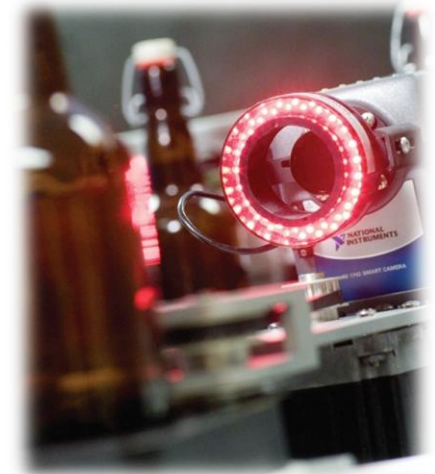
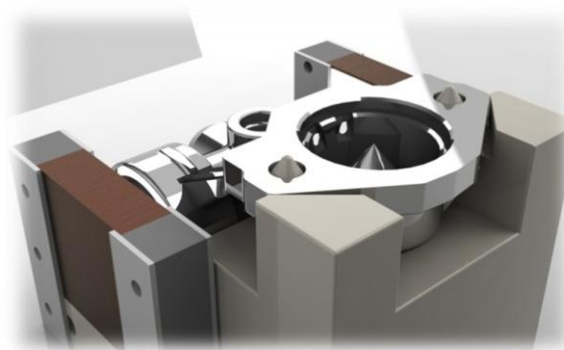


# TIFAC CORE IN MACHINE VISION



## COMPUTER VISION APPLICATION IN INDUSTRIES

Wg Cdr N. Radhakrishnan



# Topics for Discussion

2

- **About TIFAC-CORE in Machine Vision**
- **Computer Vision**
- **Fundamental Issues**
- **Industry Applications – Automotive, Pharma, Electronic Industries**

# About TIFAC CORE

3

- **DST Sponsored Programme**
- **Objectives:**
  - To set up State of the art laboratory in the area of MV and to undertake research activities.
  - To introduce the MV technology to the industries. Provide consultancy services, develop solutions, Train industry personnel.
  - To train the faculty members and students .

Director: Wg Cdr N. Radhakrishnan  
Professor  
Rajalakshmi Engineering College  
director.tifac@rajalakshmi.edu.in

# Machine Vision

4

## Machine Vision:

**Making useful decisions about real physical objects and scenes based on sensed images**

## Challenges:

- Understanding the Customers Requirement
  - Parameters to be inspected and its tolerance,
  - Location of the System installation
  - Light, heat, dust and other environemtnal condition
  - Number of components to be inspected per sececond / minute or per shift
  - Automation requirements
- Selection of Camera, Lens, Lighting System
  - Find the field of view, estimate camera resolution requirement
  - Select lens
  - Select suitable light
- Developing automation solution

# Cameras

5

- **Types of Camera**

- Area Scan vs Line Scan / Board Level Camera
- CCD vs CMOS, Grey / Colour
- Interface
- Resolution
- Global Shutter Vs Rolling Shutter
- Sensor Format

# Camera Types

6

▶ Area Scan



▶ Line Scan



# Interfaces

7

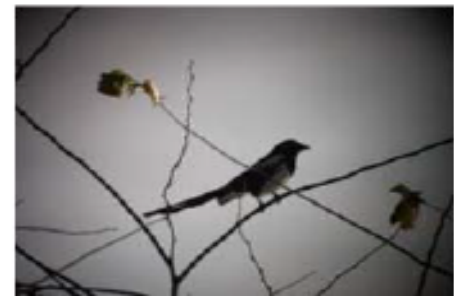
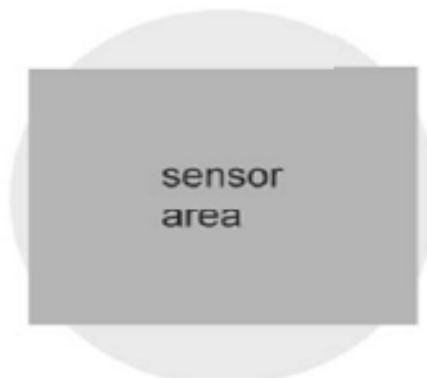
- **Firewire : 400 Mbps**
- **USB 2.0 / 3.0 : 480 Mbps / 5 Gbps**
- **Gig E : 1 Gbps**
- **Camera Link : 5.3Gbps**
- **CoXpress : 6.2 Gbps**

# Camera and Lens

8

## Lens and the Camera sensor

- ▶ Lenses can be used with any CCD camera, provided the lens design format is **larger or equal** to that of the camera.
- ▶ If the sensor is too large, vignetting (tunnel vision) will occur



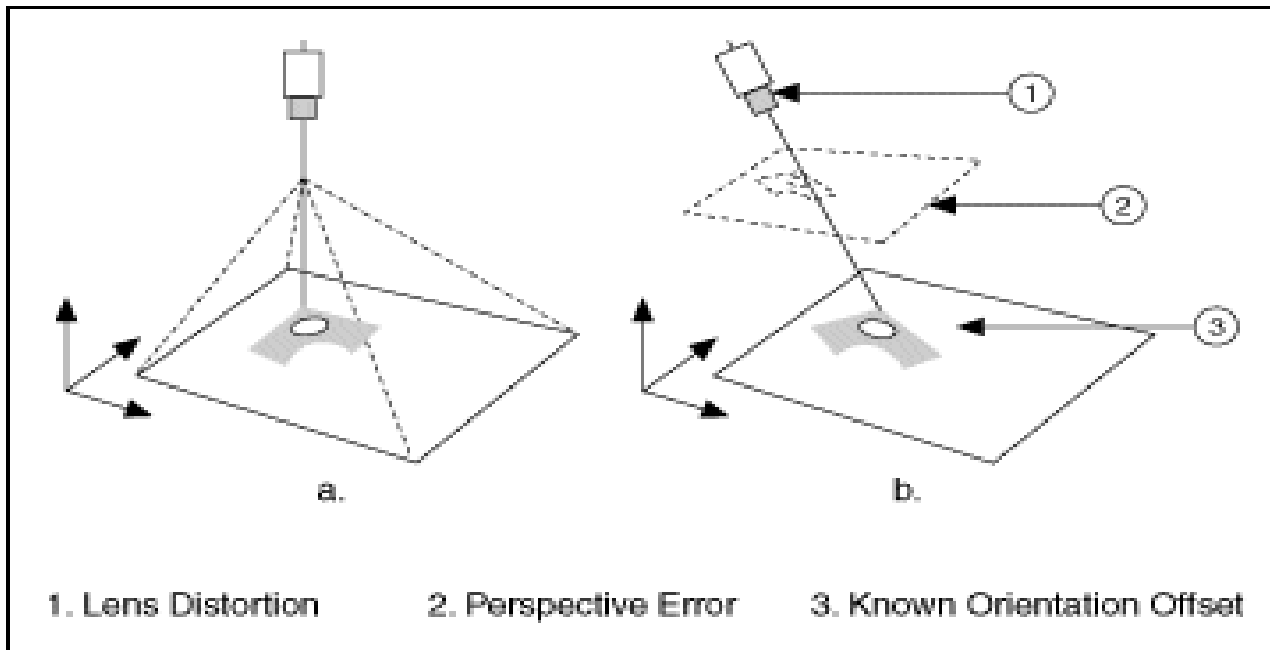


# Fundamental Issues

9

## Perspective:

### Perspective errors

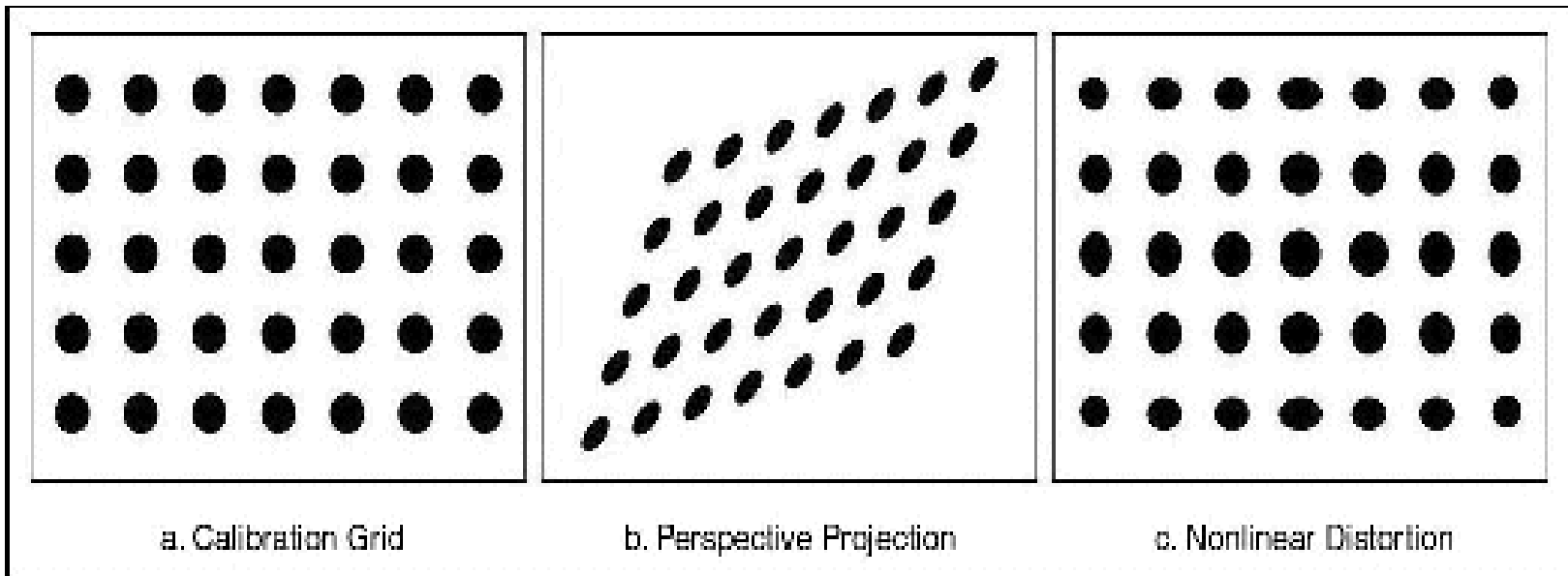


# Fundamental Issues (cont.)

10

**Perspective and Distortion (Pin Cushion and barrel) Errors occur due to camera location problems.**

Can be with spatial calibration techniques.



# LENS

11

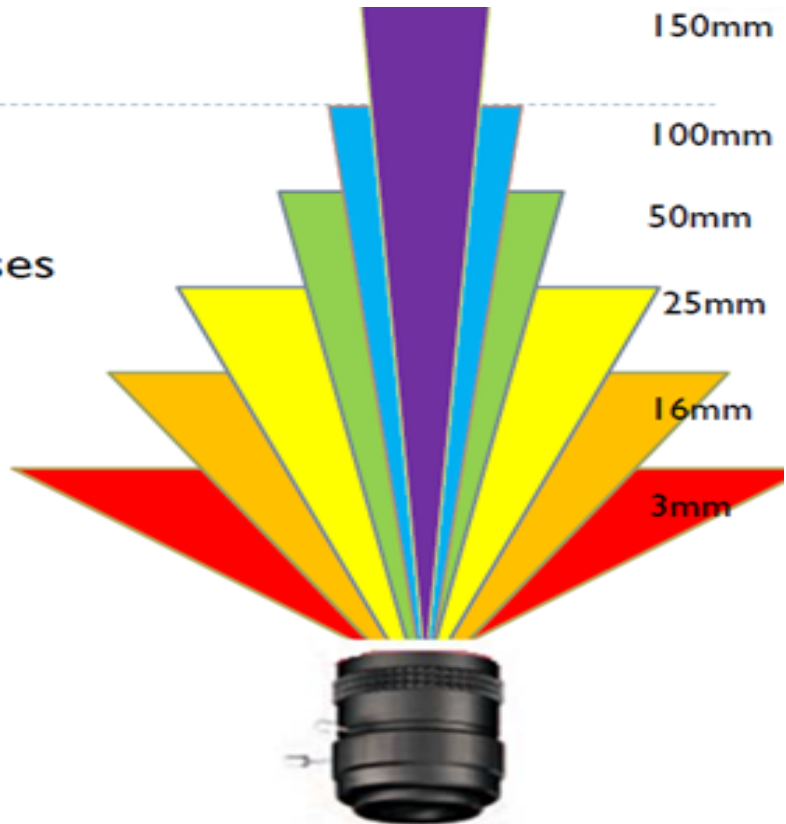
- **Normal lens vs Telecentric Lens**
- **Angle of view / Focal Length**
- **Magnification / Depth of Field**
- **F Stop**
- **Lens Mount**

# Lens Types

12

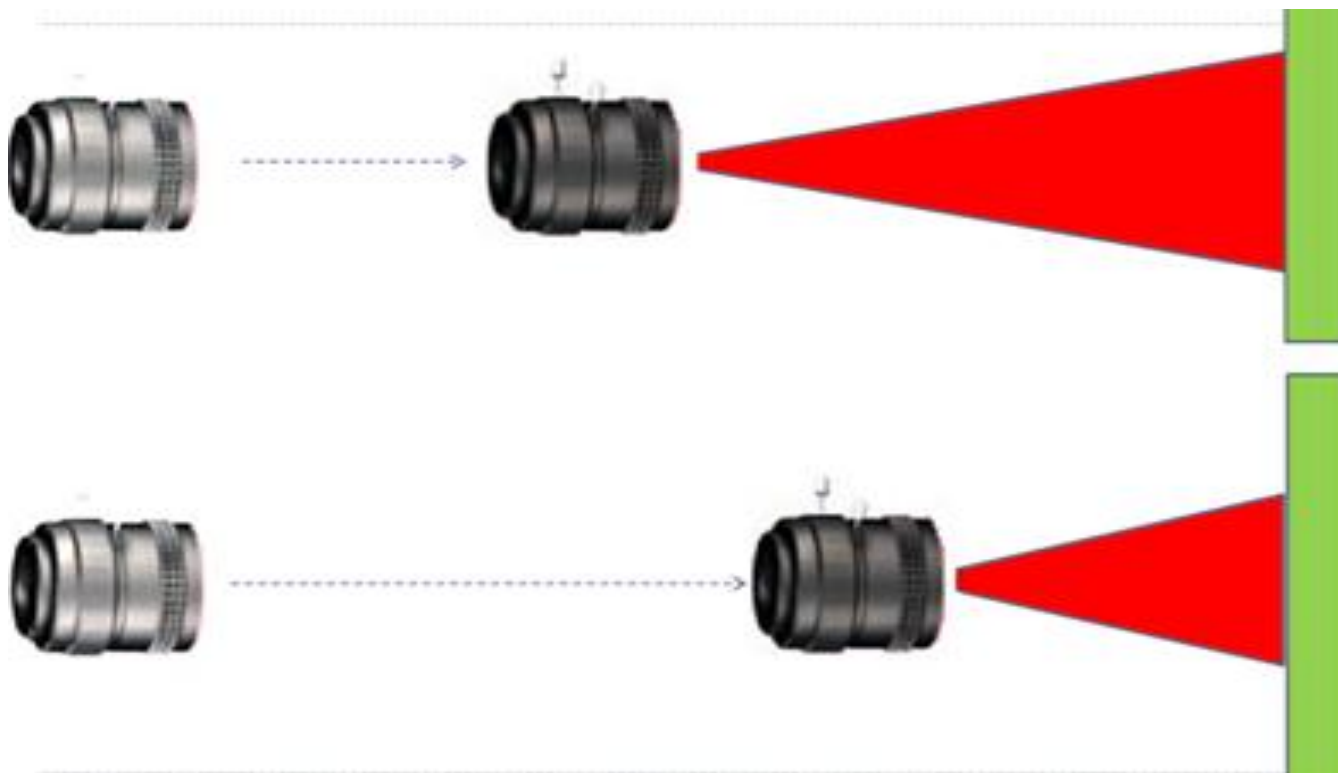
## Lens Types

- ▶ Wide Angles Lenses
- ▶ Standard Machine Vision Lenses
- ▶ Tele-centric Lenses



# Field of View, Focal Length and Standoff Distance

13

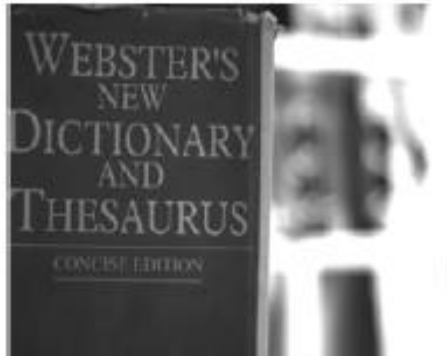


# Lens and Aperture

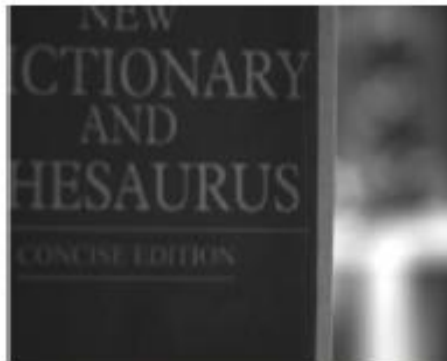
An Example

14

16mm – F1.4



25mm – F1.8



16mm – F4



25mm – F2.8



# Lens Depth of Field

15

## An Example



Captured with a 100-mm lens with F/4



Captured with a 28-mm lens with F/4



Captured with a 100-mm lens with F/22



Captured with a 28-mm lens with F/22

# Lens Selection

16

- **What to do if you need to change the image size?**
  - **To increase magnification (Smaller FOV)**
    - ✦ Use a lens with longer focal length
    - ✦ Move the camera closer to the part
  - **To decrease magnification (Larger FOV)**
    - ✦ Use shorter focal length
    - ✦ Move the camera further from part

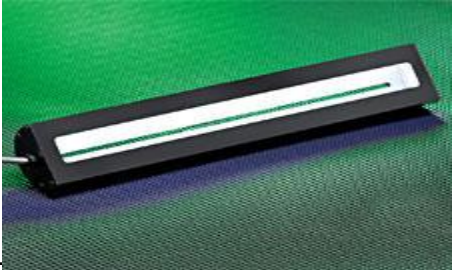
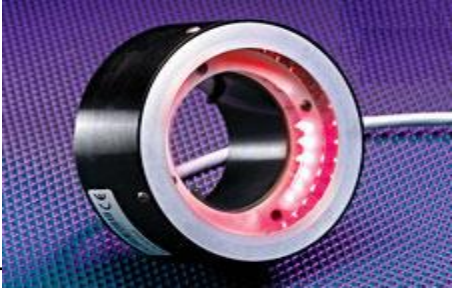

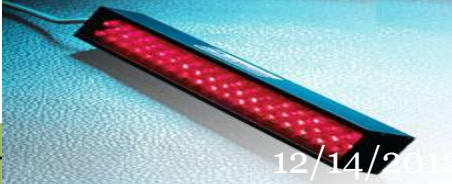


# LIGHTING

17



- **Bright Field Illumination**
- **Dark Field Illumination**
- **Back Light**
- **Diffused Light**
- **Oblique Lighting**
- **Axial Lighting**
- **Structured Lighting**
- **Collimated Lighting**
- **Doom Lighting**

# Different types of Lighting

<b>Description</b>	<b>Images</b>
<b>LED Diffuse Line Light</b>	 A long, narrow, black rectangular light fixture with a white diffuser strip in the center, emitting a soft, even glow.
<b>660nm, Bright Field / Dark Field Ring Light</b>	 A circular ring light with a black outer casing and a white inner ring, emitting a bright red light from the center.
<b>5.00 Inch, White, LED Darkfield Illuminator with mounting bracket</b>	 A circular, white LED illuminator with a black mounting bracket, emitting a bright blue light from the center.
<b>660nm, LED Broad Area Linear Array</b>	 A long, narrow, black rectangular light fixture with a red LED array in the center, emitting a bright red light.





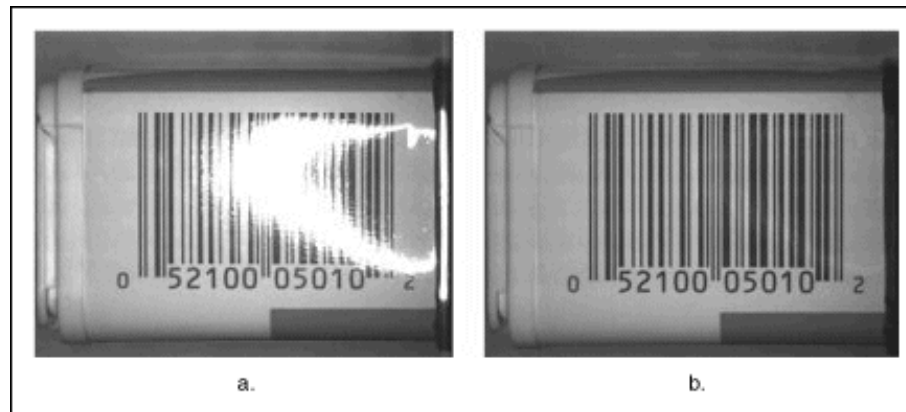
<b>Description</b>	<b>Images</b>
<b>670nm Micro-Focus Laser Line Diode, 10°, 13μm Line, Modulated with power supply</b>	 A photograph of a 670nm Micro-Focus Laser Line Diode. It is a small, cylindrical metal device with a yellow label and a coiled black cable attached to one end.
<b>6" Hemilite Fluorescent Illuminator with power supply</b>	 A photograph of a 6" Hemilite Fluorescent Illuminator. It is a white, dome-shaped device with a black ring around the top opening and a black power cord attached to the side. The background is a solid blue color.

# Fundamental Issues

21

## Lighting issues

- Ambient Light, Sunlight Changes, Seasonal Changes should not compromise image analysis and processing.
- Proper illumination leads to Faster processing time.



# Fundamental Issues (cont.)

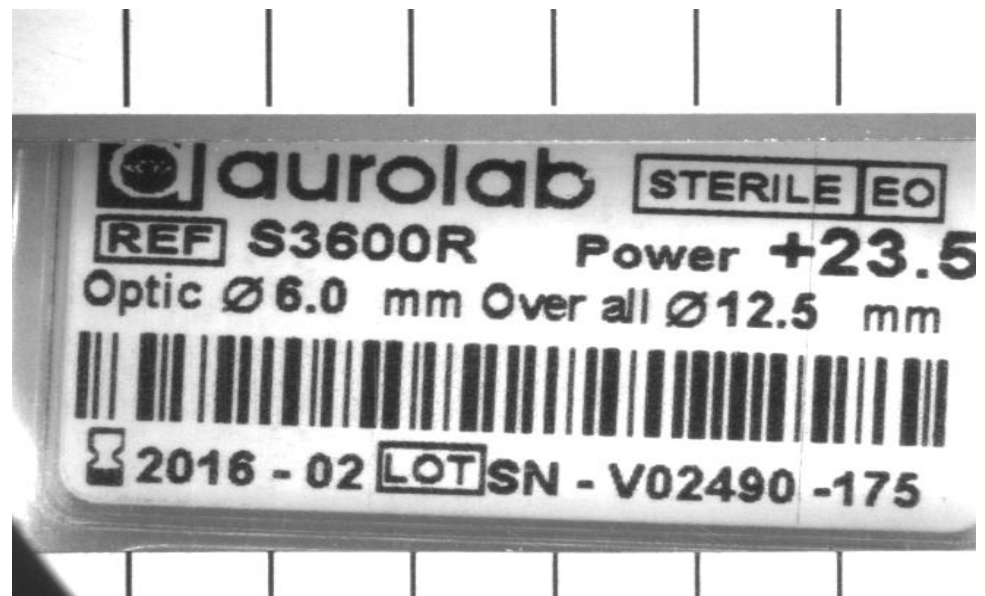
22

- Backlighting creates sharp contrasts which makes profile inspection, finding edges and measuring distances fast and easy.



