# WEB TENSION AND WRINKLES IN THE PRINTING PRESS

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## ABSTRACT

In a modern paper mill the web handling in every process stage is optimized to fulfill productivity demands. The same kind of demands also exist in the printing plants. Smooth production without runnability disturbances is a must in both cases. But in practise several problems still exist. Uneven paper profiles together with long web leads in 4-colour printing can be problematic. The shape of the web tension profile is often known but the variation across the web needs careful measurements. Because of differences in tension distribution, rolls cut from several positions on a paper machine reel can be totally different when printed in a 4-colour web.

Web tension measurements from paper machines to printing presses were carried out by the Graphic Arts Laboratory of the VTT. The same paper machine reel was measured with a portable set of measuring equipment both in a paper machine and in a winder. Laboratory analysis of the paper was carried out. The tension profiles of customer rolls were again measured in printing plants. The printed sheets were evaluated and the wrinkling phenomenon across the paper machine web was analysed. The results show that the profiles measured in printing presses originate from paper machines. Also the limitations of modern printing presses and paper itself must be taken into consideration when an optimum combination of tension and other paper profiles are aimed at in every process stage.

## 1. INTRODUCTION

Demands on smooth runnability are increasing both in paper mills and printing presses. A large amount of water on the paper in offset printing, demands for a great accuracy of the colour register, the 4-Hi printing units and a higher printing speed issue challenges to the paper manufacturers. New requirements on the evenness of the profiles across the web are becoming critical.

The control of the rheology profile of the paper web has got little attention compared to other profiles. The lack of on-line measuring methods has been one of the restrictions. Now measuring technology has developed. Several instruments for web tension profile measurements are or are soon coming on the market. These are suitable for production conditions or trouble-shooting. Still new instruments and systems are needed to measure and control web properties and conditions in printing.

The Graphic Arts Laboratory of the Technical Research Centre of Finland (VTT/GRA) has studied web tension and other runnability characteristics in several paper mills and printing presses. In addition to industrial commisions also large research projects have been performed. Newsprint production and newspaper printing have got most attention so far, as it is the easiest way to study the whole process and try to understand the formation of paper rheological profiles.

## 2. WEB TENSION OF THE PAPER WEB

### 2.1 Measuring Equipment

Web tension is normally measured as the load the web causes on a roller. This method is widely used in paper machines and printing presses. The tension profile across the web cannot be measured in this way. Several other measuring methods are described in /1/.

All tension profiles discussed in this article 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. The sensor of the device is mounted to a specially constructed beam, which gives the opportunity to scan the sensor across the paper web. Some results measured with the Tenscan device are presented in articles /1,2,3/.

### 2.2 Tension Profiles at the Paper Mill

The tension in the machine direction of the web and its profile across the web are important factors in paper making mainly for two reasons. The web must be tight enough but not too tight for runnability reasons. Secondly the web tension during drying affects many elastic properties of the paper. In most cases slack edges and wild variations in web tension along the web width exist. These disturb web handling during paper manufacturing and winding. Indications can also be observed at the printing house. Several trials have been made where the tension profile response to process changes has been studied. The results have been reported in previous articles /2,3/.

Web tension in the paper machine orginates from different process stages in papermaking. This includes the wet forming, wet pressing and drying process, of which the drying process is the most important. The dependance between moisture and tension is known: increasing the moisture content at the pope-reeler decreases tension /3/. It is also known that that higher CD shrinkage causes lower tension in web edges /3/. To achieve an even tension profile at the dry end the moisture profile should maintain even throughout the dryer section.

Optimization of the tension profile at one high-speed newsprint machine was carried out /3/. It was done by changing the re-moistening before the drying section and by adjusting the functioning of the press section. Also the furnish was increased for both edges in order to decrease the CD-shrinkage. Tension measurements were carried out in the dry end of the paper machine /3/. Result can be seen in figure 1.

