BUILDING A DEFECT FREE REEL ON THE PAPER MACHINE

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ABSTRACT

More crepe wrinkles in reels are experienced today due to larger diameter reels, more calendering to achieve a smoother finish, fillers causing increased paper density, and recycled furnish causing a lower coefficient of friction.

Reel density analysis and J-line testing are used to determine the quality of the parent reel. These tests identify the location of small crepe wrinkles in the paper. The Reel Density Monitor displays the density profile of the critical primary to secondary arm transfer, often showing a consistent density dip at the point of primary arm release. The wound in density profile is compared to the nip load between the reel and the reel drum, demonstrating the effect of the nip load on the density profile.

Examples are given from two paper machines to describe how this was used to diagnose reel build problems and optimize the parameters that control reel build.

KEYWORDS

reel, density profile, crepe wrinkles, wrinkles, primary arms, secondary arms, reel spool, reel build, J-line, bumpless transfer

INTRODUCTION

Building a reel on a paper machine is an example of winding paper. A conventional reel is a single drum winding process with no torque to help the winding. Often the nip load is poorly controlled, if at all, and the tension is only indirectly controlled by the reel drum amps.

A study of pressroom breaks has found that the vast majority of breaks were in the last set of paper off the reel and in the end (A&Z) positions.[1] Mills have also reported that winder breaks frequently occur as the paper near the reel spool is wound. Both the pressroom breaks and winder breaks indicate that there is a reel build problem. This type of problem is the motivation for centre-wind assist as a retrofit on some older reels and the new none traditional reel designs that give more control to reel build.

When the breaks occur on the winder, the operators have the advantage of immediate feedback of the problem and the relief that the wrinkle was not shipped to a customer. If the complaints come from a customer the problem is potentially much more severe. It is now out of the control of the manufacturer and weeks or months of production with high break potential have occurred.. The number of wrinkles shipped is unknown and there is a potential loss of the customer.

When the wrinkles are severe enough to cause frequent winder breaks, the usual mill response is to deliberately wind extra paper on the reel. The paper near the spool with the suspected crepe wrinkles is then slabbed off, with a resulting loss in efficiency. Another mill response is to wind smaller reels. This will also cause a reduction in machine efficiency, especially if the winder is the productivity bottleneck. If the wrinkles are not severe enough to cause winder breaks, they may get wound into the finished rolls with the potential to cause pressroom breaks.

There are a number of tests normally used to determine roll structure.[2] However, trouble shooting tools on a reel are much more limited than on a set coming off the winder. Tests such as the gap test or the WIT-WOT do not lend themselves to a roll as large as a reel from the paper machine. J-lines are useful as a trouble-shooting tool because they directly show the location and amount of micro-slip, as well as the macroscopic slip if present. They are limited to machines that have trim slitters prior to the reel. This is a small fraction of the total paper machines. The most beneficial tool is the Reel Density Monitor (RDM) due to its non-destructive nature and universal applicability.

Crepe Wrinkle Formation

Crepe wrinkles form when there is slippage between layers of paper causing compression buckling in a layer of paper below the surface of the roll.[3,4,5] When a layer of paper slips a small amount around the whole circumference of a roll the slippage will not cause a defect. A crepe wrinkle occurs when the slippage is large, localized and compressive. When the slippage occurs in the opposite direction, causing extension of the sheet, a burst can occur. In newsprint the tightening may occur at the outermost layers and the loosening further below the surface.[6]

DISCUSSION

Examples of reel build on two different machines will be described. The machines differ greatly in age but have similar reel designs. The methodology used to diagnose reel build problems and optimize the reel density profiles are shown. In addition the nip load profiles of the second machine, which has primary arm nip relief, are shown.

Two hypothesis of the source of the unusual density profiles, shown in the following sections, are also given.

Paper Machine 1

This machine was built early this century. It has an old reel with very few automatic controls and pneumatic primary and secondary arm loading. It had a history of incurring crepe wrinkles, predominately in the first 2.5 inches of paper on the reel spool. Reel density analysis was performed with a portable LSZ RDM to determine the cause of the wrinkles.

The pulse rate for this density profile was 310 pulses per meter. There were 50 wraps of paper per annulus with a new annulus every 10 wraps. This results in an 80% overlap or reuse of the paper in the next calculation of density. This reduces noise in the profile while maintaining high resolution to see precisely how the profile changes.

