The New QC1F16 Frame for the WEBFREX NV Online Thickness Gauge

Yuusaku Koga [*1] *Daisuke Tanifuji* [*2] *Takashi Hara* [*3]

Since the release of the first online thickness gauge for sheet manufacturing processes in 1962, Yokogawa has kept developing measurement and control technologies to improve the quality and productivity of sheet products such as paper and films. The current product lineup is the B/M9000VP for paper, the WEBFREX NV for general-purpose films and sheets other than paper, and the WEBFREX3ES for battery electrode sheets. In recent years, as the power source of vehicles has shifted from fossil fuel to electricity, investment has poured into lithium-ion battery plants, where the WEBFREX3ES has been widely used. The demand for separator sheets, which are a main component of lithium-ion batteries, is also increasing particularly in overseas markets. To meet the needs of the market, Yokogawa has developed a new platform with improved maintainability, the WEBFREX NV QC1F16 (F16 frame), which conforms to regulations in various countries and is compatible with the Internet of Things (IoT). This report describes the features and technologies of the F16 frame.

INTRODUCTION

Yokogawa's online thickness gauge (Figure 1) is a system for precise, online measurement of film thickness along the cross direction (CD) and machine direction (MD) of film sheets, displaying the thickness distribution graph (profile), and automatically controlling film thickness uniformity for sheet manufacturing processes. Since releasing the first online thickness gauge in 1962, Yokogawa has kept developing measurement and control technologies, while adapting flexibly to the changing environment and social needs, to improve the quality and productivity of sheet products such as paper and films. The current product lineup includes the B/M9000VP for paper, the WEBFREX NV for general-purpose films and sheets other than paper, and the WEBFREX3ES for battery electrode sheets.

Nowadays, the world is rapidly moving toward a decarbonized society, driven by the adoption of the sustainable development goals (SDGs). The auto industry is shifting to electric vehicles (EVs), which has also been called an "EV shift." Accordingly, the market for lithium-ion batteries (LiBs) for EVs is growing rapidly. LiB manufacturers are building factories at locations convenient for shipping to EV manufacturers, to meet the increasing demand. Capital investment is especially active in Europe and China.

Online thickness gauges are widely used for manufacturing battery electrode sheets, which are a major component of LiBs. See the report "WEBFREX3ES Dedicated Coat Weight Measurement System for Battery Electrode Sheets [(1)]." Similarly to LiB manufacturers, manufacturers of separator sheets, which are another major part of LiBs, are

*1 Analyzer Planning Department, Sensing Center, Yokogawa Products Headquarters
*2 Analyzer Department, Development Division, Sensing Center, Yokogawa Products Headquarters
*3 P&W Solution Sales Department, Analyzer Sales Division, Sales Center, Yokogawa Products Headquarters

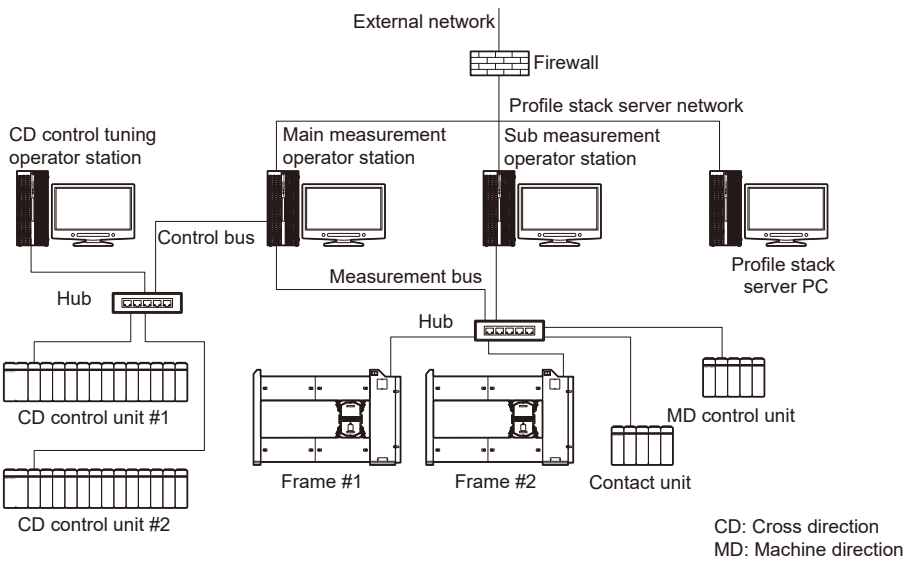

Figure 1 System configuration example of online thickness gauge

following a policy of local production for local consumption and are rushing to build new factories in various countries. Along with the expanding demand for LiB supply volume, demand is also rising for even higher capacity and greater safety of LiBs. To meet such demands, thinner separator sheets with higher heat resistance and larger-scale film manufacturing equipment are required. At the same time, the demand for measurement and control by online thickness gauges is increasing to support the manufacturing of separator sheets. These online thickness gauges must conform to the regulations in each country.

To optimize customers' plant operations, foresee failures, identify causes of troubles, and predict product quality, the data from devices of an online thickness gauge must be digitized for easier data analysis. This will also support customers' digital transformation (DX).

