THE IMPORTANCE OF TORQUE CAPACITY IN PREDICTING CREPE WRINKLES AND STARRING IN WOUND ROLLS

by

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ABSTRACT

Roll models provide information about the radial stresses and circumferential stresses that exist in a wound roll of web material. A derived quantity that is available from the radial stress profile is the torque capacity. The torque capacity is the ability of a wound roll to resist slippage when subjected to external torque. Crepe wrinkles that occur in wound rolls have been attributed to slippage. The literature available on crepe wrinkle formation is nebulous with respect to quantitative evidence available to identify parameters that contribute to the formation of the defect. A parameter associated with the winding machinery is the deceleration that rolls undergo. A method to predict crepe wrinkle formation due to slippage that results during deceleration will be presented with quantitative evidence. Starring has been attributed to negative circumferential stresses that exist in wound rolls. Slippage has never been identified as a factor that contributes to star formation. This study identifies the importance of torque capacity as a means to predict starring in center-wound rolls, and provide quantitative evidence from experimental data to support the fact that in some cases slippage is a precursor to star formation in center-wound rolls.

NOMENCLATURE

d_o	outer diameter of the wound roll
d_i	inner diameter of the wound roll
E_c	core modulus
E_r	radial modulus of elasticity
E_t	machine direction modulus of elasticity
g	acceleration due to gravity
h	web thickness

I	mass moment of inertia, $\frac{m\left(d_o^2+d_i^2\right)}{8}$
m	mass of wound roll, $\frac{\pi w \rho}{4g}\left(d_o^2-d_i^2\right)$
T_w	web line tensile stress
r_c	inner radii of the wound roll
s	outer radii of the wound roll
w	width of the web
α	angular acceleration
μ	coefficient of friction
ρ	weight density of the web material
σ_r	radial pressure
ν_{rt}	Poisson's ratio of the web material

INTRODUCTION

A web is a thin flexible continuous strip of material that is stored in a wound roll format for ease of transportation and additional processing. These rolls may be subjected to unwinding and rewinding several times before they are converted to a finished product. Many materials including paper, polymer films and metals are processed in web form. Popular techniques for winding these web materials are centerwinding and surfacewinding.

In centerwinding a torque is applied to the core of the roll being wound. Centerwinding is often performed with an idler contacting the surface of the winding roll. In surfacewinding, the roll is wound in the presence of nip(s) and the torque is applied to the winding roll via the nip roll(s), refer to Figure 1. A common configuration of the surfacewinding scheme is the two drum winder where there may be two to three nips in contact with the roll being wound. A key parameter in inducing wound roll defects during these winding/unwinding operations is inter-layer slippage. This paper focuses on the mechanics of formation of crepe wrinkles and starring, two common wound roll defects.

A crepe wrinkle is an accordion like collection of web material that runs across the width of the web material. It has been documented in wound rolls of newsprint and slick and thin grades of paper such as light weight coated papers, refer to Figures 2 and 3, Lucas [1, 2]. Crepes may involve one layer or a few layers of material which have locally collapsed in a circumferential direction at different points throughout the radius of the roll. Crepes have been described in some cases to be the ingestion of loosely wound material through a nip, Lemke et al [3], Lucas [2]. This defect affects the runnability of the roll as well as locally degrading the web quality. When rolls in which crepe wrinkles are present are unwound, the web which was accumulated as a crepe extends at low tension when the roll has unwound to the radius at which a crepe was present. While the creped web is extending it is common for the angular velocity of the unwinding roll to slow as a result of the tension control attempting to return the tension in the unwind zone to the setpoint value. When the creped material has fully extended often the web will burst as the web must withstand the steady state tension plus the dynamic tension due to the peripheral speed of the unwinding roll being less than the web line velocity. Thus this defect causes economic trauma as the rolls which contain crepe wrinkles pose problems to the converter of the wound roll and thus reflect on the quality of the roll. Another difficulty with this defect is the inability to observe the defect prior to its formation in production rolls. Crepes have been detected in wound rolls is by using "J-Lines", Lucas [2]. The "J-Lines" are carefully scrutinized for minute discontinuities in an otherwise smooth curve in the wound roll. The "J-Line" is indicative of interlayer slippage and is the result of nip induced deformations which have been documented by Pfeiffer [4] and Good et al [5,6].

The published literature on crepe wrinkles is nearly void in providing quantitative data on winding conditions or materials which were involved when the defects were induced. Factors which promote creping have been identified qualitatively and a primary parameter that has been identified is slippage within the winding roll (refer to Laumer [7], Daly [8], Lucas [1,2], Welp et al [9], Frye [10], Odel et al [11], Paananen et al [12], Lemke et al [3], Schoenmeier [13], Roisum [14, 15, 16], and Welp [17]). Web and wound roll characteristics such as the radial modulus (E_r) of the wound roll, the web caliper(thickness), and the coefficient of friction between layers and winder operating characteristics such as differential drum torque, nip load, and web tension have also been identified as key players in the formation of crepe wrinkles in the references mentioned above. A brief mention of inter-layer pressure as factor in the formation of these defects was made by Daly [8]. The dynamic effects associated with winding/unwinding rolls such as deceleration or acceleration have also been identified, Lucas [2].

Another defect which is sometimes denoted as starring occurs in wound rolls. The defect visibly appears like a star (spokes) of buckled material. Sometimes the buckles radiate from the core and proceed outward along radii of a wound roll. At other times the spokes of buckled material appear uniformly around the periphery of the core but then disapate at larger radii. Single or multiple spokes may also appear somewhere in the middle of the wound roll along a radius. Starring often permanently deforms the web and often the roll tears or bursts at the point of the most severe distortion, refer to Figure 4. Numerous sources have reported that the circumferential stress must be negative to cause starred roll defects [18-24]. This criterion alone is insuffcient to predict starring as constant tension winding often leads to large zones of negative circumferential stress in wound rolls which are free of defects.

In this study the relationship that exists between the different parameters mentioned in connection with slippage will be shown. With the help of experiments performed in the laboratory a method to predict the formation of crepe wrinkles and stars will be introduced. A strategy for avoiding these defects in a winding roll will also be discussed.

WOUND ROLL MODELS

Wound roll models reveal the variation of inter-layer pressure (radial pressure) and circumferential stress as a function of radius. Several wound roll models have been developed for centerwinding. Hakiel [25] developed and verified one of the most complete models to date. Good et al [5,6] developed and verified an extension to such models which accounted for the increase in wound-on-tension due to an impinging idler or nip roll. The development of wound roll models for surfacewinding is still in its infancy. The variation of radial stress with the radius is a quantitative measure of the quality of the roll being wound. A compendium of wound roll models and the evolution of those models to the current state of the art was established by Good [26].

