



*Connecting People, Science and Regulation*

# NEW TECHNIQUE FOR THE INSPECTION OF AMPOULES TIPS IN PRESENCE OF LIQUID DROPS

## A CASE STUDY

**Gaetano Baccinelli,**  
Sales Manager - OPTREL





# Inspection Machines

## — High speed solution

*Continuous motion  
(up to 400 pcs/min)*



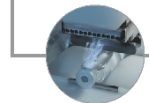
*Exacta Plus*

*Tracking cameras for high accuracy in detection*



*Exacta Easy*

*Fixed cameras for high productivity and low maintenance*

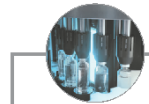


*LKD*

*Leak test machine*

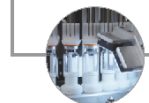
## — Medium speed solution

*Intermittent motion  
(up to 200 pcs/min)*



*MCA*

*Very flexible machines for inspection of a wide range of products*

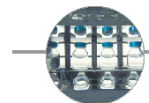


*FD*

*Dedicated machine for Freeze-Dried products*

## — Semi-automatic solution

*(up to 100 pcs/min)*

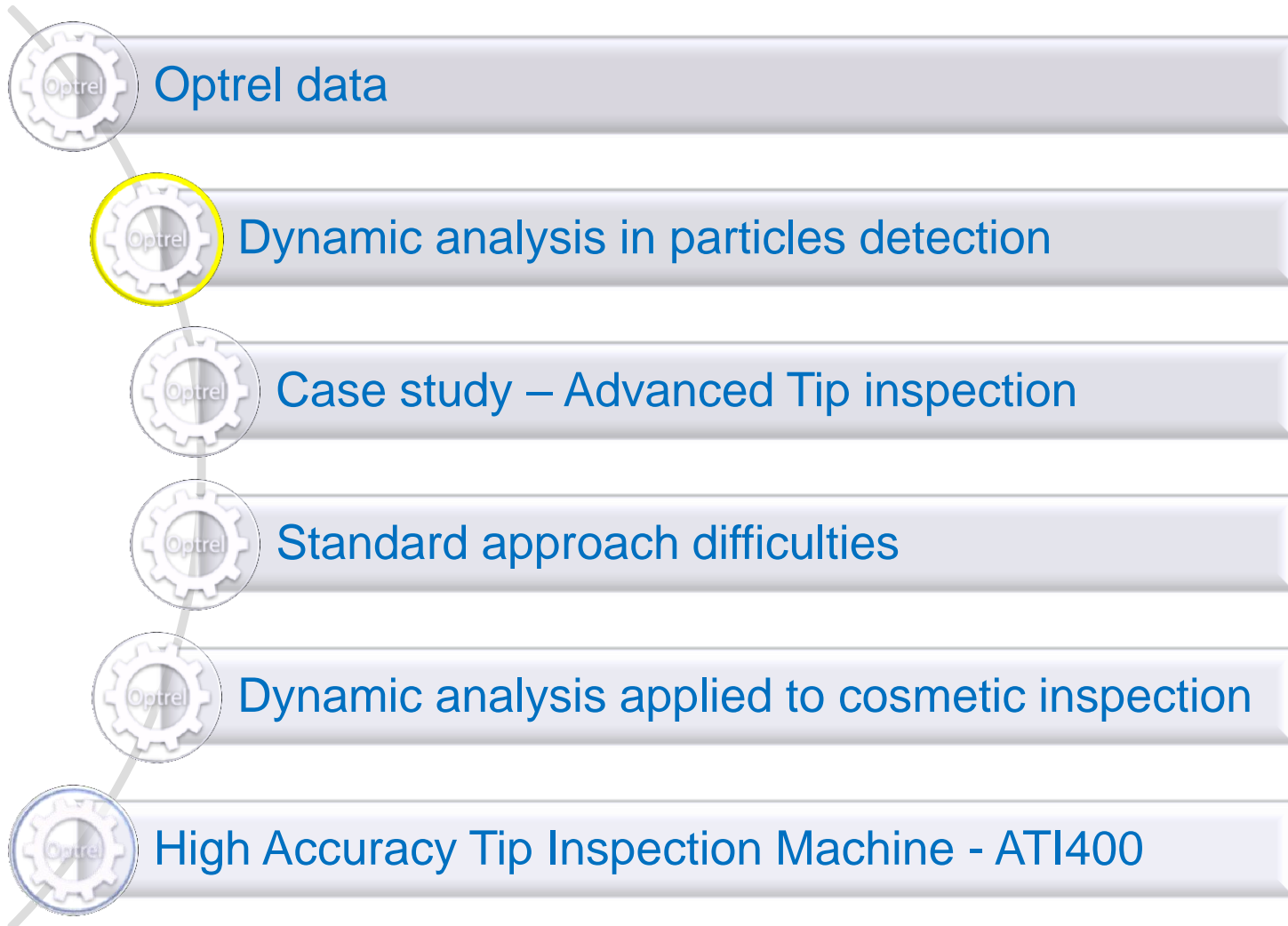


*PWL*

*Ideal for small volume inspection or critical products*



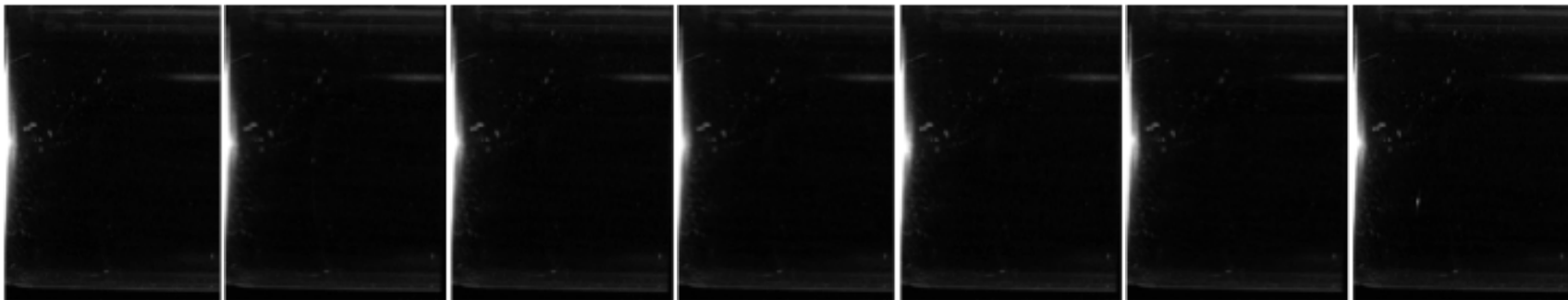
# Summary



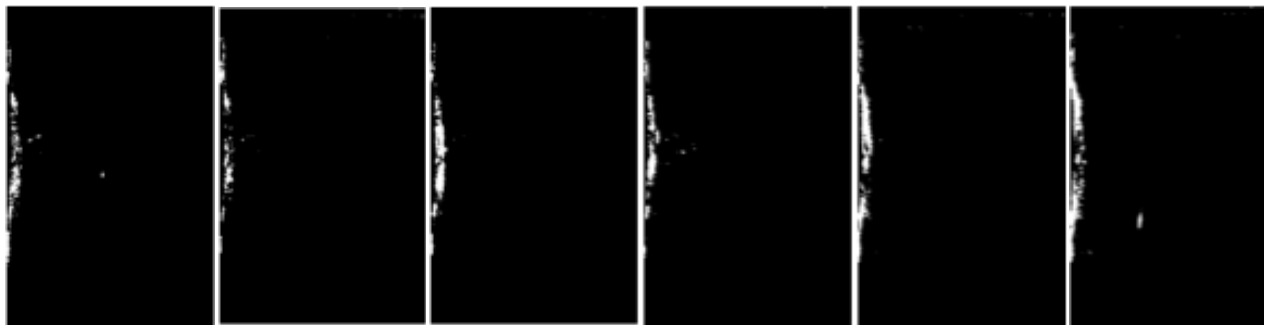


# Standard Inter-frame Analysis for Particle Inspection

Acquisition of a sequence of 12 up to 60 images from the container under inspection

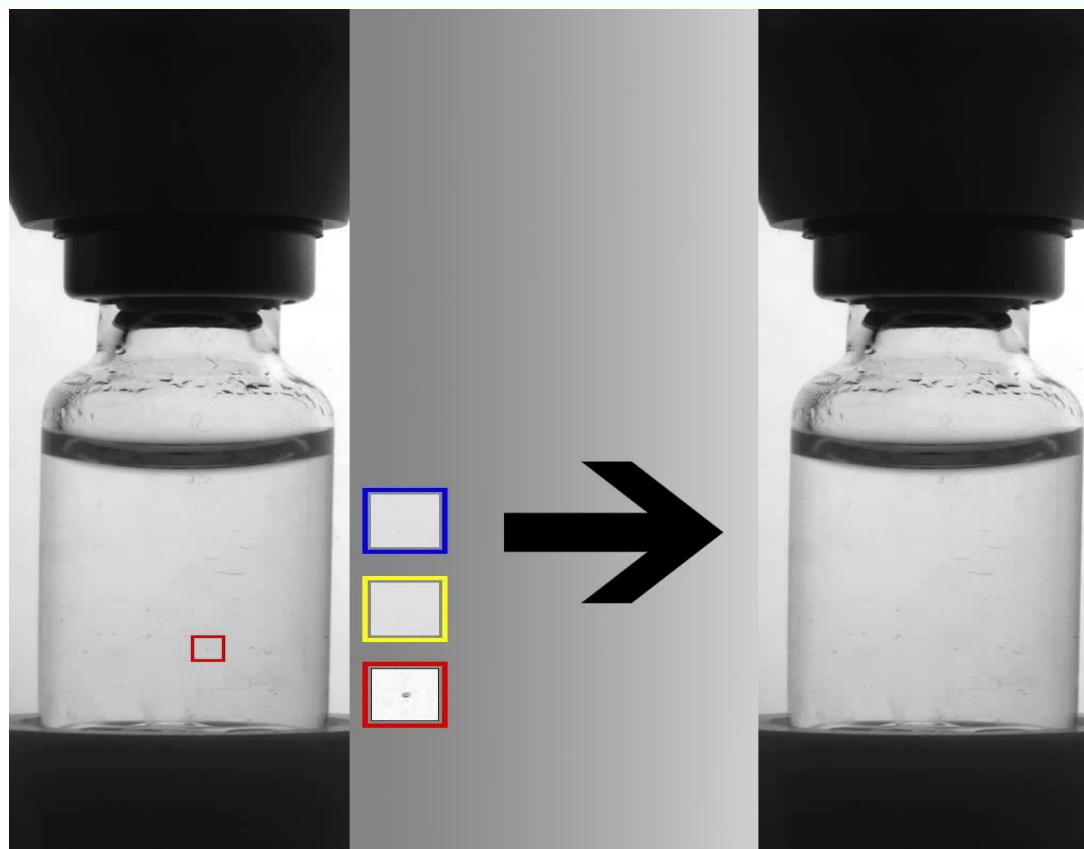


Compute the sequence of differential images one by one





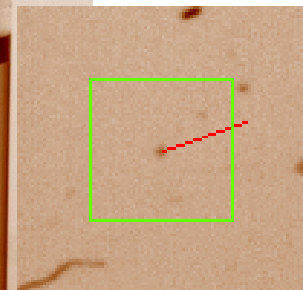
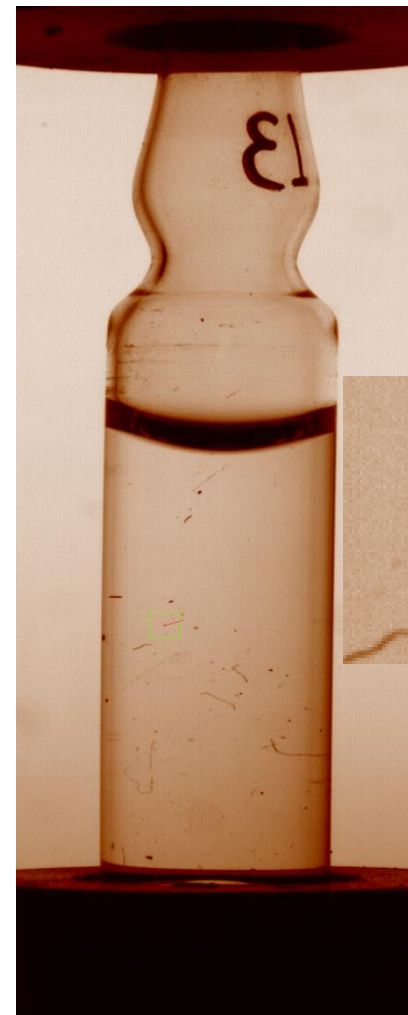
# Dynamic Analysis For Particle Inspection



- Particle trajectory reconstruction using the Kalman filter
- Trajectory post analysis filtering – lower false reject
- Analysis of the meniscus – floating particle inspection
- Analysis of the container bottom – heavy particle inspection



