WEB BAGGINESS: MAKING, MEASUREMENT AND MITIGATION THEREOF

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ABSTRACT

Web bagginess is a defect so tenacious that few machines will totally escape its grip. It is so pervasive that it can be found on materials as diverse as tissue, writing paper, carpet, nonwovens, plastic film and steel. It is so chameleon-like in its appearance that it is given many aliases such as baggy lanes, camber, layflat, puckers and many more. Yet as common as this ailment is, objective measurements are tedious or fraught with uncertainty or both. This means that culling and rejection is typically done by subjective visual appearance. As common as this ailment is, few can take a specific baggy lane and point to the machine element that made it, much less how it was made.

This paper begins by defining bagginess in three entirely equivalent ways based on variations of flatness, stress and strain. It then develops a taxonomy of bagginess by classifying the general case into major groups depending on how the stress variations are distributed. Next, it discusses all of the common and most of the arcane means of measurement. Each is described by principle of operation, application and practical difficulties. Next, the more common sources of bagginess, such as nonuniform formation and yielding during handling are described. Finally, a methodology is developed for troubleshooting bagginess whose source is not certain.

MOTIVATIONS

Web bagginess is a defect so tenacious that few machines will totally escape its grip. It can be found on web formers, calenders, coaters, printers, weaving machines, winders and so on. It is so pervasive that it can be found on materials as diverse as tissue, writing paper, carpet, nonwovens, plastic film and steel strip. While it is expected that defects share similar physics across dissimilar grades, it is very unusual for a defect to have such a range as does bagginess. Thus, even though the defect may not be the number one cause of waste on a particular machine, its total cost to the web industry could be quite large.

Web bagginess is so chameleon-like in its appearance that it is given many aliases such as baggy lanes, camber, frogbellies, layflat, puckers and many more.[1] This coupled with its appearance on such a wide variety of webs and processes lends people to believe that their situation or defect is unique, even though there is clearly an underlying commonality as we will see.

If this were not enough, bagginess is difficult to measure. While the industry has many instruments and measurements to choose from, the common ones do not correlate well to bagginess because they do not measure anything closely related to it. While there are ways to measure bagginess more directly, most are tedious or fraught with uncertainty or both. This means that culling and rejection is typically done by subjective visual appearance. This means it is difficult to research process connections and to measure progress as there are few good measurements of this vital quality parameter.

Finally, there are so many different root causes of bagginess.[2] In one case, a baggy lane could be caused by a tiny imperfection in a die lip, while in another it might be due to a local hot spot in an oven. It could be caused by a nonuniform calender nip, a misaligned roller, a spreader or a slitter. It is not unusual to have several areas of bagginess side-by-side on the same web, yet each have a different root cause. For these reasons and others, bagginess can be a very difficult problem to diagnose. Few can take a specific baggy lane and point to the portion of the machine that made it, much less how it was made. Thus, it is not surprising for people to utterly fail to make any improvement in web flatness.

Yet there is good cause for hope. It begins by understanding what bagginess really is. However, the real progress is made when you let a particular process tell you about itself and when you use those measures of bagginess which do work in a particular situation. Looking only where materials can be permanently distorted can minimize the search for the source of the defect. The source of the defect may reveal itself merely by the location and shape of the bagginess profile.

BAGGINESS PROBLEMS

There are several difficulties posed by the baggy web. First, the visual appearance of a baggy web is not as appealing as a flat web. Mere cosmetic differences can make the difference between keeping an order and losing it to a competitor, much as a dent in a fender can reduce the appeal and thus value of a car. Second, the baggy web may not coat or laminate well. In the former case, leveling coaters such meir rod and knife coaters will leave more coating in the baggy area than in the tight area[3]. In the latter case, the baggy web may refuse to bond flat to its mate, with voids or wrinkles as a result. Third, the baggy portion may float over rollers[4] causing process difficulties such as backside treat on a corona treater. Fourth, the baggy portion of the web may not wind the same as the tighter portions.[5] Fifth, the cambered web, which is a subset of bagginess, can cause guiding, tracking and web path control problems.[6,7] These would obviously raise havoc with printing registrations. As a final example, the baggy web may not feed well through machinery as a sheet, such as with the ubiquitous paper jam in a copy machine.

The most debilitating characteristic of the baggy web, however, is that it simply refuses to go through nips. As seen in Figure 1, the baggy portion of the web tends to collect behind the nip as a locally loose bulge or 'bubble'. If you are lucky, the bubble will be stable and present no great trouble. In other cases, the bubble will grow with time until it gets large enough to be entrained into the nip in a gulp, leaving the telltale smile or angled wrinkle in its wake. The reason the baggy web collects in a bubble is that it is an area of longer 'natural length'. Since the nip is essentially a metering device, the longer baggy portion accumulates and gets behind the tighter portion. If we did not have to get the web through a nip, the bagginess might otherwise pose few problems in many processes. Unfortunately, the nip is ubiquitous in converting as this is how we do calendering, coating, laminating, printing, winding and many other vital manufacturing steps.

