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Testing of glass containers with the Bright Field Analyzer

By Peter T. Millunzi, Muncie (USA)

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The Bright Field Analyzer was developed to reject glass containers with bird cage defects but it can also be used to identify and reject blisters, stones (> 2,38 mm), bad parison or final mould joints and bad settle wave. The equipment comprises a television camera and suitable stroboscopic illumination and can function by direct trans-

mission or reflection. The container is neither stopped on the belt nor touched although it is rotated. Identification of bird cages or sticking relies on the lens-like action of the root of the thread. The lower limit of identification is a root thickness of 2,38 mm.

Contrôle de récipients en verre à l'aide du „Bright-Field-Analyzer“

Le „Bright-Field-Analyzer“ (BFA) sert essentiellement à l'élimination des récipients présentant des „balançoires“. Mais il permet également de détecter les bulles, les pierres (> 2,38 mm), les joints défectueux et les fortes coutures de fond ébaucheur, et même, par un réglage approprié, les marques Lynch et de rejeter les bouteilles correspondantes. La machine comporte une caméra de télévision, un

système d'éclairage stroboscopique, muni, selon le modèle, d'un passage direct de la lumière ou de miroirs. Le récipient qui se trouve sur la bande n'est ni arrêté, ni retourné, ni touché. Lors de la détection des balançoires et des joints défectueux, on se sert de l'effet de focalisation du pied de bord du fil. La limite de détection se situe à une épaisseur du fond de 2,38 mm.

Prüfung von Glasbehältern mit dem Bright-Field-Analyzer

Der Bright-Field-Analyzer (BFA) wurde vornehmlich zum Aussondern von Glasbehältern mit Affenschaukeln entwickelt. Man kann damit aber auch Blasen, Steine (> 2,38 mm), schlechte Vor- und Fertigformnähte und je nach Einstellung auch starke Speiserwellen entdecken und die entsprechenden Flaschen aussortieren. Das Gerät arbeitet mit einer Fernsehkamera, geeigneten Beleuchtungseinrichtungen in Wechsellichtschaltung (Stroboskop) und je nach Aus-

führung mit direktem Lichtdurchgang oder mit Spiegeln. Der Glasbehälter wird auf dem Band weder gestoppt noch gedreht und nicht berührt. Bei der Erkennung von Affenschaukeln (birdcages) und Klebstellen macht man sich die Linsenwirkung der Strangwurzel zunutze. Die untere Erkennungsgrenze liegt hier bei einer Wurzelstärke von 2,38 mm.

Stones and seeds have been a problem for glass makers since antiquity. Birdcages are a more recent problem as they became more prevalent with the introduction of automatic glass forming machines. With today's emphasis on recycling and therefore the use of a high percentage of cullet, stones and seeds have been on the increase. Past methods of eliminating this kind of ware was the use of human inspectors. Since it was necessary to look at each and every container, as line speeds went up more and more people had to be added to the inspection line in an attempt to insure 100 % inspection. The glass industries' experience, like that of other industries, was that 100 % human inspection did not assure 100 % rejection of faulty ware. The reality was that the level of rejection varied from 30 to 80 % of actual defective ware. The 80 % levels are achieved when a specific defect is being looked for, such as birdcages. This usually resulted in other defects being missed as the inspectors would be concentrating on the specific one brought to their attention.

1. Steps of development

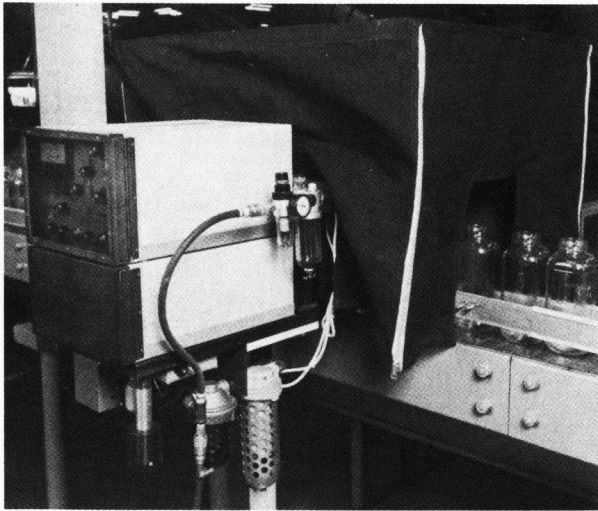
Early attempts to automate this process used machines that inspected for foreign material inside the bot-

tle in breweries. At least this machine would not get tired or distracted. These machines used photocells and had some success. These units, however, could not detect stones or seeds in the sidewalls and only gross birdcages.

