WEB TENSION PROFILES AS MEASURED IN A REWINDER AND IN A PRINTING PRESS

by

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ABSTRACT

The web tension profile has been measured with an equipment called the CTSensor (Cross Tension Sensor) during ordinary production-runs both in rewinders and in newspaper printing presses. The measuring roller was placed after the printing units.

The cross-direction (CD) tension profile from a paper machine does not vary much from time to time during normal conditions. From the measurements in the rewinder it is seen that higher moisture content gives lower tension. In the printing press the tension profile is changed, which is caused by the dampening with the fountain solution.

When one reel in the printing press is automatically changed in the flying paster, it is possible to record the changes in the tension profiles between the two rolls. Tension transients are sometimes found, but they are normally small, and should not alone cause web breaks. However, when web breaks occur it is often in connection with the flying paster. A control roller can be used to compensate the change in the bending moment, which reduces the risk for web breaks.

INTRODUCTION

Investigations regarding the tension in running paper webs have been made before. Kilmister and Malinen (1) used the CTSensor. Koskimies et al (2) used a traversing system to measure the tension profile. Eriksson (3) has designed the measurement and control roller, which has been further developed and used as a measuring device in this project.

One conclusion from these is that it is important to have a uniform CD tension profile in order to get at good runnability in a printing press, which means avoiding web-breaks, wrinkles and uncontrolled lateral movements of the web.

The present investigation was undertaken in order to study these phenomena. The measurements were made directly in a production situation. We have recorded a lot of different data from many paper rolls both at the paper mill and at the printing plant. Some rolls have been measured at both places.

Other paper parameters have been measured as well: The moisture profile has been recorded directly from the traversing measuring system in the paper machine. Grammage and thickness, surface roughness, and air permeance have been measured at different laboratories. The elastic properties have been determined with a tensile testing machine, and also with the ultrasonic method. These methods are described by Markström (4), and ultrasonic waves in paper are dealt with by Habeger, Mann, and Baum (5).

The CD tension profiles have been measured with the CTSensor. Further details are given below. The system continuously monitors the forces in different positions across the web.

TENSION MEASURING EQUIPMENT

The web tension profile has been measured with the CTSensor. It is described by Kilmister and Malinen (1).

The measuring roller is built of 21 rotors floating on air lubricated bearings. The pressure difference between the top and the bottom in the air bearing is a measure of the force from the paper web on each rotor. The roller consists of 12 rotors 55 mm wide and 9 rotors 110 mm wide. The geometrical configuration is outlined in fig 1.

Data Collection.

The signals from the differential pressure transducers are transmitted via A/D-converters to a PC. The data are stored on the hard disk. A number of other signals are also collected.

The sampling frequency has been in between 0.5 and 100 Hz. Normally 3 Hz has been used. One paper roll contains about 18 000 m of paper. During the unwinding of a roll about 8 000 sets of data are recorded. Each set consists of 27 - 30 measurement values of which 21 are from the rotors of the CTSensor.

Data Presentation.

The mV-signals from all the rotors have been converted to tension values in N/m. Most of the diagrams below show the mean value of the tension profile, where the values have been calculated as a mean value for each rotor over a paper length of 10 000 - 16 000 m. The start and the end of the runs are sometimes excluded in these calculations.

Calibration Procedure.

Each rotor has been calibrated individually. The procedure has been repeated several times at each installation.

Each rotor has been loaded with 4 different weights, 0.7, 1.7, 2.7, and

5.7 kg. For each rotor a calibration diagram has been obtained by least-squares fitting to a straight line. Fig 2 shows examples for one 55 mm wide rotor and one 110 mm wide rotor. The linearity is very good. The sensitivities are roughly 0.4 mV/N and 0.1 mV/N for 55 mm and 110 mm wide rotors, respectively.

The zero output values have been collected with all the rotors spinning unloaded with at least 200 - 300 rpm.

The measured values are independant of the speed at normal operation. The temperature influence on the signals is also found to be negligible.

A second measuring roller has also been used. This one is equipped with load cells, one on each side inside the shaft. In this way it has been possible to utilize a second independantly calibrated measuring device. The two signals from the load cells have also been collected by the PC via A/D-converters with sampling frequency 1 - 3 Hz.

MEASUREMENTS

Measurements have been made in rewinders at two paper mills and in newspaper printing presses at two printing plants. The same equipment has been used at all four places.

The measurements have been made in normal production of newspapers. Newsprint rolls were normally 159 cm wide and 125 cm in diameter with grammage 42.5 or 45 g/m^2. The newsprint was made from TMP with some added kraft pulp. No recycled fibres were used.

Measurements in the Rewinders

Reproducibility. Fig 3 shows the result from repeated rewinding of the same paper roll, 159 cm wide. Each curve represents the mean value of the measured tension profiles. Every second rewinding the paper roll has been turned 180 degrees, so that the rotors measure the different positions across the web. The measured tension profiles agree rather well.

Comparison of Paper Rolls from Different Paper Machines. Fig 4 shows the mean value of the tension profiles for paper rolls from two different paper machines. The web width is 159 cm.