BAGGINESS DEFINED

Bagginess can be defined in at least three entirely equivalent ways: as a deviation of flatness, a deviation of stress, or a deviation of strain. This gives us the flexibility to choose whichever means is most convenient to work with in any particular situation. Since they are equivalent, a web will either be baggy or will be not baggy by any of the definitions. It is also possible to quantitatively convert from one measure to another, albeit with some difficulty.

The easiest definition of bagginess is a web that refuses to lay/run flat and straight. While it is possible to use this definition for a web running in a machine, it is much safer to do so on an inspection table where the web is under no external stresses that can disturb flatness. The risk is that the web can appear to be baggy in a machine section due to nonuniformities of the machine itself, such as caused by rollers with are misaligned or vary in diameter across their widths. Experienced operators will compare the appearance of the web in several sections of the machine to tell the difference between crooked web and crooked machine. A web that is baggy will appear loose in the same CD positions in most spans. On the other hand, the web may be tight on the front in one section and loose on the back in the next if the machine is crooked. An exception to this material/machine discrimination technique is with machines with excessive deflection, such as is common on cantilevered machinery. For example, a flat web may appear loose and baggy on the front side of every section because the spans are shortened due to roller bending as seen in Figure 2.

Thus, it is much safer to remove the influences of the machine when diagnosing bagginess. On an inspection table, the baggy web will either not lay flat, or the edges will not be straight or both. The exceptions to this simple test are obvious and include hard wrinkles and curl that can cause the web to not lay dead flat even when it is not baggy. The visual inspection technique is quick, simple and can be more far more sensitive than measurements made by instrument. More will be said about this invaluable tool in the next section.

A more quantitative definition of bagginess can be made based on stress variations. A baggy web is one whose stresses are not uniform. These stresses may vary either with respect to MD (machine direction or downweb) position or more typically CD (cross direction or transverse direction) position, or both. The stresses of concern are most typically MD, but could be CD or inplane shear. This definition must be tempered so that any stress variations caused by the machine, such as by crooked or uneven rollers, temperature variations and so on are factored out. Again, we see the challenge of cleanly separating material from machine as was seen in Figure 2.

In metals and other industries these variations of stress are known as residual stresses. The part released from the mold or die has stresses locked inside, perhaps due to uneven cooling rates or forming strain variations. These stresses on thick parts are, for the most part, invisible as they are insufficient to cause significant geometry changes when resisted by the part's stiffness. This does not mean that the stresses are insignificant. Composite roller covers can have so much residual (hoop) stress locked in due to shrinkage during curing that they can split open like an over-ripe radish merely sitting in storage. Sometimes residual stresses are intended and useful, as illustrated by safety glass on automobile windows, which is designed to shatter into small pieces rather than into large wicked shards. The web, on the other hand, has very little bending stiffness, which goes as the fourth power of caliper, and thus responds much more visibly to residual stresses.

Alternatively, we can define a baggy web as one whose strains are not uniform. Again, the strains may vary with MD, CD or both. Again, the strains may be MD, CD or inplane shear or a combination. Mechanics people have long been comfortable with the interchangeability of stresses and strains through material relationships such as Hooke's Law. While the stress-based definition is more intuitive, the strain-based definition offers more options for measurement such as by the bow, fold or strip test techniques described later.

TAXONOMY OF BAGGINESS

A complete description of bagginess would specify MD, CD and inplane shear stresses at all points in the web, much as you might obtain as output from a FEM (Finite Element Model) for a plane stress case. However, this detailed mapping of residual stresses is neither practical, nor necessary. Since bagginess tends to favor certain patterns, we need only be to describe and discriminate between them. The first simplification is to focus on MD stress distributions rather than on CD or inplane shear stresses. There are several reasons for this. The MD stress variations tend to larger values in real webs. They are also easier to measure and more intuitive because we are already accustomed to thinking about that direction when working on drives and tension controls. Finally, MD stress variations capture the essence of most problems.

CD stress variations do exist, particularly in the category of baggy or tight patches. This stress is constrained, however, in that it must vary with respect to the MD. If, for example, the CD stress were compressive at a particular CD location, but uniform with MD position, this would mean that there was a 'trough wrinkle' that merely needed spreading to return the distribution to uniformity. Similar constraints exist with the MD stress which can't be uniform with CD but vary with MD as this would be pulled out by the tension system in an open span. Shear stresses are the most complicated and perhaps offer the least insight. It can be shown that shear stresses will accompany any MD or CD stresses that vary with position.

The second simplification is to focus only on the MD stress distributions that are most common as given in Figure 3. Perhaps the most common case is baggy edges. As seen in Figure 3A, the MD tension is lower at the ends than in the middle. Using the 'shape' tool for problem solving, we know that the source of the bagginess must have a similar smile or frown-shaped profile.[8,9] Unfortunately, the smile or frown profile is ubiquitous on machinery and thus makes determining the specific element and parameters that caused the baggy edges more difficult. [10] Though slightly less common, a baggy center as shown in Figure 3B can also result from a smile or frown-shaped process profile. For example, tender webs such as nonwovens might distort as they are pulled over an aggressive bent pipe spreader. The center may be stretched beyond the yield point and thus gets longer than the edges.