The model developed by Hakiel [25] for centerwinding considers the variation of the radial modulus with the radial pressure. The radial stresses predicted by the model are obtained by employing a finite difference technique to solve a second order non-linear equation relating the change in pressure in layers within a wound roll as new layers are wound on. Also available from the model is the variation of the circumferential stress as a function of the radius. The inputs to such models include web tension (T_w), the machine direction modulus of elasticity (E_t), the radial modulus of elasticity (E_r), Poisson's ratio of the web material(ν_{rt}), the core modulus (E_c), the web thickness (h), and the inner and the outer radii of the wound roll (r_c, s). A derived quantity, known as torque capacity (T_{cap}), can be generated from the results of the radial stress variation output from the model. The torque capacity quantifies the wound roll's ability to resist slippage when an external torque is applied to the roll. Wound roll models to date accrete layers of web as concentric hoops of material in an iterative process. The ability to resist slippage between the adjacent layers depends upon the radial pressure, the cylindrical area of the layers at a given radius, the coefficient of friction between the web layers, and finally upon the radius of the layer. If the radial stress profile of the roll can be expressed as $\sigma_r(r)$, the coefficient of friction as μ, the width of the web as w, and the radius r then

$$T_{cap}(r) = \mu * \sigma(r) * (2\pi rw) * r \qquad (1)$$

In a wound roll slippage occurs whenever the applied torque (T_{app}) becomes greater than the torque capacity or:

$$T_{app} \geq T_{cap} \qquad (2)$$

As an example, a winding model was implemented on a paper web whose properties are listed in Table 1. Note this is a case of a constant tension winding. In constant tension winding the torque the roll is subjected to increases linearly as the outer radius of the wound roll builds. The radial stress, torque capacity, and the applied torque which resulted from the model are shown in Figure 5 and the circumferential stresses are shown in Figure 6. Note that $T_{cap} > T_{app}$ for the entire radial domain which indicates that no slippage should occur in this roll. Please note however that had this roll been wound to a larger radius that slippage would have begun at some point. Paper commonly exhibits a plateau in radial stress for constant tension winding, as shown in Figure 5, which is due the ratio of $E_t/E_r(\sigma_r)$ being a large number. The effect of winding a larger roll in these circumstances does not alter the radial pressure at radii where the plateau in radial pressure has been achieved. Thus the torque capacity in this radial zone remains unchanged while the applied torque remains increasing linearly as a function of the outside radius of the wound roll and at some radius slippage will begin. Computations show that for this web and for the given winder operating conditions that slippage would begin when the wound roll radius reached 1.16 m and the slippage would be located at a wound roll radius of approximately 44.3 mm.

There are at least two circumstances in which slippage can be generated in a center wound roll. The first involves a decrease in wound-on-tension which might be due to a splicing operation. This will be further discussed in the section on experimental work. The second involves slippage beneath the outer layer in a winding roll. The pressure beneath the outer layer in a winding roll is:

$$\sigma_r = W.O.T./_{s} \qquad (3)$$

The W.O.T. is equal to the web line tensile stress multiplied by the web thickness in centerwinding so:

$$\sigma_{r,s} = \frac{T_w * h}{s} \tag{4}$$

The torque capacity beneath the outer layer is:

$$T_{cap,s} = \mu * \left(\frac{T_w * h}{s}\right) * (2\pi s w) * s \tag{5}$$

The applied torque is:

$$T_{app} = T_w * h * w * s \tag{6}$$

Substituting equations (5) and (6) into equation (2) yields that slippage occurs whenever:

$$\mu \le \frac{1}{2\pi} \tag{7}$$

This is interesting as it shows why it is difficult to centerwind low coefficient of friction materials such as silicon coated release papers ($\mu \approx 0.11$). This type of material generally requires combination winding to reduce the torque which is applied to the wound roll.

The parameters that have been associated with the formation of crepe wrinkles and starring also largely influence the torque capacity. The material modulus in the radial direction E_r, the modulus of the material in the machine direction E_t, the caliper of web material and the coefficient of friction between layers and winder operating parameters such as torque, nip load and web tension are inputs to the wound roll model and thereby input characteristics that determine the torque capacity. The relative importance of these parameters can be investigated with wound roll models. The radial pressures which are output from a wound roll model are most sensitive to changes in the wound-on-tension and less so to changes in either E_r or E_t. Factors such as differential drum torque, nip load, web tension, and the web/web coefficient of friction have been shown to directly affect the wound-on-tension [4-6]. Since the W.O.T. is the most influential winding model input parameter which will impact the radial stress profile which is ouput, these same factors will be important in determining the torque capacity of the wound roll. A point that needs to be emphasized is that whenever crepe wrinkles or stars were described in the literature the torque capacity was not mentioned as a fundamental parameter that could control or eliminate these defects within wound rolls.

Wound roll models which have been presented in the open literature are valid only prior to the onset of slippage. Once there is inter-layer slippage, wound roll models are not valid and the results from a wound roll model do not realistically represent variation of radial stress, circumferential stress or torque capacity within the roll. However, if slippage can be prevented by predicting the onset with wound roll models, and if many roll defects can be proven to be the result of slippage, then current wound roll models could be used to improve wound roll quality by preventing slippage related defects.

EXPERIMENTAL PROCEDURE

The parameters identified in the literature that contributed to the formation of crepe wrinkles can be grouped as physical parameters of the web material and as winder operating parameters. All of these parameters were shown to be input for the wound roll model from which the torque capacity is computed.

Another important parameter identified in the literature, related to winder dynamics, is the deceleration that wound rolls undergo in the event of splicing operations or emergency stops. The torques which are due to inertial effects associated with decelerating jumbo rolls can be quite large. Thus there is a source of dynamic torque which is the product of the mass moment of inertia of the wound roll and the deceleration that the wound roll undergoes. Monitoring the deceleration that wound rolls can undergo is relatively easy to achieve under laboratory conditions with minimum modifications to a winder. A study of the propensity of a wound roll to form crepe wrinkles in response to an imposed deceleration was made. This helps to isolate the effects of deceleration from other winder related parameters such as nip load and torque applied to the wound roll from the nips during surfacewinding.

Two basic variations of web tension were used in preparing the wound rolls that were subjected to deceleration. In one case the entire roll was centerwound with a constant wound-on-tensile stress of 896 KPa, refer to Table 1 for the physical properties of the web. The radial stress, torque capacity, and the applied torque which resulted from the model are shown in Figure 5 and the circumferential stresses are shown in Figure 6 as discussed previously in the section on *Wound Roll Models.* Care was taken to wind the rolls at a low speed such that air entrainment effects would be negligible. In the second case, the rolls were centerwound with a tension profile that varied, see Table 1. The roll was started with a winding stress of 3.65 MPa from the core to a radius of 9.27 cm, at which point the winding stress was reduced and maintained constant at 407 KPa up to a radius of 11.8 cm where the winding stress was returned to the initial value of 3.65 MPa and held constant until the entire roll was wound, refer to Figure 7. This variation was attempted so as to generate a roll that was soft and had low torque capacity in a selected radial domain. These conditions are characteristic of wound rolls with a splice in them. The torque capacity and the applied torque which resulted from the model are shown in Figure 8 and the circumferential stresses are shown in Figure 9.

While winding the rolls with a variable web tension care was taken to avoid slippage while bringing the tension back to the initial value. As described earlier there is wound roll slippage if the torque capacity is exceeded by the product of the web tension and the roll's current radius. However, if the tension is gradually increased to a higher value avoiding any instantaneous tension impulses, slippage can be minimized. This was ascertained by striking "J-Lines" in the wound roll as the roll was building up and observing and ascertaining there was not any appreciable curvature in the "J-Line" when the web tension was brought back to the initial value. The rolls wound with the two different web tension profiles were subjected to varying magnitudes of deceleration. Before the rolls were mounted on the winder, "J-Lines" were drawn on the edges of the roll so that internal slippage within the roll is visible. The core shaft of the winder was outfitted with an encoder and thus the angular velocity of the shaft could be measured accurately. The wound roll was brought to speed and decelerated using a disk brake mounted on the shaft. The angular decelerations the wound rolls witnessed were obtained by differentiating the angular velocity output from the encoder.