# Normal Light vs Dome Light

23



# Axial Light vs Normal Light

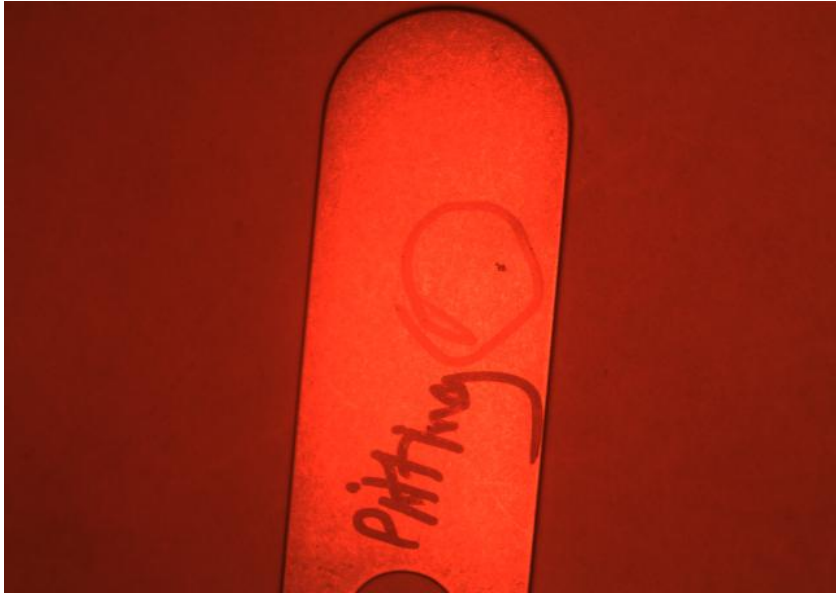
24





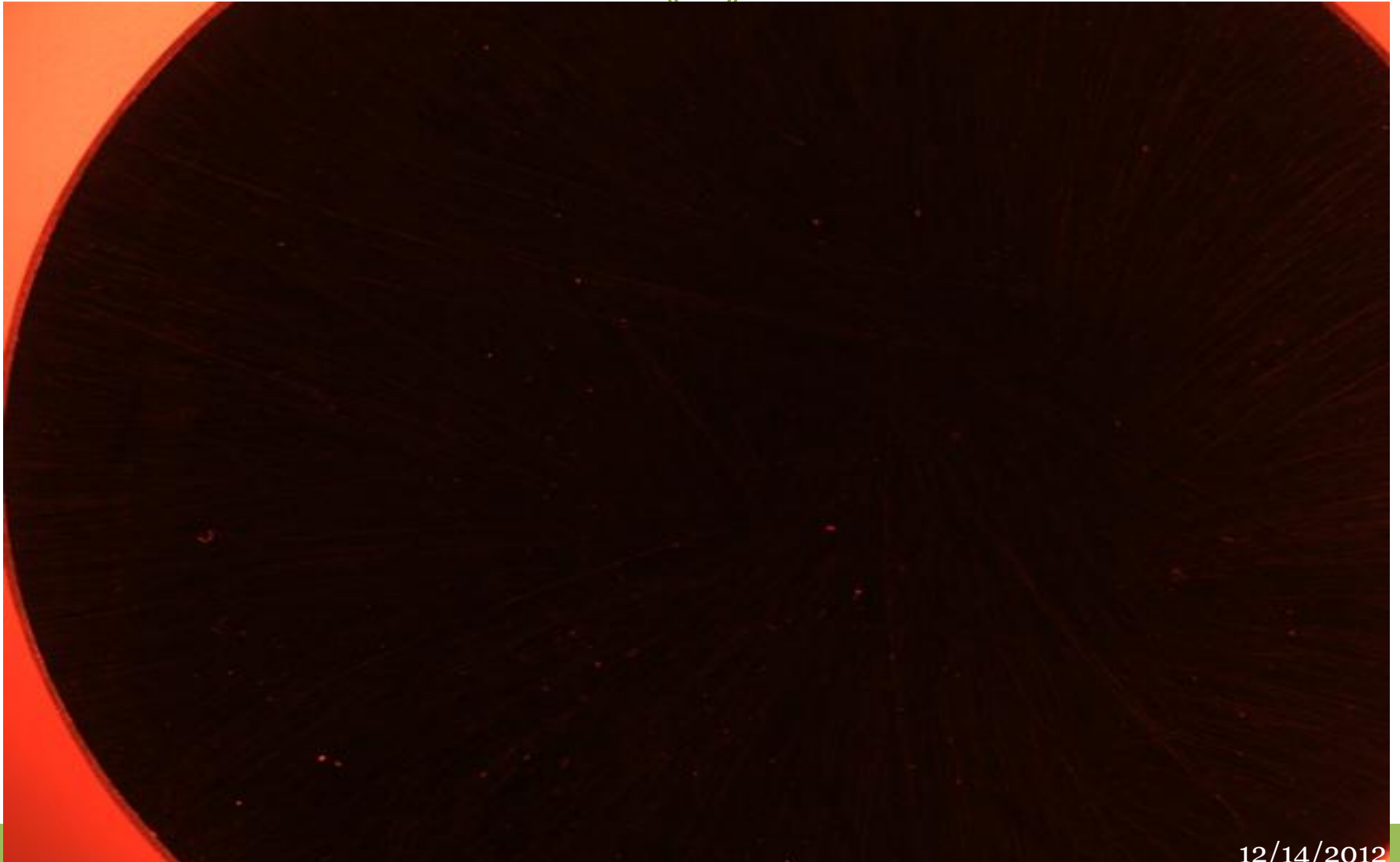
# Dark Field Light vs Normal Light

25



# Dark Field Light

26



12/14/2012

# Application Software

27

- **Matlab**
- **C ++**
- **Open CV**
- **Lab View**
- **Halcon**
- **Matrox Imaging Library**
- **Mv Impact**



---

# PROJECTS



# AUTOMOTIVE INDUSTRIES

# Brake Piston Cylinder

30

## Inspection Requirements:

- Hole Burr
- Hole Position
- Hole Missing
- Double Punch

- [Video](#)



# Brake Piston Cylinder

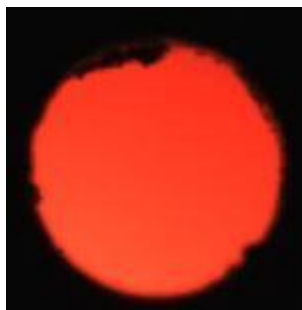
31



**Algorithm: Canny edge detector**

**Image processing steps**

1. Colour to Gray level
2. Canny edge detector
3. Circle fit
4. Euclidean distance



Burr



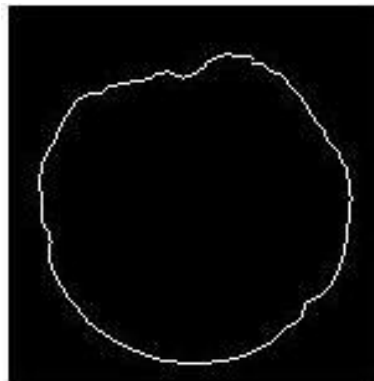
Ok

# Brake Piston Cylinder

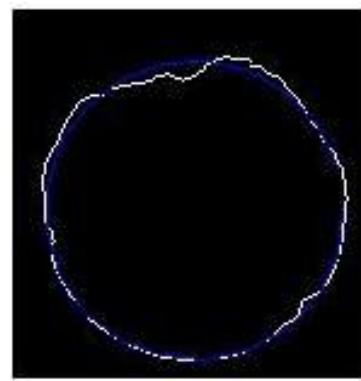
32



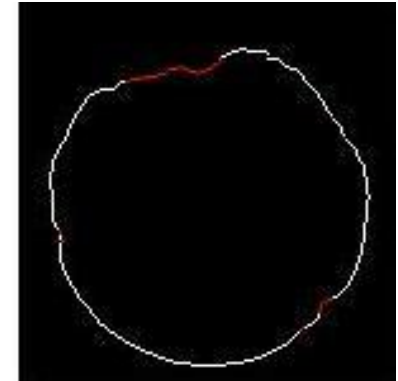
a. Captured Image



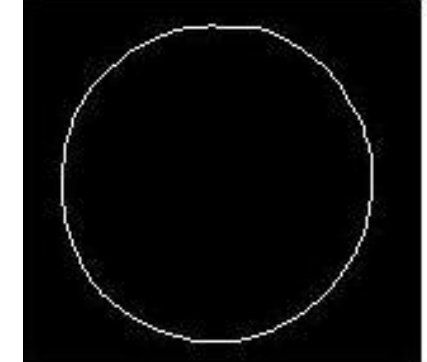
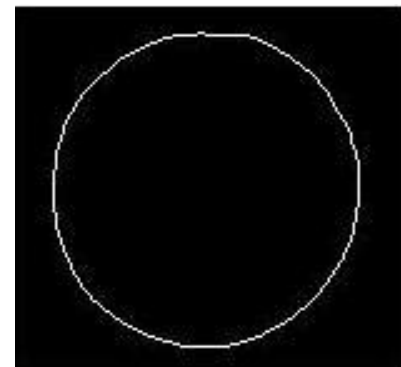
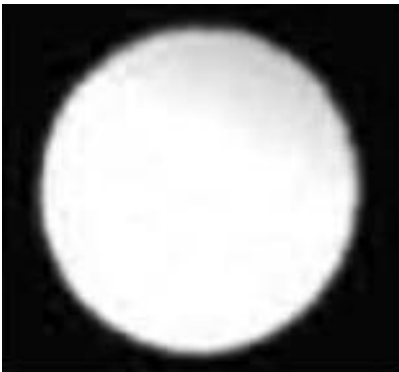
b. Output of edge detector



c. Circle Fit



d. Red pixel shows the detection of burr





# Brake Piston Cylinder

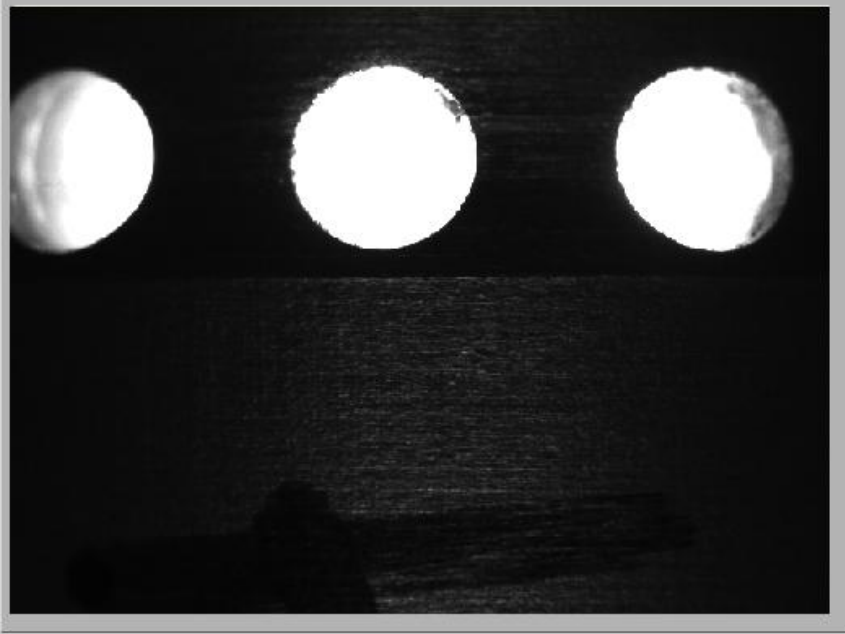
33

**Inspection of Brake Piston Cylinder**

Model Selection

- Bmw Primary
- Bmw Secondary
- Nissan Primary (22.2)
- Nissan Secondary (22.2)

Image Out



Indication

- OK
- Burr Not OK**
- Height Not OK
- Double Punch
- Hole Miss

STOP

Total	OK	Not OK
3	2	1

# Spline Gear

34

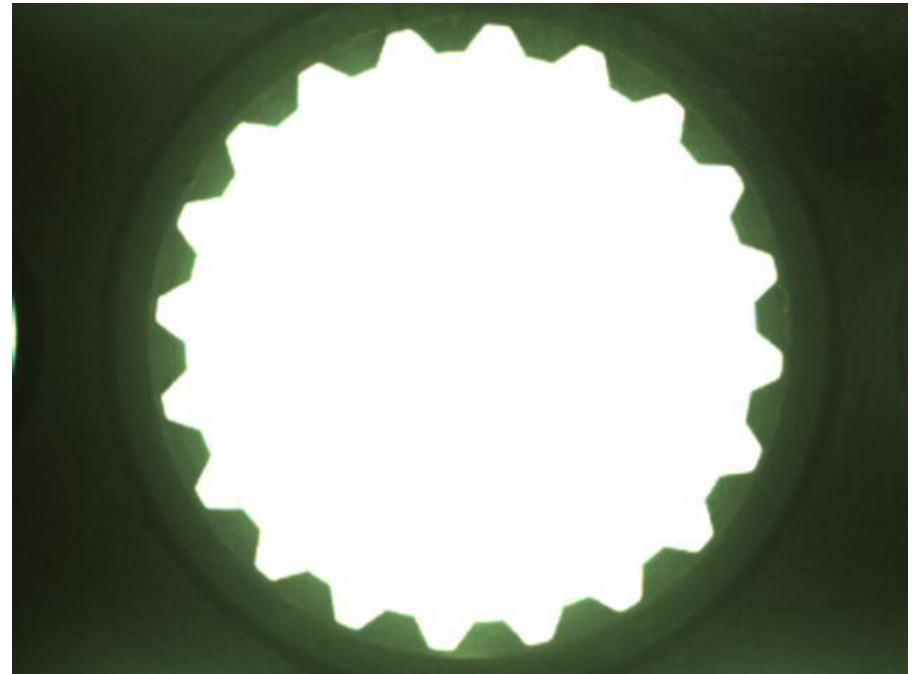
## Inspection Requirements:

- Double Broach
- Groove Miss
- Model Mix-up
- Chamfer Presence

**Algorithm : Canny edge detector**

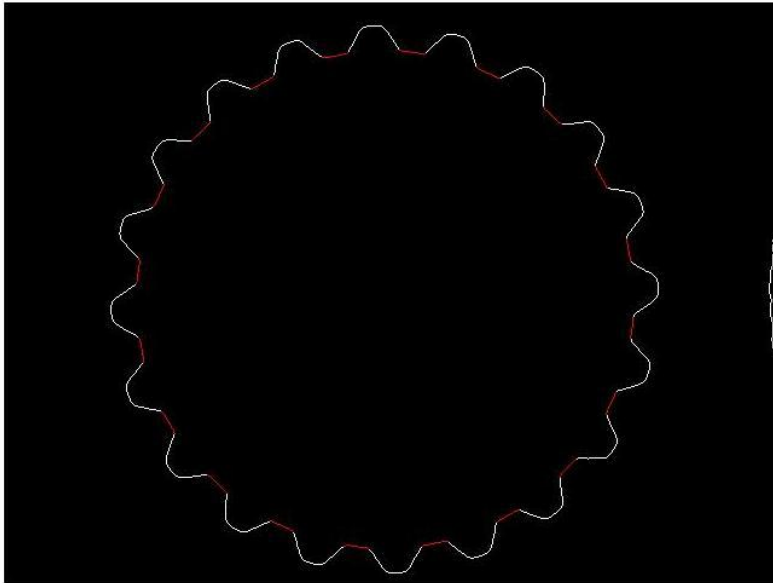
## Image processing steps

1. Colour to Gray level
2. Canny edge detector
3. Euclidean distance

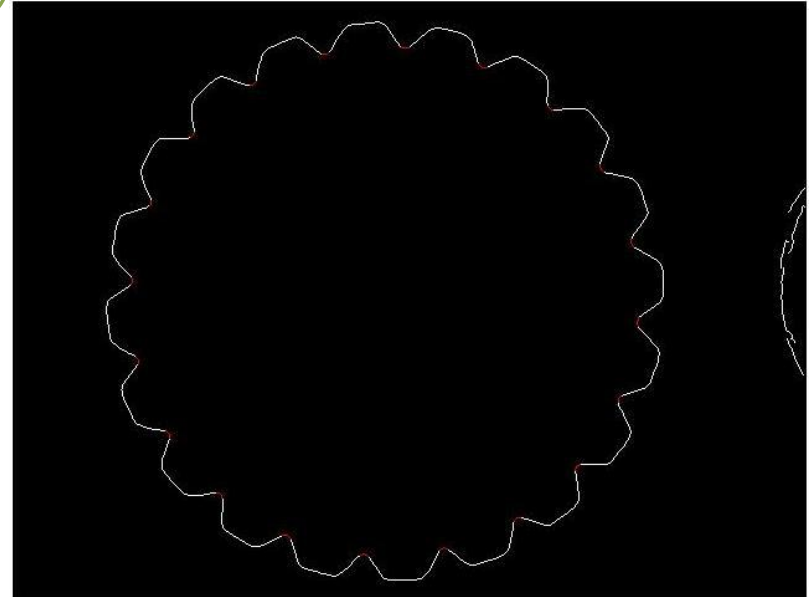


# Spline Gear

35



Ok



Double Broach

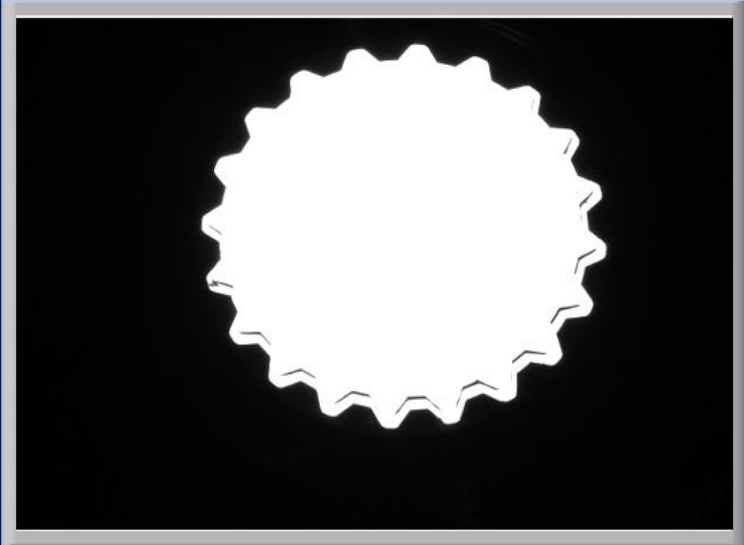
- The number of red pixels give the width of tooth
- For Ok sample the count will be more than double broached component

# Spline Gear

36

INSPECTION OF SPLINE GEAR

AC 1500i	AC 2600i
AC 1700i	AC 2600 RGA
AC 1700 RGA	UF 2000i
AC 71 BJ RGA	VR 2700
AC 2000i	AC 2300i
AC 1300 YE2	DOJ PLANISHING



OK NOT

Total 0 Accepted 0 Not\_Accepted 0 Area 0 Model number 0 Grooves 0 Broaching 0 STOP

# Flywheel

37

## Inspection Requirements:

- Checking right direction of Ring before it is pressed on to Flywheel

- [Video](#)



# Flywheel

38



**With Chamfer**



**Without Chamfer**

## Algorithm

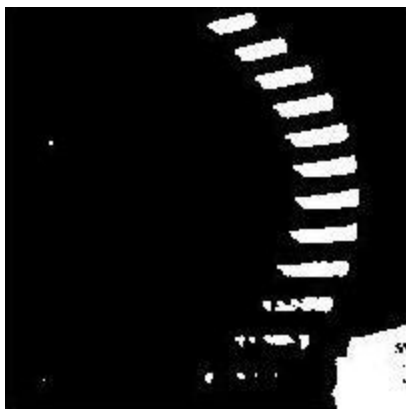
1. Morphology operation (dilation)
2. Blob analysis

## Image processing steps

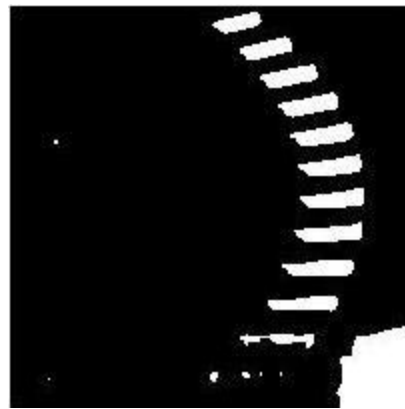
1. Colour to Gray level
2. Gray level to binary
3. Morphology operation (dilation)
4. Blob analysis

# Flywheel

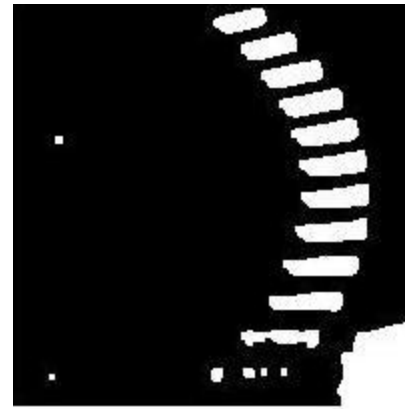
39



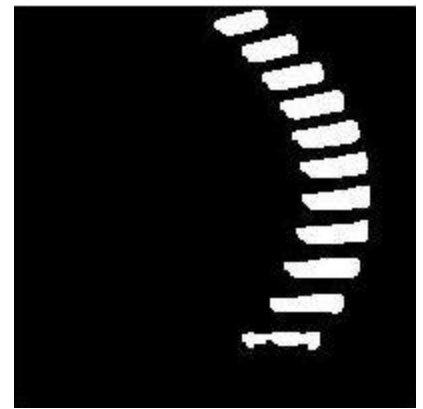
**a. Output of Thresholding**



**b. Closing**



**c. Dilation**



**d. Output of area filter**

# Flywheel

40



**a. Output of Thresholding**



**b. Closing**



**c. Dilation**



**d. Output of area filter**



# Flywheel

41

## Inspection of Flywheel for Presence and Absence of Chamfering

IMAGE DISPLAY

Model Selection

KAPPA  MXI

Ex  Do

TRIGGER

Ex - Export Model  
Do - Domestic Model

STOP

HYDRAULIC PRESS

Slide

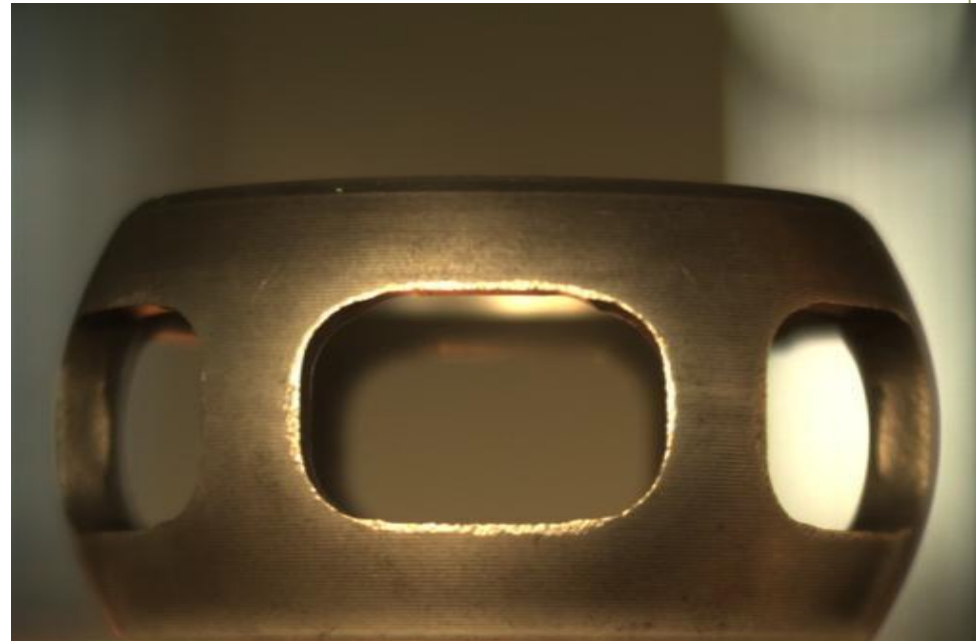
PREESS SPEED 0 5 10 15 20 25 30 35 40

# Cage Sleeve

42

## Inspection requirements:

- Side View
  - ✦ Window Width
  - ✦ Stagger Height
  - ✦ Total Length
  - ✦ Pillar Width
- Top View
  - ✦ Inner Diameter
  - ✦ Outer Diameter



