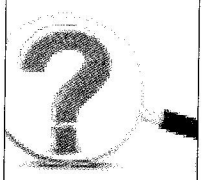
WAGING WAR ON WARP

TROUBLE SHOOTING



BOARD DEFECTS

METHODICAL ANALYSIS WILL IDENTIFY THE SOURCE OF THE PROBLEM AND REVEAL A WINNING STRATEGY.

BY WAYNE PORELL, HARPERLOVE

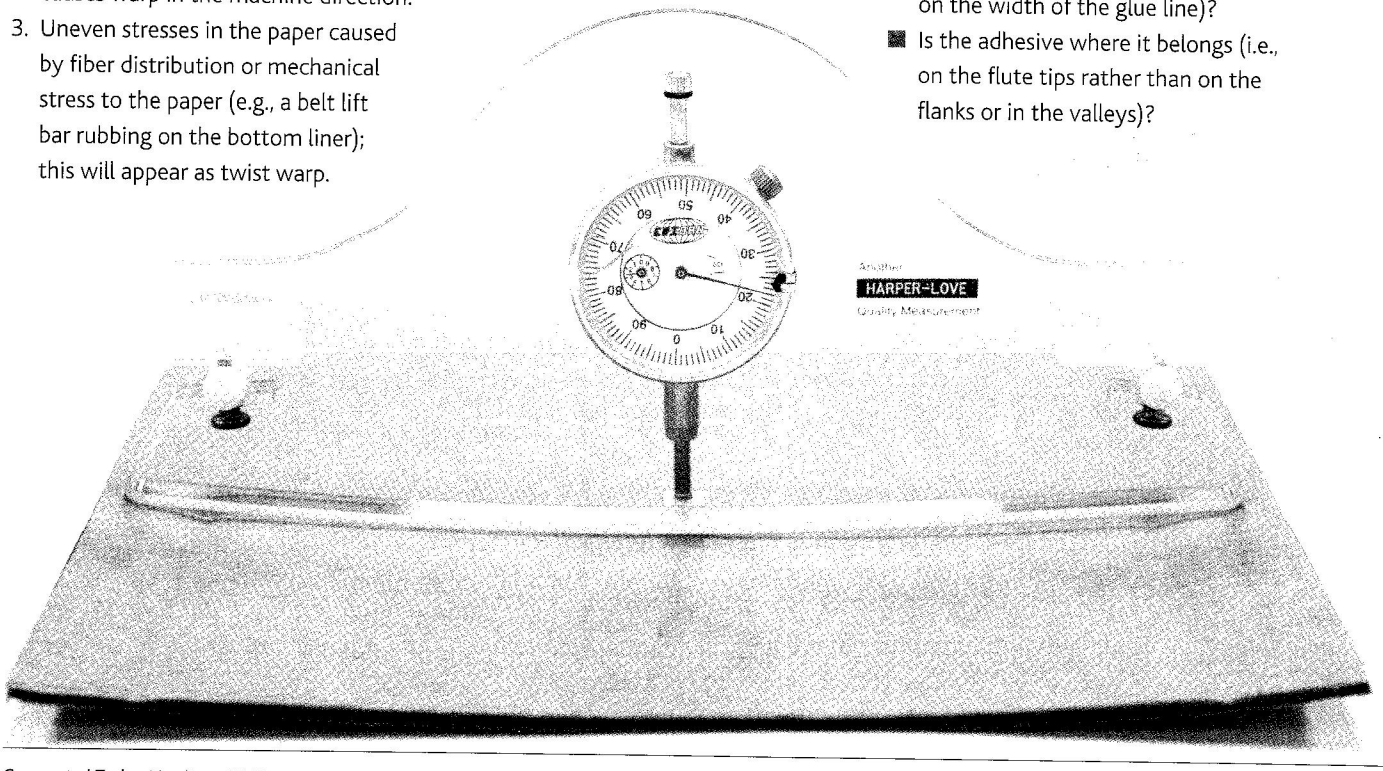
Warp is a familiar challenge in most corrugating plants. Understanding the root causes can go a long way in helping correct it. Generally, warp is caused by three conditions:

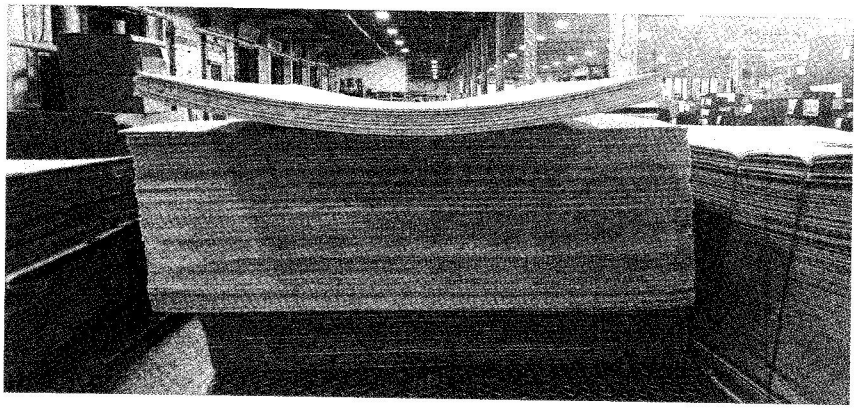
1. A moisture imbalance between the top and the bottom of the sheet; this shows up as warp in the cross-machine direction.
2. A tension difference between the top and the bottom of the sheet; this causes warp in the machine direction.
3. Uneven stresses in the paper caused by fiber distribution or mechanical stress to the paper (e.g., a belt lift bar rubbing on the bottom liner); this will appear as twist warp.

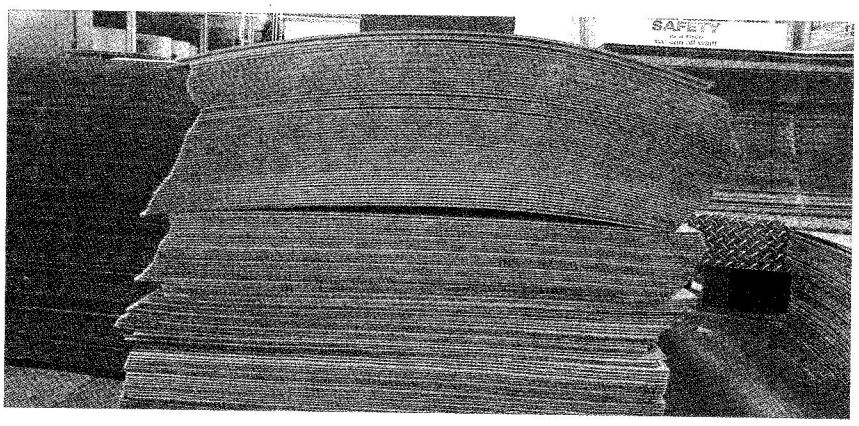
Moisture Imbalance

Improper adhesive application can have a huge impact on moisture imbalance, so it is a good place to start your investigation if you have warp in the cross-machine direction. A soak tank is an invaluable tool for troubleshooting adhesive application issues. When you soak the board apart it is important to look at the medium as well as the liners – the medium is where the adhesive is actually applied. By soaking the board and then staining the glue lines with iodine we can determine several things:

- Is the machine set up properly?
- Is the glue roll worn or damaged (and therefore applying excess adhesive)?
- Is the glue roll running at the correct speed?
- Is the wiper blade wiping the metering roll correctly?
- Is the application rate correct (based on the width of the glue line)?
- Is the adhesive where it belongs (i.e., on the flute tips rather than on the flanks or in the valleys)?







Glue lines should be measured with a glue line measurement tool and compared with the optimal width for the specific flute. Comparing the glue lines from the operator side to those of the drive side of the sheet will tell you if the glue roll and metering roll are out of parallel.