Superficially, the baggy lane may appear like a baggy center because they are both longer and looser there. However, as seen in Figure 3C, the characteristic width of a baggy lane is narrow and it has much higher stress gradients than the baggy center. Alternatively, the web may be characterized by relatively narrow tight lanes, as seen in Figure 3D, which make the remainder of the web appear baggy. The distinguishing characteristic between baggy lanes and tight lanes is which has the largest portion of the width. Another commonly discussed case is camber as shown in Figure 3E. In a case of pure camber, the stress or strain varies linearly from one side to another. Here, the web will have one slack edge while the other will be tight, causing tracking issues. Pure camber on a full width web is less common because it may be easier to identify and correct than other types. You merely need to find the tipped element and tip it the other way. However, pure camber is common on narrow webs that have been cut from a wider raw material. For example, the end cuts of baggy edged material will be cambered. Finally, the web may have baggy patches as seen in Figure 3F. The patches are local areas of excess length and/or width. Though they are common enough, they are extremely difficult to work on because most of the baggy measurement systems will not work in this case. Also, the come and go nature of the distribution can make analysis frustrating.

Obviously, the real world is seldom so smooth and symmetrical as shown in these figures. Nonetheless, the characters described above should still be distinguishing. Also, real cases seldom restrict themselves to but a single case at any one time. More often, there are multiple cases operating simultaneously. If so, the worst may be singled out for treatment first. The stress distributions are certainly free to change as the web proceeds through a machine, so that diagnosis may need to be repeated at key process locations, usually beginning at the furthermost upstream location or at the most severe location. Finally, the stress distributions can and will change with time. Normally, however, the character of most machines and webs tends to be variable across the width, but much more stable with time for at least minutes, if not for hours, days or even years. However, the stress 'fingerprint' of the web's profile can change abruptly after grade changes, machine shutdowns and especially after maintenance of certain sensitive elements such as formers and nips.

DETECTION AND MEASUREMENT OF BAGGINESS

The most important tool for bagginess detection is, for better or worse, your eye. A strain difference of as little as 1/10,000 will be readily visible on thin stiff materials. What you will observe is that baggy edges will appear as ruffles, a baggy lane as stitches oriented in the MD and baggy patches as, well, bulging patches. The reason the web does not lay dead flat, just as with wrinkling, is that it has buckled in compression to accommodate the extra length. [11] The only structural difference between wrinkling and bagginess is that while wrinkling is induced by external forces, bagginess is induced by internal residual stresses.

The safest read of the web is made when it is removed from the machine. Bright low angle lighting helps to bring out the hills and valleys. Near the machine, the web might be laid out on a flat aisleway and observed against a flashlight pointed in the MD. Better yet, many will construct light inspection booths to provide a dead flat surface and where ambient lighting is blocked on all but one side, the observing side. Controllable back and/or side lighting aids for bagginess detection while lighting underneath and overhead is used for other web quality control inspection. While visual inspection is usually nonquantitative, one can turn it into a measurement. One merely needs to count the number of 'ruffles' in a given span. The severity is the sum of their heights over some standard length. This could, in principle, be converted into a strain by assuming the ruffles assume a half-sine shape and calculating the extra length of sine of that wavelength and amplitude over the standard span length. In practice, however, we don't know what the strain of the neighboring material is. Web flatness can be measured by both contacting (LVDT) and non-contacting (laser) sensors. However, these measurements have not enjoyed wide application outside of the metals industries.

Bagginess can also be observed in a machine, but with much less sensitivity. One problem is that web line tension can pull bagginess out of compression as seen in Figure 4. Without local compression, there is no buckling and thus lack of flatness to observe. Another problem is that the roller misalignment will cause a tipping of the stress distribution as seen in Figure 5. Thus, crooked rollers will make the web appear to be baggy on one side. It is possible to quantify in-machine bagginess by measuring the sag difference across the width (e.g., ends versus center) in a long span. However, this technique only works well when the sag difference is extraordinarily high, such as might be on the baggy edges of creped tissue paper. Another in-situ technique is to feel the web's tautness with your fingertips. Again, this technique is adequately sensitive only in some situations, is accessible only in some situations and may create a threat to safety in others.

We can make use of the fact that line tension will remove compression from the web to construct a bench tester of bagginess. This tester is similar to a giant tensile tester as seen in Figure 6. A web specimen is fixed along one edge of its length on a large table. The other edge is also clamped, but this grip is moveable, such as with a hand-cranked windlass. The load on one of the grips is measured, perhaps by a spring scale that provides a helpful compliance. The load to flatten the web, which can be converted to strain via Hooke's Law, is a fundamental measure of bagginess. This load is also a good performance predictor. If the load to flatten is greater than the anticipated running tension, the web will be puckered and may not pass trouble-free through nips. If, on the other hand, the load to flatten is less than the running tension, the baggy web should run flat and probably trouble-free. This technique, while simple quantitative and fundamental, does have some limitations. First, the test technician must judge when the web is flat in the testing fixture. Some may look for dead flat everywhere, while others may allow a few stubborn but tiny puckers at their decision threshold. Second, the technique does not work as well with stiff webs that may break before they are flattened.

