Effects of Formation on the Sheet Dimensional Stability as Measured In Situ

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【**Abstract**】Formation and dimensional stability influence its quality to substantial extent. Currently there is no on-line instrument capable of measuring formation and dimensional stability simultaneously. The tensile stiffness orientation (TSO) test has been used successfully at the Long-Chen Paper Company's Dou-liu mill to improve dimensional stability of the sheets. Meanwhile, the WebForm installed on the production lines have also been worldwide used in paper machines for formation adjustment.

The on-line formation data from the PM 1 and PM 2 machines at the mill were compared synchronously with their tensile stiffness orientation angles. The results were found to enable the adjustment of slice jet to wire speed ratio, furnish composition and replacement timing of wire screen etc. to achieve enhancing formation and dimensional stability.

The results indicated the WebForm and TSO tester could be used in conjunction to assist in paper machine adjustments. The initial results led to improve formation with increasing grammages at PM 1 and a opposite trend with PM 2. When formation improves, dimensional stability also enhances, showing a positive correlation.

【**Key words**】formation, dimensional stability, grammage, tensile stiffness orientation.

紙機線上紙匹之交織與尺寸安定性之關係

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【摘要】紙機網上之紙匹交織成形及尺寸安定性影響紙性至鉅。在紙機上同時測定紙匹之交織成形及尺寸安定性尚無良法。利用抗張挺度配向（TSO）法成功地改善紙匹之尺寸安定性，同時裝在紙機上之 WebForm 儀器可供調整紙匹之成形。利用裝在 1 號及 2 號紙機上之儀器所測定之 TSO 角度大小可得線上成形數據，由所測定之數據可做調整閘片口之噴漿／網速之比值，漿料組成，換網時間之參考值，如此可強化紙之成形及尺寸安定性。現場試驗數據証明同時安裝 WebForm 及 TSO 儀器，有助紙機之調整以改善紙機生產紙匹之成形及尺寸安定性。隨著紙匹基重之增加，1 號紙機之紙匹成形可獲改善，而 2 號紙機生產之紙匹則呈相反之趨勢。綜言之，利用本驗驗所用之設備可同時改善紙匹之交織成形及尺寸安定性。

【關鍵詞】交織成形，尺寸安定性，基重，抗張挺度配向

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I. Introduction

Formation is defined as the uniformity with which the fibers are distributed in the paper. Paper is said to have uniform or close formation if the texture is similar to ground glass when viewed in transmitted light. The formation is said to have poor or wild if the fibers are unevenly distributed, giving the sheet a mottled or cloudy appearance in transmitted light.

Variations of paper size relates to paper dimensional stability. Change that occurs in the dimensions of paper with variation in the moisture content is an important consideration in the use of the paper. All papers expand with increasing moisture content and contract with decreasing moisture content, but the rate and the extent of change vary with different papers.

Both formation and dimensional stability play key role in the quality characterization of paper sheets. Producing sheet with a uniform formation and good dimensional stability is desirable for the quality of sheets. Unfortunately, there is a lack of understanding with regard to the interrelationship between these two factors. Besides, there seems to be lack of instruments capable of doing both measurements concurrently for paper quality improvement.

A tensile stiffness orientation (TSO) could provide off-line measurement of tensile stiffness index (TSI) and TSO. These two parameters have been used successfully at the paper machines of Dou-Liu Paper Mill located in central Taiwan to improve dimensional stability (Perng 1998). Meanwhile a WebForm on-line formation tester by JH Instrumentation Ltd. was employed to enhance machine runnability and to improve paper quality. Similar instruments have been successfully used in some British paper mills as well (Corecadden 1999). The objective of this research is to investigate the use of WebForm instruments on PM1 and PM2 of our mill for formation adjustment and the laboratory testing of TSI and TSO in order to understand the relationship between formation and dimensional stability and for providing reference to production lines in machine adjustment for raising quality of paper products (Moore 1999).

II. Experimental

(I) Paper machines at the Dou-Liu mill

Two paper machines were installed at the Dou-Liu paper mill in 1998, their specifications are listed in Table 1. Paper machine 1 has a daily capacity of 50 tonnes and Paper machine 2 150 tonnes. The main products are wood-free sheets, premium wood-free sheets, computer printout, base paper for art paper, colored paper, kraft paper. etc.

(II) Principles of measurements

a.TSO tester

TSO tester made by Lorentaen & Wettre (L&W) Co. utilizes ultrasonic technique to enable the adjustment of sheet dimensional stability. The principle is that rate of transmission is related to the elastic property of sheet, whereas this property can be expressed as the tensile stiffness index of the sheet. A typical polar diagram of ultrasonic fiber orientation is shown in Fig. 1. The vector from the origin to the maximum TSI as deviating from MD is a representation of majority fiber orientation in the sheet.