To meet the requirements above, Yokogawa has developed the WEBFREX NV QC1F16 ("F16 frame" hereafter, Figure 2) as the next-generation platform that meets the requirements of conformance to the regulations of each country, compatibility with the Internet of Things (IoT), improved maintainability and measurement accuracy, and ease of replacement. This report describes the features and technologies of the F16 frame.

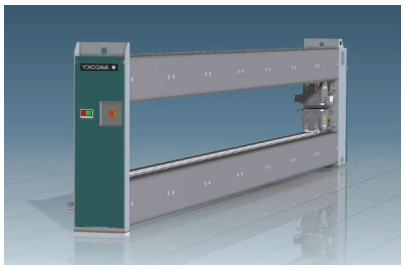

Figure 2 F16 frame (QC1F16)

FRAME

The frame for thickness measurement is a fixture supporting sensor heads that scan the film sheets. To enable the sensors to deliver their full performance, the frame must have a highly rigid basic structure and high-precision drive mechanism, and must also be maintained regularly to keep its performance for a long period. With appropriate maintenance, the frame is expected to function for more than a decade.

Frame Configuration

The configuration of the standard O-type frame is described, with the standard F6 frame (Figure 3), used for the previous models, as an example.

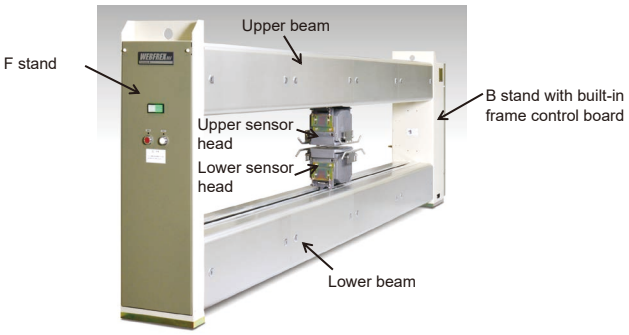

Figure 3 Configuration of the standard F6 frame (WG51F6B)

The O-type frame is a platform on which various sensors are mounted, such as Beta-ray detectors and X-ray detectors. A sensor is composed of an upper sensor head and a lower sensor head as a pair. Commands from the measurement operator station to the control board built into the frame B stand control the movements of the sensor heads, including round-trip scan,

travel to designated positions, and stop, to make measurements for controlling the thickness of the film sheets to be measured.

Frame Requirements and Background

The frame must meet the following requirements to be used as the next-generation platform.

- Conformance to regulations and standards in major LiB manufacturing countries
  Along with the projects of new manufacturing plants for separator sheets to be shipped to Europe and China, where the LiB market is expected to expand, the number of business inquiries for online thickness gauges is increasing. In line with the accelerating shift to EVs, plants for manufacturing separator sheets are expected to be built in more areas around the world. Therefore, online thickness gauges must conform to the regulations and standards of the countries in which they are used. For example, machinery directives must be met to ensure safe operation, because the drive parts of the frame are exposed to the outside due to the configuration of the frame. The mechanism of emergency shutdown during operation is the key requisite for acquiring certification.
- Compatibility with IoT
  The soundness of a frame is checked during maintenance performed when the factory is shut down, and so can be checked only several times a year. To check the frame soundness more frequently, a system to grasp the frame conditions remotely in real time is required. With such a system, service engineers and technical support staff at regional offices can remotely share information with the customer engineers at the site, which will strengthen cooperation between them and help identify the causes quickly.
- Improving maintainability
  Frame maintenance is performed by regional service engineers in each country, which requires professional skill, knowledge, and experience. However, cultivating such service engineers takes a long time and it is hard to keep pace with the rapidly growing market. To solve this problem, a system that simplifies parts replacement, sensor adjustment, etc. and can be done by anyone is needed.
- Improving measurement accuracy
  Separator sheets are becoming thinner to improve LiB performance and being coated by ceramics to improve heat resistance, while sheet manufacturing equipment is becoming larger to increase production capacity. Along with such trends, online thickness gauges are required to improve measurement accuracy and maintain machine accuracy of the frames. To enable high-accuracy measurement under various environments, auxiliary sensors are required to adjust measurement values according to the changes in environment. A system that facilitates the mounting of new sensors is also required.
- Considerations for replacement
  The environment in which a frame is installed differs from factory to factory among customers. Customers often request that a frame be designed with the minimal footprint. Replacement must also be considered to enable customers who have installed many frames in the past to replace their frames easily.

FEATURES OF THE F16 FRAME

To fulfill the requirements above, Yokogawa has developed the new F16 frame with the following features.

Conformance to Regulations and Standards in Major LiB Manufacturing Countries

At the time of publication of this report, the F16 frame has been certified for the CE marking and the Chinese GB standards. Yokogawa plans to acquire certifications for other regulations and standards in turn in the future.