Another lab test technique is the bow or fold test. As seen in Figure 7, the web is laid as flat as possible on a flat surface. The severity of bagginess is measured as the bow on the inside edge of the test specimen over a standard length. Alternatively, the web can be folded down the middle and half of the difference between the position of the edges is the same measure. These measures are also fundamental and can be converted to strains by first calculating the radius of curvature.

1) $r = l^2 / (8b)$

Next, the radius of curvature is converted to strain.

2) $e_x = w / (2r)$

and finally to stress through Hooke's Law.

3) $S_x = E_x e_x$

While the bow and fold methods are simple and among the most common of the quantitative techniques, they do have shortcomings. The most serious is that they only accurately measure the case of pure camber where stresses vary linearly from one side to the other. In any other situation, the measurements underpredict the bagginess. Indeed, with symmetrical distributions of stress, such as with baggy edges, the measurement shows no bagginess as the edges are straight (in one plane, but ruffled in the other). Also, any method where the operator touches the specimen, such as flattening the web by hand, is subject to additional uncertainty.

A very sensitive method for measuring MD strain differences across the width is the strip technique. As illustrated in Figure 8, two CD lines are very carefully marked using a square to the cut edge at stations perhaps a dozen meters apart. Then, several MD lines are marked by snapping a chalk line, which are used as guides to cut the web into strips a few centimeters wide. After cutting, the strips are pulled to align one end using the square line. The difference in the length as measured on the other square line is the strain difference. The strip test clearly shows that the baggy lane is 'longer' that the rest of the web once it is freed from its neighbors which hold it back.

The strip technique is quite sensitive if either the gage length is long, or magnifying techniques are used so that resolution can reach the parts per 10,000 necessary for some applications. It may also have the widest range of application since most materials can be measured this way. Problematic exceptions include creped tissue or uncured rubber that are easily distorted and hard to handle. However, the strip test is extraordinarily tedious, most especially the cutting step. While it is possible to use a winder to cut the strips, the squareline may be hard to make there. Thus, the strip technique is best used for special troubleshooting or qualifying of materials rather than for regular quality control.

In an ideal world, quality control measurements would be made online, rather than in the lab. This would allow quick feedback so that actions or corrections could be made. We have but three choices: flatness that was described earlier, stress or strain. Since there are no online absolute strain sensors I am aware of, we are left with measurements of stress or tension. To be useful, however, the sensor must meet many criteria. First, it must be 'mill duty', meaning simple and rugged enough for the manufacturing environment. Second, it must be affordable as compared with the costs of the rejected material. Third, it must be sensitive to tension, perhaps resolving to less than 10% of the lightest running tension. Fourth, it must have minimal cross sensitivity, such as to temperature or CD tension or edges. Finally, it must have a spatial resolution of a fraction of the web's width, perhaps less than 10%. Conventional load cells, for example, meet all but the last criterion and thus are not so useful for tension profiling across the width.

Unfortunately, the sensors that do profile seldom meet the other criteria and all seem to be fraught with one difficulty or another. [12] For example, while handheld meters have long been used to check paper machine wire tensions and other applications, they often lack resolution or repeatability. [13,14] Most have a cross sensitivity to CD tensions or web edge effects. [15,16] Some are based on sound, excuse the pun, principles of time of flight of ultrasonic pulses, but are exceedingly complex. [17-20] Others that are mill duty and sensitive are not suitable for those working within a budget. [21-24] Thus, the world still awaits an affordable, flexible and trustworthy tension-profiling sensor to troubleshoot bagginess and other web quality issues.

CAUSES FOR BAGGINESS

The causes for bagginess are myriad. In general, they might be categorized as either uneven formation/processing, or brutish handling. The first web handling cause we will investigate is the misaligned roller. A misaligned roller tilts the nominally even tension distribution so that one side is tighter than another. If that side is taken beyond the yield point, the tension distribution will have a slack edge, not unlike Figure 3E. If both sides are eventually stretched into yield someplace down the web line, the result will be similar to that shown in Figure 3A. Similarly, the middle of a web might be stretched into yield if it is pulled over an excessively bowed roller or bent pipe spreader. The results would be similar to Figure 3B.

However, it is much more common for the web to be made baggy than pulled into bagginess by handling. A common example is basis weight or caliper variations that can accumulate into ridges on a winding roll. These ridges will stretch that lane into bagginess if the ratio of the diameter difference over the diameter is greater than the yield strain of the material. For example, if paper readily yielded or crept at a 1% strain, then a diameter difference of 1 centimeter on a 1 meter diameter roll would be guaranteed to stretch the web at the high spot, no matter how tightly or loosely the roll was wound. However, the basis weight does not need to be heavy in lanes to cause bagginess, one nonwoven converter I worked with found that their baggy patches after hot calendering were due to locally heavy basis weight patches on the raw material. Obviously, forming elements such as slice lips, dies, wires and nips demand special attention. Sometimes the level of attention required to level the web is much greater than a plant might be accustomed to. Other things to be very careful about are variations in temperature, moisture, solvent, and coating thickness.