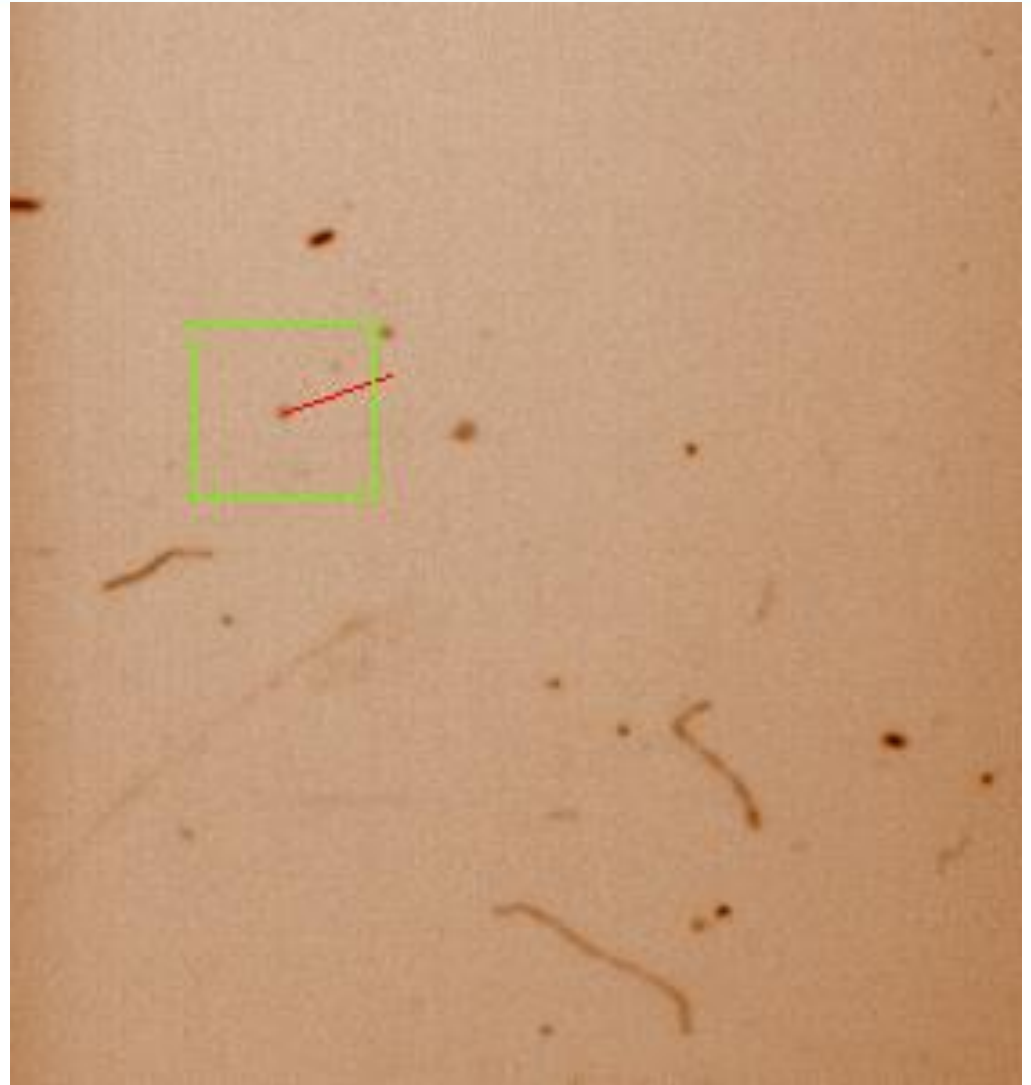
# Particle Inspection: Dynamic vs Interframe Analysis





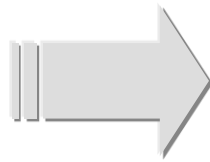
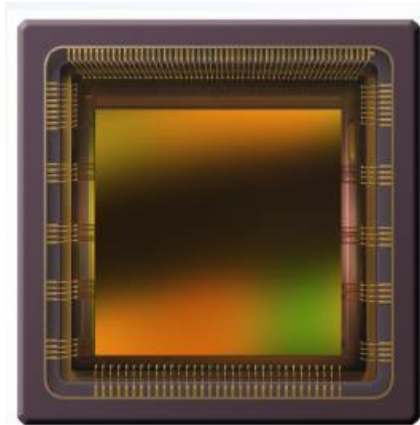
# Particle Inspection: Trajectory details

Diff Threshold = 12  
Area Threshold = 5  
Particle size < 50 $\mu$ m  
Trajectory life = 16 frames  
Field of View = 10 ml





# High speed, high resolution cameras with on-board processing



## The new camera numbers:

- 2048x2048 pixels sensor
- 359 frames per second
- 1.2 GHz Dual Core RISC processor
- 90 KLE FPGA
- 4 GByte onboard data storage
- Gigabit Ethernet Interface





# EXACTA MODELS



## Easy

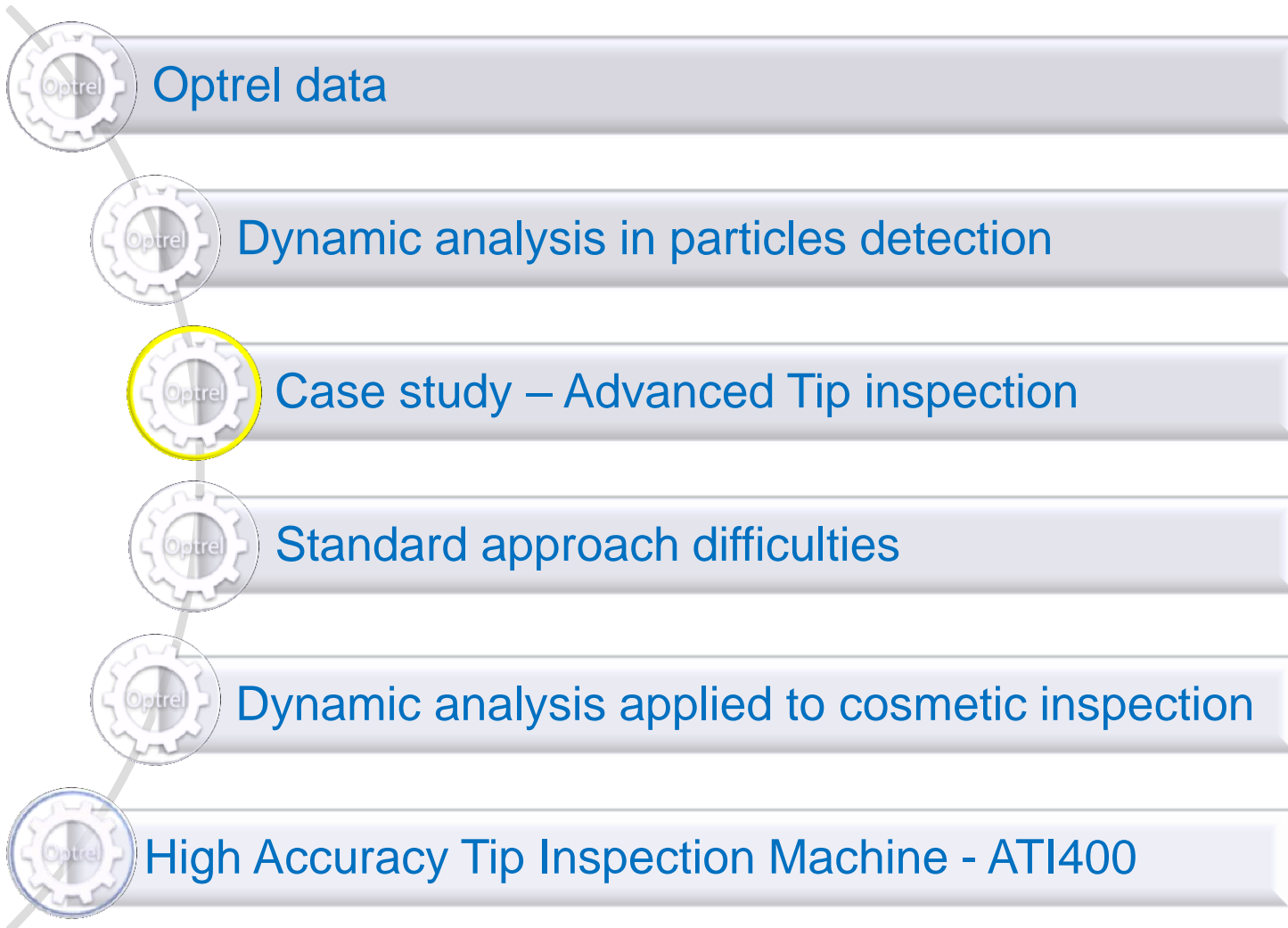
- Still cameras and illuminators
- Electronic tracking system
- 40  $\mu\text{m}$  resolution
- Ampoules up to 20ml with one camera
- Vials up to 20ml
- Cartridges

