Inspection, optical measurement and illumination solutions for the automotive parts manufacturing industry

M. Castelletti – Product Manager
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1. **Who we are**
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About Opto Engineering

simple works better
About Opto Engineering

WHO WE ARE

Opto Engineering designs and manufactures optical and illumination systems for the machine vision industry since 2002.

<table>
<thead>
<tr>
<th>Product</th>
<th>Year</th>
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<tr>
<td>Telecentric</td>
<td>2003</td>
</tr>
<tr>
<td>360° optics</td>
<td>2009</td>
</tr>
<tr>
<td>Zoom</td>
<td>2011</td>
</tr>
<tr>
<td>Illuminators</td>
<td>2014</td>
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Global presence

- Houston, United States
- Mantova, Italy
- Munich, Germany
- Shanghai, China
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1. Who we are
2. Optics and Illumination basis
3. Application Cases
Introduction

CRITICAL AUTOMOTIVE PARTS

- Crank shaft
- Connecting rod
- Gasket
- O-ring

CHALLENGE

↑ RAISE QUALITY
↓ CUT COSTS

MACHINE VISION
Introduction

MACHINE VISION SYSTEM – KEY COMPONENTS

Machine vision systems are like a chain: *only as strong as their weakest link*
Machine vision systems are like a chain: *only as strong as their weakest link*

**IT’S ALL ABOUT LIGHT**

Optics and illumination can often be the limiting factor in a system’s performance
Optics – basic lens types

- Entocentric
- Telecentric
- Pericentric
Optics – basic lens types

ENTOCENTRIC
Telecentric lenses are required for any dimensional measurement imaging application.
Optics – basic lens types

TELECENTRIC

WHEN TELECENTRIC LENSES SHOULD BE USED

- When a thick object (thickness > 1/10 FOV diagonal) must be measured
- When different measurements on different object planes must be carried out
- When the object-to-lens distance is not exactly known or cannot be predicted
- When holes must be inspected or measured
- When the profile of a piece must be extracted
- When the image brightness must be very even
- When a directional illumination and a directional “point of view” are required
Optics – basic lens types

PERICENTRIC

Convergent rays

Entrance pupil

Pericentric: entrance pupil in front of lens

Pericentric
Illumination – basic illumination techniques

FRONT LIGHT ILLUMINATION

BACK LIGHT ILLUMINATION
Illumination – basic illumination techniques

**FRONT LIGHT ILLUMINATION**

For complex shapes with curved and shiny surfaces

**DIFFUSED DOME - Bright field**

**BACK LIGHT ILLUMINATION**

To enhance surface features or textures

**LOW ANGLE RING LIGHTS - Dark field**
Illumination – basic illumination techniques

DIFFUSED BACKLIGHT

- Light coming from a variety of angles

TELECENTRIC BACKLIGHT

- Border effects removal - Enhanced Field Depth
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Applications – CASE 1

PRODUCT: Telecentric lens + telecentric illuminator

- BI telecentricity
- Nearly zero distortion
- Excellent resolution
- Simple and robust design (fixed aperture)
- Detailed test report with measured optical parameters
- Matching telecentric illuminator
Applications – CASE 1

Product: Telecentric lens + telecentric illuminator

- **High speed** production lines
  The high throughput allows for shorter exposure times

- **Silouetting** and for detecting edges and defects
  Elimination of blurred edges caused by diffuse reflections

- **Increased distance** between object and illumination source

- **Precision measurements**
  where accuracy, repeatability, and throughput are key factors

- **Complete light coupling**
  very high signal-to-noise ratio

- **Border effects removal**
  collimated rays are typically much less reflected

- **Field depth and telecentricity improvement**
  Collimated illumination geometry increases a telecentric lens natural field depth
Applications – CASE 1

PRODUCT: Telecentric lens + telecentric illuminator

Application: Videochek VVC811

Measuring and sorting of low-size turned or pressed parts wherever high throughput is required with very high accuracy.

