Eliminating production losses on a paper machine reel

Martti V. Tuomisto, Kari Sorsa, and Markku Kyytsönen

ABSTRACT: The paper analyzes reasons for production losses on the paper machine reel. New ideas and technical solutions are presented for paper mills to eliminate losses related to poor starts and other winding problems on the reel. The solutions include adjustable winding angle against the reel drum, center-driven winding, carefully controlled nip loading and web tension as well as customized reel drum grooving and friction coating. Some paper mill experiences with this new approach to windup problems are presented. The experiences include a reel on a supercalendered groundwood paper machine and a rereeler at a lightweight coated paper mill.

KEYWORDS: Cores, machine design, machinery, paper machines, papermaking equipment, problem solving, reels, winding, wound rolls.

Production efficiency studies show that, on the average, 10–20% of the gross paper machine production is lost at different stages before the paper is shipped out of the mill. The losses can be especially high with such difficult-to-wind lighter basis weight papers as supercalendered groundwood papers (SC) and lightweight coated grades (LWC). **Figure 1** shows the typical losses on SC and LWC grades. About one-half of the losses are attributable to poor starts on the paper machine reel. Coated paper mills, which operate off-machine coaters, typically experience similar problems on rereeler and coater windups as well.

Crepe wrinkles

The conventional surface-driven reel, found on most paper machines, causes inaccurate and noncontinuous nip loading between the reel drum and the parent reel during and after the turnup, as shown in **Fig. 2**. The operation of primary and secondary arms following the turnup, combined with cross-machine nip load variations, can lead to crepe wrinkles in paper layers within a few centimeters from the reel spool. Crepe wrinkles typically appear toward the web edges and run in the cross-machine direction or at a 45° angle.

The paper being wound up on a parent reel compresses the bottom layers on the reel spool. The compression is a stress that varies and is repeated many times a second during rotation. Due to the compression, the paper layers tend to slip and rub against each other, especially if the bottom part of the reel is not properly wound. This phenomenon can be seen as glossy patches on the paper when the bottom layers of the parent reel are unwound. Glossy patches often indicate the existence of crepe wrinkles. Slipping makes ridges rub off, causing a substantial drop in the tensile strength of paper. When the bottom layers of the reel are unwound, a web break may occur at the point of the last crepe wrinkle defect caused by the paper machine windup.

At the beginning of winding, when the reel spool is supported by primary arms, the weight of the reel spool is relieved by 70–90%. In practice, the middle area compression can be many times the compression on the edges where the nip load is close to zero, as shown in **Fig. 3.** When lowering the reel spool onto the secondary rails, the situation is the opposite as the parent reel edges are compressed by loading with the secondary arms. This means that there is a change from a tight middle and loose edges toward tighter edges with a loose middle.

