Measurement and correction of baggy edges on paper machines

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ABSTRACT

A new tension beam was developed to measure the cross-machine directional tension profile of paper webs. The beam, composed of 50 individual Teflon pads resting on load cells, allows the measurement of the tension profile of a 1270 mm wide web. Tension profile measurements allow us to quantify the level of web bagginess with an accuracy of 5%. Tension analysis showed that the tension difference between the two edges of an edge roll can be as high as 200%. In most of the time, tension profile variations are related to cross-machine direction moisture variations. It was also found that drying history variations could cause tension profile non-uniformity in the cross-machine direction (CD). There are many possible ways to correct bagginess, particularly the reduction of CD moisture variations and the application of a moisture bias at the edges. Some common problems and solutions are described.

INTRODUCTION

Cross-direction (CD) non-uniformity of web tension is known to affect runnability on the paper machine, on the winder, and on the customer's printing press and converting lines [1, 2, 3]. Non-uniform tension leads to bagginess and slack edges, which create wrinkles, web wandering and corrugations. A non-uniform tension will affect runnability on the paper machine in the drying section, the calender and the finishing operation [2, 3, 4]. On the paper machine it is often observed that the tension drops at the edge of the machine [5]. This probably contributes to the classic poor pressroom performance of edge rolls [6]. Non-uniform tension profiles affect the performance of the web during printing and converting operations. Non-uniform tension profiles also affect print registration as it affects lateral stability of the web.

Converters and printers have limited solutions to web bagginess. The paper rolls are either rejected or the web tension is increased to "eliminate" bagginess. The sheet must be stretched in the machine direction to reduce the slack edge on the lower tension side. The tension on the opposite side increases and the stress exerted on the web could exceed the strength of the paper, resulting in a web break. To maintain good runnability, sufficient tension must be kept between the minimum and maximum values in every part of the web [1, 3]. In addition, it was shown recently [7] that a non-uniform web will affect web tracking, with the sheet moving in the direction of the lower tension.

Bagginess is often observed at the customer's operation but cannot be quantified. The general complaints are that the bagginess creates wrinkles and misregistration on a printing press, and creates wrinkles and warp on a corrugating line. The cross-machine direction tension profile is not traditionally measured or controlled, and there is no objective way to evaluate the uniformity of the CD tension profile from the basic paper properties. The prediction of the tension profile from paper properties such as moisture and TSI-TSO, can be very difficult and often inaccurate. Many mills report that they are not able to relate bagginess to the basic CD properties of the web.

Eliminating bagginess is a difficult task. A trial and error approach to solving bagginess with visual observation is a long process and leads to uncertain results. Solving bagginess rests on the capacity of the papermakers to quantify the tension profile so that they can quantify the impact of changes on the machine operation on the tension profile uniformity. A successful tool for measuring web tension is METSO Automation's IQ tension beam [8, 9]. It is a non-contact method for measuring the web tension profile on-line. The use of this beam requires a machine speed higher than 400 m/min, to form an air film between the paper and the beam. It can be installed on the paper machine or on the printing press. Potential limitations are the cost and the resolution, since the sensor spacing is 100 mm at the edges of the machine and 300 mm in the center (where the tension is usually more uniform).

To investigate the tension profile at high resolution and on webs moving at lower speed, and verify possible relationship with other web properties such as moisture and basis weight at high resolution, a new tension beam has been developed. The tension beam measures paper web tension and its profile in cross tension at high resolution and with a high accuracy. In this paper we first describe the tension beam and present results from the measurements on different grades of paper. Case studies of tension analysis and problem solving for baggy edges are also presented.

METHODOLOGY

The first design criterion was to develop a system that can measure the web CD tension profile with high accuracy and high resolution. The system had to be sensitive enough to detect small tension variations within a width of only a few mm. Other design criteria were: no web speed effect, reasonable cost and easy maintenance and calibration. Several designs were analyzed and a preliminary study showed that the most feasible solution consisted of paper traveling over units mounted on a load cell. We have developed a 127 cm (or 50 inches) wide tension beam using fifty individual 25 mm wide Teflon pads. All pads were assembled on the beam before being machined on the lathe at a radius of 125 mm. The load cells were added to the beam on the lathe and a dial indicator was used to adjust all units with 2.5 micrometers of precision. Pictures of the tension beam are shown in Figure 1.

