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DECOSYSTEM - QVISION MULTICAP

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INTRODUCTION

MULTICAP is an Artificial Vision System for the inspection of aluminum and plastic closures to detect the typical defects of this kind of production. The complete configuration includes the use of 9 acquisition units: 1 for the inspection of the border, 1 for the inspection of the liner, 1 for the inspection of the top print and a special unit with 6 cameras for the inspection of the external sidewall (fig. 1).

However, the modularity of the system allows to install fewer modules, depending on the customer requirements.

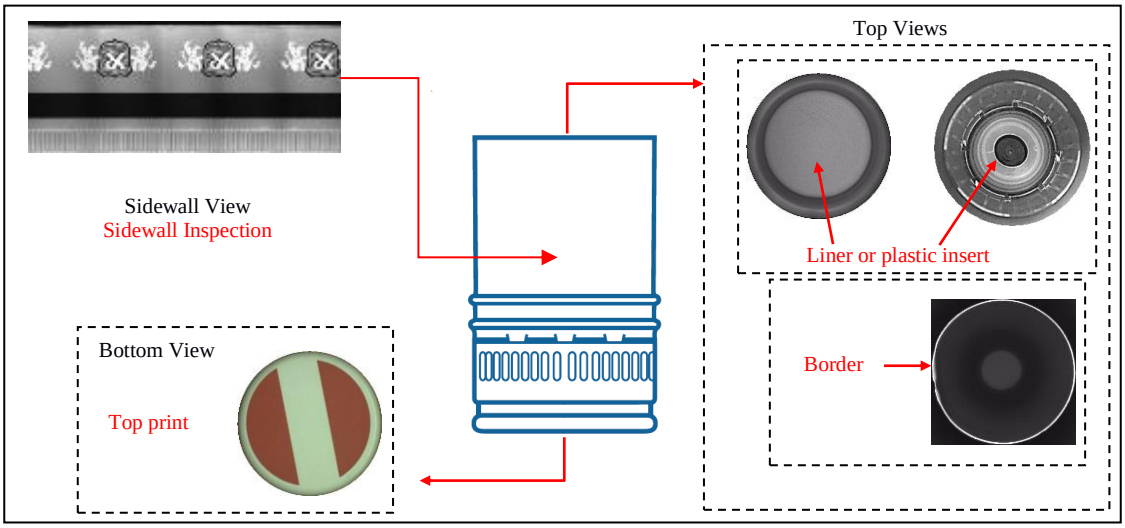

Fig. 1

The proposed solution requires the installation of the system on a mechanical device designed to properly transport the closures under the acquisition units. This device is placed at the end of the production line, before packing the caps. The inspection is performed while caps are properly conveyed on a star-wheel and/or a conveyor belt (lined and spaced).
The shell-border and the liner are inspected with top views: in this case the installation can be done either on a star-wheel or on a conveyor belt.
The top print is inspected with a bottom view and the observation usually takes place through a hole in the plate that supports the star-wheel, while the cap is kept in the star's pocket by a rubber belt or moves on a special glass, while the sidewall inspection requires a conveyor belt, where caps move properly lined and spaced.

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TECHNICAL DESCRIPTION

1 SCOPE OF SUPPLY

Defects detection in production process of aluminum and plastic caps duly transported and oriented by a dedicated mechanical device.

2 SPECIFICATIONS

Cap formats:	**30 x 44 / 30 x 60 / 31,5 x 60 / 36 x 52 mm (dedicated tooling required by size)**
Max production speed:	**30.000 to 36.000 pph**
Inspections:	**Shell-Border, Liner, Top Print and Sidewall**

3 NAME OF THE PROPOSED SYSTEM

MULTICAP FULL

4 INSPECTION OPERATED BY THE SYSTEM

4.1. Shell-Border Inspection

The acquisition unit for this inspection includes a high-speed area scan camera equipped with a very wide-angle lens, in order to enhance also small border cut-out. The lighting system is a high intensity led ring-light, designed for an optimal detection of the border edge.

With this camera, it is possible to detect defects as:

- Shell cut-out (lack of material),
- Ovality,
- Folded border,
- Corrugated cap (only large defects),
- Deformations.

NOTE: In case closures of different heights have to be inspected on the same machine, it is required to adjust the position of the border acquisition unit, in order to maintain the proper working distance from the border of the cap.