Troubleshooting the source of bagginess can be difficult for many reasons as was discussed earlier. Nonetheless, there are two vital tools. The first is to note that the source of bagginess can only be an element that has the ability to permanently deform the web. This obviously includes any forming element, but seldom does it include conventional web handling elements such as idler rollers, spreaders and even winding with the exception of the gage band. Thus, on a large machine with a hundred rollers and elements touching the web, perhaps only ten are capable of web distortion. The second tool, the shape tool, screens this list even further. Thus, baggy edges can only be caused by an element that has a smile or frown shaped profile. [10] The very much-shortened list of possibilities that survives both of these tests is all that need be investigated more seriously.

FIXING OR LIVING WITH A BAGGY WEB

The ideal way to deal with a problem is to prevent it from happening in the first place. Thus, troubleshooting the element that causes the bagginess should be given priority, even though it may not be easy. You will know when you have the right answer when you can touch the spot on the particular element that is causing the bagginess, and most tellingly, make it come and go at will. Barring that, you may try to fix the bagginess after it has been created. Unfortunately, this involves careful and uniform yielding of the material. [25] Yielding can damage the web even more easily than it can fix it, especially if it is not done carefully and uniformly. Besides, this is not an option for most materials.

If you can't prevent or fix the bagginess, you must live with it. The first tactic is to adjust tensions, usually upward, in an attempt to make the system more forgiving. Second, you should eliminate every nip that is not absolutely required, and consider aggressive spreading upstream of those that remain. The final tactic is to salvage the web by slitting it into narrower widths. Indeed, the baggy lane is not 'defective' unless accompanied by a tighter lane and vice versa.

The baggy web is for many reasons, as we have seen, a very challenging web manufacturing and converting problem. It can be a most perplexing, formidable and tenaciously difficult problem. In some cases, the most effective treatment for baggy webs will be to pray that these troubles never visit your plant.

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Figure 1 – Bubble behind the nip

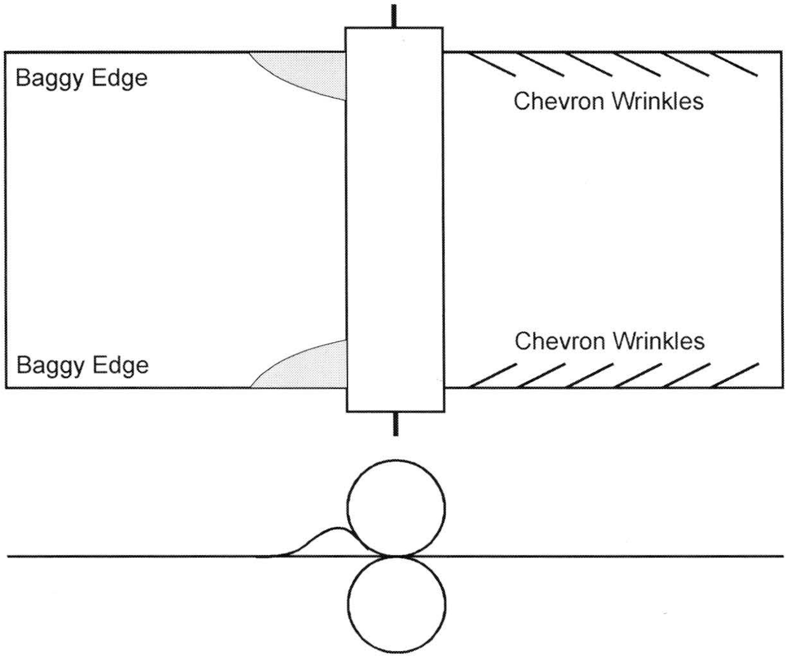


Figure 2 – Baggy 'Appearance'