Each unit included an S-beam load cell, a half Teflon cylinder 25 mm wide, and an aluminum support. Teflon was chosen because of its low friction coefficient. The Teflon pads are not directly mounted on the load cells but rather pivot on a rod and rest on the load cells using adjusting screws and loading buttons. All units are fixed to an aluminum H beam that was designed to minimize flexion.

Figure 1: The new tension beam installed on the lathe during its fabrication (left), inside view of the 50 load cells (center) and the beam in operation with paper on it (right).

The tension beam was installed near the unwind stand of roll structure tester (Figure 2). This equipment has the facilities for installing, threading and unrolling large paper rolls (127 cm wide rolls X 127 cm diameter) at constant machine direction tension. All 50 units were connected to a PC and Labview software was used to acquire the data. All load cells were individually calibrated using a 10 kg weight. Linearity and repeatability of the voltage were also verified for each load cell.

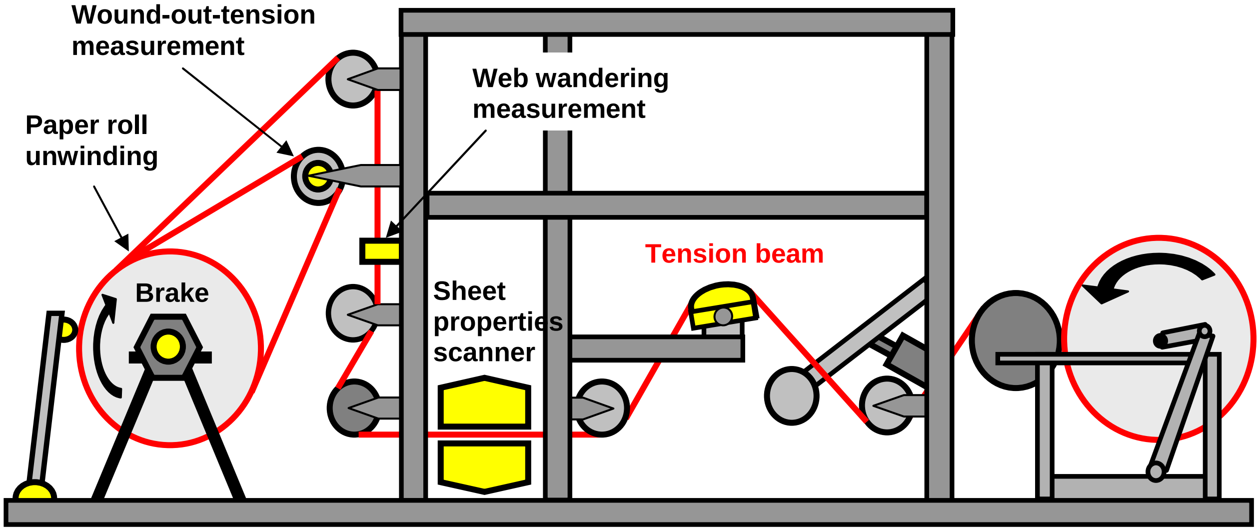
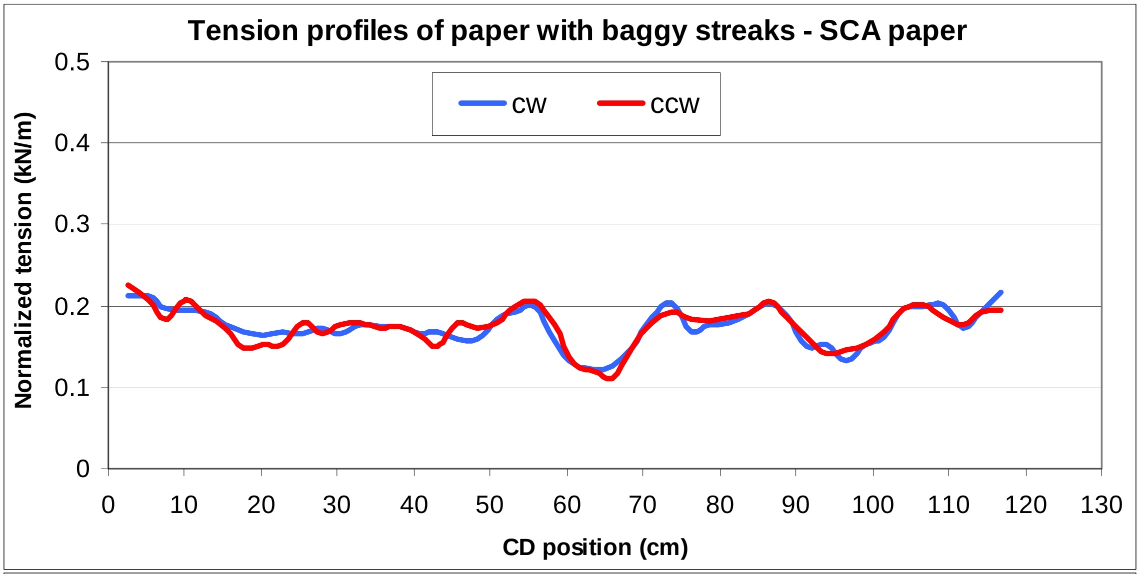