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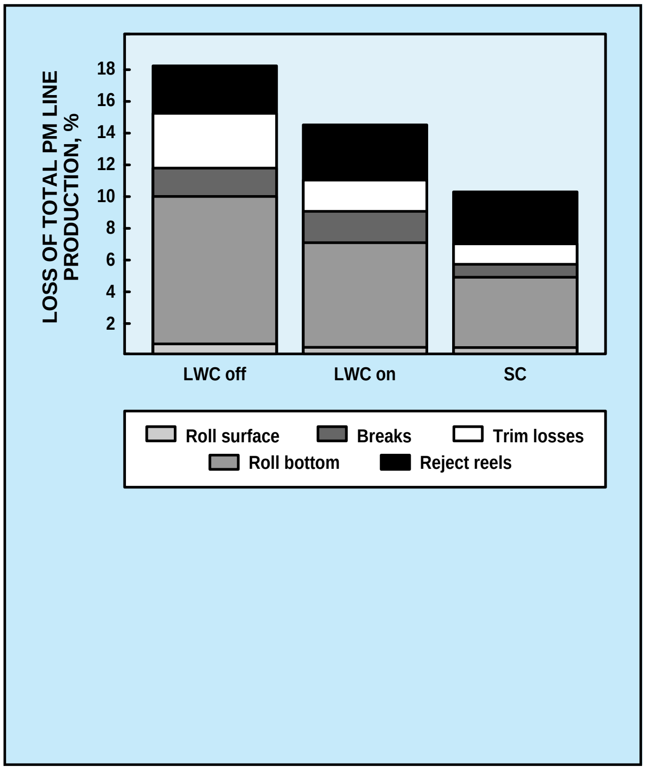
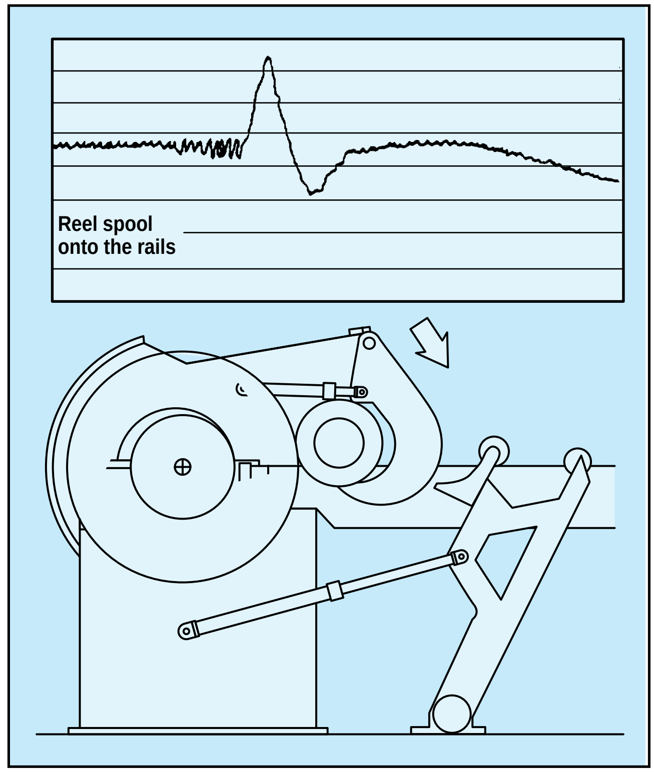
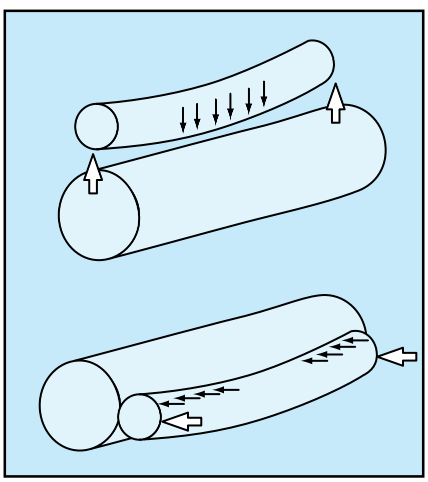
1. Typical production losses on SC and LWC grades



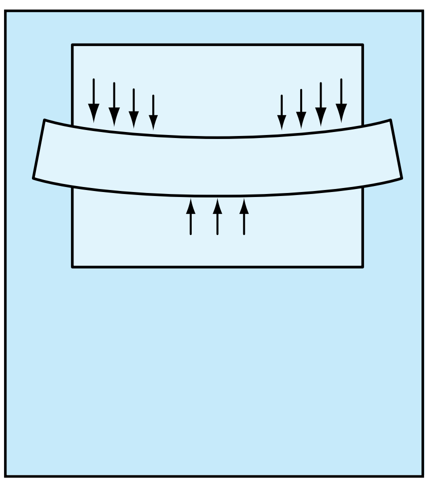
2. Nip load variations measured during a turnup on a conventional surface-driven reel



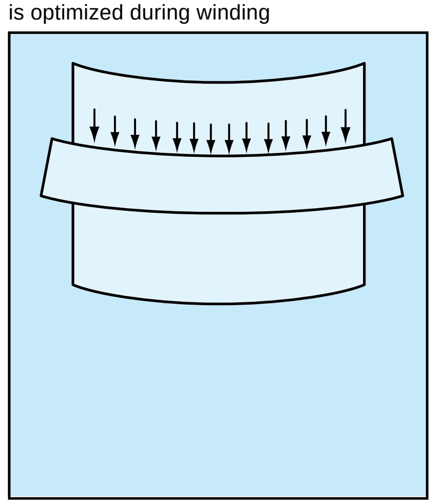
3. Cross-machine nip load variations when using an uncrowned reel spool



