# Nip impressions

**William B. Kennedy**

Whenever two or more rolls form a nip, the resulting "squeeze" is used to remove liquid from the web passing between the rolls. This is called a press and is commonly found in the paper, printing, and textile industries, to name a few. An external loading system is used to regulate the amount of force applied to the press. This force is usually referred to as pli (pounds per linear inch of face). Each press is designed to operate up to a maximum pli consistent with the needs of the web passing through the nip.

Values used for pli range from a few hundred up to as much as 2500. For a 200-in. face press, 2500 pli × 200 in. = 500,000 lb of force applied at the nip. Even a lightly loaded press, say 250 pli, would require 50,000 lb of force at the nip with the same 200-in. face. The metal cores used in the press will bend or deflect a certain amount, depending on the metal used and its physical properties and dimensions. The core shell thickness and diameter also control the deflection.

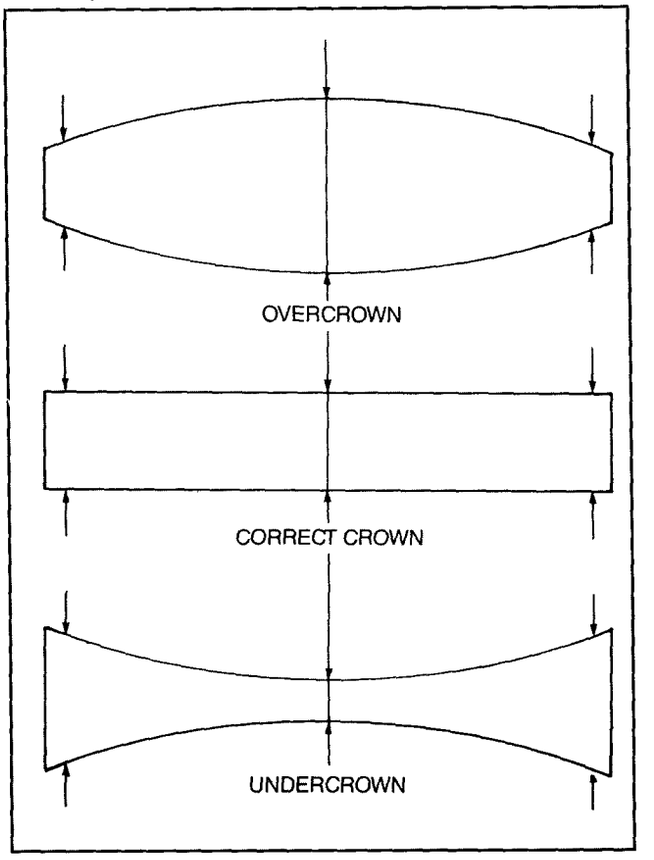
When press rolls deflect under load, they will bear against each other heavily on each end and very little if any at the center. In order to overcome this phenomenon, it is necessary to crown the covers of the rolls just the right amount to achieve a uniform nip across the entire roll face. "Crowning" the covers is a procedure of grinding them to a larger diameter at the center than the ends in order to compensate for the deflection. This is essential to provide uniform liquid removal from the web and to avoid high-pressure concentrations in the covers.

A means of checking the nip for uniformity is by taking a nip impression. This involves placing something in the nip that will visibly record the variations in width. A combination of carbon and plain paper or embossed aluminum foil is commonly used for taking impressions. Either will provide a permanent record of the nip width variations that existed when the test was made. It is important to note that nip impressions taken with freshly ground roll covers in the press will produce the most accurate and reliable results.