## Plus

- Camera tracking system
- 25  $\mu\text{m}$  resolution
- High speed 300 fps
- Cosmetic controls
- Freeze dried inspection
- Hybrid version for solid/liquid



# Summary





## Customer requests

- Important multinational customer asked us to develop a machine for inspecting ampoules' tip for **small black spot** (<50 $\mu$ m) and **tip shape deviations**
- The product, being an ethanol-based solution, has a relevant disposition to produce **drops of liquid** difficult to remove
- The product is **light dark** so even a proper illumination is not enough for reducing the impact of liquids drop on the control



# Summary



Optrel data



Dynamic analysis in particles detection



Case study – Advanced Tip inspection



Standard approach difficulties

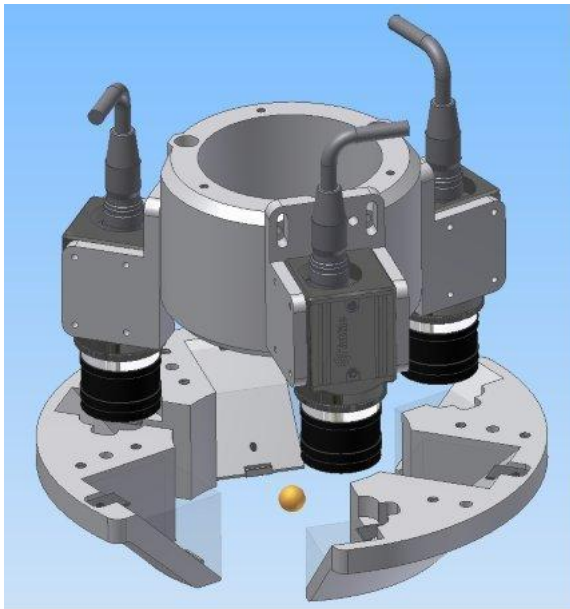


Dynamic analysis applied to cosmetic inspection



High Accuracy Tip Inspection Machine - ATI400

# Standard Tip Shape inspection



## Parametric definition of the tip shape model

PSI Rev. 6.3.0

Mode Maintenance User Optrel Format 10 ml Recipe 10ml Amber Batch

Edit programs and settings

ST1E - ST1 ST2E - ShapeR2 ST2O - ShapeR2 ST3O - ST3

Auth/Approval  
Mah  
Mathonge  
Maxim  
Logic

Function

Parameters

Name	Value	Def.	Min	Max
#00	EDGE SUM THRESHOLD	4	0	1000
#01		0	0	255
#02		0	0	100
#03		0	0	100
#04		0	0	100
#05	LUT LOW VALUE	102	0	255
#06	LUT HIGH VALUE	140	0	255
#07		0	0	255
#08		0	0	255
#09		0	0	255
#10	RING ROI TOP	228	0	1000
#11	RING ROI BOTTOM	324	0	1000
#12	RING ROI RIGHT	420	0	1000
#13	RING ROI LEFT	300	0	1000
#14		0	0	100
#15		0	0	100
#16		0	0	100
#17		0	0	100
#18		0	0	100
#19		0	0	100

Results

Name	Value	Conv.	Min	Max	Display
200	LIGHT	121	1	50	255 OFF
201	HEIGHT	454	1	400	455 ON
202	ANGLE DEVIATION	0	1	0	18 ON
203	SHAPE TOLERANCE	2	1	0	10 ON
204	RING THICKNESS	75	1	10	40 ON
205	EDGE SUM TOLERANCE	0	1	0	270 ON
206		0	1	0	100 OFF
207		0	1	0	100 OFF
208		0	1	0	100 OFF
209		0	1	0	100 OFF
210		0	1	0	100 OFF
211		0	1	0	100 OFF
212		0	1	0	100 OFF
213		0	1	0	100 OFF
214		0	1	0	100 OFF
215		0	1	0	100 OFF