At least 90% of the adhesive applied at the doublefacer should transfer from the medium to the liner. This shows that the doublebacker hold-down devices on the machine are functioning correctly. At the singlefacer it is quite common to transfer 100%.

Excess adhesive will impart excess moisture to the board and will increase the likelihood of warp. If all the applied adhesive is not completely gelled through the corrugating process, post-warp will occur as the board dries. The optimal amount of adhesive for a given board grade should be determined by a soak test and pin adhesion test.

Not all glue machines are the same – one with a 25-quad glue roll and one with a 35-quad roll will not apply the same amount of adhesive when running with the same gap.

Up-warp or down-warp can be caused by any of the following:

- Excessive adhesive application
- Run speeds not consistent with the glue roll gap
- Overheating the liner(s)
- Incorrect glue roll speed

A glue roll that is running slower than the paper speed will apply adhesive to the front side of the flute. Conversely, a glue roll running faster than the paper speed will apply adhesive to the back side of the flute. Both issues will cause warp because the machine can only gel the adhesive that is on the flute tip.

When adjusting for up-warp, an operator might add wrap to the singleface web to correct the warp issue, but really should be lessening the wrap on the doubleface liner. A heat gun is very useful in making the optimal adjustments.

Sometimes increasing corrugator speed will flatten out the board because this helps bring the liner to the optimum running temperature and moisture content. Remember, the faster the corrugator runs the less adhesive you should apply to make a good bond. A moisture difference greater than 1.5% from the singleface liner to the doubleface liner can cause warp.

Tension Issues

End-to-end warp is usually caused by tension issues, which can include:

- Preheaters not turning
- Roll stand brakes not functioning properly
- Splicers not controlling the braking correctly on small diameter rolls
- Rolls that do not turn freely
- Web guides improperly maintained
- Excessive drag in the hotplate section

Recycled liners sometimes do not create sufficient drag on the preheater drums to turn them. When this happens, condensate accumulates in the bottom of the preheater and creates a temperature differential around the drum. You may have to adjust the wrap to obtain proper heat.

Splicers should be set up on at least a quarterly preventive maintenance program to ensure the bearings and rolls move freely and create minimal drag. Automatic splicers control the braking as the rolls get smaller. If these controls are not working correctly, added tension to the liner will cause problems. If the brakes wear down or the calipers are not working freely, they will not apply the appropriate braking resistance, which also creates tension problems.

Web guides should be cleaned and inspected weekly. When using vacuum guides, the vacuum holes can become

clogged with dust, creating less vacuum and therefore less tension. In systems with a tension roll, the cover on the roll should be inspected for wear. When the covers become smooth they need to be recovered with semi-rough surface tape to add drag to the web.

Drag in the hot plates section can create tension warp. Older, worn plates are particularly prone to this problem. To avoid the cost of purchasing new hot plates, some plants install an automatic lubricating system at the mouth of the doublebacker. It is set up to respond to an increased amperage load on the drive motor. When the amps increase due to drag, the system sprays lubricant on the bottom liner, which is then transferred to the hot plates, reducing drag.

Uneven Stresses

Twist warp may be caused by improper machine alignment. Machine alignment can be checked by tramming the individual components to each other. Web side guides should be square to the machine. As corrugator belt wear occurs, it may be necessary to adjust the bridge tracking rollers to ensure the web is in the center of the belt. Wrap arms on older preheaters can be out of alignment due to wear in the gears from years of use. The use of self-aligning wrap arm rolls may be less costly than replacing the gears or the preheater.

Be Methodical

We'll probably never conquer warp completely, but we can reduce it so it doesn't interfere with downstream operations. A systematic analysis of moisture content, tension issues, and uneven stresses on the paper will help you produce drier, firmer, flatter board. ■

Wayne Porell has more than 40 years of experience in the corrugated industry. He started with Baltimore Box in 1977 and then worked for Westvaco. He joined HarperLove in 1998 and is a Senior Technical Representative serving customers primarily in the Northeast where he has helped numerous plants with corrugator issues and improved their waste, productivity and quality.

