Web Wrinkling:

Challenges and Factors,

Solutions and Results

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Overview

Of the many challenges a plant manager or process engineer might encounter in managing a converting line, the problem of web-based wrinkling can be one of the most confounding. Converters transport miles of material across dozens of rollers and through multiple machines; these complex processes can easily result in wrinkles, torn material, misaligned cutting & slitting, poor adhesion and laminate characteristics, and many other potential problems. Obviously, any problem can result in wasted stock or material, wasted manpower, decreased production output and – worse of all – these factors affect a company’s bottom line.

The single most common problem, the issue of web wrinkling, will be discussed here. We’ll look at the most common causes, then we’ll examine some of the most common and effective solutions.

The Problem in Detail

In order to truly understand why webs wrinkle and why spreader rolls work, it is necessary to understand the most important web handling principal when it comes to wrinkling. This principal states that a web will seek to align itself perpendicular to a roll across the entry span of that roll. Additionally, for this principal to hold true and actually affect web behavior, *traction* must be present between the web and the roller.

However, almost every piece of equipment, roller, and twist or turn in the processing line represents a potential source of web wrinkling. The properties of the web or substrate itself can also contribute to wrinkling.

<u>Machine characteristics that might cause wrinkles include:</u>

- ***Rollers that are not positioned perfectly perpendicular to the web (skewed rollers or skewed web)***
    - **This is the most important and critical source of web wrinkling**
    - The web must feed into the roller at a perfect 90 degree angle. Any other angle will cause tension on one side of the web, and slack at the other end of the web – all of which results in bagging and wrinkling.
- ***Idler roll buckling or deflection:*** This is basically a bending or arching of the roller. This happens for a variety of reasons:
    - The roller core is too weak (roller is not rigid or strong enough / too thin)
    - The web is applying too much downward or upward force on the roller due to the web’s angle of turn (the harder the turn, the more weight is applied to the roller) or because the web is stretched too tight on a turn
    - The web stock is just too heavy
- ***Rollers are out-of-round or bent***
    - If rollers have even a very slight oval shape, this can cause vibrations and web bounce; this can lead to air between the roller and web, uneven tension, and wrinkles.
    - Also, even if the rolls are perfectly round, the roller shaft may be bent, which can cause similar negative effects. Plant engineers should examine runout/TIR carefully.
- ***Tension variations across different sections of the converting line***
    - When web tension goes from high to low tension, excess slack is developed, and this slack is the fuel of wrinkles

- ***Rollers that are not parallel to each other***:
  - This can lead to significant wrinkling, especially if the skewed rollers have 'grip' to the web (good traction on a misaligned roll just makes the problem more pronounced)
  - This is basically a variation of the #1 cause on the list: non-perpendicular rollers
- ***Air entrapment between the web and roller:***
  - Good contact between the web and roller is important. If there is not enough contact between the roller and the web (due to lack of tension, uneven tension, improper roller design, or other factors) then air pockets can develop. Air pockets lead to slippage, and slippage can lead to wrinkles.
- ***Roller surface design / Rollers without sufficient grip***
  - This ties back to the idea of maintaining a certain amount of friction between the web and roll. Friction can make the web stick to the roll; this prevents air pockets from developing between the roll and the web. So smooth-coated steel rolls (no rubber, no thermal-sprayed grit, no grooves) can be problematic; and the associated / resulting air pockets can be problematic.

Every plant manager should realize that loss of friction between the roller and web can potentially lead to wrinkling. One of the leading causes of loss of friction is air entrapment between the web and roll. This can be caused by a number of factors.