EXPERIMENTAL RESULTS

A summary of the experimental outcomes for the case of the rolls wound with the constant tension is reported in Table 2. Interlayer slippage occurred when the torque capacity of the wound roll was exceeded by the dynamic torque. The dynamic torque is given by :

$$T_{dynamic} = I\alpha \quad (7)$$

A conservative estimate of the moment of inertia I for the wound roll was used by considering the entire wound roll. No slippage occurred when the dynamic torque was lower than the torque capacity of the wound roll. Slippage did occur when the dynamic torque was greater than the torque capacity of the wound roll. Crepe wrinkles occurred when the deceleration torque exceeded the torque capacity by at least three times for the case of the constant web tension profile. Thus, crepes occurred when:

$$T_{app} \Rightarrow I_{max} * \alpha_{max} \geq 3 * T_{cap-min} \quad (8)$$

The crepe wrinkles occurred in the core region where the torque capacity is the minimal for the case of the rolls wound with constant tension. In Figures 10, 11 and 12 examples of rolls which exhibited no slip, rolls which did exhibit slip, and rolls which exhibited slip and crepe wrinkles are shown respectively. The results of these experiments may be summarized as follows:

- Slippage occurred when the torque capacity was exceeded by the dynamic torque
- Applied torques in excess of the torque capacity are required to generate crepe wrinkles
- No nips were involved during the formation of these crepe wrinkles
- The location at which the crepe wrinkles occurred was the location of the lowest torque capacity in the roll

The rolls wound with the stepped profile in web tension described in the *Experimental Procedure* showed expected and unexpected results. It proved to be difficult to wind good rolls with this profile in tension. If the web-tension change occurred as an impulse during a transition from the low to higher web tension, slippage begun and once the slippage proceeded to a certain extent there was a "star" that formed accompanied by a snapping sound in the wound roll, refer to Figure 13. This mode of formation of the starring defect where slippage precedes or for that matter is associated with the defect formation was never reported in the open literature. The location of the "star" is in the region of the wound roll where there is low torque capacity, refer to Figure 8. To successfully wind these rolls without starring the winding tension profile had to be slightly altered. Instead of instantaneously increasing the winding stress from 407 KPa to 3.65 MPa at a winding radius of 118 mm the winding stress was increased from 407 KPa at 118 mm to 3.65 MPa at 124 mm and then held constant until the final winding radius of 144 mm had been achieved, refer to Figure 7. Both slippage and starring were absent from these rolls which were next submitted to deceleration tests. Crepes and stars occurred in these rolls deceleration where the torque capacity was the minimal and the slippage was confined to that region, refer to Figure 14.

In Figure 8 the torque capacity and applied torque is shown for the case in which the winding stress was instantaneously stepped from 407 Kpa to 3.65 Mpa at a winding radius of 118 mm. Note that the torque capacity is continually changing in the wound roll throughout the period of the wind as long as the radial pressures are changing. In Figure 8 note that the torque capacity is shown at two instants in time, one in which the roll had completed winding to 118 mm in outside radius and a second instant when the roll had completed winding at 144 mm. The applied torque is shown as a function of radius but at any instant the applied torque is constant throughout the roll and is simply the product of the current winding tension and outside radius of the wound roll, s. An expansion of the low torque capacity region of Figure 8 is shown in Figure 15. Note that at 118 mm as the winding stress is returned to 3.65 Mpa that the applied torque is several times the torque capacity, indicating that slippage should occur in the outside of the winding roll at that instant (i.e. s = 118 mm). The circumferential stresses after the roll completed winding to 118 mm and at 144 mm were shown in Figure 9. The result of the increase in winding tension is that the circumferential stresses which were low but tensile in the 118 mm region were driven to high compressive values.

In Figure 16 the torque capacity and applied torque are shown for the case in which the winding stress was ramped from 407 Kpa to 3.65 Mpa as shown in Figure 7. The torque capacity is shown at three instants during the wind. The first curve shows the torque capacity after winding the low winding stress segment at 407 Kpa has been completed (i.e. s = 118 mm), the second curve shows the torque capacity after the ramp up in winding stress to 3.65 Mpa has been completed (i.e. s = 124 mm), and finally after the roll has been completely wound (i.e. s = 144 mm). The applied torque is shown again as a function of radius and at any instant the applied torque is constant throughout the roll and is simply the product of the current winding tension and outside radius of the wound roll, s. An expansion of the low torque capacity region of Figure 16 is shown in Figure 17. Note at 118 and at 124 mm that the applied torque is less than the torque capacity, indicating that slippage should not occur in the winding roll. The circumferential stresses after the roll completed winding to 118, 124, and 144 mm are shown in Figure 18. It is again apparent that the increase in winding stress has resulted in compressive circumferential stresses but note that the ramp in winding stress has dramatically decreased the level of compressive stress.

CONCLUSIONS

The results of the constant winding tension tests, the variable winding tension tests with an instantaneous step in winding tension, and the variable winding tension tests with a ramped increase in winding tension all bear witness to the validity of using torque capacity as a measure of roll quality. In each case a torque capacity profile could be developed based upon the output of a wound roll model and compared to the applied torque, which could be due to decelerations or to winding tension, to ascertain whether slippage would occur or not.

Crepe wrinkles are the result of gross slippage which has occurred in most cases within one wrap of a winding roll. Although the crepes shown in this paper are the result of deceleration tests it is probable that nips in contact with wound rolls can cause tangential forces which induce applied torques above and beyond the torque capacity of a wound roll.

The existence of compressive circumferential stresses within the wound roll is inadequate means to generate star defects within wound rolls. Stable rolls were wound at constant tension with compressive circumferential stresses. Decelerations of a magnitude which would generate dynamic torques in excess of the torque capacity were required to generate defects which in this case were crepes. The rolls which were wound with the stepped profile in winding tension proved that a combination of slippage and compressive circumferential stress was required to generate stars. Additional proof was given by the rolls which were wound with a ramp in winding stress from 407 Kpa to the final stress of 3.65 Mpa. These rolls were successfully wound without defects but had compressive circumferential stresses wound within the rolls. Both stars and crepes resulted after slippage was induced by deceleration. Wound rolls subjected to shocks have been shown to star given the presence of compressive circumferential stress, Pfeiffer [27], and thus others have shown that a disturbance is required to generate the defect

The concept of preventing starring within wound rolls by never applying torques to the roll which exceed the torque capacity provides a promising means of reducing roll defects.

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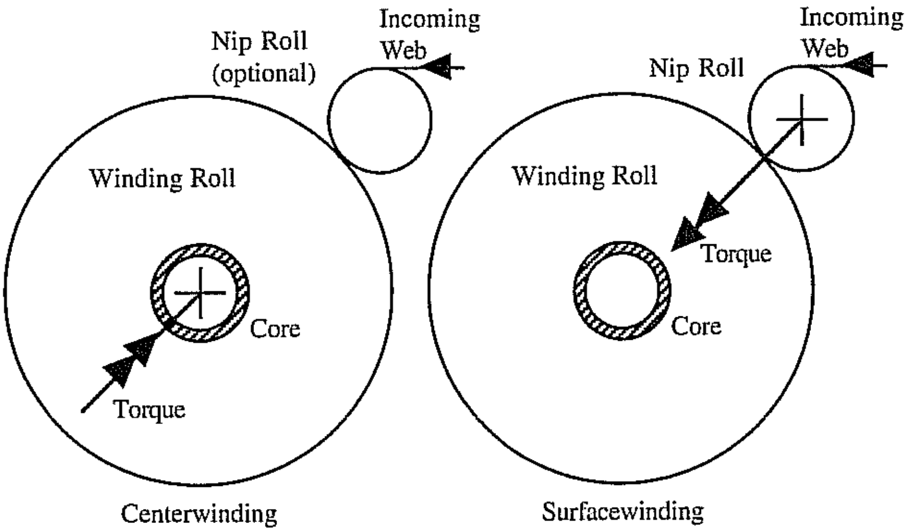