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WARP is Caused b

- The Moisture imbalance between line
- The Tension imbalance between line

Simply nothing else!

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Tension Imbalance Cross M

- Causes of Cross Machine Tension Imbalance.
  - Out of parallel wrap arms.
  - Out of parallel roll stands.
  - Heavy build-up of adhesive, wax or coa on warp arms.
  - Housekeeping on Bridge guides blockin vacuum.
  - Caliper profile difference in liner/mediur
  - Equipment installed out of parallel.

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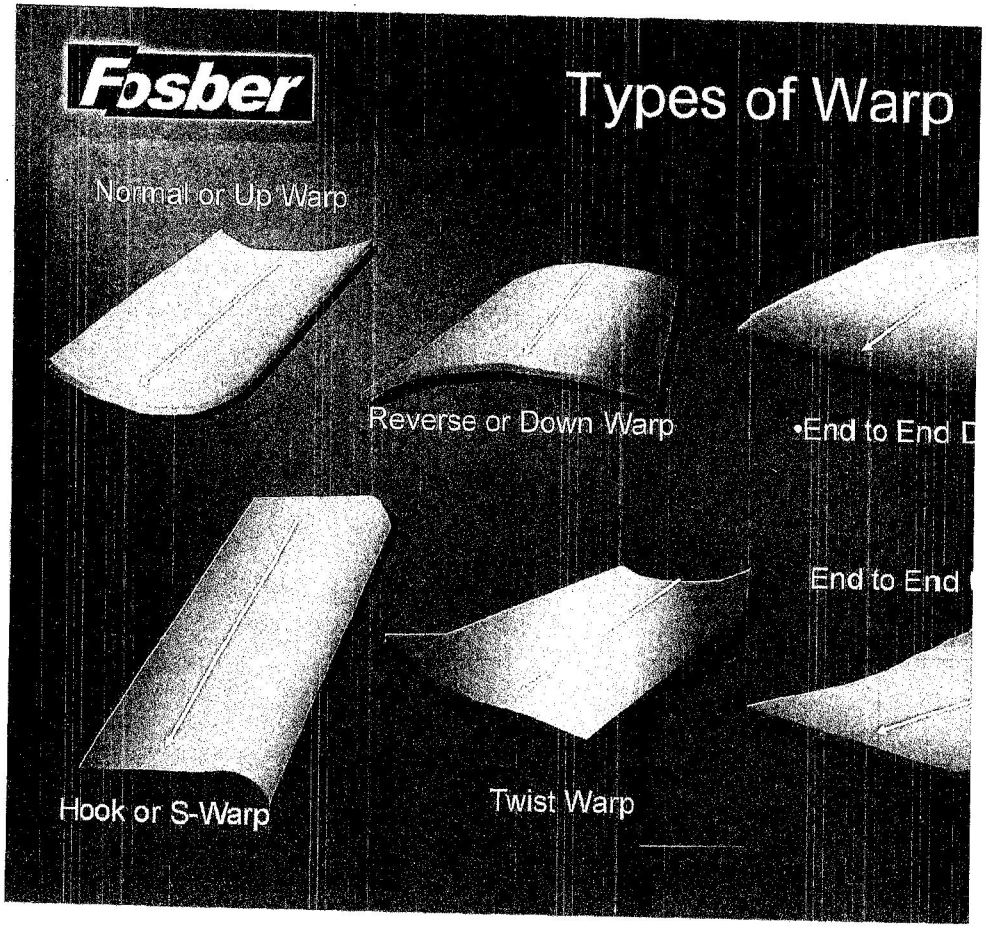
Types of Warp



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Reverse or Down Wa

- Steps to eliminate:
  - Decrease starch gap at Doublebacker.
  - Decrease top Pre-heater wrap at Doublebacker.
  - Decrease Singlefacer liner wrap.
  - Decrease wrap on Singlefacer medium.
  - Increase Steam Shower on Singlefacer medium.
  - Increase Bridge Festoon to Maximum capacity.
  - Increase Doublebacker liner wrap.
  - Check roll for moisture.