The variation in the paper from one of the machines amounts to as much as 300 N/m, roughly ±50 % of the mean tension.

Variation between Paper Rolls Taken from Different Positions in one Paper Machine. Paper rolls of 42.5 g/m^2 grammage from four different positions in one paper machine were measured and compared with rolls from the same position, but produced one week later and of 45 g/m^2 grammage. The result is shown in fig 5. The pattern is stable over this time period.

Tension Profile Stability for Paper Rolls Produced within 10 Hours and from the Same Position in one Paper Machine. Fig 6 shows the mean value of the tension profiles for four different paper rolls. The pattern is very stable. For one roll the backstand tension has been adjusted to approximately twice the normal level. However, the magnitude of the tension variations across the web are the same.

Measurements of the Same Paper Roll after 6 Months Storage. Two paper rolls were first measured in one rewinder. Then they were stored under normal conditions for about 6 months. After that they were measured again, but now in another rewinder.

The result is shown in fig 7. The tension superimposed by the rewinders are different. The elastic properties seem to a large extent to be unchanged during even a long storage period, when the paper is subject to the forces inside such a paper roll. These forces have been studied by Eriksson (6).

Comparison between the Tension Profile and Paper Properties. Other paper properties have also been measured, such as moisture content, thickness, grammage, air permeance, and tensile stiffness.

Fig 8 shows diagrams for paper rolls from four different positions in a paper machine. CD moisture content and tensile stiffness index (TSI) are plotted together with the tension profiles in the rewinder and in the printing press. It is obvious that the moisture content variations are reversed compared with the tension variations as measured in the rewinder.

The correlation with the tensile stiffness index is not very evident. As the tensile properties have been measured in a conditioned environment (23 deg C, 50 % RH), the moisture content variations probably have been reduced, which also changes the tensile properties.

Effects of a Misaligned Roller. The alignment of the rollers in the rewinder must be very precise, in order to minimize tension gradients across the web. What happens when the nearest roller is misaligned is shown in fig 9. The guide roller is mounted about 1 m from the CTSensor-roller.

Each step in the curves corresponds to 0.15 degree change in the alignment of the guide roller.

Measurements in the Newspaper Printing Presses

Characteristics of the Printing Press. Fig 10 shows the total tension in the web and the press speed. When the press suddenly is stopped, the web tension increases steeply. When the speed has become zero, the tension decreases to a low value. During the stand-still the tension increases slightly, because the moistured web is drying. After a while the press is started again, and the tension increases from 70 to 150 N/m. When the printing cylinders are pressed against the paper a short disturbance is distributed into the paper. The disturbance can be clearly seen as a transient in the web-tension curve.

In fig 11 a trace for the moisture content of the printed web has been included. When the fountain solution is added, the moisture of the paper increases from the original level of 8 %. It stabilizes at about 10 %, and the tension at about 125 N/m.

Reel Changes. In the printing press most of the web breaks have occurred in connection with the flying paster. Therefore it is especially interesting to study the web tension variations during a reel change. One typical recording is shown in fig 12. Here the tension increases and then slowly returns to its original value. Similar observations have been reported by Eriksson (3), and by Scheuter and Belau (7).

When a reel change takes place, the new reel often has a different tension profile. This means that the web tension distribution can change drastically. In (3) there are several examples of this, and it is also shown how a bending moment can be calculated from a skew force distribution.

The dimensional stability of the web is also important to keep the printing "in register". For this, uniform tensile stiffness as well as uniform and small hygroexpansivity are desired properties.

Fig 13 shows the tension profiles during a reel change. In this case the tension increases sharply at one edge of the paper web. Such changes in the tension distribution sometimes causes the web to move laterally, and sometimes creases will occur. The risk that the web will break will also be higher.

It is possible to compensate the change in the bending moment with a control roller, as described in (3). This is one possibility to reduce the web break frequency. It is important to keep the web tension and the bending moment within certain limits. An example of such a working range for one printing press is shown in fig 14.

Comparison between Tension Profiles for the Same Reels Measured in the Rewinder and in the Printing Press. Fig 15 shows tension profiles of the same reels measured first in the rewinder, and then in the printing press. In the latter the CTSensor-roller was installed after the printing units. Fig 8 includes similar curves.

The tension profile is influenced by what happens in the printing nip, and by the addition of fountain solution. There are many factors which determine this pattern. One seems to be tensions built-in already at the fabrication process in the paper machine.

CONCLUSIONS

The CTSensor is well suited for the continuous monitoring of the tension profiles in rewinders and in printing presses. One advantage is that it can be used on printed webs. It could also be built to measure full width webs directly in the paper machine.

The resolution in the cross direction can be improved by using only 55 mm wide rotors. By faster sampling it is also possible to improve the resolution in the machine direction for studies of tension transients.

The CD tension profile from a paper machine is very stable. From the measurements in the rewinder it is seen that higher moisture content gives lower tension, so the tension variations are reversed compared to the moisture variations. As discussed in (2) the moisture content normally is the most important factor controlling the tension variations.