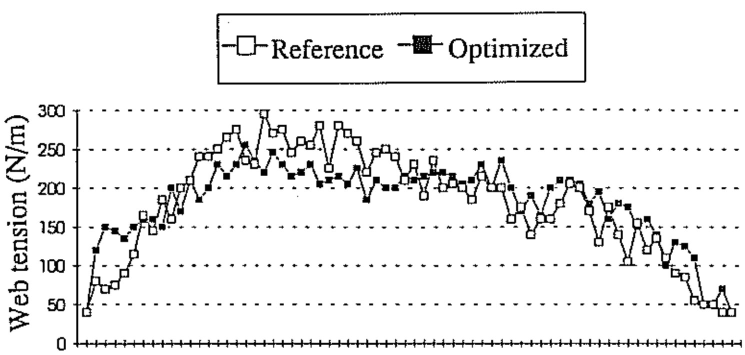


Figure 1. The web tension profile before adjustments (reference) and the optimized tension profile.

It can be seen that changes made evened out the tension profile in the middle areas of the web. Also the tension in the edge areas clearly increased. Anyway the edges are still slacker than the middle areas due to the higher CD-shrinkage. A new design concept in dryers is needed to even out the CD-shrinkage profile in newsprint machines.

The web tension profile of newsprint on the **winder** originates from the web tension profile measured on the paper machine. So the slack areas are still slack and tight areas are still tight on the winder. The variations in web tension can be smaller or bigger than on the paper machine depending on the tension level adjusted at the winder. A higher tension level leads to stronger variation.

With super calandered paper we have observed that calandering can change the shape of the tension profile. Results from these studies will be published later.

## 2.3 Web Tension on the Printing Press

An even web tension profile on the press before the printing units is wanted because wild variations in the tension profile can cause wrinkles, register errors, flutter and web breaks. These problems become even bigger, when a poor tension profile exists together with strong tension variations caused by the printing press. Wrinkles can develop before the printing unit, when a web with a strong tension variation in profile is passing the guiding rolls or the infeed unit or is approaching the printing unit. A web break may occur, when only a part of the web is carrying most of the load. /4,5/

The web tension profile at the printing press is built up from intreractions between paper, ink, water and the printing press. The tension profile in the customer roll originates from the paper mill. Warehousing has its own effects on the paper reel, mainly caused by the creep and relaxation phenomena. The web tension level at the press can be controlled either manually or automatically before and after the printing units. All the rotating components of a printing press (rolls, cylinders, motors, folder unit) affect the tension variations in the web. Also the rotating paper roll has its own effect on variation, especially when it is out of roundness. /4,5/

The dampening water and the ink printed on the paper change the rheological properties of the paper. It is known that the elastic modulus of the paper is strongly dependent on the moisture content of paper /6/. When water is transferred onto the web, the elastic modulus as well as the web tension in the printed areas become lower than in the non-printed areas. So tension profiles after printing units are dominated by the printing process itself.

To our knowledge no printing press equipped with a tension profile measuring device exists. In order to find out how the tension profile changes from the paper machine to the press we made measurements with our device in both places. Results can be seen in figure 2. It was found that the web tension profiles in customer rolls originate from the paper machine and the winder. Measurements were made from the same paper machine reel. On the press the web tension was measured just after the reel stand. The paper grade was newsprint (40 $g/m^2$) and the profile at the press consists of 6 reels. The product was offset printed newspaper.

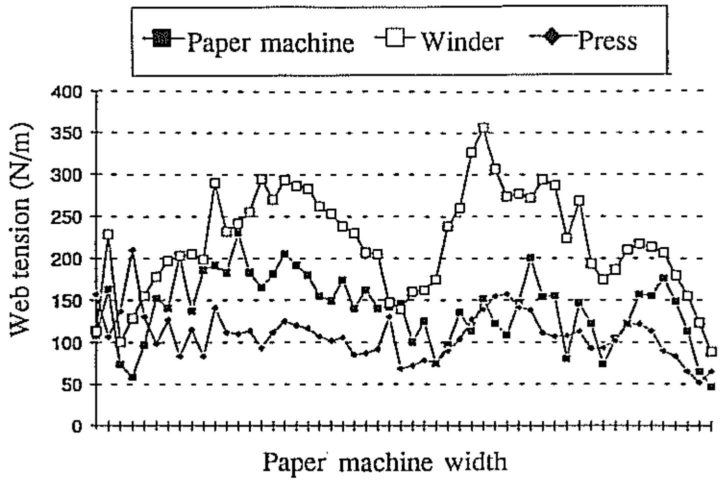


Figure 2. Measured tension profiles in the paper machine, in the winder and on the press.