Each paper machine has its idiosyncretic TSI polar diagram. The typical TSI MD/CD values for various paper grades are listed in Table 2. Papers with good stability usually must

Table 1. Paper machine specifications at the Dou-Liu paper mill.

Items	PM 1	PM 2
Trim width, m	2.8	3.6
Headbox style	Rice Barton	KWM
Wire section	Fourdrinier with watermark	Fourdrinier with Escher Wyss top wire
Press section	2P + press roll	2P + press roll
No. of drying cylinder	36	42
Surface sizing	Size press	BTG, HSM Roll
Calender	Steel rolls ×4	Hot ware steel roll ×2
Controllers	Winder counter	B/M presize + winder B/M ctrs
Others		IR drying, Air turn

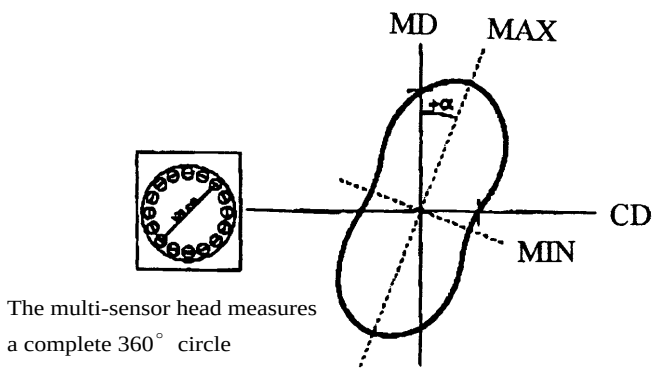


Fig. 1. A typisal polar diagram for TSI.

Table 2. Typical TSIMD/CD for various grades of papers.

Paper grade	$TSI_{MD/CD}$
Sack kraft paper	1
Photocopy paper	1.8 ~2.2
Printing paper roll	2.3~ 3.3
Newsprint paper	3.5~ 5.5
Tissue, medium and boxboard	2.0~3.0

have their TSO controlled to within 50, the criterion for photocopy paper is more stringent and must be within ±30.

b.WebForm

Webform employs visible light to penetrate paper sheet and determine the formation of sheet through light absorption. In general, on-line formation testers are fixed devices or single light source type. WebForm could be mounted on a tripods or movable supports to scan the web, usually installed on both front and back sided of a machines. WebForm also has wide area of measurement than a typical single light source type. The instrument could be set to work on 4 different cross-direction widths, and display various analyses diagrams on a monitor, these could show a formation indices based on 3, 6, 12 and 48mm floc sizes and with the running machine, scan the formation indices in cross-direction width, in the range of 1.5 ~12nm (called micro), 24~192mm (called macro), and 384~24,000mm (called large), respectively. These results of comparison graphs were used for the reference of operators. The higher the formation indices , the poorer the formation.

(III) Webform instrument

A portable Webform instrument was provided by JH Instrumentation Ltd. accompanied by Mr. Marcus Moore, and experted on the instrument for setup adjustments. Synchronously TSI and TSO were measured. The parameters tested included jet/wire ratio, furnish composition and wire change etc.

III. Results and Discussion

(I)Tesing results of WebForm on paper machine 1

Considering facility constraints and the grade of paper produced, we have no attempt to adjust parameters. The observations entailed that

a. for paper with grammage of greater than 170gsm, Webform was inadequate.
b. for paper with grammage of greater than 120gsm, the formation was better than that of the 80gsm (Fig. 2) There was no apparent periodic disturbances.

(II) Testing results of WebForm on PM 2

During the course of observations using the WebForm instrument, sheet grammage, jet/wire ratio, furnish composition and wire change variables were modified for comparison. The results suggest that:

a. The sheet formation on front side was generally inferior to the back side, indicating uneven wire configuration which needed adjustment.
b. The jet/wire ratios of 1.02 1.03 provided the best formation.
c. There was no serious periodic disturbance.
d. Wire change lowered front-back and periodic variations.
e. Sheet grammage of 65gsm had better formation than that of 70gsm.

(III) Comparison of the formation of front vs. back side for PM 2

Dimensional stability was assessed with $TSI_{MD/CD}$ and TSO. The smaller the TSO angle, the better the dimensional stability. The $TSI_{MD/CD}$ values must be kept to a certain range to attain an admirable dimensional stability. Formation of the corresponding sheets was measured using formation indices (PRW), the smaller the formation indices, the better or more uniform formation of the sheet.

