PROCESS CRITICAL NIPS

Controlling nip characteristics

AIMCAL
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Nip Control AB

1. Measurement & optimization of process critical nips
2. Easy-to-use hand held, high-precision instruments
Outline

1. General nips
2. Force & pressure
3. Definitions
4. Rubber - material
5. What is a roller nip?
6. Nip parameters & rubber change
7. Calculations
8. Measuring principles
9. Addendum

General Nips
Who wants to calculate/measure?

MACHINE BUILDERS & ROLLER MANUFACTURERS

Interested in:
- Total Force (Newton)
- Line Force (Newton/mm)

PROCESS / APPLICATION OWNERS

Interested in:
- Nip Pressure (Newton/cm²)
- Nip Width (mm or inch)

General Nips
Force vs. Pressure

\[ P \text{ [N/cm}^2, \text{ kgf/cm}^2 \text{ or psi]} = \frac{F}{A} \]

Weight onto surface

Weight onto specified area

General Nips
Repeatability & Accuracy

- High Accuracy
  - High Repetability

- Low Accuracy
  - High Repetability
  - Low Repetability

General Nips
Nips to be measured by process owners

**TRANSPORT NIPS**

Typical applications
- General web feeding
- Web tension
- Web guiding
- Winding

Rollers used for **TRANSPORT** are not intended to modify the properties of the web in a permanent way.

**PROCESSING NIPS**

Typical applications
- Lamination/Bonding/Marrying
- Coating/Priming
- Glueing
- Chilling
- Squeezing
- Sealing
- Hologram
- Printed electronics

Rollers used for **PROCESSING** are intended to permanently modify the web or a fluid in a targeted way.

General Nips
Rubber - a living material

Material & Production

Material characteristics
- Non-compressible
- Viscous-elastic

Design Parameters
- E-module - bulk value (N/m²)
- Hardness - surface value (Shore A)

Production variations
- Raw materials
- Dosing spread
- Mixing conditions
- Storing of uncured rubber
- Curing temperature, pressure and time

Application

Roller applications
- Roller rotation and roller squeeze create constant stress and relaxation

Energy consumption
- Level of impact, rotation speed & rubber parameters determine energy loss & temperature increase

Change in rubber from roller working cycle
- Temperature
- Humidity
- Exposed load
- Roller revolutions & Production speed (running profile)
- Chemical attack on roller cover
- Extraction of plasticizers may increase hardness

General Nips
Compliant & Rigid Roller → Roller Nip

- The nip creates a pressure profile while determining desired, or undesired nip characteristics

- The pressure profile is defined in:
  - Nip Pressure
  - Nip Width

- A constant pressure profile facilitates a stable production process
- No extra strain on production equipment

General Nips
Nip Width & Pressure Profile

General Nips
# Relation Process Parameters in a Nip

**Fixed nip** - both rollers mechanically locked to each other

<table>
<thead>
<tr>
<th>Roller Action</th>
<th>Line Force ($F_L$)</th>
<th>Nip Width ($W_N$)</th>
<th>Nip Pressure ($P_N$)</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
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<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>More penetration</td>
</tr>
<tr>
<td>Shrinking</td>
<td>▼</td>
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**Floating nip** - one roller mechanically locked, the other force controlled

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Results from Rubber Change 1(2)

Fixed nip - both rollers mechanically locked to each other

General Nips
Results from Rubber Change $2(2)$

Floating nip - one roller mechanically locked, the other force controlled.

General Nips
Approximate Rules *)

Change in rubber hardness

- Increase of 10° Shore A gives +60% increase in nip pressure
  - graphic rollers

Change in rubber temperature

- Increase of 20°C (36°F) gives +50% increase in nip width
  - graphic rollers
- +10°C (18°F) doubles ageing speed

*) maintaining same impact setting
Calculation Formulas
Line Force, Total Force & Average Nip Pressure

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

Average Nip Pressure \( P_{\text{Avg}} = \frac{F_{\text{Tot}}}{A_{\text{Nip}}} \) [N/cm²]

Comments: To push two roller together force is needed on both sides of the roller \( F_1 \) & \( F_2 \). Total Force (\( F_{TOT} \)) is calculated by adding these two forces together. To be able to analyze the nip more in detail we need to know the Nip Area (\( A_{\text{NIP}} \)). This is done by multiplying the contact length of the nip (\( L_N \)) and the contact width of the nip (\( W_N \)). Calculations for Line Force (\( F_L \)) and Average Nip Pressure (\( P_{\text{AVG}} \)) are shown too. This data can be used to calculate the AVERAGE NIP PRESSURE in a nip.
Quick Calculations of Average Nip Pressure (using data from prior page)