These trials with newsprint show that the tension profile has to be straighten out on the paper machine.

## 3. WRINKLES

### 3.1 Wrinkling Phenomenom

The wrinkling phenomenom in the printing press can be seen as cockling of paper in the machine direction of the web. Both paper properties and printing process affect the presence of wrinkles.

When wrinkles appear before the first printing unit the whole web will not be printed, in other words when the wrinkle is opened non-printed areas appear. Especially in newspaper printing, wrinkling after the printing unit is more common . It is difficult to read a newspaper page with wrinkles as part of the text is hidden from sight. Readers often complain that the newspaper has to be smoothed out.

Many different reasons for the occurence of wrinkles have been presented in literature. A fundamental reason is often the uneven profiles of the paper. The adjustments of the press rollers can be incorrect or there may be dirt on the roller surfaces, which affect the running of the web. The stress applied onto the paper web by the printing unit varies with the use of colours in the newspaper. In offset printing the amount of dampening water depends on how many printing units are used. /4/

## 3.2 Measuring Method for the Wrinkling Index

The connection between wrinkling and the tension profile across the web was studied in with two test series. There paper production on a newsprint machine and the printing of the rolls was followed up.

The wrinkling index was calculated by counting the wrinkles per width unit in printed newspapers. In both cases full width rolls (160 cm) from five different positions in the paper machine reel were cut. At press 1 the wrinkling index was calculated per paper roll and so the paper machine reel was divided into five parts. At press 2 the wrinkling index was calculated per printed newspaper page, so the parent reel was divided into 20 parts.

The use of colour in the newspaper and the influence of the printing press itself (age and condition), must be taken into account when comparing results achieved with different printing presses. In both cases the measurements were performed on the four-colour pages of a newspaper. On press 1 four colours were printed on two printing units and on press 2 on one unit (satellite).

## 3.3 Results

In figure 3 you can see the wrinkling index defined from different presses. On press 1 the wrinkling index is higher. Printing press 1 was considerably older than press 2.

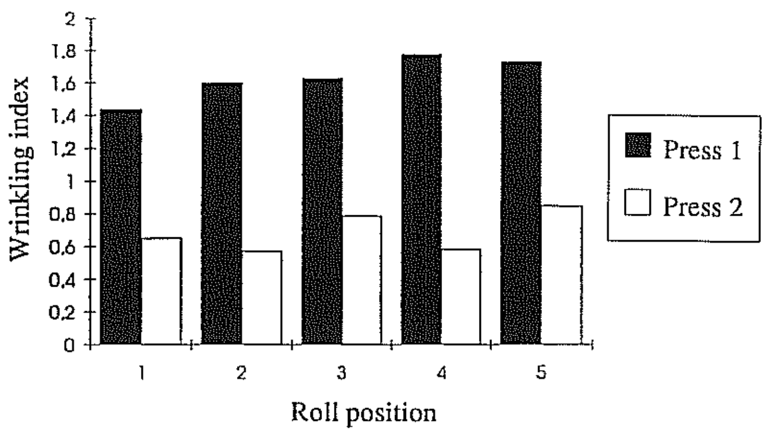


Figure 3. The wrinkling index defined from printed newspapers, rolls cut from five positions in the paper machine reel.