Baseline Condition

Data was initially collected with no changes made to the machine or to the normal operating practice. The density profiles, Figure 1, show an extremely large, sudden density dip of 60-80 kg/m^3 (about 10% of the total density) which does not occur at a consistent distance from the reel spool. When the raw tach pulse count data is examined more closely it shows that this dip occurs within one 10 wrap annulus of paper

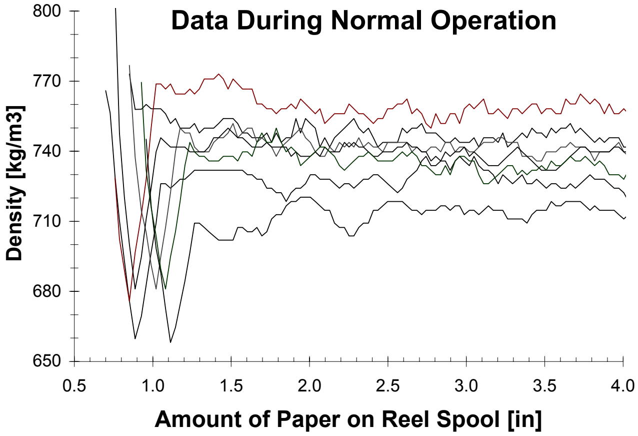
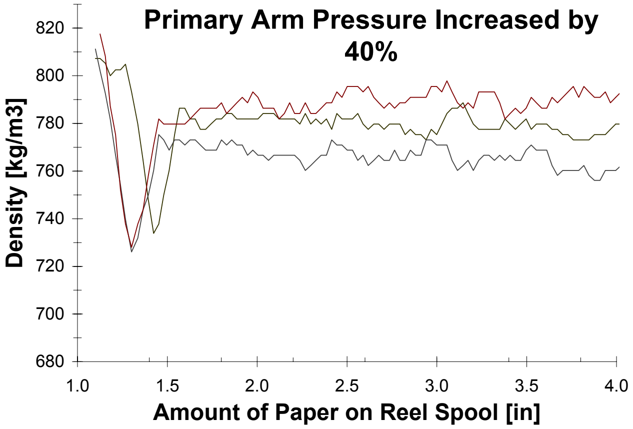


Figure 1 Reel build data taken before any changes to the operating procedure were made

Increased Primary Arm Loading

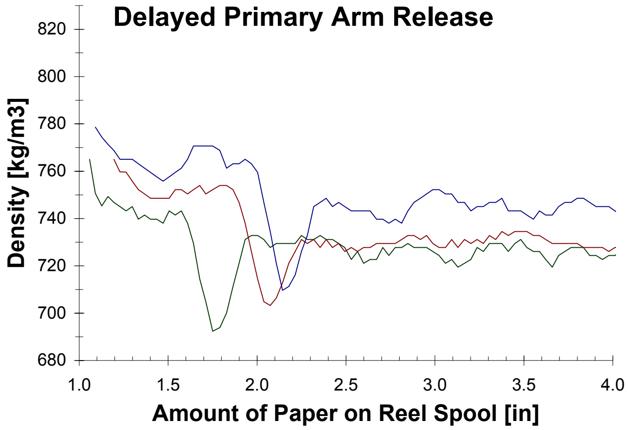
The primary arm loading was increased by 40% to increase the density in the initial region of the reel. Figure 2 shows that the density during primary arm build has increased. The density dip has decreased to about half its former magnitude when compared to the density in the secondary arms (to about 40 kg/m^3).



- Figure 2 Density Profile with primary arm loading increased by 40%

Delayed Release of Primary Arms

Using the normal TNT (Torque, Nip, Tension) rules of reel build, the most plausible reason for the density dip was a low nip load. This could be caused by the primary



- Figure 3 Effect of delayed primary arm release

arms releasing the reel spool prior to the secondary arms loading it. To determine if this was the case, the release of the primary arms was delayed with no change in the time of the secondary arm loading.

The results, shown in Figure 3 clearly show that the density dip remains, but has moved to a larger diameter. Visual observation showed no sign of the reel spool being pulled away from the reel drum during the transfer. From this we conclude that the density dip is caused by the abrupt primary arm release.

Paper stress analysis (Initial hypothesis)

The paper length in the low density annulus was compared with paper length in the remaining annuli. It was found to be about 12 mm longer over a total paper length of about 16 m. This translates into a strain reduction of $700\mathrm{x}10^{-6}$ m/m or 1.8 pli (E=850,000 psi and caliper=0.003”) from the average wound in tension. Since the change probably occurred over a smaller number of wraps than the 10 wraps used in the calculation, the wound in tension at this point could easily be negative.