The correct method of taking nip impressions so that you may have confidence in the analysis of the results is as follows:

1. Remove the web, felt, or fabric from the nip.
2. Clean and dry the surface of each roll.
3. Open the press nip sufficiently to insert the impression material (carbon or foil) across the full roll face, extending at least 6 in. beyond the ends.
4. Use pressure-sensitive tape, if necessary, to hold the impression material in place on one of the rolls.
5. Rotate the press rolls to locate the impression material at the center of the nip as seen from the ends.
6. Slowly close the press without any load.
7. Gradually bring the loading up to the operating level or desired test load. Be careful to adjust both front and back pressure regulators evenly together.
8. Maintain the loaded nip for one minute.
9. Gradually unload the press to "zero" load, again adjusting front and back regulators together.
10. Open the press only after it is fully unloaded.
11. Carefully remove the impression material from the press. Avoid tearing, folding or wrinkling.

**1.** Basic types of nip impressions




Kennedy is application and technical service manager with Stowe Woodward Co., 333 Turnpike Rd., Southborough, Mass. 01772.

At this time, it is essential to document some pertinent information regarding the impression and to attach it directly to the material.

- Indicate machine direction of web travel.
- Show the applied load used.
- Identify front and back ends.
- State the full length of roll face.
- Show the outside diameters of each roll.
- Determine the cover hardness and thickness of each roll.
- Specify the crown on each roll at the time of the test. (A far more precise analysis is possible if both roll covers are freshly ground.)
- Identify the machine number and press location.
- Date the test was made and by whom.

With the impression complete and documented, you can now make an analysis of what is happening in the nip.

The first step is to fold the impression in half to locate the center and label it. Next, measure 2 in. from each end of the impression and draw a line across the nip width.

Now compare the two end widths to each other. If they are approximately the same by measurement, this will confirm the press was symmetrically loaded. If they are quite different, the press may not be evenly loaded on each end. Possibly one side of the press may have closed first, creating a momentary high pressure and resultant wider nip. It is not possible to be sure which condition exists, unless someone has observed the press while closing.

Another impression should be taken, with careful attention to how uniformly the press closes. If one side persists in closing first, you must use the opposite smaller nip width to determine the amount of miscrown, if any. **Figure 1** shows basic types of nip impressions.

Measure the nip width at the center of the impression and record along with the end measurement. Use a magnifier and a scale calibrated to 0.01 in. and round to the nearest gradation.

You can now use the following equation to determine the amount of miscrown, if any:

$$C = \frac{(W_2^2 - W_1^2)(D1 + D2)}{2(D1 \times D2)} \quad (1)$$

where:

C = Diametral crown correction

W1 = Nip width at centerline

W2 = Nip width 2 in. from the end

D1 = Diameter of one roll

D2 = Diameter of the other roll

If C is negative, the press has too much crown.
If C is positive, the press has too little crown.

Note that the total crown of both rolls must be considered when making the correction. For example:

W1 = 1.40 in. at centerline

W2 = 1.52 in.; 2 in. from end

D1 = 23 in. with 0.010 in. crown

D2 = 22 in. with 0.005 in. crown.

$C = (1.52^2 - 1.40^2)(23 + 22)/\ 2(23 \times 22) = +0.0156$ in. = 0.016 in. (2)

Note that with only 0.12 in. difference in nip width from centerline to end the miscrown is significant. This emphasizes how important it is to use precise measurements in the equation instead of a quick visual comparison and snap judgment.

Total crown at time of test:

Roll 1
0.010 in.
Roll 2
0.005 in.

Total:
0.015 in. Correction: 0.016 in.

New total crown: 0.031 in.

The crown distribution between the two rolls is generally a matter of choice or preference. Some guidelines:

**I.** Possible combinations of crown distributions resulting in the same total crown

| | | | | |
|---|---|---|---|---|
| Roll 1 | 0.010 | 0.015 | 0.020 | 0.026 |
| Roll 2 | 0.021 | 0.016 | 0.011 | 0.005 |
| Total: | 0.031 | 0.031 | 0.031 | 0.031 |