# Cage Sleeve

43

**Side View**



**Top View**

# MN Furnace Ltd

INSPECTION

## MODEL SELECTION

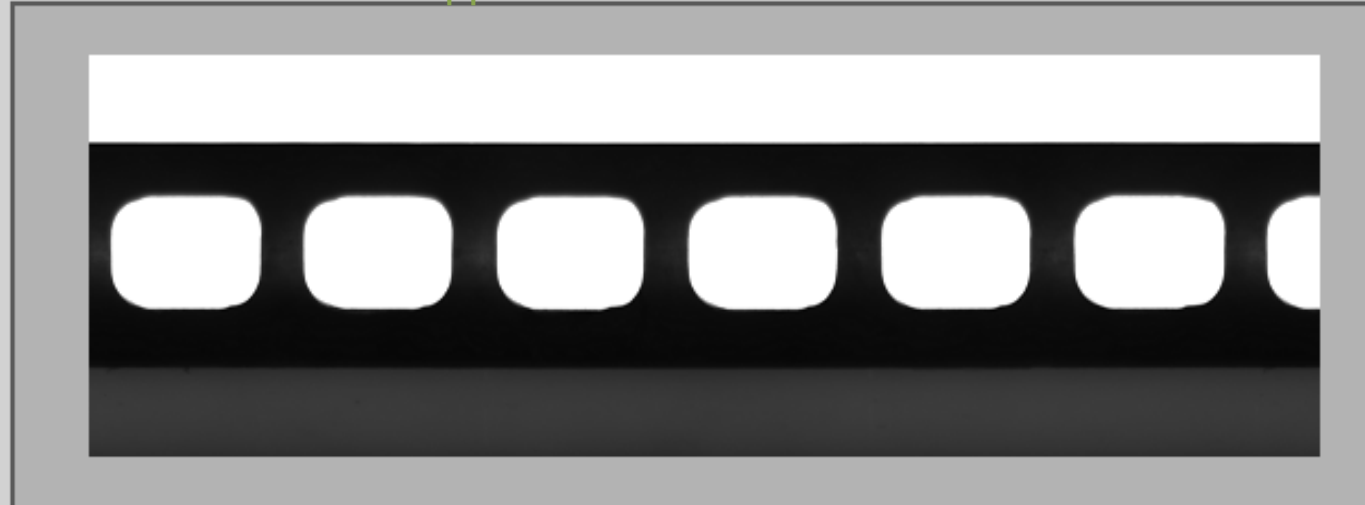
Model 1

Model 2

Model 3

## IMAGE DISPLAY

44



## RESULT

OK

Height NOT OK

Pillar NOT OK

Width NOT OK

## COUNTERS

OK  
40

Height NOT OK  
40

Pillar NOT OK  
0

Width NOT OK  
5

Total  
85

# Forged Brake System Component

45

## Inspection requirements

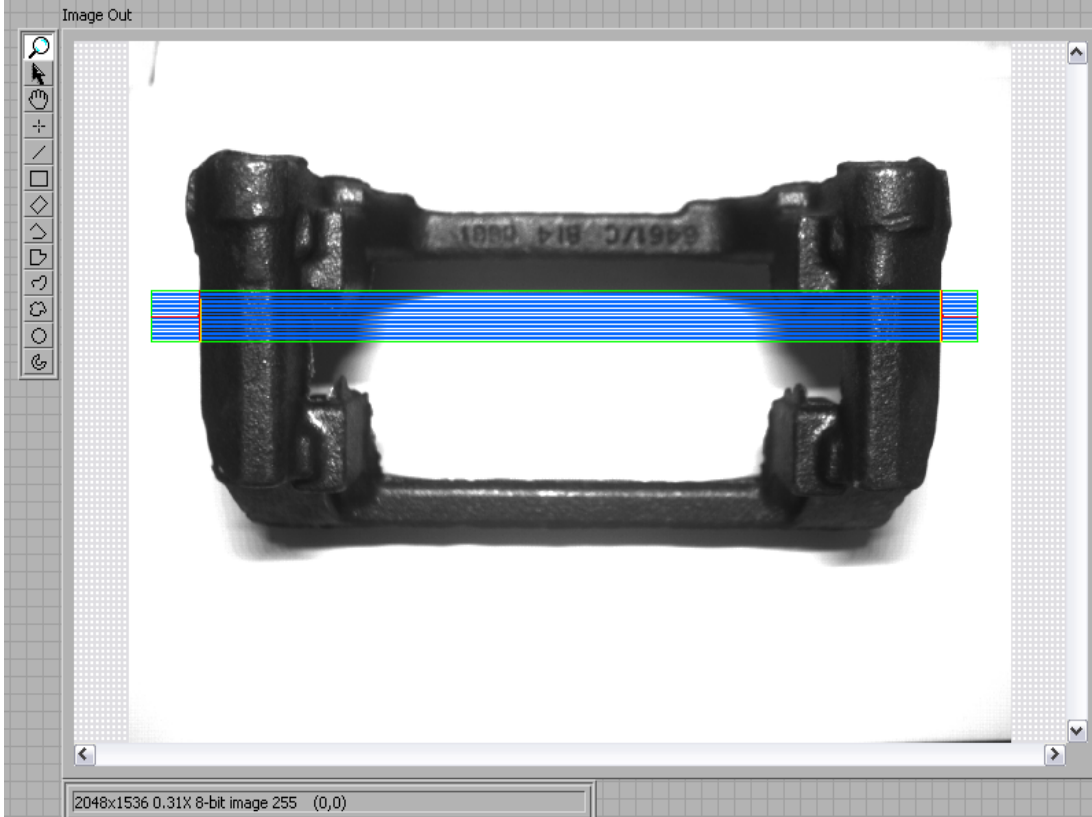
- Inward Bend
- Outward Bend



# Forged Brake System Component

46

## BRAKE CARRIER INSPECTION



INWARD BEND



OUTWARD BEND



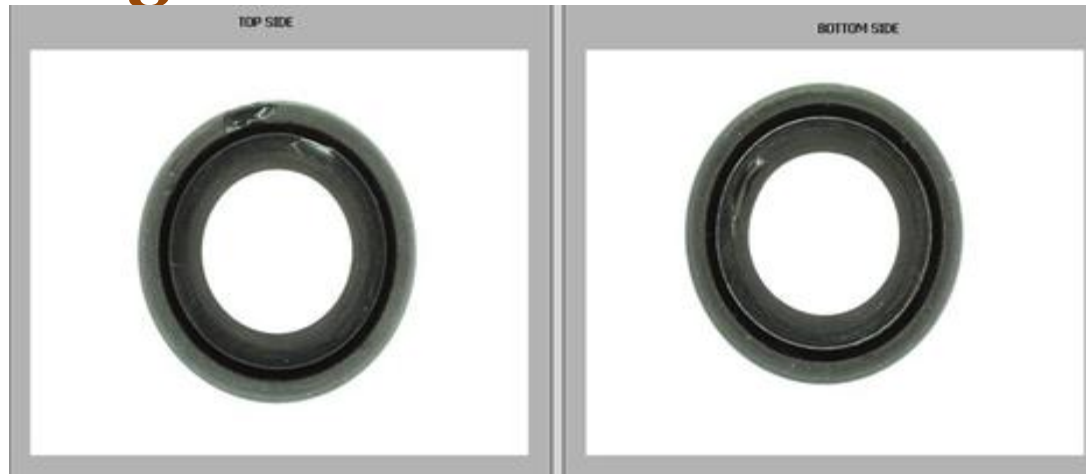
OK



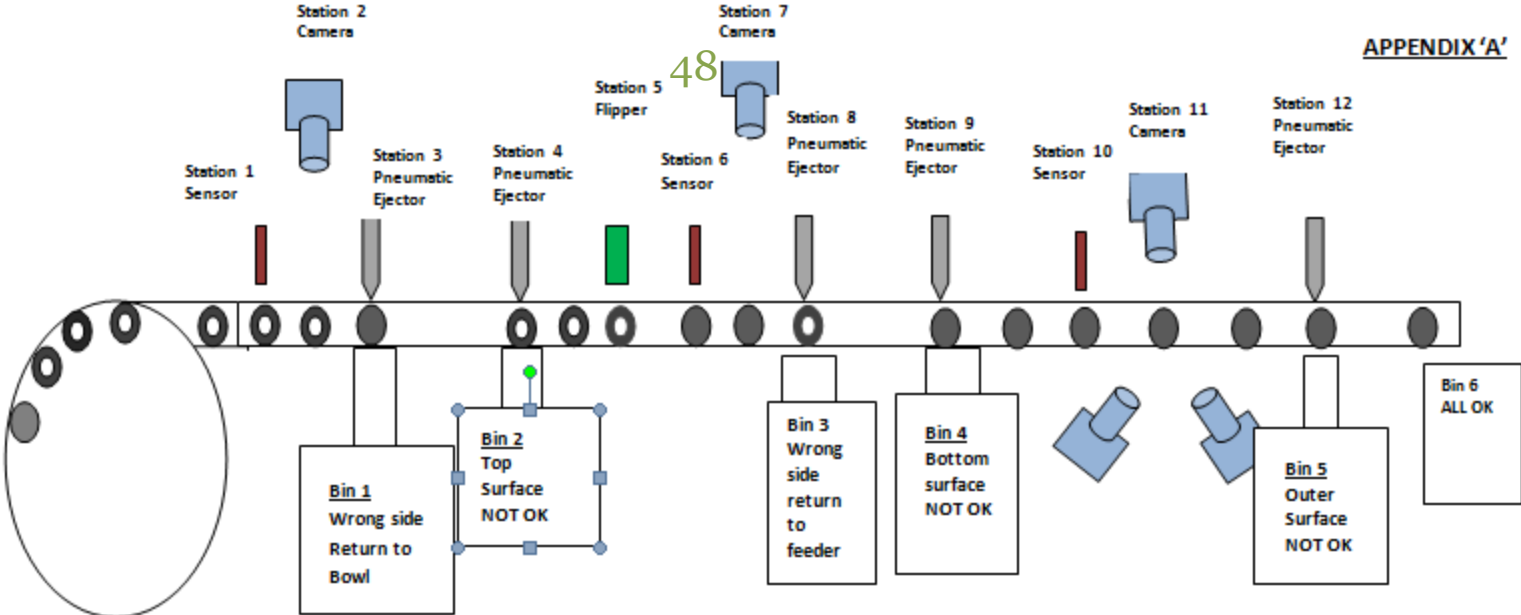
# Oil Seal Inspection

47

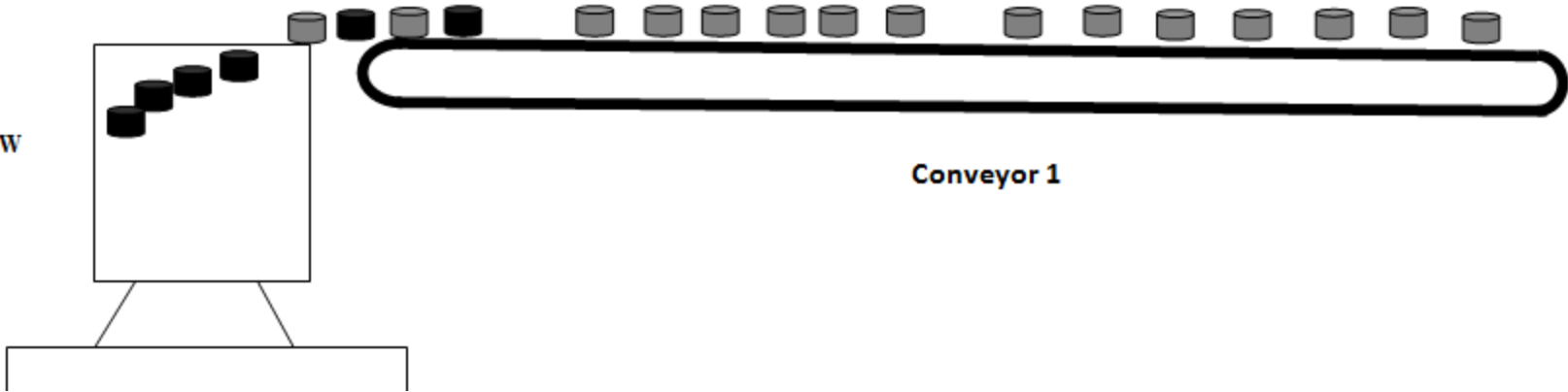
- **Dimensional Accuracies of Inner / Outer Diameter**
- **Presence / Absence of Spring**
- **Surface Defects on all sides: Top, Bottom and on the periphery.**
- **Tear Damage on the Outer Surface**



TOP VIEW



SIDE VIEW





Fenners India Limited Side Surface Inspection

Model Selection	Camera 1	Camera 2	Camera 3	OK	Not OK
<input checked="" type="radio"/> Model 1				<input checked="" type="checkbox"/>	<input type="checkbox"/>
				<input type="checkbox"/>	<input checked="" type="checkbox"/>
				<input type="checkbox"/>	<input type="checkbox"/>
				<input type="checkbox"/>	<input type="checkbox"/>

**OK : 1      Not OK : 1      Total : 2**

# Two Wheeler Fuel Cock Assembly

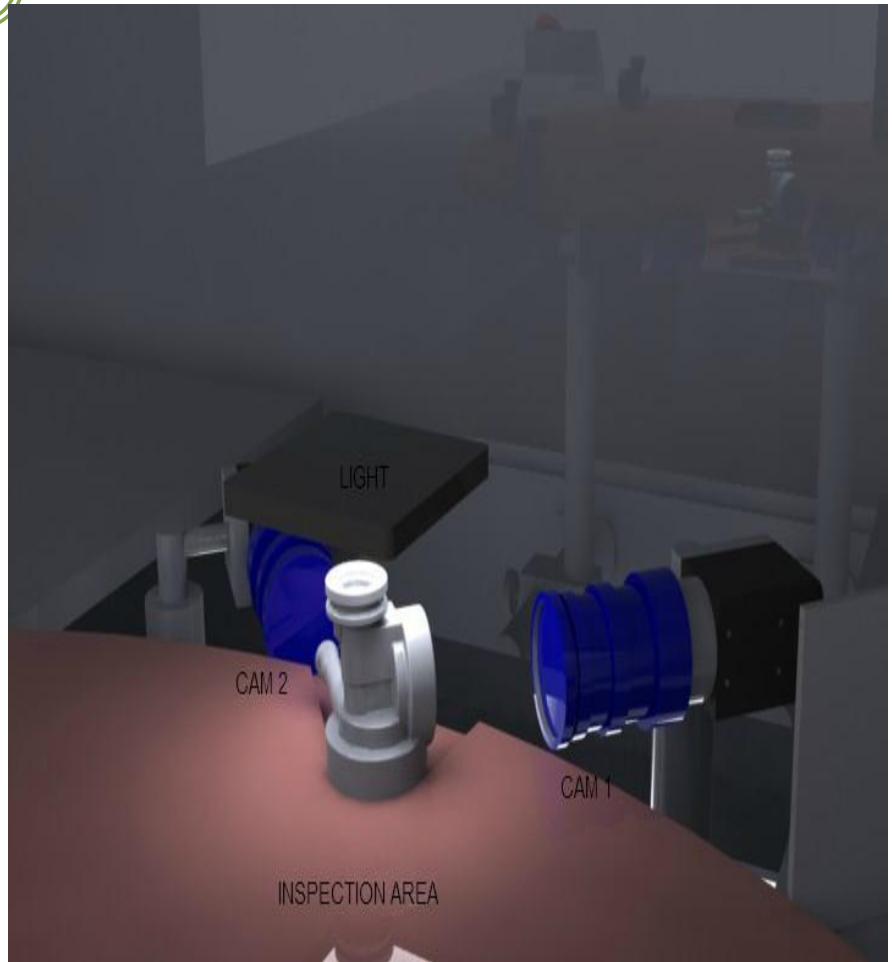
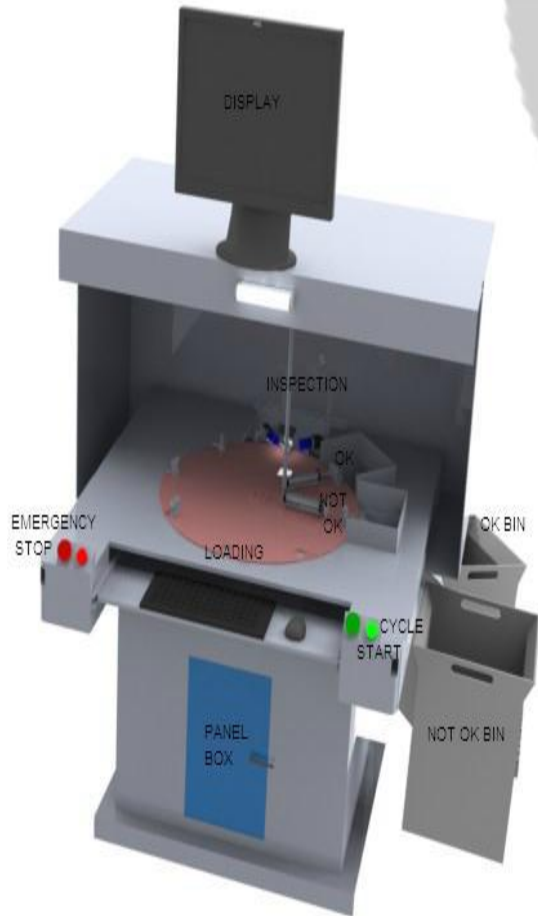
50

- Presence of through holes
- Presence of burr inside the holes.



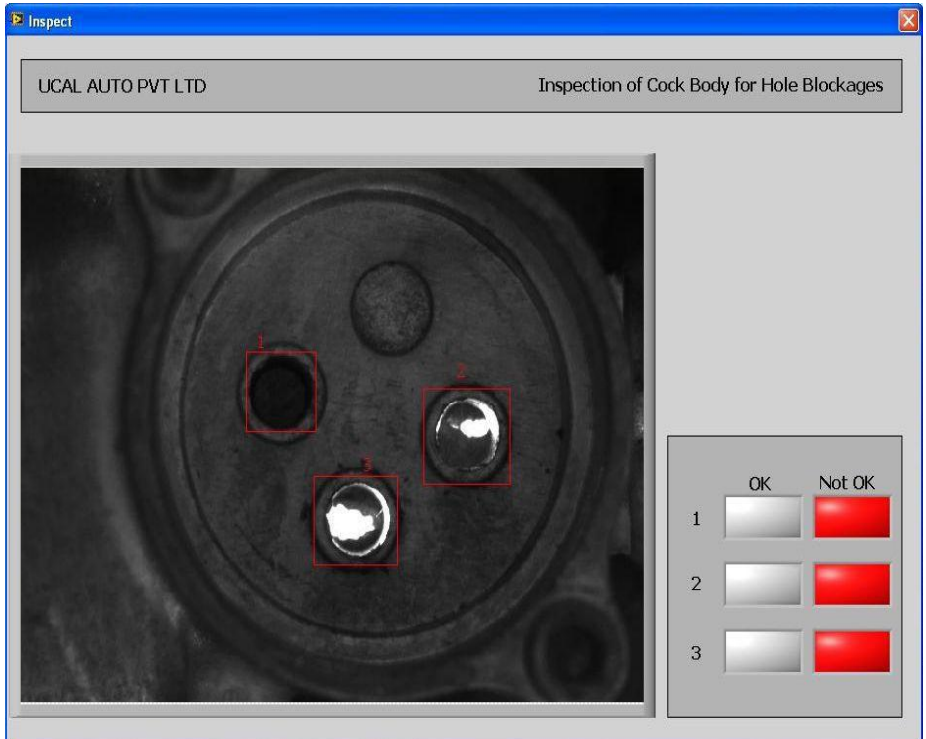
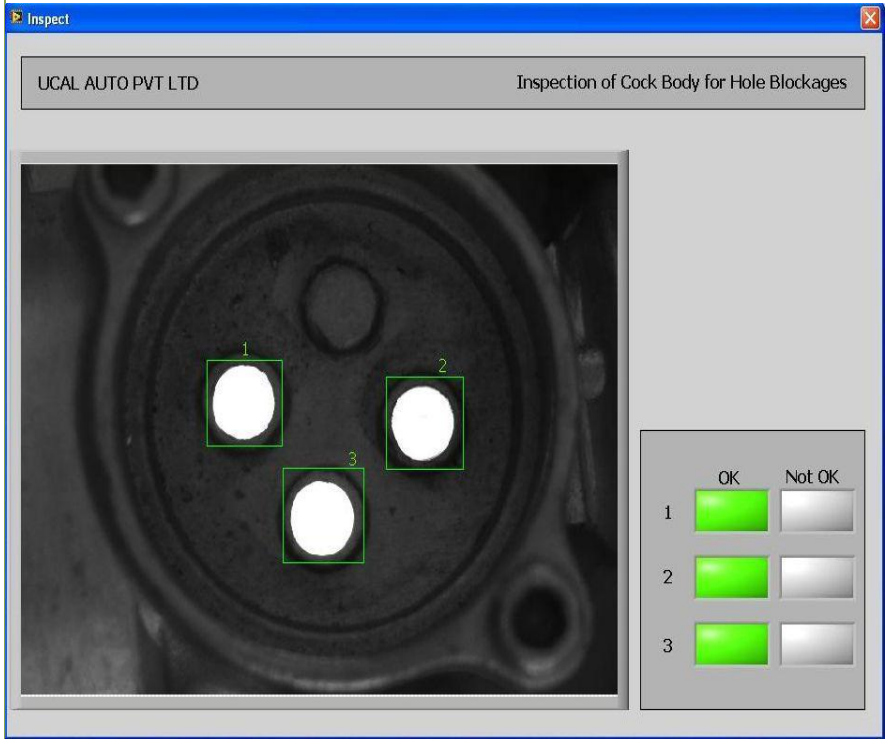
# Two Wheeler Fuel Cock Assembly