Radius change (Alternate hypothesis)

Due to the reduced load at the point of contact, the effective radius (distance from the centre of the reel spool to the point of contact on the reel drum) of the reel will grow when the primary arms release. This increase in radius leads to additional paper being wound onto the reel spool and showing up as a density dip. Subsequent annuli would also have this additional amount of paper. Since the density calculation uses the difference in length between two annuli, and the difference is a one time effect, the density change only occurs where this length difference (radius change) is present.

Whichever hypothesis is correct, the density dip shown in Figures 1, 2 and 3 represents an abrupt change in reel build. Small wonder that problems occur.

Paper Machine 2

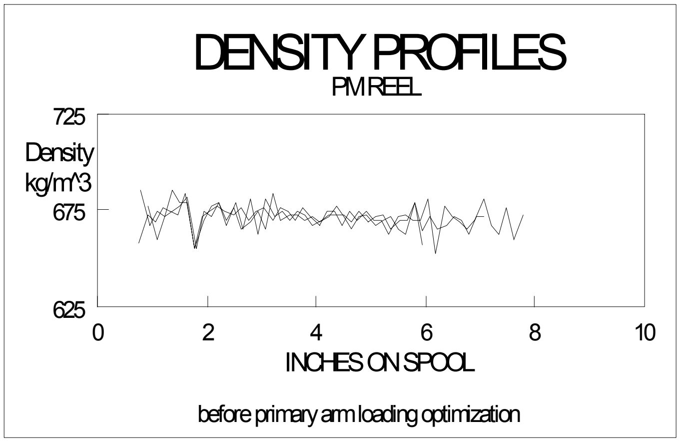
This machine was built in the early eighties and also has pneumatic primary and secondary arm loading. To combat crepe wrinkles the mill installed primary arm nip relief from a machine builder. The nip relief is designed to be equal and opposite to the nip load from the reel spool weight. It is also designed to eliminate the doubling in the nip load due to the loading of both the primary and secondary arms during the transfer. The programming of the nip relief was done by mill personnel within the existing PLC. This was combined with new cobra jet turn-up showers and a new air assisted gooseneck to ensure consistent turn-ups with a very tight wrap of the tail.

After all this work was completed the mill was still battling crepe wrinkles.

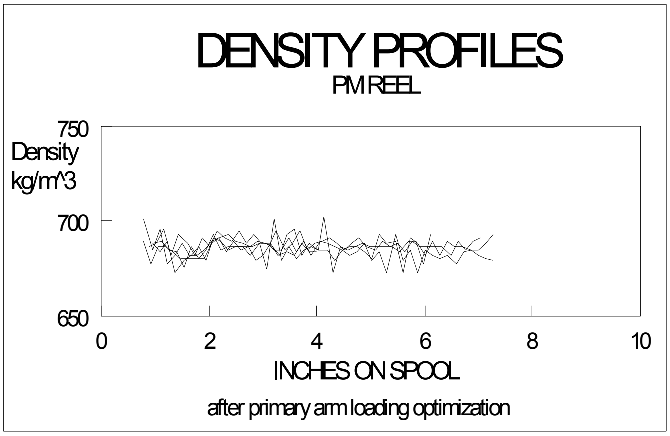
Density Profiles

The measuring conditions for the density analysis were 395.7 pulses per meter, 50 wraps per annulus with a new density point every 10 wraps giving the same 80% overlap as in the previous reel.

Density profiles in the secondary arms were taken, Figure 4, which show the same type of density dip as Reel 1 only much less pronounced. This was an



- Figure 4 The density profiles after the bumpless transfer was installed. Note the repetitive downward density spike at 1.75" jacket.



- Figure 5 The density profile after the bumpless transfer was optimized

indication that double loading on the transfer from primary to secondary arms was still present. Nip relief had been installed and programmed to prevent this double loading, which is referred to as bumpless transfer. When the PLC programmers were shown these results they checked the bumpless transfer program and found timing errors between the nip relief, primary and secondary arm loading.

When the timing of the bumpless transfer was optimized, the density profile was measured again and is shown in Figure 5. This greatly reduced the number of crepe wrinkles and reduced the snap-offs at the winder. For certain grades of paper the mill could increase the reel size without crepe wrinkle problems.