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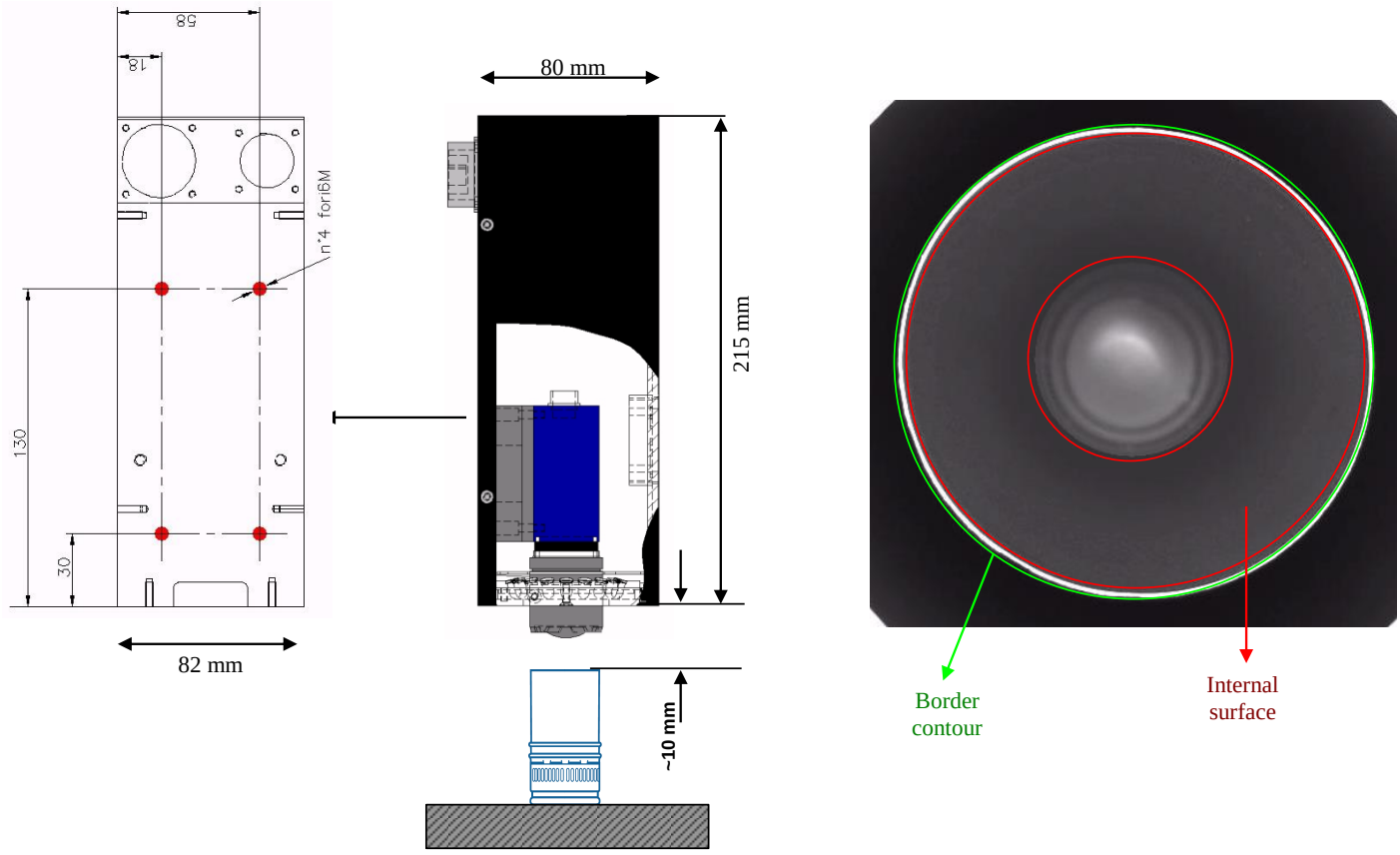
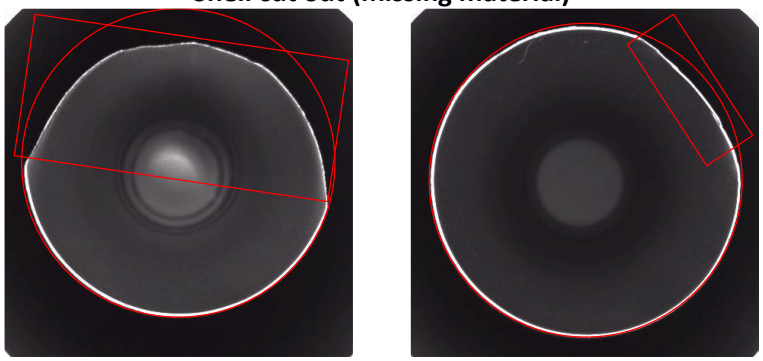


Border acquisition unit – layout.
(The above layout is indicative, both dimensions and working distance could change to improve the reliability of the vision system)

Good sample

Shell cut out (missing material)



Thanks to the special wide-angle lens, it is possible to enhance lack of material on the cap border: these are detected by analyzing and measuring the circular shape of the profile. With this configuration, it is possible to detect also very small defects.

Folded border

This defect has the same appearance of the previous one (missing material). Therefore, the same consideration can be made.

Ovality

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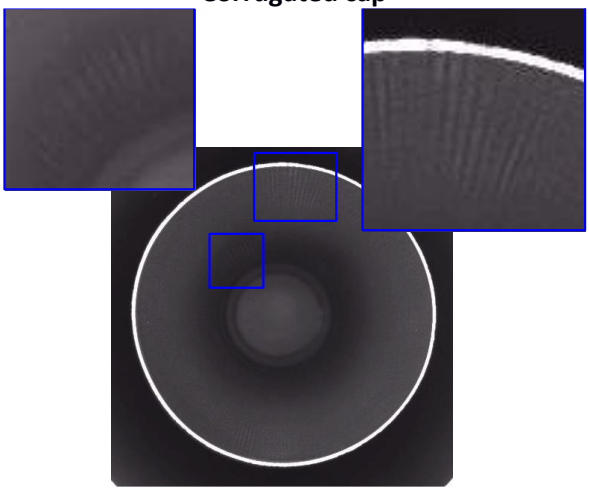
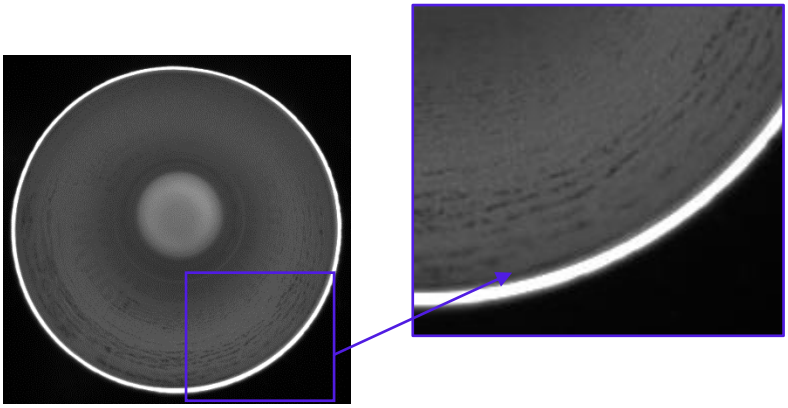
Corrugated cap



This defect is located on the inside surface of the cap. It can be observed also with the camera for border inspection, thanks to the special wide-angle lens, but the contrast is very low

Defect detection reliability is low as it depends on the length and on the depth of the traces of the defect

Paint marks



This defect is located on the internal side surface of the cap. It can be observed also with the camera for border inspection, thanks to the special wide-angle lens, but focusing decreases away from the border.

Defect detection reliability: depends on the level of contrast between the color of the paint and the color of the wall. It depends also on the quality of focus and the resolution (worst in the areas closest to the bottom, and so worst on long caps).