Figure 1 - Centerwinding vs. Surfacewinding

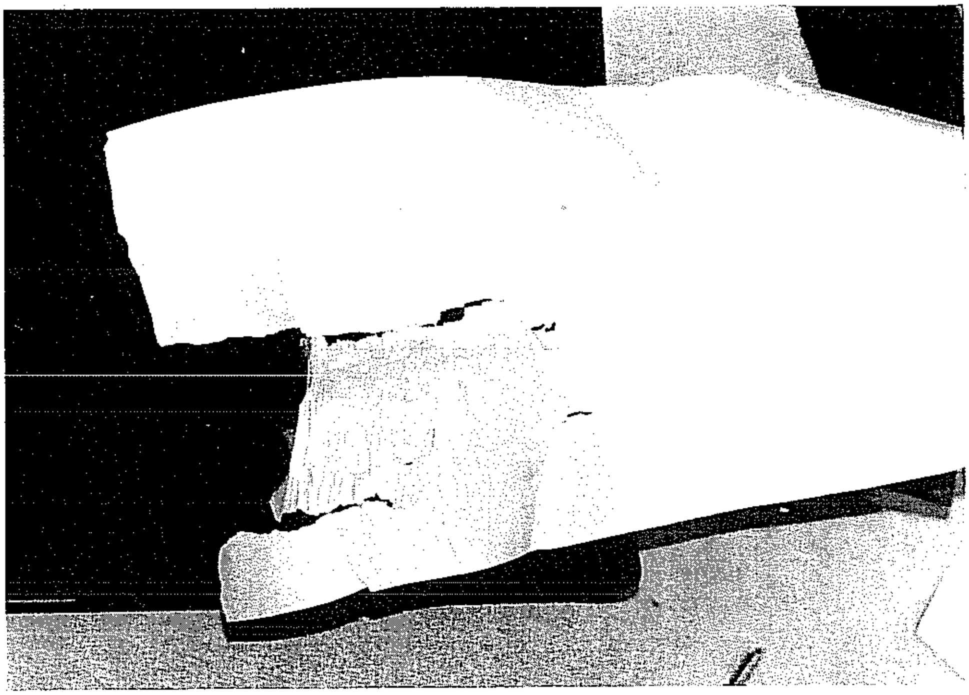

Figure 2 - A Crepe Wrinkle

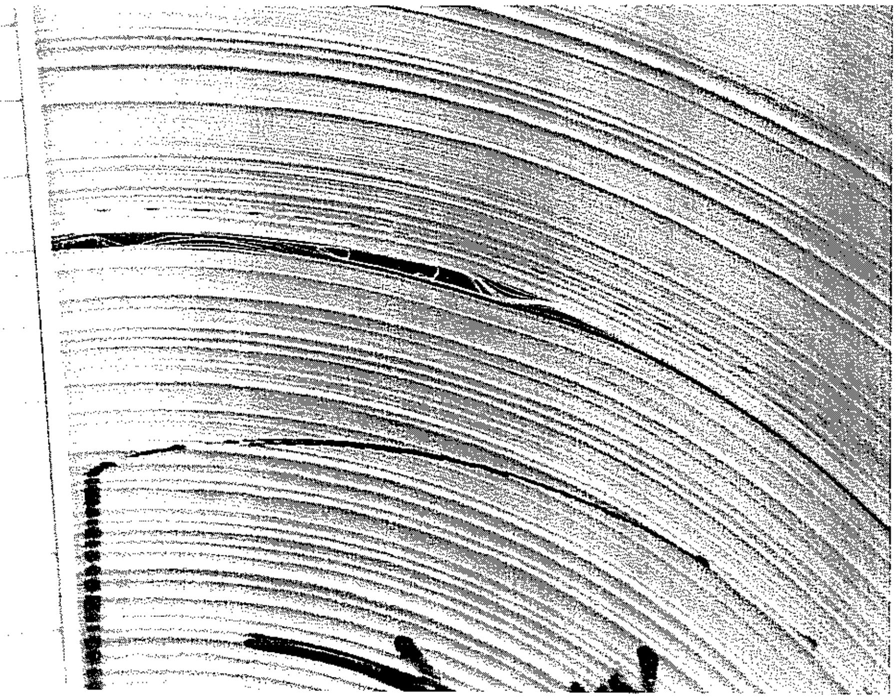

Figure 3 - Edge View of a Wound Roll with Crepe Wrinkles

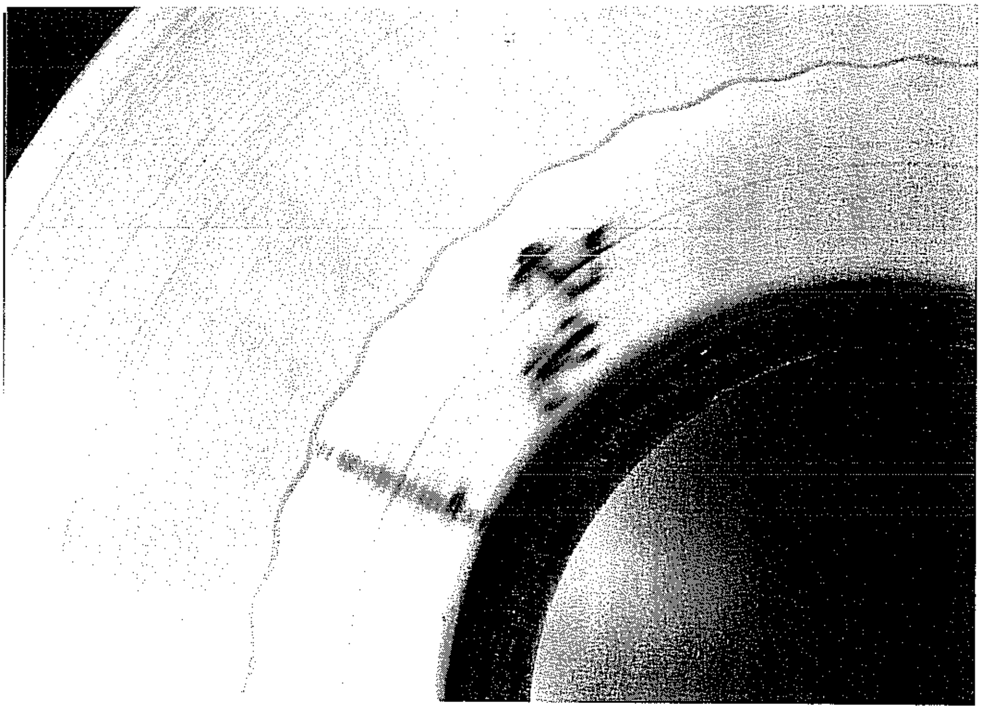

Figure 4 - Star Defect in a Centerwound Roll

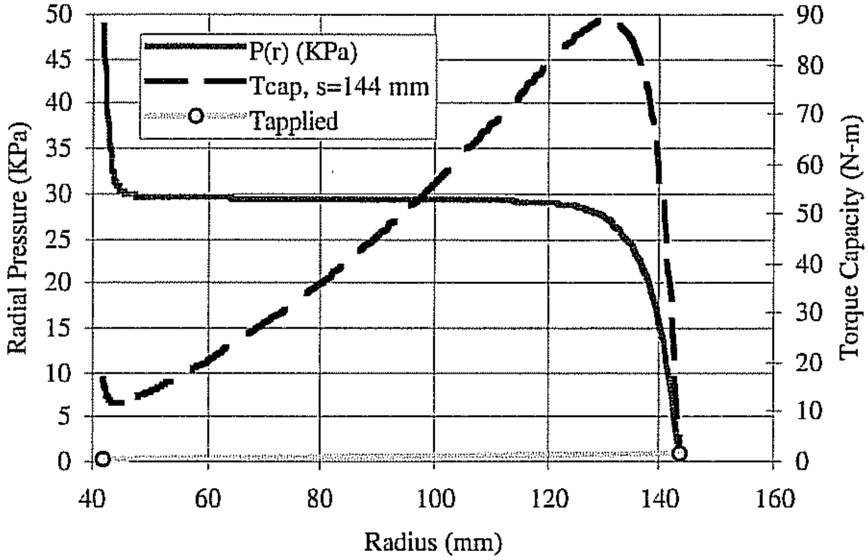

Figure 5 - Radial Pressure, Torque Capacity and Applied Torque for Constant Winding Tension Profile