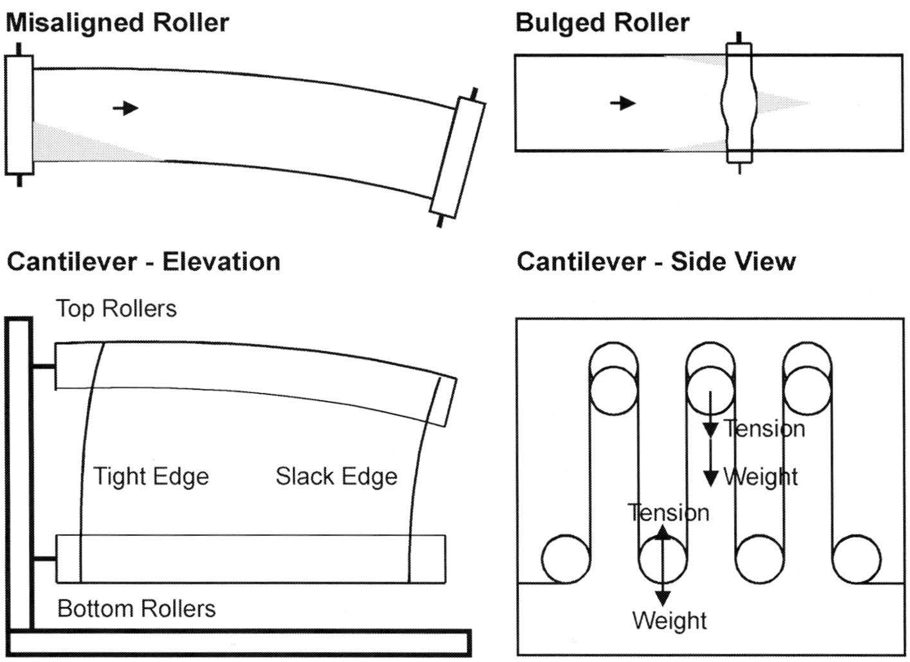


Figure 3 – Classification of Bagginess

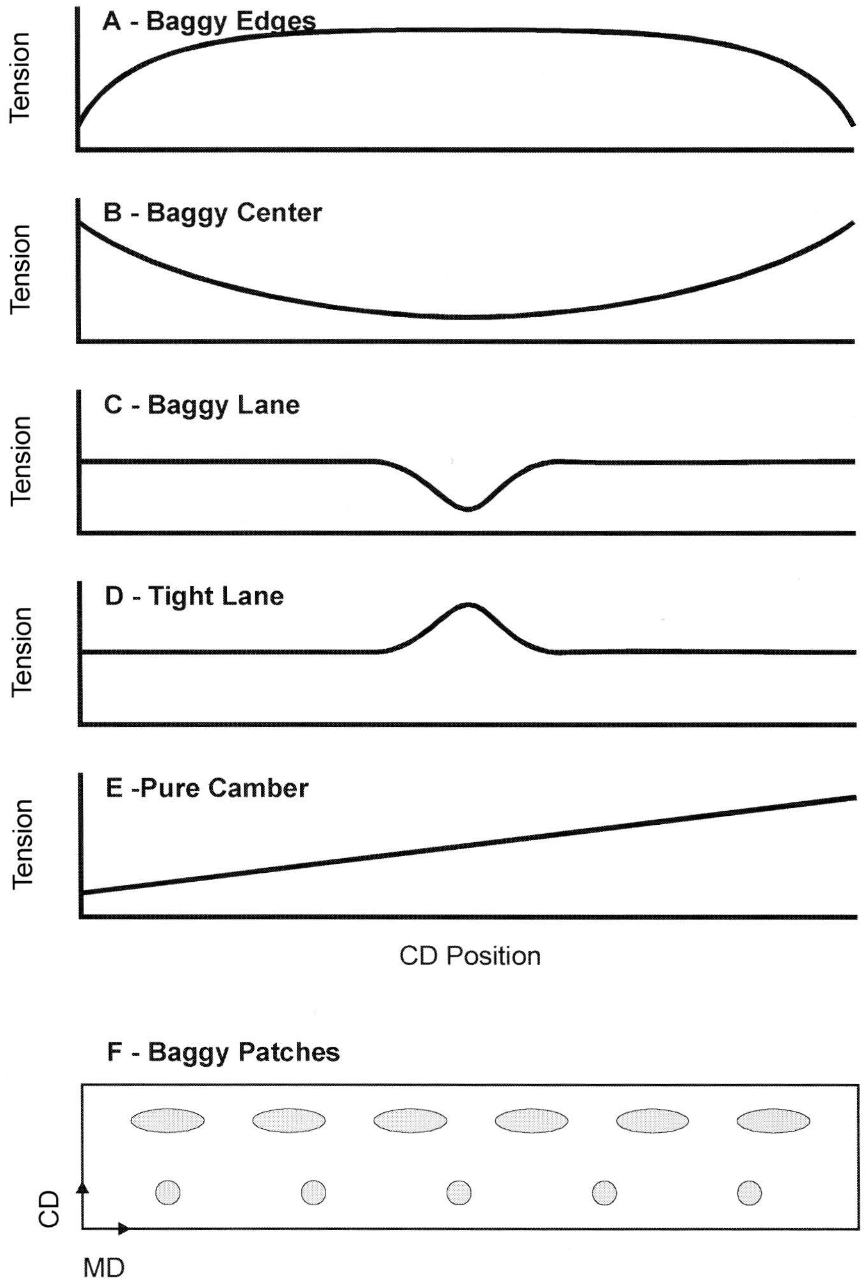


Figure 4 – Effect of Line Tension on Tension Profile

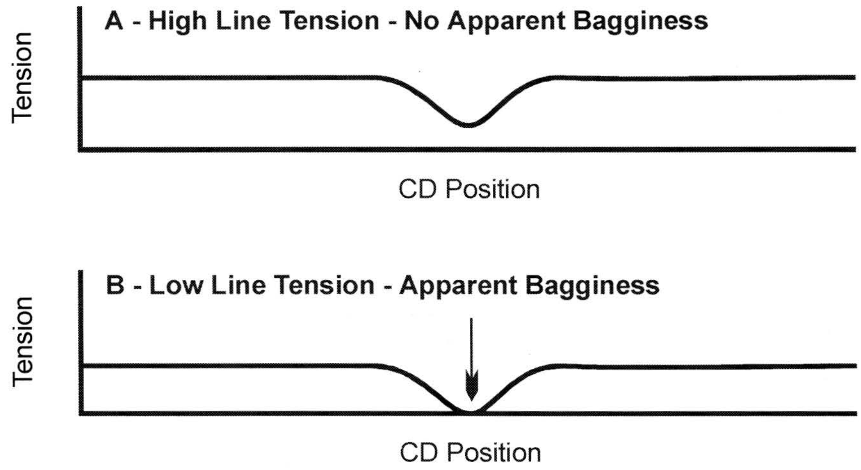


Figure 5 – Effect of Roller Misalignment on Tension Profile