51



# Two Wheeler Fuel Cock Assembly

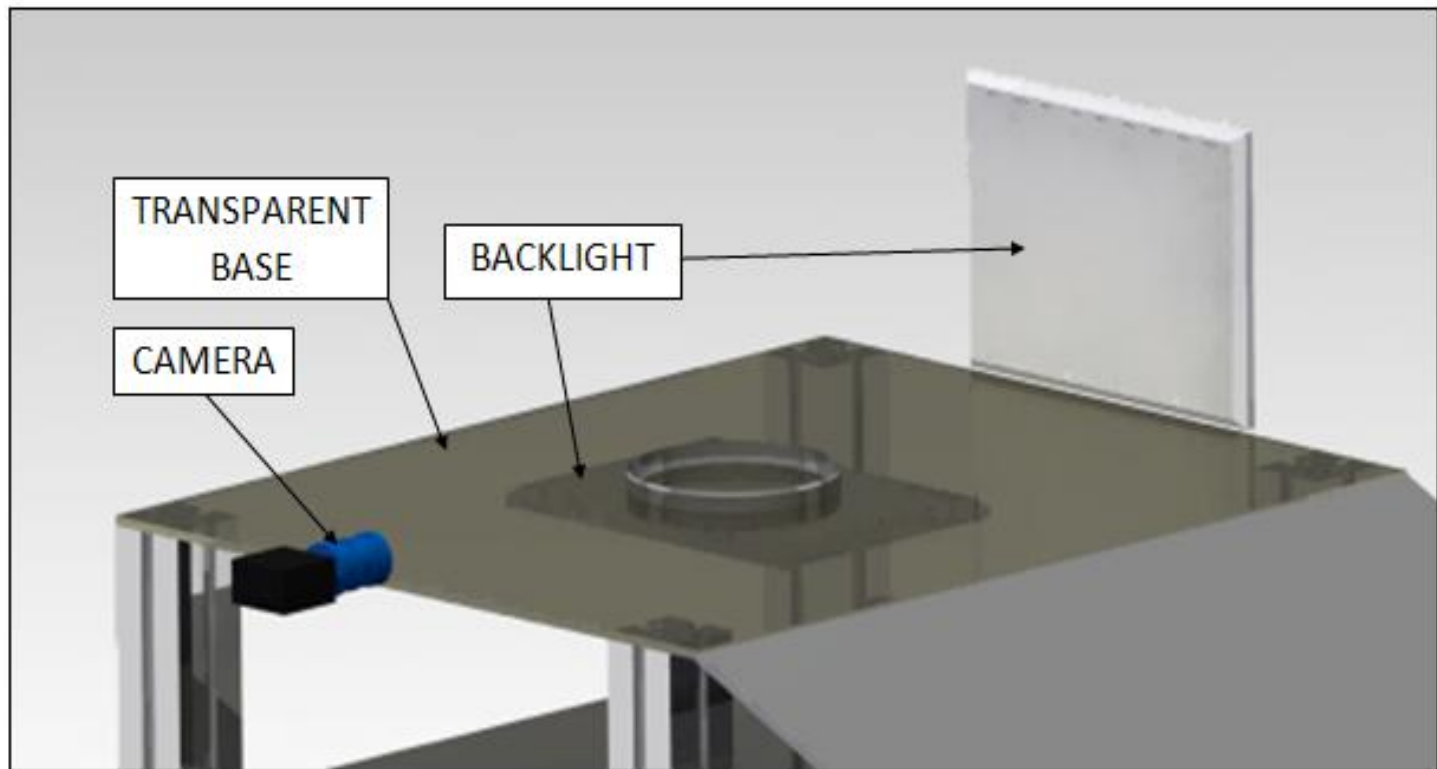
52



# Metal Inserts Inspection

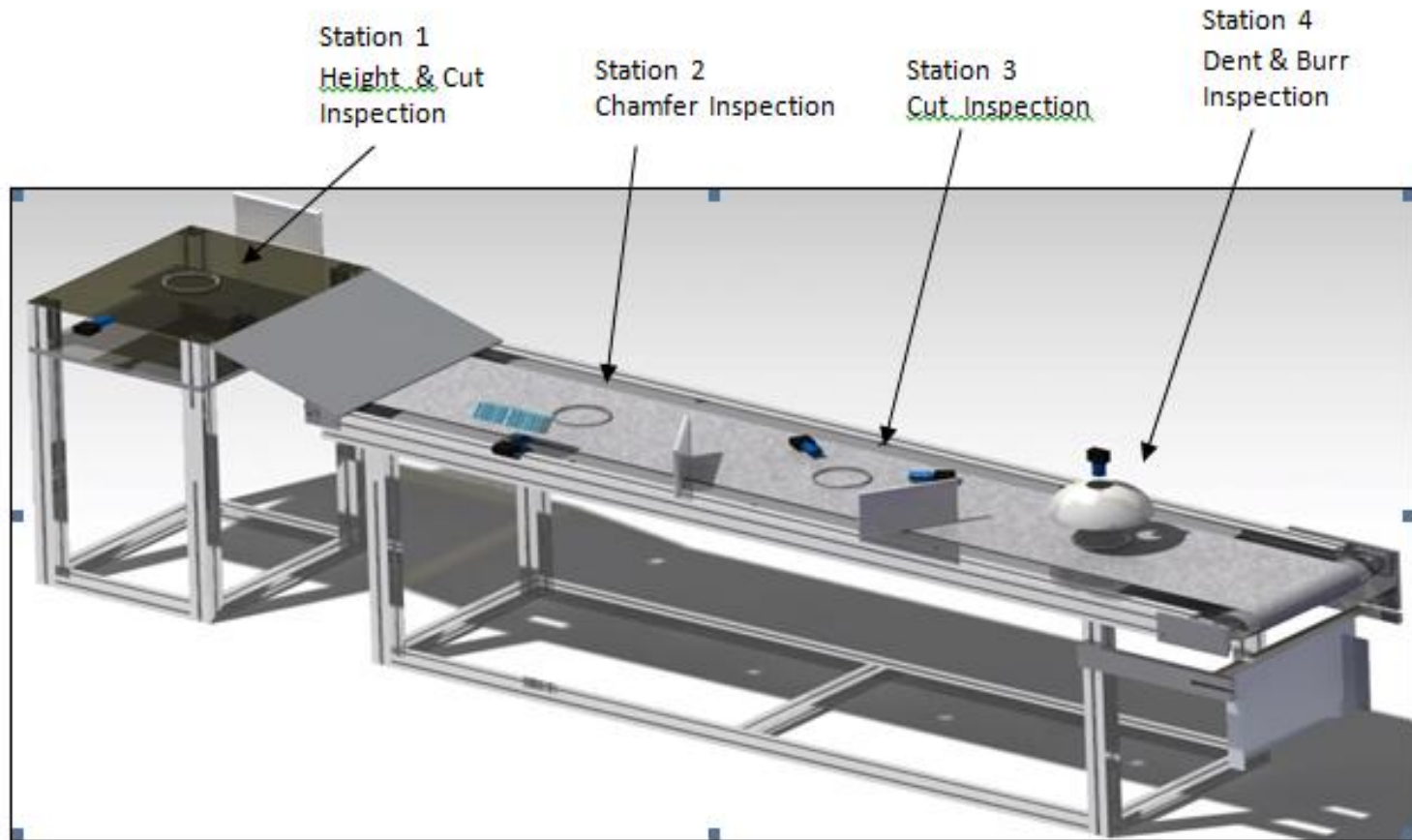
53

Missing chamfer, Height variation, Cut, Dent, Burr



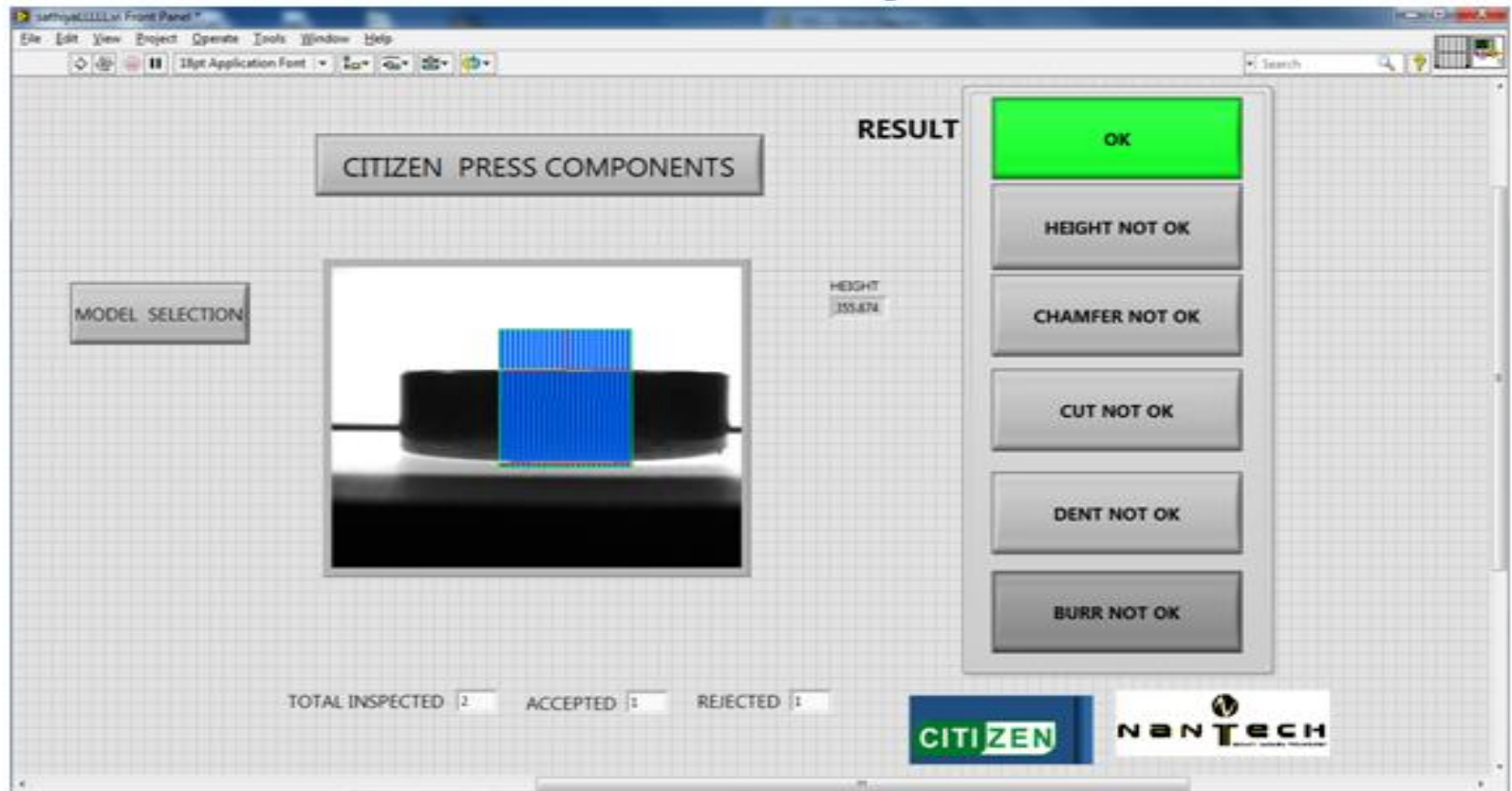
# Automation Set Up

54



# Height Inspection

55



# Height Not OK

56

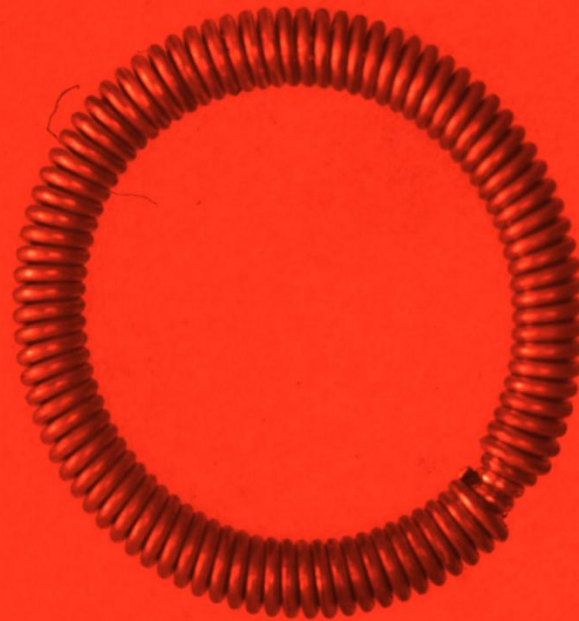
The screenshot displays a software application window titled "sathya.LLLL at Front Panel". The interface includes a menu bar (File, Edit, View, Project, Operate, Tools, Window, Help) and a toolbar with various icons. The main workspace is a grid with a central 3D model of a component. A blue rectangular area is overlaid on the model, indicating a specific feature being inspected. To the left of the model is a "MODEL SELECTION" button. Above the model is a label "CITIZEN PRESS COMPONENTS". To the right of the model, the text "HEIGHT 178.498" is displayed. On the right side of the interface is a "RESULT" panel containing several buttons: "OK", "HEIGHT NOT OK" (highlighted in red), "CHAMFER NOT OK", "CUT NOT OK", "DENT NOT OK", and "BURR NOT OK". At the bottom of the interface, there are counters for "TOTAL INSPECTED 4", "ACCEPTED 2", and "REJECTED 2". Logos for "CITIZEN" and "NANTECH" are located at the bottom right.



# Spring Quality Inspection

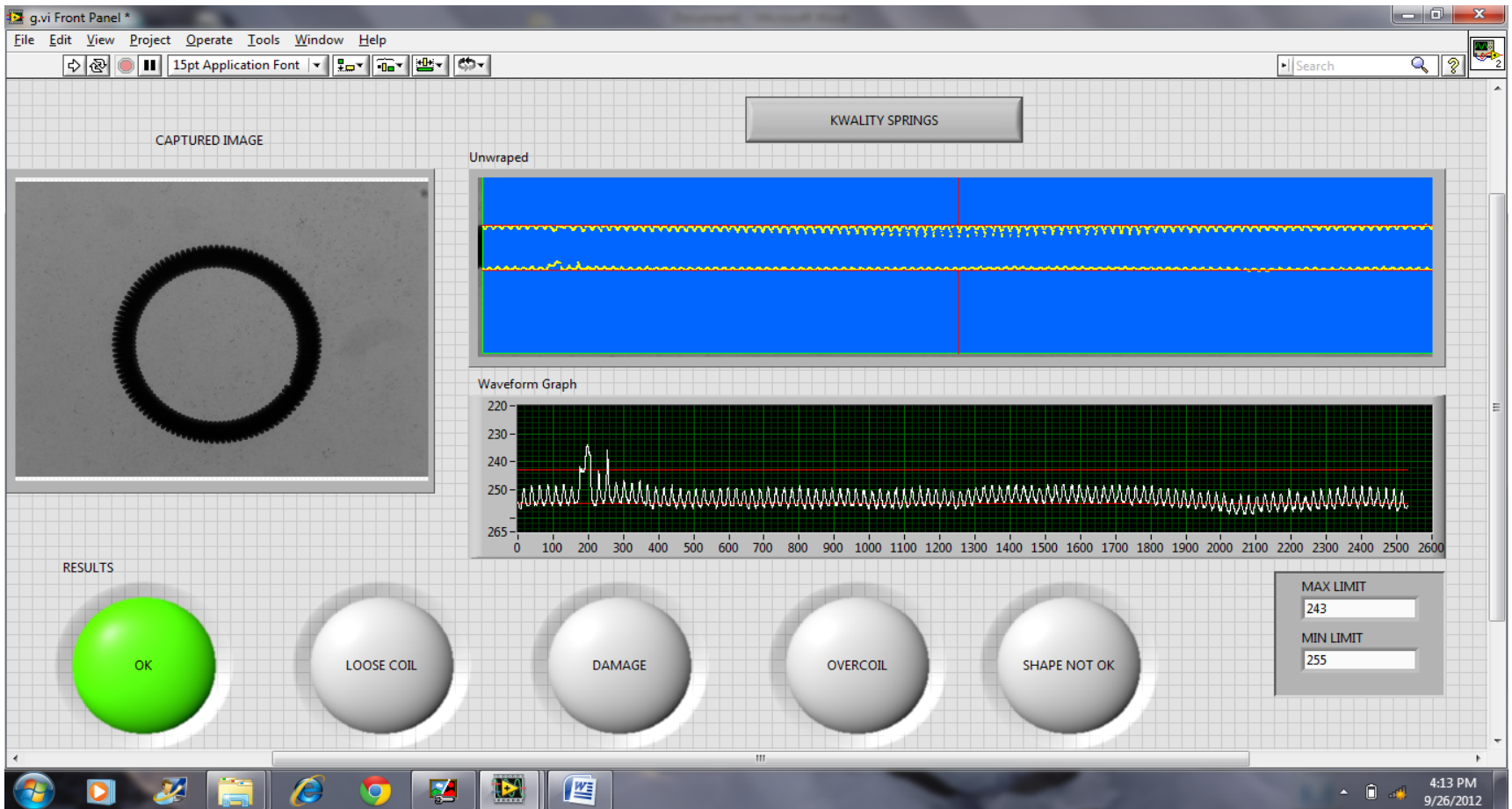
57

- **Loose Coil**
- **Over Coil**
- **Waviness**
- **Damage**



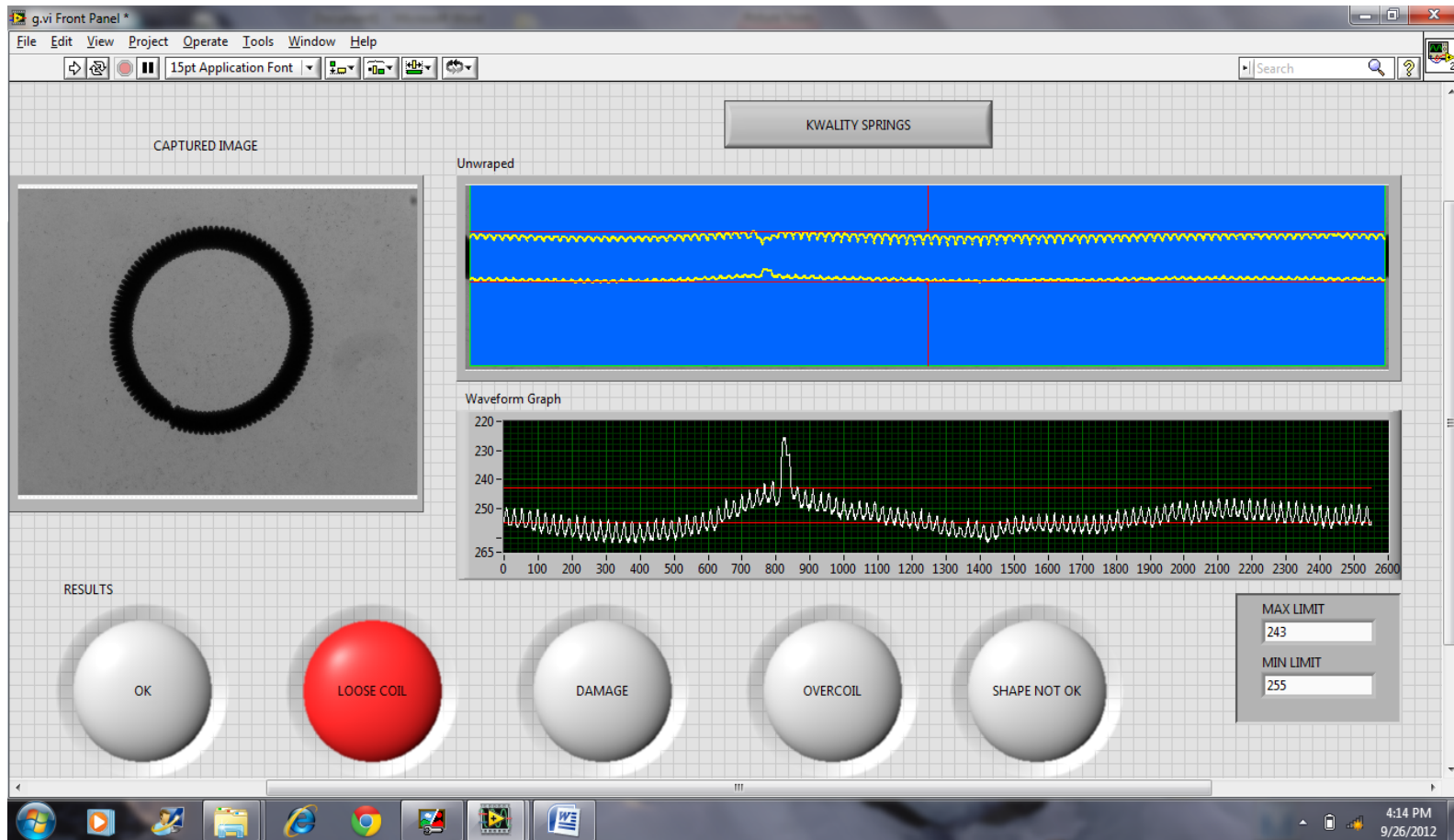
# Spring Quality Inspection

58



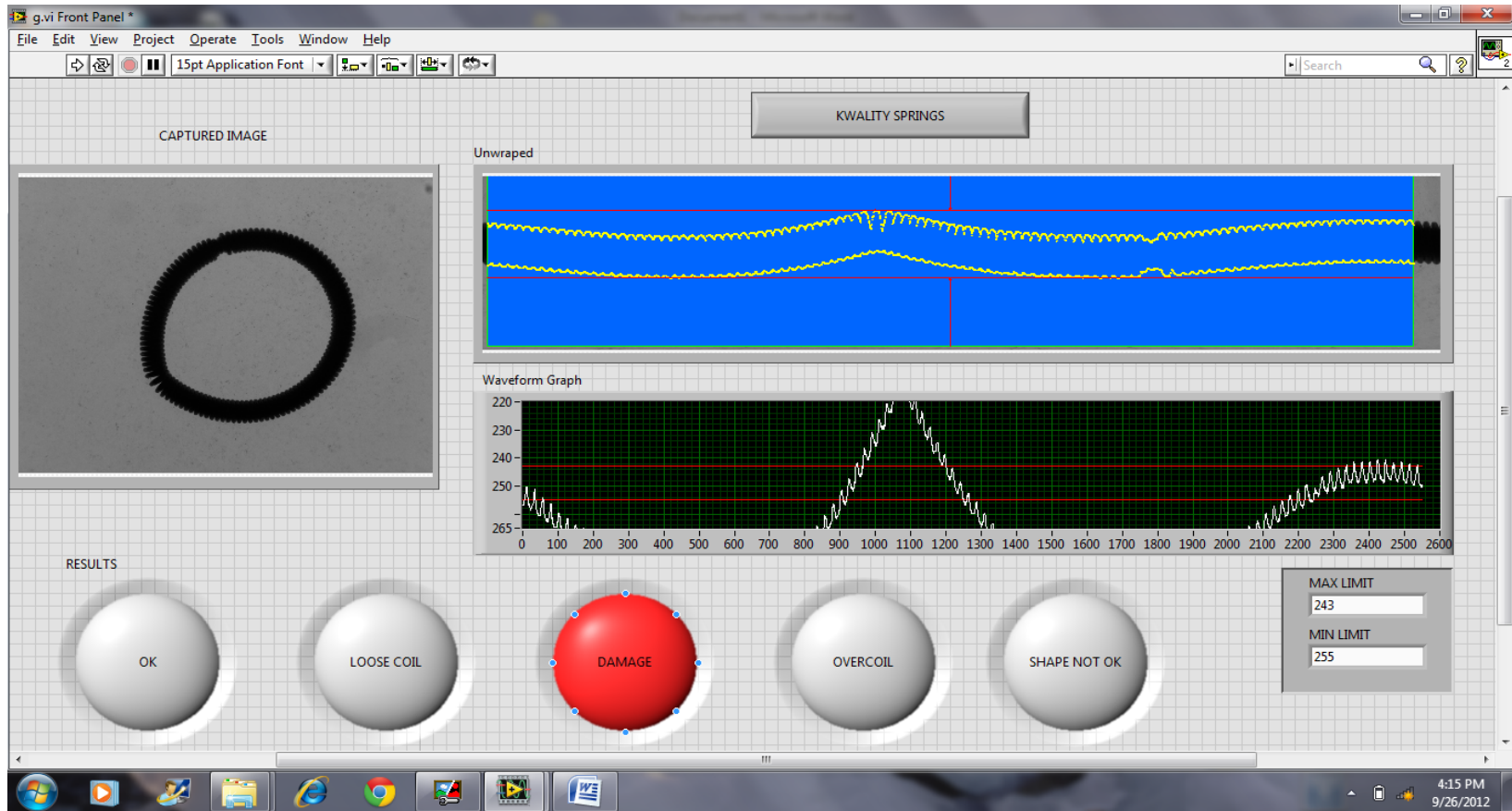
# Spring Quality Inspection

59



# Spring Quality Inspection

60



# Bar Code and Embossed OCR Comparison

61



# Bar Code and Embossed OCR Comparison


62

Inspect

### Royal Enfield

Matching of Barcode Label and Tappet

Camera 1




ROYAL ENFIELD  
U3S5C0CH173161  
Model Code: 861309  
Model Desc: CLASSIC 350 DOMESTIC