In figure 4 is shown a wrinkling index across the whole paper machine reel measured at press 2. More commonly wrinkles were noted in the middle parts of the roll. This is understandable as a wrinkle can spread and straighten out towards the edge. A wrinkle generated in the middle remains visible in the paper. A roll cut from the edge of the paper machine reel had the most wrinkles.

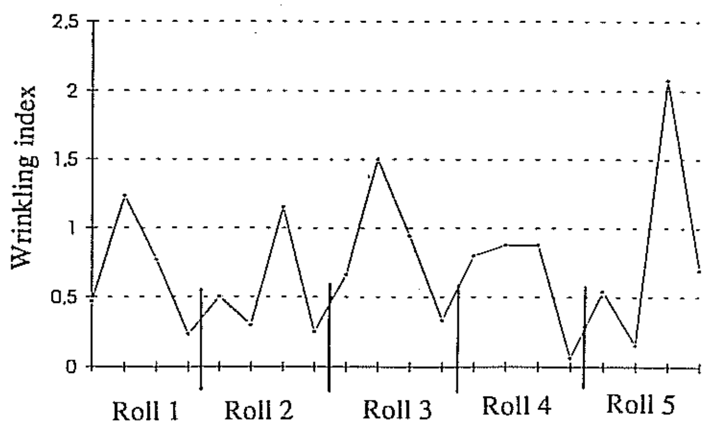


Figure 4. The wrinkling index of press 2, 5 rolls corresponding to 20 newspaper pages across the parent reel.

On press 1 the web tension was measured between the printing units. The position was not ideal for measuring the original tension of a roll as the web had gone through the first printing nip. On press 2 the measurements were made directly after the reel stand before the first printing unit.

The web tension profile of the edge rolls on press 1 followed the corresponding profile of the parent reel edge measured at the paper mill. Rolls cut from certain position of the paper machine reel were slack. In this position a slack area was also measured on the winder.

The tension level on the printing press was held constant during most of the measurements. The influence of printing press 1 was observed in the web tension profile, as a slack value was nearly always measured in two positions (40 and 120 mm from the edge) regardless of the roll.

A slack spot measured at the paper mill (winder) was found from the customer roll on press 2, figure 5. Furthermore really slack edges were observed on some edge rolls.

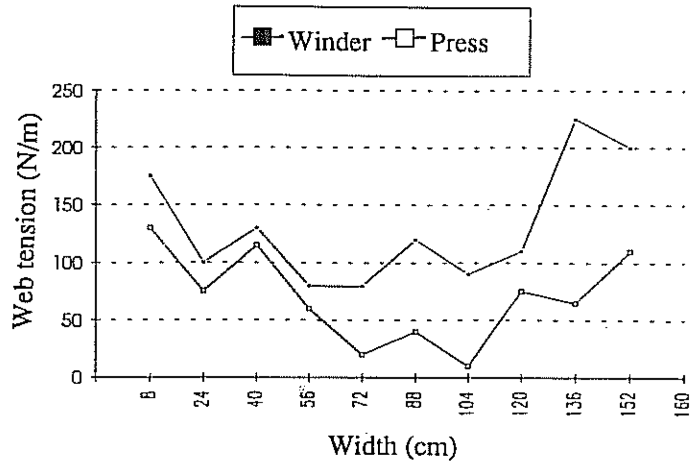

Figure 5. The web tension profile of a roll with a slack middle area on the winder and on the printing press.

The wrinkling index defined from press 2 and the corresponding web tension profile of the paper machine are described in Figure 6. The amount of wrinkles seems to depend on how much the web tension in the middle differs from the tension at the edges of the web.