<u>Web qualities that can cause wrinkles include:</u>

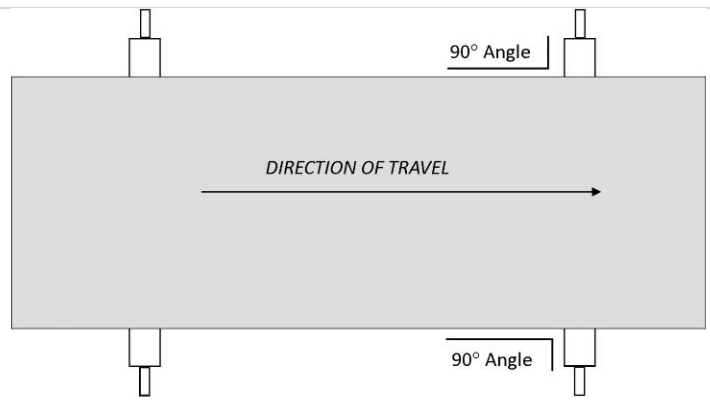
- ***Thickness variations across the web width***
  - It the web's thickness is not uniform, its stretching characteristics will not be uniform, making it difficult to produce a 'smooth stretch'
- ***Web bagginess***
  - Baggy center with tight edges; baggy edges with a tight center
  - Random unevenness in stretch tension across the width of the web

Solving the Problem

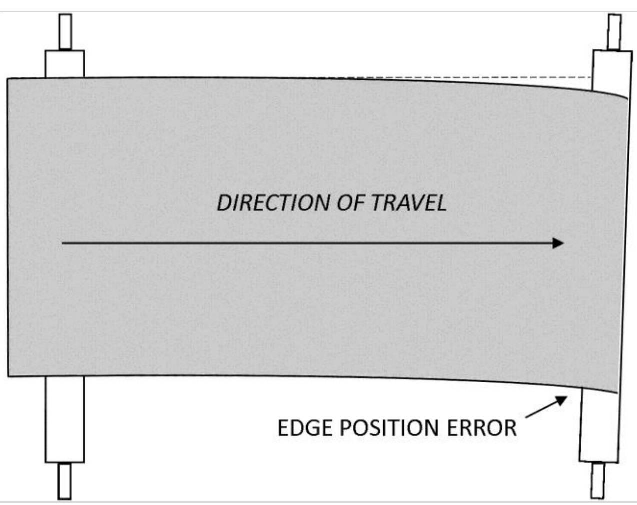
Wrinkles are a very common problem with paper, plastic film, and foil webs. When lateral compressive forces – produced by any of the previously mentioned factors – cannot be avoided, then wrinkling occurs. Web spreader rollers, either singularly or in multiples/sets, are often called upon as a solution to this problem.

Spreader rolls perform functions such as:
- spreading a web
- stretching the web
- generally causing the web to flatten out without tearing it.

However, before deciding to install spreader rolls, Menges Roller highly recommends the plant in question undergo a complete machine alignment process. Engineers should painstakingly adjust all rollers and guides to insure they run at the exact angle specified. As stated earlier, a primary cause of web wrinkling is web stock running at a non-perpendicular angle to the roller.



This figure indicates the proper angle of attack web stock should take as it enters the roller. This rule should be followed no matter what the roller type, or whether the web path is sloping up or down. Any angle other than a perpendicular (90°) angle will cause resistance and bunching on one side of the web, and bagginess on the other side, which leads to wrinkling.



This figure indicates an often-seen error in roller alignment and edge positioning as the web enters the roller face. This is a very common error in machine calibration, almost always resulting in significant wrinkling. Tension is very high at one end (top), while the other (bottom) has little tension, inducing bagginess and wrinkling.
Also, if the problem is not solved, the bagginess and wrinkling could carry on down the converting line.

Roller geometry should also be examined, testing runout (TIR: total indicated runout) and ensuring the rollers are not out-of-round, which often causes vibration. Even if rolls are perfectly cylindrical, bent shafts and roller cores might also cause vibration; this results in web bounce, which leads to loss of friction between the web and roller (introducing air between the web and roll), ultimately resulting in web wrinkling.

Plant managers should take care to ensure all rollers are perfectly cylindrical, with a minimum amount of TIR, and aligned within tolerances appropriate to the web material.

In certain cases, wrinkles can also be avoided by correcting certain errors in the converting process. Is the equipment installed as suggested by the OEM? Is it being used for the job it was designed to perform? Is the linespeed within the parameters specified by the equipment manufacturers?

