What We Know (That Just Isn't So) - Myth Busting in Web Handling

David R. Roisum, Ph.D.
Finishing Technologies, Inc.
Neenah, WI 54956

ABSTRACT

This paper proposes a metric for the permeation of the science of web handling into industry. The variable of interest is misunderstandings, myths if you will, that are common in plants. The origin of the myths is unimportant and often undeterminable. What is important is whether the old plant conventional wisdom has been replaced by the new science of web handling. Perhaps the most common myth is that spiral taping or grooving of rollers spreads the web. However, there are many other misconceptions in the areas of tracking, tension control and winding that are least as limiting. This paper lists these myths, their possible arena of application, the dangers of assuming validity in applications where they are not correct and references for our current best understanding.

KEYWORDS

Web_Handling; fallacies; spreading; tracking; traction; tension_control; winding

Science is but an image of the truth.
- Francis Bacon

It ain't so much the things we don't know that get us into trouble. It's the things we know that just ain't so.
- Artemus Ward

INTRODUCTION

Web handling as an area of knowledge rather than as a collection of disparate observations is about a quarter century old. It is appropriate to review our progress. Progress in any field, web handling included, is not only measured by its progress near its points of origination but also its permeation throughout. The path is long for new understandings originated by the researchers to pass through the gatekeepers to the early adopters and so on down the line until it reaches every corner the plant floor. To answer objectively how far we have come, we must have metrics. Metrics could include new mechanical designs reflecting these new understandings. It could show itself as control strategies that align themselves closer to key variables determined by models. However, these would not be responsive metrics as machine purchases or even upgrades may not reach many plants for a decade or more. While we may see the response of early adaptors more quickly, it tells us little of overall permeation. Also, machine builders have been highly stressed by economic conditions for most of a decade. We might not expect that new understandings and thus new designs will be as forthcoming in such an environment.

Metrics could include training that reflects physical laws and empirical connections found by recent research. However, formal training, such as at conferences and seminars, is hit-or-miss among technical people and mostly a miss at the floor level. Even so, there is some encouraging news on the training front because perhaps as many as 10,000 people have been trained in web handling [1]. While this is encouraging, there is still a long way to go because this may represent only 10% of the technical and management positions and perhaps only 1% of the total workforce in the wide world of web handling. While not everyone needs be web literate in a web handling plant, there are many more that could benefit.

In this paper I propose a different metric. It is how far we have come in replacing mythology with science. Whether these current understandings stand the test of time is not relevant, science is always provisional. It is only whether these understandings have been adopted that is relevant. The areas of misunderstanding include the gamut of web handling topics including spreading, wrinkling, tracking, traction, tension control and winding. The paper is as much a paean to science as it is an urge for better communication and teaching and marketing by the scientists. An equal critique could be given for communication in the other direction, from the plant floor to the technical departments, but that would be a topic for a different discussion.

WHAT IS A FALLACY?

A fallacy is an error in thinking or reasoning [2]. It may be a belief that is inadequately supported by the facts. It may be a belief that does not follow from the facts. It may be a belief that does not consider all of the facts. It may be a belief that follows from the facts, but where the ‘facts’ are in fact premises or assumptions that are not in themselves true. A common outcome of any of these cases is thinking wrong or worse, doing wrong. Occasionally, it means doing the right thing, but for the wrong reasons.

Science, for all of its virtues, has had its share of fallacies. A sun-centered universe and transmutability of elements are just two of uncountable errors previous generations of scientists held as true. There is no reason to believe that we entirely escape errors like this even today [3]. Even so, the scientific method is one of the greatest intellectual achievements of modern man. It helps keep us from fooling ourselves. It can be applied to any falsifiable theory. This theory is left standing for another day if it is compatible with data. However, it can be felled at any moment if the results are not reproducible. In this sense, our understanding is evolving as a ‘best fit’ to current information. Our conclusions are always provisional. Here we are not so concerned with the truth, whatever that might mean, of our current scientific understanding of web handling. Rather, whether these new truths overcome the fallacies that are common in the plant.

SPIRAL GROOVES OR TAPE SPREAD THE WEB

Of all fallacies, the belief that spiral grooving or taping of rollers spreads the web is one of the oldest and most pervasive. Machine builders will prefer to spiral groove from the center out when annular may work as well and spiraling from one side would be more economical to machine. Whether the builders themselves still believe these grooves have a spreading affect is immaterial; their customers do. It is not worth the trouble to convince them otherwise. Besides, if the builder did not provide spiral grooves, the operator will be inclined to apply masking tape in a spiral outward fashion. Here the tape may indeed provide a benefit, but that is not spreading as far as we know. It might improve traction and air handling capabilities and thus be legitimately useful even though not for spreading.