**II.** Variable crown incremental sequence

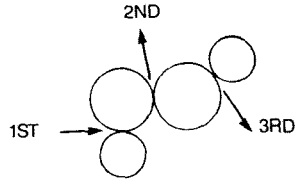
| *Load, pli* | *Hydraulic "crown adjust," psi* | | | *Air pressure "load," psi* |
|---|---|---|---|---|
| 0 | 5 | | | 10 |
| 25 | 12 | | | 12 |
| 50 | 20 | | | 15 |
| 75 | 27 | | | 17 |
| 100 | 35 | Load | | 19 |
| 125 | 43 | hydraulic | | 21 |
| 150 | 50 | first | | 24 |
| 175 | 57 | | Unload | 26 |
| 200 | 65 | | air | 28 |
| 225 | 73 | | first | 30 |
| 250 | 80 | | | 33 |
| 275 | 88 | | | 35 |
| 300 | 95 | | | 37 |

Above values based on .025 in. crown on variable crown roll
.045 in. crown on granite roll
.070 in. total crown

**III.** Sequence for incremental loading and unloading

| | *Load* | *Unload* |
|---|---|---|
| Bi-nip | 2nd nip, 1st nip | 1st nip, 2nd nip |
| Tri-nip | 2nd nip, 3rd nip, 1st nip | 1st nip, 3rd nip, 2nd nip |

2. Tri-nip incremental load sequence.




| 2ND PRESS | | 3RD PRESS | | 1ST PRESS | |
|---|---|---|---|---|---|
| PLI | PSI | PLI | PSI | PLI | PSI |
| CLOSE | 14 | CLOSE | 0 | CLOSE | 20 |
| 189 | 26 | 129 | 10.5 | 129 | 20 |
| 237 | 33 | 194 | 14.5 | 167 | 24 |
| 271 | 38 | 259 | 18.5 | 196 | 27 |
| 319 | 45 | 324 | 22.5 | 229 | 30.5 |
| 360 | 51 | 373 | 25.5 | 267 | 34.5 |
| 401 | 57 | 438 | 29.5 | 305 | 38.5 |
| 439 | 62.5 | 503 | 33.5 | 343 | 41.5 |
| 483 | 69 | 568 | 37.5 | 376 | 45 |
| 500 | 71.5 | 600 | 39.5 | 400 | 47.5 |

| COMPENSATION FOR VACUUM | | | | | |
|---|---|---|---|---|---|
| 85 | 10 | 33 | 2.5 | 77 | 5.5 |

LOADING SEQUENCE ——→ 2-3-1
UNLOADING SEQUENCE ←—— 1-3-2

- 60% on the soft cover; 40% on the hard
- Proportion by diameter
- Both rolls equal
- Crown to be interchangeable with other positions.

The total crown required must be met regardless of the distribution. For this example, possibilities include the combinations shown in **Table I.**

It is useful, if time permits, to take impressions at various loads if it is planned to change the load for some reason. The tests will provide the correct crown for future reference.

The procedure as described above is for taking impressions with plain, grooved, or blind drilled covers in a simple two-roll press. Special procedures are required for the following press arrangements:

- Any press using a suction roll
- Any press using a variable crown roll
- Three- and four-roll presses (bi-nip and tri-nip).

## Suction roll

The vacuum force can be considerable enough to cause the suction shell to deflect a significant amount in addition to the nip load. If we ignore this when taking a nip impression, the results will not be precise.

Calculation of this vacuum force may be made with this simple equation:

$$\text{Vacuum pli} = 0.4912 \times W \times V \times F \qquad (3)$$

where:

0.4912 = conversion factor from inches of mercury vacuum to psi

W = width of the vacuum box from end view

V = vacuum level in inches of mercury

F = efficiency factor for the extent that the box seals, F = 0.9 (90%) for most suction rolls.

Example: A 5-in. wide box at 20 in. of mercury vacuum.

$$\text{Vacuum pli} = 0.4912 \times 5 \times 20 \times 0.9$$
$$\text{Vacuum pli} = 44.2 \text{ pli}$$

The basic problem is that when a nip impression is taken without vacuum, at the load for which it is crowned, it will indicate some amount of overcrown, even though the crown may be correct. To compensate for this, we must increase the load by some amount. Since the vacuum affects only the suction shell, we cannot use the entire vacuum pli. A close approximation is to use about 70–75% of it. However, a more precise amount can be calculated by the press manufacturer, who should be contacted.