In the printing press the tension profile is changed when the web is dampened with the fountain solution. The correlation between the tension profiles measured in the rewinder and in the printing press after the printing units, is normally not very obvious.

It is possible to record the change in the tension profile during the flying paster. These disturbances can, together with other factors, lead to a web break. Most of the web breaks in the printing press happen when the splice moves through the press. With the special control roller it is possible to reduce the web-break frequency.

However, the goal must be to produce newsprint with a sufficiently uniform tension distribution, when at the same time taking into account other restraints on the paper parameters. More experiments are required to establish the nature of such a control system and how it can be realized. This work is the subject of a EUREKA project, being conducted on a paper machine in Switzerland and employing a 43-rotor CTSensor.

ACKNOWLEDGEMENTS

We are very grateful for have been given the opportunity to work in real production situations in the paper mills and in the printing plants. Especially we would like to thank the printers and operators who have given us much help and to whom we also caused extra trouble. These are Mr E. Nieminen and his staff at Tidningstryckarna Aftonbladet Svenska Dagbladet AB, Mr G. Karlsson and his staff at Göteborgs-Posten Teknik, Mr L.-G. Eriksson and his staff at Stora Feldmühle Kvarnsveden AB, and Mr A. Hillvall and his staff at SCA Ortviken AB. We would also like to thank Prof L.Malmqvist for his support and encouragement during this project. We are also grateful to Davy McKee (Poole) Ltd for placing the CTSensor at our disposal. Assistance from Stora Technology AB and SCA Research AB is gratefully acknowledged.

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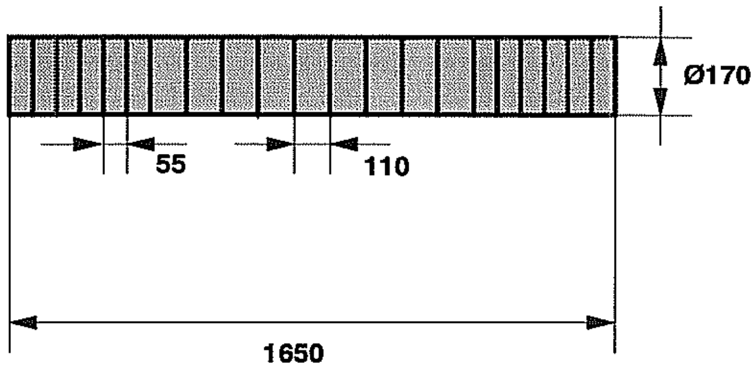

Fig 1. Geometrical configuration of the CTS-roller.

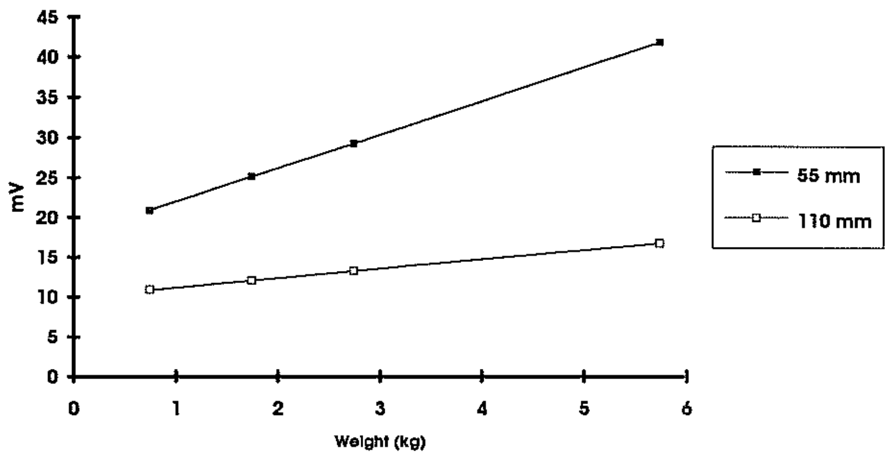

Fig 2. Calibration diagrams for a 55 mm wide rotor and a 110 mm wide rotor.

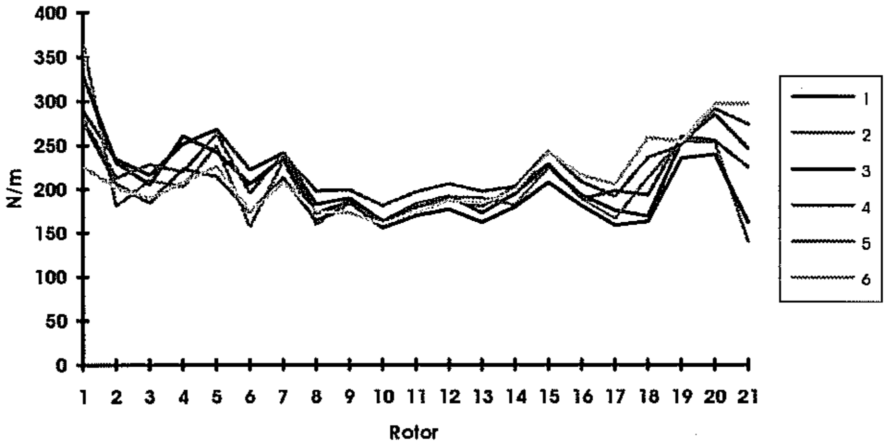

Fig 3. Tension profiles for repeated rewinding of the same paper roll.