Effect of different jet/wire ratios and grammages on the dimensional stability and

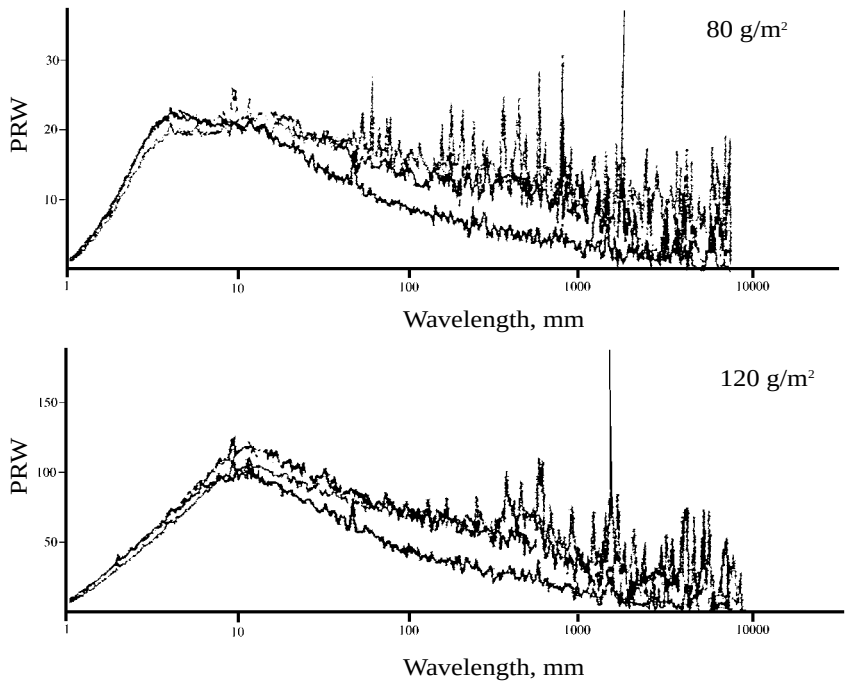


Fig. 2. Comparison of sheet formation between 80 gsm and 120 gsm at PM1.

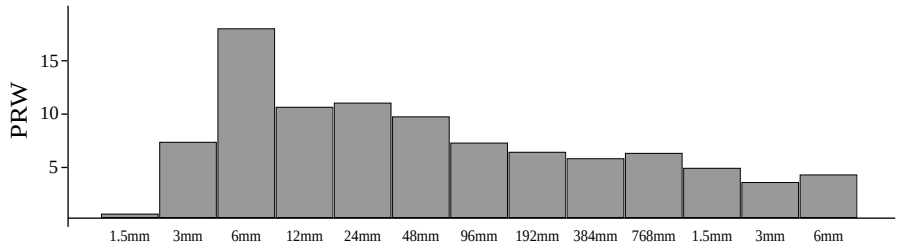
Table 3. Effects of different jet/wire speed ratios on the formation and dimensional stability.

Grammage g/m²	Jet/wire ratio	Dimensional TSI MD/CD	stability TSO angle	Formation index (FS) Micro vs Macro
70	1.01	2.12	-1.24	65.9 / 37.2
	1.02	2.31	-1.75	56.7 / 33.1
	1.03	2.30	-2.27	61.6 / 33.3
65	1.01	2.08	-1.78	base paper for coating
	1.02	2.21	-0.09	base paper for coating

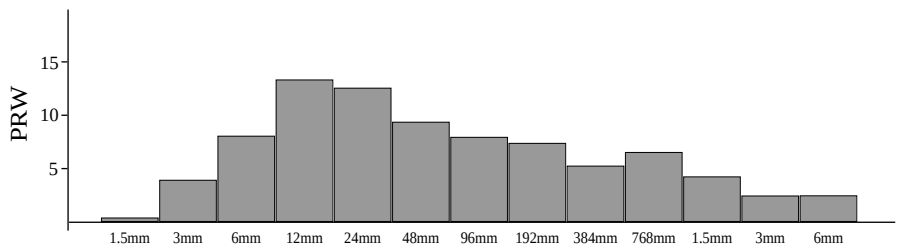
formation are shown in Table 3. Dimensional stability (TSO_{angle}) and formation shows consistent proportionality, suggesting that high quality will not only have good formation, but consistently exhibit good dimensional stability as well.

IV. Conclusions

During this trial, TSO tester and WebForm instruments suggested that they could be used effectively to adjust paper machine runnability parameters thus gave better formation and dimensional stability. In addition we derived the



Paper length (front (operation) side)



Paper length (back (drive) side)

Fig. 3. Comparison of sheet formation between front and back sides of PM 2.

following concluding remarks:

1.For PM 1, increasing sheet grammage entails better formation.

2.For PM 2, decreasing sheet grammage entails better better formation.

3.Along with improved formation, dimensional stability of the sheet also increased. There is a positive correlation between these two variables.

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