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Analysis and Control of Camera Type Weft Straightener

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***Abstract*—**In general, fabric is heat-treated using a stenter machine in order to dry and fix its shape. It is important to shape before the heat treatment because it is difficult to revert back once the fabric is formed. To produce the product of right shape, camera type weft straightener has been applied recently to capture and process fabric images quickly. It is more powerful in determining the final textile quality rather than photo-sensor. Positioning in front of a stenter machine, weft straightener helps to spread fabric evenly and control the angle between warp and weft constantly as right angle by handling skew and bow rollers. To process this tricky procedure, the structural analysis should be carried out in advance, based on which, its control technology can be drawn. A structural analysis is to figure out the specific contact/slippage characteristics between fabric and roller. We already examined the applicability of camera type weft straightener to plain weave fabric and found its possibility and the specific working condition of machine and rollers. In this research, we aimed to explore another applicability of camera type weft straightener. Namely, we tried to figure out camera type weft straightener can be used for fabrics. To find out the optimum condition, we increased the number of rollers. The analysis is done by ANSYS software using Finite Element Analysis method. The control function is demonstrated by experiment. In conclusion, the structural analysis of weft straightener is done to identify a specific characteristic between roller and fabrics. The control of skew and bow roller is done to decrease the error of the angle between warp and weft. Finally, it is proved that camera type straightener can also be used for the special fabrics.

***Keywords*—**Camera type weft straightener, structure analysis, control, skew and bow roller.

I. Introduction

WEFT straightener is an important device machine being in front of stenter machine for correcting web distortion. Correcting web distortion is able to influence textile quality. Fig. 1 shows stenter processing structure system for textile straightening and heat treatment. [1]

The warp and weft orthogonal patterns of the woven fabric are distorted in the manufacturing process. Several methods have been investigated to correct for skew phenomena that are tilted or curvature that curves like bow. [2]

In order to detect the deformed fabric, photo sensor detecting method was generally used. In recent years, demand for high-quality fabrics and special fabrics has increased, resulting in technological limitations.

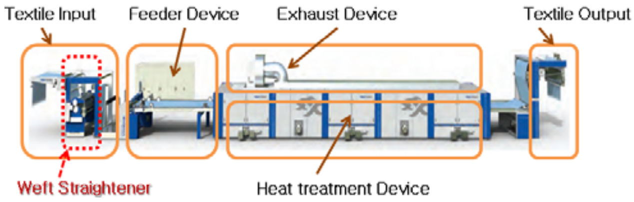

Fig. 1 Weft straightener position in stent processing system

Weft straighteners are developed by leading companies and are produced by BIANCO in Italy, EL and MAHLO in Germany and PLEVA in Switzerland. BIANCO uses a high-sensitivity optical sensor to detect the distortion of the fabric. EL can detect various fabrics such as woven and knit using matrix camera. MAHLO has developed a weft straightener that recognizes patterns by cameras and controls and calibrates simultaneously. PLEVA uses a high resolution CCD camera to measure the warp of the fabric and acquires a wide range of images by using the scanning method. [3]-[6]

Weft straighteners and add-ons developed by the mentioned companies are known as the world's best-performing mechanical systems with advanced technology [3]-[6]. Depending on the manufacturer, the function of the weft straightener is different, but the major commonality is the adoption of a large number of cameras for image detection. Image detection function, automatic control and monitoring system of the system are also commonly applied.

When a camera of line scan type is used in comparison with the photo sensor method for detecting the original image, it becomes possible to measure the deformation of the original at a high speed and precisely, and it becomes possible to automate the entire system.

In this study, we developed a camera that improves the detection of fabric deformation for productivity improvement. So, reducing the influence of the light source improves the pattern image detection ability. Weft straightener has been designed to calibrate fabrics and its performance was examined. [7]-[9]

II. Line Scan Camera and Fabric Detection Algorithm Development

A. FPGA

Camera type weft straightener is advantageous in that it is easy to detect the inclination of the fabric by detecting the area using the area scan. However, it is impossible to measure the density accurately because it is not able to capture the entire

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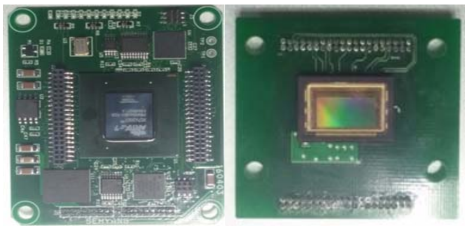
fabric passing by. There is a disadvantage that the correction time is relatively long. The line scan method has been chosen because of accurate density measurement.

