

ISIS2008



ArcelorMittal

**25 Years Experience,
Continuous Improvements and Developments
in
Infrared Surface Inspection (Therm-O-Matic®).**

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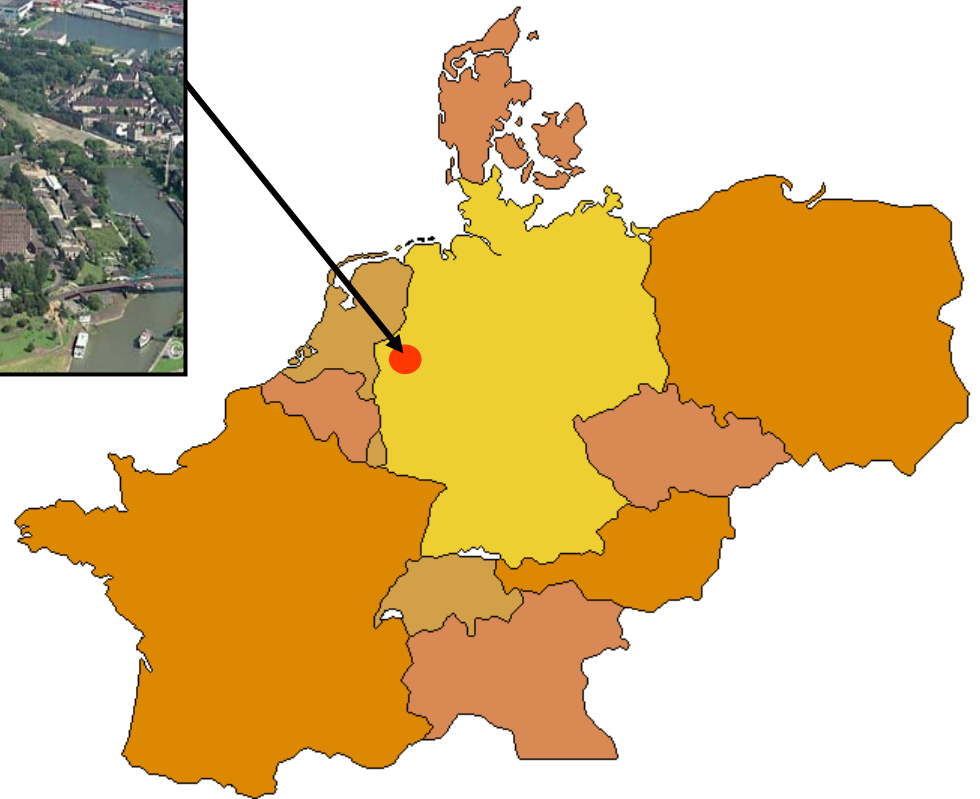




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Presentation of our company

Long Carbon Europe – ArcelorMittal Ruhrort



2007 production 1,2 Mio t of semi-finished materials



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Presentation of our company

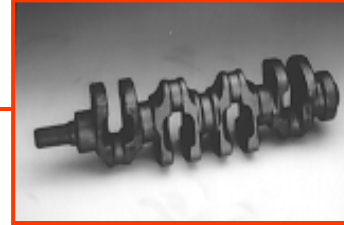
The way of using steel from Ruhrort

rolled billets
(63 – 200 mm rcs)



main
quality
groups

forging steels (micro alloyed ferritic perlitic, quenched and tempered, case-hardening)



steels for cold-heading and for cold extrusion



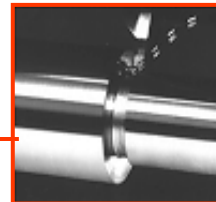
spring steels



roller bearing steels



free-cutting steels
(Pb alloyed)