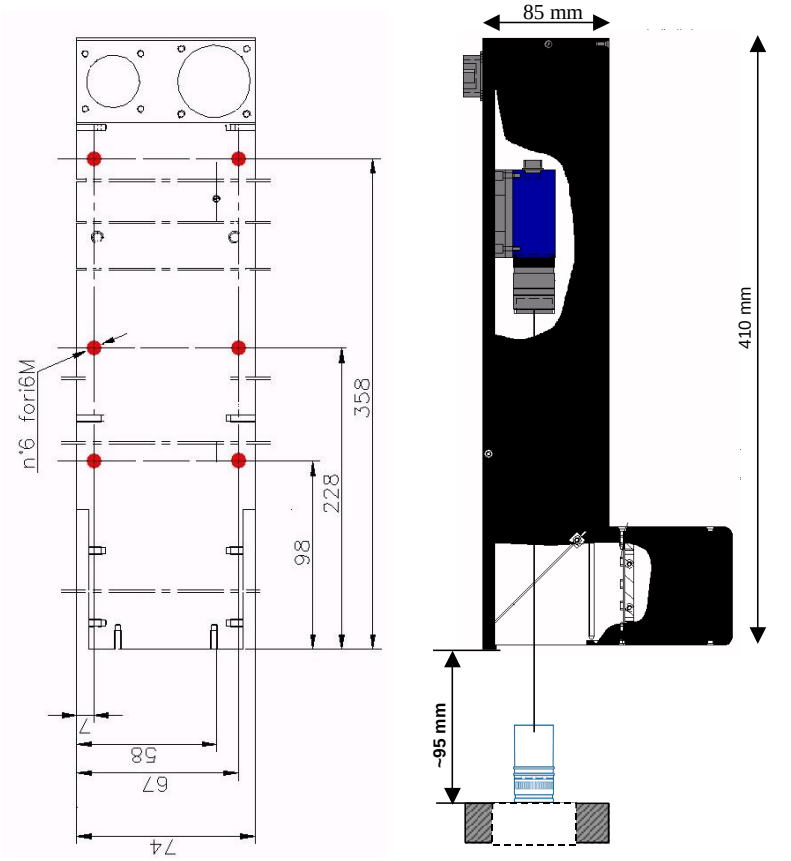
4.2. Liner Inspection

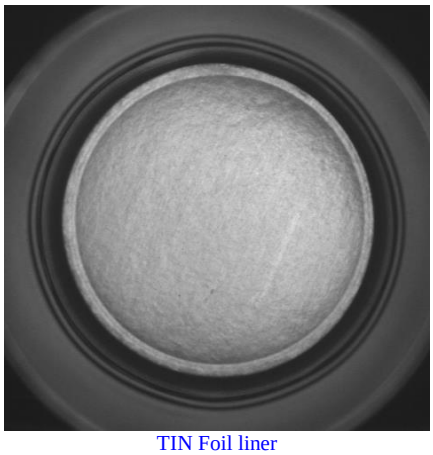
This unit is composed by a high-speed digital camera, equipped with a "medium-focal length", to obtain a good spatial resolution, in order to detect also defects with small dimension. The lighting system is diffused-coaxial, with high intensity white LEDs. The lighting system has been designed to enhance the typical defects on liners.

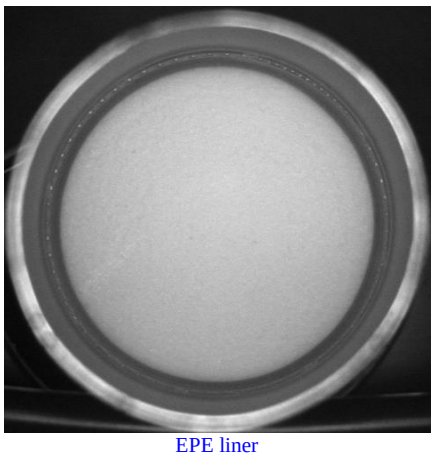
With this camera it's possible to detect defects as:

- Liner cutout (missing material),
- Dark spot,
- Wrinkled liner,
- Missing liner,
- Liner badly inserted,
- Upside down liner (only metal foil liner),
- Scratched liner (the possibility to detect this kind of defect is related to the depth of the scratch that, to be detected, must appear contrasted on the uniform surface of the liner);

Below a drawing showing dimension and working distance of the standard unit, with an example of images acquired with this optical geometry. This configuration allows to obtain a good uniformity, also on difficult material, as the tin-foil liners which are very reflective.



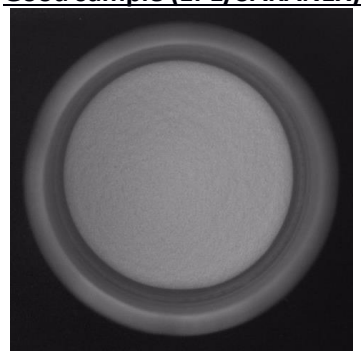

TIN Foil liner


EPE liner

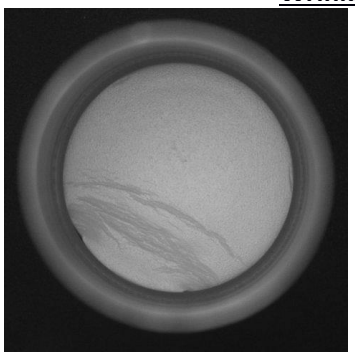
Liner acquisition unit – layout

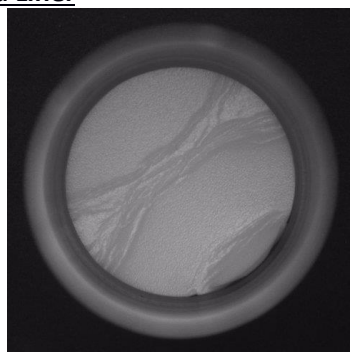
(The above layout is indicative, both dimensions and working distance could change to improve the reliability of the vision system)

Good sample (EPE/SARANEX)



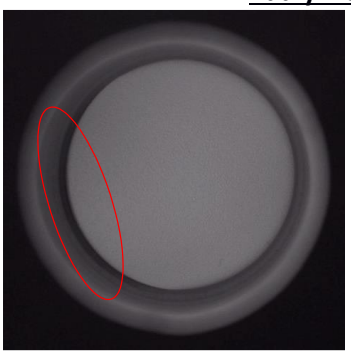
Wrinkled Liner

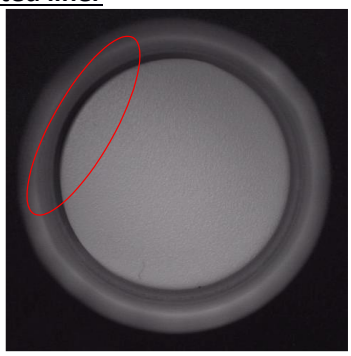




This defect affects the uniformity of the good liner, with the presence of shadows caused by the wrinkles.