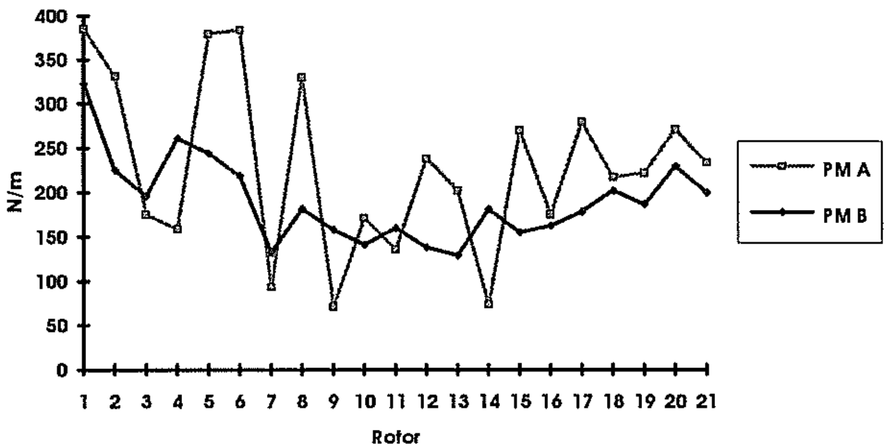

Fig 4. Tension profiles for paper rolls from two different paper machines.

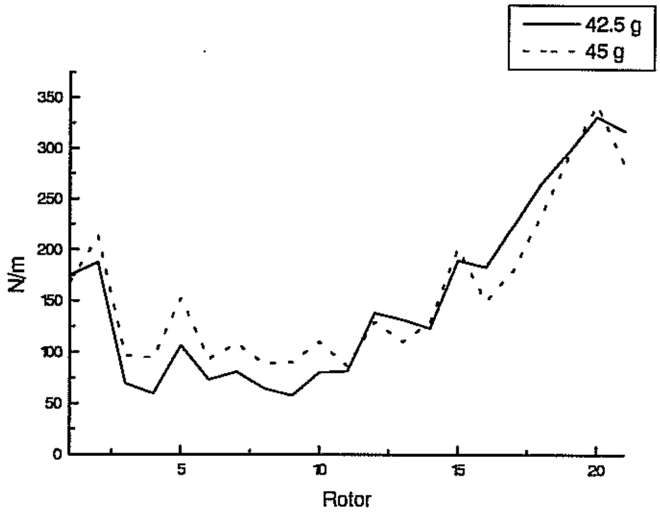

Fig 5 a. Tension profiles for paper rolls from four different positions (a-d) in one paper machine. The rolls have a grammage of 42.5 g/m^2 and 45 g/m^2, respectively, and are produced with one week in between.

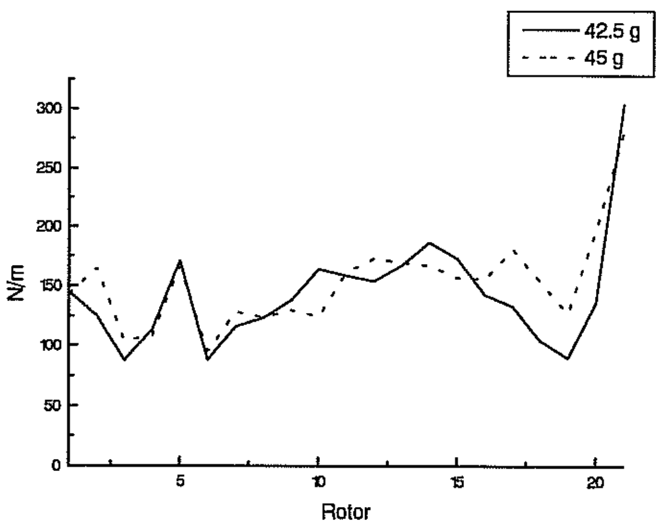

Fig 5 b.

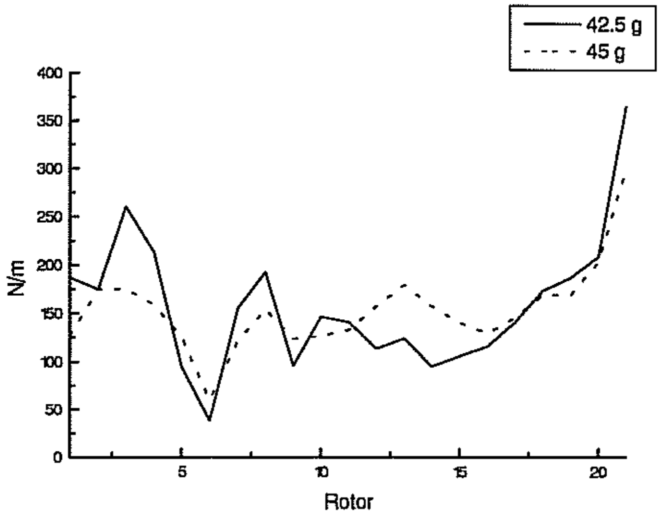
42.5 g
45 g
400
350
300
250
200
150
100
50
0
N/m
5
10
15
20
Rotor

Fig 5 c.

