New Methods to Analyze the Steel to Rubber Roller Interface

or

What's Happening in Your Nip?

By

Stephen Huff: Technical Manager
ABBA Rubber Intl.

Chuck McWilliams: Systems Product Manager
Tekscan, Inc.

Abstract:

Common to most converting lines are nip rollers. These roller-to-roller interfaces perform many different tasks from conveying the web through the machine to performing complicated processing steps. Most of the knowledge base on nips comes from experience or "rule of thumb." Data explaining the behavior of the web when it is squeezed between a hard roller surface (steel) and a compliant roller surface (elastomeric covered) is scarce. This paper will examine and demonstrate some of the leading edge methods being used to analyze the inner workings of a steel-to-rubber process nip.

Introduction:

In order to make consistent product on converting lines, the footprint of the process nip needs to be even. If the process nip footprint is not even, then the product will suffer. Thinner products and faster line speeds make the process footprint even more critical. Even the slightest variation in the nip can cause thousands of dollars in scrap.

In order to make sure that nip impressions are even it is necessary to understand the causes of nip variation. The sources of variation include:

- Roller deflection
- Roller misalignment
- Uneven loading
- Roller diameter variations
- Rubber hardness variations
- Web thickness variations [i]

Measuring Nip Impressions:

Once the sources of variation are identified, the next task is to figure out how to quantify the rubber to steel roller nip. Through measurement, the sources of variation can be minimized or eliminated before any product ever comes near the footprint.

There are many ways to measure or observe the nip impression or footprint. Most of the methods to observe the footprint are qualitative. For these measurements, some type of substrate is placed between the rollers and the nip is closed. Upon the closure of the nip, the substrate is permanently marked. The shape of the footprint is then observed. The common substrates involved in these types of measurements include:

- Knurled Foil
- Carbon Paper
- Paper with Pressure Sensitive Coatings (Pressurex)

The resulting marked substrate is checked for shape and consistency. Some of the common nip impression shapes represent the following line conditions:

Examples of Static Nip Impressions

Good Nip

Crown too high for given

Unbalanced loading or misalignment

Crown too low for given load

As technology has progressed, newer ways to examine nip forces have been introduced. The nip footprint can now be measured electronically and have quantitative numbers attached to the measurement instead of just having a picture to ponder. Electronic measuring methods include:

- Strain Gages Permanently Mounted to the roller body
- Substrates Printed With Electrically Resistive Inks

Both methods produce discrete numbers that can be used in displays and data analysis. The strain gage method indirectly measures the nip impression because it measures the force on the core (internal to the roll body) but does not actually measure the shape of the footprint itself.

The second type of electronic measurement method uses substrates that are printed with resistive inks that change their resistivity based upon the amount of force they see. These types of sensors make direct measurements since they are in fact present in the nip itself when it is closed. One version of this type of sensor uses a printed grid to produce a force output. The other type of sensor in this family measures the actual width of the nip footprint.

Nip Data:

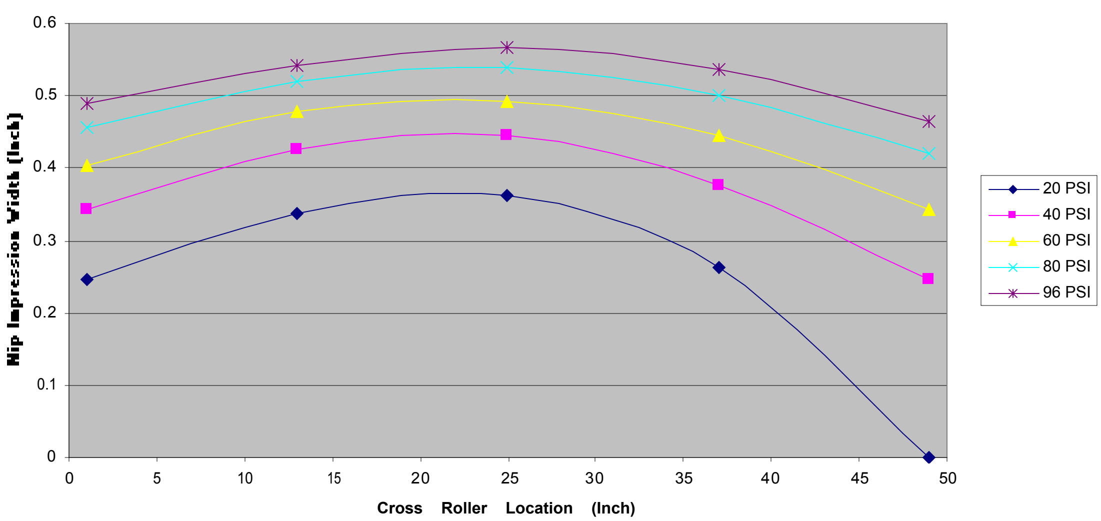
For this paper, test measurements were made using a technology that Tekscan is in the process of commercializing. These sensors are placed directly in the nip and then are able to directly measure the exact width of the nip down to a resolution of less than 0.001 inch. Tekscan also makes a similar but more elaborate sensor system that goes in the nip that is used to measure force.