Figure 2: Schematic representation of the tension beam installation on the roll tester

All equipment rolls were aligned using a very accurate laser technique. Even with roll alignment completed, a calibration procedure was developed to take into account any minor roll misalignment that can affect the tension profile. Roll alignment is very critical since a few microns of roll misalignment would lead to major differences in the front-to-back tension measurements.

Validation of the method of measurement was achieved by measuring two paper rolls clockwise and counterclockwise. Paper rolls for the tests were unwound at a speed of 100 m/min and a MD tension of 0.175 kN/m at the tension beam. Figure 3 shows two examples of the tension profiles from two different paper rolls (clockwise vs counter clockwise). The first one is SCA paper (74 gsm – 117 cm wide) with baggy streaks in the middle (zones of lower tension). The second paper is standard newsprint (48.8 gsm – 127 cm wide) for which the edges had over-dried, leading to higher tension at the edges of the roll. For both papers, the two profiles (clockwise and counter clockwise) are similar. An average difference of 0.00875 kN/m on the average tension of 0.175 kN/m (1 PLI) was found between the two profiles (5% of error).



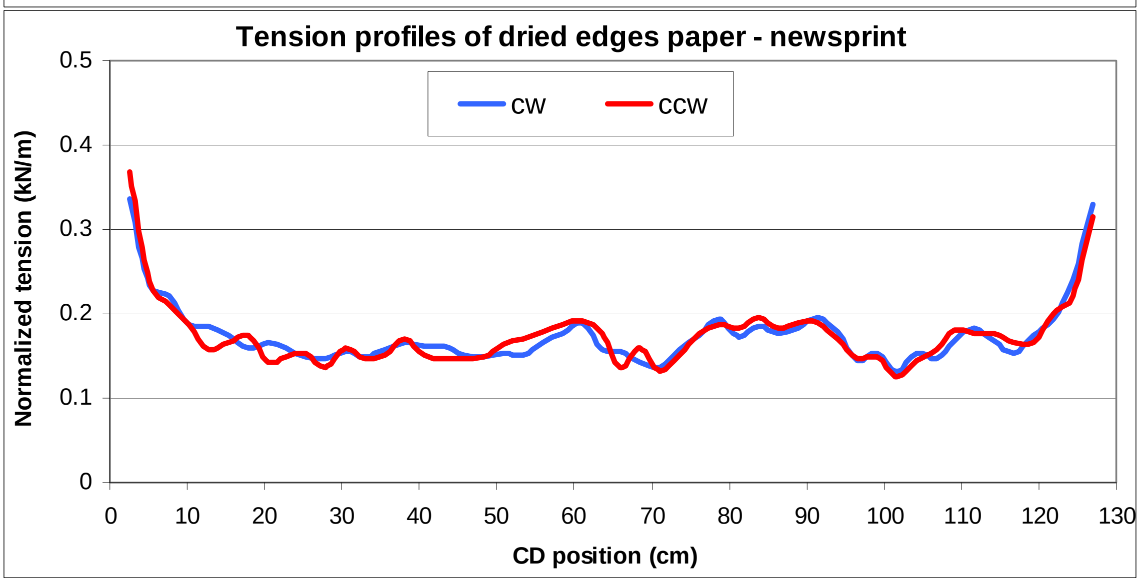


Figure 3: Tension profiles for two rolls: clockwise (cw) vs counter clockwise (ccw) measurements on the 127 cm wide tension beam

RESULTS AND DISCUSSION

Using the tension beam, we have evaluated the tension profiles of many individual edge rolls from different paper machines. Samples have included newsprint, directory grades, fine paper, SCA, and board. The main objective of the measurements was to quantify the CD tension profiles of baggy edges and try to correlate them with paper properties and machines operations. Even if the tension profiles varied significantly among various machines, we found that many CD tension profiles inversely correlate with moisture content CD profiles. This will be discussed in one case study below.

