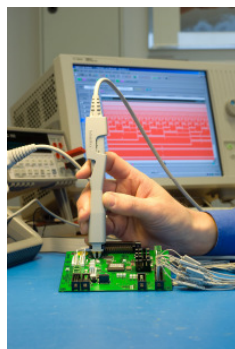


Automatische Prüfung von Laser- und Punktschweißverbindungen in der Automobilindustrie mittels Wärmefluss thermografie

Forum Automatica, Neue Messe München,
Communication Area, Halle 1
Freitag 13.Juni.2008 10:45-11:30

Dr.-Ing. Christoph Döttinger,
Thermosensorik GmbH

> Thermosensorik GmbH Company Profile

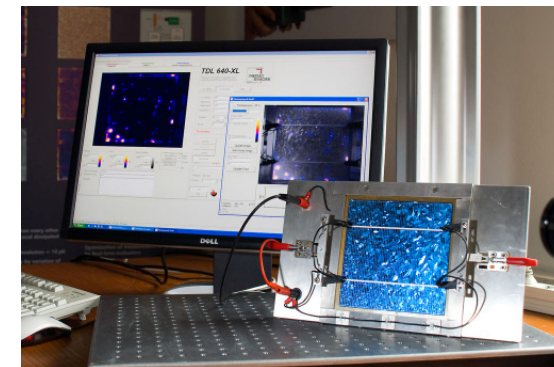


Company History

- > 1998 founded as Spin-off of the University Erlangen-Nürnberg
 - > 2003 Thermosensorik GmbH erhält Gründerpreis der IHK Nürnberg
 - > 2006 May First Investment Closing
 - > Siemens Venture Capital
 - > Siemens Technology Accelerator
- SIEMENS**
- > 2008 10 Years Thermosensorik GmbH

Company Facts

- > Based in Erlangen
- > 33+ Employees
 - > 80% Univ. Degree
- > 110+ Systems Installed Base ... pure cameras to fully automated In-Line-Systems



> Thermosensorik GmbH
Produkt Spectrum: Infrarot-Cameras and Add-Ons



> Thermosensorik
Infrarot-Cameras



> Lenses



> Engine Focus



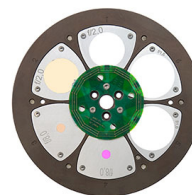
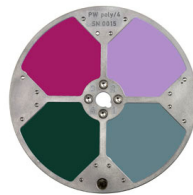
> Glasfibre Interface



> BlackBodies



> Filters



> Thermosensorik GmbH
Product Spectrum: Laboratory and mobile systems



> NDT Laboratory system



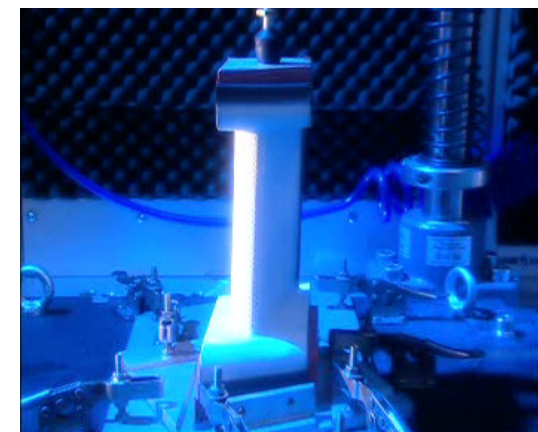
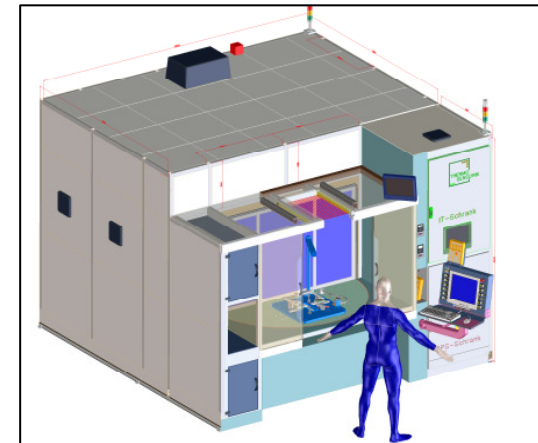
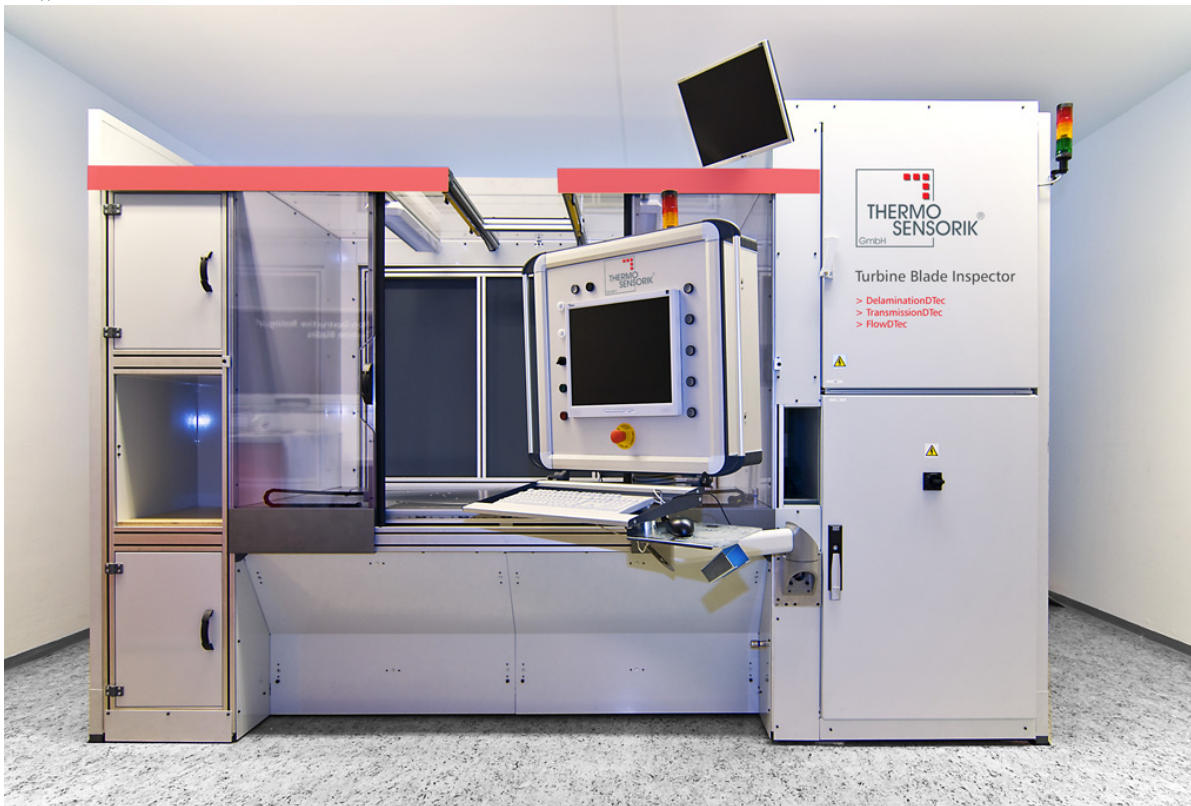
> Mobile system



> Application specific systems

> Thermosensorik GmbH
Product Spectrum: Automated Inspections Systems

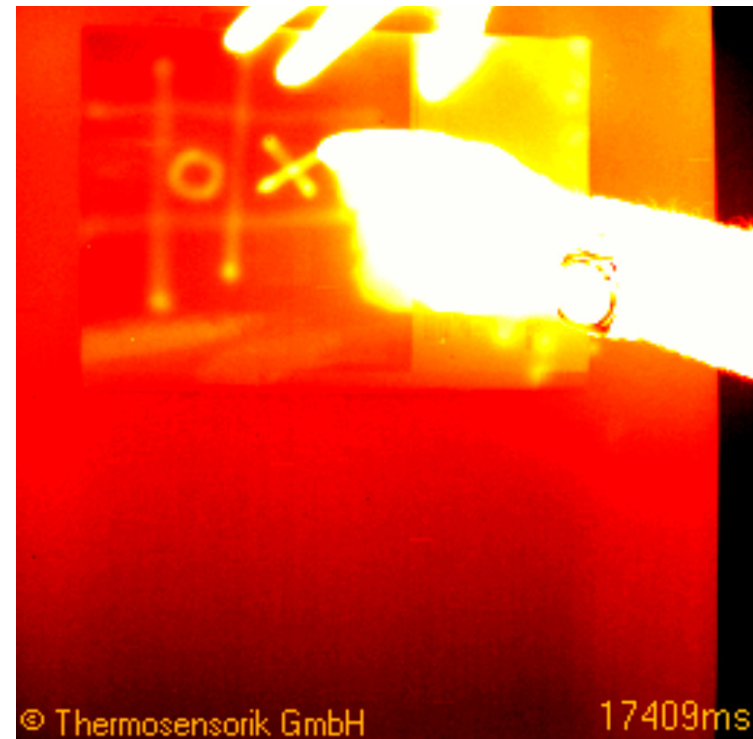
> Turbine blade testing
„Second Generation“



