the product is within specification? Intuitively, it would seem that if all the components of a system were operating at maximum efficiency, the system as a whole would also be operating at maximum efficiency. In the case of a paper machine, this should translate into higher speed, less steam consumption, more uniform coat and size distribution, longer life of roll covers and felts, and an overall increase in machine efficiency. The critical roll covers come in many compositions such as polymeric, composite, and filled rubber.

A nip is formed when two rolls are loaded against one another. The load is usually expressed in pounds per linear inch (PLI) (kN/m). Rolls are normally crowned, either positively or negatively, to compensate for core bending and distortion under applied loads. If the crown is not correct, the load will vary across the roll face. Some areas will have higher loads while adjacent areas may have lower loads. The running characteristics of covers are highly load dependent. A non-inclusive list of cover properties dependent on applied load (PLI) (kN/m) include heat buildup, speed differential with the mating roll, wear, and surface deterioration. All of these factors would be uniform if the nip were equal across the roll face.

Uneven heat buildup during operation can result in thermal crowning which can in turn distort the specified crown. In severe cases, heat generation may result in cover separation from the metal roll core. A melt down starting below the surface and above the metal may be the result with some cover materials. Internal water cooling may or may not alleviate this condition.

Uneven loading of nipped rolls can result in a speed variation between rolls, with and without different cover hardnesses. Varying the load (PLI) (kN/m) across the roll face also results in varying speed differentials. The result of these variations in speed differential is accelerated cover wear and more frequent grinding to return the surface to its desired operating condition.

Rubber can stretch and return to its original length on a recurring basis without deterioration. This property remains true as long as the amount of stretch is below what is termed its critical elongation. If that critical elongation is exceeded, cracking will occur quickly. Since rubber is incompressible, it must stretch when going through the nip. The amount of stretch depends on the line load (PLI) (kN/m). In the case of the harder cover materials that are used today, crack prevention can be improved by ensuring a uniform nip load exists across the entire roll face.

In addition to the effect on roll covers, non-uniform cross machine direction pressure distribution in the nip will have varying degrees of effect on paper properties and press felt life. This effect is more pronounced if the rolls involved are made from hard material i.e., granite, ceramic, metal, and even bone hard polymeric covers.

The following information should be shown on or attached to every nip impression:

1. Centerline diameter to the closest 1/64 in. (0.4 mm) on both rolls.
2. Machine number and nip identification i.e., 1st press, size press, etc.
3. Mill roll identification numbers.
4. Identification of tending and drive sides of the impression.
5. Date and time of day.
6. Loading pressure used. If different on tending and drive sides, so specify. If gauge pressure¹ is used, also state equivalent (PLI) (kN/m).

¹ Conversion of gauge PSI (bar) to (PLI) (kN/m) is a detailed calculation (requiring press loading system data) that has already been done by the original supplier of the equipment. This is commonly given to the mill (as a conversion chart) at press installation and should be kept on file.

7. Indicate if the rolls were newly ground or old rolls (indicate installation date).
8. Design crown for both rolls.
9. Other items of interest such as whether the impression taken on hot rolls and the direction of roll rotation.

Taking the nip impression

The following instructions are general in nature since there are a variety of press configurations and roll types installed, and it would not be possible to provide comprehensive information to cover all cases. It is recommended that in those cases, where there are multiple nips or controlled crown rolls, the press or calender stack supplier be contacted to get detailed instructions on taking nip impressions on its equipment.

Rolls should be newly ground before taking nip impressions that will be used to establish crown changes. A roll is crowned to compensate for deflection due to roll weight, vacuum, clothing tension, and normal running nip load. A nip impression taken on worn rolls will not produce an accurate indication of the deflection but will show the loading characteristics under the current conditions of operation.

Rolls should be rotated for at least an hour before taking the impression to eliminate any effects of core sag.

Observe all safety precautions since the nip points are considered areas of high risk.

The nip impression medium will be referred to as “nip paper” although it may be any of the four media referred to above. While the general instructions that follow are guidelines for taking nip impressions, the suppliers of the various nip impression media do provide detailed instructions for use of their products.

In multiple/cluster roll press sections, adjacent rolls should also be loaded to provide the correct operational affects on the nip being measured. For instance in a tri-nip type press arrangement, all three nips should be loaded.

Static nip impressions

1. Pull out a length of nip paper long enough to overhang both ends of the roll.
2. Tape the paper to one of the rolls, being sure that the nip paper is straight along the roll width. In the case of using a two-part system, make certain the two layers are put together correctly.
3. Rotate the roll, if necessary, so that the nip paper will be in the center of the nip when the nip is closed.
4. Close the nip using the minimum amount of pressure to bring the rolls together. Load both sides at the same time. **Remember, all nip impression media measure the maximum pressure they have been subjected to.** If a non-uniform rate of loading (one end loading before the other) occurs, the nip impression will reflect this and will not give a realistic representation of the pressure distribution in the nip (this is not an issue with electronic nip impressions).
5. Gradually increase the pressure on both ends at the same time until the desired loading has been reached.
6. Hold for one minute.
7. Gradually decrease the pressure uniformly from both ends until the rolls disengage.
8. Remove the nip impression paper and examine the impression obtained to be sure it appears representative of the entire nip (not necessary for electronic nip impressions).
9. If another nip impression is to be taken, rotate both rolls so the new nip impression will not be taken in the same place as the previous one(s) were.

Slow rolling nip impressions

Slow rolling nip impressions are usually taken by feeding micro-encapsulated films through the nip at low speeds. One should mark the tending end of the film before the test, since there is a chance that the film will not be in the same orientation after the test. One may also crease the film (or use a pen or fingernail to scribe) at the ends of the felts or rolls to mark the edges. Before the test, the film is usually taped to a roll or press fabric. Avoid using duct tape, since it is difficult to remove. Also, it is best to tape the film outside the loaded face at the end of the roll, where the tape will not be loaded. A thick application of tape across the film can negatively influence the readings. After the measuring medium is installed on the roll, the machine is started at its slowest speed and then stopped after the film has passed through the nip so the film may be retrieved. The film should be retrieved gently, since it will record kinks and finger marks, especially on the lower pressure range films. The films are generally removed from the protective envelopes and rolled up while awaiting interpretation.