4. Typical internal nip stress imposed by a rigid paper mass on a less rigid reel spool



5. Internal nip stresses imposed by a paper mass on a reel spool when the reel structure is optimized during winding

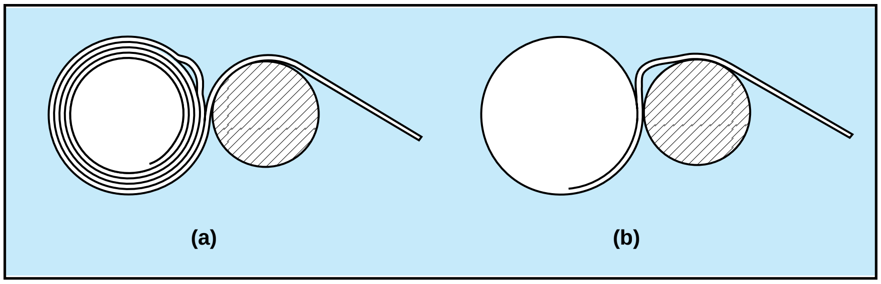


Internal stresses

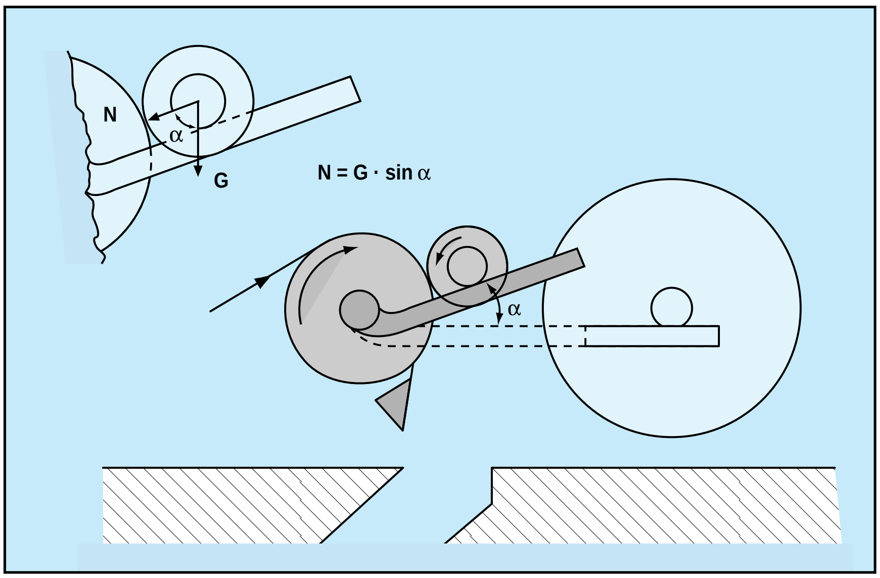
Paper layers inside a parent reel can resist fairly high internal radial stresses without the paper being damaged, if the reel structure in the radial direction (from the turnup to the final diameter) is good. This means that the layers nearest to the spool must be properly and uniformly tensioned to support the final reel weight over the initial paper layers.

Measurements show that paper, when wound up on a spool, makes the entity formed by the paper mass and the reel spool more rigid. Therefore, the stresses imposed by the rigid paper mass on the less rigid reel spool develop mainly at the edges, which explains the occurrence of crepe wrinkles in these areas (**Fig. 4**). Peak stresses at the edges can be evened out by winding less tightly—especially toward the end of a winding cycle (**Fig. 5**).

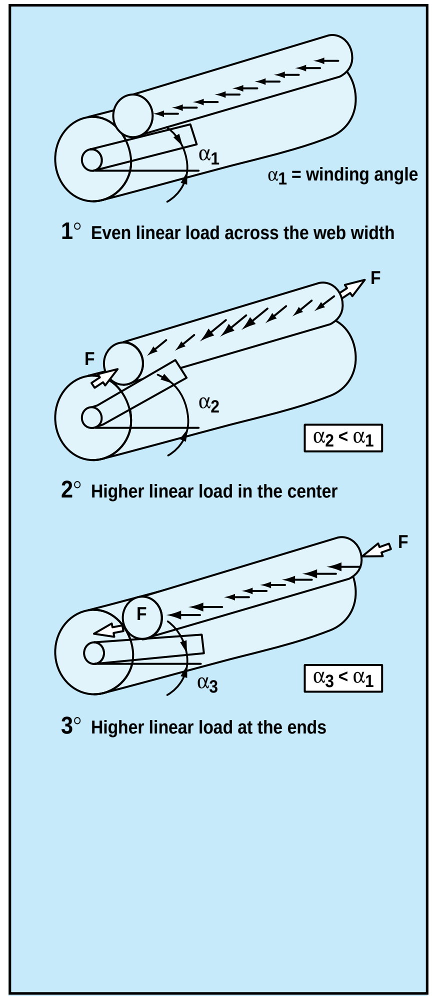
6. Low-porosity paper grades have two kinds of air bag problems: (a) between top two layers, and (b) on the reel drum.



7. The adjustable winding angle and center drive provide a smooth start after turnup. The nip load *N*, which is a sine component of the parent reel weight, needs to remain uniform without peaks



8. Principle of nip load profiling in the cross-machine direction



The rigidity of the reel spool can be increased by making it larger in diameter. Once the reel spool rigidity approaches that of the paper mass, the edge stresses will be reduced, because the spool will support the paper mass more evenly.