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Things that cause Mois Imbalance

- Starch Application
- Liners Themselves
- Water Sprays
- Coatings
- Heat issues
- Downtime
- Corrugator Belt

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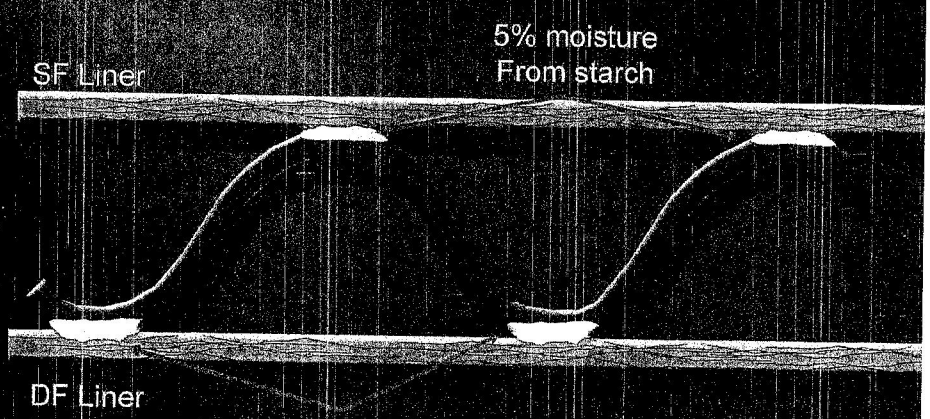
Warp due to Moisture Imb



Moisture from the starch will penetrate the fibers closest to the surface and expand.

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Twist Warp

- Twist warp is;
  - a combination of End to End warp and normal or reverse warp. Caused by either excessive polar angles in one or both liners, or uneven stress in one or both liners during the corrugating process.
- If persistent – usually machine related
- If comes and goes – usually paper related.

* The polar angle is defined as the angular difference Between the machine direction and the average fiber direction of the paper.

Twist Wa

- Make adjustments for tension and then adjust for either reve warp.
- Check machine parallel: Splic wrap arms, Roll stands, and I
- Check for build up on all rolle
- Check Paper.

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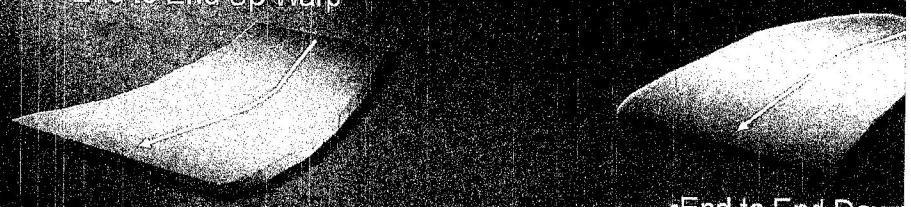
End to End Up & Do

End to End Up Warp



•End to End Down

- Decrease bridge tension.
- Decrease singlefacer liner tension.
- Increase Doublebacker liner tension.

- Reduce Double liner tension.
- Increase Bridge tension.
- Increase single tension.

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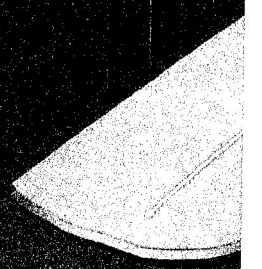
Normal or Up War



- Steps to eliminate;
  - Reduce the starch gap at the singlefacer.
  - Reduce doublebacker liner wrap.
  - Reduce steam shower to the Medium.
  - Increase top liner preheater at the doublebacker.
  - Increase singlefacer liner wrap.
  - Increase wrap to the medium.
  - Check roll with moisture meter.
  - Reduce amount of festoon on bridge.