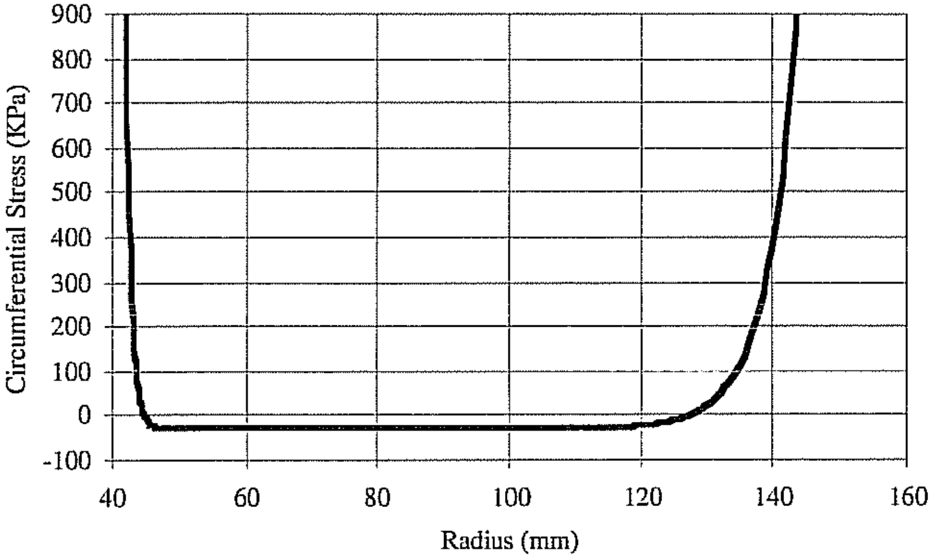

Figure 6 - Circumferential Stress for Constant Winding Tension Profile

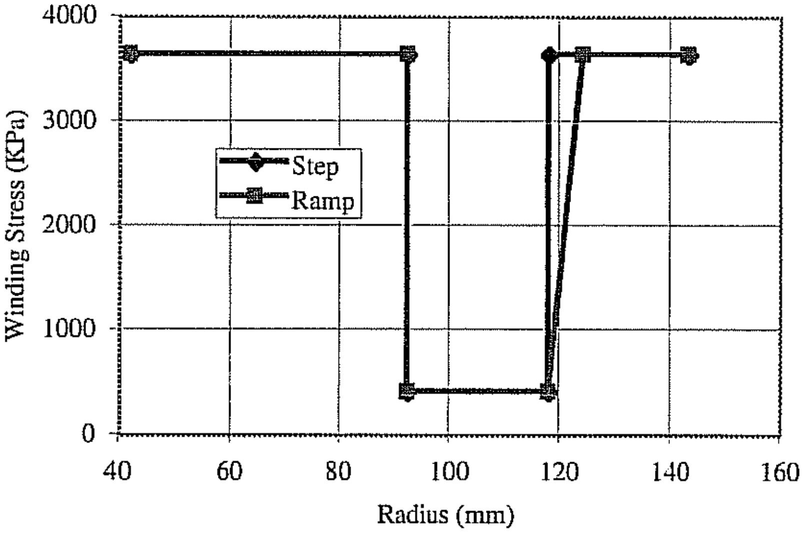

Figure 7 - Winding Stress Profiles

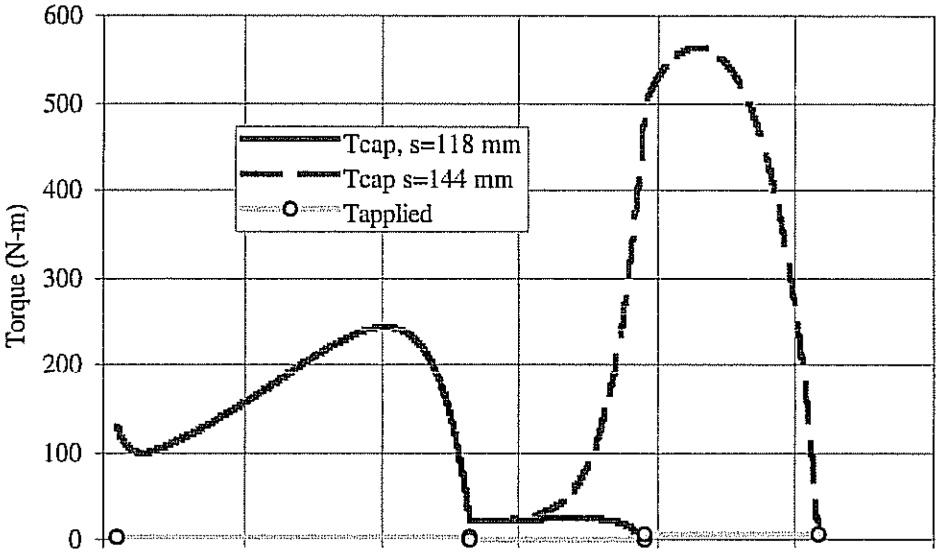

Figure 8 - Torque Capacity for a Step in Web Tension

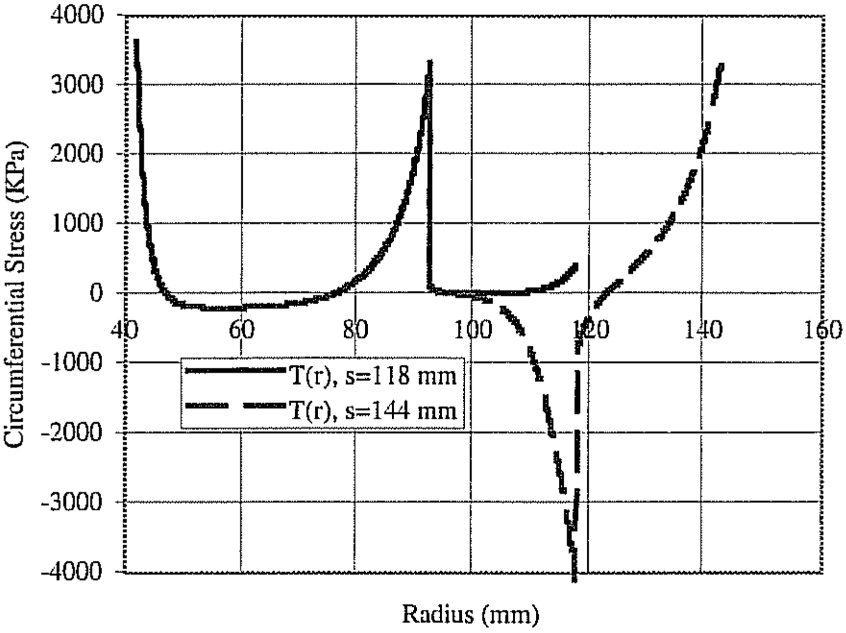

Figure 9 - Circumferential Stress for a Step in Web Tension