Available information:
• Total Force $F_{Tot}$ in [N] on shafts
• Nip Width $W_N$ in [cm]
• Nip Length $L_N$ in [cm]

Calculation

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

Available information:
• Line Force $F_L$ in [N/mm]
• Nip Width $W_N$ in [mm]

Calculation

$$P_{Avg} = \left(\frac{F_L}{W_N}\right) \times 100 \text{ [N/cm}^2\text{]}$$

General rule: Peak Nip Pressure $P_{PN} \approx$ Average Nip Pressure $P_{Avg} \times 1.4$ (sinusoidal profile)
Calculated Average Pressure vs Pressure Profile

Same calculated average nip pressure can have different pressure profiles
Measurement Principles
Measuring Methods

How to measure

Static mode
(nip width)

Semi-dynamic mode
(nip pressure)

To think of ……

Position of sensor element

To think of ……

Inching speed, reverse rotation, lifting

Measuring
Measurements of Nip Profile

Peak Pressure in N/cm²

Sampling of pressure values (N/cm²)

Semi-dynamic measurements
Pressure sensitive sensor element (N/cm²)

Nip width in mm/inch

Nip width between rollers

Static measurement
Length sensitive sensor element (mm or inch)

Measuring
Measuring Strategy

Parallel alignment & straightness
At least three positions
Left  Middle  Right

Concentricity
At least four positions

- Mis-alignment
- Swelling
- Shrinking
- Shaft bending
Influences Sensor Thickness (Fixed nip)

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

Influence if sensor blade is thicker than web
  ➔ measured value relative and at elevated level

Nip Pressure curve increases

Sensor Blade

Thickness 0.2 - 0.4 mm
(0.008 – 0.015”)

Nip Width increases

Note: Floating nip = no pressure curve change

Measuring
Summary

- Machine builders, roller manufacturers and process owners have different objectives.
- Applied force, rubber temperature, rubber hardness and ageing affect nip characteristics.
- Pressure profiles with the same average pressure can have very different shape/nip characteristics.
- Average nip pressure calculation formulas are available.
- Peak nip pressure is approx. 1.4 times average nip pressure.
- Digital nip measurements can improve production process.
- To measure is to know!
ADDENDUM

Measuring instruments help achieve stable, cost-effective production

Pressure Indicator

Roller Nip Indicator
Objectives Digital Nip Measurement

Improve setting and control of process critical nips
  • Exact digital, repeatable and operator independent nip measurements
  • Statistical trend analysis and follow-up possible

Thereby achieve
  • Optimized product & process quality
  • Lower product cost
    ✓ Less scrap
    ✓ Higher production speed/more production time
    ✓ Fewer customer complaints
  • Quicker and easier method -> more frequent nip checkings
  • Continuous process improvement and increased job satisfaction
One system for Nip Width

Nip Width Indicator™

300 mm sensor blade length
Nip width 2 - 20 mm

500 mm sensor blade length
Nip width 5 - 50 mm

Specification

• Rubber to rubber/plastics/metal; 20 - 80° ShA
• Smooth surfaces
• Maximum pressure (peak): 200 N/cm² (290 psi)
• Display resolution 0.5 mm / 1/100”

OPTION
Traceable calibration unit

Telescopic extension arm
Full reach 2 meters

hansson•nips
- trend analysis software -
Two systems for Nip Pressure

**Pressure Indicator™ High Pressure version**

- Nip Pressure in Newton/cm² (peak)

**Specification**
- Rubber to rubber/plastics/metal; max 94° ShA
- Smooth surfaces
- Pressure range (peak): 20 - 999 N/cm² (29 - 1450 psi)
- Nip width: ≥ 5 mm (0.2”)
- Substrate labels for lamination applications, etc.
- Display resolution 1 N/cm²

**Telescopic extension arm**
- Full reach 2 meters

**Pressure Indicator™ Low Pressure version**

- Nip Pressure in Newton/cm² (peak)

**Specification**
- Rubber to rubber/plastics/metal; max 94° ShA
- Smooth surfaces
- Pressure range (peak): 3 - 50 N/cm² (4 - 73 psi)
- Nip width: ≥ 5 mm (0.2”)
- Substrate labels for lamination applications, etc.
- Display resolution 0.5 N/cm²

**Traceable calibration unit**

**hansson®nips**
- trend analysis software -
Thank you!

For more information
Contact info@nipcontrol.com