- Key always take away before you add.

force and the applied weight. Both methods, horizontal and incline plane, give essentially equivalent results. Both methods are not well suited to give reliable estimates of kinetic friction coefficients. A schematic relating the two methods is shown in figure 20-18.

The claim of TAPPI and ASTM that the two methods give equivalent results is technically correct, assuming that the equipment works as intended. Our experience is that the incline method is superior because it depends only on gravity. The horizontal plane method requires a force gauge. These are notoriously unsatisfactory. Uneven surfaces cause them to swing back and forth. Moreover, it is difficult to maintain a uniformly taut cable as the sample slides.

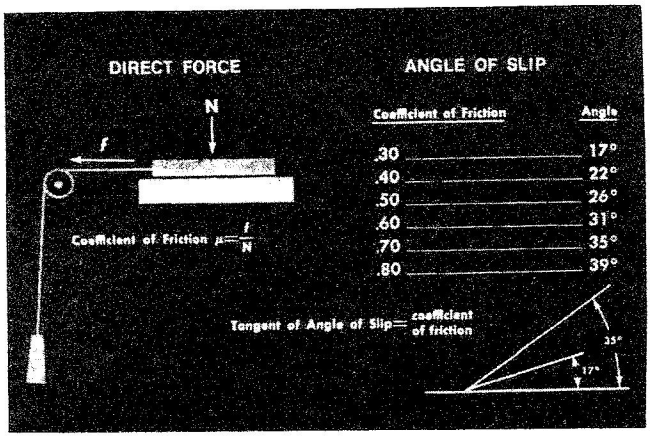


Figure 20-18. Schematic of horizontal and incline plane method.
Photo courtesy of Container Corporation of America

WARP

The problem of warp has been studied extensively by the Container Industry Development Corp. (CID) under James F. Stevenson. Their procedure is to define a "warp factor" as inches of warp in a sheet 24 inches wide. It varies by the square of the width, e.g., each of the following sheets has a warp factor of 0.25:

1/16" in 12"
1/4" in 24"
1" in 48"
4" in 96"

Board is considered "flat" if the warp factor is ± 0.25 WF.

Warp shapes are:

Normal	Edges warp up.
Reverse	Edges warp down.
S	Combination of normal and reverse
End-to-End Up	Ends warp up.
End-to-End Down	Ends warp down
Twist Warp	Diagonal warp combination of end-to-end and side-to-side in one sheet.

Stevenson's comments on why warp occurs are quoted from his report to CID[4]:

WHY WARP OCCURS

Broadly speaking, warp is caused by non-uniform changes in the dimensions of the components of the corrugated structure, particularly the liners. The predominant force causing these changes is moisture, since moisture content has a pronounced effect on paperboard dimension. This property is called "hygroexpansivity." Hygroexpansivity is much greater in the CD (cross machine direction) than in the MD (machine direction) and it is in the CD that the most serious warp problems occur. This is also why wet streaks are so troublesome.

As a rough guide, each 1% moisture change will change CD dimension by 0.06 to 0.10%. Since moisture change during the board's progress through the corrugator can approach 15-20%, relative dimension changes of .9 to 2.0% can occur. On an 80-inch wide sheet, this amounts to 0.72 inch to 1.6 inches.

It is not surprising, therefore, that careful control of moisture is essential to the production of flat board.

Temperature changes also will cause dimensional change in paperboard. However, its effect on warp is thought to be relatively minor. It is difficult to isolate the effect of temperature by itself, since a change in temperature frequenly is accompanied by, or actually causes, a change in moisture content.

It is believed that CD warp formation can be explained by moisture changes and differentials occurring in the process.

Of particular importance are the moisture conditions existing at the point of firm double face bond, which normally takes place in the hot plate section. Superimposed upon these moisture conditions are the forces caused by mechanically restraining the combined board in a flat condition between the top belt and the hot plates while firm bond is being achieved.