There are two advantages of line scan. First, since the detection can be performed for all the yarns, it is possible to measure a precise fabric density. Second, since the algorithm can be operated on each line, the response speed is faster than the range scan.

Large data of about 5 Gbps per camera, total 20 Gbps is loaded. Data of whole fabric are used for density measurement. Generally, in case of image processing, a frame grabber and a camera link are used to operate an algorithm using a computer. However, considering the characteristics of the environment, it is not suitable for the risk of cost, noise, and system down, and it is embedded with FPGA (field-programmable gate array).

B. Line Scan Camera

The sensor part of the developed line scan camera which is shown in Figs. 2 and 3 is directly designed and manufactured. The camera includes a sensor unit and an image processing unit, and the image processing result is directly transmitted to the control board. When detecting the yarn in the weft straightener, the shooting range should be set to 1 inch for each yarn, and the focus was adjusted by detecting the fixed value.



(a) (b)

Fig. 2 Line scan camera parts: (a) drive and (b) sensor

(a) (b)

(c)

Fig. 3 Line scan camera system: (a) cover-box, (b) module, (c) assembly

C. Fabric Detection Algorithm

The algorithm is designed to operate by self-judgment without any user's operation even if the line speed and fabric are changed. The maximum line speed is 180 m/min and the fabric density is 300 T. Fabric detection algorithm was developed considering the following points.

1) Precise density detection possible
2) Special fabrics can be calibrated as well as general fabrics
3) Even if the line speed and fabric density change, it can be judged and corrected by itself without user's operation
4) Fast response time

The order of the image processing algorithm is shown in Fig. 4. The frame of the camera is requested by using the pulse of the encoder according to the time which is easy to calculate. The line speed is calculated using the encoder pulse. The fabric type is determined based on the data of the previous image and the set value of the sensor is changed accordingly. If the type of fabric changes, the inspection proceed is done after changing the sensor setting.

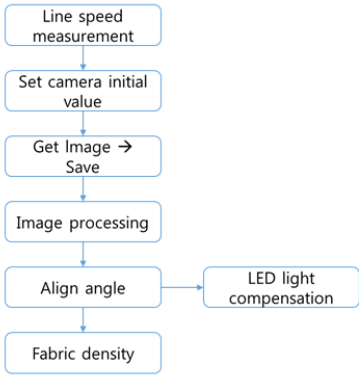
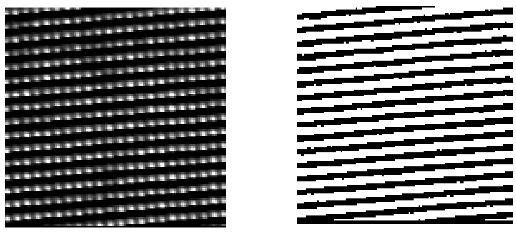


Fig. 4 Algorithm flow chart

After the setting is completed, the CMOS sensor can acquire 10 bit gray data and use LVDS clock to transmit data at a maximum speed of 240 Mhz by using SERDES (Serializer, Deserializer) instead of general buffer.

Angle and density detection are performed after the image processing is performed on the sorted data. The angle and density detection algorithms consist of three major parts. The first is an average value of the fabric detection image. The second process is hysteresis analysis and processing. Finally, angle and density detection are based on hysteresis binary images. In hysteresis analysis, the hysteresis method is applied rather than the Sobel filter, so accurate data for fabric analysis can be obtained shown in Fig. 5.