Standard Operating Procedures (Or Lack of Them)

Over time the mill started noticing a different problem. A smooth turn-up was not consistently achieved, which led to a reduction in the primary arm loading to 2/3 of the recommended value. While decreasing the number of missed turn-ups, this caused problems with sheet control and wrinkles while the primary arms were being lowered. To combat this new problem the hydraulic nip relief was turned off just prior to the spool being lowered to the secondary arm rails. Some operators continued turning off the nip relief hydraulics while others left them on, while the primary arms were lowered. Still others turned the hydraulics back on just after the reel spool hit the rails enabling the bumpless transfer part of the nip relief. Thus the turn-up procedure depended upon the operator. This shows the importance of standard operating procedures based on measured performance rather than each operator performing an operation based on perceived performance.

The effect of these changes on the propensity to form crepe wrinkles was not taken into consideration. Crepe wrinkles did come back as a problem. We were not aware of the changes in operating procedure when asked to resolve this new wrinkle problem. Thus the work described below is a systematic attempt to isolate the problem.

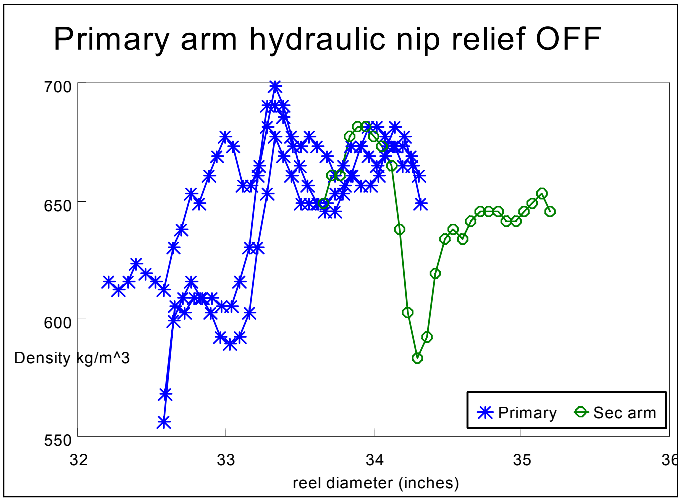
J-lines

To determine the source of the problem, J-line testing was done on the winder. The J-line occasionally showed a slippage of up to 5 mm from one layer of paper to the next. These discontinuities were only found on the last set off the reel in the top 100 mm with most in the top 50 mm. When the rolls with the discontinuous J-lines were slabbed down, crepe wrinkles were found about half the time. To determine if this could be a function of winder deceleration, the winder was stopped and restarted with the set partially wound. This intermediate stop did not show any J-line discontinuities or evidence of crepe wrinkles. It was noticed that the discontinuities coincided with a pronounced ridge in the reel being unwound. From this it was concluded that the problem was still coming from the reel.

This machine has trim slitters before the reel so a J-line test can be made on the reel as it is being built. They cannot be snapped until the trim slitters are in place with an additional 100 mm of paper resulting in about 130 mm of paper on the reel. Even with these difficulties, J-lines were attempted. The same type of discontinuity in a few J-lines was found in the jumbo about 250 mm from the spool. When this paper was followed through to the winder and the wound rolls again slabbed down, small crepe wrinkles of about 35 mm in length were found in the roll.

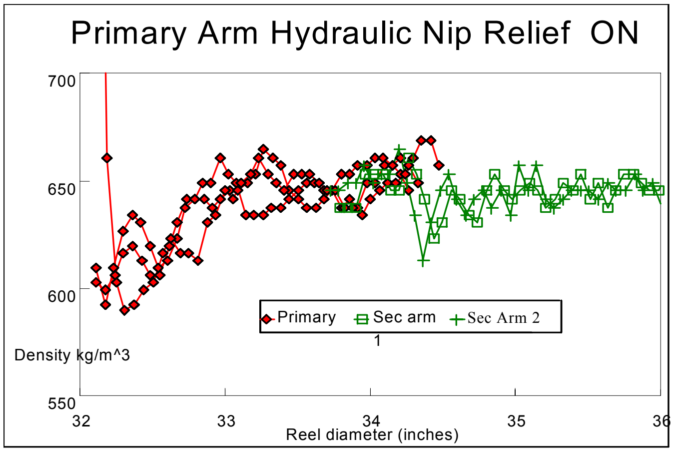
Reel Density Profiles

The density profile of the reel when the nip relief is turned off, Figure 6, shows a density dip at a diameter just larger than 34”. This density dip was quite consistent and occurred when the primary arms were releasing the reel spool.



• Figure 6 The density profile with the hydraulic nip relief turned off.

A number of density profiles were then taken with the hydraulic nip relief on as designed. The results in Figure 7. show that the density dip at the point of primary arm release has virtually disappeared with just a small effect visible.