At the point of firm double face bond, the single face liner can be expected to be wetter than after reaching equilibrium in in-process storage. Not only is the moisture added by the single face adhesive not completely removed in its progress through the single facer and bridge, but moisture from the double face liner and its glue line can be driven up into the single face liner. Therefore, as it loses moisture in storage, it will shrink, causing the edges of the combined board to warp up (normal warp).

At the point of firm double face bond, the double face liner can be expected to be drier than after reaching equilibrium in in-process storage. Tests on a number of corrugators have shown that the double face liner is essentially completely dried out in the hot plate section. Since firm bond is not reached until most of the glue line moisture is removed, it is safe to assume a low double face liner moisture at the time of firm bond. Therefore, as it gains moisture in storage, it will expand, causing the edges of the combined board to warp up (normal warp).

Since what happens to both single face and double face liners causes normal warp, how do we ever make flat board?

The answer is that there is a third, opposing, force

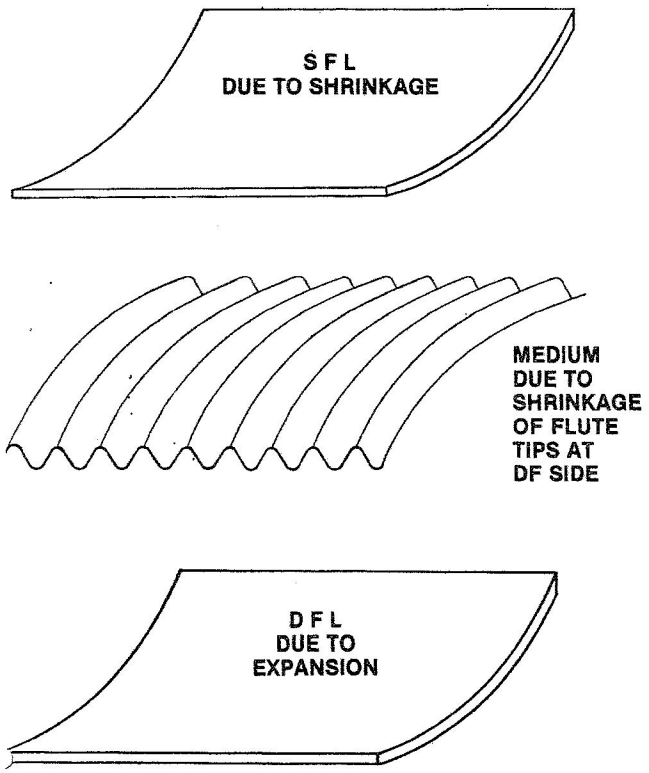


Figure 20-19. Forces in combined board at equilibrium.
Illustration courtesy of CID, Inc.

which must cancel out the two liner forces. That opposing force is the tips and shanks of the flutes at the double face glue line. At the point of firm double face bond, they are quite wet from the double face adhesive, plus the moisture being driven out of the double face liner and the adhesive by the hot plates. As the tips and shanks lose moisture in in-process storage, they shrink, causing the edges of the combined board to warp down (reverse warp). To make flat board, this force must exactly balance the two liner forces previously described. This shrinkage of the flute tips not only reflects loss of dimension due to moisture loss, but also to the fundamental characteristic of paper on being wetted and then dried to shrink to less than its original length.

This can best be illustrated by wetting the tips of the flutes of a single face web and observing its behavior. On wetting, the flute tips and shanks will expand and the board will assume a normal warp shape. However, as the tips and shanks dry out and come back to equilibrium, the board shape will revert to flat and then to substantial reverse warp. If the board were wet again, it would assume even more reverse warp on reaching equilibrium. In fact, one sample which was wet five times actually assumed a cylindrical shape.

Refer to figures 20-19 through 20-21.