The experimental set-up consisted of five nip sensors evenly spaced over a 50-inch wide EPDM covered roller of known diameter and a steel roller also of known diameter. Data was collected while the nipping force was varied at set increments. The diameter and roller alignment were also varied at controlled increments so that data could be collected to examine how the nip impression would vary. Experiments were conducted to test the reliability and the accuracy of the sensors.

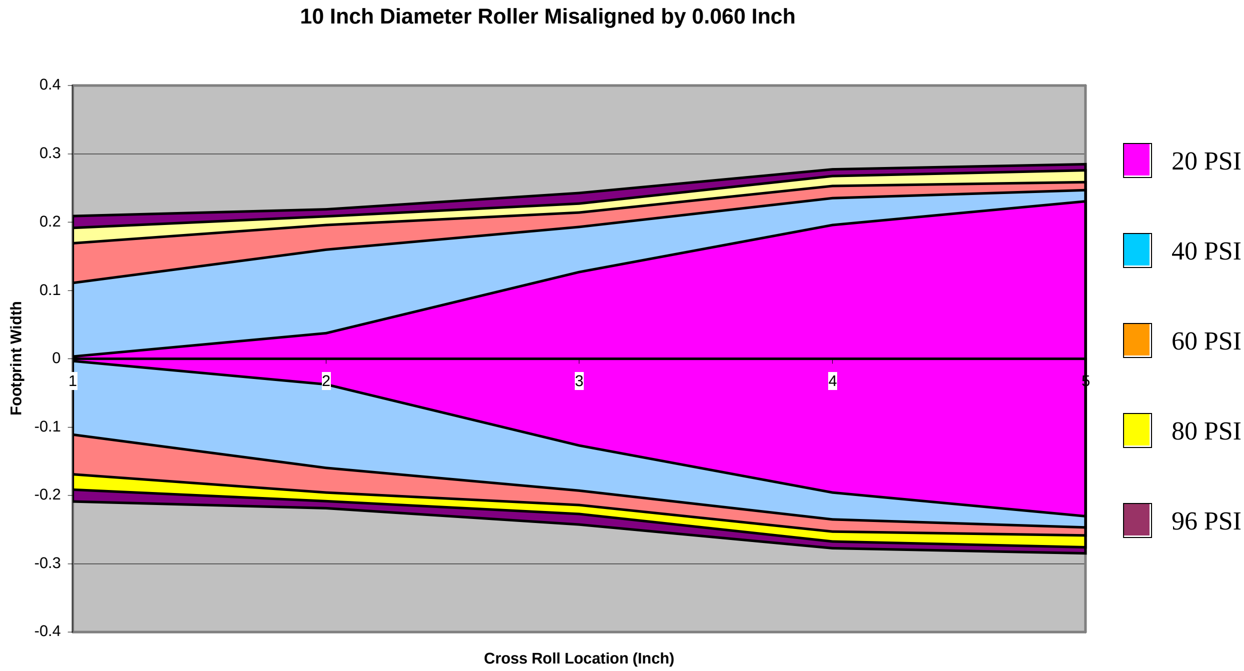
Results:

The nip sensors did in fact produce data that was expected. Misaligned rollers produced footprints consistent with imprints taken on carbon paper. Crowned and straight rollers produced similar consistent data. The following chart displays the sensor data for a crowned roller with a 0.125-inch thick rubber wall at varying nip stand pressures. It is clear from the chart that the shape of the nip footprint remains same but increases proportionately in width with force on the nip stand.

9.25 Inch Diameter With Crown - Aligned



Because the sensors record discrete numbers, the data can be presented in many different ways. The chart below depicts the footprints of a nip that was intentionally skewed by 0.060 inch. The rubber roller had a diameter of 10.0 inches and a sidewall of 0.50 inch thick EPDM. There are 5 separate plots superimposed on the same axis to represent five different operating pressures.



The sensors' output clearly show the footprint of the nip is highly dependent on the amount of force put into nipping the rollers together. It also shows that the relationship between the force and the footprint is proportional but not linear.

Conclusion:

As a person who has had to take many nip impressions over the years using carbon paper or pressure sensitive papers, I found the new electronic sensors much easier to read. With non-electronic gages it can be very difficult to know the magnitude of the footprint variation from one end to another. There is no question with the nip sensors. The system tells you directly the amount your nip width varies in raw numbers.

While the electronic nip sensors produce nice neat numbers to read and display it should be noted that these numbers are somewhat relative. The sensors are capable of reproducing the same nip impression shapes over and over. The absolute numbers that correspond to those shapes however vary slightly. As an alignment tool, the sensors are invaluable. However, the sensors should not be used to try and attain the same exact width measurements on a repeatable basis.

---

[i] Walker, Timothy J, "Measuring Pressure Variations in Rubber – Steel Nips", AWEB 2006