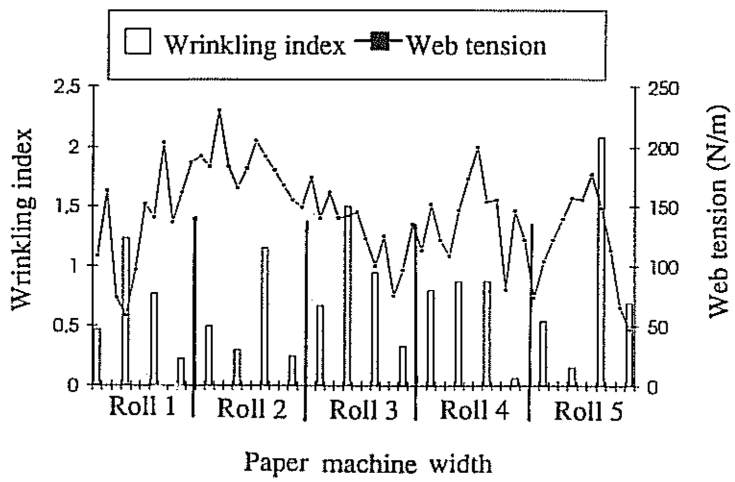


Figure 6. The wrinkling index of the rolls from press 2 and the corresponding web tension profile of the paper machine.

The reducing of wrinkling through tension requires a correctly chosen tension level on the printing press in addition to an even tension profile all the way from the paper machine.Usually a four-colour web is held tight in order to make the register control easier. As the tension profile cannot be adjusted on the printing press the only possibility is to change the web tension level.

## 4. CONCLUSIONS

Improving the evenness of the tension profile results in higher efficiency and better product quality of paper making, winding and printing processes. The dry weight and moisture content profiles must be under better control already after the press section in the paper machine. This makes it possible to achieve even web tension and other rheological paper properties. An even tension profile may help printers to avoid wrinkles. As the tension profile cannot be corrected on the printing press, it is essential to do it at the paper mill.

The basic shape of the web tension profile originates from the paper machine and the winder. The effect of the printing press becomes evident after the first printing unit. The printing presses together with the dampening water used in offset printing may change the profile so that the initial tension cannot be seen any more.

Tests made for newsprint show that most wrinkles develop in the middle areas of the roll in the newspaper press. The amount of wrinkles seems to depend on how much the web tension in the middle differs from the tension at the edges of the roll. On the contrary a slack area, especially at the edges of the web, does not directly lead to great wrinkling tendency. It was also found that the printing press has a clear effect on wrinkling. In this case the older machine produced more wrinkles. Sometimes reduction of the tension level reduces the amount of wrinkles.

No clear correlation between wrinkling and other paper properties was found. This is obvious as the changes made in the paper machine were to some extent hidden behind the process variation. The role of the printing press must be taken into consideration when searching for a correlation.

The biggest problems in wrinkling studies are the limited amount of rolls printed per night in a reel stand and the lack of measuring equipment for wrinkling. So when looking for statistical dependences one must go through long and costly studies.

The VTT/GRA is now performing a three-year long project to improve paper runnability by controlling the rheological properties of the paper. Web properties are specified in the paper machine in order to produce acceptably low quality variations through the process to the printing press. The most important disturbances in printing are here web tension variations, wrinkles and register errors. Newsprint, SC- and LWC-papers are included in this study.

## REFERENCES


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## QUESTIONS AND ANSWERS

Q. Was the web tension on the same level in the different presses? Was the tension level adjusted during the tests?

A. The web tension levels in these two presses were different, because press 1 did not have an infeed unit, and press 2 did. So, the crew could influence the web tension with the infeed unit in press 2, and if the wrinkling index was too big, then they adjusted this tension.

Q. Did press 1 and press 2 have a similar web lead through the presses?

A. No, the type and the lay-out of the printing units were different. Four-color web was printed with two printing units in press 1, and one satellite unit was used in press 2.

Q. Why was the tension profile in the winder so different in comparison with the profile measured in the paper machine?

A. Yes, that is true. Measurements were carried out in a single drum winder, and the placement of the measuring head was seen in one of the figures during the presentation. This measuring place was between spreading rollers, so the effect of spreading the web can be seen in the shape of the tension profile.

Q. Would an adjustable roller after the unwinding help to correct the tension profile?

A. Yes, it can help in some cases, when there is a slack edge in the tension profile. It will help before the first printing unit, after which the situation may be different again.