If these adjustment and alignment procedures are not successful in remedying the web wrinkling problem, installing web spreaders is recommended. Additionally, we must realize that wrinkles do sometimes occur even if it seems all the proper adjustments and calibrations have been made throughout the process line. One notion we have to understand is that it is almost impossible to achieve perfect harmony across every element of a complex converting process: it is almost inevitable that one of the factors will be slightly out of tune, whether it be a machine, the web stock itself, or just a single misaligned roller, guide or blade.

<u>Web Spreaders: Location, Quantity and Design:</u>

For plant managers and engineers that have decided to use web spreader rollers to eliminate web wrinkling, the following factors should be considered: Location, Quantity and Design.

Location:

One key approach for eliminating wrinkles in the converting process is developing a systematic solution that isolates the wrinkles, sequestering them within the confines of a specific converting operation. Wrinkles can tend to spread throughout a production line, so isolation is quite important.

- Menges Roller recommends installing web spreader rollers just prior to any questionable converting operation. This sets-up the converting station with a smooth-flowing web, properly prepared for manipulation via the actual converting process. Sometimes it can appear as if the converting operation itself is causing wrinkles. Yes, this is possible; but engineers should check to make sure the actual web condition (as it enters) is not the culprit. If the web's condition is at all questionable at the entrance to the converting station, install web spreader(s) as needed.
- In situations where the converting equipment or converting station appears to be causing the wrinkles, engineers should make sure the wrinkles are eliminated before they are passed along to further stations. So in these situations it is important to install web spreader(s) at the tail end of the machine. Even if a process or machine is making very small wrinkles, it is important to eliminate them; wrinkles have a tendency to grow, so pro-active approaches work best.
- In rare cases, it may be necessary to install web spreaders on both sides of a process. This is usually not necessary, but it has been done it extreme cases of web wrinkling. This condition is primarily seen where older equipment is being utilized or when machine calibration mechanisms are non-existent or non-functioning.

Quantity:

The number of web spreaders necessary to accomplish the task depends, well, on the task. What are the conditions? Do we see massive wrinkling? What level of wrinkling is acceptable to plant management? At what level of wrinkle will your machines not accomplish their converting task successfully? How well does the web stock respond to the web spreaders in question?

In most cases, one web spreader at the entrance to a converting station will be sufficient in smoothing the web sufficiently for proper execution of the conversion process. However, the Menges Roller Team has seen rare instances where it has been necessary to install 2 or even 3 web spreaders in a row. More often than not, it is better to install several along the whole conversion line – which maintains web smoothness in a uniform fashion, never allowing the web to get to the stage where it is wrinkling so bad that you need 2 or 3 in a row.

Due to the large number of factors and variables – and the fact that each plant is different – it is impossible to make blanket statements about how many web spreaders should be used without carefully examining the specific situation at hand.

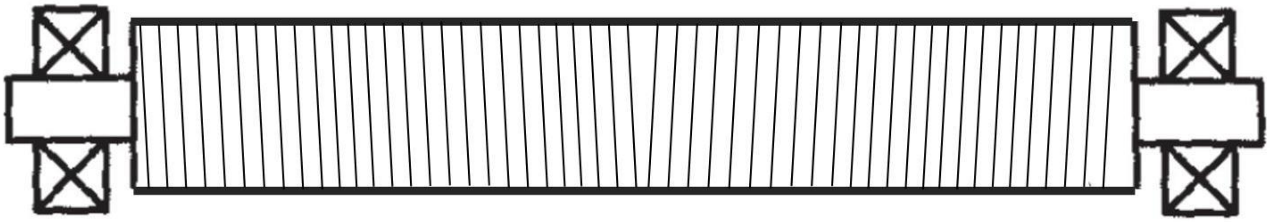
If a converter has a modern plant with smooth operations in "just this one problem area" then it does not make sense to install web spreaders at multiple points: solving the problem with one or two well-designed rollers, placed in the proper position, should be sufficient. But if the plant has a consistent "ready to wrinkle" state across the entire operation, then it makes sense to install multiple web spreaders in several key points.