The widespread belief that these spiral features rest on perhaps three contributing factors. The first is that of the barber pole optical illusion. This can be very convincing to the uncritical eye. An example of how our senses can fool us is to spin rapidly several times, stop and then note how the room appears to and even feels like it is still spinning. The second is that for the longest time everyone assumed that there was spreading without seeking the facts of the case. The technical term for this fallacy is *argumentum ad populum* while the common name is ‘science by consensus.’ The third fallacy is wishful thinking, known as the Pollyanna Principle, or confirmation bias. People wanted to believe that spreading could so easily be achieved. People wanted to believe that the general practice was based on solid principles rather than mere unsupported belief.

Even when doubt was expressed and even when the possibility of inducing wrinkles instead of removing them was suggested, the spiral practices continued unabated [4]. Another half-decade and thousands more rolls were thus treated before anyone even bothered to check. When measurements were finally made, the spreading of spiral grooving was shown to be zero in a landmark paper by Swanson who also investigated the controversial but popular compliant cover spreader [5]. Unfortunately, this test was never formally repeated and published (though is has been recently confirmed in an unpublished study by a machine builder.) Even so, there is no web handling science that would suggest otherwise. The extremely rare exceptions to the no spiral spreading rule that are reported are either anecdotal or so obscure that the general conclusions stands firm. The scientists have thus made up their mind. As scientists, however, we still must continue to have an open mind about even the most suggestive and cherished theories. We must be especially careful because this conclusion is in opposition to the still widespread and strong belief held in the plants. I have posted a challenge to the industry to find the exceptions to the spiral fallacy. At the date of this publication, no one has offered any [6].

This spiral spreading belief would be relatively harmless, only costing a bit of effort, except for two things. First, this spiral feature distracts us from treatments that *can* help us spread. Second, spiral features not only do not spread, they in fact can cause wrinkles. Two of three ways a web can conform to a groove result in the tendency to wrinkle as seen in Figure 1 [4]. The tendency to damage the web are situations with either inelastic deformation and or where the web slides into the groove. Only elastic deformation without sliding is benign.

TO REDUCE WRINKLING INCREASE/DECREASE TENSION

Operators develop strategies to cope with problems such as wrinkling. Since the tension knob is most accessible, they will start there. Operators conclude correctly from experience that increasing/decreasing tension, pick one, helps to reduce wrinkling. However, Good has clearly shown that relief might be obtained in <u>both</u> directions provided the system will allow you to move far enough [7]. A summary of this landmark research is given in Figure 2. In the case of roller misalignment induced wrinkling; reducing the tension might allow the web to break loose from one of the misaligned pair and in doing so does not force the web into such extreme in-plane bending to conform to the normal entry law. In this and other cases, it might also be possible to increase tension and 'muscle' your way out of the problem as is described by Mohr's Circle [8]. The bottom line: when wrinkling check both extremes of tension.

THE WEB TRACKS TO THE TIGHT SIDE

Owners and operators of printing presses and winders and many other processes where edge quality is important are quite concerned about web tracking behavior. The norm is to capture wide ranging behavior in a simple encompassing rule, such as that is *the web tracks to the tight side*. It is hard to say where this belief originated. What is known is that it is wrong as often as not. This is not so much as a fallacy of the general rule, *dicto simplicter*, it is that the general rule does not even generally apply.

There are three common driving mechanisms: misaligned rollers, diametrally varying rollers and a baggy edge. Within each of these are two sub cases: traction and sliding. Walker and Roisum have both taught that the web tracks to the tight side in only about half of these half dozen *cases* [9, 10]. However, if you look at the two most commonly occurring *situations*, misaligned rollers in traction and baggy webs in traction, you would find that in the plants tracking is more often than not to the <u>slack</u> side. These cases are summarized in Figure 3.

It is interesting to note that this tracking myth is still alive and well despite the longstanding contrary evidence and documentation. Bruce Feiertag and John Shelton been trying to bury this myth for decades with hands on demonstrations and teaching [11]. Swanson verified baggy steering cases using closed form analysis and experimental verification [12]. However, simple observation could have settled the matter long ago. If you have a roll-to-roll process, you should easily see the change of path when a roll with a front side bagginess is replaced by one with a back side bagginess. A simple witness line would confirm the direction. However, any guide or registration system would also record the upset. It is interesting how we can get caught up in supposed truths when they are in fact sometimes the mythology of conventional wisdom. In the case of conventional wisdom, everyone assumes the tight side rule was *true* without checking it. In my own personal case, I assumed the conventional rule was *false* in the case of bagginess simply because the experts modeled and measured it. I am almost as guilty, by not checking against the real world. The only consolation I can hide behind is that at least I did do my formal homework. The consensus of the experts is the tight side rule is false more often than not.