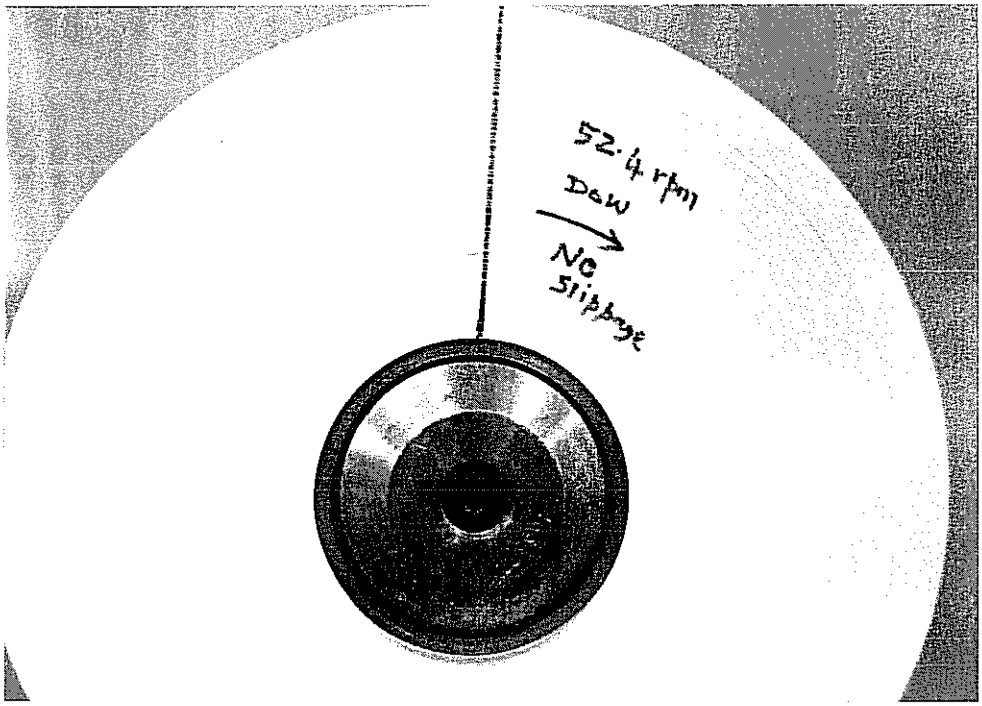

Figure 10 - Deceleration of a Roll Wound at Constant Tension - No Slippage

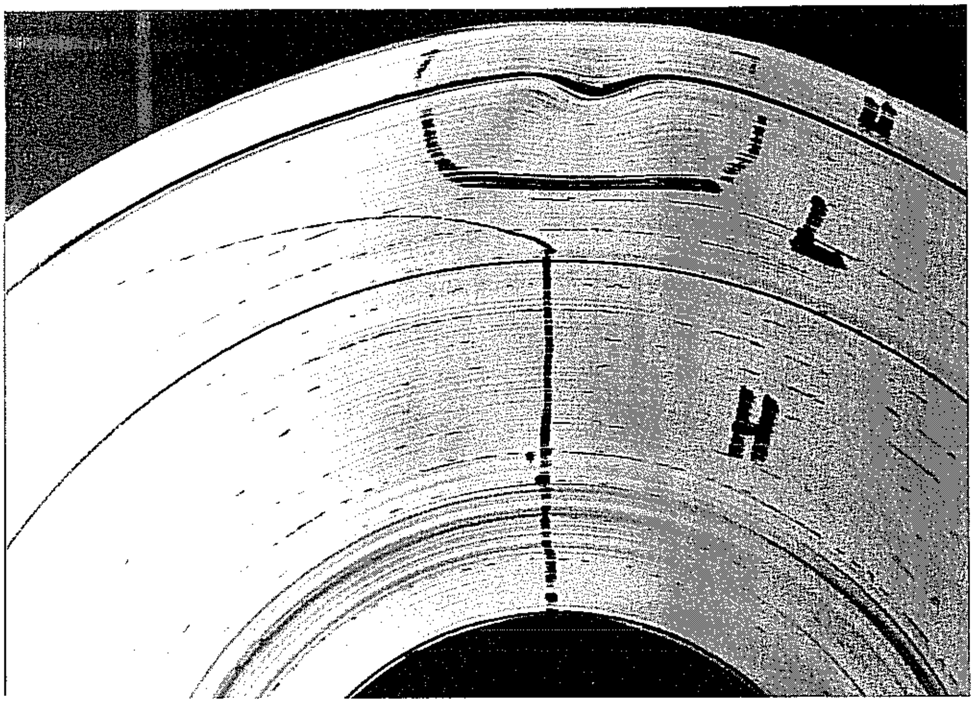

Figure 13 - Stars Resulting from a Step Change in Winding Stress

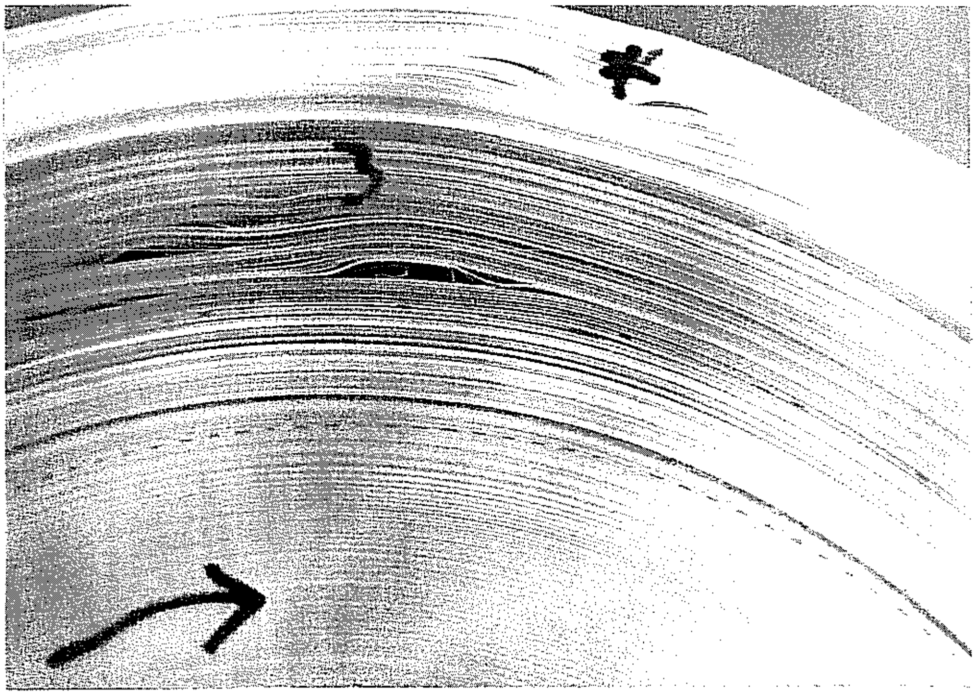

Figure 14 - Stars and Crepes Resulting from Deceleration Tests on a Variable Tension Wind