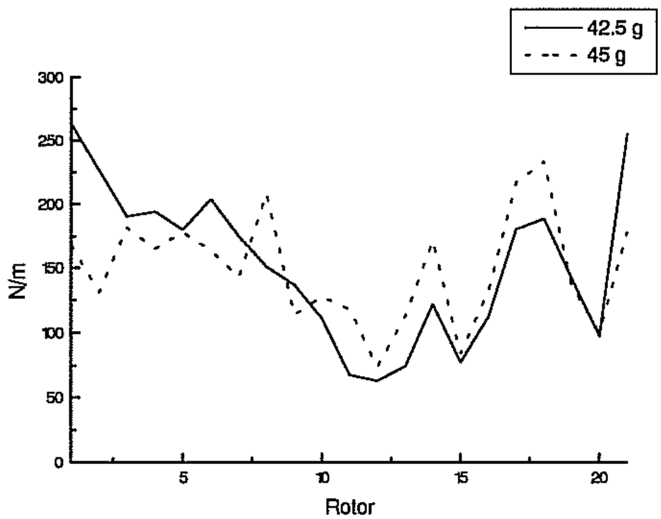
42.5 g
45 g
300
250
200
150
100
50
0
N/m
5
10
15
20
Rotor

Fig 5 d.

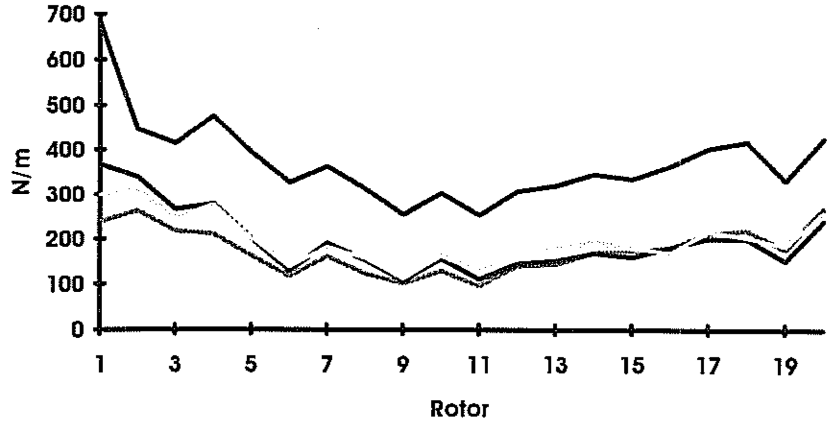

Fig 6. Tension profiles for four different rolls taken from the same position in one paper machine and produced within 10 h.

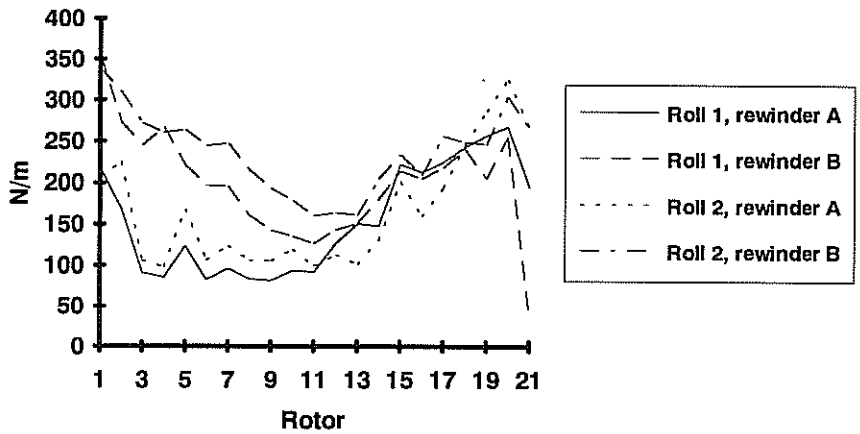

Fig 7. Comparison of measurements of the same paper rolls but in two different rewinders and with 6 months in between.