TRACTION

Large rollers have more traction than small rollers.

> The laws of traction are so well known that dozens of papers as well as a chapter in a book detail the equations [13]. The only cases where large rollers have more traction are in the presence of non-coulomb friction, such as with adhesives or which mechanical interlocking such as on textiles against rough rollers. However, even more common is reduced traction due to air entrainment with increasing roller diameter [14]. Even so, the most common case is near total independence of traction on roller diameter. Wrap angle, tension and the coefficient of web/roller friction are the factors of significance.

You need a nip for good traction.

> True, you might desire more traction capacity, but only when you are slipping. Increasing the traction capacity in other cases changes nothing except to increase costs. A good analogy is four wheel drive. It is almost never needed or helpful. In fact, engaging four-wheel when you are not slipping will come at a cost: poor handling, poor gas mileage as well as poor tire and gear train life. In the case of nipped rollers, the penalty is an extreme increase in the tendency to wrinkle due to imperfect rollers or imperfect webs, i.e., bagginess. Other costs may include more expensive equipment and increased maintenance of the nipped rollers. The primary problem here is a confusion of terminology between traction *capacity* and the state of traction (or slipping). We use the same word for two different things. More traction *capacity* does not necessarily mean more traction, such as when you are not already sliding.

Rough rollers have better traction than smooth rollers.

> True, rough rollers have better traction *capacity* in two cases. The first is an improved ability to deal with the loss of traction due to air entrainment. The second is against deformable webs such as textiles. Unfortunately, increasing the roughness of a roller against a smooth product at low speeds, say less than 30 MPM, is likely to *decrease* the traction capacity. In this case you are paying more (initial cost and more frequent maintenance) to solve a problem that may not exist (slippage) and in doing so increase the risk of a problem you are trying to solve and may even add a new cost (marking the web) [3].

In all of these cases, there is a basis for the traction belief. Each is true in a very narrow range of situations. However, they all suffer from the fallacy of the general rule, *dicto simplicter*.

WINDING

It is better to wind looser.

> There are three categories of winding defects with regard to tension. High tension defects, low tension defects and defects that do not respond to tension. If you look at any compendium of defects and risk factors, you will find that the defects are approximately evenly distributed among those three cases [15]. Thus, this belief would be true less than half of the time. Table 1 lists some of the most common defects in regard to roll tightness.

The most important winder setting is taper tension.

There is a myopic focus on taper tension in web manufacturing and converting. The concept of taper is more widely known as 'roll structure' in the paper industry. Most winders can program web tension to vary with diameter. Thus, operator and process engineer alike are obligated to enter some value for taper. It seems to be a trend that the less understood a parameter is, the more likely it will be the focus of attention, or perhaps blind hope. Taper certainly falls into that category. While it has importance in certain situations, such as telescoping, its usage is blown far out of proportion to its utility.

Tension is only one of the TNT's (tension, nip, torque and speed) that affects the tightness of the wound roll. It is well known that bulky products, such as tissue or textiles, respond so strongly to nip that almost no attention should be paid to tension as far as roll build goes. Rather, tension is set based on getting the web to the winder rather than for tightening or loosening a roll. Thus we see the fallacy of the general rule in action.

Even if a winder system was only equipped with tension or responded primarily to tension, taper would not be the first concern. Instead, overall or average tightness would be the first concern. Most defects in winding, if they even are sensitive to tension, respond more to average tightness than to taper. They only major exceptions are one of the many types of starring and a couple of the many types of telescoping. Thus, of literally more than a 100 defects, only a couple respond to taper.

It is now clear that winders are most easily programmed with the two point method [16]. Here, we set the starting tightness as a best compromise for tight and loose defects that appear in the bottom part of the roll. Similarly, we set the ending tightness as a best compromise between tight and loose defects that appear on the top part of the roll. The computer merely connects the line between the core and the end. The advantages are simplicity of knowing how to respond to any situation and consistency of well understood units (tension).

