Wall thickness measurement for non-round ware

Heidi Olson describes an optical probe, designed by Precitec Optronik for the wall thickness measurement of non-round containers. Using a specialised optical design, the probe enables measurement at angles more than double that possible with other techniques. This is advantageous for both rotating measurement of non-rounds, as well wall thickness determination on highly decorated containers.

The chromatic confocal measuring technique uses a white light source. The white light is delivered from the control unit to the probe via an optical fibre. With no moving parts or electronics, the optical probe comprises a series of lenses that expand the chromatic variation of the light, causing each wavelength to be focused at a different distance. The focused light is then reflected back into the system and analysed on a spectrometer.

In the case of glass containers, a wavelength will be reflected at both the inner and outer surface, resulting in two peaks. The distance between these two peaks corresponds to the thickness of the container. This measuring range is used to name the optical probes. For example, the 12mm probe has a separation between the blue and red focus of 12mm in air, which corresponds to a maximum thickness measurement of approximately 18mm in glass.

Figure 1: 12mm and 15mm probe stacked for a measurement comparison on an oval bottle. See also table 1 for 12mm and 15mm data.

	12mm optical probe	15mm optical probe
Measurement range	12mm	15mm
Working distance	54mm	57mm
Resolution in z	360nm	450nm
Accuracy	3.6µm	
Spot diameter	30µm	20µm
Lateral resolution	15µm	10µm
Numerical aperture	0.27	0.46
Measurement angle to surface	+/- 15°	+/- 27°
Dimensions	Length: 61.1mm Diameter: 36mm	Length: 158.1mm Diameter: 84mm
Weight	281g	2000g

Table 1: Performance comparison for 12mm and 15mm optical probes for CHRocodile white light sensors.

Since the wall thickness measurement is light-based, the most critical aspects of the measurement tool are the delivery and analysis of that signal. The optical design determines the amount of light reaching the surface, as well as the acceptance angle for the return signal. Optics with a high numerical aperture and larger physical size will have the ability to measure at greater angles than normal. For example, the 15mm probe from Precitec has a numerical aperture of 0.46 and a diameter of 87mm, resulting in an acceptance angle of +/- 27°. This design also works well for the measurement of a broad spectrum of thicknesses. With this probe, it is possible to measure glass thickness from 300µm to more than 20mm.

In respect to the analysis of the return signal, Precitec has developed a high sensitivity control unit with enhanced dynamic range. This results in the accurate depiction of the wavelength peaks. The width of the peaks greatly affects the resolution with which a thickness measurement can be determined. High quality optics and a precisely configured sensor combine to achieve submicron resolution at high speeds.

LIGHT SOURCE OPTIONS

In the CHRocodile family of products, there are numerous control units and probes that can be configured for use on nearly all containers. Current light source options include halogen (CHRocodile E or M4), xenon (CHRocodile X) and LED (CHRocodile S or SE). The CHRocodile M4 is the most common sensor in the glass industry, using a single halogen bulb to drive up to four independent measurement channels at speeds of 4kHz each.

CHRocodile SE is an LED-based system, also with 4kHz scan rate, which performs well online for flint and amber. Additional sensors are available for the measurement of dark ware.

There are also probes designed for a full range of thicknesses, from less than 300µm to more than 30mm. Depending on the number of measurement locations required per bottle, a combination of varying probes can be used to achieve the most accurate results. The 8mm and 12mm probes are the most widely used for glass container measurements, specifically those performed inline. Their small size yet large measurement range combine to fit well inside the inspection machines for most standard bottles.

For most bottles, three of the latest 15mm probe may not fit but it can be combined with one or two 12mm probes to generate a measurement of the difficult portion of the body, as well as a measurement in the neck or shoulder region (see figure 1 and table 1).

Figure 2 shows the measurement data using both the 12mm and 15mm probes on an oval container. The larger coverage area achieved by the high numerical aperture 15mm probe results in thickness values on a larger

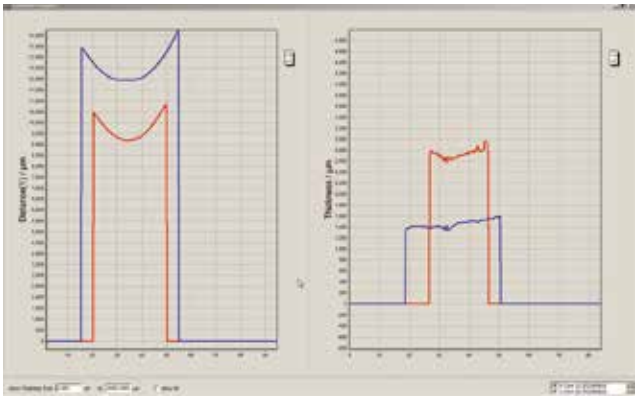

Figure 2: The blue (15mm probe) and red (12mm probe) represent the distance and thickness measured on the bottle shown in figure 1.

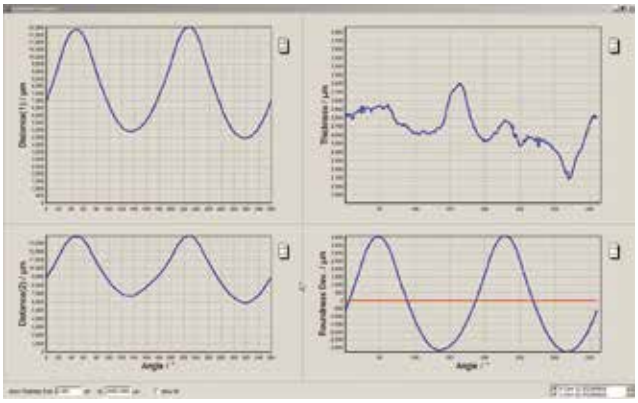

Figure 3: Measurement data for a full rotation of the oval-shaped bottle with the 15mm probe.

portion of the container and with proper positioning, the potential to measure the entire circumference.

Precitec has designed the probe with added features for both protection and integration. The front lens of the probe can be removed and replaced by the user if damaged, without affecting any of the intricate internal probe optics. The fibre output on the back of the probe was also modified for this probe, with a 90° angle, so that the fibre can be routed more easily inside of the machine. These features, as well as the overall optical design come together to offer a full thickness measurement on many non-round containers. Figure 3 illustrates this ability on the oval container shown in figure 1. The first and second distance values refer to the outside and inside surface of the bottle as it rotates. The thickness is measured for the entire 360° rotation, also enabling the ovality measurement shown in the bottom right portion of the figure.

The chromatic measurement of glass containers has opened up another realm of possibility for inspection. With the high measurement rate of the CHRocodile control units and increased measurement data from this probe, it is possible to measure non-round wall thickness inline, at speeds of up to 500 bottles/min. ■

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