In this section, we will present typical case studies of tension measurements and analysis that are related to baggy edge problem. We will show how the tension measurement allowed us to diagnose the problem and to find a solution.

Case study #1: Baggy edge correction by changing the drying history – newsprint grade

The mill had problems with loss of register from paper rolls produced at the back side of a newsprint machine (Figure 4). Many customers rejected paper rolls from that position and requested only rolls from the centre of the machine. The loss of registration appeared to be related to a lack of tension at the back of the machine. The back roll is shown unwinding on Figure 10. The lack of tension at the edge of the machine is clearly visible. The mill's attempts to correct the tension at the back by optimizing fiber alignment were not successful. There was also an observation that the TSI MD appeared to be highly correlated to the problem, in such a way that the mill observed a drop in the TSI MD at the back of the machine. Front and back rolls (45 gsm newsprint) were analyzed with the tension beam.

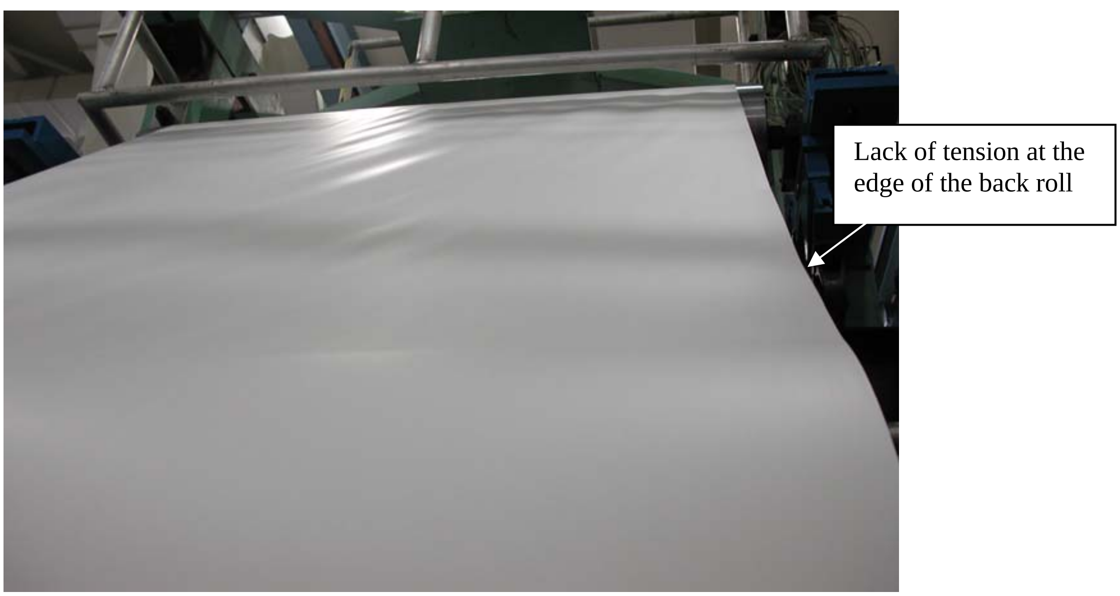


Figure 4: Case study 1 - Baggy edge problem at the back of the machine is clearly shown here at the unwind station of the roll tester

Each roll was unwound at a speed of 100 m/min and an MD tension of 0.175 kN/m at the tension beam. The tension profile was not uniform for the two rolls (Figure 5), especially the back edge roll which show a sharp tension decrease towards the back edge of the machine. For the front edge roll, the tension dropped by 0.1 kN/m while the back dropped by 0.3 kN/m to almost zero tension. Based on our experience, a tension drop of more than 0.175 kN/m (over 127 cm roll width) at the edges of a newsprint machine would create runnability problems.

The TSO and TSI profiles as well as basic sheet properties (moisture, basis weight and thickness) did not explain the drop of tension at the back of the machine. The observation of the control profiles of the moisture shows that the Steamtrol actuator opening (moisture control in the press section) had the same asymmetry in its profile as the tension profile. A low opening of the actuator at the back indicated that the sheet had a tendency to be drier at the back. The CD control gave an indication of the adjustment of the machine that will affect the drying history and therefore tension profile.