TENSION CONTROL – THE BIGGEST CHALLENGE

Dancers are better than load cells or vice versa.
AC is better than DC and digital control is better than analog.
Infeed nips, rider rolls on winders and many other positions should be driven.
Why would we want to drive both laminator rolls?
Motors should share load rather than fight each other.
The path is long so we should add a drive to help the web along.
We are running at slow speed so tension control should not be a big challenge.
We are having trouble with tension control so we should add a drive
We are having trouble with tension control so we should get a new drive.

The area of tension control is one of the most mysterious in a plant. The forces in the web are invisible unless one has a load cell at all areas of interest. However, the number of web drive motors, brakes and clutches far exceeds the number of web tension readouts. Most of the tension-like readouts that are found on web machines are in strange units such as air pressure on a dancer. The forces applied by the drive are even more invisible unless one is blessed with the rare understanding of what an ammeter reading represents to the web. The relationship between motor effort and web results is baffling to most. Zero on the ammeter does not mean zero in web handling. More ammeter means less web tension change across the drive point, but does not tell you what the tension actually is. Worse yet, all of this changes with common process changes such as merely changing speed (inertial effects) or even changing coat weight add-on or dryer temperature when in draw control.

Operators know or strongly suspect that tension settings connect to real waste and delay concerns. However, these connections are weak and erratic. Consider web breaks. Common sense says that a higher tension will break the web more frequently. However, this is much harder to verify than most would ever suspect. Other factors such as web quality and machine condition also factor heavily in web breaks. The same is true with wrinkling which may get better or worse as tension increases. However, wrinkling also responds to many other factors even more strongly.

Tension control is difficult even for experts. Web drives, such as found on winders, laminators and printers, are far more complicated than most motors found in any other industry. Even seemingly simple looking elements like bowed rollers or two drum winder guide rollers are in fact quite complicated to drive correctly. It is difficult to find a drive control designer who is web handling literate or a field service engineer who is competent to tune these exceptionally difficult controls [17]. Not surprisingly, things go wrong frequently [18]. This situation is a witch's cauldron of troubles that is perhaps the greatest challenge to web handling at this time. I am not optimistic that this situation will be remedied in the near future. What is ironic is that longitudinal behavior is one of the oldest and strongest areas of web handling research. Yet it has left the practitioners so far behind that they reinvent the wheel for lack of experience and readily available expert resources.

CONCLUSION

Much progress has been made in web handling in the last 25 years as the result of analytical and empirical research. This effort is paying off by reducing waste, delay and confusion on the plant floors. Web handling has become somewhat of a 'household word' so to speak. Most in technical and management positions at least know roughly what it means and where it might apply. Even so, we have much work to do to communicate this to the practitioners. Most still hold on to their cherished beliefs, some of which are wrong as we have known for some time.

BIBLIOGRAPHY

1. Roisum, David R. *Problem Solving*. http://www.webhandlingblog.com/ December 19, 2006.
2. Roisum, David R. ***Critical Thinking in Converting***. TAPPI PRESS, 2002.
3. Roisum, David R. *Winder Wisdom.* Tappi J., vol 82, no 10, pp 86-91, October 1999.
4. Roisum, David R. *The Mechanics of Web Spreading.* 2nd Int'l Conf. on Web Handling, Oklahoma State Univ, June 6-9, 1993.
5. Swanson, Ronald P. *Testing and Analysis of Web Spreading and Anti-Wrinkle Devices.* 4th Int'l Conf. on Web Handling Proc., Oklahoma State Univ, June 1-4, 1997.
6. Roisum, David R. *Do Spirals Spread?* . http://www.webhandlingblog.com/ August 17, 2006.
7. Gehlbach, Lars S. and Good, J.K and Kedl, Douglas M. *Prediction of Shear Wrinkles in Web Spans*. Tappi J., vol 72, no. 8, pp 129-134, Aug 1989.
8. Roisum, David R. *The Mechanics of Wrinkling.* Tappi J., vol 79, no 10, pp 217-226, October 1996.
9. Walker, Timothy J. *Web Handling*. Shortcourse notes, TJW Associates, 2006.
10. Roisum, David R. ***WEB101.*** TAPPI PRESS, 2006.
11. Shelton, John J. *Effects of Web Camber on Handling.* 4th Int'l Conf. on Web Handling Proc., Web Handling Research Center, Oklahoma State Univ, June 1-4, 1997.
12. Swanson, Ronald P. *Mechanics of Nonuniform Webs.* 5th Int'l Conf. on Web Handling Proc., Web Handling Research Center, Oklahoma State Univ, June 6-9, 1999.
13. Roisum, David R. ***The Mechanics of Rollers***. Chapter 4, TAPPI PRESS, 1996.
14. Knox, K.L. and Sweeney, T.L. *Fluid Effects Associated with Web Handling* Ind. Eng. Chem. Process Des. Develop., Vol. 10, no 2, 1971, pp 201-205, 1971
15. Smith, Duane. ***Web and Roll Defect Terminology***. DEStech Publications & TAPPI PRESS, 2007 (a major update of a 1995 publication of the same name).
16. Good, J. Keith and Roisum, David R. ***Winding Machines, Models and Measurements***. TAPPI PRESS, 2007.
17. Roisum, David R. *Why we having more drive difficulties – an opinion*. Converting Magazine, Web Works Column, pp 64, February, 2004.
18. Roisum, David R. *Are we having more drive difficulties?* Converting Magazine, Web Works Column, pp 56, January, 2004.

