THE INSIDE STORY OF NIPS

Measuring Nip Pressure and Footprint

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"To measure is to know"
Lord Kelvin

"If you can not measure it, you can not improve it"
Lord Kelvin

“Refining is inevitable in science when you have made measurements of a phenomenon for a long period of time”
Charles Francis Richter

“In a few years, all great physical constants will have been approximately estimated, and the only occupation which will be left to men of science will be to carry these measurements to another place of decimals”
James C. Maxwell

“There is nothing new to be discovered in physics now, all that remains is more and more precise measurements”
Lord Kelvin
Possible consequences of un-parallel rollers or incorrect pressure

Source: ROLL AND WEB DEFECT TERMINOLOGY; 2nd Edition
R. Duane Smith, et al.

- Bursts
- Roll - knots
- Roll – slack winding
- Profile variation
- Twisted roll
- Tin canning
- Sideshift
- Edge dishing
- Roll edge - width growth
- Crepe wrinkle
- Diagonal shear wrinkle
- Hard wrinkles
- Cutter wrinkles
- Blisters
- Film split pattern
- Misting
- Uneven gussets
- Delamination
- Poor adhesion
- Pinholes
- Scratches
- Knots
- Tunneling
- Micro-scratches
- Web breaks
- Tension variations

General Nips
1. Measure process critical nips
2. Easy-to-use hand-held devices
3. Printing industry background
Outline

1. What is a nip?
2. Nip Applications
3. Formulas
4. Influences from nip temperature & roller/cylinder hardness
5. Pressure and footprint
6. Sensor influences & technology
7. Measurement methods & strategy
8. Measuring instruments
9. Trend analysis & continuous improvements
What is a Nip? 1(2)

- The meeting point of
  - Rollers/cylinders
  - Fluids and different solid materials

- The nip itself is forming a nip pressure curve and specific, desired, or undesired nip characteristics
  - Nip pressure (average and peak)
  - Nip width
  - Footprint/contact area
  - Roller/cylinder hardness
  - Through-put material hardness

![Nip Pressure vs Nip Width Graph]

**General Nips**
What is a Nip? 2(2)

- Harder roller pushed into a softer roller
- Rubber is not compressible, but elastic
- Nip pressure curve may change over time
Nips in Different Roller Applications 1(2)

Two distinct categories: **TRANSPORT** or PROCESSING

Typical transport applications include:
- General web feeding
- Web tension
- Web guiding
- Winding purpose

Rollers used for TRANSPORT are not intended to modify the properties of the web in a permanent way
Two distinct categories: TRANSPORT or PROCESSING

Typical processing applications include:
- Graphics
- Coating
- Priming
- Lamination
- Chilling

Rollers used for PROCESSING are intended to permanently modify the web or a fluid in a targeted way.
Line Force, Total Force & Average Nip Pressure

\[ F_{\text{Tot}} = F_1 + F_2 \text{ [N]} \]

Contact Length \( L_N \)

Contact Width \( W_N \)

Footprint/Contact Area

Footprint \( A_{\text{Nip}} = L_{\text{Nip}} \times W_{\text{Nip}} \text{ [cm}^2\text{]} \)

Line Force \( F_{\text{Line}} = \frac{F_{\text{tot}}}{L_{\text{Nip}}} \text{ [N/mm]} \)

Average Nip Pressure \( P_{\text{Avg}} = \frac{F_{\text{Tot}}}{A_{\text{Nip}}} \text{ [N/cm}^2\text{]} \)

General Nips
Quick Calculations of Average Nip Pressure

Available information:

- Total Force $F_{Tot}$ in [N] on shaft
- Nip Width $W_N$ in [cm]
- Nip Length $L_N$ in [cm]

**CALCULATION**

- $P_{Avg} = \frac{F_{Tot}}{L_N} * W_N$ [N/cm$^2$]

Available information:

- Line Force $F_L$ in [N/mm]
- Nip Width $W_N$ in [mm]

**CALCULATION**

- $P_{Avg} = \frac{F_L}{W_N} * 100$ [N/cm$^2$]
Peak Nip Pressure $P_{PN} \approx$ Average Nip Pressure $P_{Avg} \times 1.4$ (sinusoidal profile)
Change of Rubber Temperature

