BM9FS1 ONLINE FIBER ORIENTATION SENSOR

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The fiber orientation (fiber arrangement) formed when the paper passes through the wire part of the paper machine was found to be a key characteristic in determining paper quality. Conventionally, the fiber orientation characteristic has been measured offline after the production is complete. Nippon Paper Industries Co., Ltd. and YOKOGAWA have jointly developed the world's first fiber orientation sensor systems that can measure and control such a characteristic online, thus enabling stable production of high quality paper. This paper outlines the measuring principles and control method of fiber orientation.

INTRODUCTION

The fiber orientation formed when paper stock is processed on the wire part of paper machines is known to be a key physical property in determining paper quality. Conventionally, this fiber orientation has been measured offline after production is completed. Nippon Paper Industries Co., Ltd. and Yokogawa have jointly developed the world's first fiber orientation sensor system capable of the online measurement and control of this physical property of paper on the paper machine.

The fiber orientation sensor has initially been used to control the curl of high-quality paper for copiers or printers and to reduce time spent on production losses. It has become evident, however, that the sensor is also effective for newsprint paper and paperboard in addition to such high-quality paper. The fiber orientation significantly contributes to dimensional deformation as typified by paper curl or distortion, and affects the physical characteristics of paper, including tensile strength and shear stress. By appropriately manipulating fiber orientation in the paper manufacturing process, it is possible to improve the curling characteristics and reduce paper jams in copiers and printers. This strategy is also effective in relaxing temperature and humidity control conditions during paper storage and preventing the collapse of paper sheet pile cargo during transport. With the awareness of these application needs, we plan to broaden the field of use for the fiber orientation sensor. Figure 1 shows an external view of Yokogawa's fiber orientation sensor.

MEASURING PRINCIPLES AND FEATURES OF FIBER ORIENTATION SENSOR

The fiber orientation sensor conducts measurement by taking advantage of the fact that light reflected by the cellulose fibers of paper surfaces has anisotrapy. As shown in Figure 2, light which is reflected when incident perpendicularly onto a paper surface varies in how it diffuses depending on the paper surface fiber conditions. Since the reflected light is more intensely diffused in the radial direction of fibers than in the axial direction, the form of the intensity distribution becomes elliptical according to the fiber orientation. The short axis of the reflected light's intensity distribution represents the orientation of the paper fibers, thus enabling the fiber orientation angle of the paper to be measured. The ratio of the short axis to the long axis in the intensity distribution refers to the ratio at which the paper fibers are oriented, thereby enabling the orientation index of the paper to be measured. By simultaneously mounting a fiber orientation sensor on both the top (felt side) and bottom (wire side) of the paper sheet, it is possible to measure two sidedness in the orientation angle and orientation index between the top and bottom sides of the paper. Figure 3 shows an example of the paper quality characteristics that can be determined with the fiber orientation sensor.

The main features of the BM9FS1 fiber orientation sensor are as follows:

- As a reflective sensor, the BM9FS1 supports both single-sided mounting and two-sided mounting.
- An infrared light source is used to eliminate noise components in the visible light region.
- The detection circuits of the light-emitting and -detecting elements filter out external light.
- The low-reflectivity window filter prevents the degradation of the S/N ratio.
- Consistent measurement is ensured by the emission energy control circuit being tuned to the detection sensitivity of the photodetector.

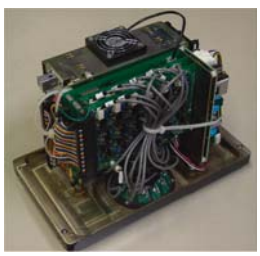

Figure 1 Sensing Unit of the Fiber Orientation Sensor

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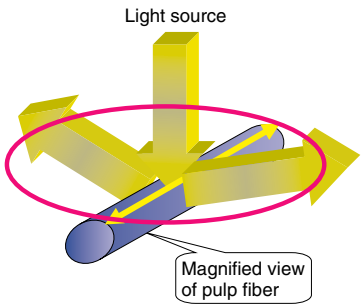

Figure 2 Measuring Principle of Fiber Orientation Sensor

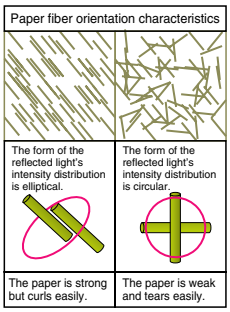

Figure 3 Characteristics Visualized Using Fiber Orientation Sensor

- Any of moving parts has been eliminated from the measuring unit to increase durability.
- To improve spatial efficiency, the shared standard reference plate used for sensor calibration is positioned between the oppositely placed each of sensors.