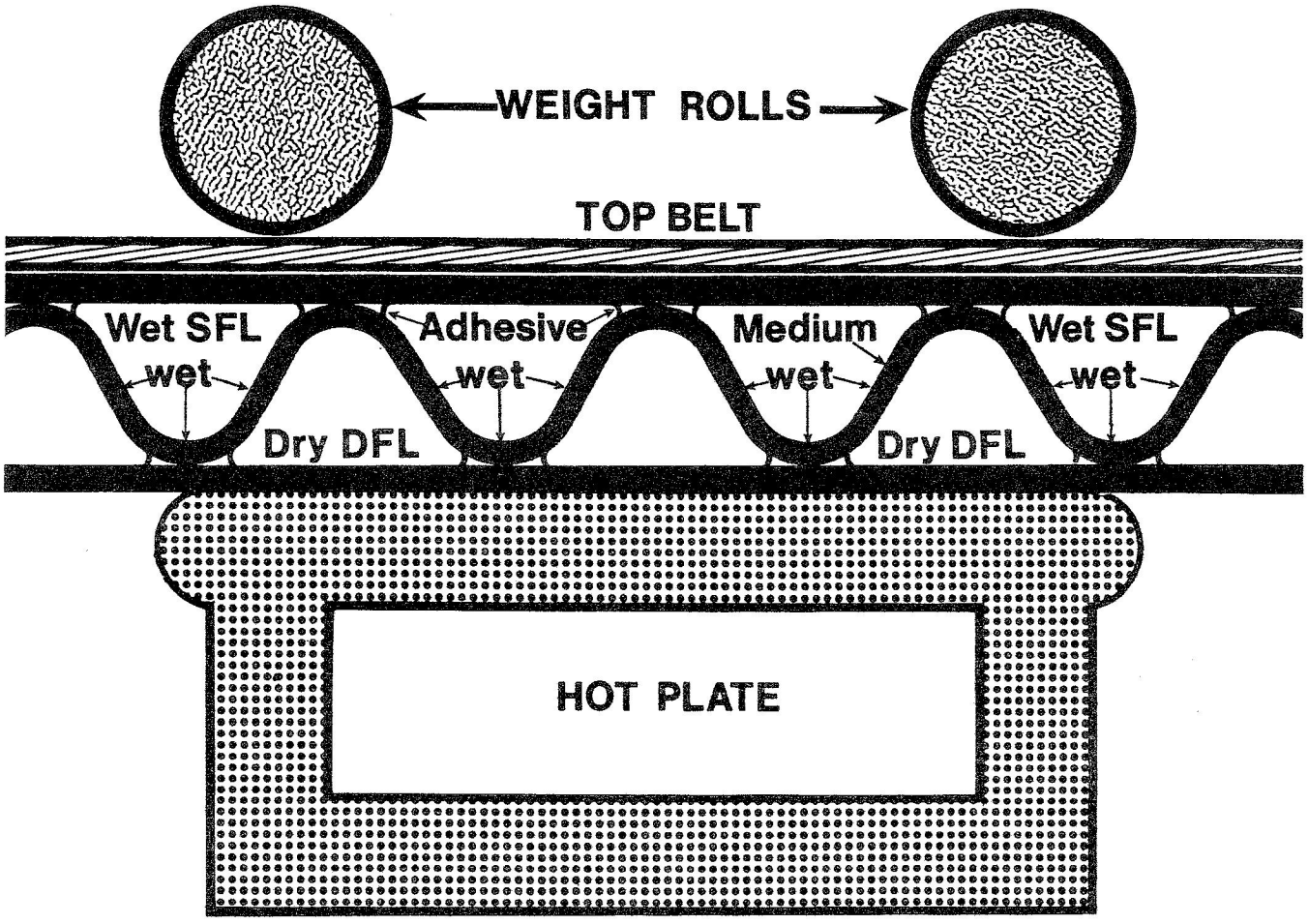


Figure 20-20. Combined board at point of firm bond.
Illustration courtesy of CID, Inc.