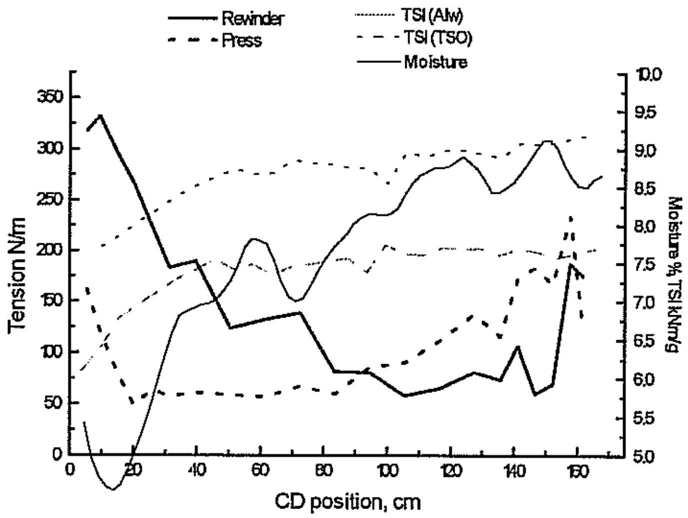

Fig 8 a. Tension profiles in the rewinder and in the printing press compared with moisture content and tensile stiffnes index (TSI). TSI (Alw) measured in a tensile testing machine, TSI (TSO) measured in an ultrasonic tensile tester. Four different positions are shown (a-d).

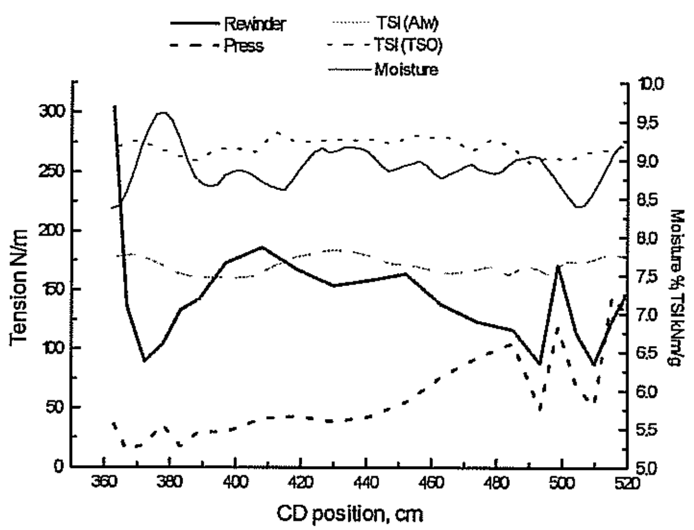

Fig 8 b.

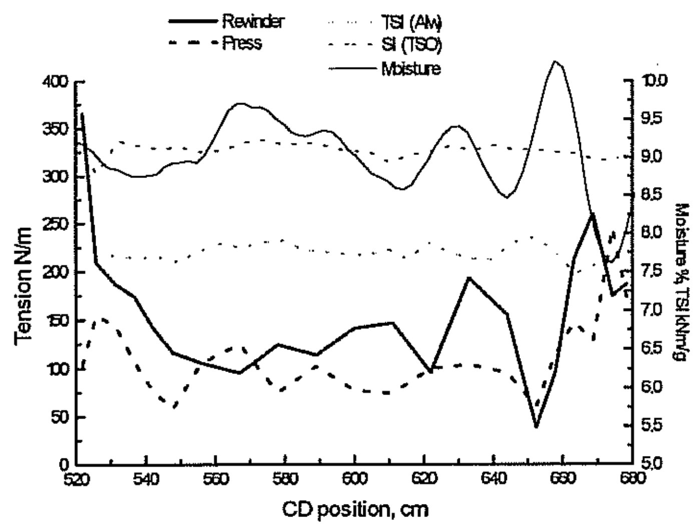
Rewinder
Press
TSI (Aw)
SI (TSO)
Moisture
Tension N/m
Moisture % TSI kNm/g
CD position, cm

Fig 8 c.

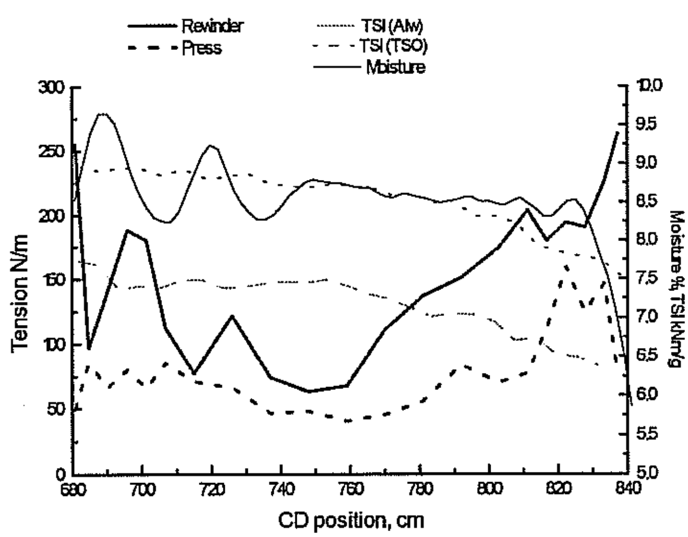
Rewinder
Press
TSI (Aw)
TSI (TSO)
Moisture
Tension N/m
Moisture % TSI kNm/g
CD position, cm

Fig 8 d.