• Figure 7 The density profiles with the hydraulic nip relief on

Nip Load

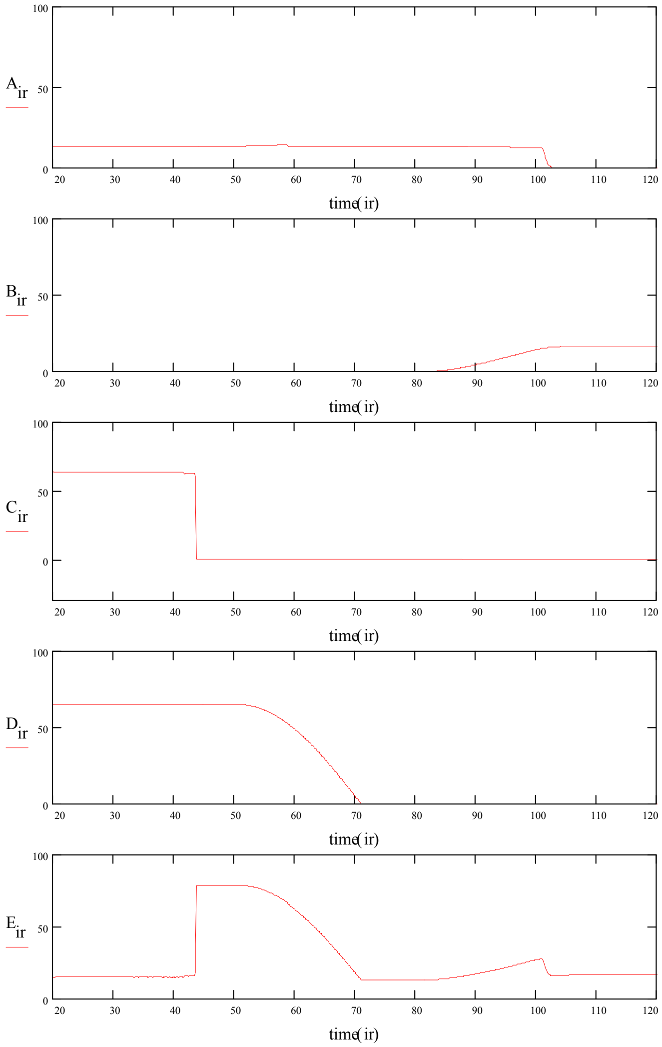
Since this is a traditional reel, there is no centre wind assist to give the equivalent of a torque differential in the reel build. This leaves the paper tension and the nip load as the only factors controlling the reel build. The nip load was expected to be the controlling factor so it was checked in detail.

Newsprint machines should have a nip load of about 17 pli. The nip load was checked by measuring the primary and secondary arm cylinder loading pressures, the hydraulic nip relief pressure, and the tilt of the primary arms. The other variable that affects the nip load is the friction in the primary arm slides and in the secondary arms. The amount of friction is expected to be larger in the primary arms but this effect was not measured.