Parameters

Image F0

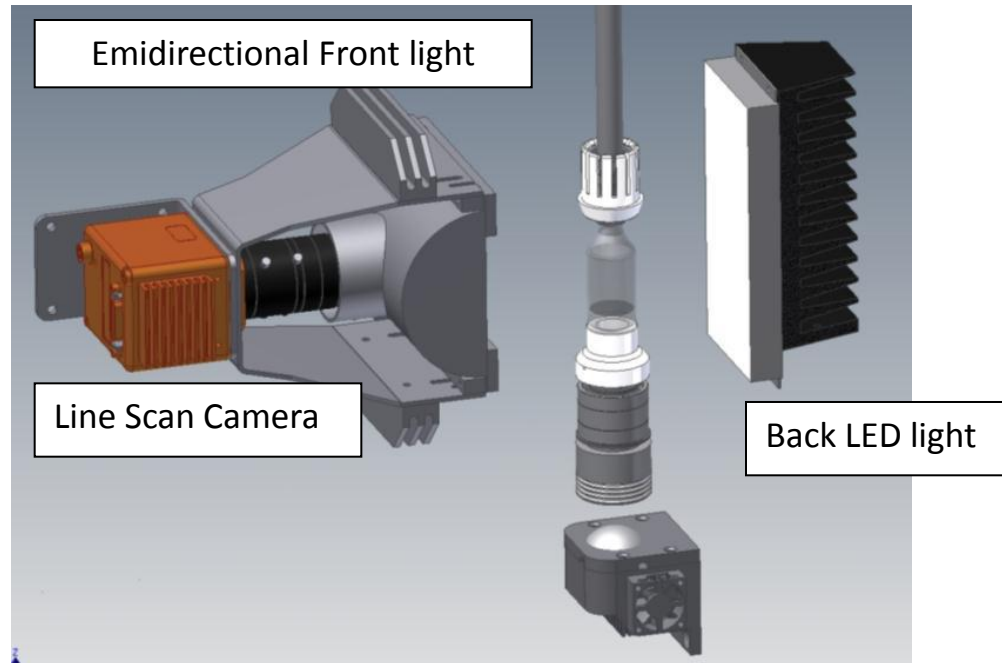
Image F0

Grab before run

Tool F0T0



# Linear Scan Camera for Standard Tip Inspection

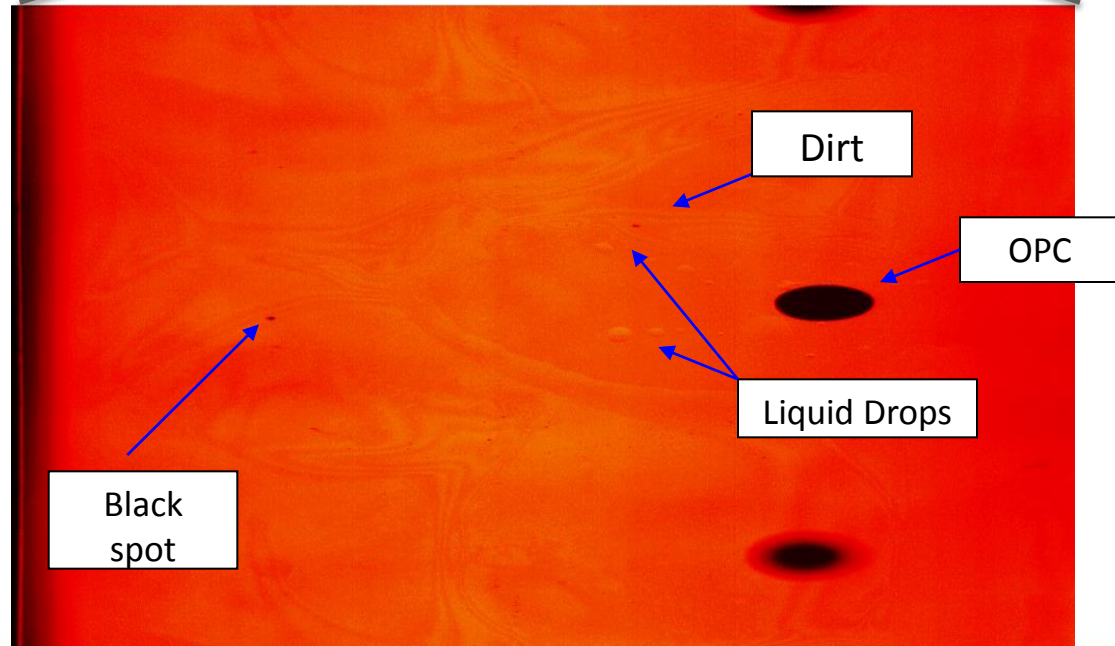
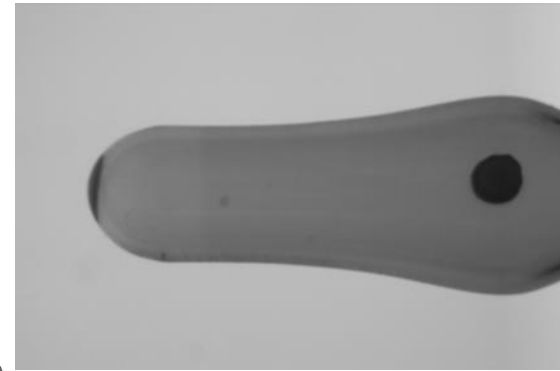
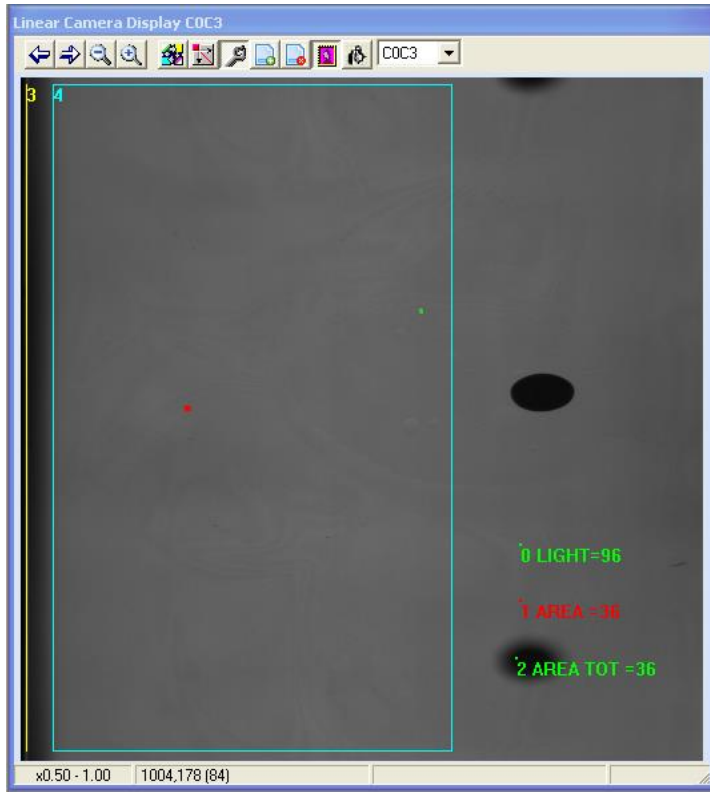


- Special linear scan camera ranging from 512 pixel up to 2048 pixel that guarantee high inspection resolution.
- Special emidirectional light sources developed by Stevanato Engineering.
- The container is rotated in front of the camera in order to scan the whole surface of the vial.



