VARIATION OF THE WEB TENSION AT THE ROLL CHANGE IN THE PRINTING PRESS

by

H. Linna, P. Moilanen, A. Mahonen and M. Parola

VTT Information Technology
Finland, Europe

ABSTRACT

Rapid changes of the web tension take place at the roll change in the printing press. Variations in the machine direction depend on the tension control system and variation in the cross direction is strongly affected by paper and roll properties. The web tension profile can be measured with a single sensor scanning across the web or with a special beam equipped with several sensors. In this paper findings from the studies carried out with different tension measurement systems are presented. In the long-term study the effect of paper machine reel position as well as the changes within the roll and between the rolls on the web tension profile are underlined.

INTRODUCTION

An even web tension profile in the printing press is important because wild variations in the tension profile cause wrinkles, register errors, flutter and web breaks. A significant number of web breaks occur at the roll change. Therefore the variation of the web tension profile at the roll change is a challenging subject to study in order to improve the runnability.

The importance of an even web tension profile already in the paper manufacturing process has been understood, while the correlation between the web tension profile in the paper machine and in the printing press has been discovered in our earlier studies on newsprint [1] - the tension profile has been found to originate in the paper manufacturing process. The web tension profile in the paper machine is influenced by every process stage. Wet forming, wet pressing, drying, calendering and winding processes each have their effect on the structure and rheological properties of the paper and therefore on the web tension profile.

The main role of the headbox and the wire section is to produce a smooth wet web with homogeneous material and fiber orientation distribution. It is well-known that the strength of the paper decreases and the variability of the local tension increases as the basis weight of the web becomes more non-uniform. The most important factors affecting the web tension in the wet forming process are the distribution of the solids and the moisture content, the web density and the fiber orientation. A wild fiber misalignment profile may cause various in-plane stability problems and variations in the grammage, moisture, paper strength properties, and the web tension.

The wet press nips are controlled to enter either a constant loading profile or a constant moisture profile. A zone-controlled nip load and steam box equipment are nowadays widely used actuators in the press section of the paper machine. An uneven moisture profile that originates in the press section always results in uneven elastic property and web tension profiles, although the moisture profile is corrected later. The remoisturizing unit is suitable for local tuning but it should never be used for large-scale control. Unfortunately there is no complete commercial moisture measuring system that could be used to measure the moisture profile of the relatively wet web immediately after the press section.

It is difficult to maintain an even tension profile through the drying process. The cross direction (CD) shrinkage profile tends to be convex with great local variations in it. The external forces in the CD towards the edges cause the highest internal CD stress in the middle of the web, which then decreases close to zero on the edge. Previous mill trials have shown that a greater CD shrinkage on the edges results in MD tension relaxation, sheet flutter, etc.

VTT (Technical Research Centre of Finland) has, together with Valmet, carried out runnability studies in paper mills for several years. The formation of the web tension profile as well as the response of the tension profile to the process changes on the paper machine have been studied. Also the effect of the web tension profile on the runnability on the printing presses has been determined.

Some results of the tension measurements in connection with the printing press roll changes are shown in this paper. The variation of the web tension has been measured on two heatset-offset presses, where the reel stands were rebuilt while the study was going on. A long-term study has been carried out on a rotogravure press, where all the printed rolls were measured during a three-month follow-up period.

MEASURING EQUIPMENT

Measuring principles

The web tension in the machine direction is normally measured as the load caused by the web on a roller. The tension profile across the web cannot be measured in this way. Using a movable sensor, the web tension profile can be recorded in separate points across the web.

Rapid changes of the tension profile take place at the roll change. Only a narrow area can be measured with a single sensor. The measuring principles of these instruments are discussed in [2]. The rapid changes in the profile can be recorded using a set of equipment where several sensors are placed side by side on a beam across the web. The measuring devices by Valmet and Davy McKee are of this type.

The measuring device developed by Valmet has a beam that is used to deflect the paper web from its normal direction. The measurement is contactless because of a thin layer of air between the web and the rounded surface of the beam. The pressure of the air layer in small perforations of the beam is measured and it correlates with the web tension. The resolution in the cross-direction depends on the number of the pressure sensors [3].