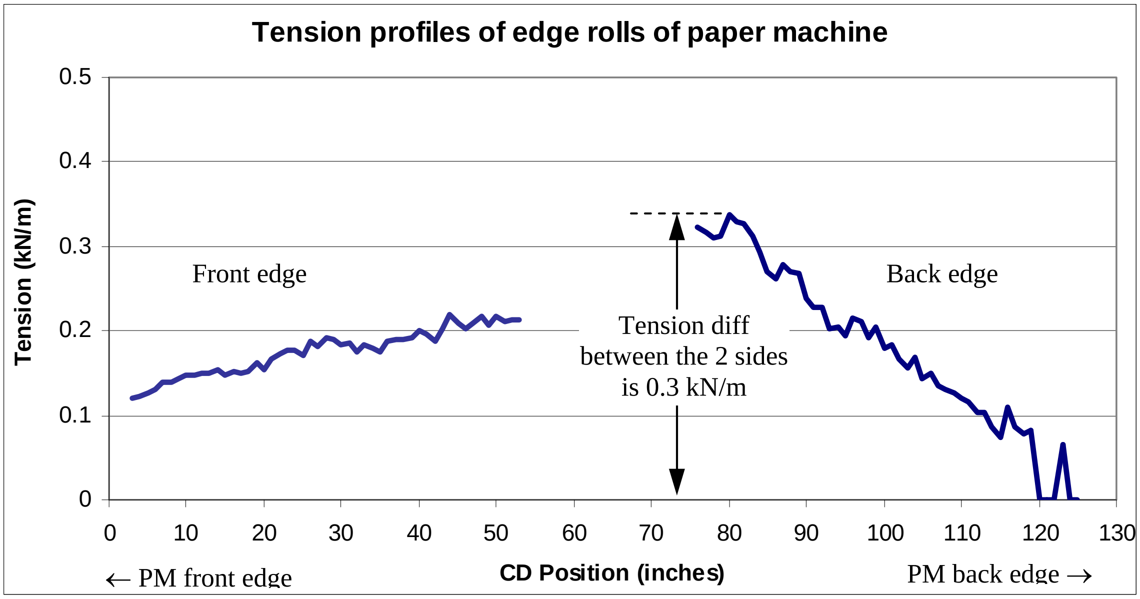


Figure 5: Case study #1 - Tension profile in CD with significant decrease of tension for the back edge roll Z

Trials were then conducted at the mill to evaluate the effect of changing solids content at the edges (with steambox actuator set-points) after the press section on the CD tension profile [9]. For each trial, edge rolls were tested for CD tension analysis. Adding more steam at the edges (edges drier before the drying section) showed that the tension increased significantly and therefore eliminated the baggy edge at the back of the machine. Using drying audit data in a drying simulation program, we determined that the tension profile was related to non-uniform drying. Modifications introduced in the drying section helped to improve the tension profile. As shown in Figure 6, the difference in tension between the two profiles for the Z position rolls was decreased from as much as 0.3 kN/m to about 0.1 kN/m.