# Standard product carbonization on ampoules tip

Using linear cameras the drops of liquid don't cause any false reject in **normal conditions**





# Customer's Product Difficulties with Standard Inspection

Black spot

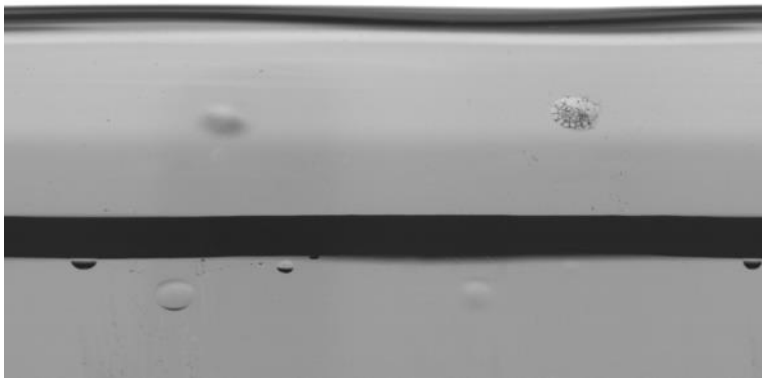


Ideal situation

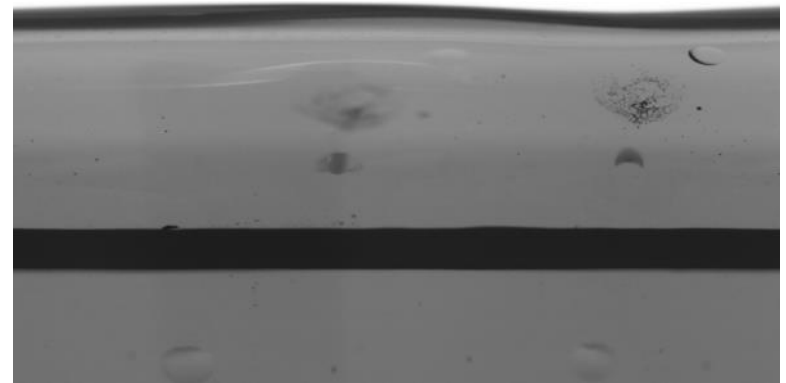
Black spot



Drops below color ring



Drops below color ring



Drops below tip



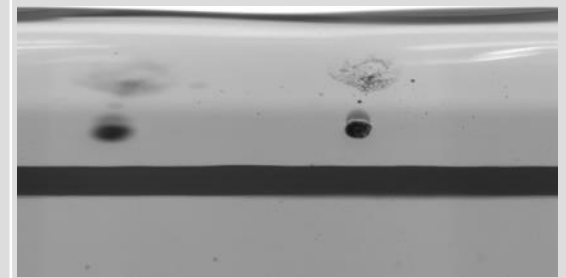


# No Effective Strategy for Keeping Empty Tip

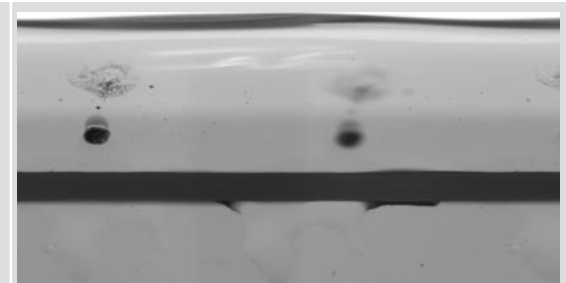
We tried also to investigate any possible method for emptying the ampoules' tip just before inspection but **drops grow very fast** again.

The effect is a consequence of the fact that the volatile part present in the product has a lower surface tension than the water part. If, for example, alcohol is mixed with water, a region with a lower concentration of alcohol will pull on the surrounding fluid more strongly than a region with a higher alcohol concentration. The concentration difference is probably due to the fact that both alcohol and water evaporate from the film present on the tip after emptying, but the alcohol evaporates faster, due to its higher vapor pressure. The resulting decrease in the concentration of alcohol causes the surface tension of the liquid to increase, and this causes more liquid to be drawn up from the film to form the large drops.