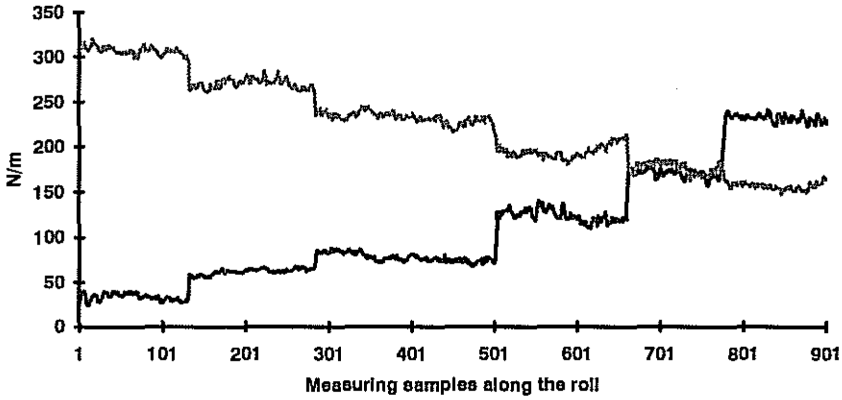

Fig 9. Change of tension values from two rotors when one guide roller is misaligned.

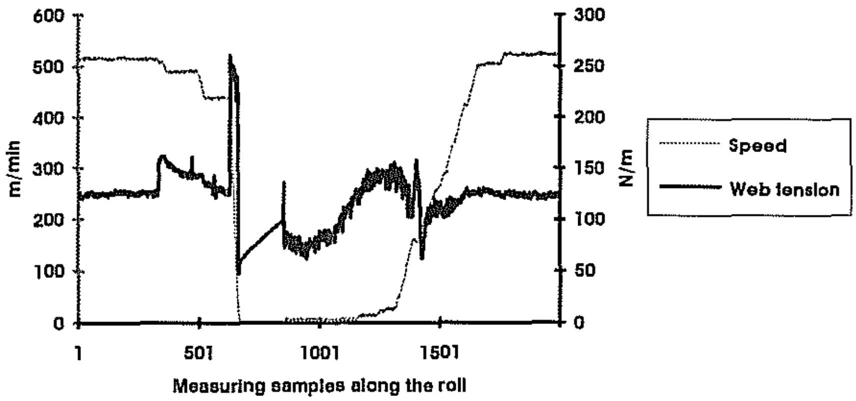

Fig 10. Speed and web tension in a printing press.

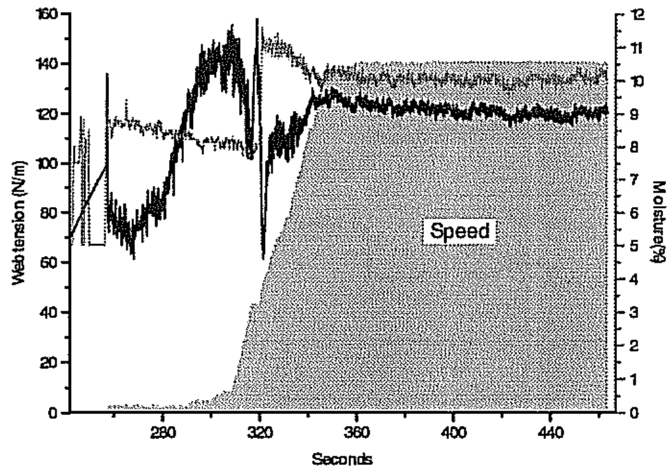

Fig 11. Start up of a printing press and moisture content in the web measured after the printing units.

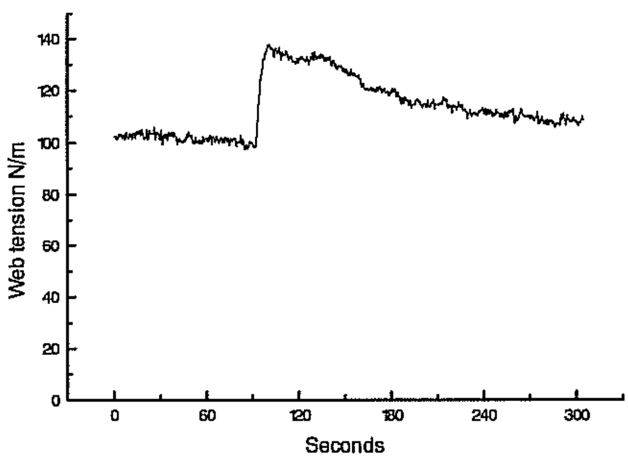

Fig 12. Web tension behaviour at a flying paster in a printing press.