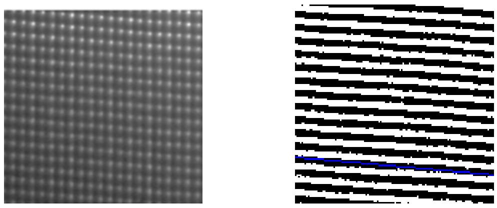


(a) Image by sobel filter (b) Image by hysteresis method

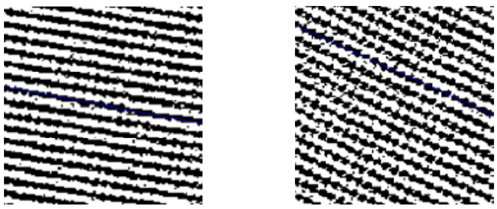
Fig. 5 Fabric image pattern process result

D. Test for Algorithm Verification

Algorithm was created with HDL code using MATLAB. Figs. 6 and 7 are the result images of testing based on the algorithm validated with MATLAB. Two types of fabrics with different densities were tested with varying angles. The density of the fabric is the number of weft per inch. The fabrics used for the tests were 200 t and 30 t of normal fabrics.

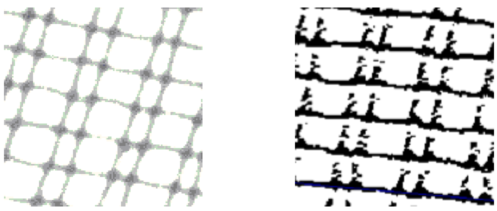


(a) Original image (b) Processed image (5deg.)

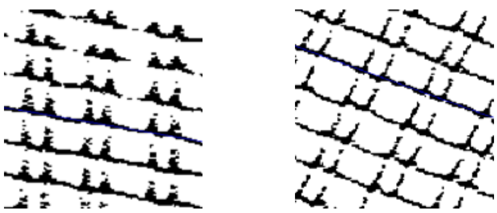


(c) Processed image (10deg.) (d) Processed image (30deg.)

Fig. 6 Image processing result of common fabric (200t)



(a) Original image (b) Processed image (5deg.)



(c) Processed image (10deg.) (d) Processed image (20deg.)

Fig. 7 Image processing result of common fabric (30t)

III. Simulation

For the dynamic analysis, the ability to calibrate the fabric passing through the rollers was analyzed using ANSYS and DAFUL software. Fig. 8 shows the analysis conditions. The tension on the fabric was expressed as moving at a speed of 100 mm/s. There skew rollers and two rollers were used. The coefficient of friction was 0.1. [10]

Fig. 9 is a wireframe representation of the shape of the fabric passing through the straightener. The process of deforming the fabric is shown.

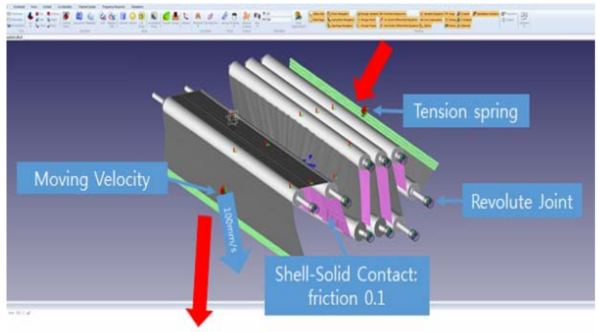


Fig. 8 Analysis conditions (DAFUL dynamic analysis software)

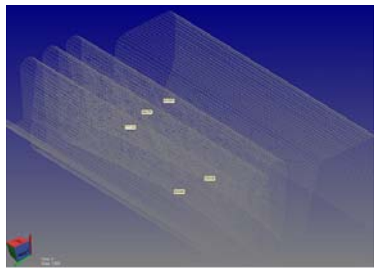


Fig. 9 Analysis conditions (DAFUL dynamic analysis software)

Fig. 10 shows the simulated results for evaluating the effects of skew rollers and bow rollers at a constant speed of far-end feed with node points at specific locations on the fabric.

Fig. 11 shows the simulation results of the effect of the friction coefficient of the fabric on the roller and fabric slip. The coefficient of friction of special fabrics used in this study is in the range of 0.1 ~ 0.3. The basic data necessary for tension control and speed control of the fabric can be obtained according to the influence of the friction coefficient.

IV. Control and Experimentation

For the test of the fabric correcting ability, the fabric must be supplied with constant meandering or curvature. For this purpose, a simulator was developed for the experiment of the developed weft straightener. The simulator is designed to be able to continuously feed the fabric and to apply skew and curvature to the fabric. Basically, it is composed of a device for applying the skew and curvature of the fabric in substantially the same form as the configuration of the weft straightener and a device for feeding and conveying the fabric in connection with the weft straightener.