The Shapemeter developed by Davy McKee uses a machine-wide roller which is divided into several rotors. Each rotor has an independent air bearing. The CD tension profile is recorded on the basis of the load indicated by each rotor. A prototype unit has been tested in narrow web rewinders and printing presses [4].

Some web tensions discussed in this paper have been measured with the Tenscan device made by ABB Strömberg Drives. This web tension meter uses laser to measure the passing time of a sound wave in the web [5]. The sensor of the device is mounted on a specially constructed beam which allows to scan the sensor across the paper web. Some measuring results received with the Tenscan device in the paper mill are reported in the articles [1, 6]. VTT's beam also allows the use of other sensors. Some work has been done with simultaneous measuring of the web tension with the Tenscan and the moisture with an IR-based device.

Measuring procedures

Two separate studies are discussed in this paper. In the heatset-offset plant, the variation of the web tension was measured before the infeed unit on two printing presses. The measurements were carried out before and after the reel stand rebuild. The Tenscan device was used. Most of the roll changes were recorded when the sensor was in the middle of the web. The measuring frequency of Tenscan is one measurement per second.

In the rotogravure press, the Valmet device was installed on the reel stand before the infeed unit for three months. One profile with 35 separate measuring points across the web was recorded every eight seconds.

RESULTS

Heatset press

In this case study, the printer wanted to find out how strong tension fluctuations occur during the roll change. The present reel stand worked with a zero speed splice and a vertical festoon for the press output. The problem was the unstable register and the dot gain after the splice. In addition to this, web breaks were common, especially during the roll change. It was assumed that tension peaks coming from the roll change would be strong enough to exceed the preset tension level of the infeed unit. An example of the web tension signal at the roll change is shown in Fig. 1.

Before the roll change, the web tension remained at the preset level (250 N/m). Four minutes before the change the tension began to rise slowly and the highest measured peak at the splice exceeded 500 N/m. This was double the preset level. After the splice the tension decreased under 200 N/m, and then again began to approach the preset level. The same shape of the tension signal could be noticed in all the measured roll changes. Since the highest tension peaks exceeded the preset tension level of the infeed, these disturbances were carried straight on to the printing units.

After the reel stand was rebuilt the web tension was measured with the same measuring device on the same open web lead before the infeed unit (Fig. 2). At this time no strong peaks in the measured tension were observed at the roll change and the number of web breaks relating to the roll change had substantially decreased.

This was probably due to the better function of the new tension control system and the robust structure of the new reel stand. The festoon was now longer and in a horizontal position. The longer paper web in the festoon gives more time for the acceleration of the new roll.

Rotogravure press

In the rotogravure press the study was carried out during a period of three months and about 1,500 rolls were measured at the reel stand before the infeed unit. The web tension profile measurements were carried out with the measuring device developed by Valmet. The sampling rate of the cross-direction (CD) profiles was normally one profile per eight seconds. The printed paper grades were SC and LWC.

The effect of the paper machine reel position. A closer analysis was made with one papermaker's rolls (SC-paper). It was found that the tension profile of a single customer roll was dependent on its position on the machine reel. Fig. 3 shows the tension profiles of rolls cut in two different positions. It can be seen that the tension profiles clearly differ by position. According to the results the tension profile originates in the paper machine. This contributes to our earlier studies on newsprint.

The effect of supercalendering. It was found that the supercalender can affect the tension profile, as can be seen in Fig. 4. The paper was made in the same paper machine and the rolls were cut in the same machine reel position. The rolls were produced in two supercalenders. The supercalender did not change the shape of the tension profile, but it increased the variation of the tension across the web. The effect of the supercalender presumably results from the differences in the nip load and its profile. The rolls made in the supercalender No. 2 had a stronger variation in the tension profile. It was also found that these rolls had more web breaks at the roll change than the rolls made in the supercalender No. 1. The break rates were 5.6 % with (54) rolls made in supercalender No. 1 and 13.3 % with (60) rolls made in supercalender No. 2.