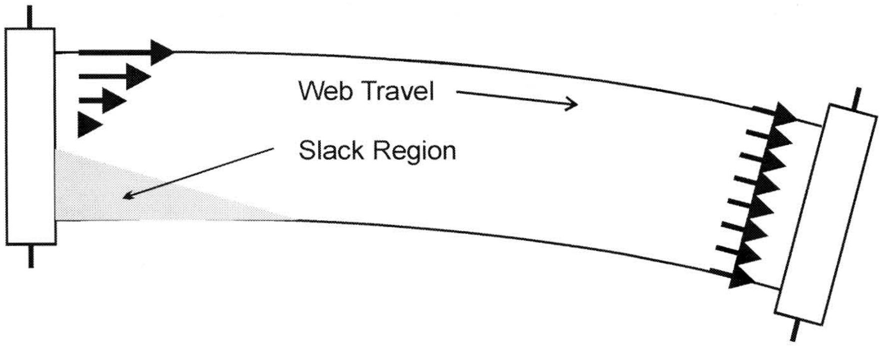


Figure 6 – Bench Measurement of Bagginess

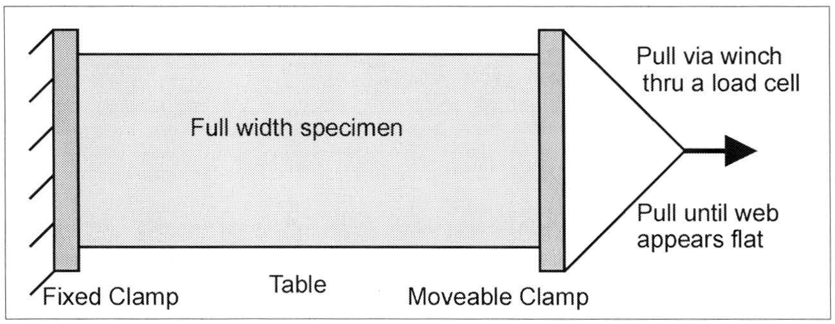


Figure 7 – Bow/Fold Test

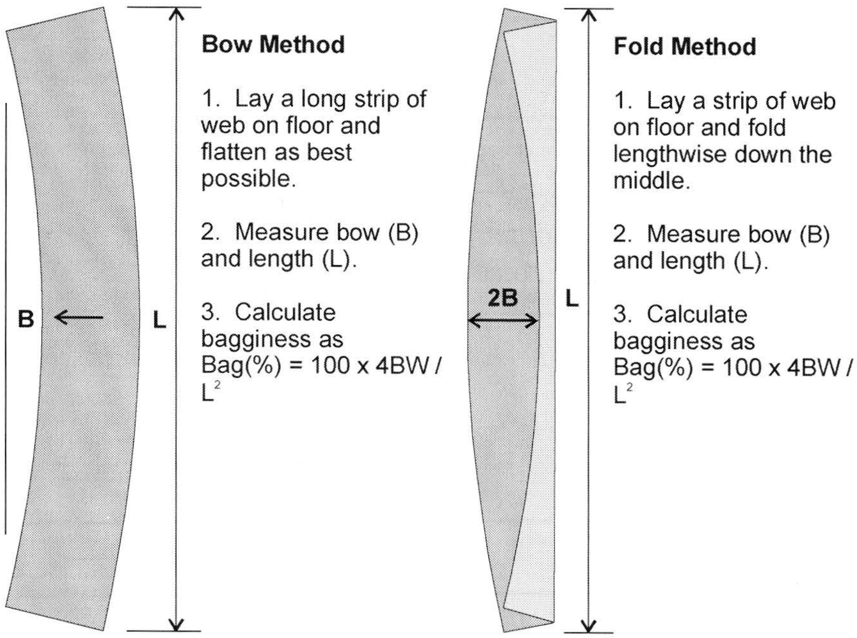
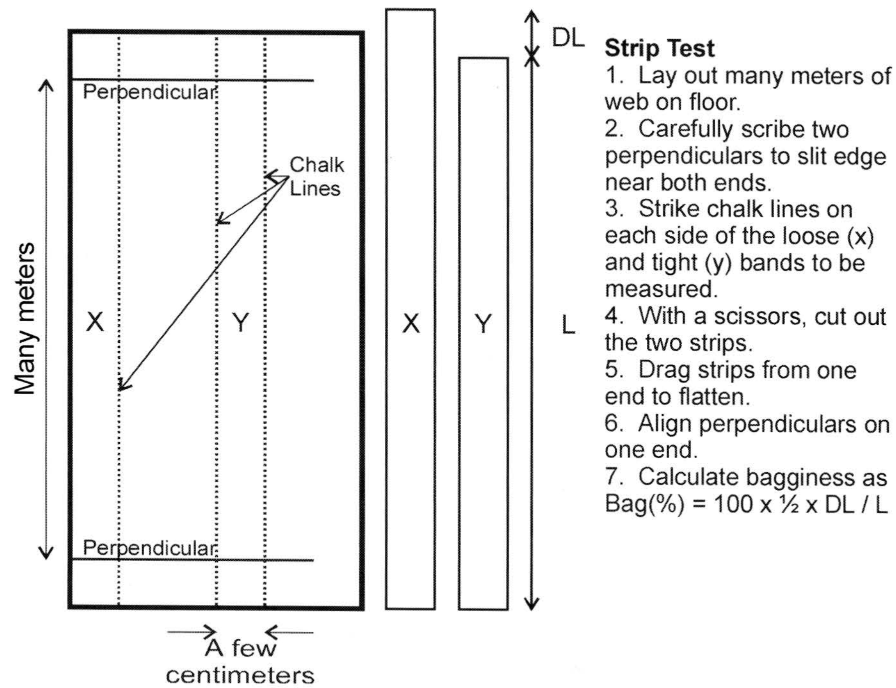