Structural Design of the Frame (Improving Maintainability and Measurement Accuracy)

The I-type steel used for the standard F6 frame has been replaced by an H-type steel to make the frame lighter, reduce the impact of frame deformation on measurement accuracy due to self-weight, and improve manufacturability. I-type steels were used in a tapered structure with the thickness decreasing from the center toward both ends between two flanges. Therefore, the drive mechanism included many parts tailored to fit the tapered structure, and assembling the frame took a long time. In contrast, an H-type steel allows a planar structure which reduces the number of parts, assembly man-hours, and environmental loads during transportation.

During frame designing, the impact of the change of steel type on frame deflection was evaluated by using structural analysis software, and the optimum beam structure was selected among several candidates to achieve the maximum beam stiffness. As a result of the light-weight beam with an H-type steel and the improved beam stiffness, the frame deflection has been reduced by 30% as compared with the previous frames (Figure 4).

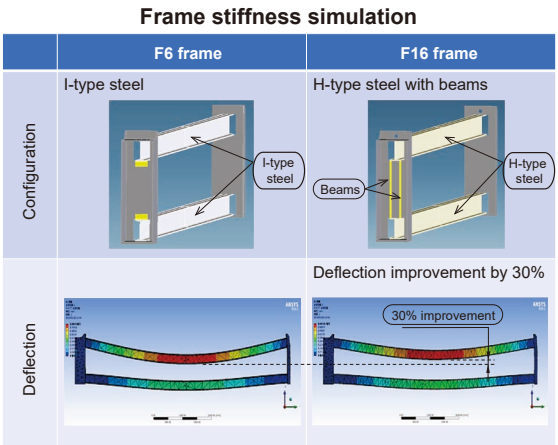

Figure 4 Structural analysis of the frame

High-Density Design (Conformance to Regulations and Standards, Improved Maintainability, and Consideration for Replacement)

The number of devices to be mounted on the frame has increased, because many protection circuits are required on the frame control board to meet the safety standards. The small size of devices, embedding of functions in firmware, and high density of design have enabled the required devices to be mounted on the control board for the F16 frame, even though it is the same size as that of the standard F6 frame. Thus, the F16 frame offers replaceability in the existing market.

Improved Flexibility to Requirement Specifications (Consideration for Replacement)

The length of the F16 frame can be selected from 55 variations, each one differing by 100 mm, as compared with 20 variations for the standard F6 frame, to meet various requirements for the installation footprint. In many cases the film sheets do not pass through the frame horizontally, and there are requests for tilted sensor heads. Accordingly, a specification of tilted sensor head with the tilt angle within ±8º (the gap between the upper and the lower sensor heads must be 23 mm or less) has been added to the standard lineup.

Digitized Frame Data (Compatibility with IoT and Improving Measurement Accuracy)

Monitoring circuits and operating circuits have been added on each device in the sensor heads and the frame control boards to digitize the data from each device and send them digitally. As a result, the amount of data handled remotely has increased more than 50-fold as compared with the previous models (Figure 5). Thus, information on the soundness of the frame can be checked in real time on the screens in the operator station without interrupting the operation. This makes it easier to identify the causes of troubles and reduces the downtime significantly. It also reduces the sensor tuning time during start-up and maintenance of the frame and improves accuracy.

The digitization improves noise immunity and reduces the impact of noise, which has been a problem in analog signal transmission.

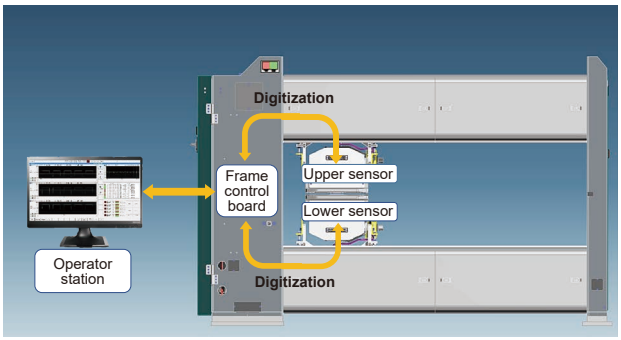

Figure 5 Outline drawing of communication within the F16 frame

FUTURE OUTLOOK

An increasingly wide variety of functional sheet products are expected to be developed and manufactured in the future using new materials and advanced materials, to satisfy environmental requirements and for miniaturization. To meet such market needs, Yokogawa must keep offering optimal solutions for each product category. In order to foresee failures, it is also necessary to identify the causes of troubles and predict product quality by integrating and analyzing all sensing data, to further improve customers' operations. The F16 frame is a platform developed to support digital operations meeting such requirements. Using the F16 frame, Yokogawa plans to develop new sensors and expand solutions to deepen cooperation with other applications. These will greatly help customers develop their DX.

CONCLUSION

Leveraging the F16 frame, Yokogawa will firmly establish its name in the global market of separator sheets for LiB, and expand its business into other film markets.

REFERENCES

(1) Takaaki Kishino, Yoshihiko Hagiwara, Takeo Haraguchi, "WEBFREX3ES Dedicated Coat Weight Measurement System for Battery Electrode Sheets," Yokogawa Technical Report, Vol. 62, No. 1, 2019, pp. 9-14