Table 1 – A few Examples of Tight and Loose Winding Defects

Loose Defects (Roll Damage Common)	Tension Insensitive (Often Operational)	Tight Defects (Web Damage Common)
Flat spots	Bad Splice	Blocking
Out-of-Round	Wrong Core	Core Crush*
Telescoping*	Wrong Roll Width	Corrugations
		Gage Bands > Bag
		Tin Canning

Figure 1 – Wrinkling Tendency of Grooving

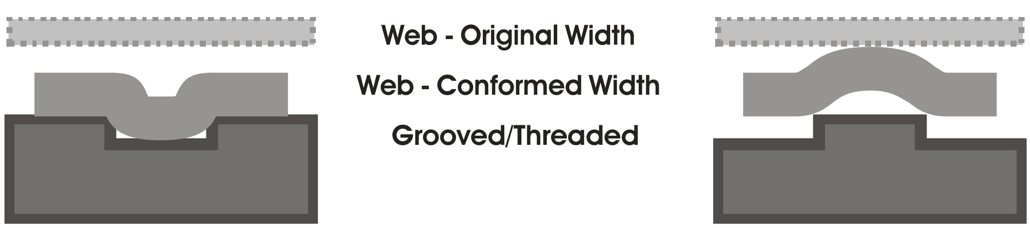

Figure 2 – Effect of Tension on Wrinkling

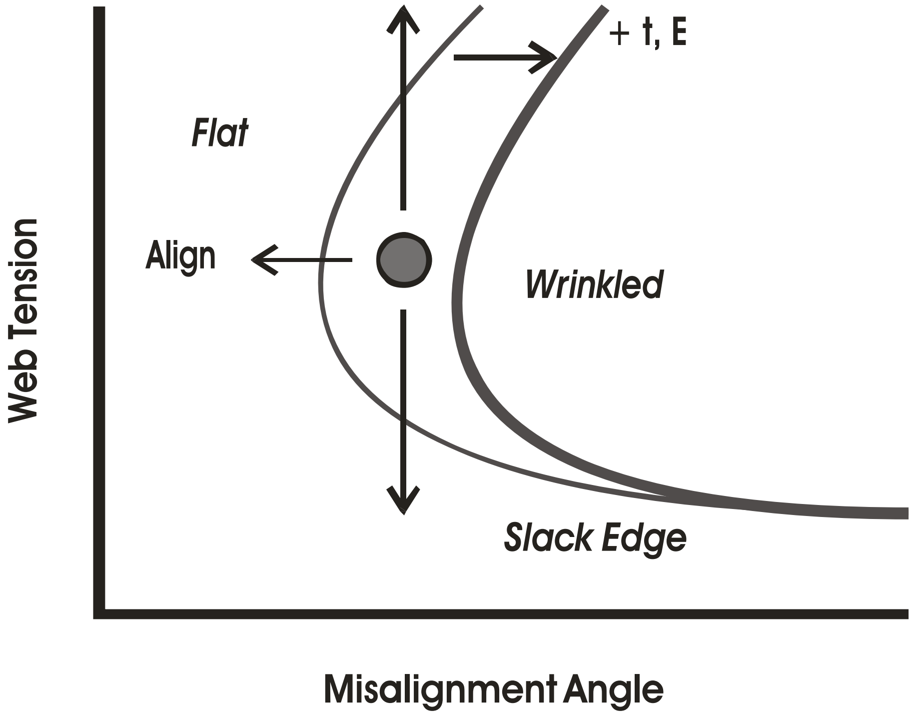

Figure 3 – Tracking Cases