When rubber temperature increases, while maintaining the same impact setting, nip width increases

Approximate rule: increase of 20°C (36°F) gives +50% increase in nip width

(Rollers for Graphic Printing)

\[ P_{\text{Avg}} = \frac{F_{\text{Tot}}}{A_{\text{Nip}}} \]

If “\( A_{\text{Nip}} \)” increases more than “\( F_{\text{Tot}} \)”

\( \Rightarrow \) Lower Nip Pressure

Example: soft rubber or softening

General Nips
Change of Rubber Hardness

When rubber hardness increases, and maintaining the same impact setting, the nip pressure increases.

Approximate rule: increase of 10° Shore A gives +60% increase in nip pressure

(Rollers for Graphic Printing)

\[ P_{\text{Avg}} = \frac{F_{\text{Tot}}}{A_{\text{Nip}}} \]

If “\( F_{\text{Tot}} \)” increases more than “\( A_{\text{Nip}} \)”

⇒ Higher Nip Pressure

Example: hard rubber or hardening

Approx rule: +10°C (18°F) doubles aging speed
Same Nip Width – Different Pressure

Nip Pressure

Nip Pressure Profile 1B

Nip Pressure Profile 1A

Nip Width

General Nips
Measurements Inside a Nip

• When sensor blade thickness equal to web \((w \text{ or } w/o \text{ substrate labels})\)
  ➞ no influence ➞ measured value absolute & true level

• If sensor blade thicker than web
  ➞ measured value relative and at elevated level

Influence if sensor blade is thicker than web thickness

Nip Pressure curve increases

Sensor Blade

\(P_{PN}\)

Thickness 0.2 - 0.4 mm
\((0.008 \text{ – } 0.015”\)

Nip Width increases

General Nips
Measuring Methods
How to measure

Static mode
(nip width)

Semi-dynamic mode
(pressure)

To think of ……
Position of sensor element

To think of ……
Inching speed, reverse rotation, lifting, sideways measurement

General Nips
Nip Width and Pressure Curve Measurements

Generic Nip Profile

- Peak Pressure in N/cm²
- Nip width in mm/mil
- Pressure profile inside nip
- Nip width between rollers
- Sampling of pressure values (N/cm²)

Static measurement

Length sensitive sensor element (mm or mil)

Dynamic measurements

Pressure sensitive sensor element (N/cm²)
Measuring Strategy
Where to measure

Parallelism and straightness
At least three positions

Left Middle Right

Shaft bending

Concentricity
At least four positions

Swelling

Shrinking

General Nips
Measuring Instruments

Nip peak pressure in Newton/cm²

- Metal to hard plastics/rubber
- Smooth surfaces
- 20 - 999 N/cm² nip pressure (peak) (29 - 1450 psi)
- ≥ 5 mm (0.196”) nip width
- 10 - 70°C (50 - 158°F) nip temperature
- 0.2 mm (0.0078”) sensor blade thickness
- Substrate labels for lamination, etc.
- Safety front

Pressure Indicator™

NEW NANO TECHNOLOGY

320 Newton/cm² nip pressure

Pressure Indicator™
Measuring Instruments

Nip width in mm or inches

- Metal to hard plastics/rubber
- Smooth surfaces
- 1.5 - 20 & 10 - 50 mm nip width (0.06 - 0.79 & 0.39 - 1.97 inches)
- 20 - 50°C (68 - 122°F) nip temperature
- 0.4 mm (0.015”) sensor blade thickness
- Safety front

Roller Nip Indicator™

3.5 mm nip width (also displayed in mil)

Width
Trend Analysis Software

hansson•nips

World’s first software for quality control of roller/cylinder nips

- Monitor nip pressure trends
  - Parallel pressure
  - Absolute pressure level

- Excel based
- Easy-to-use

General Nips
Summary

• Nips are often process critical
• Average nip pressure calculation formulas are available
• Peak nip pressure is approx. 1.4 times average nip pressure. But pressure curves with the same average pressure can have very different shape/nip characteristics
• Applied force, rubber temperature, rubber hardness and aging affect nip characteristics
• To measure nip pressure curves, sensor elements inside nips are needed
• To measure is to know!
Thank you!