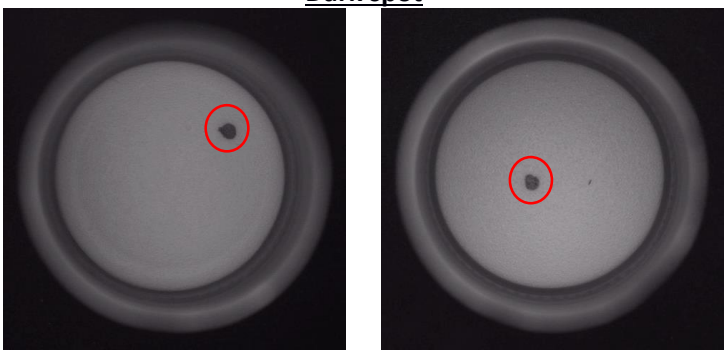
Badly inserted liner





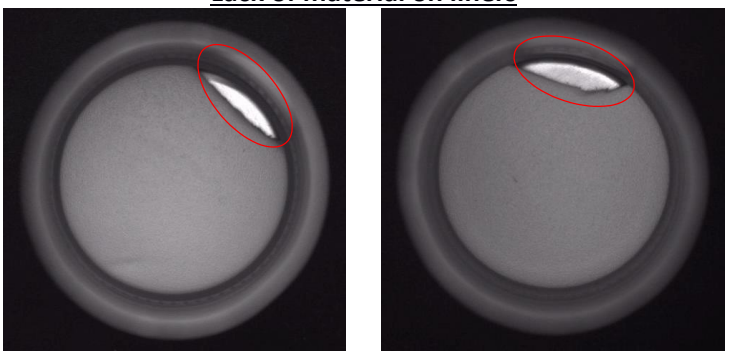
It is possible to detect this defect by analyzing the circular shape of the liner: when it isn't inserted a shape error or ovality error occurs.

Dark spot



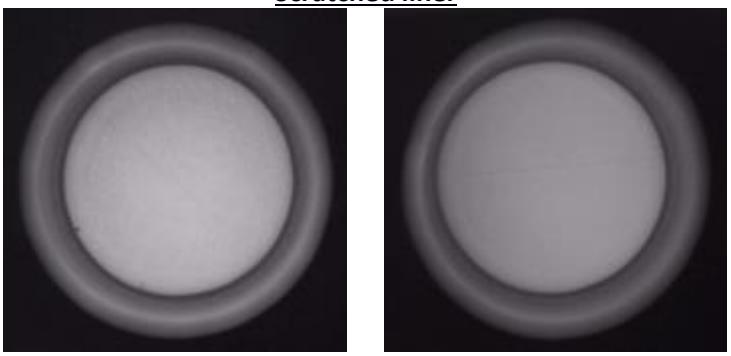
This is a typical high contrast defect; it is detected by analyzing the surface of the liner, looking for dark color spots.

Lack of material on liners



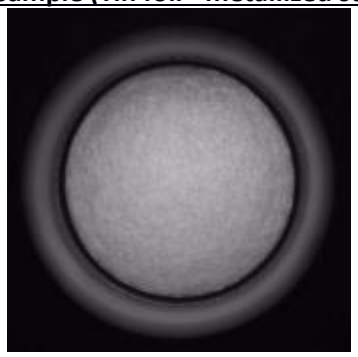
It is possible to detect this defect by analyzing the circular shape of the liner: if a cut-out is present, a shape error or ovality error occurs.

Scratched liner

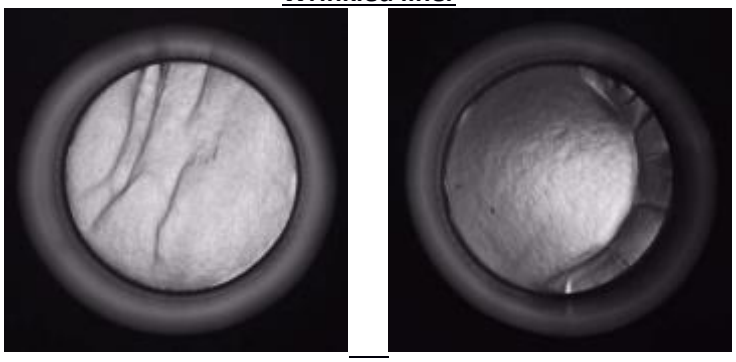


On this kind of liner (EPE) the defects on the samples are almost invisible. Defect detection reliability is weak.

Good sample (Tin foil - metallized surface)

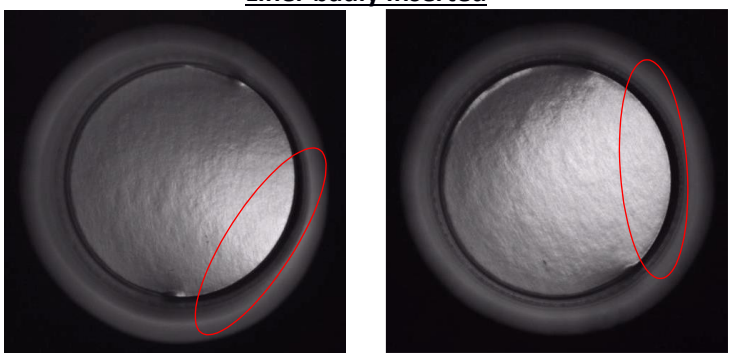


Wrinkled liner



This defect affects the uniformity of the "good" liner, with the presence of shadows caused by the wrinkles.

Liner badly inserted



It is possible to detect this defect by analyzing the circular shape of the liner: when it isn't inserted a shape error or ovality error occurs.

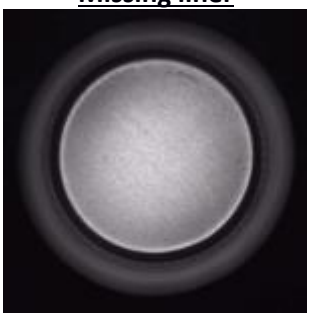
Dark spot

This is a typical high contrast defect; it is detected by analyzing the surface of the liner, looking for dark color spots.

Lack of material on liner

It is possible to detect this defect by analyzing the circular shape of the liner: in case of missing material a shape error or ovality error occurs.

Missing liner



It is possible to detect this defect by comparing the measurement of the diameter of a reference good liner with that of the circular shape of the bottom of the cap that will have a lower value.