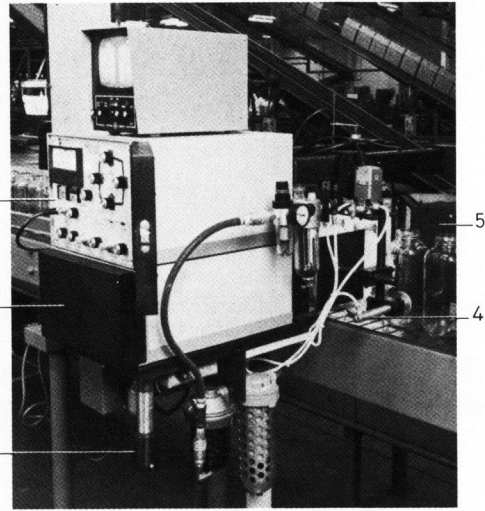
Beginning in the 1960's, Ball Corporation began a study of the problem using video as the sensing device. The first units appeared in the marketplace in 1971. These early models were an improvement over other methods but they suffered from the need to be frequently adjusted and the effects of the harsh environment. Work continued to upgrade the system. Lenses, lighting and optics generally were improved. As new advances were made in TV cameras, they were incorporated. Advances in electronics were also made and incorporated. Today a reliable, steady device the Ball Corp. has called the Bright Field Analyzer.

2. Description of the device

The Bright Field Analyzer (BFA) is an electronic device using a television camera, video processing and logic circuitry to detect birdswings (birdcages), stuck glass and other defects in flask and round ware. The Model 422 is for flasks, while the Model 450M is for



a)



b)

Figures 1 a and b. The 450 Bright Field Analyzer on a glass line; a) with the hood on top, b) with the hood removed (1: electronic chassis; 2: camera; 3: cooling system; 4: reject system; 5: strobe lights).

round ware. We will discuss the 450M. The 422 uses the same general configuration but because it is viewing a relatively thin container, it can look straight through it, while the 450M has to use mirrors and two strobe lights to look at round ware. Both the Model 422 and 450 use space quality components. The TV camera in the BFA is the same brand as that used by Ball Corporation Aerospace Group when they constructed the Viking I and II Mars Space Capsule TV Systems to send pictures back to earth. The electronic components were chosen to provide the same quality. This was done to insure consistent performance under the harsh environment of a glass plant.

Figure 1a is a 450 Bright Field Analyzer (BFA) on a glass line in the Ball Glass Plant in Asheville, North Carolina (U.S.A.). Figure 1a shows how it looks in normal operation with the hood on top. The hood is to keep out extraneous light. Figure 1b shows the same unit with the hood removed. The major parts are: 1: electronic chassis; 2: camera; 3: cooling system; 4: reject system; 5: strobe lights. Note that in this particular job we are inspecting a 2 l rectangular orange juice bottle. Since the BFA does not stop, rotate or handle the bottle in any way, the shape, within limits, does not affect its ability to inspect the bottle.

3. Theory of operation

The theory of operation for the BFA is as follows:

A birdcage will have a root where it attaches to the wall of the bottle. The root becomes a lens that concentrates light thus generating a dark spot on the face of the TV camera cathode ray tube. This dark spot is then detected as a rapid change in voltage level. To determine whether a dark spot is a defect, the BFA measures its width, height and intensity. The width (that is horizontal size) of the defect is measured by the number of scan lines

that the spot intersects. In normal commercial use of a TV camera the scan line goes horizontally from left to right from the top to the bottom of the vidicon tube when you view the scene from behind the camera. In the 450 application, the scan line goes vertically from top to bottom and from right to left. The electronics then counts the number of lines that the dark spot intersects. The BFA can detect down to a one line defect. To insure a high reliability, we specify that the BFA can inspect birdcages and dark spots down to 2,38 mm in diameter.