> Thermosensorik: "Heat" becomes visible

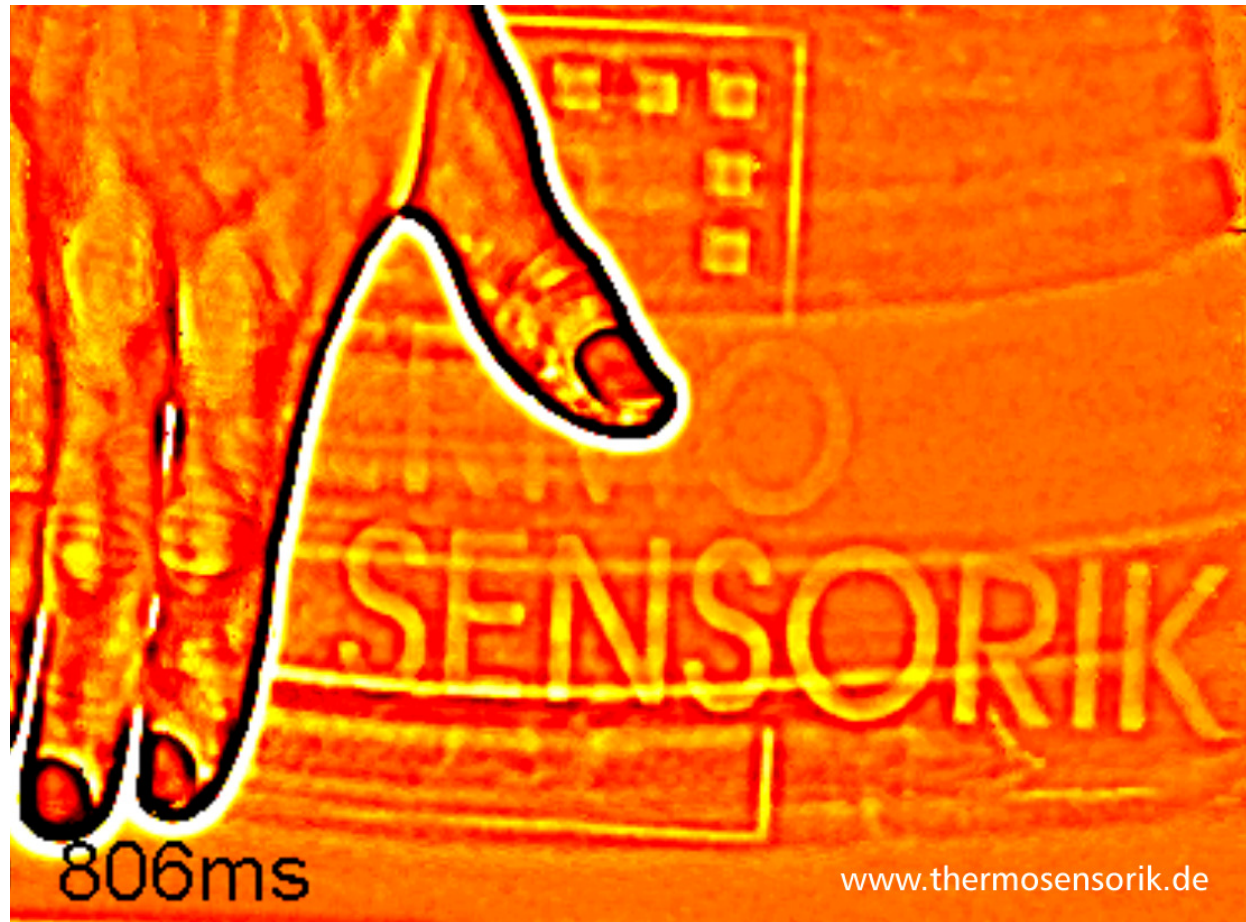


Hand on paper ...



„Nodes and Crosses“

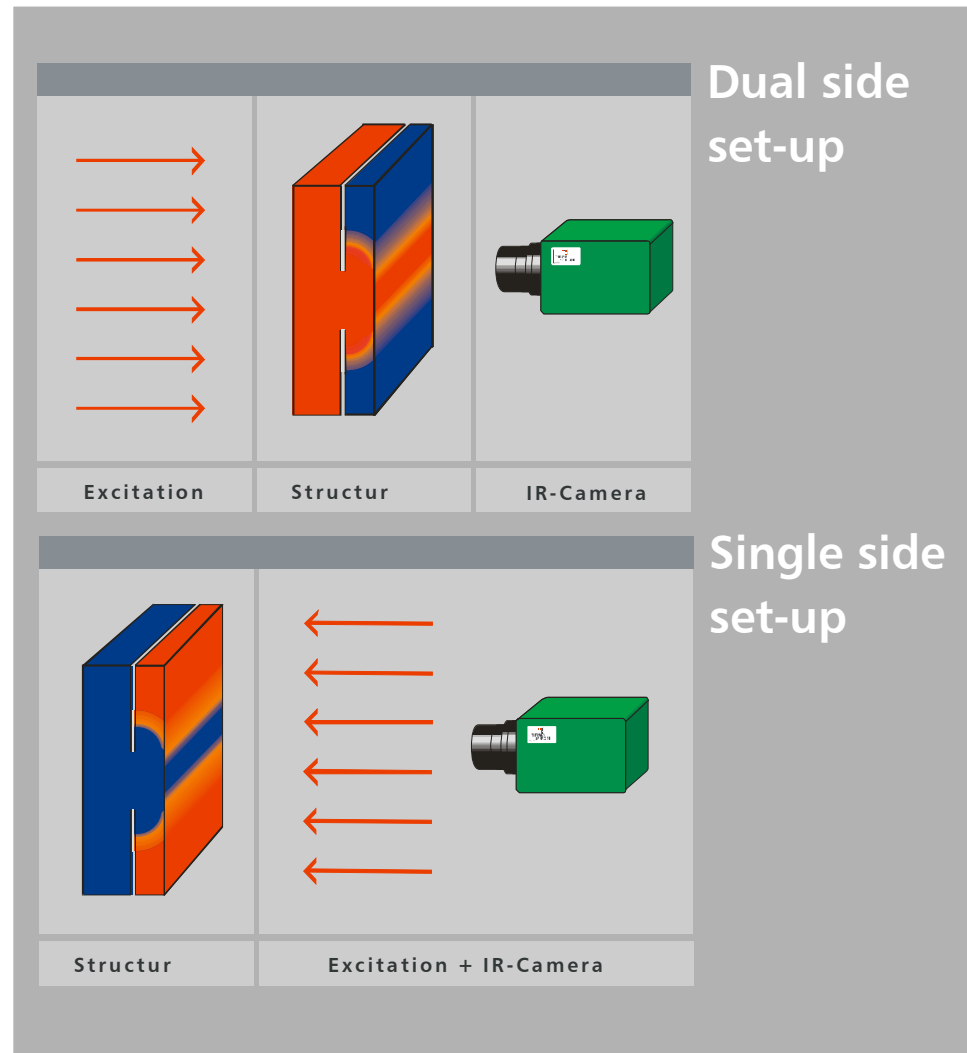
> The hidden Logo ...



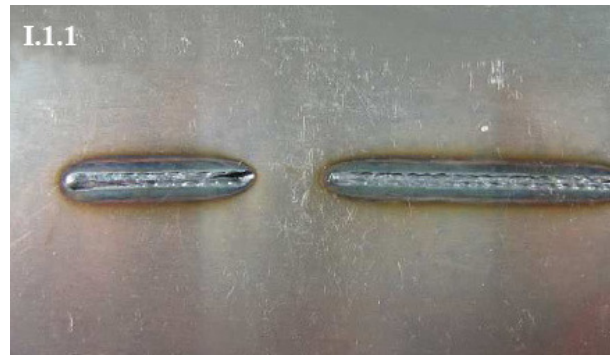
Heat Source: Human Hand

Sensor: IR-Camera

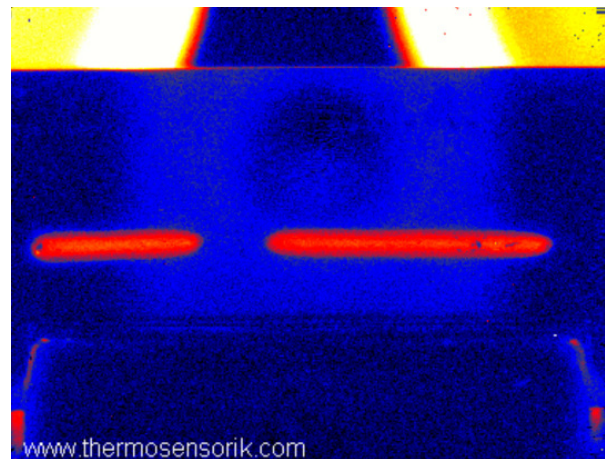
> Heat Flux Thermography Principle of Laser Weld Inspection ...



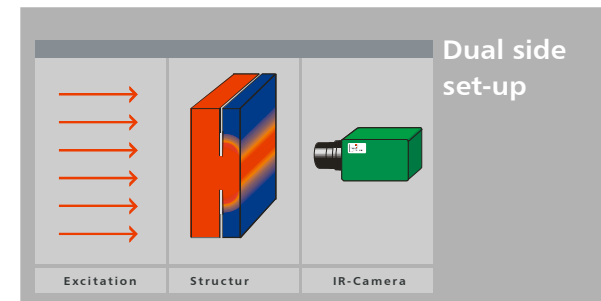
> Heat Flux Thermography Principle of Laser Weld Inspection ...