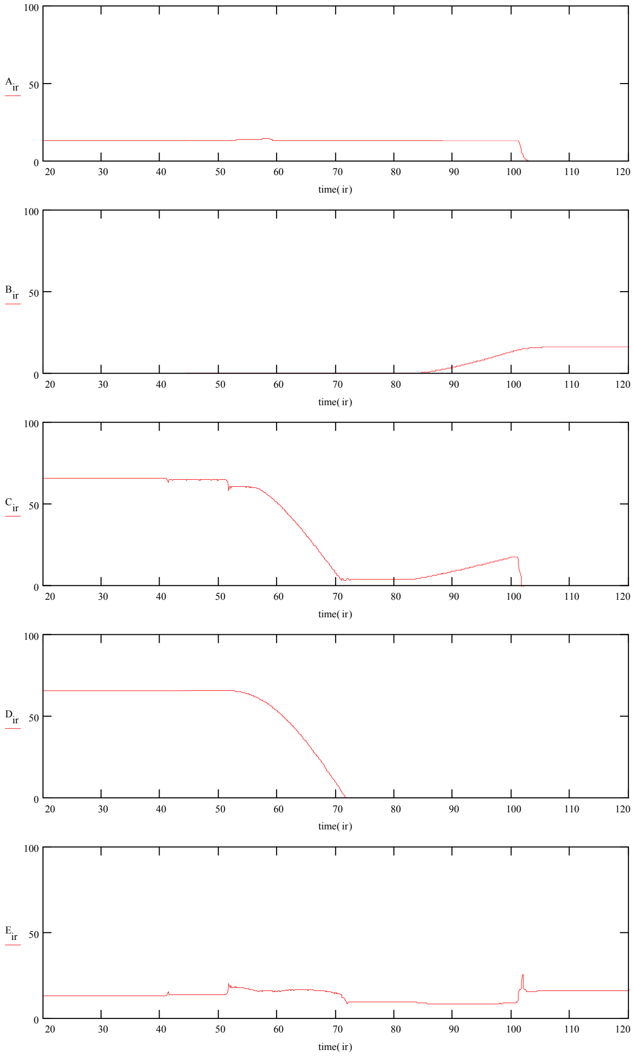
The loading profile when the hydraulic nip relief is turned off is shown in Figure 8. The nip load from the primary arms is 12.5 pli. As mentioned above, the nip load was deliberately low to reduce the number of missed turn-ups. The hydraulics were turned off just prior to the reel spool being lowered at about 43 seconds in Figure 8, increasing the nip load to about 75.5 pli. Once the spool is on the rails the weight of the spool is no longer contributing to the total load and the nip load is back down to 12.5 pli. At about 84 seconds the secondary arms start loading against the reel spool. This is a fairly slow loading taking about 15 seconds. At just over 100 seconds the primary arms unload rapidly, in about 2 seconds. After the transfer the nip load remains at approximately 17.5 pli. The other interesting feature is that as the primary arms are lowering, the loading pressure on the primary arms increases slightly. The reason for this is unknown.

Figure 9 shows the nip load profile with the hydraulic nip relief operating as designed. During the time of primary arm lowering the nip relief does not quite compensate for the reel spool weight. This coincides with a reduction in the nip relief pressure seen in the 3rd profile of Figure 9, just after 50 seconds. The timing of the nip relief is not perfect during the bumpless transfer phase of the loading. The nip relief pressure drops off a little before the primary arm pressure, giving a nip load of 25.5 pli at 102 seconds. This is 1.5 times the normal loading, still well below the double loading that otherwise would have occurred, but much higher than it should be. This example shows the limitations of programming the PLC to give nip relief based on time with no feedback from the primary and secondary arm loading pressures or positions.

Figure 8 and Figure 9 show that the secondary arm loading takes about 15 seconds while the primary arm unloading takes only 2 seconds. The large difference in loading versus unloading time will certainly make the unloading more likely to cause a problem. This may explain why a problem in the density profile is consistently found at the point of primary arm release.



• Figure 8 The nip load with the hydraulics turned off just prior to the primary arms being lowered. The components from top to bottom are a) the primary arm contribution, b) the secondary arm contribution, c) the hydraulic nip relief contribution, d) the gravitational loading on the reel spool, and e) the total effect of the above contributions.



• Figure 9 The nip load profile with the hydraulics on for the duration of the test. The components from top to bottom are a) the primary arm contribution, b) the secondary arm contribution, c) the hydraulic nip relief contribution, d) the gravitational loading on the reel spool, and e) he total effect of the above contributions.

SUMMARY AND RECOMMENDATIONS

This paper has shown how to identify and reduce variations in reel build uniformity that lead to crepe wrinkles. The first tool used was the on-line reel density monitor. The second tool used was monitoring the pressures and primary arm angle contributing to the nip load. The third tool was J-line testing on the reel.

The density profile of a typical reel built with no nip relief has been shown to have a density dip at the point of primary arm release. The density dip can vary in magnitude from extremely large to quite small. This density dip is related to crepe wrinkle formation.

The exact reason for this dip is unknown, but it consistently occurs when the nip load reduces as the primary arms release the reel spool. The most plausible explanation is that it is due to the effective change in the radius of the reel when the primary arms release the reel spool. With the primary arm release taking 2 seconds as measured on the second machine, this will definitely take place within one 10 wrap annulus. This hypothesis also matches the reduction in magnitude of the density dip in the first reel examined, when the primary arm loading was increased making a denser start. This increased hardness would reduce the change in radius when the primary arms were released.

When it is possible to use J-lines on the reel as it is being built, they can provide very valuable information on the building reel. The discontinuities are particularly valuable in providing insight into the wrinkling process.

The importance of the nip load on the reel build has been measured and the results shown. The limitations of nip relief applied on a timing basis with no feedback is also shown. The example shows that the timing is close but not correct. Any small change in the timing of the loading due to operational changes will make the existing loading profile obsolete.

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