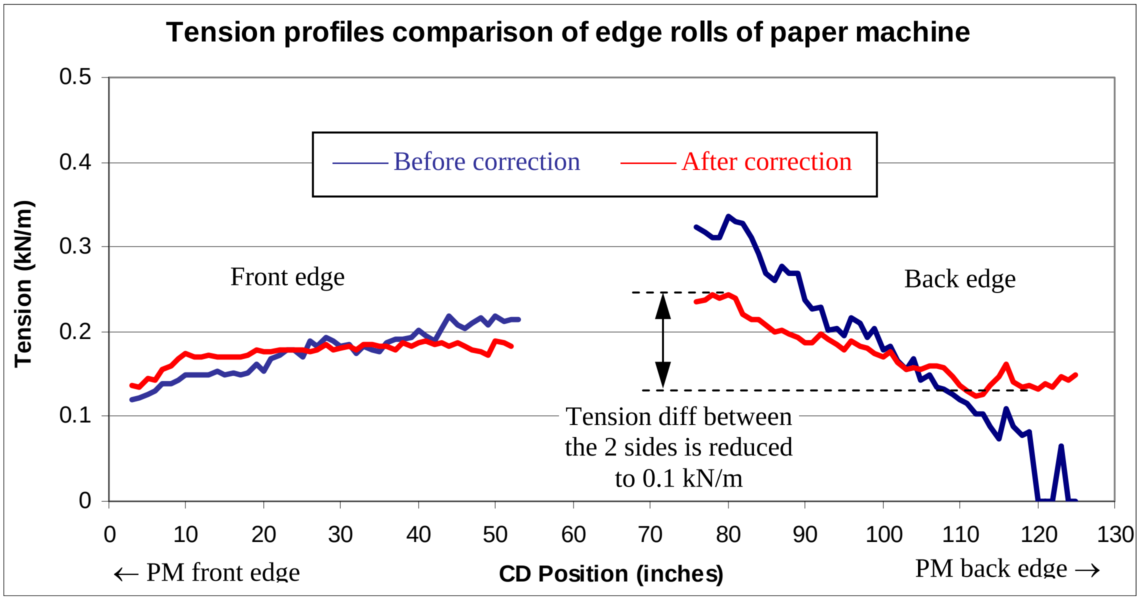


Figure 6: Case study #1- Tension profile comparison before and after drying modifications at the edges

Case study #2: Baggy edge correction by correcting moisture profile – fine paper grade

The second case study is different from the first case because the tension profiles of the edge rolls are increasing towards the paper machines edges. However, the problem is seen as baggy edges at the pressroom at the exception that the side of the roll that has the lowest tension is towards the inside of the machine (instead that being at the edges). The Figure 7 shows the tension profiles of the two edge rolls as seen on the machine. The two edges clearly show higher tension towards the machine edges, with a tension difference of more than 0.2 kN/m between the two sides of each edge roll.

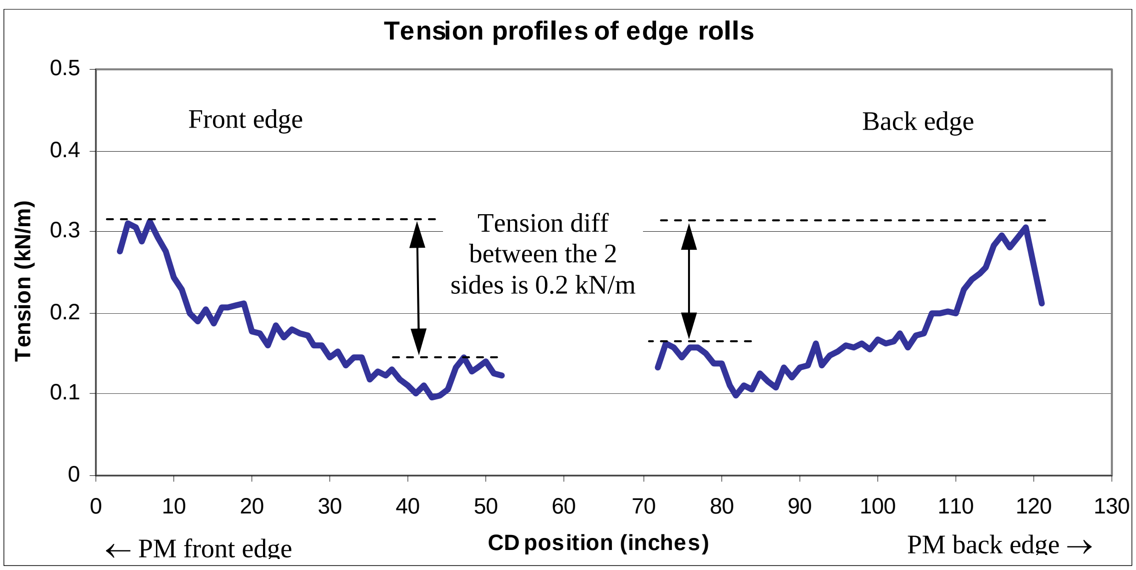


Figure 7: Case study #2- Tension profile in CD with significant increase of tension towards the machine edges

After looking at the CD paper properties of basis weight, moisture, caliper and ash (provided by their on-line scanner at the reel), we found that there was a significant relationship (R^2 = 0.73) between CD tension and CD moisture. Higher the moisture content in the paper, lower the tension and vice-versa (Figure 8). A moisture variation of 0.5% causes a tension decrease of more than 0.15 kN/m. So the increase of tension towards the edges of the machine is explained by non-uniform moisture CD profiles at the edges.