EXAMPLES OF ORIENTATION CHARACTERISTICS MEASUREMENT AND CONTROL

Figure 4 shows an example of the sensor's system configuration. Processed signals data transmitted from the sensing elements of the fiber orientation sensors is sampled by the BFOC and reaches the central measurement unit (CMU) through the BFOP. Orientation angles and indices profiles are composed using this CMU. Yokogawa's built-in controller, which is free of hard disks and any moving parts such as fans, has been adopted as the CMU to increase reliability and maintainability.

Figure 5 shows an example of measurement and control data obtained using the measurement system. In every graph, the horizontal axis denotes positions in the cross-machine direction of the paper machine. Figure 5-① is a graph obtained by sampling manufactured copy paper in the cross-machine direction and plotting the differences between the top and bottom fiber orientation angles. Figure 5-② is a graph obtained by measuring and plotting the degree of curl (magnitude of warpage) when the sampled paper is cut into A-4 size pieces of paper. This figure confirms that there is a relationship between the difference between the top and bottom orientation angles and the degree of distortional curl. Figure 5-③ is a graph showing the result of controlling the difference between the top and bottom orientation angles during

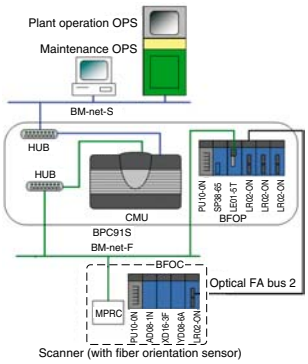

Figure 4 Configuration Example of Orientation Characteristics Measurement System

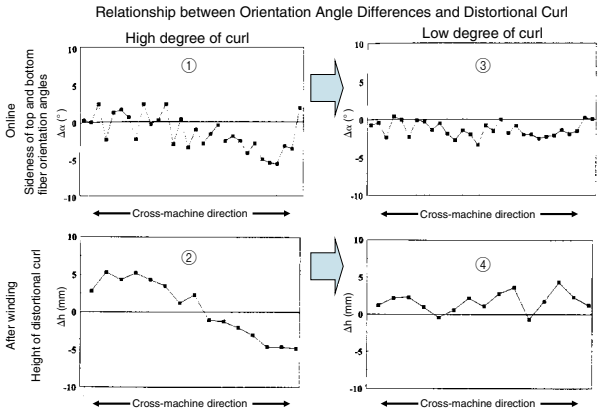

Figure 5 Example of Measuring the Fiber Orientation Characteristics of Copy Paper(1)

papermaking. Figure 5-④ is a graph obtained by measuring and plotting the degree of curl in paper sampled at this point in the same manner as explained in Figure 5-②.

These results demonstrate that we were able to reduce the change Δh (Max - Min) in the degree of distortional curl in the cross-machine direction from 10 mm to 5 mm. It has thereby been proven that continuously monitoring and controlling fiber orientation in the copy paper manufacturing process is essential in order to maintain product quality.

It is also known that orientation angle changes in the cross-machine direction can be controlled by partially adjusting the Z-axis opening of the headbox slice lip from which paper material is jet out. Consistency control must also be carried out, however, in combination with the control of such changes since the basis weight in the cross-machine direction also changes at this point.

CONCLUSION

In this paper, we have introduced the measuring principles and applications of the online fiber orientation sensor. Although only examples using copy paper have been shown due to space limitations, it is known that paper fiber orientation are responsible for color drifts and sheet breaks in high-speed printing machine for newspaper where color printing is being applied more frequently than ever before. In addition, there are reported cases in the USA and Europe that claim that the physical strength and twist curl (warp) of paperboard as a liner for corrugated box are related to fiber orientation. This indicates that the field of application for the fiber orientation sensor will become increasingly wider.

We will continue to concentrate on making the fiber orientation sensor even more precise and economical, while at the same time optimizing fiber orientation control.

In closing, we would like to express our sincere appreciation to Nippon Paper Industries Co., Ltd., who were extraordinarily cooperative and underwent numerous difficulties with us during our joint research. ◆

REFERENCE

(1) ABE Hiroshi, "Development of On-line Surface Fiber Orientation Meter." Session A-2 in Summary of Fiscal 2000 Annual Meeting's Lecture Abstracts from Japan Technical Association of the Pulp and Paper Industry, 2000, p.25 (in Japanese)