Long-term study. From the whole material (1,500 rolls) the average web tension profiles were calculated for every roll. The maximum, minimum and average values of these profiles were defined. The distribution curves for the maximum and minimum differences from the average tension are presented for each measured roll in Fig. 5. It can be seen that almost every roll had an uneven tension profile.

The changes in the tension profile within the roll were also studied. It was found that the cross-direction (CD) tension profile changed from the top of the roll to the layers near the core but the basic shape of the CD profile remained in most cases. The strongest variations in the web tension profiles were normally measured in the surface layers and the profile smoothened slowly when unwound towards the core. This is probably due to the stronger tension relaxation in the surface layers and the effect of the roll diameter on the tension. Fig. 6 shows typical changes in the web tension during printing. Rapid changes in the profile within the roll were also found. These changes were observed when there was a mill splice in the roll.

The variation in the web tension profile during the roll changes was examined with parameters calculated from the difference profiles between the successive rolls. In this examination, the tension profiles used in the calculations were measured before and after the roll change. The distribution curves for the maximum, minimum and average values of the difference profiles are presented in Fig. 7. It can be seen that the web tension level remains almost constant at the roll changes. This effect is a result of the tension control system of the press. The maximum and minimum distributions of the difference profile clearly differ from zero, which means that the shape of the profile changes significantly almost in every roll change. The changes in the tension profile were found to be greater between the successive rolls than within the roll. The speed of the alteration in the tension profile in the roll change can be seen in Fig. 8. In these measurements (500 Hz) it was found that the tension profile changes dynamically and the different parts of the web behave differently.

CONCLUSIONS

For troubleshooting purposes the web tension measurements can easily be performed with a transportable set of equipment, like the Tenscan device connected to the beam system. Measurement of rapid changes and long-term variation of the tension profile is possible with permanently mounted devices. In this study the tension measurements were carried out on heatset-offset presses with the Tenscan and on a rotogravure press with the Valmet device.

In the case study of the heatset-offset press, the printer suspected that the reel stand was working improperly and decided to perform the tension measurements. The printer has normally at least three alternatives: tuning of the reel stand, change of the driving parameters or rebuilding of the reel stand. Optimum tuning is a must for continuous high-speed production. The change of the driving parameters - for example dropping the speed at the roll change - is an unsatisfactory solution, because in this case new register problems arise and the press is not in full use. In this study, the printer decided to replace the reel stands because production efficiency and a minimum of disturbances were the key elements.

According to the studies on the rotogravure press, the tension profile of a single customer roll was dependent on its position on the paper machine reel. This suggests that the tension profile originates in the paper machine. The conclusion contributes to our earlier studies.

It was also found that supercalendering affects the tension profile and the runnability of the paper. The supercalender did not change the shape of the tension profile, but it increased the variation of the tension across the web. The paper produced in the supercalender, which formed the paper web more, had more breaks than the paper produced in the other supercalender. The effect of the supercalender on the tension profile can be understood by the fact that the calender nips cause an irrecoverable deformation in the paper web, depending on the paper caliper and the nip load profiles.

It was found that the variations of the tension in the cross direction (CD) were usually greater at the top of the roll than near the core. This can be explained by the fact that the variations of the caliper profile in the winder cause a variation in the diameter profile of the customer roll. This effect cumulates as the roll diameter grows. The tension relaxation and its interaction with the roll diameter profile is stronger in the surface layers of the roll.

The variation in the web tension profile during the roll changes was examined in the long-term study. It was found that the shape of the tension profile changes significantly almost in every roll change. The changes in the tension profile were found to be greater between the successive rolls than within the roll. It was also found that the tension profile changes rapidly and the different parts of the web behave differently. So when the roll changes, also the shape of the tension profile changes. This happens because the rolls from different positions are printed in a random order and the printer cannot know how different rolls behave. The change in the tension profile at the roll change is rapid and can cause instability of the web and further on lead to a web break. As the CD tension profile of the roll is dependent on its position in relation to the paper machine reel, the rapid CD tension variations at the roll change can be reduced by using rolls from only one position in one job.