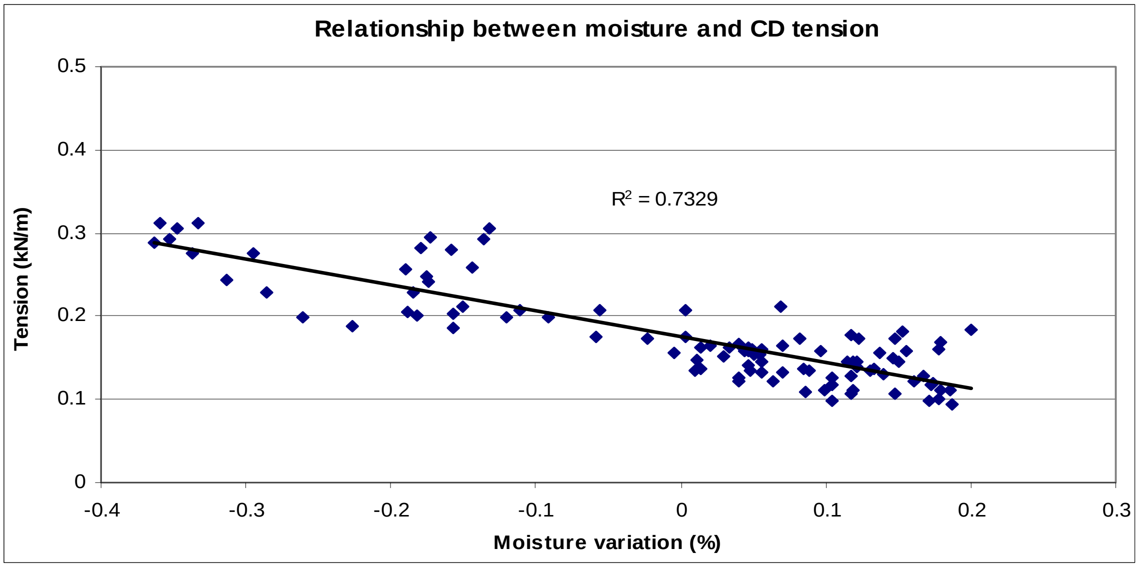


Figure 8: Case study #2- Relationship between CD tension and CD moisture profiles at the reel

An easy way to correct the non-uniform tension profile is to correct the CD moisture profile at the reel. As the sheet will be wetter, it will take longer to dry and will elongate thus decreasing the CD tension of the web and making its profile more uniform. The mill is actually working on correcting the moisture profiles at the edges to correct the non-uniform tension profiles. Correction will then be verified using the tension beam.

Case study #3: Baggy edge correction by applying moisture bias – directory grade

The third case study is similar to the second case, with a different solution. The third case also demonstrates how the moisture content can be an important parameter in CD tension variations. The bagginess problem was located at the back of the machine, causing wrinkles, CD misregistration and pressroom web breaks. Tension profile measurements showed that there was a 0.25 kN/m tension difference between the two sides of the back rolls. Tests at the mill showed that the CD moisture profile was uniform after the press section and after the dryer section. This indicates that something in the dryer section caused the web to elongate more at the back, and therefore produce bagginess.

Based on previous research on the influence of moisture and modulus of elasticity on tension as well as on some research in the literature [9], it was proposed that a moisture bias at the back edge of the machine would solve the problem. The moisture difference between the zones where the tension is uniform (center) and the zones where the tension is lower (back edge) was calculated for all CD positions. The tension correction was only applied to the last 127 cm of the machine width where the bagginess zone was located. By the help of the steambox installed at the press section, the mill applied a moisture bias (reduction of moisture up to 2% over the last 127 cm). Figure 9 shows the tension profiles before and after moisture bias application. It is clearly shown that the tension non-uniformity for the back rolls was improved by using moisture bias. Without moisture correction, there was a difference of 0.25 kN/m between the two sides of the 127 cm wide web. With the application of moisture bias, the tension difference was reduced to near zero and the slope became close to zero. This helped web tracking on the presses and eliminated the misregistration problems for the back edge rolls. Now the paper machine is always operated with a 2% moisture bias at the back, which does not cause any other runnability problem in the pressroom.

