Graphene

The Beverage Electronic Inspection Company

Camera-based systems and slanted caps: when newer is not better

Slanted caps are today mainly detected by mean of CCD- or CMOS-camera equipped systems. Their reference point, the zero of all measured heights, is always the neck ring of the bottle, as visible in the image down. This technology, ideal to detect inclined or too-high caps over vertical bottles, fronts an intrinsic limit when trying to infer the inclination of caps lying over necks of bottles 'bent into tolerance'.

It can't reject slanted caps over the (frequently) inclined PET bottles, inclined because of irregularities of the bottle's base. Down an example: if the neck of the bottle is “bent into tolerance”, CCD-camera system shall consider it a correct bottle (false negative).

LASER inspection of Slanted caps

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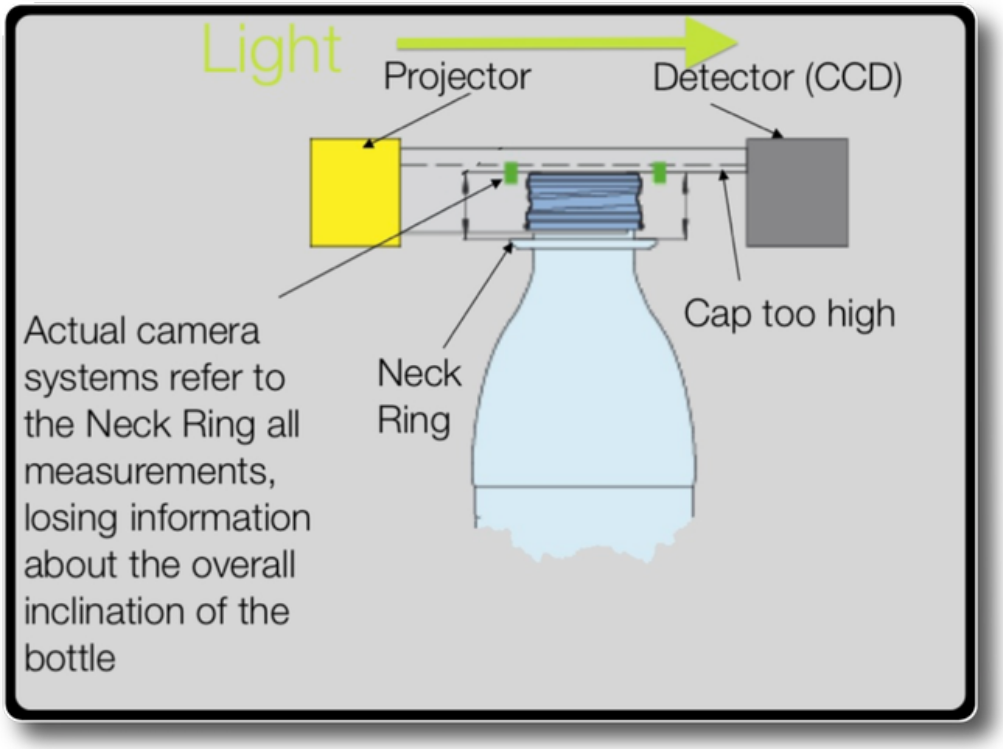
(inclined-cap-with-laser.pdf)



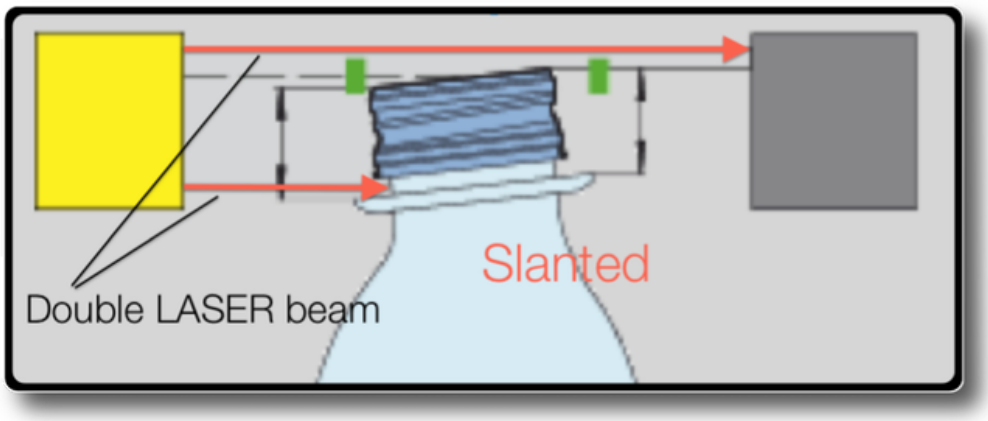
Slanted cap inspection performed the way today standard, by mean of a camera system, fronts an intrinsic limit when trying to infer the inclination of caps lying over necks of bottles 'bent into tolerance'. It can't reject slanted caps over the (frequent) inclined PET bottles, inclined because of irregularities of the bottle's base

(original image authored by Krones AG, www.krones.com)

The traditional LASER solution

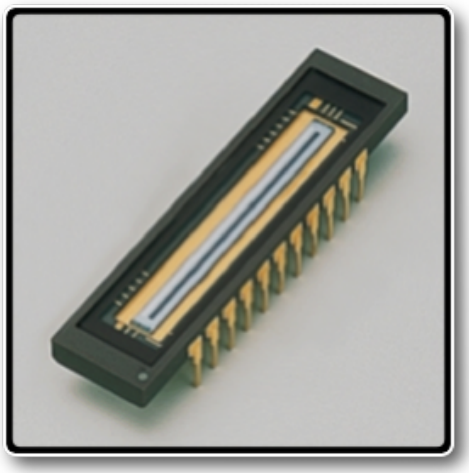
Until around ten years ago it was standard another approach to the same problem: light was collimated to ~ 2 mm, by mean of a small lens in the LASER fiber-optic Detector. Most important: the reference point was the conveyor holding bottles. Being referred to the conveyor, rather than to the neck ring, it was possible to detect also special defects otherwise, defects today unfortunately considered 'correctly closed bottles' by the CCD-camera systems costing twenty times more…

The same bottle, as seen by a Laser system based on the Conveyor, shall be correctly detected defective (true positive) and rejected. LASER beams' solution is today nearly unknown to Bottlers because Vendors invariably and actively propose the one (much more expensive) based on cameras. It is, however, a permanent option into Vendors brochures.