After emptying



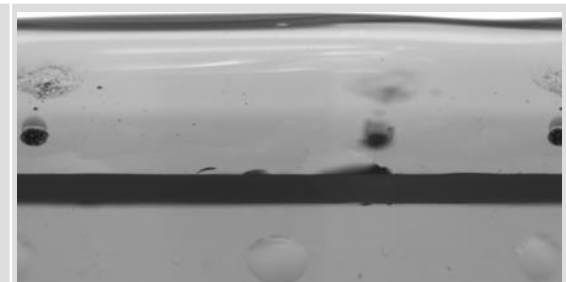
After 10 seconds



After 20 seconds

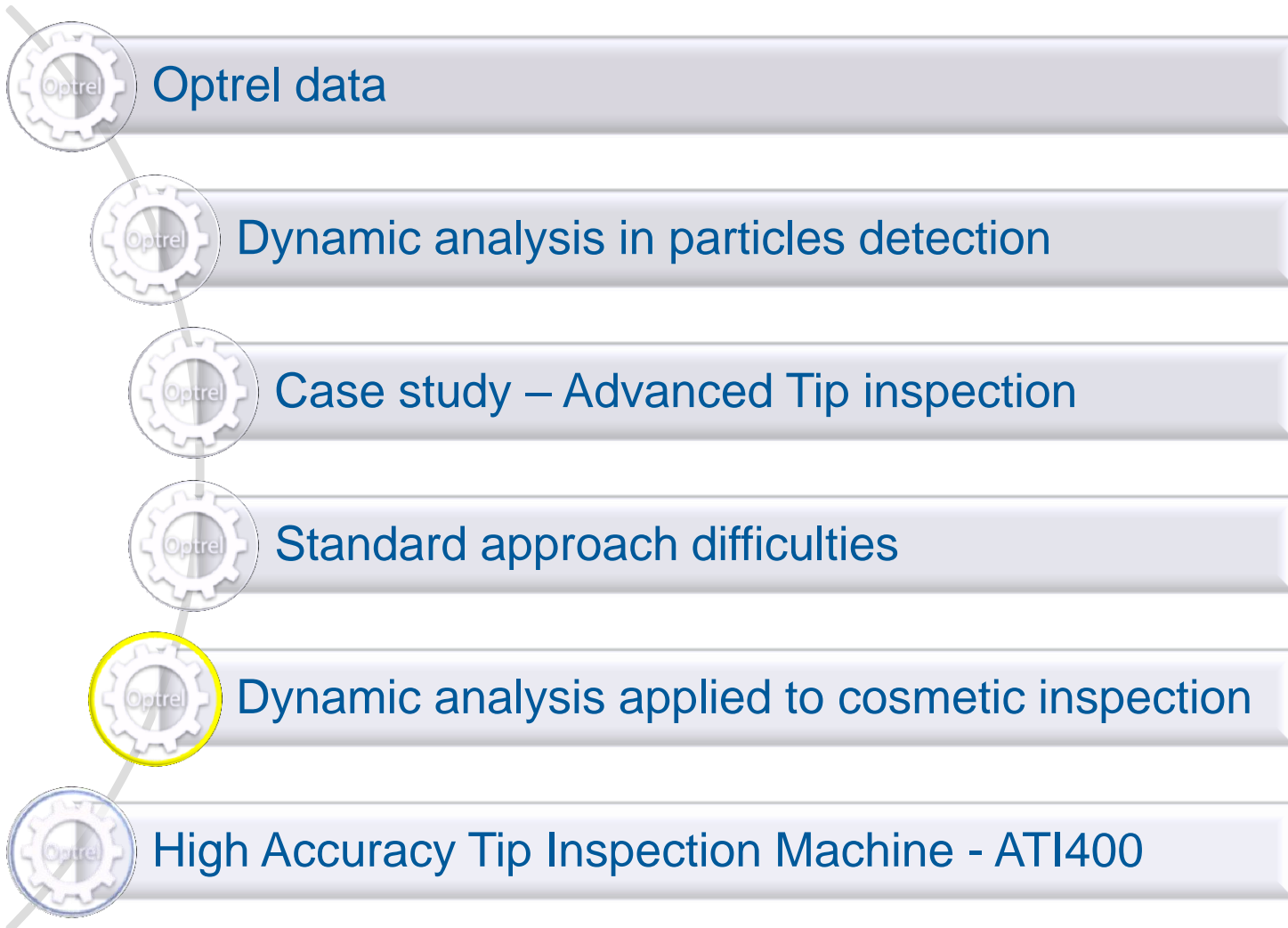


After 30 seconds





# Summary





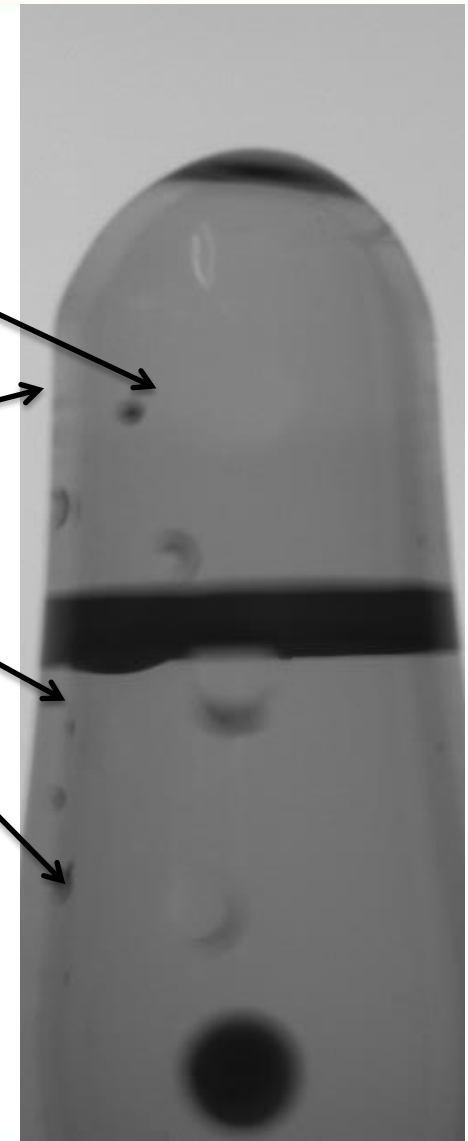
Black spot



Drops

IDEA: liquid drops behave differently from cosmetic defects.

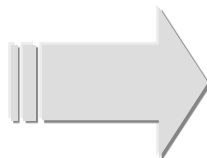
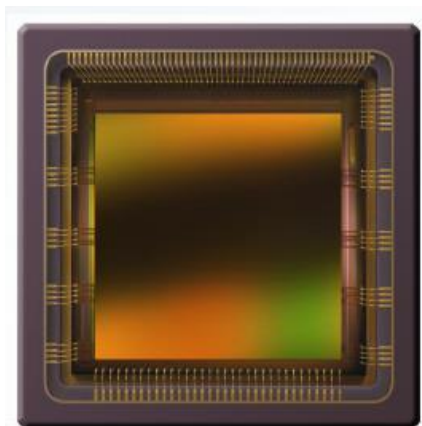
Following the change of appearance it is possible to determine the nature of the contamination





# Requirements for Dynamic Analysis of Tip @ $<50\mu\text{m}$

- High resolution – 2000x2000
- High speed – 32 images per rotation
- 128 Mbytes per container to elaborate in 150 msec
- Pre-processing in FPGA





# Examples of Tip Dynamic Analysis



False reject  $< 1\%$  even in presence of liquid drops



# Examples of Tip Dynamic Analysis #7

PVSI Rev. 6.3.0

Login | Mode | Batch | Home | Counters | Display | Recipe | Programs | PLCParams | Language | Tools

Acquisition time: 140 | Max: 140  
 Processing time: 023 | Max: 024  
 Total time: 163 | Max: 164

Mode	Maintenance	User	Optrel	Format	10 ml	Recipe	10ml Amber	Batch
ST1E - B10	2 (1.6%) MAX AREA	2167 MAX SUM AREA	2167	ST30 - B10	0 (0.0%) MAX AREA	0 MAX SUM AREA	0	0
SPIN OK	0 LIGHT TEST	165		SPIN OK	0 LIGHT TEST	181		

Totals	
Black Spot	Accepted: 120 (98.4%)   Rejected: 2 (1.6%)   Not inspected: 0 (0.0%)   Total: 122

15:48:52 - N1-EMERGENCY



# Examples of Tip Dynamic Analysis #4

SVSI Rev. 6.30

Login Mode Batch Home Counters Display Recipe Programs PLCParams Language Tools

Acquisition time 140 Max 140  
 Processing time 022 Max 023  
 Total time 162 Max 163

Quit

Mode	Maintenance	User	Optrel	Format	10 ml	Recipe	10ml Amber	Batch			
ST1E - B10	2 (1.6%)	MAX AREA	58	MAX SUM AREA	58	ST30 - B10	0 (0.02%)	MAX AREA	0	MAX SUM AREA	0
SPIN OK	0	LIGHT TEST	166			SPIN OK	0	LIGHT TEST	179		

Black Spot Totals  
 Accepted 120 98.4% Rejected 2 1.6% Not inspected 0 0.0% Total 122

15:48:52 - N1-EMERGENCY



# Dynamic Tip Shape Analysis

- Shape analysis in rotation on 8 images
- Automatic compensation of tip oscillation
- Worst deviation evaluated Inside and Outside correct shape

The screenshot displays the PDA software interface for dynamic tip shape analysis. The main window is split into two panels. The left panel shows a grayscale image of a vial tip. The right panel shows the same vial tip with a blue outline representing the analyzed shape. The software interface includes a menu bar at the top with options like Mode, Maintenance, User, Optrel, Format, 10 ml, Recipe, 10ml Amber, and Batch. Below the menu bar is a table with columns for various parameters and their values. An on-screen keyboard is visible on the right side of the interface. At the bottom, a summary table shows the results of the analysis.