Barcode Read

U3S5C0CH173161

Camera 2



TWINS PARK  
350

OCR Read

350

Status

Inspection Status


Total : 2  
OK : 1  
Not OK : 1

Inspect

### Royal Enfield

Matching of Barcode Label and Tappet

Camera 1




ROYAL ENFIELD  
U3S5C0CH173161  
Model Code: 861309  
Model Desc: CLASSIC 350 DOMESTIC

Barcode Read

U3S5C0CH173161

Camera 2



TWINS PARK  
EFI-500

OCR Read

EFI-500

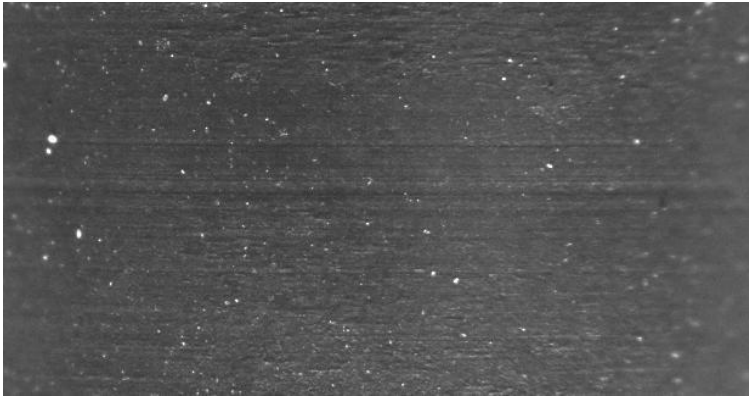
Status

Inspection Status

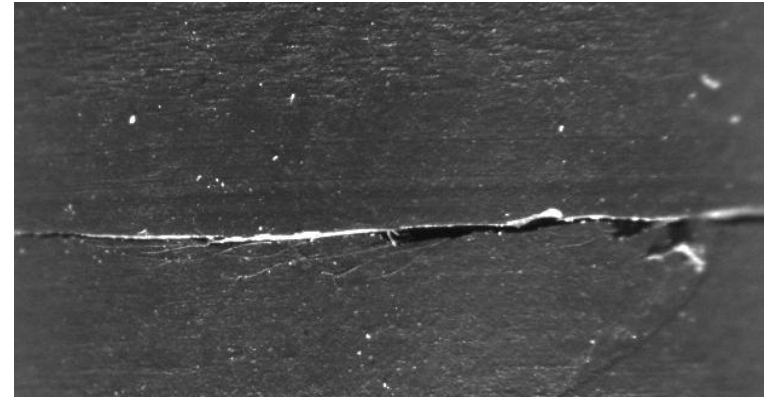
Total : 2  
OK : 1  
Not OK : 1

# Texture Analysis

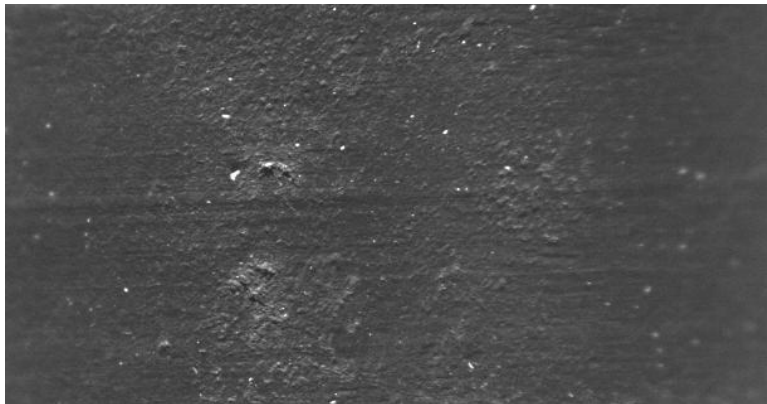
63



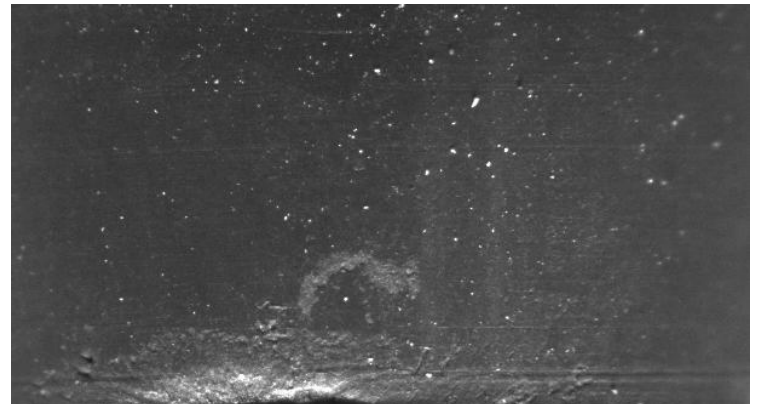
a. Good textured surface



b. Surface with crack



c. Surface with blow holes



d. Surface with blemishes

# Texture Analysis

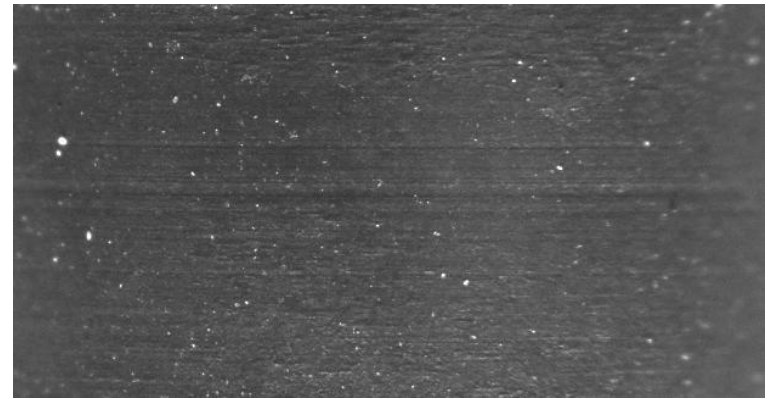
64

## Image Processing steps

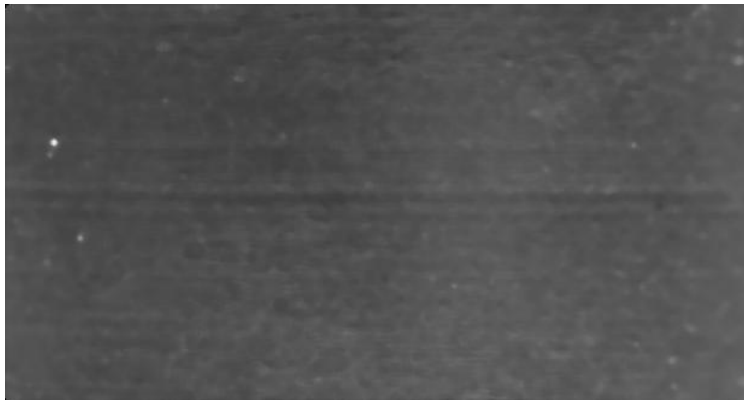
- Preprocessing

It involved removal of dust particles based on surrounding pixels rather than using median filter.

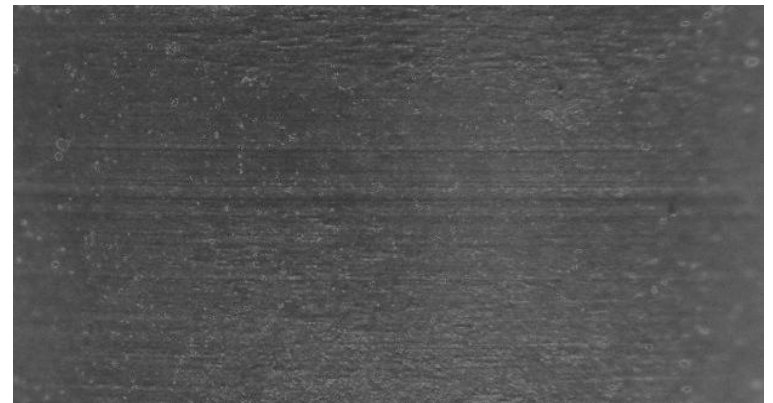
- Texture analysis based on GLCM



a. Input image



b. Output of median filter



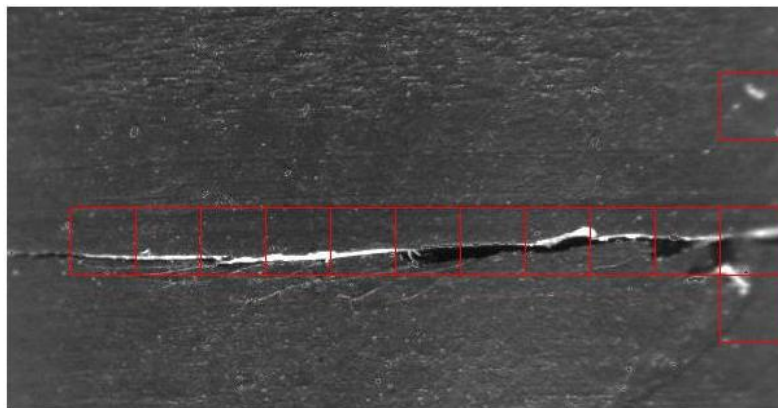
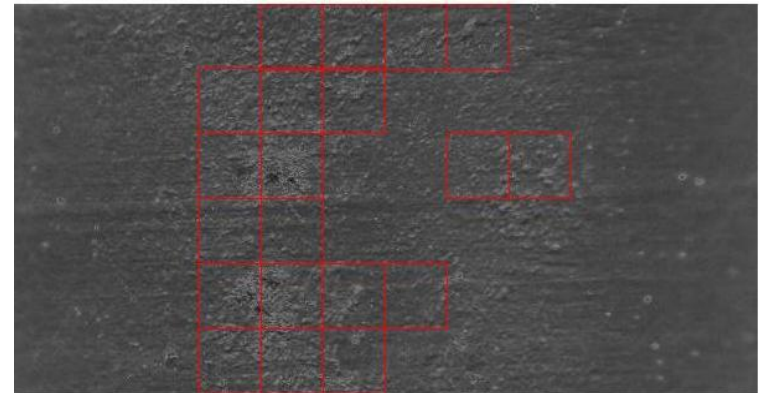
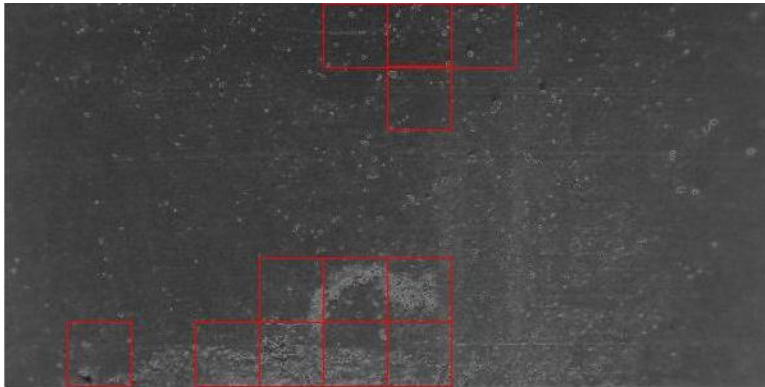
c. Output of preprocessing based on the surrounding pixels



# Texture Analysis

65

## Output of Texture Analysis

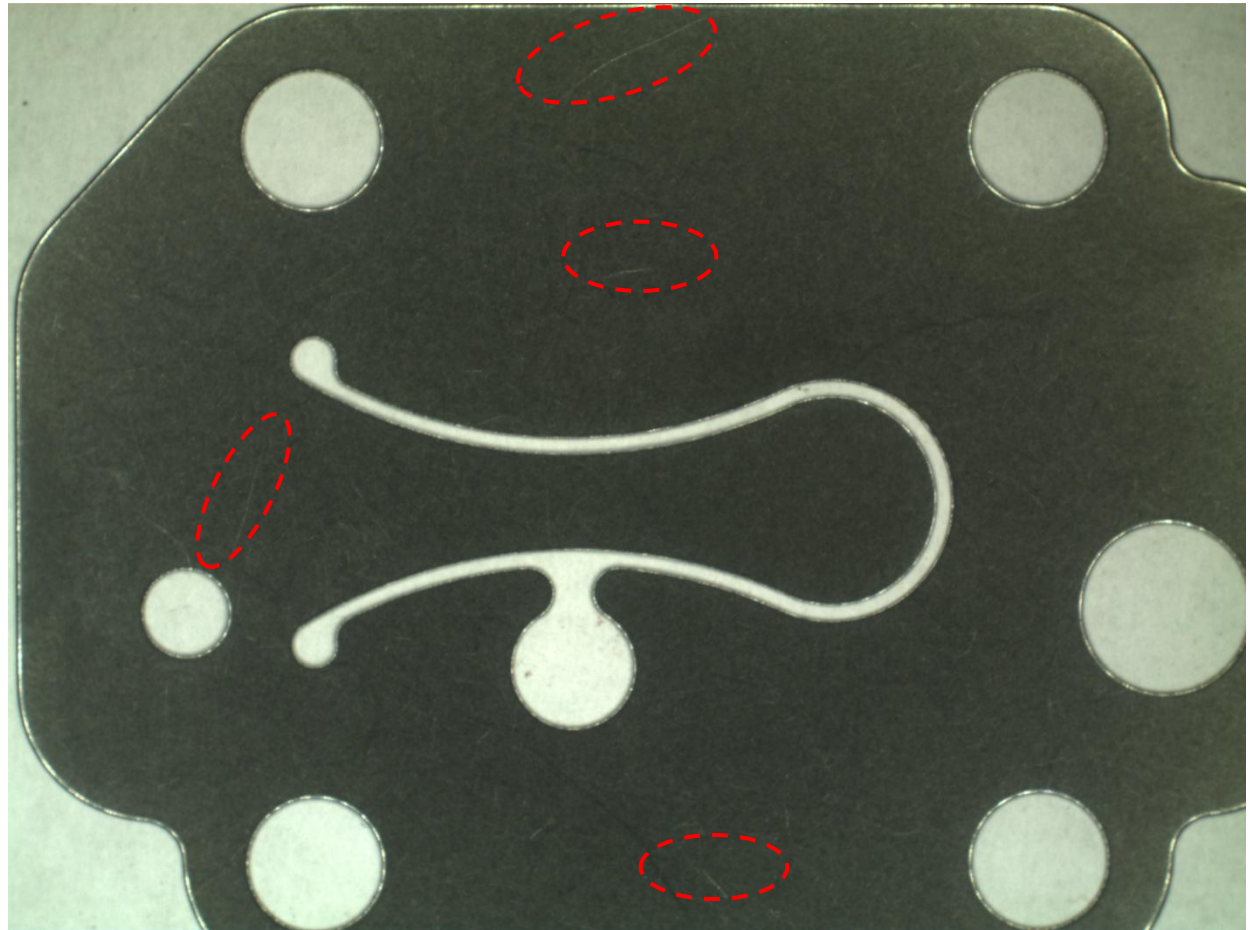


# Scratch detection

66

## Inspection Requirements:

To detect scratches on  
metal surface



# Scratch detection

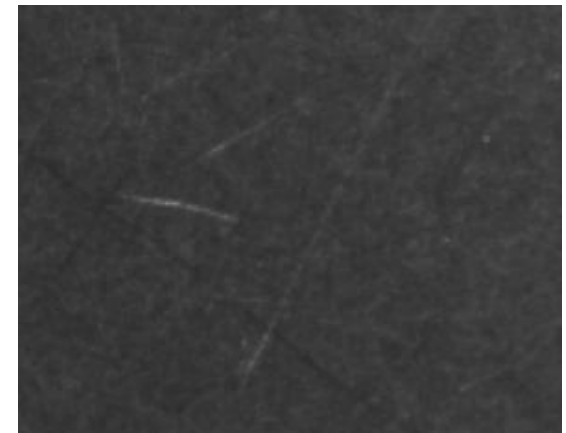
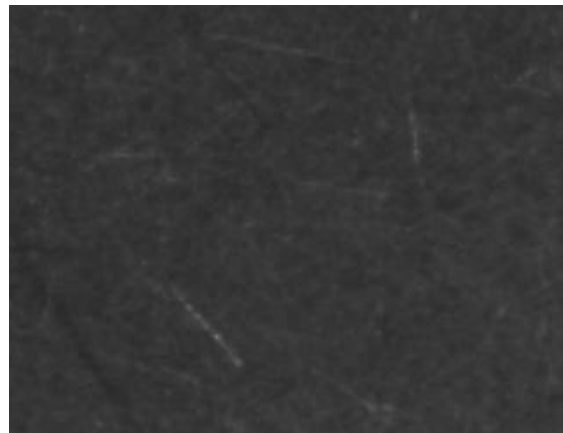
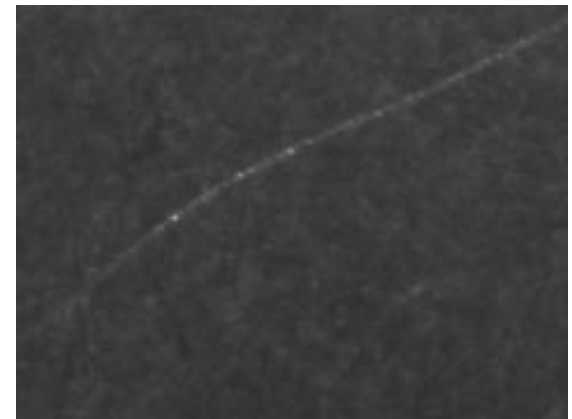
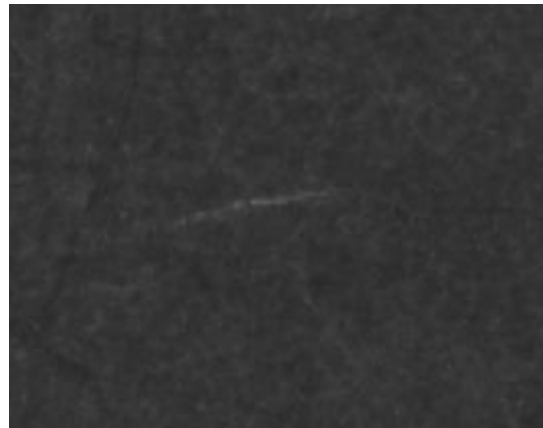
67

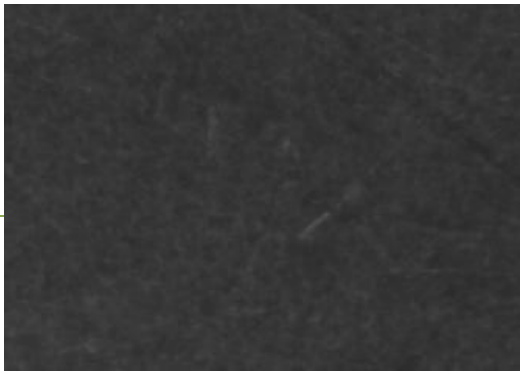
## Algorithm

Hausdorff dilation distance.

## Image processing steps

- Detection of band of intensity levels in iteration.
- Hausdorff dilation distance between the pixels between consecutive iterations.

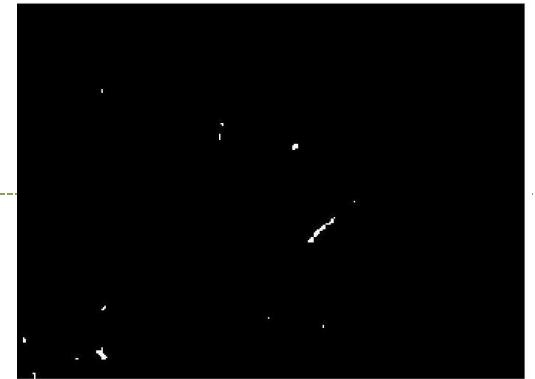




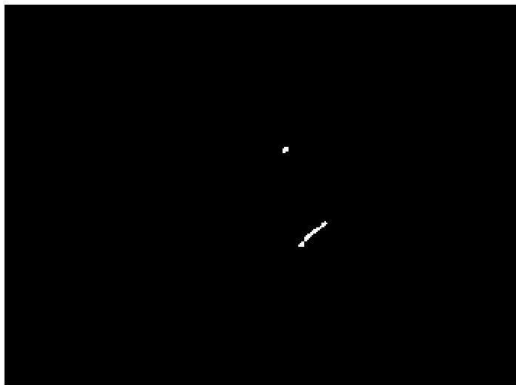
**(a) Gray level image**



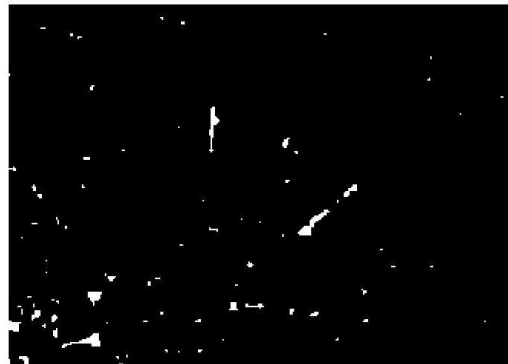
**(b) Binary image at first iteration**



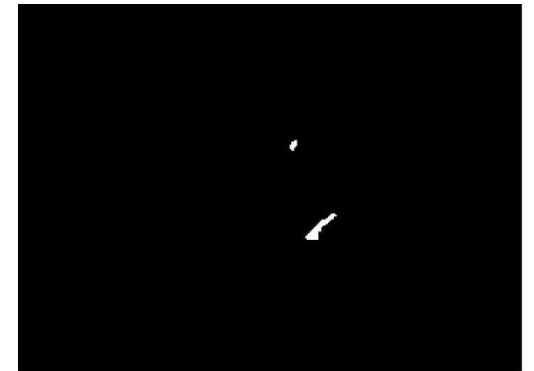
**(c) Binary image at second iteration**



**(d) Image obtained after computing Hausdorff distance between (b) and (c)**



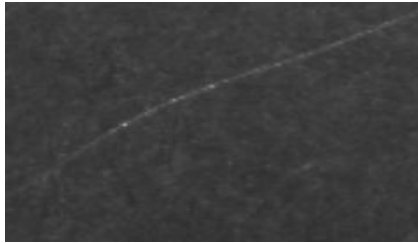
**(e) Binary image at third iteration**



**(f) final image (Image obtained after computing Hausdorff distance between (d) and (e))**

# Scratch detection

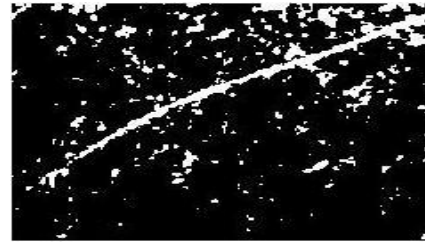
69



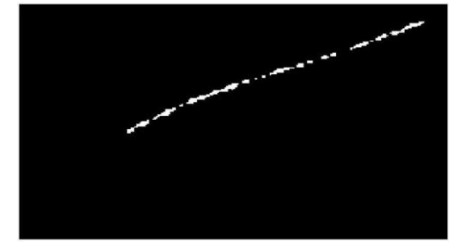
Input Image



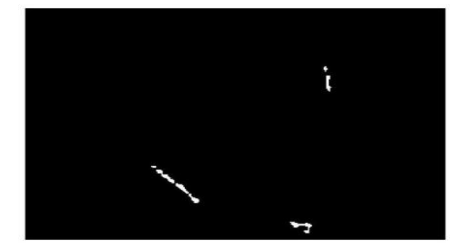
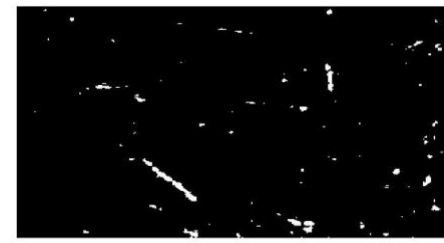
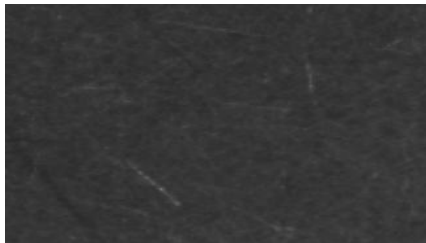
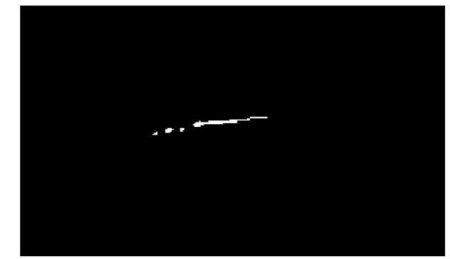
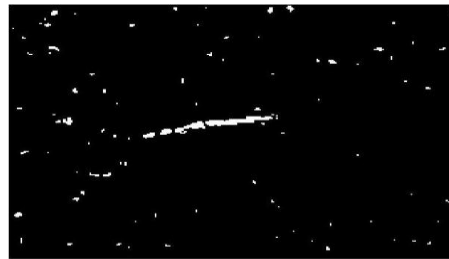
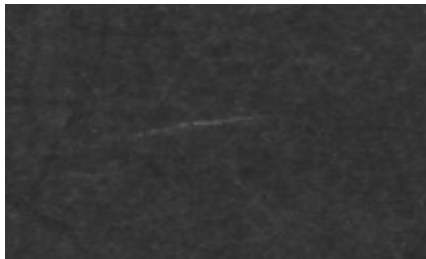
Triangle method  
(Histogram)