Strong fluctuations in the web tension profile may cause wrinkling of the web, which degrades the quality of the printed product. The roll with a very uneven tension profile has a greater probability to break, especially if there is a weak point (for example a shive or a hole) in the tense area of the web. Also the slacker areas of the web may be prone to breaks. This can be understood through wrinkling and also by the instability of the web, especially when the slack area turns into a slack strip before the folder. Many printers say that mill splices in the inner parts of the roll are critical in regard to web breaks. This can be partly due to the rapid changes in the tension profile.

An analysis of the data collected in the long-term study is going on. This analysis focuses on the possible effect of the web tension profiles on the web breaks and on the amount of waste. The results of these studies will be published later.

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FIGURES

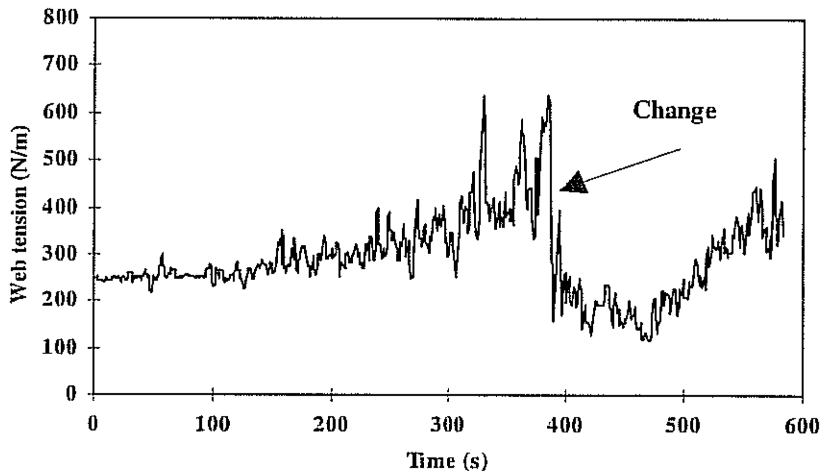

Fig. 1 Web tension at the roll change before the infeed unit.

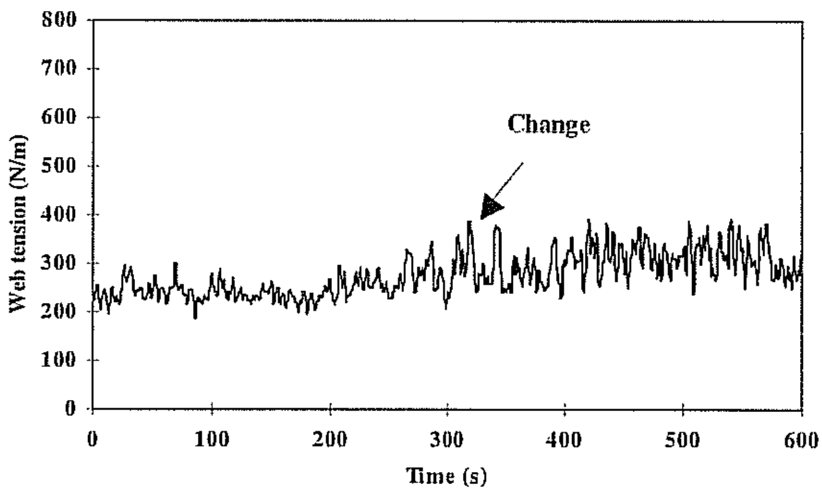

Fig. 2 Web tension at the roll change before the infeed unit after the rebuild.