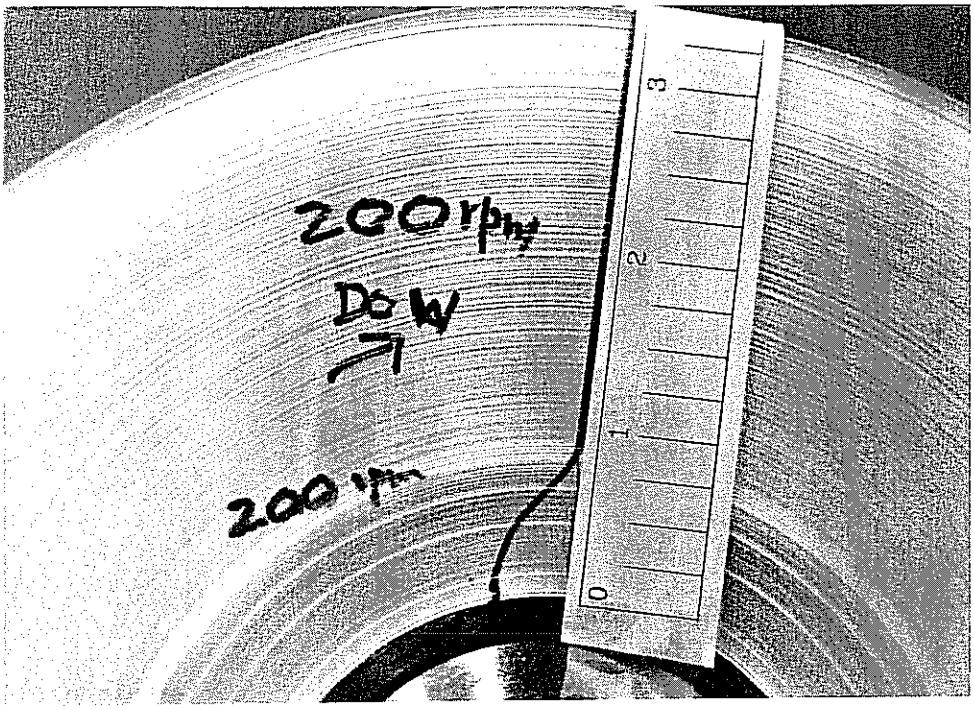

Figure 11 - Deceleration of a Roll Wound at Constant Tension - Slippage

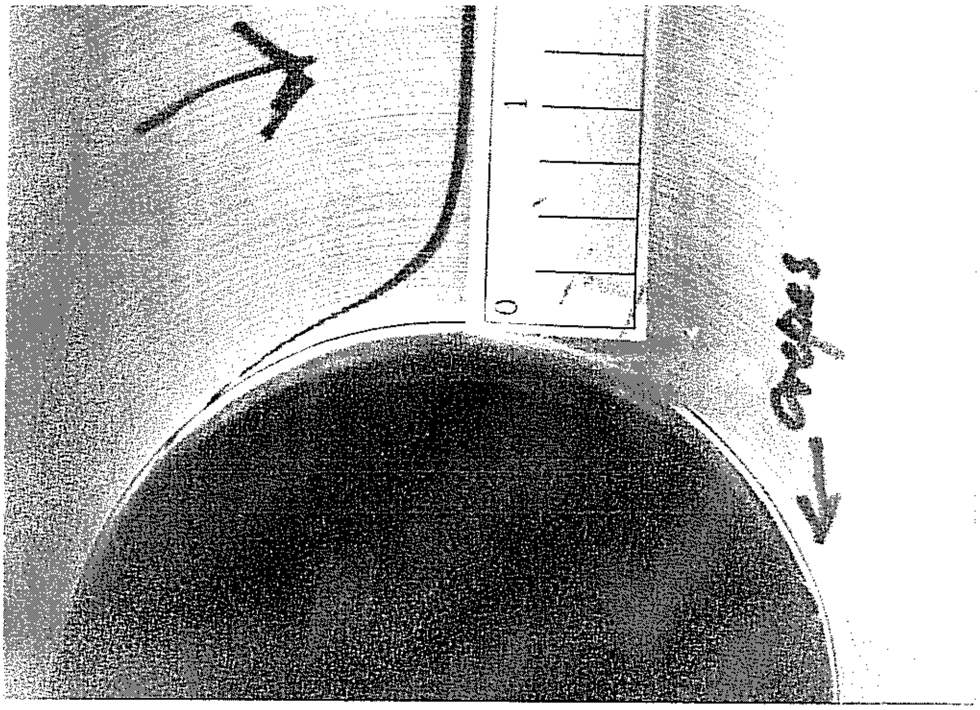

Figure 12 - Deceleration of a Roll Wound at Constant Tension - Slippage and Defects