Global thresholding

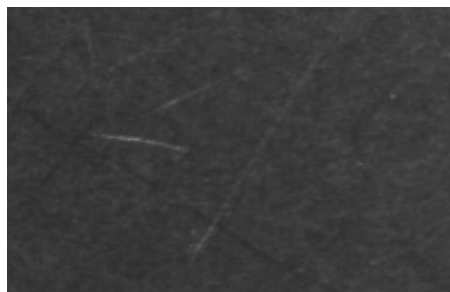
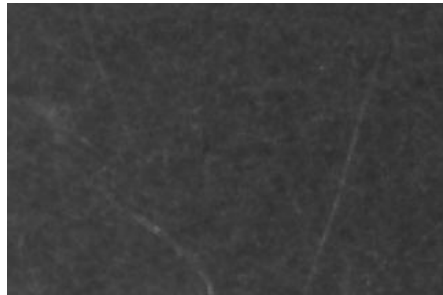
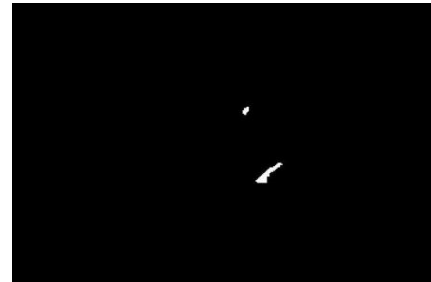
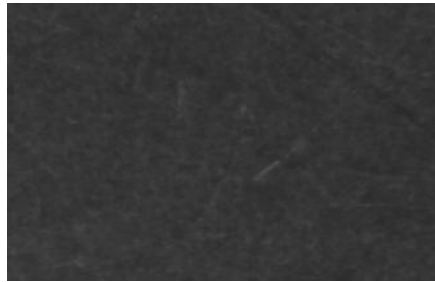


Based on hausdorff  
dilation distance



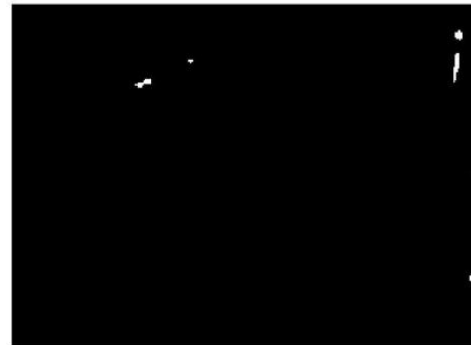
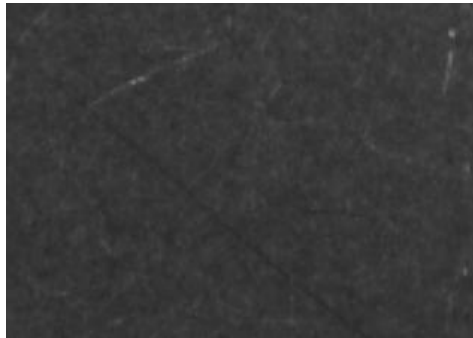
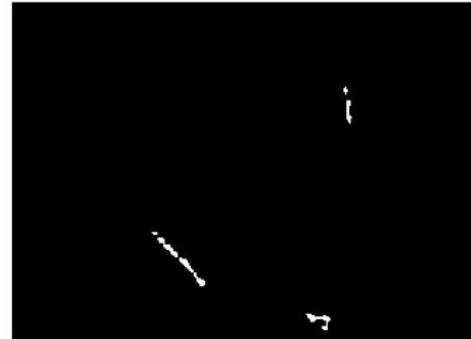
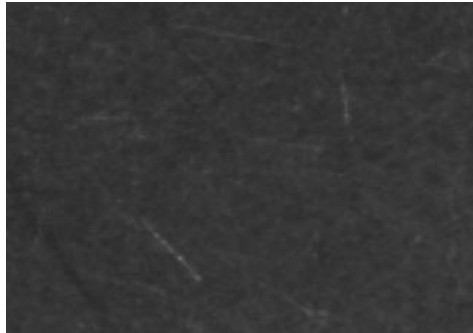
# Scratch detection

70



# Scratch detection

71



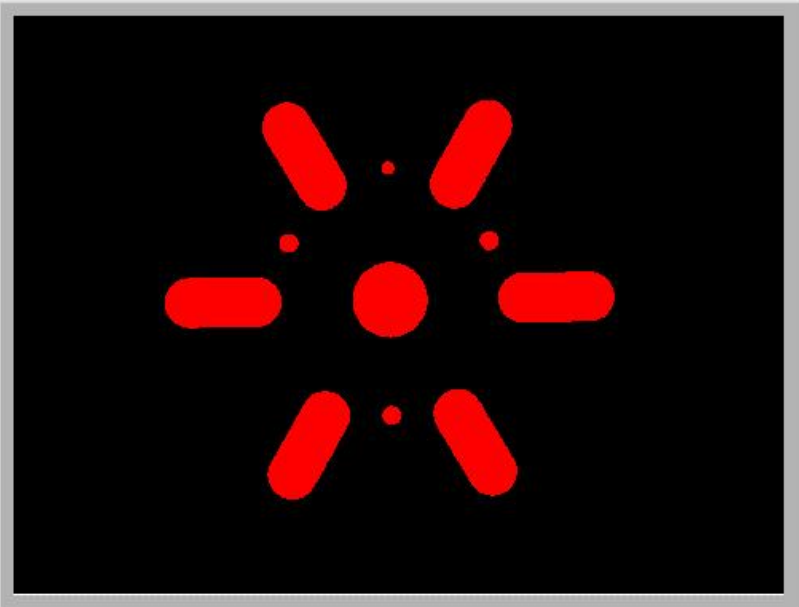
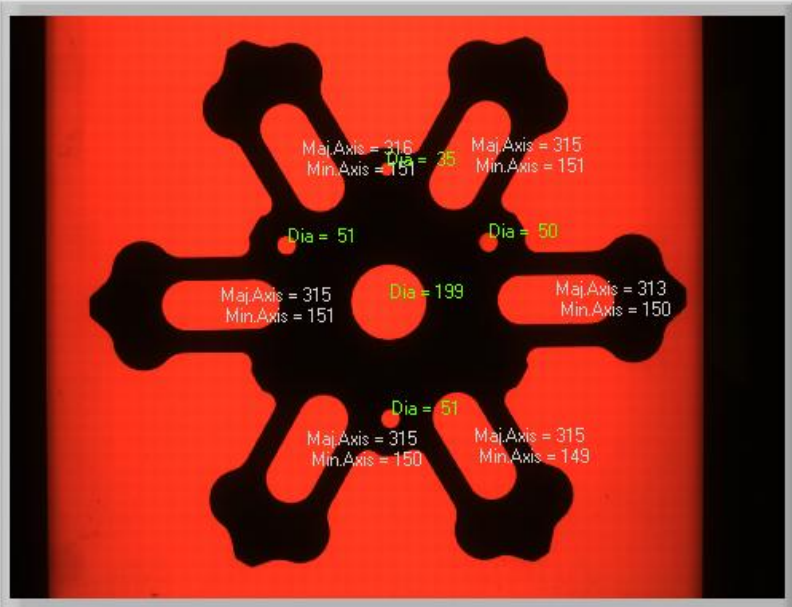
# Reed Valves

72

## Dimensional Verification of Valves

Captured

Processed



\* All Dimensions are in Pixels

Total Area in Pixels : 1096734

Number of Holes 11

OK

Not OK

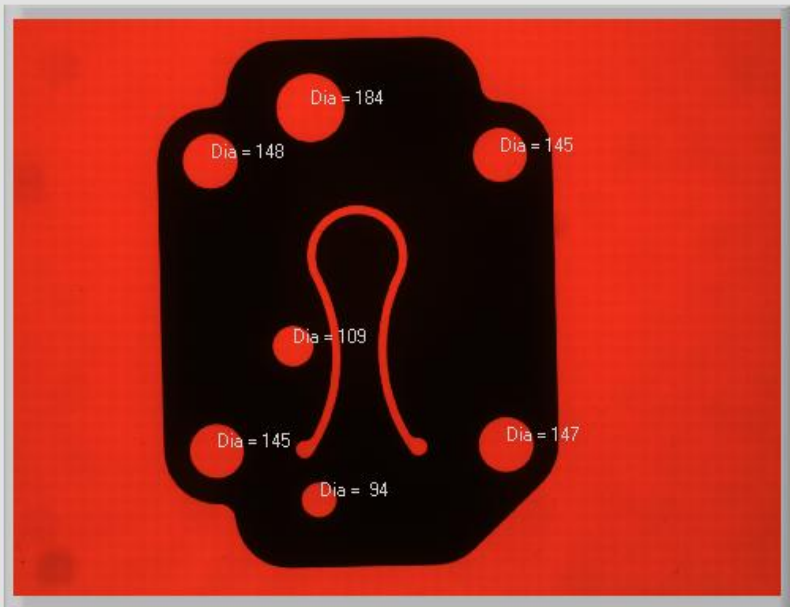


# Reed Valves

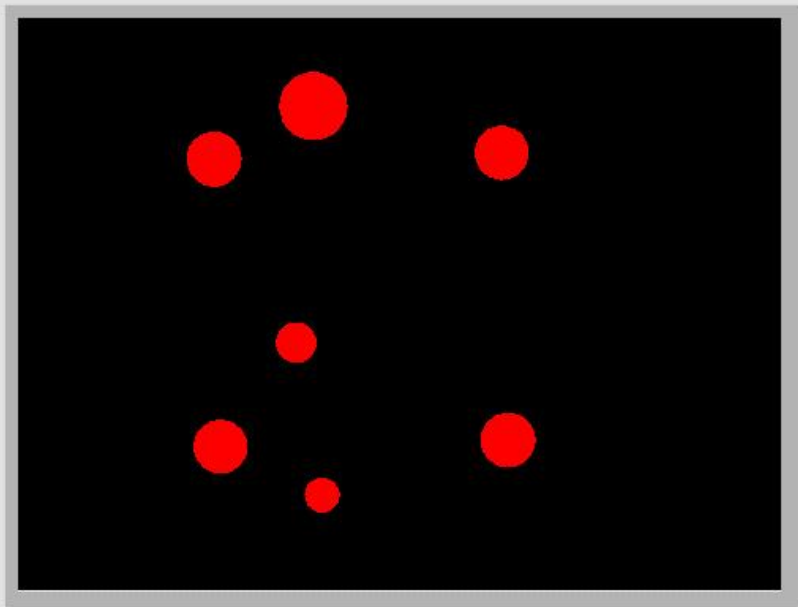
73

## Dimensional Verification of Valves

Captured



Processed



\* All Dimensions are in Pixels

Total Area in Pixels :