<table>
<thead>
<tr>
<th>VVC811</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Camera</td>
<td>5 MP CCD Matrix B/W</td>
</tr>
<tr>
<td>Resolution</td>
<td>Up to 2452 x 2054 pixels</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Depending on camera resolution and image areas size, e.g. 32x24 mm &lt; 0,03 mm with 780 x 580 pixels 32 x 24 mm &lt; 0,003 mm with 2452 x 2054 pixels, each with subpixel factor 4</td>
</tr>
<tr>
<td>Performance</td>
<td>Up to 700 parts /min (depending on part size and feeding system)</td>
</tr>
<tr>
<td>Rotary table drive</td>
<td>Programmable servo drive with safety clutch</td>
</tr>
<tr>
<td></td>
<td>Factory calibration certificate</td>
</tr>
<tr>
<td></td>
<td>Granite / aluminium sandwich design</td>
</tr>
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Image courtesy VESTER Elektronik
Applications – CASE 1

Product: Telecentric lens + telecentric illuminator

Application:

Inspection Machine for nuts with rotary glass table
Applications – CASE 1

Product: Telecentric lens + telecentric illuminator

Application

OFF LINE optical devices for coil / spring measurement

<table>
<thead>
<tr>
<th>Model</th>
<th>Field of View</th>
<th>Test Accuracy</th>
<th>Smallest allowable thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>61 x 51 mm</td>
<td>0.008 mm + 0.05%</td>
<td>0.15 mm</td>
</tr>
<tr>
<td>B</td>
<td>90 x 75 mm</td>
<td>0.01 mm + 0.05%</td>
<td>0.25 mm</td>
</tr>
<tr>
<td>C</td>
<td>138 x 115 mm</td>
<td>0.01 mm + 0.05%</td>
<td>0.3 mm</td>
</tr>
</tbody>
</table>
Applications – CASE 2

One of the most important parameters in specifying motorized zoom lenses is:

**MAGNIFICATION REPEATABILITY**

Magnification repeatability shows to what extent the lens will achieve:

the same magnification over a number of zoom cycles
Applications – CASE 2

Product: TCZR072
8X 4 STEP MOTORIZED BI-TELECENTRIC ZOOM LENS FOV: 72 mmm

Conventional zoom

Magnification change achieved through Lens displacement along the axial position

Uncertainty about the lens position along the z axis limits to the lens position resolution along the z axis

UNCERTAINTY about magnification repeatability
Applications – CASE 2

Product: TCZR072
8X 4 STEP MOTORIZED BI-TELECENTRIC ZOOM LENS FOV: 72 mmm

TCZR

Magnification change achieved through Internal carousel

No uncertainty about the lens position along the z axis

UNMATCHED REPEatability
MAGNIFICATION Constancy
Applications – CASE 2

Product: TCZR072
8X 4 STEP MOTORIZED BI-TELECENTRIC ZOOM LENS FOV: 72 mmm

PERFECT MAGNIFICATION CONSTANCY
No need of re-calibration, after zooming

EXCELLENT IMAGE CENTER STABILITY
Each magnification maintains its FOV center

PERFECT PARFOCALITY
No need of refocusing when changing magnification

4X FLEXIBILITY
Provides 4 different magnifications

Ease of use
Increased reliability
Time saving
Applications – CASE 2

Product: TCZR072
8X 4 STEP MOTORIZED BI-TELECENTRIC ZOOM LENS FOV: 72 mm

Application: V-CAD Rapid
Optical device for the measuring of 2D geometries in back and surface lights for the measurement of length, diameter, distance, radii, angle, thread, groove, contour generation, CAD comparison...