Air bags

On dense and low-porosity grades, such as coated papers, an air bag may develop either in the parent reel between top two paper layers or on the reel drum, as shown in **Fig. 6**.

Air bag problems in the parent reel are caused by air pumping into the nip between the top paper layer and the incoming web. The tight nip prevents air from settling within the parent reel. After having collected a sufficient amount of air, the air bag often starts moving toward the edges and then, occasionally, passes through the nip, causing wrinkles and broke.

A reel drum air bag develops when the nip that exists between the incoming web and the reel drum sucks in air. This air collects in a pocket in front of the tight winding nip.

Both types of air bag problems can be eliminated by proper reel drum grooving and friction coating. Single or double grooving of the reel drum allows air to pass continuously through the winding nip. The groove profile and pattern are determined mostly by the properties of the paper being wound. Nip load, web width, and operating speed are factors as well in the selection process.

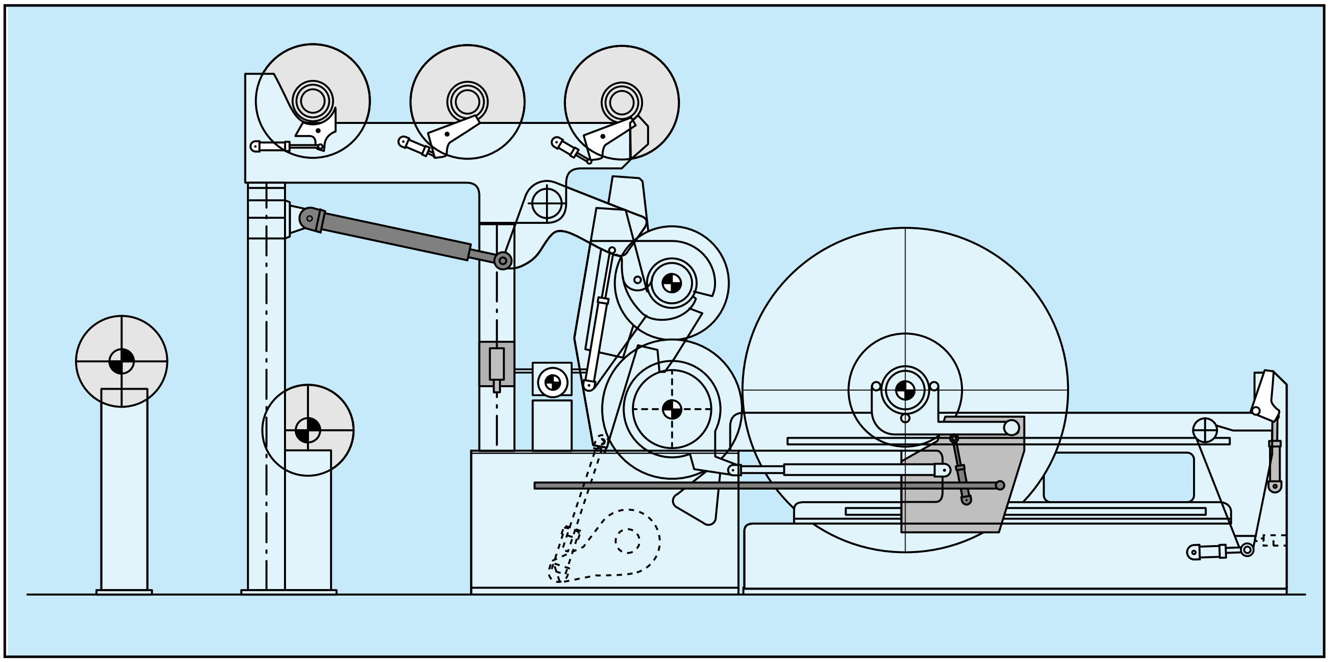
Eliminating losses

Adjustable winding angle

A uniform nip load distribution in the cross-machine direction can be achieved by gradually changing the position of the parent reel in relation to the reel drum, as shown in **Fig. 7**. The winding angle is adjusted according to the desired nip load. A center drive, combined with a uniform nip load, provides a smooth start for a parent reel.[1]

[1]Kyytsönen, M., "Optireel—A New Reeling Concept," Valmet Paper Machine Days Proceedings, June 11–12, 1992, Jyväskylä, Finland.

9. High-efficiency paper machine reel



The system also allows nip load profiling in the cross-machine direction as shown in **Fig. 8**.