The height of the defect is measured by the length of time the scan line takes to pass through the spot. This is actually an electronic pulse generated by the intersection of the scan line with the spot and the logic measures the width of this pulse. The intensity of the spot is measured by the height of the pulse and is in reality a measurement of voltage.

The purpose of the strobe lights are two-fold. The first is to provide a high intensity light source and the second is to freeze the container motion. That is, they operate like a flash bulb for your still cameras. By using a high intensity light source we eliminate any ambient or random light affecting the ability of the TV camera to differentiate between the defect and the rest of the container. Because we wish to look at only one container at a time we require a minimum space between bottles equal to 12,7 mm.

The BFA mechanics permit it to be completely independent of the conveyor line as you can see from figure 1b, everything is supported by the BFA stand and frame. The unit can be adjusted in height to accommodate conveyor heights from 91,44 to 121,91 cm.

The TV camera has a Vortex Cooling System which uses compressed air (see figure 1b, item 3). In addition to providing cooling for the camera the air from the camera enclosure is exhausted into the electronics chas-

sis to provide moderate cooling. Although the electronic components are capable of operating at the elevated temperature, the extra cooling gives longer life. The camera requires cooling because of the vidicon tube's limitations.

4. Working area

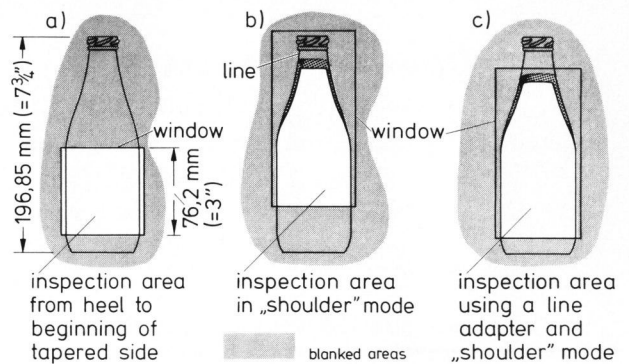
The BFA handles containers up to 114,3 mm in diameter and 304 mm high. The inspection area, or window as it is called, without shoulder operation, is 139 mm high by 101,6 mm wide anywhere on the container body. With shoulder operation the height is 152,4 mm down from the finish. For very tall bottles, such as wine bottles, we have developed an adapter to permit inspection of the shoulder and/or neck area.

Figures 2a to c show the different standard inspection areas. In figure 2a is to be seen the inspection area without the shoulder mode. Maximum window height is 139 mm and in this drawing it shows a window height of 76,2 mm. Figure 2b shows the inspection area in the shoulder mode. In this particular inspection, the top of the window must be above the finish of the bottle because the finish is what triggers the system. Figure 2c shows the inspection area using the adapter and the shoulder mode. Note that the window top is now below the finish, permitting increased inspection of the body.

The size of the viewing area is a compromise between maximum defect definition and maximum viewing area, both of which are dependent on the optics. Increasing the size of the viewing area decreased definition. Decreasing the size of the viewed area results in greater definition but the maximum ware size which can be inspected will be smaller. The size of the viewing area, therefore, becomes a compromise.

5. Conclusion

With the above operating information, it is summarized what the BFA can and cannot do.



Figures 2a to c. Different standard inspection areas; a) without the shoulder mode, b) in the shoulder mode, c) with the adapter and the shoulder mode.

- a) The main objective of the BFA was to reject birdcages. It is capable of rejecting with a 98 % reliability all birdcages with a root diameter of 2,38 mm or larger.
- b) It is capable of sorting out seeds, stones and similar defects with an 80 % reliability with a diameter of 2,38 mm or larger.
- c) It is capable of sorting out mismatched mold and blank seams.
- d) Feeder waves (settle waves) may and may not be sorted, depending on their optical characteristic. That is, if it causes a rapid change in light level. Turning down the control which controls the response to light levels will reduce rejection if feeder waves (settle waves) are considered acceptable but it will sacrifice the reliability to detect birdswings.
- e) The BFA will respond to decorations in varying degrees because of the optical effect as in settle waves.

The Bright Field Analyzer (BFA) is currently being used in glass plants in Europe and Japan, as well as the United States.

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