<table>
<thead>
<tr>
<th>SPECS V-CAD RAPID</th>
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<tbody>
<tr>
<td>Objective</td>
</tr>
<tr>
<td>Field of View X/Y</td>
</tr>
<tr>
<td>Magnification</td>
</tr>
<tr>
<td>Depth of field</td>
</tr>
<tr>
<td>Focus length Z</td>
</tr>
<tr>
<td>Working Distance</td>
</tr>
<tr>
<td>Repeatability</td>
</tr>
<tr>
<td>Length measurement uncertainty</td>
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Application
- Piston rings
- Bar steel, wire
- Cutting tools for wood
- Wooden parts
- Turned parts
- Rubber sealing profile (also with metal part inside)
- Plastic profiles
- Aluminium profiles
- Springs
- Circuit boards
- Extrusion dies

Image courtesy Schneider MessTechnik
Applications – CASE 3

Products: TC4K090 + LTCL4K090-G

Flat telecentric lenses and illuminators for 4k linescan cameras
FOV = 90 mm

- **Compact design**
  UNIQUE “Flat” shape for easy integration

- **High telecentricity & low distortion**

- **Detailed test report** with measured optical performances

- Dedicated 45° mirror accessories

- **Enhanced field depth** when TC4K + LTCL4K are combined
Applications – CASE 3

Products: TC4K090 + LTCL4K090-G

Flat telecentric lenses and illuminators for 4k linescan cameras
FOV = 90 mm

Application:
SHAFT MEASURING MACHINE
Optical device for crank shafts, gear shafts, cylinder liners/sleeves measurement
Applications – CASE 4

PRODUCT: Telecentric lens TC12096 + Collimated Illuminator LTCLHP096-G

APPLICATION:
Automatic visual inspection machines for sealings (circular and complex pieces)
rubber gaskets, plastic items, metal parts and most other components

<table>
<thead>
<tr>
<th>SPECS</th>
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<tbody>
<tr>
<td>Field of View</td>
<td>500x500 mm</td>
</tr>
<tr>
<td>Max. sample dimension OD</td>
<td>Ø500 mm</td>
</tr>
<tr>
<td>Min sample dimension OD</td>
<td>Ø 1,8 mm</td>
</tr>
<tr>
<td>Min ID dimension</td>
<td>Ø 0,8 mm</td>
</tr>
<tr>
<td>Min CS dimension</td>
<td>Ø 0,5 mm</td>
</tr>
<tr>
<td>Resolution</td>
<td>0,001 mm</td>
</tr>
<tr>
<td>Accuracy for size less than 90 mm (± 3 sigma)</td>
<td>± 0,009 mm</td>
</tr>
<tr>
<td>Accuracy for size bigger than 90 mm (± 3 sigma)</td>
<td>± 0,020 mm</td>
</tr>
<tr>
<td>Max sample thickness</td>
<td>30 mm</td>
</tr>
</tbody>
</table>
Applications – CASE 5

PRODUCT: Dome + Low angle illumination system LTDMLAB2-WW

Illumination area Ø = 60 mm

Two independent illumination units in one single solution
Dome unit for homogeneous illuminations and low angle unit for dark field lightning can be independently operated.

Ultra-high power light output and strobe mode only operation
For the inspection of fast moving object and extended LED lifetime.

Rugged industrial design with built-in industrial connector
For easy integration into any machine vision system.

Compatible LTDV strobe controllers available
For easy and appropriate power, control and synchronization of the illuminator.
APPLICATION: SURFACE INSPECTION OF RUBBER, PLASTIC AND METAL SEALINGS

Type of check: - Cuts – Scratches - Inclusions - Haloes

PRODUCT: Dome + Low angle illumination system LTDMLAB2-WW

Illumination area $\varnothing = 60$ mm
Applications – CASE 5

PRODUCT: Dome + Low angle illumination system LTDMLAB2-WW

Illumination area Ø = 60 mm

APPLICATION: SURFACE INSPECTION OF RUBBER, PLASTIC AND METAL SEALINGS

Type of check: - Cuts – Scratches - Inclusions - Haloes