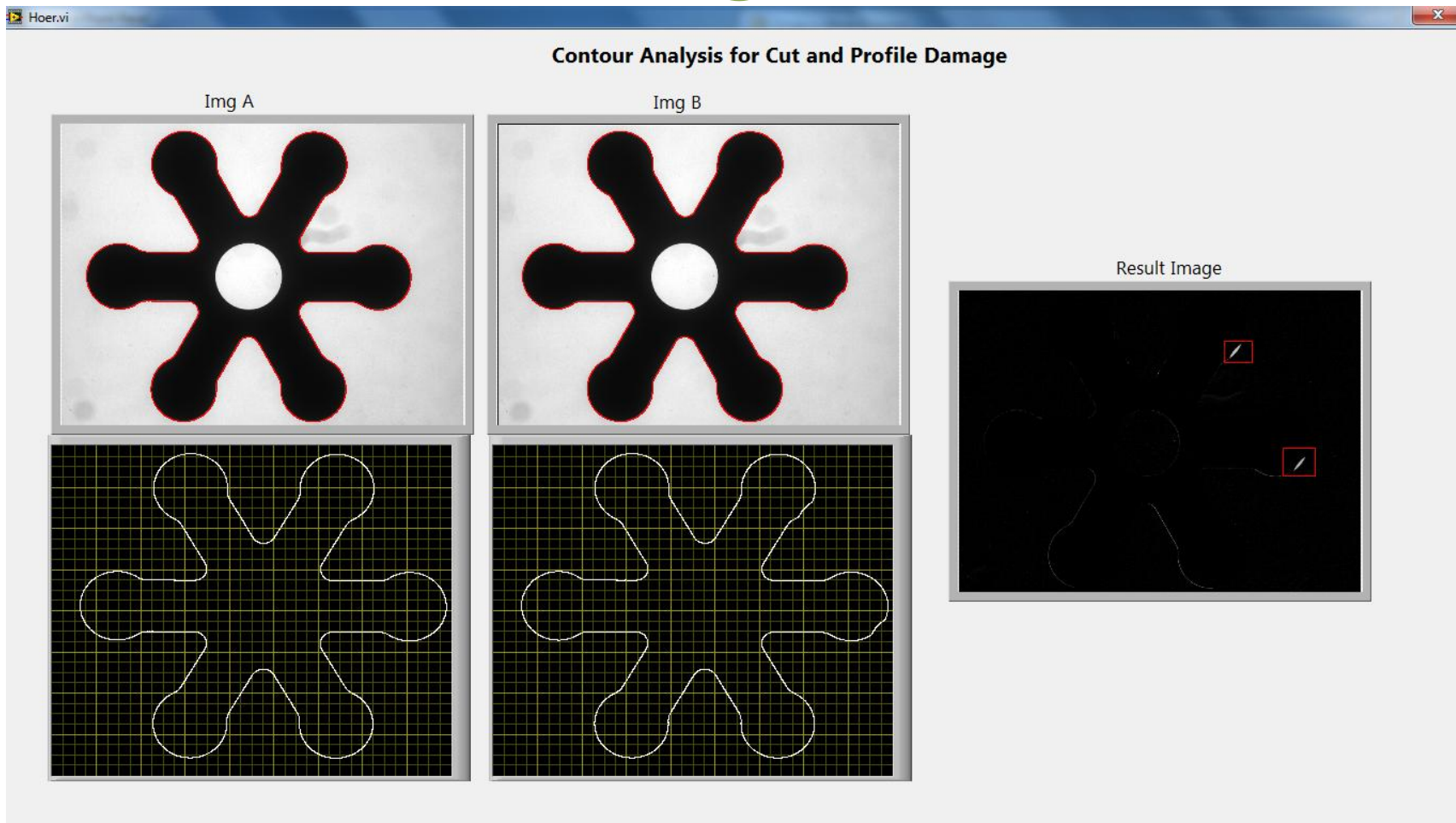
Number of Holes

OK

Not OK

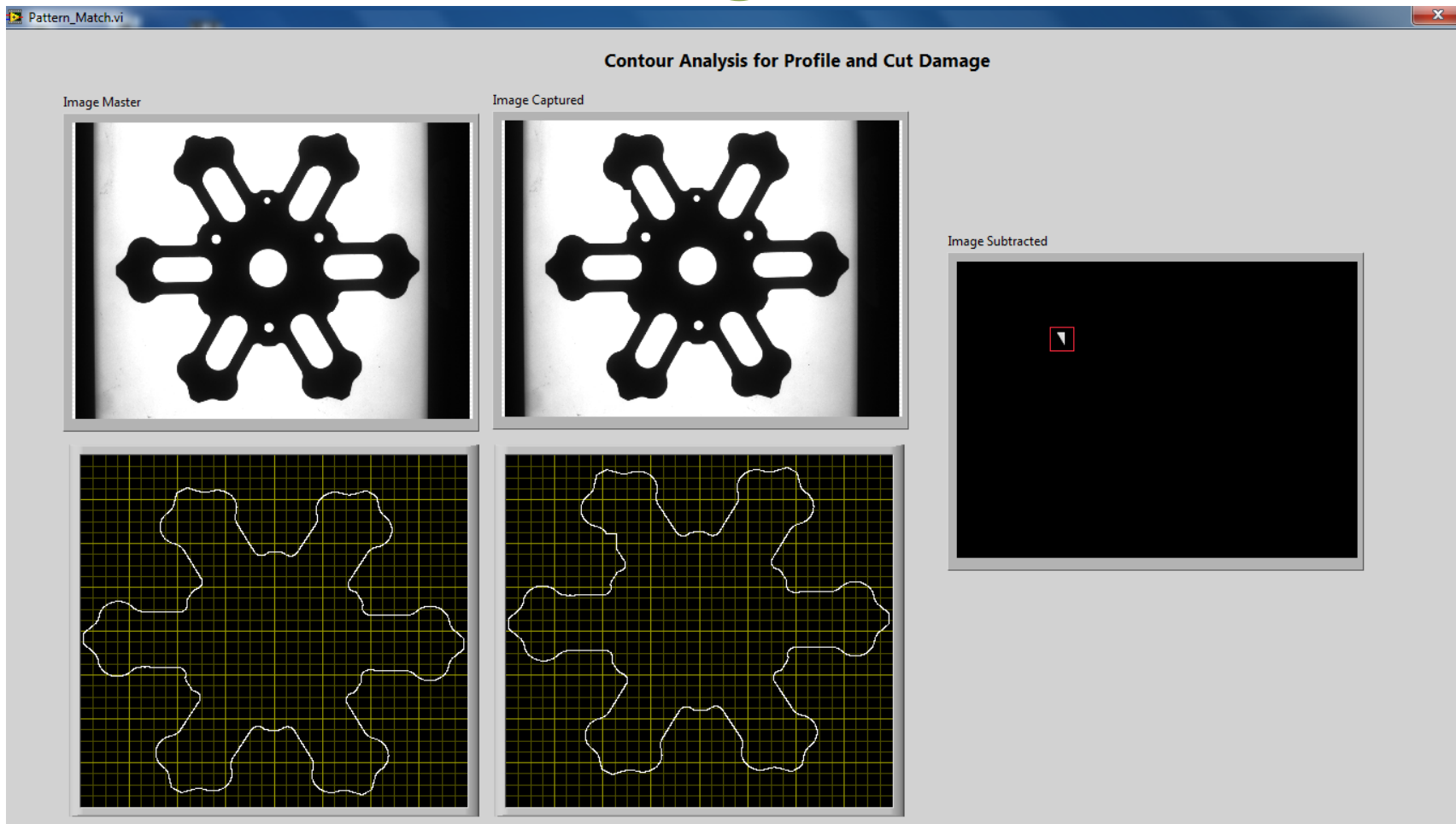
# Reed Valves

74



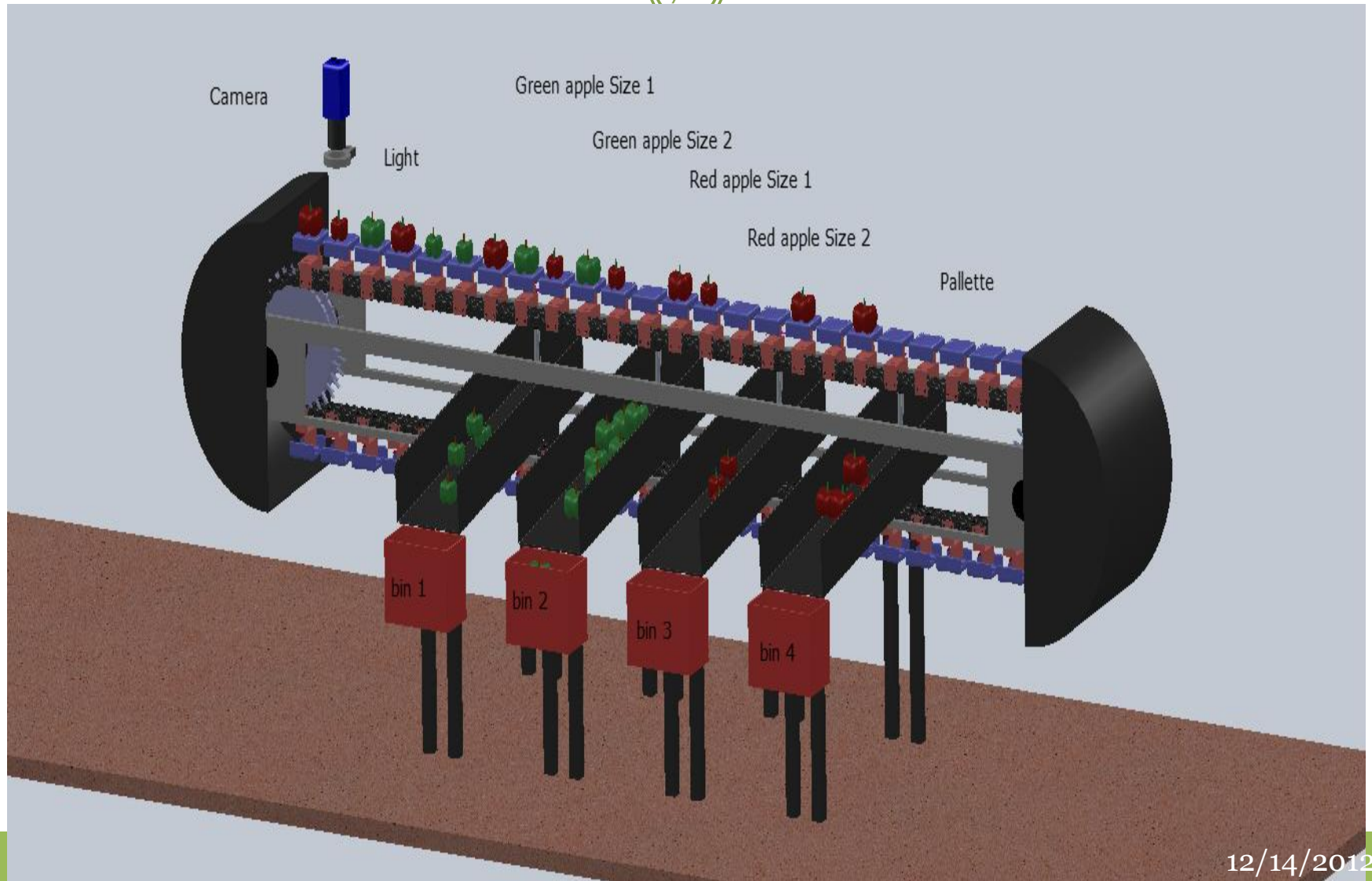
# Reed Valves

75



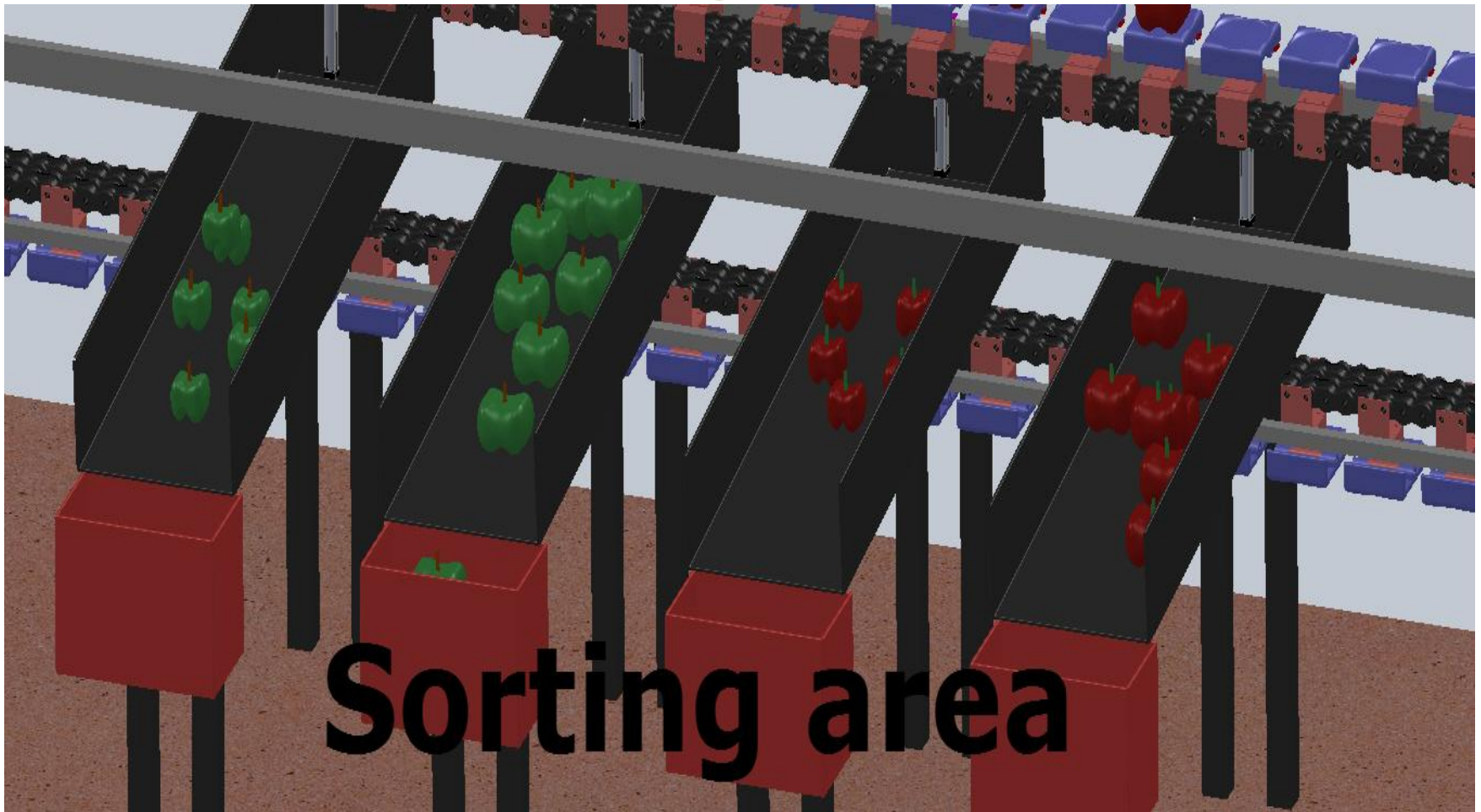
# Fruit Sorting Machine

76



# Fruit Sorting Machine

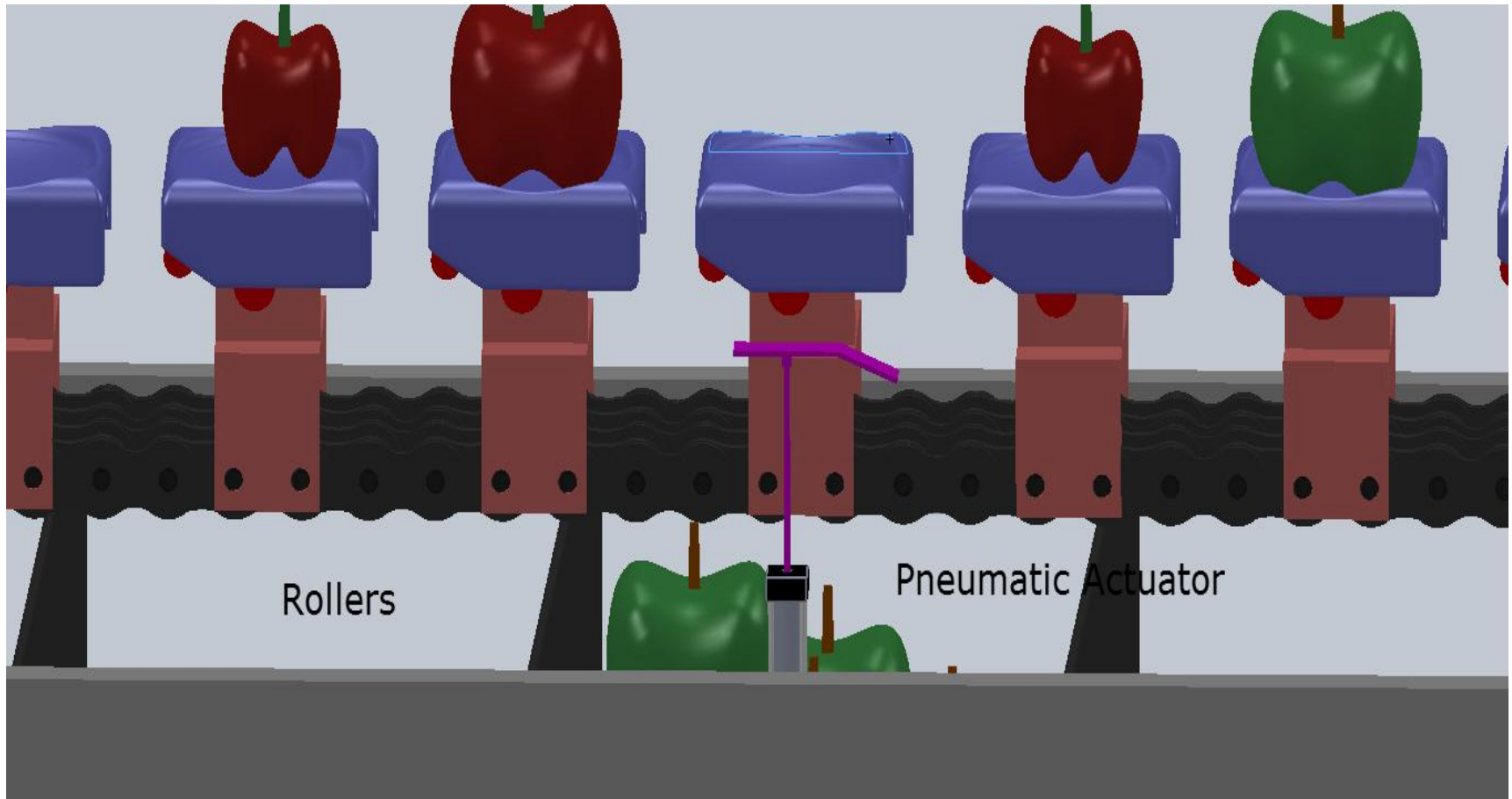
77



**Sorting area**

# Fruit Sorting Machine

78



79

# ELECTRONICS INDUSTRIES

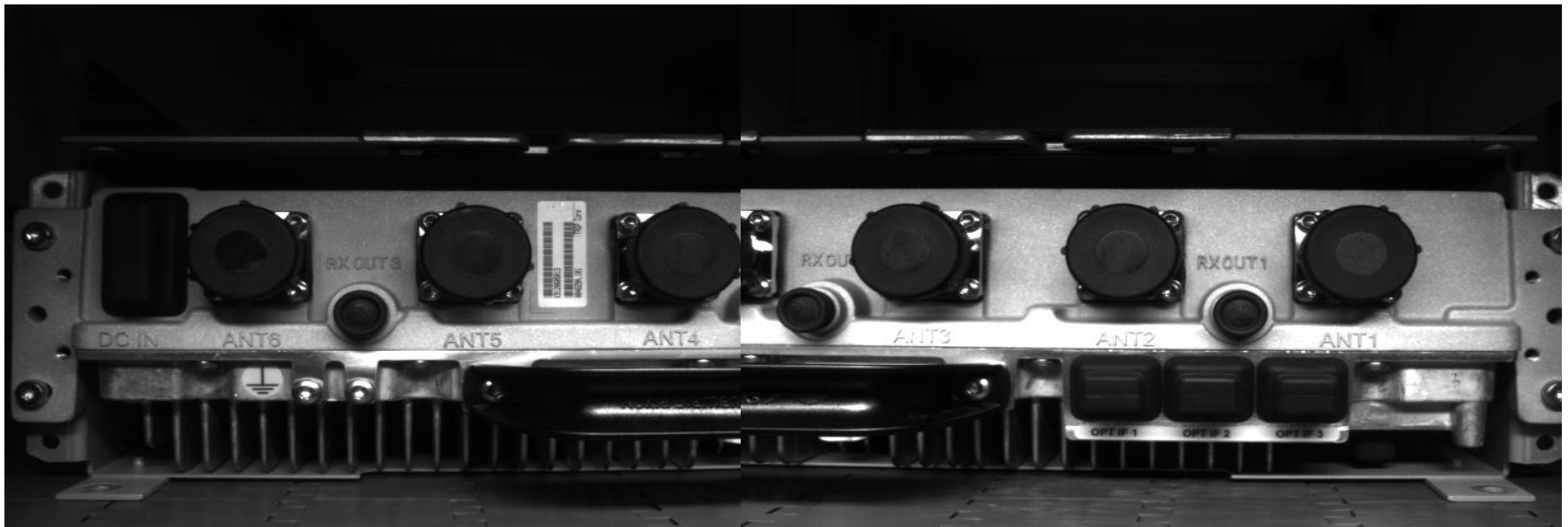
# 3G Equipment

80

## Inspection requirements:

- Cap Presence
- Label Presence, Position, Orientation
- Fan Presence

[Video](#)





# Inspection of 3G FRGP Unit

81

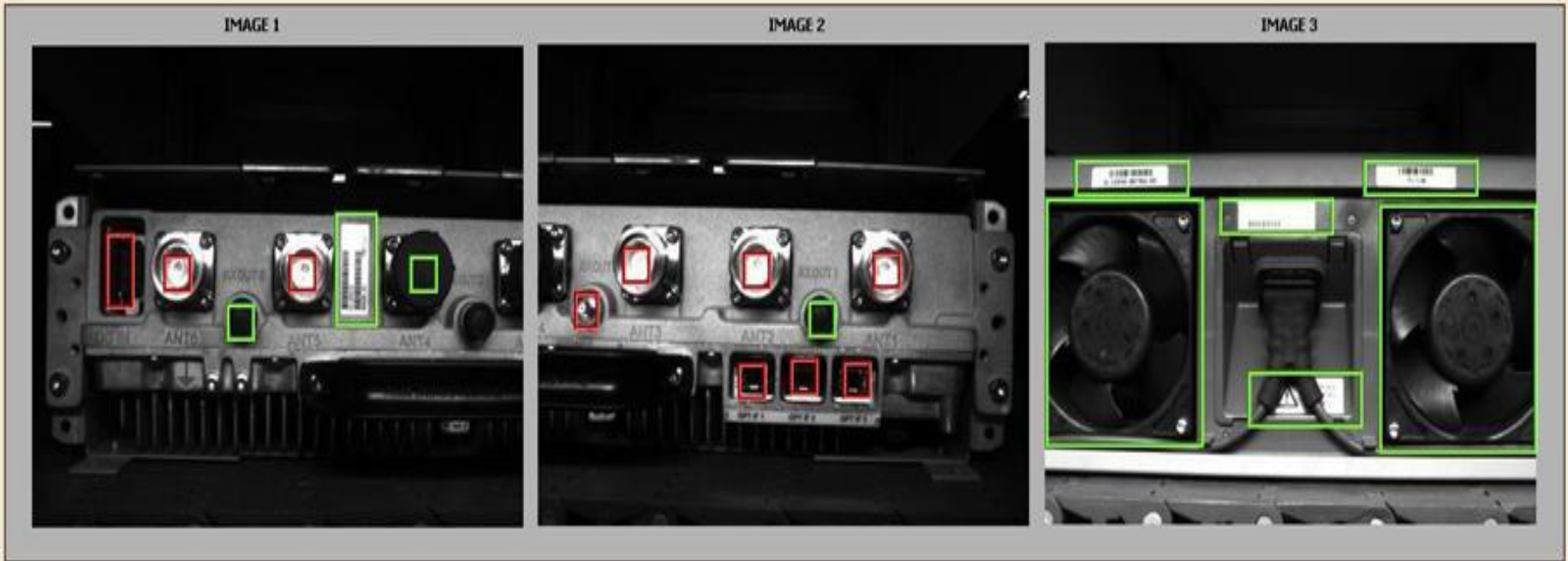


OK

Not OK

# Inspection of 3G FRGP Unit

82



OK

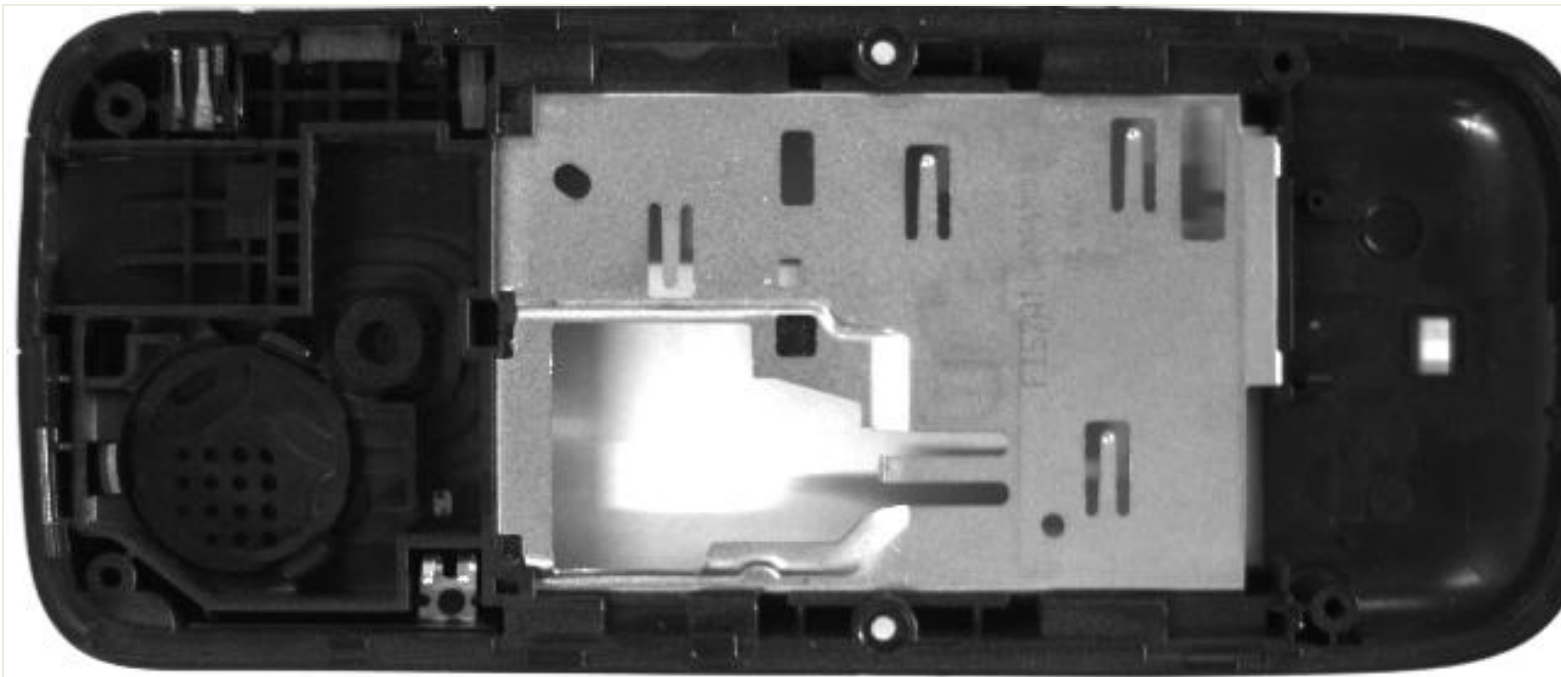
Not OK

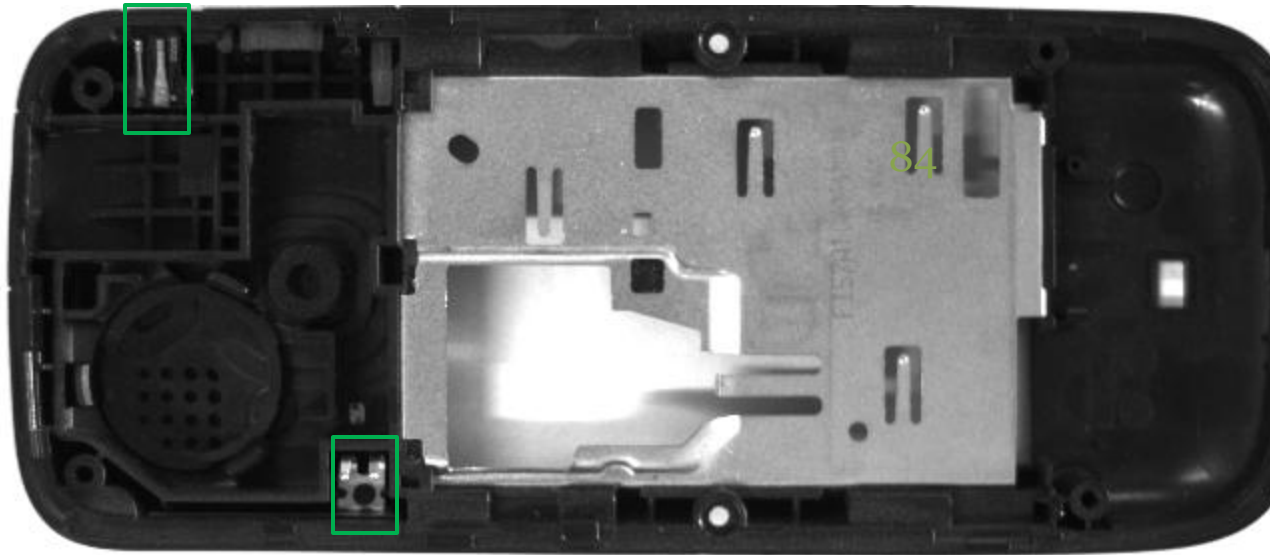
# Mobile Panel

83

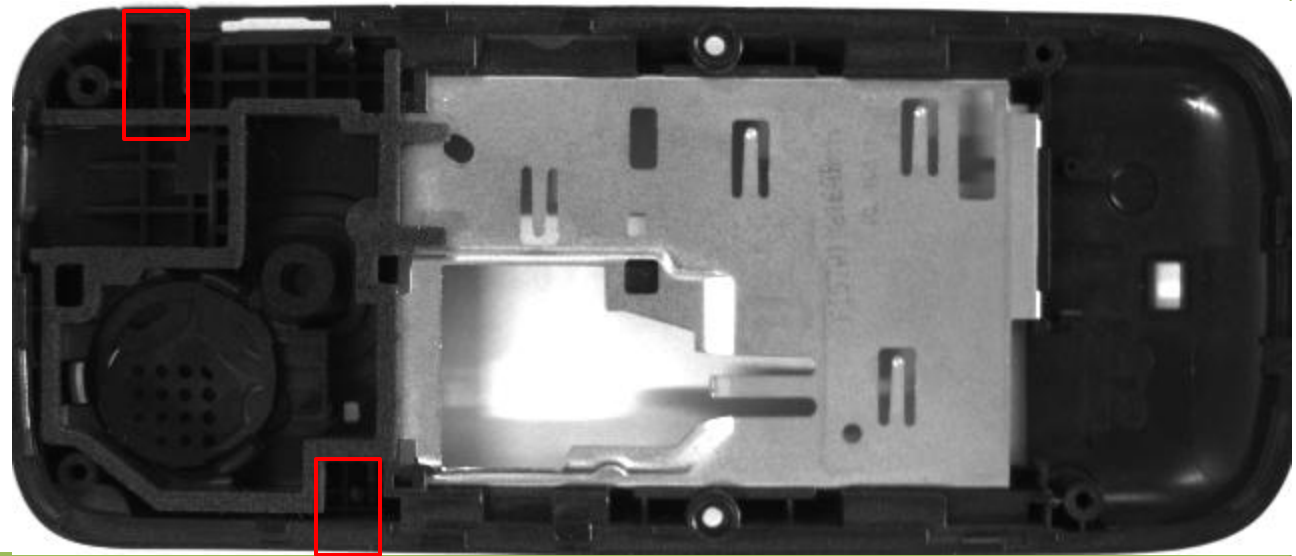
## Inspection requirements:

- Checking for Part Presence
- Dimensional Verification





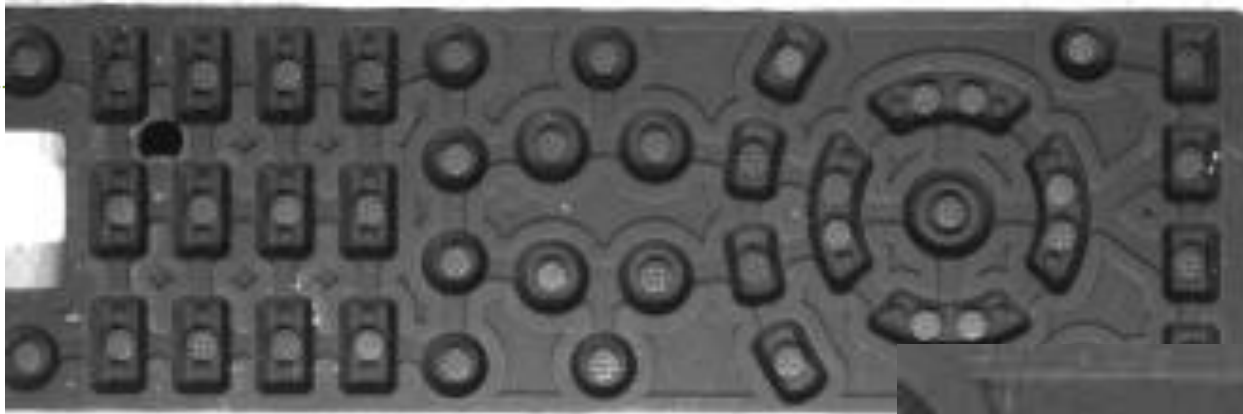
**OK**



**Not OK**

12/14/2012

# Applications – Yes/No



86

# PHARMA INDUSTRIES

# Cataract Lens

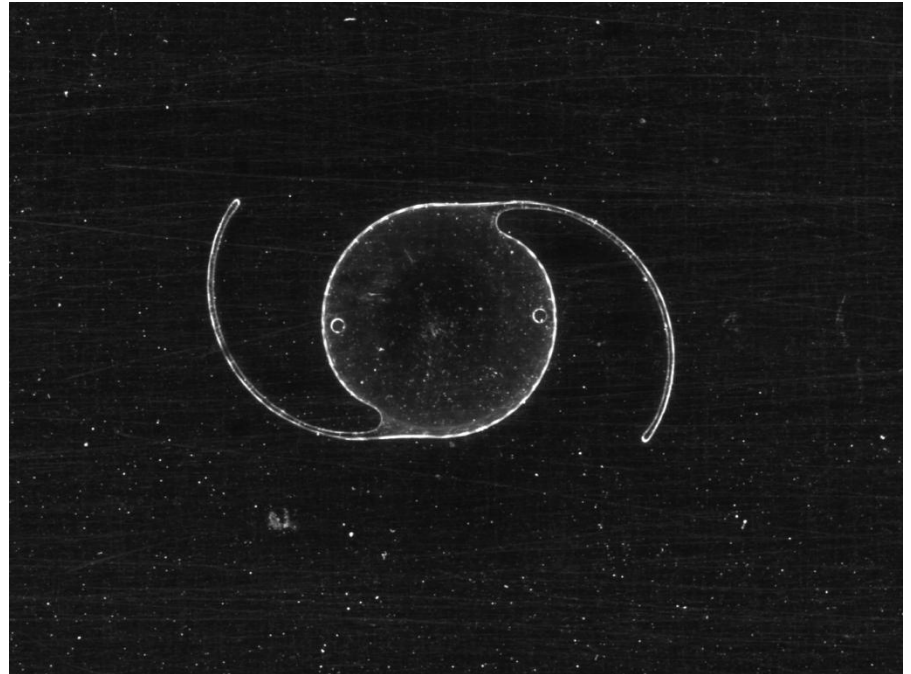
87

## Inspection Requirements:

To measure the radius of curvature of fixation members

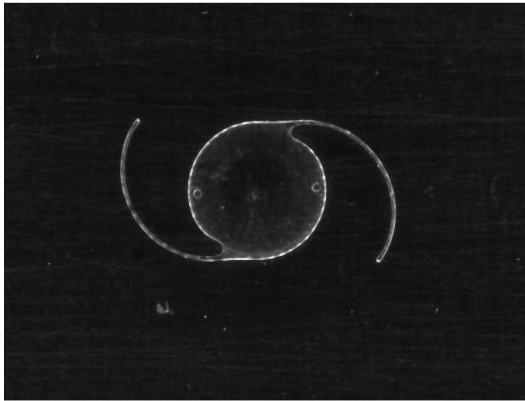
## Image Processing steps

- Median filter
- Gray level to binary
- Dilation
- Fill holes
- Erosion
- Image subtraction
- Contour detection
- Circle fit