Photo

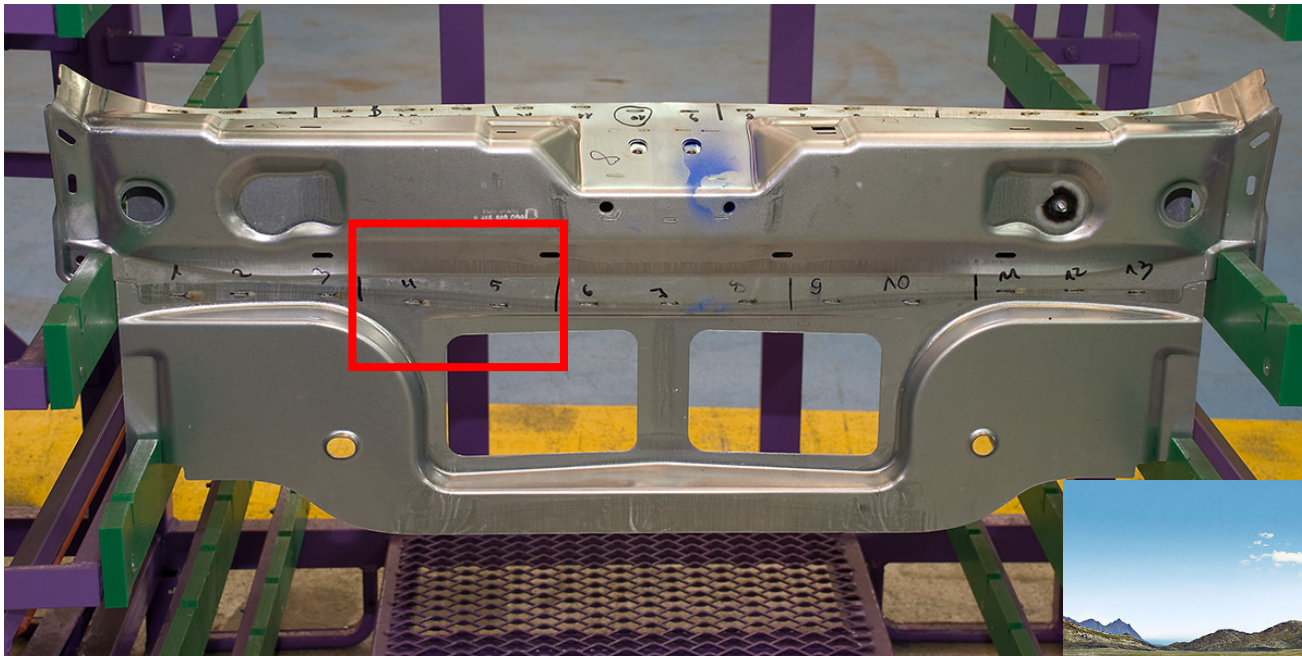


IR-Video



Test Setup

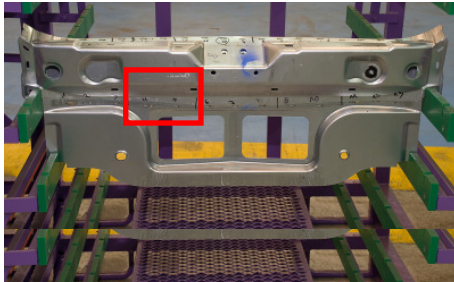
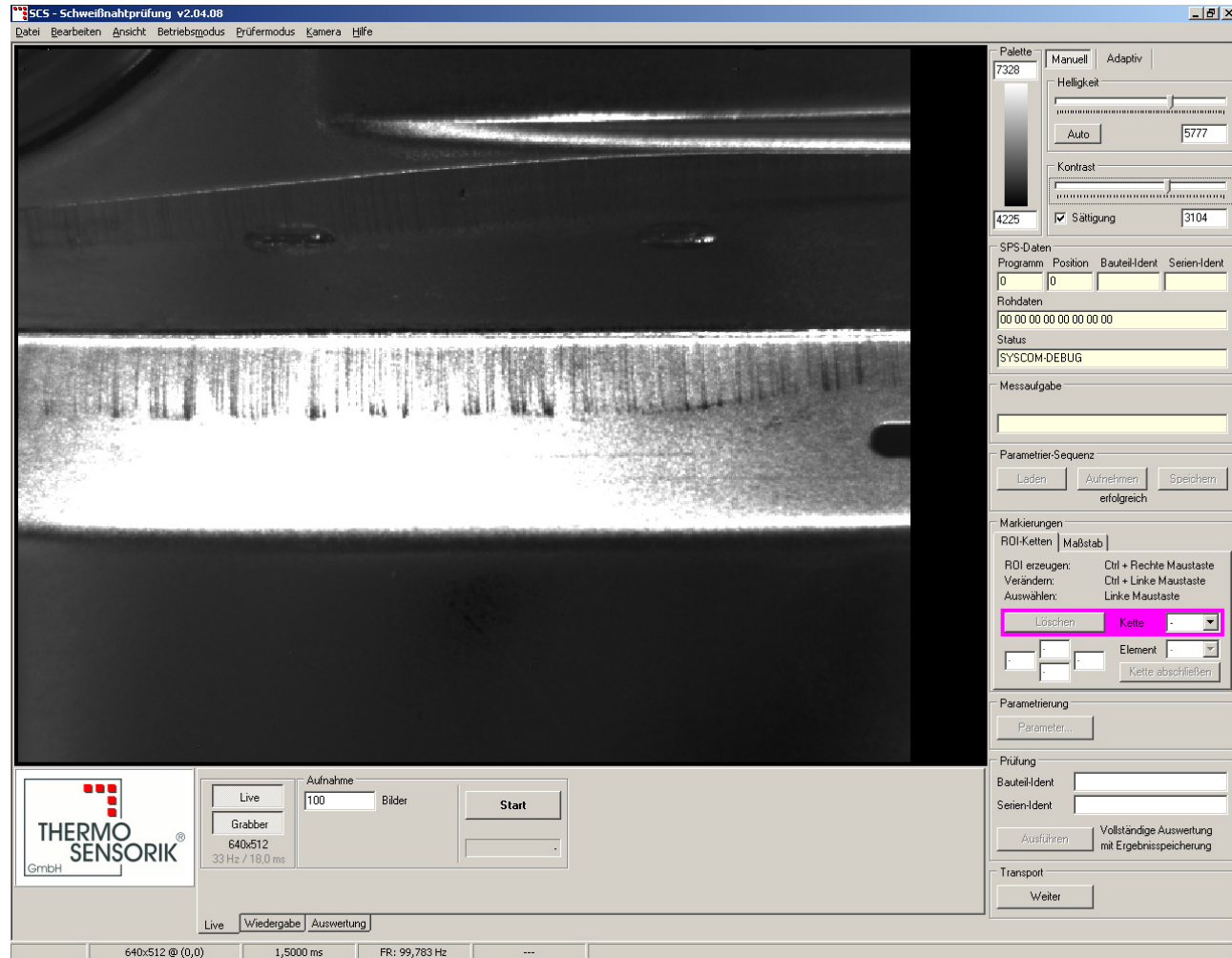
> Application Example: Back End of Volkswagen EOS



- > 31 laser lines
- > tested in 10 groups
- > field of view with 2-4 laser lines each



➤ Heat Flux Thermography Principle of Laser Weld Inspection ...

SCS - Schweißnahtprüfung v2.04.08

Datei Bearbeiten Ansicht Betriebsmodus Prüfermodus Kamera Hilfe

Palette: 7326
Manuell Adaptiv
Helligkeit: 5777
Kontrast: 4225
Sättigung: 3104

SPS-Daten
Programm: 0 Position: 0 Bauteil-Ident: Serien-Ident
Rohdaten: 00 00 00 00 00 00 00
Status: SYSDOM-DEBUG

Messaufgabe:

Parametrier-Sequenz
Laden Aufnehmen Speichern
erfolgreich

Markierungen
ROI-Ketten Maßstab
ROI erzeugen: Ctrl + Rechte Maustaste
Verändern: Ctrl + Linke Maustaste
Auswählen: Linke Maustaste
Löschen Kette Element Kette abschließen

Parametrierung
Parameter...