Mode	Maintenance	User	Optrel	Format	10 ml	Recipe	10ml Amber	Batch
SIZE - B0	1 (0.02) HEIGHT	454 ANGLE DEVIATION	0 (51.20 - B0	16 (0.22) HEIGHT	467 ANGLE DEVIATION	7		
SHAPE TOLERANCE	2 RING THICKNESS	75 EDGE SUM TOLER...	0 SHAPE TOLERANCE	3 RING THICKNESS	75 EDGE SUM TOLER...	0		

Shape	Totals
Accepted	8275 98.9 %
Rejected	96 1.1 %
Not inspected	17 0.2 %
Total	8371





# Interactive Tip Shape Analysis

Tip under analysis

Tip shapes correlation

The screenshot displays the TipControl software interface. The main window shows a 3D model of a tip with a red bounding box around the tip area. The interface includes several panels:

- TipControl settings:** Includes navigation icons (Zoom, Pan, Rotate) and a 'Load Image' section with 'Load from file' and 'Select PVSII Bank' (Bank-0).
- Tip Model Load/Save:** Includes 'Load model' and 'Save model to .DXF' buttons, a 'Tolerance' slider (L to H, 10), and 'Max Angle Curv.' (4.00).
- Operation:** Includes 'Get edge profile' and 'Check Fit' buttons, and a 'Fast edge' checkbox.
- Tip profile data:** A table showing analysis results:

Type	Value
Edges	3
Edge points	522
Angle	0.02 °
Tip Height	551.5
Max Phi curv	5.88

- Edge Fit:** A table showing fit statistics:

Type	Value
Match points	86
Fit Score	92.3%
Max Gap	8.79
Mean Gap	3.14

- Angle Fit:** A table showing error metrics:

Mean error	Max error
3.56	3.91

- Graphs:** Includes 'Angle graphs', 'Distance graph', and 'Model profile'. The 'Model vs Tip angle profile' graph shows Phi [°] vs Edge Points. The 'Angle Fit Error' graph shows Fit Error vs Displacement.
- PVSII banks:** A row of five thumbnail images showing different tip shapes.

The status bar at the bottom indicates: Defected or out of standard tip. Ready. PVSII Bank: Bank-2 Model file: profile3.DXF Execution time: 4.18 [ms]

Tip shapes fit with model



# Summary



Optrel data



Dynamic analysis in particles detection



Case study – Advanced Tip inspection



Standard approach difficulties



Dynamic analysis applied to cosmetic inspection

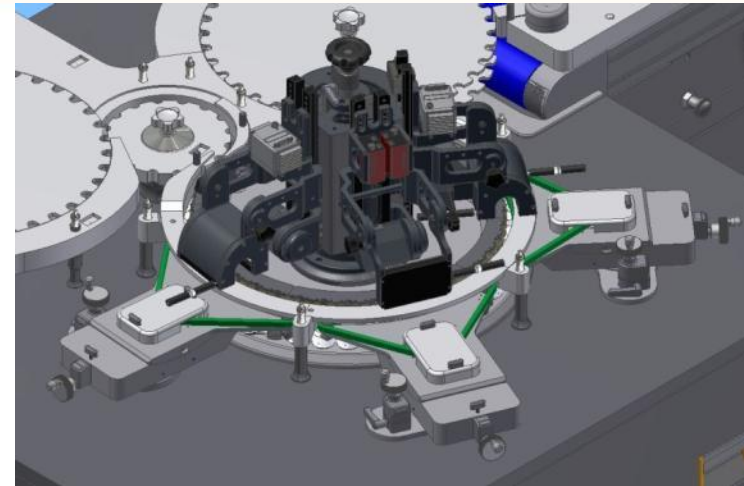
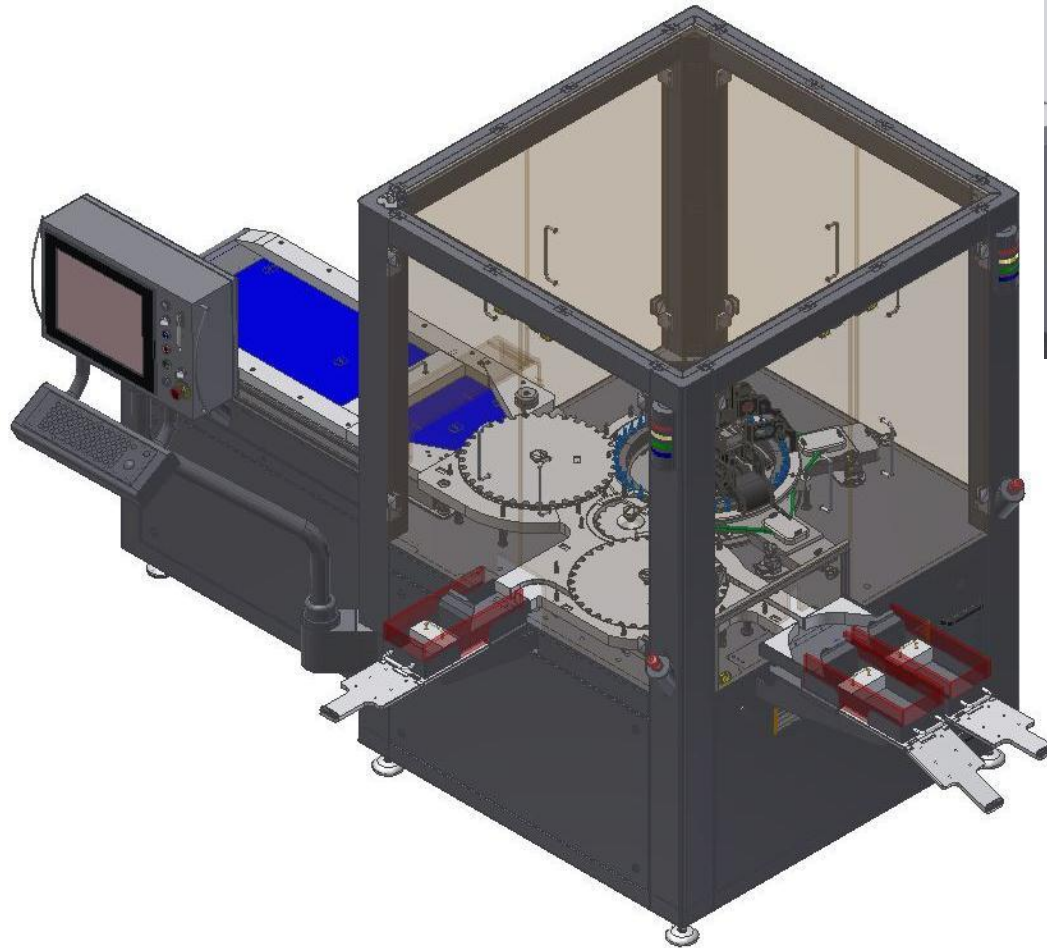


High Accuracy Tip Inspection Machine - ATI400



# ATI400 - Small footprint, accessible, cleanable

Tip completely free for unobstructed inspection



- Dedicated rotation for each inspection synchronized to vision
- Customized illumination system
- Easy change parts

# Video ATI400





Thank you for your attention

[www.stevanatogroup.com](http://www.stevanatogroup.com)

[www.optrelinspection.com](http://www.optrelinspection.com)