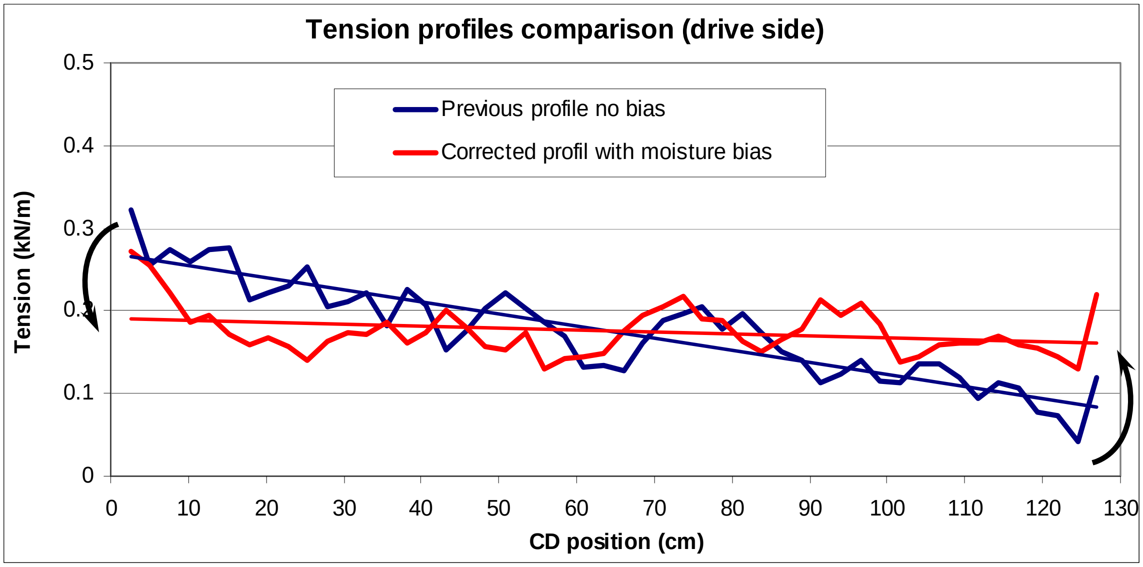


Figure 9: Case study #3 - Correction of tension profile with the application of moisture bias

CONCLUSION

A tension beam was developed to quantify CD tension profile of paper web. With a high accuracy (<5% error) and a high resolution (50 units over 127 cm width), this new tool was successful in measuring the tension non-uniformity of different types of paper grades. A reconstruction method was also developed to evaluate the tension profile of a full width paper machine. Bagginess and baggy edge can be quantified at low cost and corrected by changing the drying history of the web from the press section to the reel. The tension beam can be used to monitor the tension profiles corrections and later to ensure the uniformity of the profiles with time.

REFERENCES

1. Lindqvist, U.; Jantunen, J.; Linna, H.; Marttinen, T.; Meinander, S.; Virtaperko, L.; and Ylinen, R. (1983). “Studies on runnability problems.” Papri ja Puu – Papper och Tra: 4:305.

2. Parola, M.; Sundell, H.; Virtanen, J.; and Lang, D.; (1999). “Web tension profile and printing press runnability.” PAPTAC 85th annual meeting, Montreal, Canada, p. B341.

3. Parola, M.; Mahonen, A.; and Linna, H.; (1995). “Improving runnability by controlling the web tension profile.” Proceedings of the first EcoPaperTech International conference on Papermaking and Paper Machine Technology. Helsinki, Finland, p. 61.

4. MacDonald, J.D.; Pikulik, I.I.; and Daunais, R. (1988). “On-machine stress-strain behaviour of newsprint”, J. Pulp Paper Sci. 14: J53.

5. Parola, M.; Vuorinen, S.; Linna, H.; Kaljunen, T.; and Beletski N.; (2001). “Modelling the web tension profile in a paper machine.” 12th Fundamental Research Symposium, Oxford: p. 759.

6. Fox, J. (1999). “Back from the edge? – Mill experiences on the problems of edge reels.” Newsprint production and use – the future of newspapers seminar. London, UK.

7. Olsen, J.E. (2005). “Lateral mechanics of baggy webs at low tensions.” Proceedings of the Eighth International Conference on Web Handling, Oklahoma State University, Stillwater, OK, USA: p. 25.

8. Akerlund, K., Happonen, E.; and Mustonen, H. (1995). “Web tension profile measurement: a tool for runnability control.” Automation Days, Finnish Society of Automation, Helsinki, Finland, p. 329.

9. Kniivila, J. (2001). “On-line tension profile optimization via moisture profile controls on the newsprint papermaking process.” Proceedings of the Sixth International Conference on Web Handling, Oklahoma State University, Stillwater, OK, USA: p. 325.