Prüfung
Bauteil-Ident:
Serien-Ident:
Ausführen Vollständige Auswertung mit Ergebnispeicherung

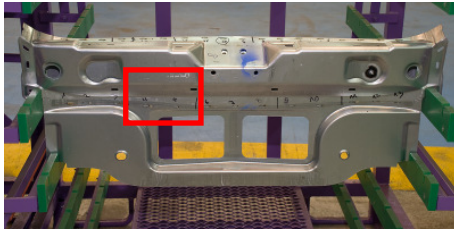
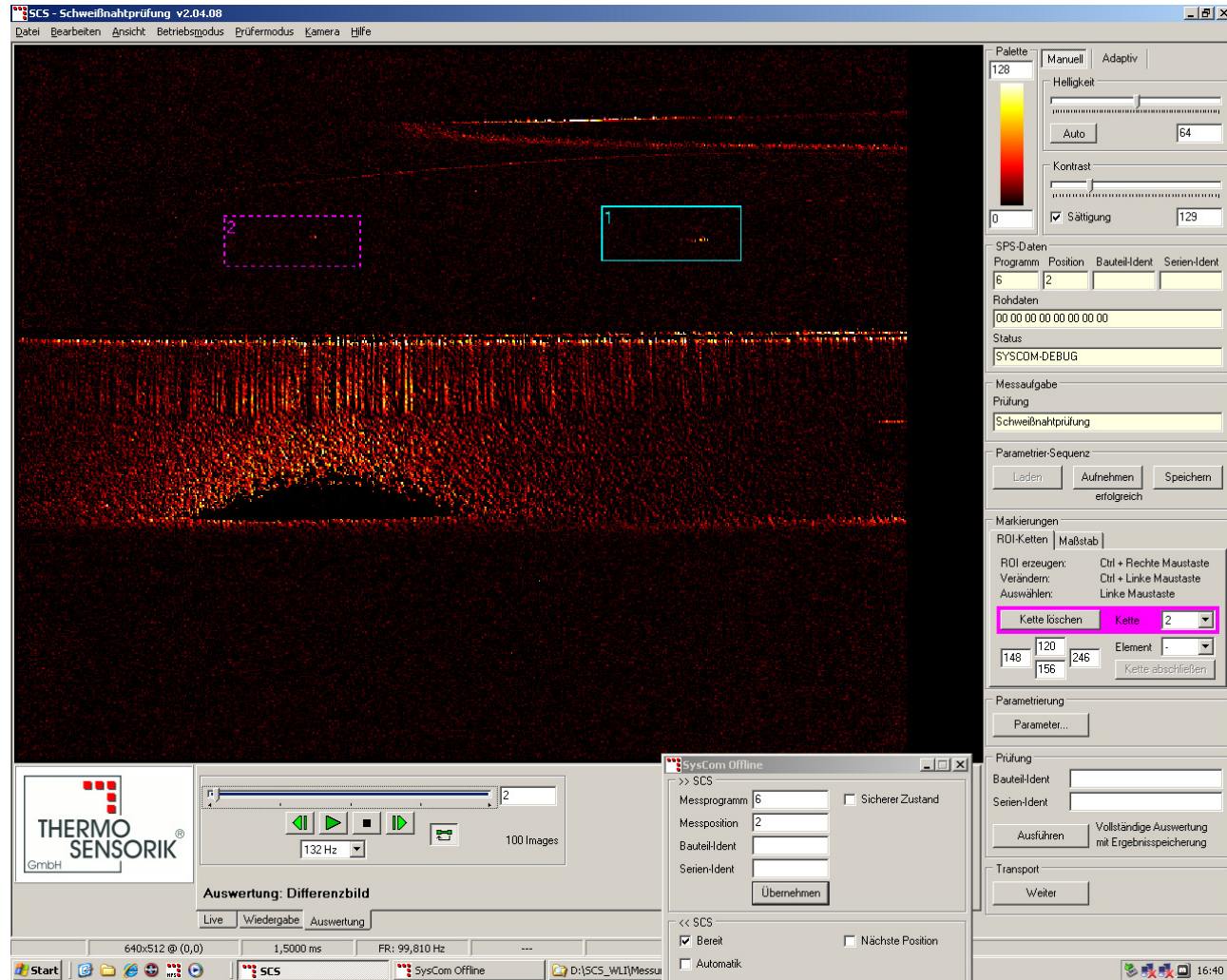
Transport
Weiter

Aufnahme
Live Grabber 640x512 33 Hz / 18.0 ms
100 Bilder Start

Live Wiedergabe Auswertung

640x512 @ (0,0) 1,5000 ms FR: 99,783 Hz

➤ Heat Flux Thermography Principle of Laser Weld Inspection ...

SCS - Schweißnahtprüfung v2.04.08

Manuell | Adaptiv

Palette: 128

Helligkeit: 54

Kontrast: 129

SPS-Daten

Programm	Position	Bauteil-Ident	Serien-Ident
6	2		

Rohdaten: 00 00 00 00 00 00 00

Status: SYSCOM-DEBUG

Messaufgabe: Prüfung

Prüfung: Schweißnahtprüfung

Parametrier-Sequenz

Kette löschen | Kette: 2

148 | 120 | 246 | Element: | 156

Parameter...

Prüfung

Bauteil-Ident

Serien-Ident

Ausführen | Vollständige Auswertung mit Ergebnisspeicherung

Transport

Weiter

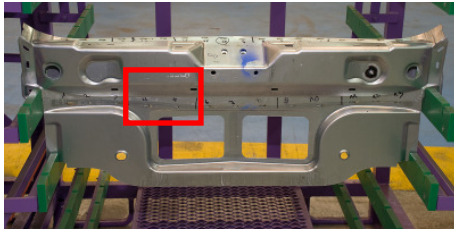
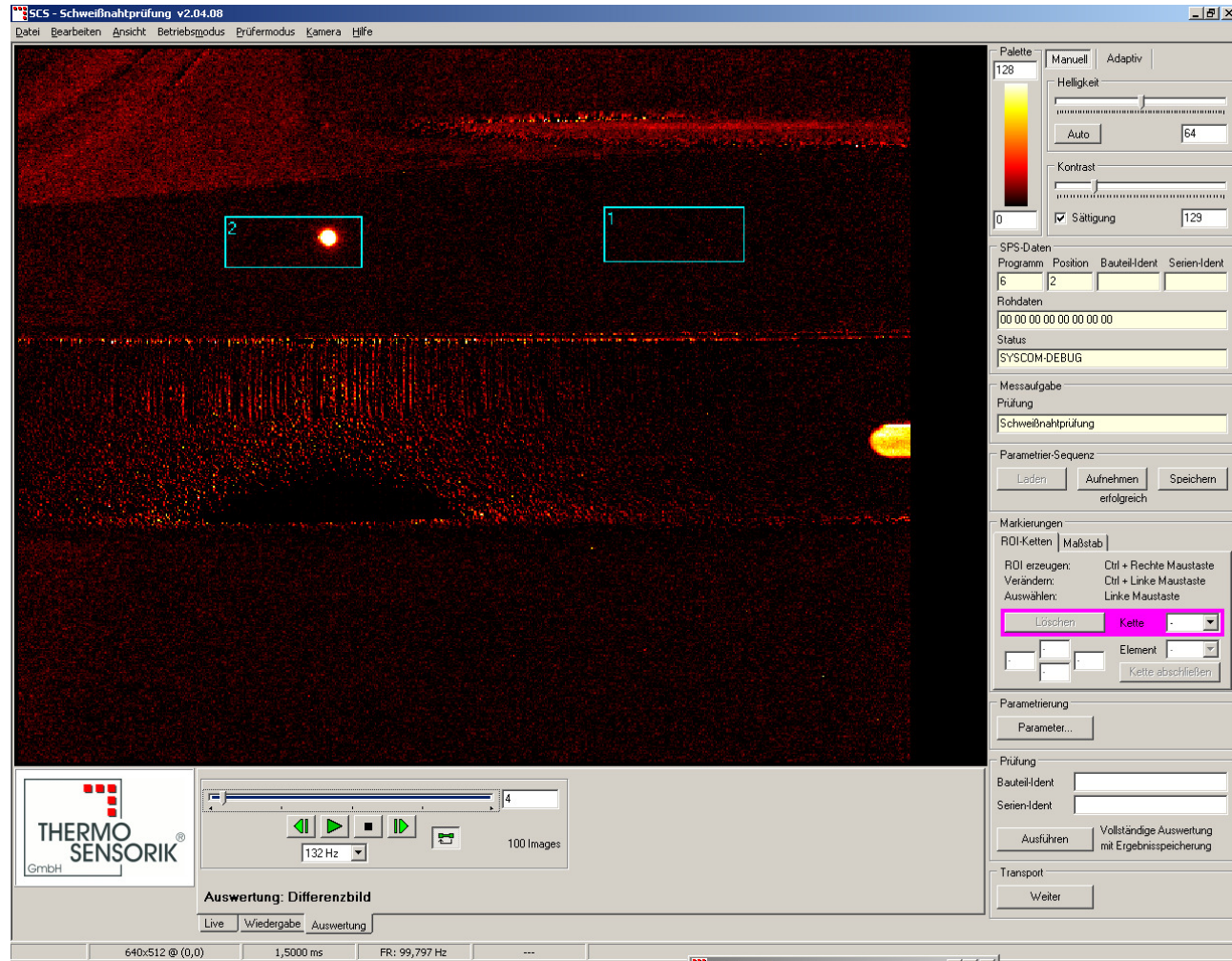
640x512 @ (0,0) | 1,5000 ms | FR: 99,810 Hz

Start | SysCom Offline | D:\SCS_WL1\Messu

16:40

Picture 2 of the IR-video (flash trigger)