The skew rollers and bow rollers are configured to manually adjust the angle of the rollers using a handle for applying the meander and curvature of the fabric. The maximum skew angle of the fabric is 30° and the curvature is 20°. The skew applied angle can be determined by using the moving distance of the manual handle, the handle position, and the trigonometric function.

The complete equipment with fabric is shown in Fig. 12. The simulator was mounted on the weft straightener, the fabric is deformed at a certain angle, and its calibration performance was examined. Experiments were carried out at a warping angle of 30° and a curvature of 20°.

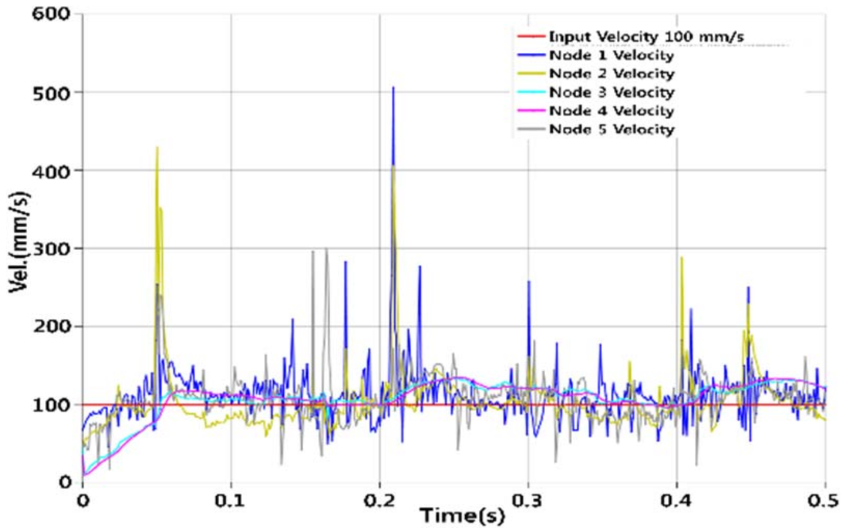
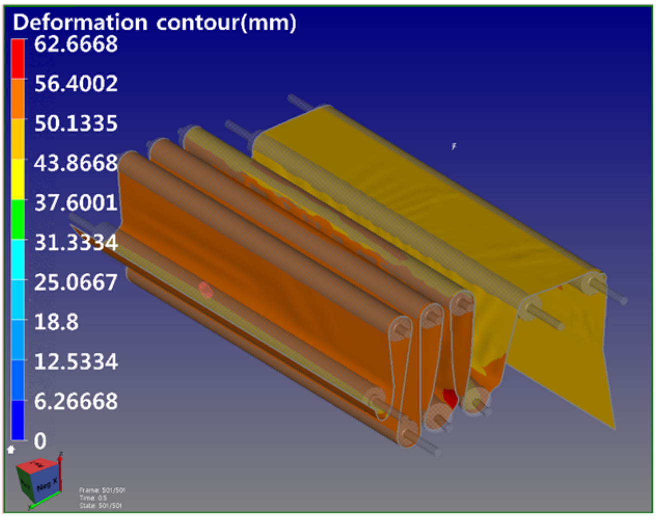
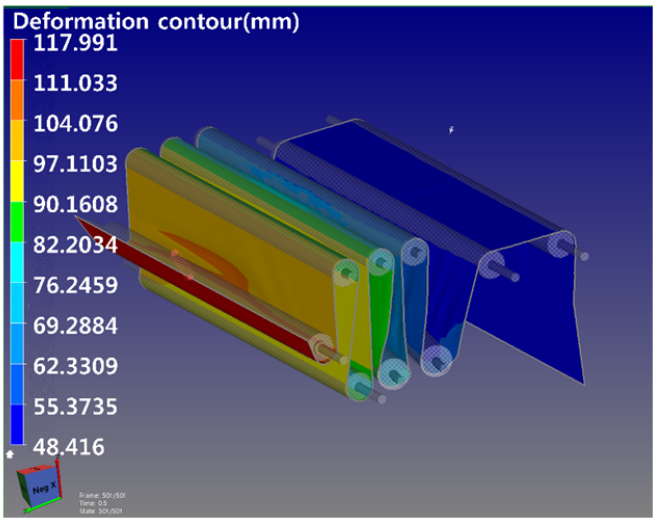