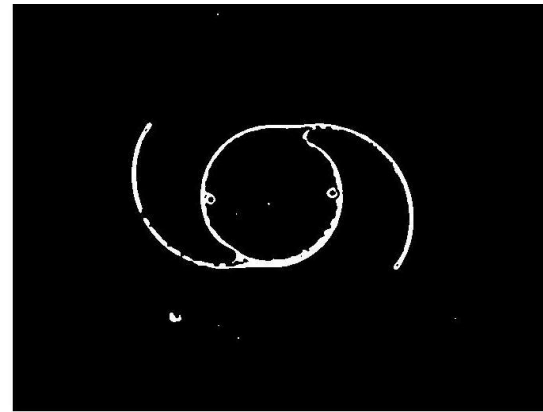


# Cataract Lens

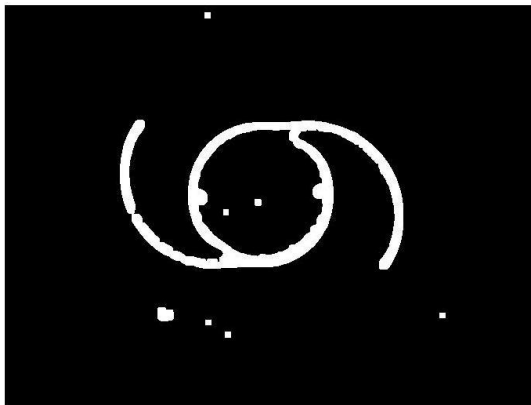
88



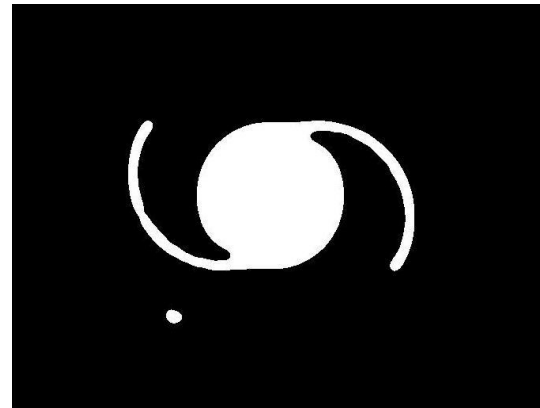
a. Median filter



b. Thresholding



c. Dilation

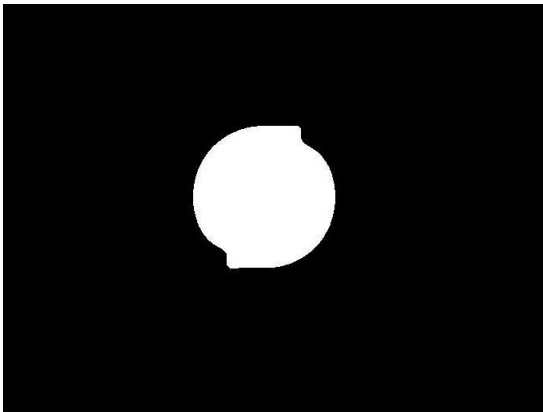


d. Fill holes

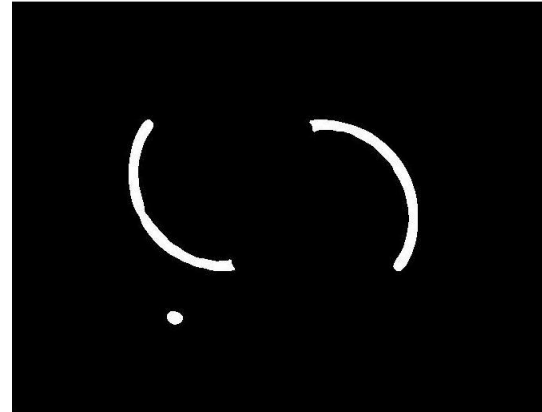


# Cataract Lens

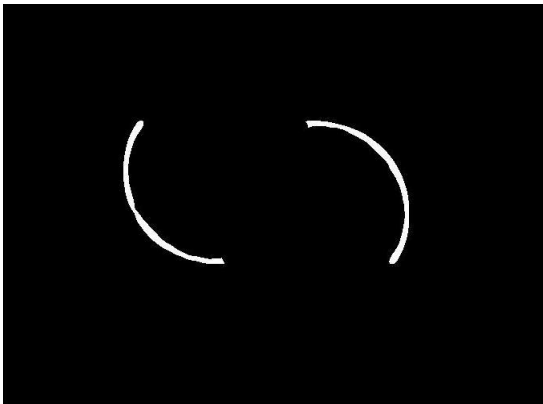
89



e. Erosion



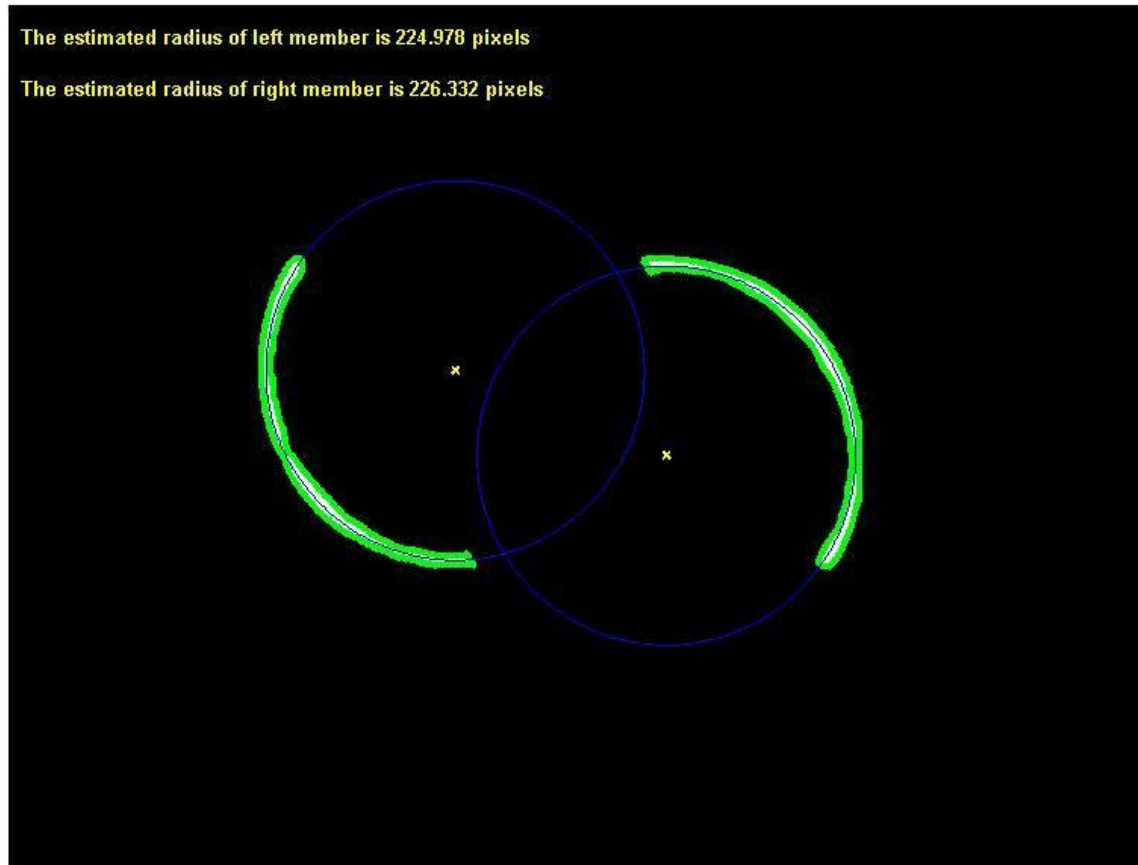
f. Image subtraction



g. Erosion

# Cataract Lens

90



h. Final output

# Blister Pack

91

## Inspection requirements:

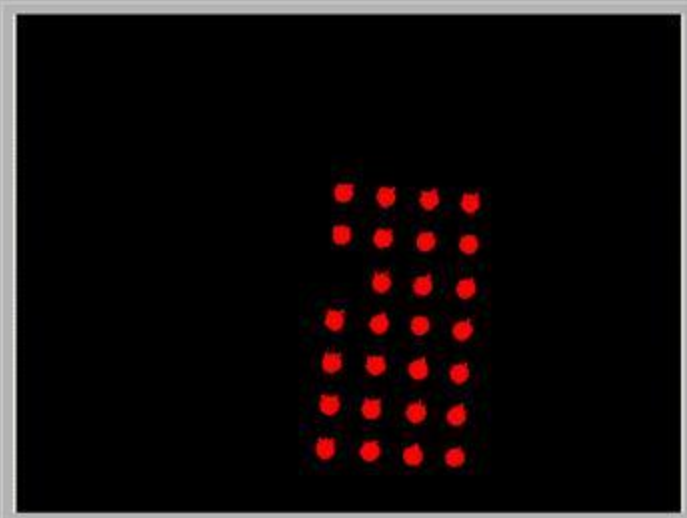
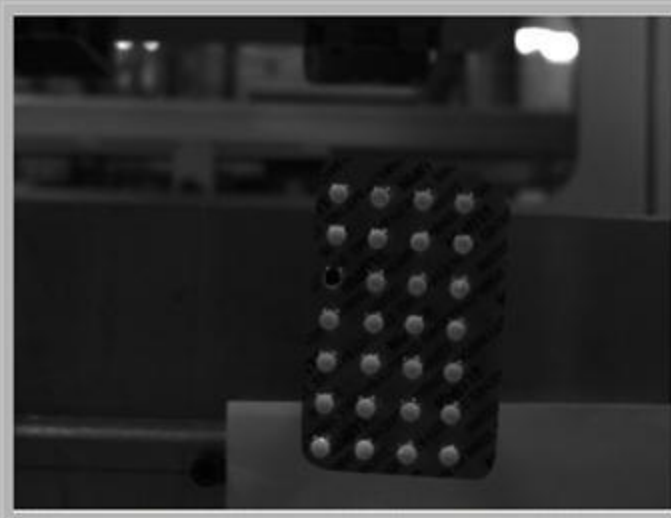
- Missing Tablets
- Broken Tablets
- Color Sequence Verification
- Label Reading



# Missing Tablet Inspection

92

Blister Pack Inspection

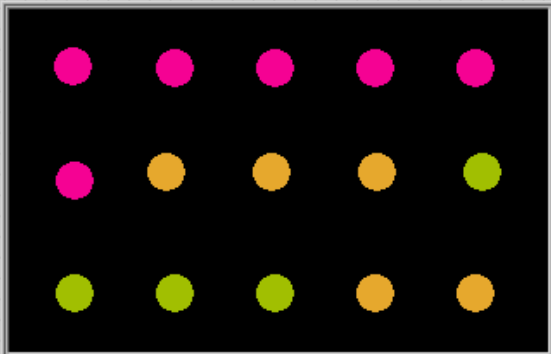


Blisters Found : 27

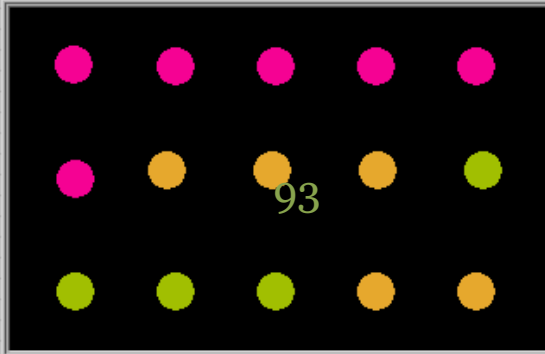
Notch

Blister

Template Model



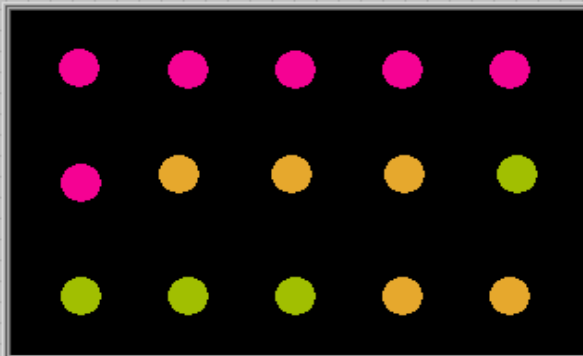
Image



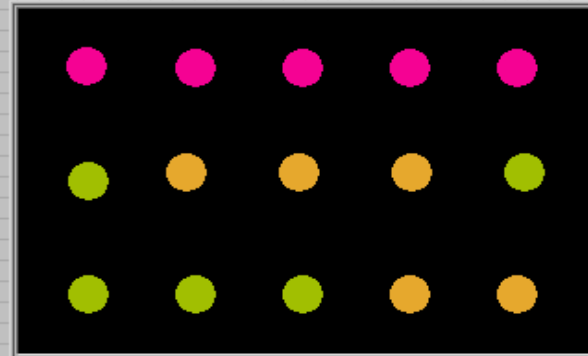
# Color Sequence Identification

Color Identification

Template Model



Image



Color Identification

# Label Reading

Label Reading



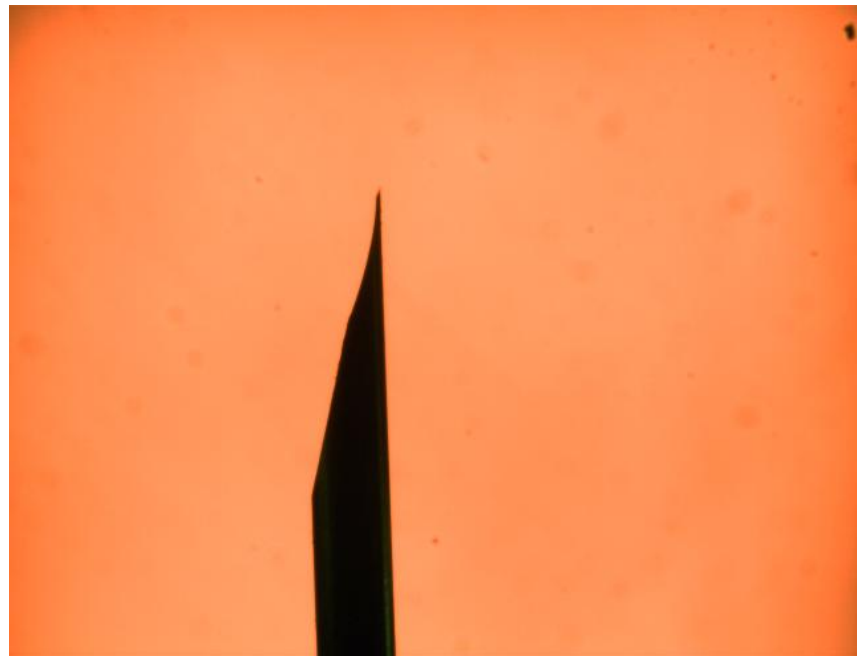
LOT NO: 11880001/ EXP DATE: 02.2011

# Needle

95

## Inspection requirements:

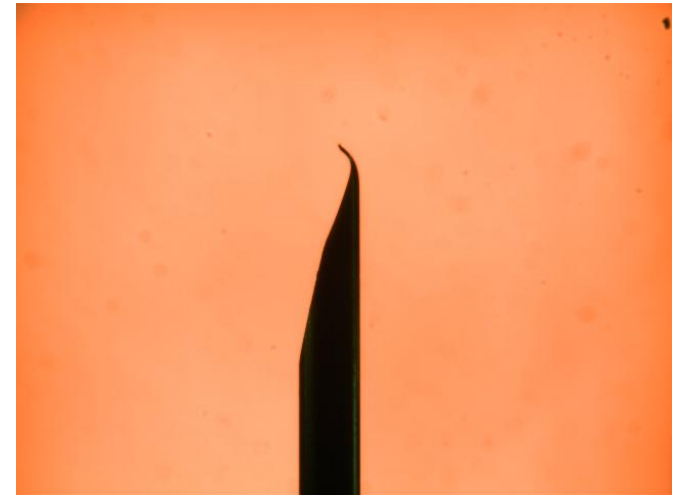
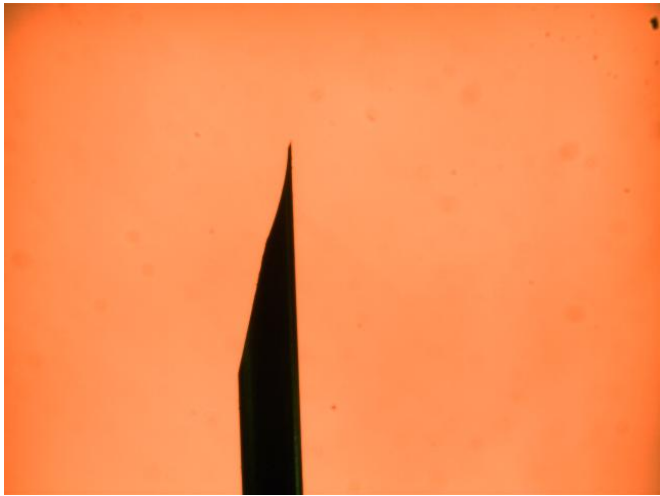
- Tip Damage
- Orientation
- Glue Inspection



- Video

# Needle

96



## Image processing steps

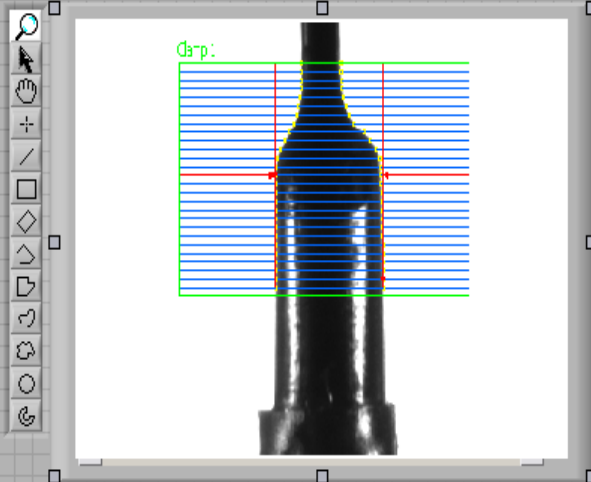
1. Colour to Gray level
2. Canny edge detector
3. Euclidean distance
4. Morphology operations (Dilation and Hole Fill) for orientation



# Inspection Panel

## NEEDLE INSPECTION

Image 3



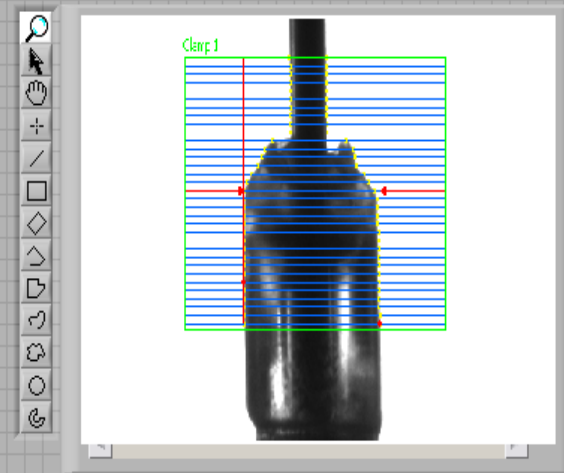
OK LH



cone LH



Image 5



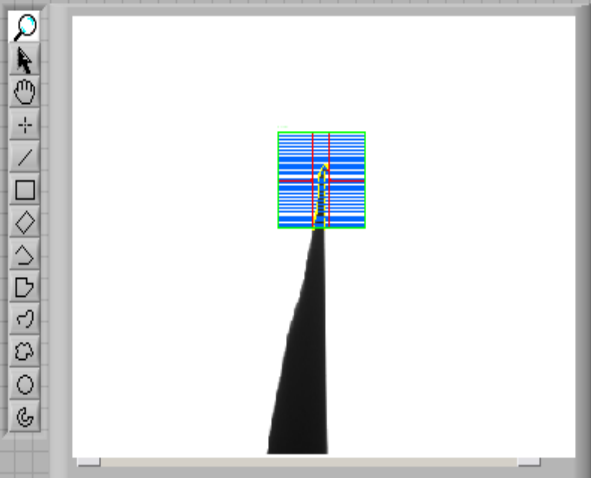
OK



CONE RH



TIP 8



OK RH 2



BEND RH



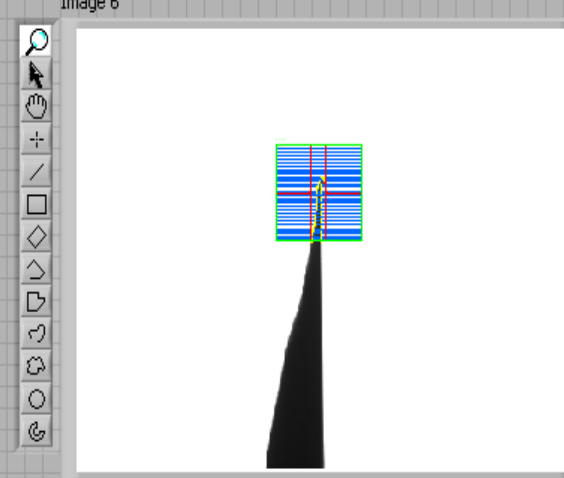
HEIGHT RH 2



ORIENTATION 2



Image 6



OK RH



BEND RH



HEIGHT RH



ORIENTATION



Stop

STOP

Stop 2

STOP

# Barcode Reading

98

- Reads the Barcode and print the label





**ANY QUESTIONS**