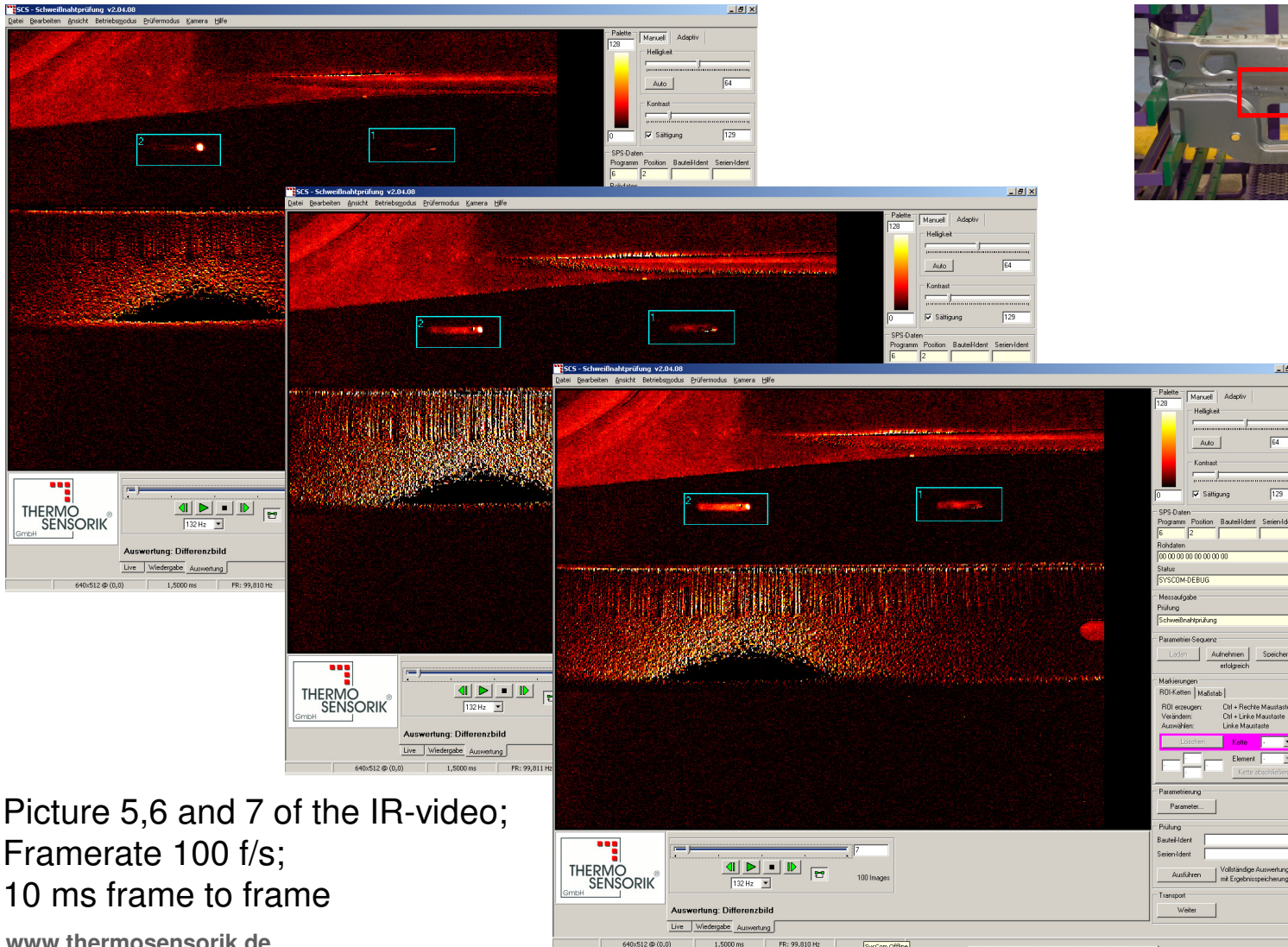
> Heat Flux Thermography Principle of Laser Weld Inspection ...

The screenshot displays the SCS - Schweißnahtprüfung v2.04.08 software interface. The main window shows a thermal image with a bright spot in the center, labeled '2' in a blue box. A cyan box labeled '1' is positioned to the right. The interface includes a menu bar (Datei, Bearbeiten, Ansicht, Betriebsmodus, Prüfmodus, Kamera, Hilfe), a palette (Manuell, Adaptiv) with brightness and contrast sliders, and a table for SPS-Daten (Program, Position, Bauteil-Ident, Serien-Ident). The table shows Program: 6, Position: 2, Bauteil-Ident: , Serien-Ident: . Below the table are fields for Rohdaten, Status (SYSCOM-DEBUG), and Messaufgabe (Schweißnahtprüfung). The interface also features a 'Markierungen' section with 'Löcher' and 'Kette' buttons, and a 'Parametrierung' section with a 'Parameter...' button. The bottom status bar shows 'Auswertung: Differenzbild', 'Live', 'Wiedergabe', 'Auswertung', and technical specifications: 640x512 @ (0,0), 1,5000 ms, FR: 99,797 Hz.

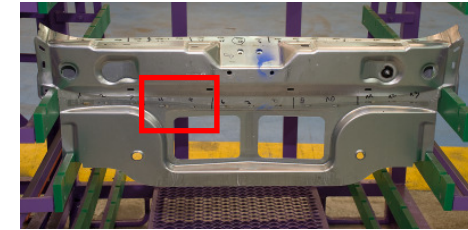
20 ms later ... picture 4 of the IR-Video

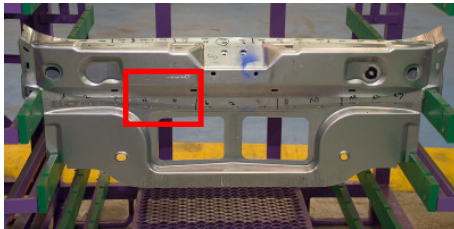
➤ Heat Flux Thermography Principle of Laser Weld Inspection ...



Picture 5,6 and 7 of the IR-video;
Framerate 100 f/s;
10 ms frame to frame

www.thermosensorik.de





Schweißnahtprüfung - Ergebnisse

```

Laufzeit : 522,47 ms
Error Flags: 0000.0000.0001.0001
             : 0000.0000.0000.0000

* Schweißnaht fehlerhaft

### Schweißnaht ###

* Schweißnaht in Ordnung

Anzahl Nahtteile: 1
Ist-Länge : 14,26 mm ( 62,00 pixel)
Soll-Länge : 10,00 mm
> Prozent : 142,61 %

ROI-Koordinaten : (14/10) (77/22)

### Durchschüsse ###

* Ein Loch gefunden
# 01 : (71/15) (77/17)

### Poren ###

* Keine Poren gefunden

### Schmitte ###

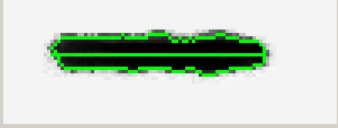
* Keine Schmitte gefunden

prm_in[00] = 0,000
prm_in[01] = 0,000
prm_in[02] = 0,000
    
```