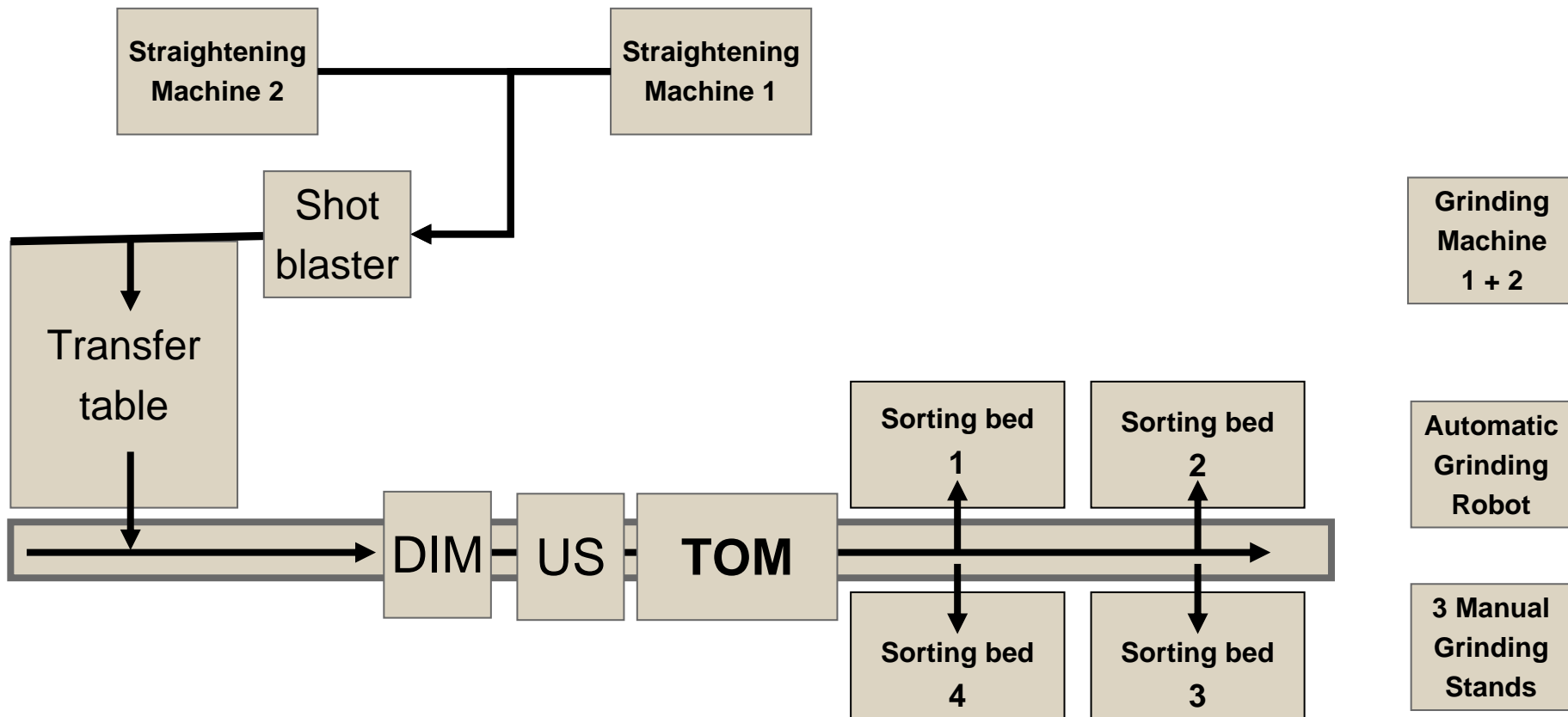
Steel cord



rolled billets
(125 - 175 mm rd)



Layout Billet Conditioning Line



Therm-O-Matic[®] Principle

- Temperature of the surface will increase momentarily by the induced current in the surface of a billet when running through a HF-coil.
- If there is a defect open to the surface, the defect will create an additional local temperature increase ΔT in the defective area.
- 4 IR-scanners take a temperature profile across the billet as it moves through the machine.
- 4 signal processor units analyze the temperature image to detect defects deeper than depth thresholds for marking.
- The increase of ΔT is proportional to depth of cracks