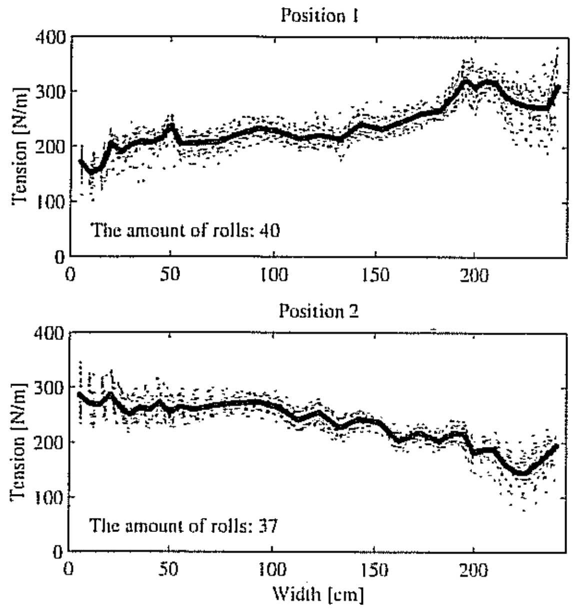

Fig. 3 The web tension profiles (in the press) of customer rolls cut in two machine reel positions. The dashed line represents a single measurement and the solid line represents the average profile.

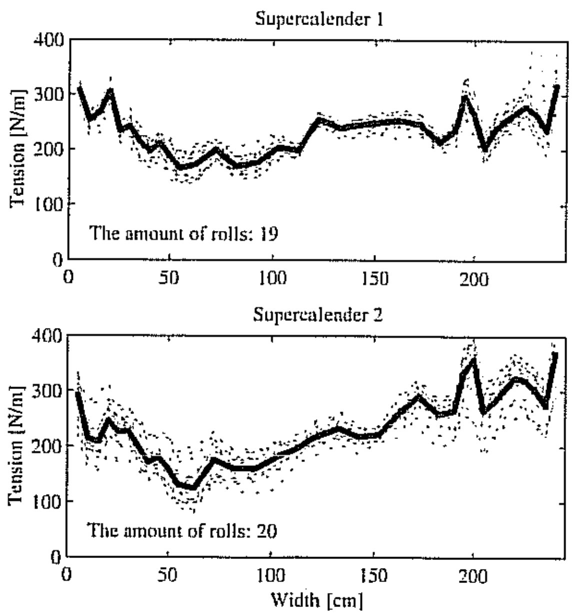

Fig. 4 The effect of the supercalender on the web tension profiles. The rolls were produced with different supercalenders and cut in the same position of the paper machine reel. Every second machine reel was produced with supercalender No. 2. The dashed line represents a single measurement and the solid line represents the average profile.

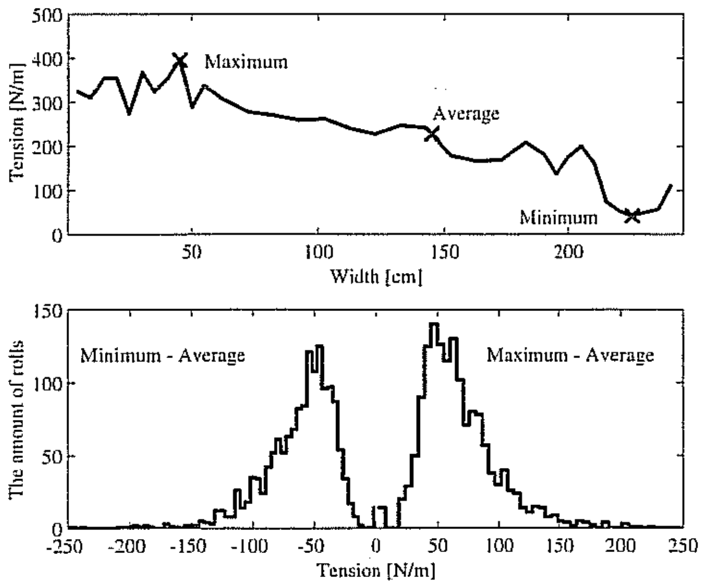

Fig. 5 The distribution curves (bottom) calculated from the maximum, minimum and average values of the average tension profiles. The number of the measured rolls was about 1,500.