Schließen

Zoom-Faktor: 3x

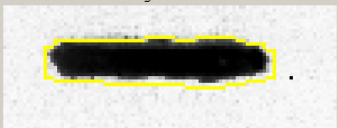
Schweißnaht - Ergebnisbild




Durchschuss



Schweißnaht - Bearbeitungsbild



Pore / Einschnitt



> Automated Laser Weld Inspection – Teach In Process: Set ROI



Image Adjustment

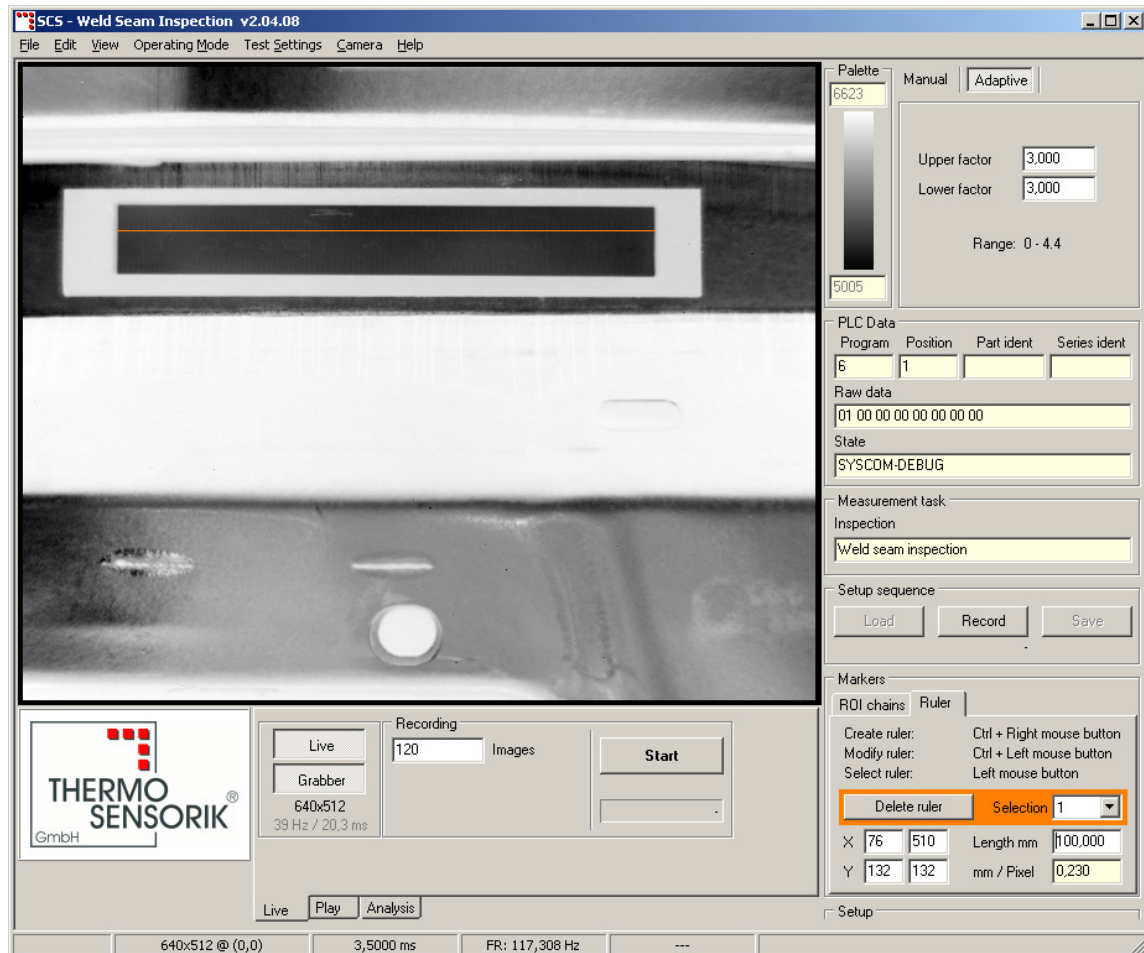
Profi-/Interbus Communication

Parameter Setting

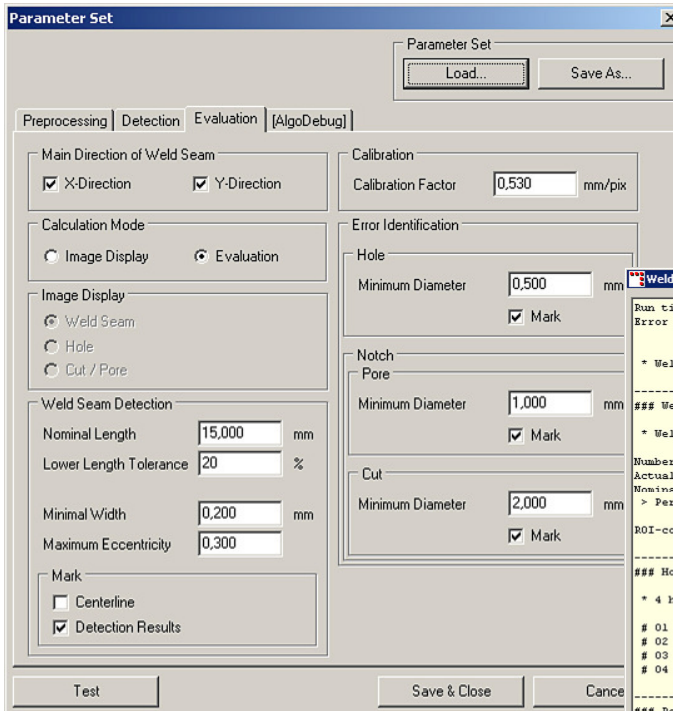
„IR-Videorecorder“

> Automated Laser Weld Inspection Teach In Process: Length Calibration

- > Calibration with 100mm ruler
- > 0,230 mm/Pixel
- > Resolution of IR Camera 640x512 Pixels
- > Field of view: 147,2 mm x 117,76 mm „like a postcard“



➤ Automated Laser Weld Inspection Teach In: Parameterisation



Parameter Set

Preprocessing | Detection | Evaluation | [AlgoDebug]

Main Direction of Weld Seam
 X-Direction Y-Direction

Calculation Mode
 Image Display Evaluation

Image Display
 Weld Seam
 Hole
 Cut / Pore

Weld Seam Detection
 Nominal Length: 15,000 mm
 Lower Length Tolerance: 20 %
 Minimal Width: 0,200 mm
 Maximum Eccentricity: 0,300

Mark
 Centerline
 Detection Results

Calibration
 Calibration Factor: 0,530 mm/pix

Error Identification

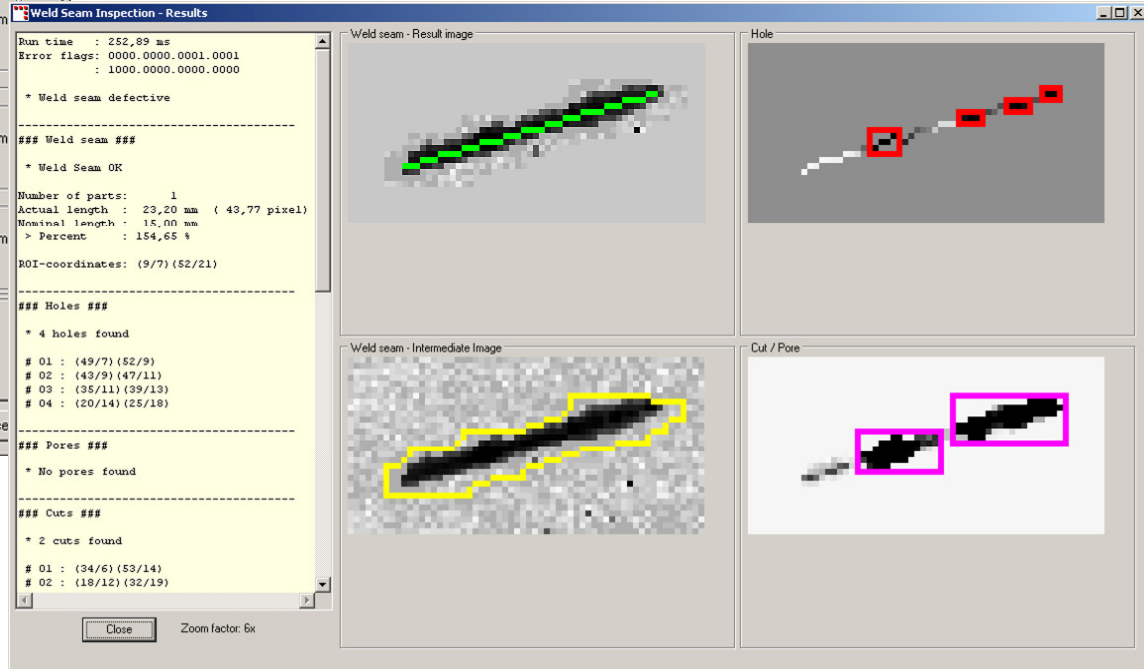
Hole
 Minimum Diameter: 0,500 mm
 Mark

Notch
 Pore
 Minimum Diameter: 1,000 mm
 Mark

Cut
 Minimum Diameter: 2,000 mm
 Mark

Buttons: Test, Save & Close, Cancel

Parameter Setting



Weld Seam Inspection - Results

Run time : 252,89 ms
 Error flags: 0000.0000.0001.0001
 : 1000.0000.0000.0000

* Weld seam defective

 *** Weld seam ***
 * Weld Seam OK

Number of parts: 1
 Actual length : 23,20 mm (43,77 pixel)
 Nominal length : 15,00 mm
 > Percent : 154,65 %

ROI-coordinates: (9/7) (52/21)

 *** Holes ***
 * 4 holes found

01 : (49/7) (52/9)
 # 02 : (43/9) (47/11)
 # 03 : (35/11) (39/13)
 # 04 : (20/14) (25/18)

 *** Pores ***
 * No pores found

 *** Cuts ***
 * 2 cuts found

01 : (34/6) (53/14)
 # 02 : (18/12) (32/19)

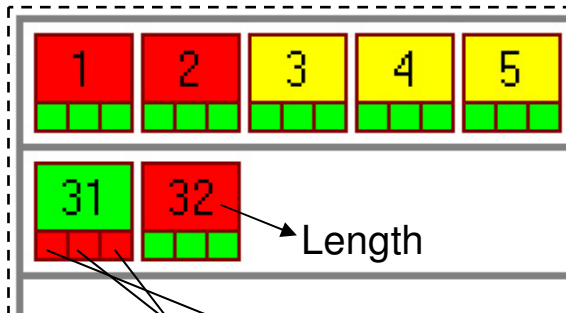
Buttons: Close, Zoom factor: 6x

Pretest for
Parameter-Check

> Automated Laser Weld Inspection Typical Result File

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
31	32																												
00028_F0003																									2008-04-30 12:49:42				