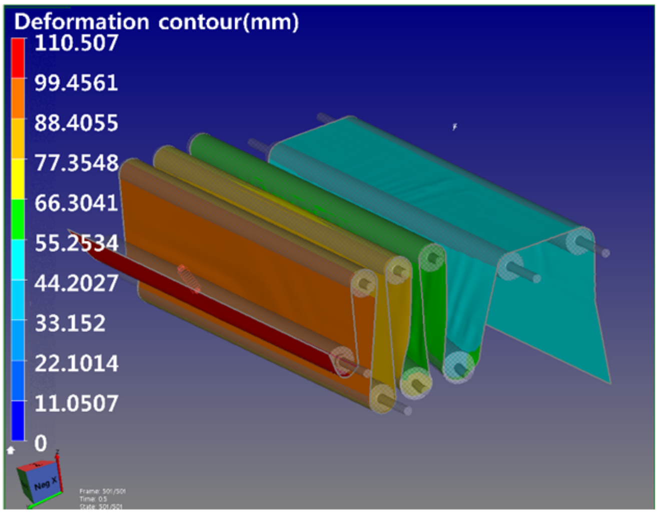
Fig. 10 The velocity of each node moving on the fabric



(a) Coefficient of friction μ=0.1



(b) Coefficient of friction μ=0.2



(c) Coefficient of friction μ=0.3

Fig. 11 Tension distribution according to friction coefficient variation

Fig. 12 Weft straightener and simulator test configuration

Fig. 13 shows the angle of the fabric before calibration and the measured value after calibration. Before the calibration, it is possible to confirm that the fabric is inclined at a certain angle. After the calibration, it can be confirmed that the fabric is aligned relatively horizontally, and it is confirmed that the measurement is made after a certain time after control of the weft straightener. Fig. 14 shows the results before and after correction when curvature is given. Comparing before and after calibration that calibration has been done well.

Fig. 13 Comparison of before and after controlling weft straightener (skew angle)

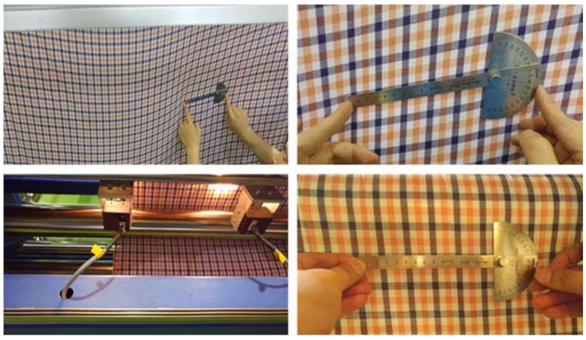


Fig. 14 Comparison of before and after controlling weft straightener (bow angle)

V. Conclusion

We developed a fabric calibrator using line scan camera technology that can recognize image patterns. For this purpose, we have developed a calibrator system using skew and bow roller, line scan camera, weft angle image processing algorithm, roller fabric contact simulation, and a device for calibration evaluation.

We developed line scan camera drive and sensor to detect the weft angle of fabric and fabric image detection algorithm for control.

To verify the performance of the developed fabric calibrator, we evaluated the ability of the fabric to fabricate a simulator that artificially twists the fabric. As a result of the evaluation, it was possible to calibrate the skew 30° and bow 20° which are required performance of the developed fabric calibrator. The calibrated fabric is a fabric that is woven at regular intervals with common fabrics.

Simulation results show that it is necessary to reflect the influence of the sliding between the roller and the fabric on tension and speed control for accurate fabric calibrations.

In the case of special fabrics (combi, mesh, twill, yoru) other than plain fabrics, the density and angles of the fabric are different from those of normal fabrics due to the characteristics of the fabric. Therefore, it is necessary to improve the line scan camera and algorithm so that even if the kind of fabric changes, calibration angle of the equipment will be increased by adding rollers.

Acknowledgment

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