The center drive through the reel spool and the surface drive through the reel drum make it possible to apply a programmable torque split between the drives. On slippery paper grades, such as SC and LWC papers, it is beneficial to coat the reel drum with friction coating to avoid any slippage in the nip. Also, proper grooving of the reel drum and polyurethane coating of the reel spools are helpful on many paper grades.

New paper machine reel concept

Figure 9 presents a paper machine reel with primary arms that can lower the reel spool to a desired, variable winding angle after the turnup. The center drive is an essential part of the system to produce a good start without crepe wrinkles.

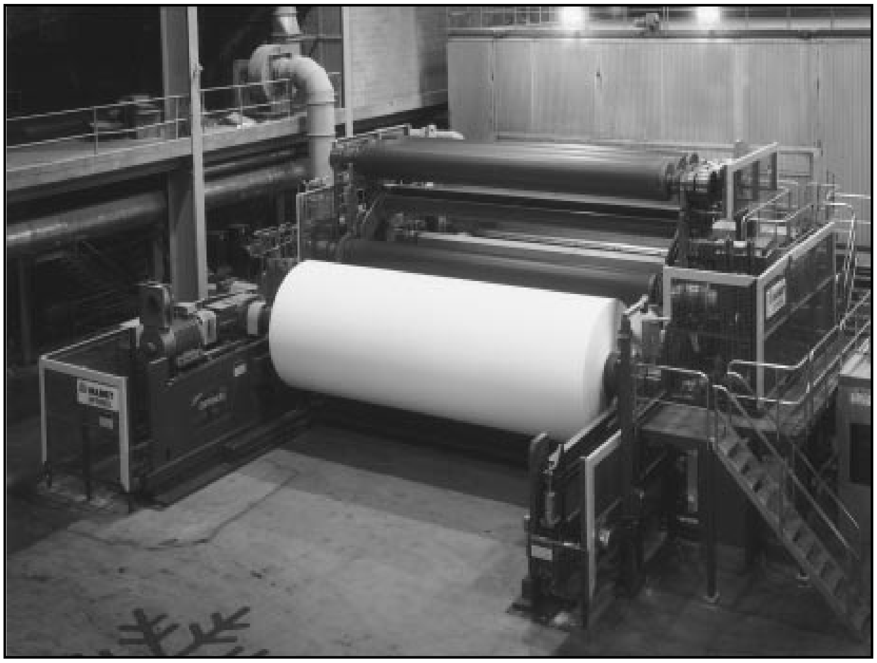
Once the parent reel is lowered all the way to the secondary rails, its travel in the horizontal direction takes place on carriages, not on reel spool bearings. The carriage system allows a low friction, smooth movement of the parent reel while it is building up on the rails.

10. Blandin Paper Co., Grand Rapids, MI, operates a rereeler with rails which can be raised and lowered for variable-angle nip loading of the parent reel

Paper mill experiences

A lightweight coated mill in Minnesota recently rebuilt a rereeler with variable-angle winding and center drive systems (**Fig. 10**). The winding angle is adjusted by raising and lowering the secondary rails, as rereelers do not have primary arms.

After a similar rebuild, a Finnish LWC mill has been able to reduce the bottom broke being left on the reel spool at the rereeler from 35 mm to the current average of 6 mm.[2]



11. A center-driven, adjustable-angle paper machine reel for SC grades at Madison Paper Industries mill, Madison, ME.

In other words, the mill has reduced the losses due to slab-offs by 85%, resulting in additional 5000 metric tons/year of paper going to the off-machine coater through the new rereeler.

Two months after the startup of the first rereeler, the same LWC mill in Finland decided to add a similar windup to another rereeler which conditions base stock reels for an off-machine coater.

Madison Paper Industries recently rebuilt its SC paper machine with a reel concept that includes the features for minimizing production losses due to a poor start after the turnup (**Fig. 11**).

Again, a similar installation at a new Finnish SC mill confirmed that the average amount of paper being slabbed off from the bottom of the parent reel is down to 400 m/reel compared to about 1600 m/reel on the conventional surface-driven reel at the same mill.[2] This means that the mill will produce 4500 metric tons/year more saleable paper by eliminating 75% of losses related to poor starts and crepe wrinkles.

Summary

Crepe wrinkles in the initial layers of paper near the reel spool are a major source of production losses on many printing paper grades. The defects are caused mainly by inconsistent nip loading after the turnup and air bags ahead of the nip.

Crepe wrinkle problems can be solved by using variable-angle winding on the paper machine reel, combined with a center-drive system. Proper grooving and friction coating of the reel drum are helpful on many paper grades as well. TJ

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[2] Tyrväinen, M., "Optireel Increases PM Line Productivity," *Valmet Paper News* 8 (2): 12(1992), Helsinki, Finland.