Result Grafic



Length

Holes

Pores

Cuts

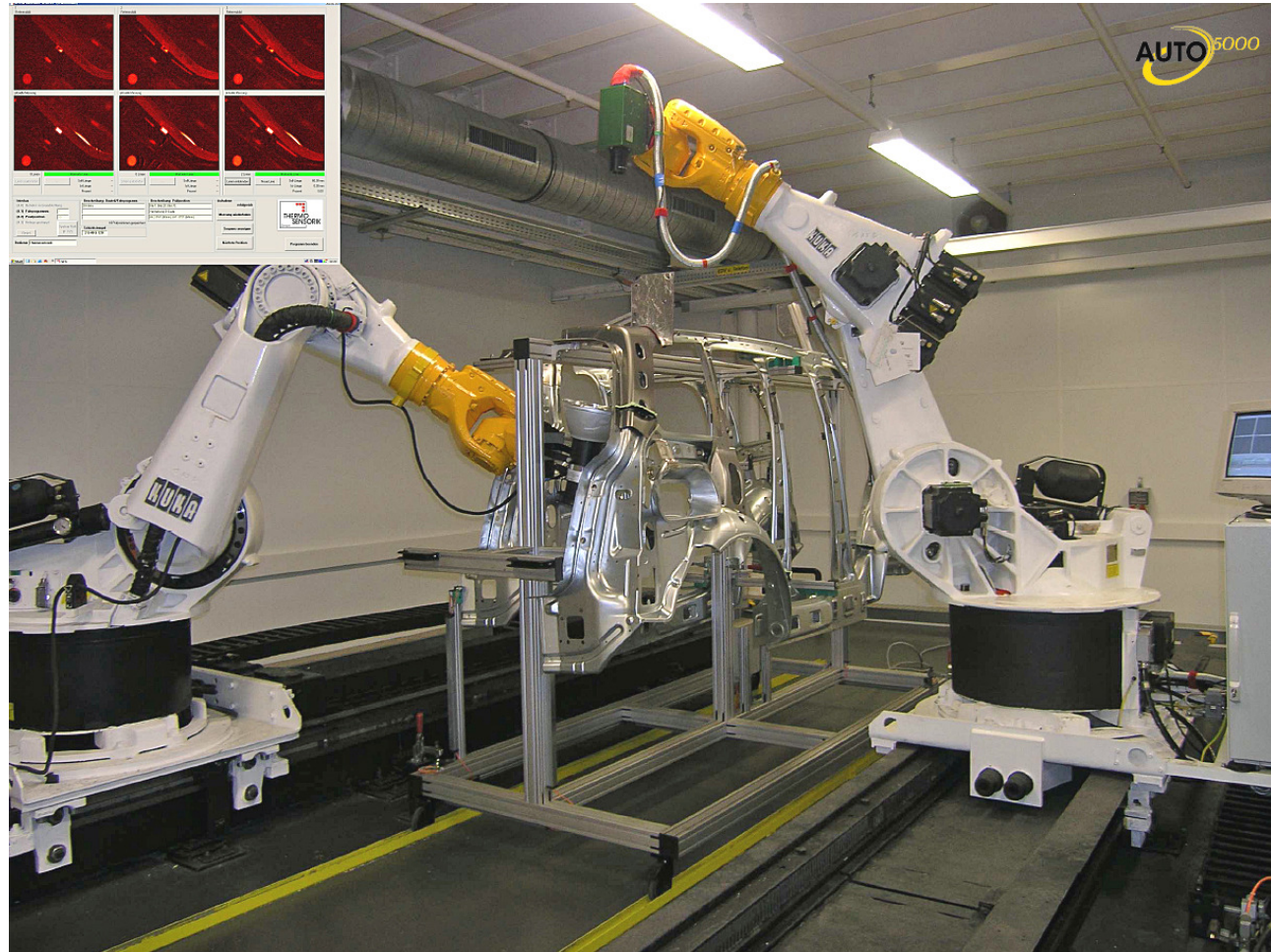
Result List

Line#:	Progr/Posit/Line:	length	%	holes	Pore	cut
0001	F0003/P0001/s01	5.802 mm	39 %	0	0	0
0002	F0003/P0001/s02	0.000 mm	0 %	0	0	0
0003	F0003/P0001/s03	12.219 mm	81 %	0	0	0
0004	F0003/P0002/s01	13.646 mm	91 %	0	0	0
0005	F0003/P0002/s02	13.297 mm	89 %	0	0	0
0006	F0003/P0003/s01	12.662 mm	84 %	0	0	0
0007	F0003/P0003/s02	12.254 mm	82 %	0	0	0
0008	F0003/P0003/s03	14.904 mm	99 %	0	1	0
0009	F0003/P0004/s01	13.315 mm	89 %	0	0	0
0010	F0003/P0004/s02	12.589 mm	84 %	0	0	0
0011	F0003/P0005/s01	13.723 mm	91 %	0	1	0
0012	F0003/P0005/s02	12.995 mm	87 %	0	0	1
0013	F0003/P0005/s03	11.165 mm	74 %	0	1	0
0014	F0003/P0006/s01	13.546 mm	90 %	0	0	0
0015	F0003/P0006/s02	29.604 mm	197 %	1	0	0
0016	F0003/P0006/s03	30.407 mm	203 %	0	2	1
0017	F0003/P0006/s04	24.610 mm	164 %	0	0	0
0018	F0003/P0007/s01	14.510 mm	97 %	0	0	0
0019	F0003/P0007/s02	25.828 mm	172 %	4	0	1
0020	F0003/P0007/s03	14.388 mm	96 %	0	0	0
0021	F0003/P0007/s04	13.069 mm	87 %	0	0	0
0022	F0003/P0008/s01	14.436 mm	96 %	0	0	0
0023	F0003/P0008/s02	17.797 mm	119 %	2	1	1
0024	F0003/P0008/s03	35.642 mm	238 %	6	1	0
0025	F0003/P0008/s04	13.546 mm	90 %	0	0	0
0026	F0003/P0009/s01	30.015 mm	200 %	4	1	2
0027	F0003/P0009/s02	27.156 mm	181 %	4	1	1
0028	F0003/P0009/s03	29.154 mm	194 %	0	1	2
0029	F0003/P0010/s01	14.735 mm	98 %	0	0	0
0030	F0003/P0010/s02	29.371 mm	196 %	1	2	2
0031	F0003/P0010/s03	20.079 mm	134 %	1	1	1
0032	F0003/P0011/s01	0.000 mm	0 %	0	0	0

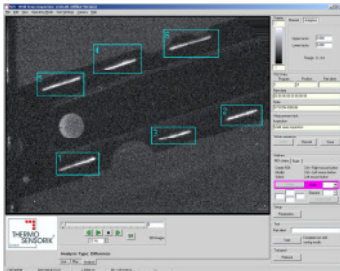
> Automated Laser Weld Inspection System



➤ Two Setups: Position of IR-Camera/Flash fixed or position of component fixed



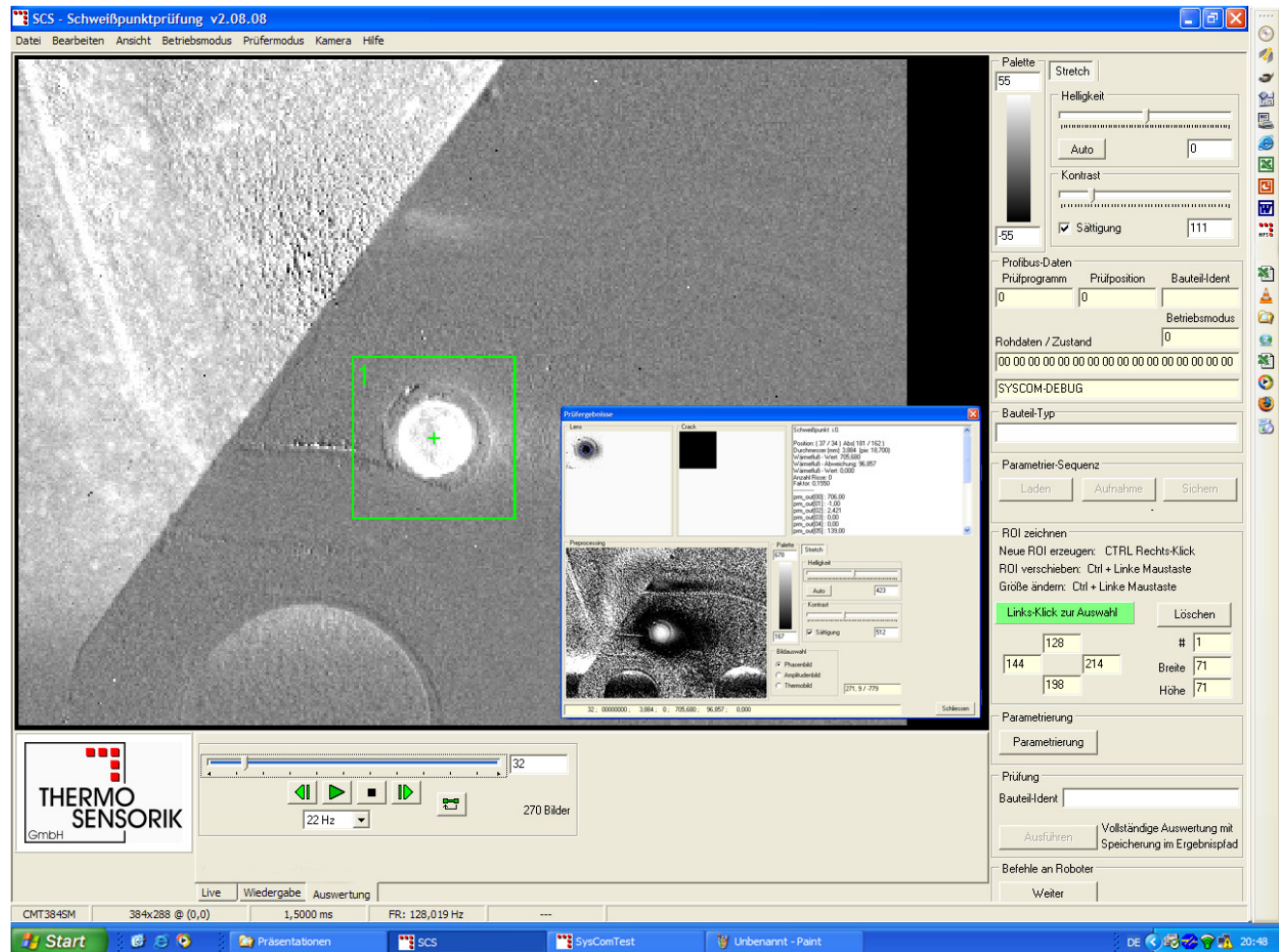
> Automated Weld Inspection Systems Scope of Delivery