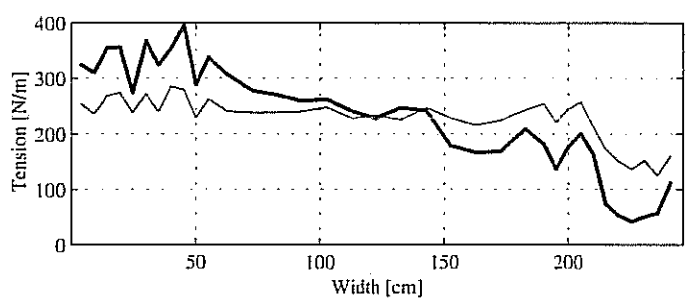

Fig. 6 Typical tension profiles measured in the surface layers (thick line) and in the bottom layers (thin line).

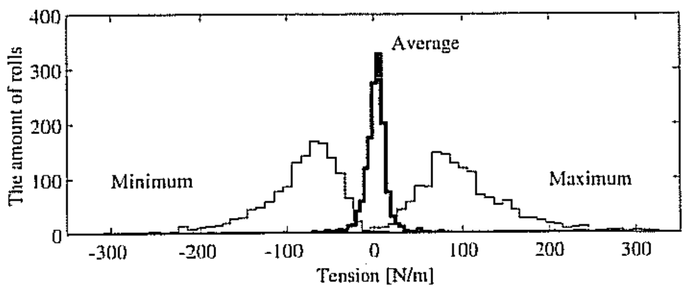

Fig. 7 The distribution curves calculated from the difference tension profile of each roll change. The number of measured rolls was about 1,500.

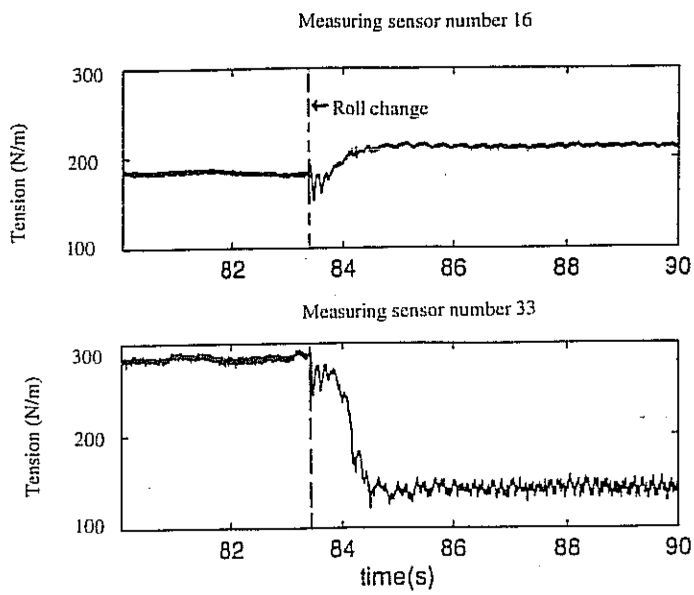

Fig. 8 The changes in the web tension during a roll change. The measurements were carried out simultaneously with two sensors and the sampling frequency was 500 Hz.

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6/20/95 Session 4 1:10 - 1:35

Question - You have demonstrated that the web tension varies according to position, but do you see that the set number has any influence?

Answer - We didn't study that matter, so we didn't see it.

Question - Having measured the web tension, have you made any conclusions on how to regulate it or control the paper machine?

Answer - Yes, we have made some studies concerning control in the paper machine and they are also listed in the references. The basic thing is to keep the moist profile or even outer moisture profile and try to have it in throughout the ? .

Question - Two simple questions. What's the velocity of the press?

Answer - About 800 meters per minute.

Question - And I assume this is the draw control tension since the tension doesn't adjust from its set. Did it come back by control?

Answer - Yes, it did come back by control.

Question - Which one? Figure 8? Did the tension over time drop to a new level?

Answer - Yes, that is only at one point we measured. It is not representing the average.

Question - You correlated the web rates with the point of lowest tension. My first thought would be that web rates were at the maximum tension in areas of very high stress on the sheet. What failure mode did you expect at this very low tension?

Answer - In this press, the strips at the folder, when they got slack, broke there. That was the main problem with this press, so when you get the slack strip it is unstable.

Question - Is that a wandering problem?

Answer - Yes.

Thank you.