Figure 8 – Strip Test



Name & Affiliation	Comment
D. Pfeiffer – JDP Innovations	We had a discussion earlier about tin canning and ridges that are circumferential around the roll and I just thought of another cause. That is humidity welts in materials which grow in the cross direction when humidity is active.
Name & Affiliation	**Answer**
D. Roisum – Finishing Technologies, Inc.	I did not distinguish whether strains were caused by tension, moisture, or temperature. It does not really matter, we could create a tension difference, as we saw in the previous two discussions with moisture or temperature. Therefore, the risk factors are gauge, temperature and moisture variations. These are the three things you commonly review to start with.
Name & Affiliation	**Question**
D. Jones – Emral Ltd.	You mentioned pure camber as a problem with bagginess. I'm wondering what your experience is on the lateral stability, wander, tracking issues caused by cambered webs?
Name & Affiliation	**Answer**
D. Roisum – Finishing Technologies, Inc.	It depends on which industry you're looking at. With materials like metals and board which are very heavy, slight amounts of camber will often cause stick slip behavior, where the web runs over and comes back as camber fights to go on one way and the machine tries to take it the other way. What you see on very heavy materials is a fight going between the web and the machine. On light materials, such as in the printing industry, it's major trouble for registration. If they have camber, for example, and if they cut an 'A' roll off of the front side of the machine, and then they go to the 'Z' roll, or the backside of the machine for the next supply roll, very often their registration controls are going to be out of sync for several minutes as it tries to home in on this new camber and get the colors to register. Many printing press people take advantage of this knowledge by running all of the 'A' rolls first in sequence then all of the 'Z' rolls. Actually, the smart ones pick the middle rolls first and hope they got enough rolls to get them through their shift and let the others deal with the end rolls.
Name & Affiliation	**Question**
B. Feiertag – OSU	One of the most common observations about baggy lanes is gauge variations wound into a roll. In other words, you may form the web and it might be nice and flat, but it's got gauge variations. As you wind the roll and the layers

	increase, the radial and circumferential stresses increase to the point where you actually stretch the material. If it's a polymer material for example, it will take a set over a period of time and it may or may not come out when you unwind the material. What I've commonly found is that bagginess will be bad at the beginning of the roll and as the roll progresses your bagginess will get less and less which is a clue to the fact that the source can be these gauge variations.
Name & Affiliation	**Answer**
D. Roisum – Finishing Technologies, Inc.	Very true. One of the sources of deformation is winding. We had a discussion this morning. The claim was that most of our winding problems in some grades come from profile variations more than they do the nominal winding tensions. So, if you wind over a gauge band, you're going to have trouble. First, the wound roll is the most sensitive measurement of caliper we have by about one or two orders of magnitude beyond test lab measurements. Second, the wound roll is the fussiest customer for caliper in part due to these gauge bands but perhaps other defects too.
Name & Affiliation	**Question**
K. Good – OSU	I think the offline measurements that you speak of here are good for looking at the defects that are persistent down the machine direction. I see many cases where the defects are not persistent and they crop up at a CD location then they disappear and then they perhaps move to another CD location. We are beginning to see use of closed loop control based upon a cross width tension profiles and other measurements. There is certainly a place for on-line measurements as defects are not always length-wise persistent.
Name & Affiliation	**Answer**
D. Roisum – Finishing Technologies, Inc.	This is true. An important troubleshooting clue is, if the problem moves from one location to another, you can pretty much eliminate the winder from being a larger part of the cause. Winders normally are not capable of changing the web non-uniformity from one shape to another, this typically makes upstream forming elements suspect.