Design:

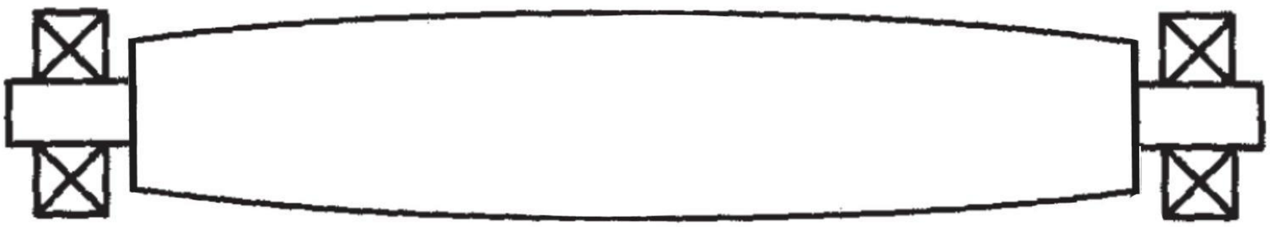
The design of a web spreader can also be a key factor in determining the effectiveness of solving the problem, and thus determining how many are required. If the design works really well, just install one. If the design is only partially effective (because the wrinkling problem is quite excessive), then even the best web spreader may require multiples of 2 or 3 to be installed.

Web spreaders fall into three main shape categories, with multiple variables for material covering compound, material grooving and texture options, and size dimensions. Quite often, certain shapes are associated with certain finishes or certain rollcover compounds. But remember, it is possible to mix and match compounds, shapes and textures into any number of combinations: this is just a summary – *the best solution is to always look at your specific situation and problem, then develop a customized solution.*

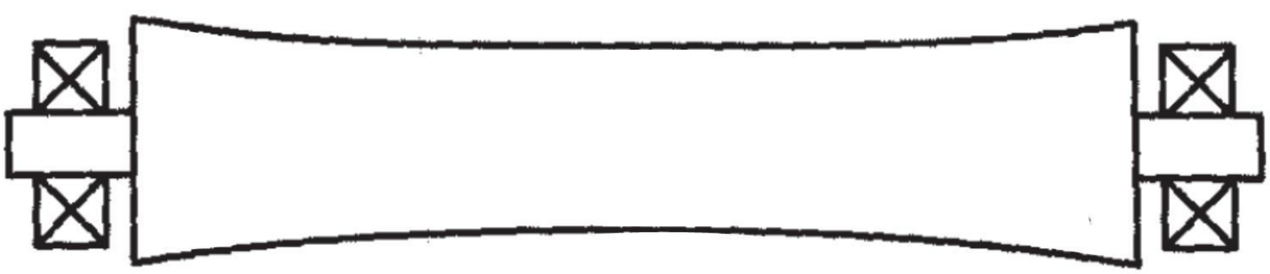
All of these designs and options are available through Menges Roller. We encourage customers to work closely with roller engineers. Small design tweaks can make a significant difference, and only an experienced converting expert or engineer can provide the advice necessary to select the proper materials, design, texture and profile.



This is the 'traditional' web spreader design. It is rubber coated and has grooves that stretch the web from the center outward toward the edges. There are dozens of rubber compounds available, with various levels of hardness, chemical resistance and ability to withstand abrasion. The groove angle, depth and spread are other variables. Designers should keep in mind a web-spreader's need to have significant friction with the web.



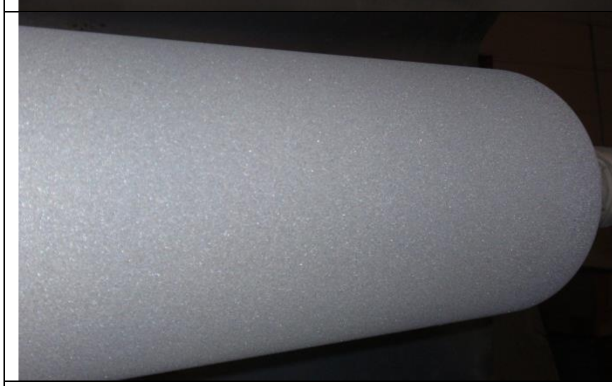
This is the 'convex crown'. A crown can be built into any roller, and this design is not typically used as a stand-alone web spreader. The crown is usually not dramatic (usually not visible to the naked eye) and is often calculated in hundredths or thousands of an inch. Most crowned rollers are rubber covered and the crown is shaped on the rubber. However, some crowned rolls are steel or aluminum; it is possible to crown metal. If steel or aluminum is used (no rubber cover), friction-enhancing finishes are sometimes applied to the metal, including acid etching or flame-sprayed thermal coatings.