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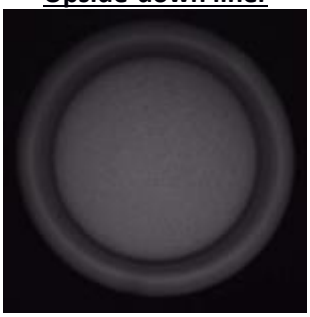
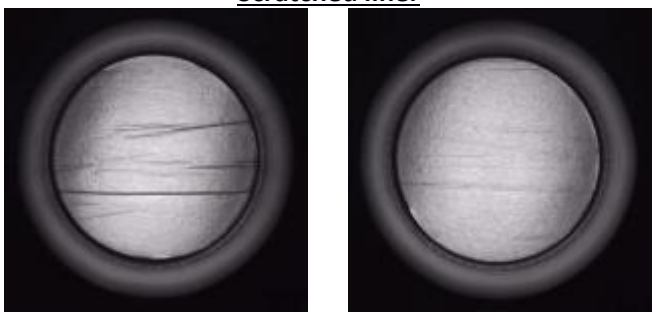
Upside-down liner



If a tin foil liner is inserted upside-down, its color appears darker than the metalized side.

Scratched liner



The reliability of the system in detecting this kind of defect depends on the “depth” of the scratches. It is possible to detect only coarse scratches; otherwise, the contrast is too much low.

Defect detection reliability is low as it depends on the length and on the depth of the scratches.

4.2.a Plastic insert Inspection

Closures can be produced with plastic inserts assembled inside (dispenser, valve ...), instead of liner.
The application program is able, as an alternative to the standard liner inspection (see previous § 4.2), to inspect also caps with the internal inserts thanks to a specially designed software module, detecting the typical defects of this kind of production.
Because of the huge variety of dispenser types, it is important to have samples to define the proper system configuration. Depending on the model, it is in fact possible that a different type of acquisition unit is required.
In case on the same line both caps with liner and with dispenser are produced, there are some different possibilities, depending on the model of dispenser:

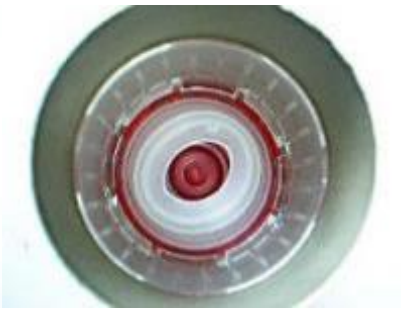
- If the dispenser can be inspected with the same lighting system used for the liner, only the acquisition unit described at the previous paragraph is required,
- As an alternative, if the border camera allows a proper view of the dispenser, it is possible to use a special function present on the software, that adds a dedicated control of the pourer,
- Finally, in case the dispenser requires a dedicated lighting system and/or a different optical geometry, an additional acquisition unit (or an additional module) is required (to be quoted separately), to replace the standard one when the production changes from caps with liner to caps with dispenser.

Below we refer to a typical model of dispenser, with internal sphere:

The detectable defects on the internal plastic inserts are

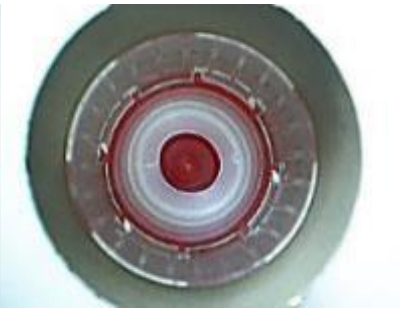
- Incorrectly inserted insert;
- Crumpled insert;
- Damaged (cut-out) insert;
- Missing insert and/or sphere;
- Dark spot on the white insert;

Badly-inserted insert



Crumpled insert

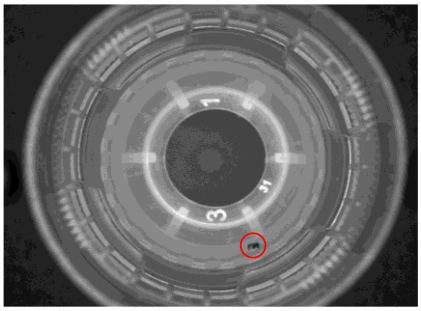
Insert with cutout



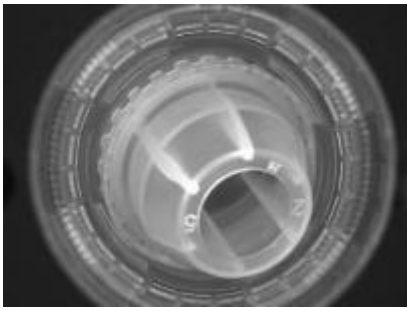
Missing sphere

Missing insert

The two pictures below show example of defect detection:



Dirt



Bad assembly

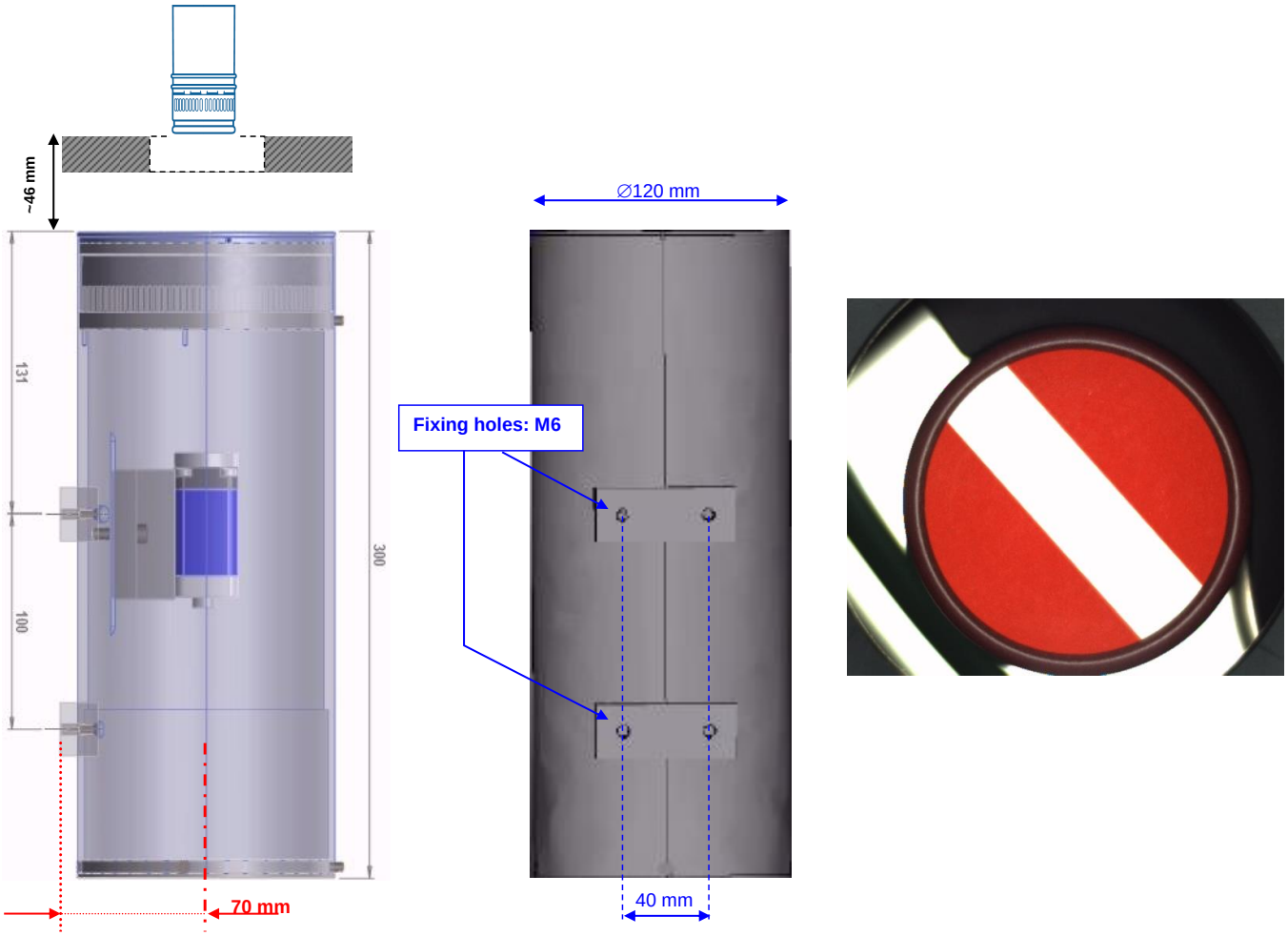
4.3. Top Print Inspection

The system uses a high-speed area scan color camera in order to check, in addition to logo centering, also macro defects on printing and coarse color errors. The lighting system uses high intensity white LEDs.

With this camera it's possible to detect defects as:

- Color variations,
- Logo centering,
- Dirt,
- Scratches,
- Macro defects on print logo,
- Mixed deco.

The following picture shows the principle:



Logo acquisition unit - layout
(The above layout is indicative, both dimensions and working distance could change to improve the reliability of the vision system)

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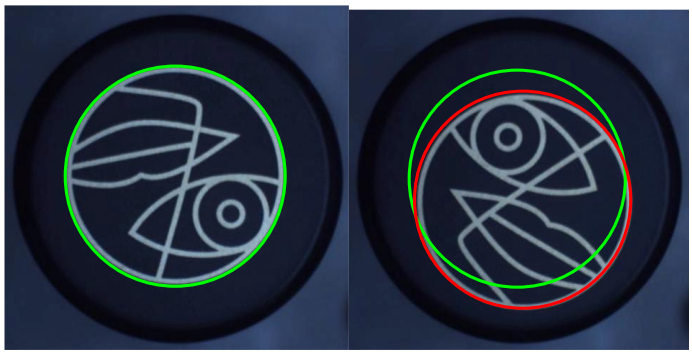
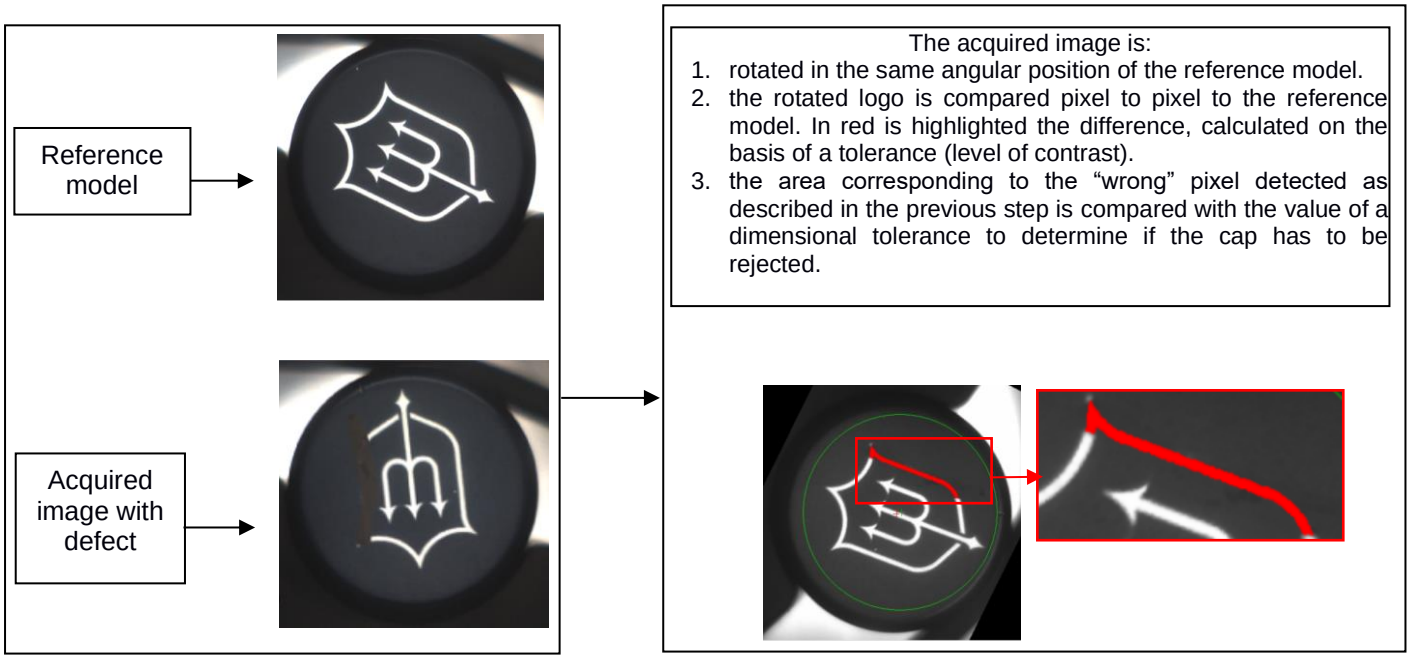
Logo centering inspection



Good sample Logo off center

Logo defects inspection



Logo color inspection

Color variation

The system verifies the color shift of the logo comparing it to the master sample. It is useful for macro-variation.