- > Thermosensorik delivers ...
 - > System Control and Command Software with Laser/Spot Weld Inspection PlugIn
 - > Detection: IR-Camera (Robot ready)
 - > Excitation Source
 - > Initial Parameterisation
 - > Customer Training

- > Customer adds ...
 - > Robots
 - > General Control Unit

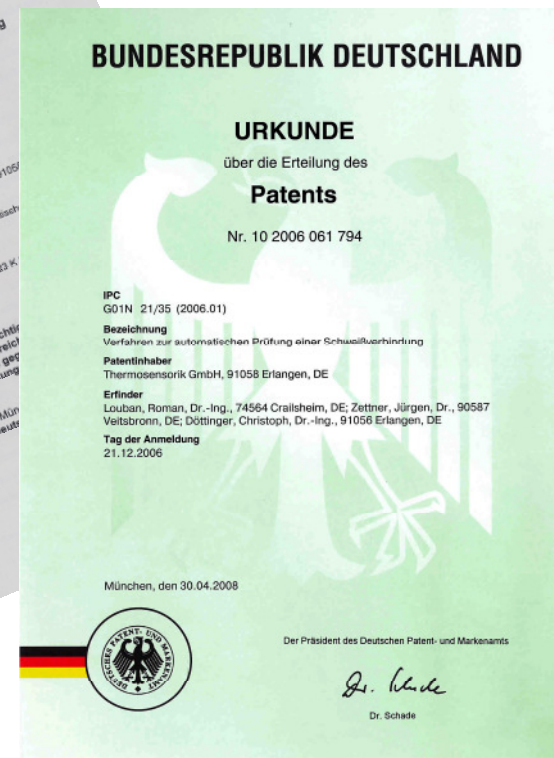
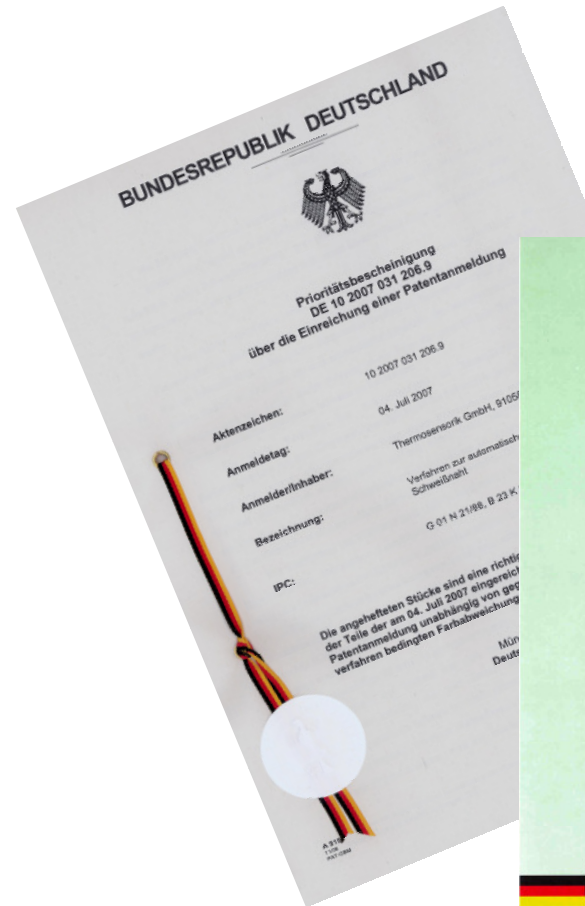
> Automated Spot Weld Inspection



The screenshot displays the SCS - Schweißpunktprüfung v2.08.08 software interface. The main window shows a grayscale image of a spot weld on a metal surface, with a green square ROI (Region of Interest) centered on the weld. A smaller inset window, titled 'Prüfergebnis', shows a magnified view of the weld with a red crosshair and a 'Prüfung' status indicator. The interface includes a menu bar (Datei, Bearbeiten, Ansicht, Betriebsmodus, Prüfermodus, Kamera, Hilfe) and a toolbar. On the right side, there are several control panels: 'Palette' with 'Stretch' and 'Helligkeit' (brightness) and 'Kontrast' (contrast) sliders; 'Profibus-Daten' with fields for 'Prüfprogramm', 'Prüfposition', and 'Bauteil-Ident'; 'Rohdaten / Zustand' with a 'SYSKOM-DEBUG' section; and 'Bauteil-Typ'. Below these are 'Parametrier-Sequenz' buttons ('Laden', 'Aufnahme', 'Sichern') and 'ROI zeichnen' instructions. A table shows ROI parameters: X (128), Y (144), Z (198), # (1), Breite (71), and Höhe (71). The bottom of the interface features a 'THERMO SENSORIK GmbH' logo, a 'Live'/'Wiedergabe'/'Auswertung' control bar with a 22 Hz refresh rate and 270 Bilder, and a status bar with technical data: CMT3845M, 384x288 @ (0,0), 1,5000 ms, FR: 128,019 Hz.

> Innovations protected by Patents

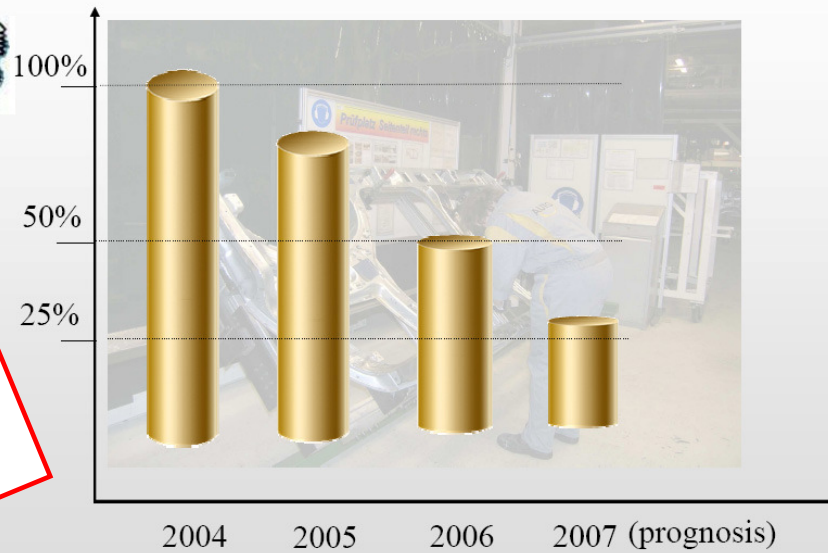
- > „Verfahren zur automatischen Prüfung einer Schweißverbindung“
- > „Verfahren zur automatischen Inspektion einer Schweißnaht“



> **Benefit ...**



**Reduction of quality control costs
by application of thermography**



**Auto 5000 / Volkswagen
statement
at EALA Jan 2007**

Andreas Kropf

EUROPEAN AUTOMOTIVE LASER APPLICATION 2007

Bad Nauheim, Januar 2007

> No manual work anymore!

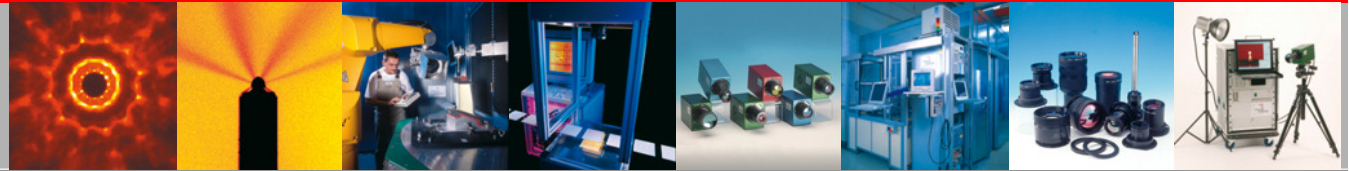




> You find us on Automatica 2008

The Automatica logo consists of a blue rectangular background. On the left side, there is a stylized icon of a grid of squares. To the right of this icon, the word "AUTOMATICA" is written in large, bold, orange capital letters. Below "AUTOMATICA", the words "INNOVATION AND SOLUTIONS" are written in smaller, orange capital letters.

> **Thermosensorik GmbH**
welcome to
Area B2, Booth 109



Thank you

Thank you

Thank you

Thank you

Thermosensorik GmbH
Am Weichselgarten 7
91058 Erlangen
Germany
Phone +49 9131 691-400
www.thermosensorik.de