A cheap and simple to operate double barrier of LASER thin beams allows to detect and reject also slanted caps over bottles 'bent into tolerance' by random factors. PET bottles are particularly prone to this kind of events, due to their plastic nature (original image authored by Krones AG, www.krones.com)

What is obtained applying the LASER slanted cap inspection to an Inspector yet based on a cap check with camera system



Two different configurations exist for the LASER check of slanted caps:

- the traditional, adopting a single mono-channel LASER Detector;
- the modern, adopting a linear array of LASER detectors.

An example of the modern solution in the image on right side. This linear array model features 1024 pixels, 25 micrometer each. Its active area has a total lenght of 26.5 mm: enough to satisfy a wide range of Bottling Controls' necessities.

The traditional solution, definitely the cheapest, is obtained coupling a fiber photo sensor, with functions of Trigger, to a second and superimposed fiber optic photosensor, both in the barrier version with:

- Projector and Detector;
- thin beam (1.5 – 2.0) mm, originating by a LASER LED;

allows to check closures' excessive height.

In this application, the second and upper fiber optic photo sensor, has the possibility of continous adjustment along the vertical axis.

Defects' detection ratios are always, with extremely rare exceptions, associated to false rejects.

An example of those few cases when adding an inspection to a system, does not increase at all the total false rejects of the system, is the case of the inductive digital metal cap inspection checking for presence of capped glass bottles in the infeed of an Empty Bottle Inspector, as an EBI protection. The glass of the bottles is not a ferromagnetic material: it is really necessary to have metal arounf the inductive sensor to obtain its switching.

Then, is really nil the additional false reject expected adding this inspection to the EBI.

But, this is not the case of the LASER slanted cap inspection, one which can be influenced by e.g. the accumulation of dust over its lenses, emulating a non-existing too-high cap.

The intrinsic Quality of the ensemble:

- bottle;
- closure;

say, the fluctuations of the heights for each one member of their populations, strongly limit the minimum difference of height that it result really possible to detect. As an example, for medium-to-high Quality of glass bottles closed with metal closures, it is not possible to detect an excessive height:

$$< 1.0 \text{ mm}$$

And, when considering PET bottles closed by PET caps, these digits increase becoming:

$$> 2.0 \text{ mm}$$

These performances, associated to an additional false rejection, commonly:

$$< 0.01 \%$$

Caps 'bent into tolerance' are a porcentage of all of the caps out of tolerance, in the range:

$$(5 - 10) \%$$

We invite the reader to acquire with the due scientific skepticism the digits given him on Vendor's brochures, as 'Technical Guarantees' about Caps' rejects by mean of camera-equipped systems. They are too frequently based on unreal assumptions, different than the Operative Reality of the Bottling Line. More, they feature a systematic tendency to fill of:

$$99.999\ldots\ldots \%$$

what has to be expected. Keeping apart a row of Real Causes lowering those expectations, the Bottler shall later observe (associated to False Rejects ratios compliant with the Technical Guarantees), only:

$$(90 - 95) \%$$

of detection. To play the Food and Beverage Safety game the only thinkable way, the winning one, Bottlers have to consider all of the Scenarios. When desireful to reduce around ten times the occurrences of slanted caps (a synonimous of: 'not closed bottles') say:

$$(5 - 10)\% \quad => \quad (0.5 - 1)\%$$

should have to firmly request this cheap option to the Vendor, closing this way an otherwise unavoidable gap into their defences.

The modern approach to the solution of this problem, implying an array of extremely small LASER photodectors, is more expensive than the traditional one and, allows to reach the same performances shown above at the cost of an additional false reject ratio an order of magnitude smaller.

Alternatively, it is always possible to increase the sensibility, e.g.:

$$1.0 \text{ mm} \Rightarrow 0.2 \text{ mm}$$

keeping false rejects on the same value < 0.01 % shown above.

Intuitive Operation Advantage

Finally, one more "plus" of this option lies in the fact that its operation is extremely simple. So intuitive that whoever, whatever his technical skills, is capable to manage it. On the opposite, camera-based systems really require special trainings of the Line Maintenance Staff. There are plenty of situations when the camera system is, due to several possible reasons, generating pure false rejects.

In a modern high speed Bottling Line, a false reject :

$$> 2\ \%$$

when referred to a flow 50000 bph, means:

$$> 1000 \text{ bph}$$

"good bottles" rejected each one hour.

In these cases, the Bottler has difficulty to encounter all of those who are necessary to manually remove all these bottles by the reject accumulation Conveyor or Table, to prevent the entire Line stop.

To have an alternative cap check, nearly immune from false rejects like the LASER slanted cap inspection, reveal its full advantages in these cases. It results possible to Production Supervisor the simple temporary exclusion (until the next intervention of the Plant's Electronic Maintenance Staff) of the individual camera inspection creating false rejects stopping the entire Bottling Line, without to reduce really the Quality getting out to the Market. It means to have an emergency exit, a Production parachute.

In conclusion, we have an optional system existing in two variants, whose adoption is strongly suggested to Bottlers: the traditional particularly cheap and the modern more expensive.