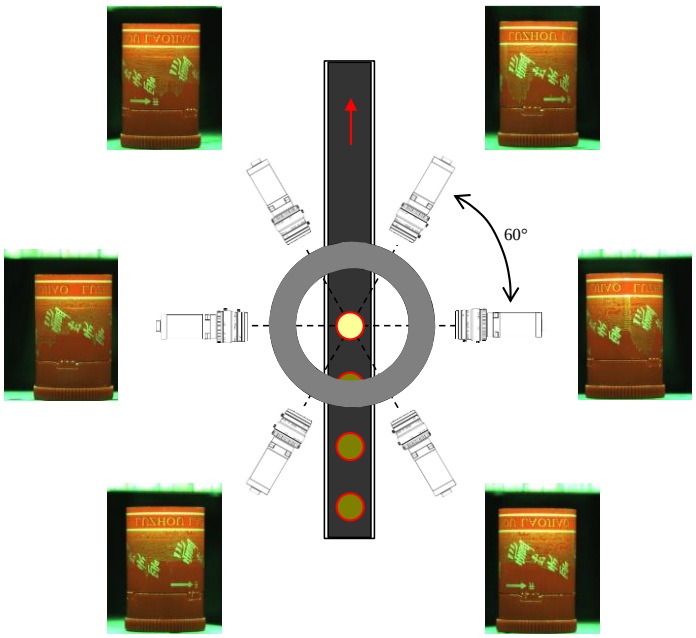
4.4. Sidewall Inspection

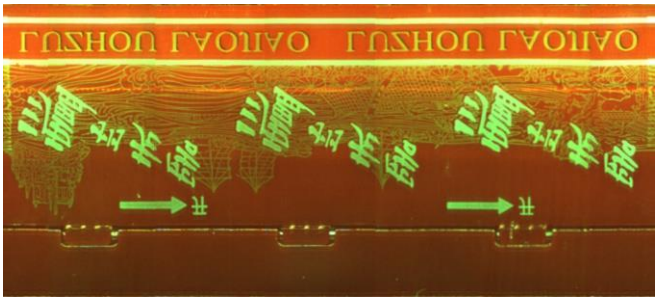
The inspection of the sidewall is performed with a six color cameras unit. The cameras, placed a 60° from each other, scan all the lateral surface of the cap. The lighting system is a high intensity LEDs ring-light, designed to illuminate with high uniformity the external lateral surface of the closures. An additional light beam in the inside allows inspecting proper making of the closure, as for example the cutting.

After the acquisition of the images through the six views, the software reconstructs the complete horizontal development of the external lateral surface of the cap, aligning the edges of the six acquired images.

For the mosaic only the central part of each 60° image is used, in order to limit the reduction of information in the part of images more distant from the optical axis. In any case, before joining and aligning the six images, a geometrical calibration is applied to each image to correct the optical distortion.

Below the geometry of the sidewall standard unit, together with the six acquired images and the one resulting from the merging.





Resulting mosaic of the six 60° images, after geometric correction

With this dedicated unit, it is possible to detect defects as:

- Rough color variations,
- Logo centering,
- Dirt,
- Scratches,
- Incomplete decoration,
- Missing print,
- Non registered colors.

4.4.1. Sidewall Side Technical explanation

After the acquisition of the images through the 6 views, the software reconstructs the complete horizontal development of the cap, aligning the edges of the 6 images.

To avoid the problem of image distortion, the system includes a reference target (fig. 2) which consists of a cap covered with a pattern (fig.1) of a grid with equidistant circles (wrapping), the coordinates of dots are used during the calibration to remove the distortion of the grid.

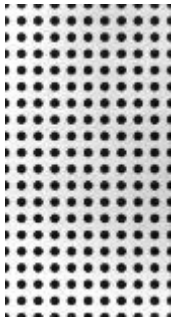


fig. 1

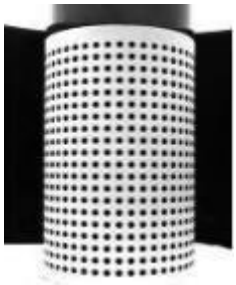


fig. 2

The parts of the image used to make the reconstruction are the central parts of the images, in order to eliminate possible distortions caused by the perspective.

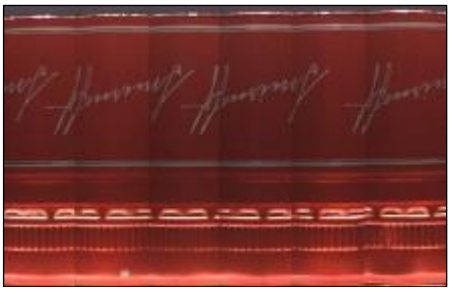
In the following pictures, you can see the difference between a scanned image without geometric processing (fig. 3) and an image developed by our software with geometric correction (fig. 4).

fig. 3
Reconstruction without correction

fig. 4
Image with wrapping calibration

The following image shows an example of reconstruction of a closure made without mapping calibration (fig. 1) and an example of reconstruction performed with a different closure made with mapping calibration (fig. 2).

In the second example, the reconstruction is very accurate and the closure is not deformed in the areas of overlap. The reconstruction is better also thanks to the fact that the images are shaded with a "fade" effect in the points of overlap (cross-fade).



ex. 1
Reconstruction made without wrapping

ex. 2
Reconstruction with wrapping calibration

4.4.2. Side Wall Inspection Defect Examples

Dirt on the surface

Mark on the surface

Color Variation

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Lack of material

Broken bridge

Registration

Scratches on the surface

Mark on the surface

4.4.3. SPECTRO INSPECTION SOFTWARE

For the Sidewall Inspection, DeCoSystem inspection software (Spectro) is used. It has a very intuitive operator interface with a fast setup and an amazing defect detection management packaging.
Standard features are:

- All operations can be carried out using the touch screen
- Easy to learn and easy to use GUI interface
- Fast and automatic set up (new job can be started in a minute)
- Easily define different areas of job with different tolerance levels
- Great reliability in the detection of defects produced during the offset process
- Full report and automatic storing of all production process data
- Different levels of login
- Remaster feature of a single portion of the image
- Toggle visualization of defects
- Fast review of the last 10 defects
- Quick zoom function
- Sensitivity adjustment during running
- Dedicated algorithm for the management of the overlapped areas between cameras

Tolerances

Defects can be divided into user-defined classes and tolerance set-up can be class-specific. The surface can be divided into more than one area, each one with its own specific set of tolerances.
The set-up of new models and of the associated tolerances will become normal routine among the operators or among the supervisors which might be dedicated to this task.
Password-protected menus allow selective access to the system and tolerance set-up can be restricted to appointed personnel. The standard operator can only use a simplified tolerances set: LOW, MEDIUM-LOW, MEDIUM, MEDIUM-HIGH, HIGH.