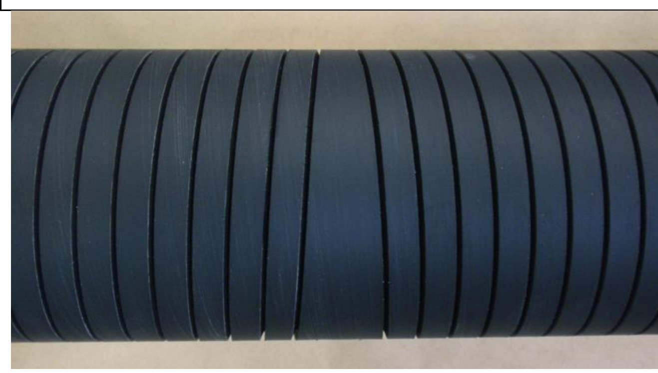
This 'parabolic' concaved design is an alternate version of the convex design, and the same material options apply. It may be rubber covered or have an all metal design, with or without a friction-enhancing surface finish such as acid etching or flame-sprayed coat. The increased diameter toward the outside edges works to pull the web's ends tight. Having a larger diameter at the ends increases surface speed at the edge of the web, pulling the web outward, thereby eliminating wrinkles. One advantage this design has over the convex design is this tends to 'steer' the web into a pre-set track a bit more effectively, eliminating drift.

Hybrid web spreaders are also available. This aluminum roller has grooves milled into it which similate the pattern you would see in a traditional rubber-coated web spreader.

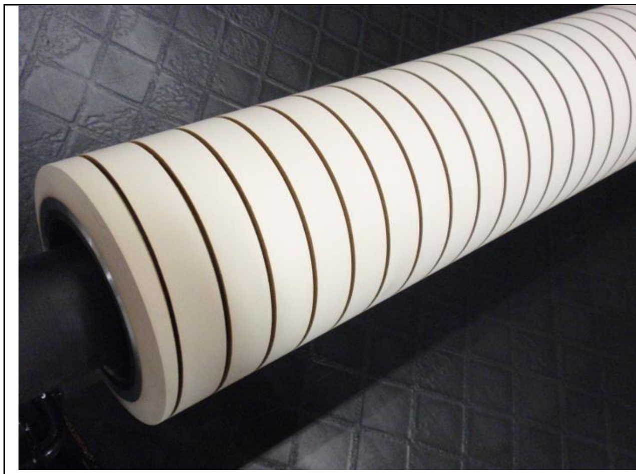
These twin rollers have been acid etched, creating a matte finish along the roller face. This finish adds a certain amount of friction as the roll meets the web.



This roll has been thermal sprayed with a tungsten carbide material. This coating not only provides friction and grip (it is slightly rough to the touch), but it has tremendous chemical and abrasion resistance properties.



These two pictures show a traditional rubber-covered web spreader, with grooves that push a web outward. The type of rubber used can be an important factor in determining the grip a web spreader has on the stock.



Deadshaft web spreader without bearing assmbly.

Wedshaft web spreader completely assembled.

Web wrinkling is a problem that has existed since the industrial revolution. Materials and processes have changed, but the laws of physics have not. A solution that worked yesterday (on different material running on a different machine) may not work with a problem you're having today. And, just like cars or airplanes, converting machines do have design faults – but rarely are they recalled and fixed for free by the manufacturer. To a certain extent, OEMs rely on the ingenuity of plant managers and the expertise of aftermarket suppliers such as Menges Roller to optimize machine performance and realize converting process efficiency.

This document was designed to help converting technicians and engineers understand the basic factors surrounding web wrinkling, and then explain the most common solutions. Highly-scientific documents and technical papers are available on this subject. Should you require more information, speak to a Menges Roller Sales Engineer.