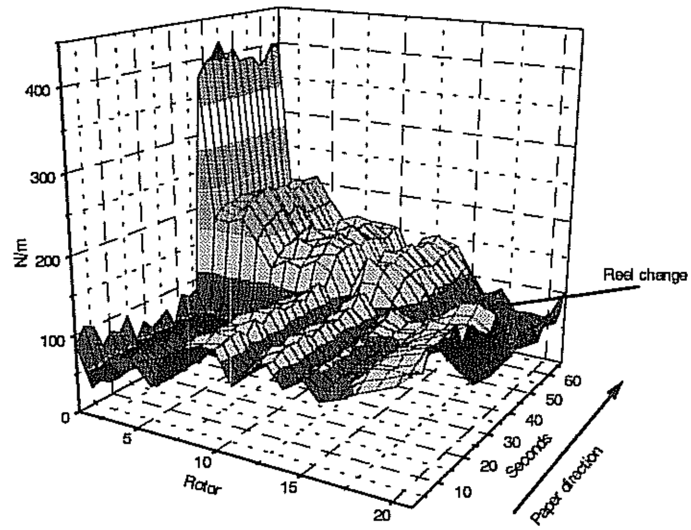

Fig 13. Tension distribution at a flying paster (reel change).

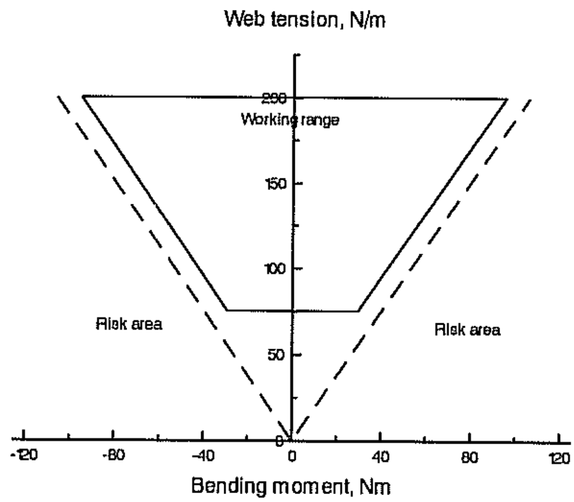

Fig 14. Suitable working range for web tension and bending moment in a printing press.

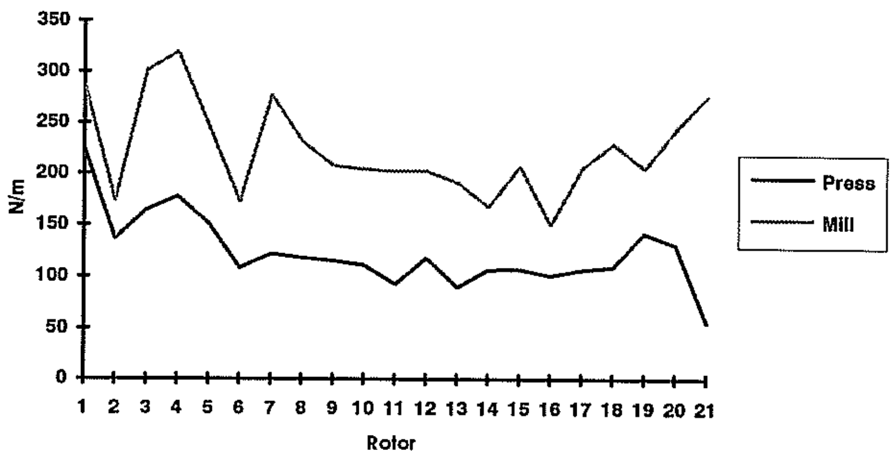

Fig 15: Comparison of tension profiles of the same reels measured in a rewinder and the in a newspaper printing press.

QUESTIONS AND ANSWERS

Q. Which factors are most important for the tension distribution in the paper web?

A. The moisture content variation is the most evident factor. The thickness is important, but normally its variation is very little. In Fig. 4, the paper roll from the paper machine A shows tension variations due to thickness variations across the web.

Q. The different measurements in Fig. 8 seem to have different resolution in the cross direction. What is the reason and how does it influence the comparison?

A. For the tension distribution, there are 21 values across the web width as there are 21 rotors. The moisture values come from the traversing measurement system in the paper machine. The tensile testing is made on strips cut from the web. The curves with fewer measured points do not show finer details of the variations.

Q. Is there any possibility that the measured values are influenced by some kind of cross-talk between the signals from the different rotors?

A. No, the signals are completely separated. However, if the rotors stick together, the readings get erroneous. This can happen if printing ink gets in between the rotors.

Q. Fig. 3 shows the measurements from different rewindings. What is being changed?

A. The paper roll had to be turned 180 degrees between the rewindings. In the first rewinding, one part of the paper web is measured by rotor 6, for example, and next time by rotor 16, and next time by rotor 6, and so on. In Fig. 3, this has been corrected so what is shown as measurements from rotor 6 comes from the same cross direction position of the paper web.

Q. The bending moment in Fig. 14, what is it?

A. It is measured with a roller with one load cell at each side of the shaft. The moment is proportional to the difference between the forces measured by the two load cells.

Q. Which rotor signals are shown in Fig. 9?

A. Rotors number 2 and 20, not the values from the edge rotors.

Q. Would it be possible to sleeve the outside diameter of the steel rotors with a softer type material such as rubber or polyurethane?

A. Yes, sets of individual rotors have already been supplied coated with materials such as polyurethane to conform with surface materials of adjacent pass line rollers.