Set Up

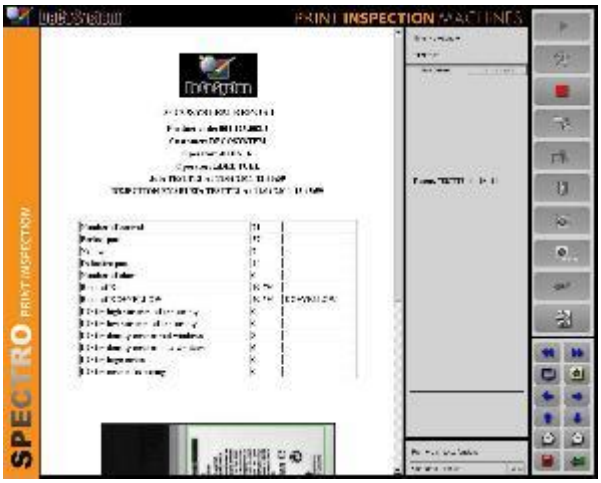
The software is easy and user-friendly and it doesn't require any experience in the use of PC. Set-up operation for the product's change is automatic: the operator has nothing more to do except inputting or recalling the client - and/or product-code; a supervisor is only necessary in case of tolerances variation (these menus need a password).

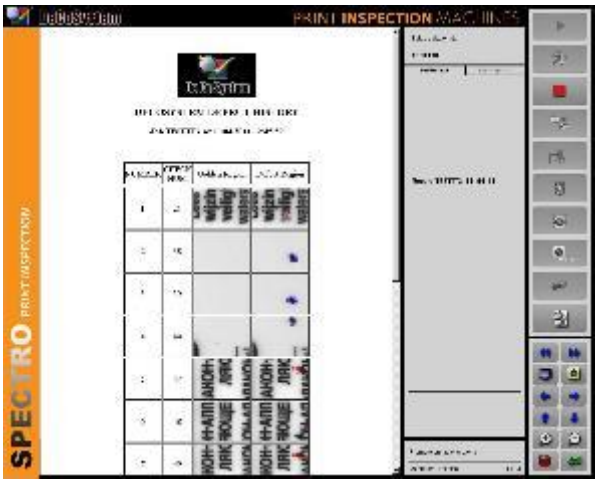
Report

On the display monitor, four main windows are shown:

- Overview windows, showing the complete image and the checks status.
- Zoom Area, showing the magnified window pointed in the Overview Window
- Semaphore window indicating the overall status of the control (OK, WARNING, ALARM)
- Data windows: giving the detailed report of defect counts and statistics.

Data about the controls, defects and any other and real time information on the ongoing production can be made available in form of reports or data file. The reports with the analysis of the detected errors can be graphically or digitally printed, they can be filed and transferred to a network computer.





Defects

SPECTRO vision systems are able to carry out a 100% analysis of the typical defects produced by the printing process. In particular, it is possible to point out and to classify the dimension of the main printing defects: color mis-registration, lack or excess of color, black spots, dirt, color variations, scratches, position of the print. The dimension of the different defect-classes can be selected by the operator using an access password.

5 CLOSURES TRANSPORTATION UNIT

Depending on the inspection, we have different requirements from the point of view of the mechanical transportation system. In any case, we consider the most common case, with capsules oriented with the open side up.

Border and liner inspection, which requires top views of the closure, can be performed either on a conveyor belt (with caps moving properly lined and spaced) or on a star-wheel. The star-wheel solution is preferred, because of the better accuracy and stability in caps holding, required especially for the inspection of the border using a wide-angle lens.

The Top Print inspection requires a star-wheel transportation, where a bottom view is possible through a hole in the main plate while the cap is held in the star-wheel pocket by a rubber belt or slips on a special glass. This inspection cannot be performed on a belt because in this case the Top-Printing surface is not visible, being hidden by the belt.

The Sidewall inspection requires the caps are firmly transported well-spaced and aligned on a conveyor belt.

Below the main construction requirements for the different transportation systems:

- Star-wheel requirements:
  - The color of the star-wheel and of the other mechanical parts (holding edges…) in the inspection area must be **opaque black**, to avoid light reflections that can affect the quality of the images. This is mainly required for the border inspection where a dark background, which maximizes the contrast with the border contour, is required. For this reason, the main plate has to be opaque-black or, in alternative, we suggest to install an insert (black) on the plate, in the border inspection area.
  - For the Border inspection, the border must protrude some mm (min. 5 mm) from the top surface of the star-wheel and of the holding edges.
  - For all the inspections, the cap must be held steadily in the pockets during the movement, avoiding oscillations.
  - It is possible to reject the defective closures in two different modes:
    - after a configurable number of steps starting from the inspection position. In this case it is required that the reject command can be synchronized with the step-signal, the same signal used to synchronize the images acquisition when the cap is in the center of the field of view. This mode is not suggested with production speed over 15.000 pph.
    - the ejection is managed by a supervision unit (PLC), using an encoder installed on the star-wheel axis. In this case, it is possible to reject the defective closures anywhere, setting the proper number of encoder pulses respect to the synchronized signal (step signal of the star-wheel).

    In both cases (especially for the first one) the mechanical position of the ejection must be designed to allow a proper ejection with the possibility of a fine adjustment.

- Conveyor belt:
  - Caps must move aligned and spaced (the minimum distance depends on the cap diameter: for a 30mm diameter capsule we require a space between two consecutive caps around 70-80 mm. The required alignment must better than +/- 0.5 mm.
  - A stable movement, without oscillations, is required. This is particularly important when the cap height is significantly higher than the diameter (for example 30 x 60 mm). For this reason, the conveyor belt is equipped with a vacuum system with a pump that aspires through holes on the belt, to increase the stability of the closures during the movement. The suction will be stopped immediately after the acquisition area, to not hinder the ejection of the defective cap.
  - The color of the belt and of the other mechanical parts in the inspection area is opaque black, to avoid light reflections that can affect the quality of the images.
  - The holding edges will be interrupted in the inspection area, both to avoid undesired effects on the images and to allow the ejection of the defective caps.
  - The ejection can be performed immediately after the elaboration, or in a position after the acquisition area, using a supervision unit and an incremental encoder installed on a roll of the belt: in this case the defective piece can be rejected anywhere after the last inspection, setting an offset with a proper value of encoder pulses.