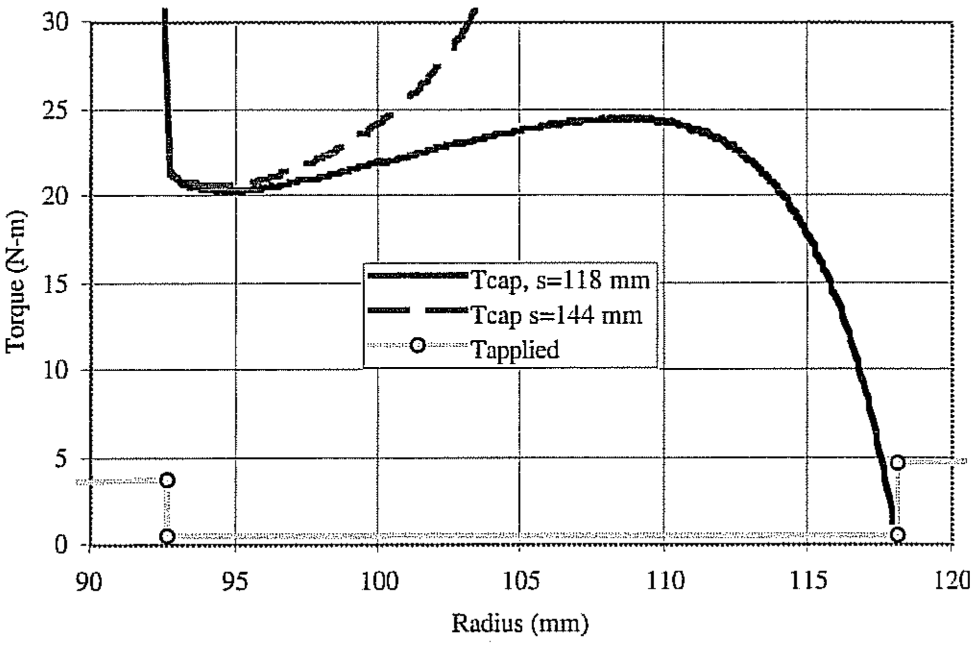

Figure 15 - Zoom on Minimum Torque Capacity Zone of Figure 8

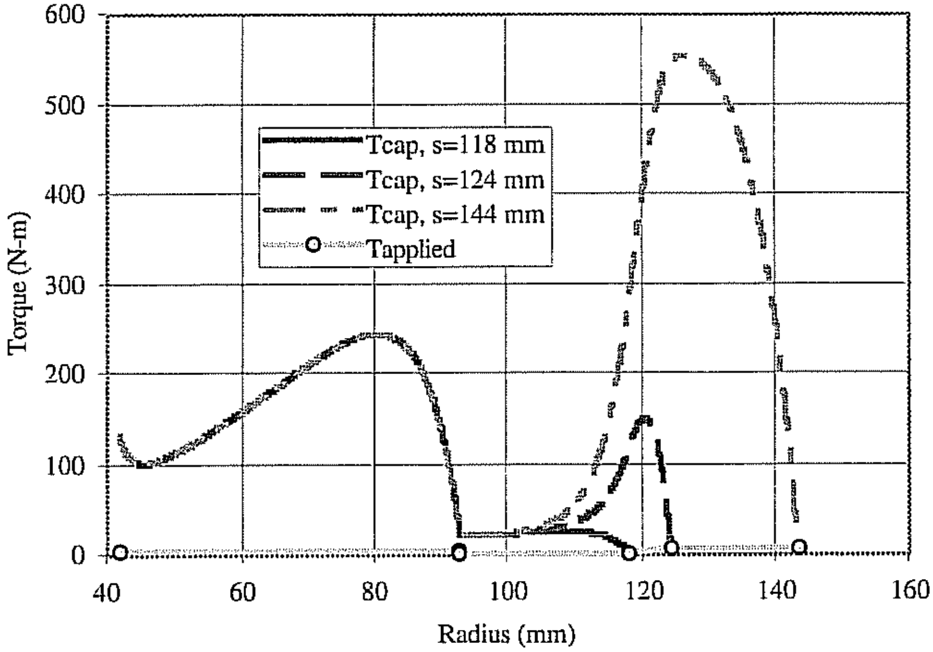

Figure 16 - Torque Capacity for a Ramp Tension Transition

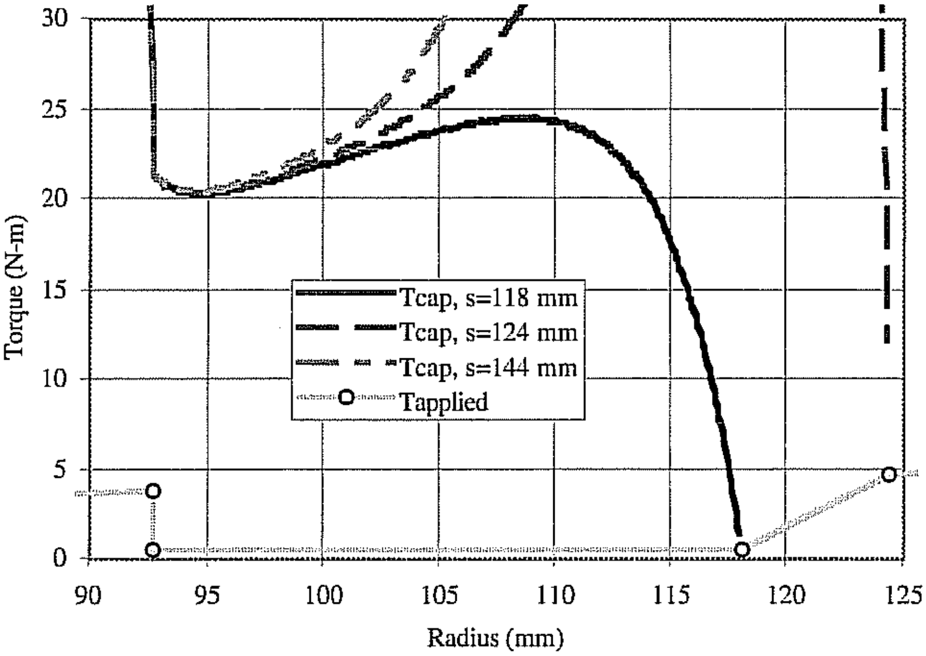

Figure 17 - Zoom of Low Torque Capacity Zone in Figure 16

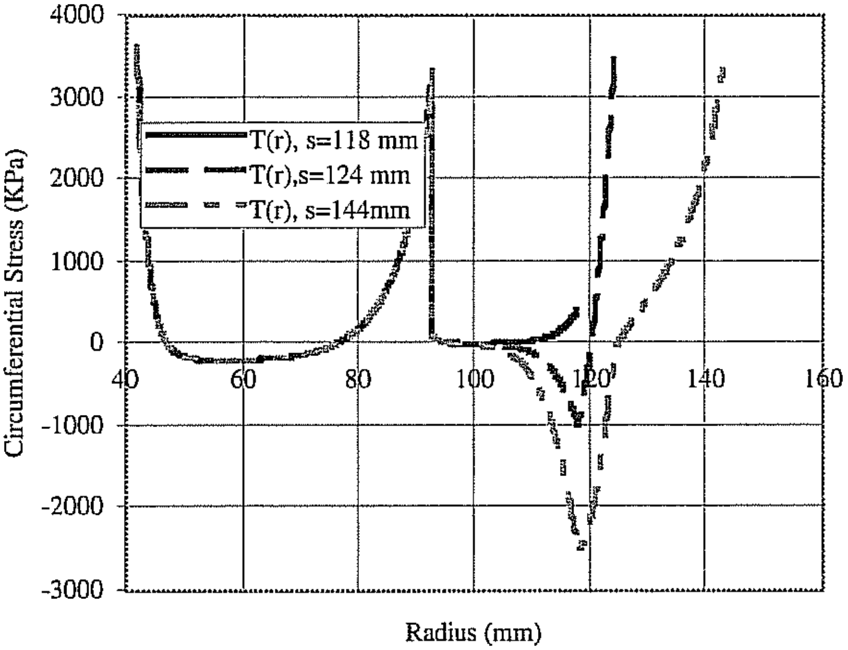

Figure 18 - Circumferential Stresses for a Ramp Tension Transition

Winding Stress (Constant Tension Case)	896 KPa
Winding Stress (Variable Tension Case)	3.65 Mpa from 41.9 to 92.7 mm 407 Kpa from 92.7 to 118 mm 3.65 Mpa from 118 to 144 mm
E_r	$930.1+38.8\sigma_r-0.0108\sigma_r^2+1.05*10^{-6}\sigma_r^3$
E_t	1.66 GPa
h - web thickness	71.1 μm
μ - coefficient of friction	0.2
l - web width	15.2 cm
ν_{rt}	0.01
Wound Roll Dimensions	41.9 mm I.R. and 144 mm O.R.
Core	38.1 mm I.R. and 41.9 mm O.R., steel

Table 1 - Winding and Web Parameters

Photograph	I	Nature of Defect	$\lvert\alpha\rvert_{max}$	Torque (N-m)	
	(N-m-s^2)		(rad/s^2)	Applied$_{max}$	Capacity$_{min}$
	0.0726	Crepe/Slip	434	31.5	11.6
Figure 12	0.0726	Crepe/Slip	354	25.7	11.6
	0.0726	Crepe/Slip	301	21.8	11.6
	0.0726	Crepe/Slip	284	20.6	11.6
	0.0726	Crepe/Slip	258	18.7	11.6
Figure 11	0.0726	Slip	160	11.6	11.6
	0.0726	Slip	139	10.1	11.6
Figure 10	0.0726	No Slip	71.5	5.2	11.6
	0.0726	No Slip	40.1	2.9	11.6

Table 2 - Summary of Deceleration Tests Performed on Rolls Wound at Constant Tension

Vaidyanathan, N.; Good, J.K.
The Importance of Torque Capacity in Predicting Crepe Wrinkles and Starring within Wound Rolls
6/19/95 Session 2 2:25 - 2:50 p.m.

Question - You have instrumentation that consists of encoders on winder shafts and you mentioned noise. I was just wondering if you had an inspiration to come up with a winder alarm that would signal when a roll should be checked for crepes or other possible defects because of jumps or other noises produced.

Answer - I don't understand. Noises in my data acquisition system?

Question - No, the onset of slipping conditions.

Answer - Oh, the squeaking noise?

Question - The squeaking noise would occur or a jump in velocity on an arbor or some other indication that would alert people doing quality control to inspect the situation to see if some damage had occurred.

Answer - Well, the squeaking usually occurs in film. I haven't heard a whole lot of squeaking in paper. A snapping sound occurs in paper. As far as instrumenting the winder for velocity differences, there has been a study done in Sweden done some time ago, but the idea with this study was to show wound-roll models it's easier to predict these things rather than go into expensive instrumentation.

Comment - Dave, it's an interesting point you bring up. So many facets of defects not only occur within wound rolls. People listen to the structure to see if there's something wrong with it. To my knowledge, no one has done that; it might be interesting.

Question - When you're talking about crepe wrinkles, in general, we ought to be more discriminating when we talk about crepe wrinkles because if we're not careful, we can generate a lot of confusion. We know that a type of web failure, which is a fine buckling mode, can occur as a result of several different mechanisms found near the core when you're supporting a heavy weight. or a very heavy roll found in the vicinity of the core. Then, you have this mechanism here which is generated. It may be somewhat of a contrivance, but enough to demonstrate the point. In the paper industry, I don't know if I've ever seen this type of failure--ever. You'd have to have a pretty poorly-wound roll to have it. There's no question from a mechanical view that it can exist and be demonstrated. The paper industry commonly refers to a crepe wrinkle as a nip-induced defect . So when you talk about crepe wrinkles, you have to be careful in describing which type of mechanism we're dealing with because they're entirely different animals even though the failure may look similar.

Answer - Your comment is well taken. When I referred to the literature, specifically yours in particular, there was a whole bunch of confusing issues. We have the nips generating crepe wrinkles and at the same time, we have deceleration in the rolls with the nips, having crepe wrinkles on them. So there again it's easy to get carried away with thinking that crepe wrinkles that were formed due to deceleration alone, were formed by nips and vice versa. And what I wanted to do here is just isolate what happens when you slam rolls in isolation. We wanted to study deceleration in isolation, which we wanted to quantify by this method.

Question - The point is well taken. You've cut out one little niche and described it. I've demonstrated crepe wrinkles with only half an inch of paper rolling down the floor, so there wasn't much deceleration in that.

Answer - In my closing statement, there are other means by which a loosening torque could be generated that could cause this cropping to occur.

Thank you.