## Variable crown roll

A variable crown roll is designed and calibrated to create the correct amount of crown within the range of loads at which it is intended to operate. It is possible that for some reason it may have gone out of calibration. To check this, you must be familiar with the press controls and know how to use the "nip load curve" provided by the manufacturer. The calibration is based on a specified amount of total crown required in the press and will be found on this curve. Also on this curve are the specific hydraulic "crown adjust" pressure values vs. pli and the "load" pressure values vs. pli. The crown adjust pressure is what changes the amount of additional crown required to maintain a uniform nip where the load pressure actually applies the load. For each pli level used, there is a specific "crown" pressure and a corresponding "load" pressure shown on the curve.

It is necessary to examine the condition of the press controls to be sure they function properly. Gauges should be easy to read and identify. Some interlocks may have to be bypassed to allow loading without the drive in use. A manual setting may have to be used. All of these details must be resolved before proceeding.

Make a sequential list of crown adjust pressure with

corresponding load pressure vs. pli, starting at 0 pli, increasing by increments of 25 pli or less up to the test load. **Table II** is an example of such a list.

Proceed as follows with the impression material placed in the open press:

1. Set crown adjust regulator to zero output.
2. Set front and back load regulators to zero psi.
3. Close the press with load selector value.
4. Adjust front and back load regulators together until rolls slightly nip with both ends coming up together.
5. Bring the crown adjust regulator up to the minimum pressure shown on the nip load curve list previously prepared.
6. Now adjust the load regulators together to the corresponding pressure setting.
7. Continue alternately to raise the crown adjust regulator to the next increment, allowing it to stabilize before raising the load pressure to its corresponding pressure. Follow this sequence up to the test load.

Note that the reason for this sequential incremental loading is to make certain the ends of the rolls do not load before the center. If you were to advance the load pressure before the crown adjust pressure, this could result in a false nip impression even though a temporary high end loading occurred.

Once the test load is reached and held for one minute, the press should then be unloaded in the reverse incremental sequence. Start with the load pressure, followed by the crown adjust pressure, until the press is fully unloaded. Then open the press to remove the nip impression. Be sure to document the same information previously identified, and attach this along with a copy of the nip load settings to the impression.

If the press is over- or undercrowned by more than 0.005 in., the calibration must be adjusted by a well-qualified technician, preferably from the firm that manufactured the variable crown roll.

## Three- and four-roll presses

Multiroll press nips are interrelated in that a change in one nip load changes the deflection in the remaining nips. Impressions must be taken with all nips loaded simultaneously. Loading is done in a specific sequence and by increments. If a suction or variable crown roll is included, the procedures previously covered must also be used. It is essential to have the crown curve as furnished by the press builder to determine vacuum compensation required for each nip. The crown required for each roll at various load combinations will also be found on this curve. Loads and corresponding crowns used should be documented in a clear precise manner.

A nip load curve from the press builder is also essential to identify the required pressures for each nip.

The sequence for incremental loading and unloading is shown in **Table III**. The tri-nip incremental load sequence is shown in **Fig. 2.**

Use increments of 25-50 pli. Remember that a variable crown roll increment should not exceed 25 pli.

Prepare a sequential list of increments from the nip load curves. Be sure to add the vacuum adjustment for each nip as found on the crown curve.

With all the nips unloaded and open, locate the impression material in each and proceed to close, then load in the appropriate sequence and the chosen increments. After all nips have reached their test levels and remained for one minute, then proceed with the appropriate unload sequence. When all nips are fully unloaded and open, then remove the impressions for analysis. Remember to document all pertinent information as previously mentioned.

Much technique regarding interpretation of nip impressions has been omitted for the sake of brevity.□