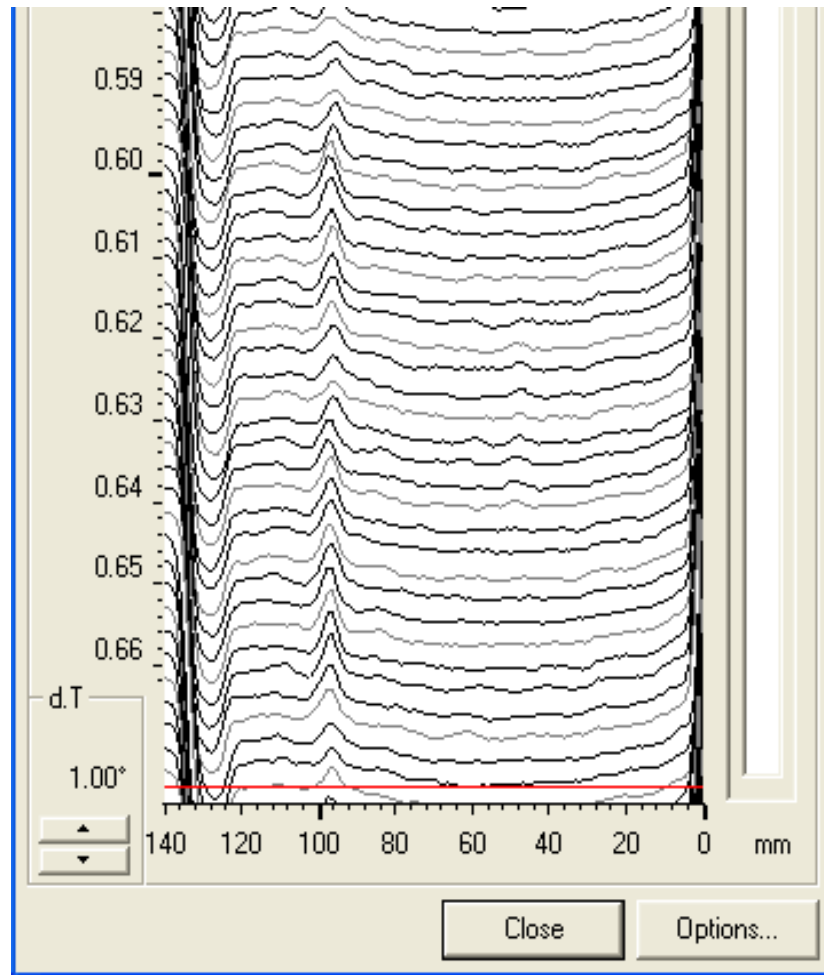
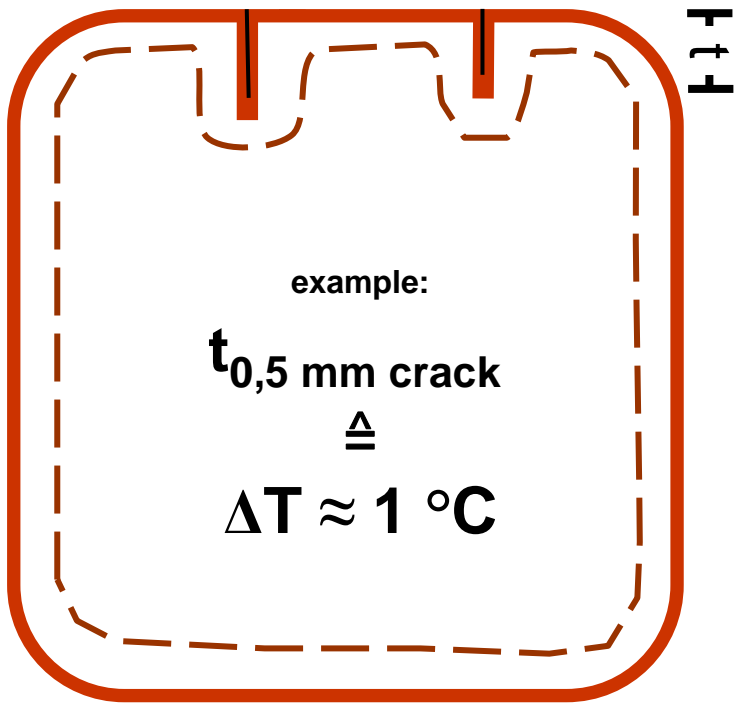
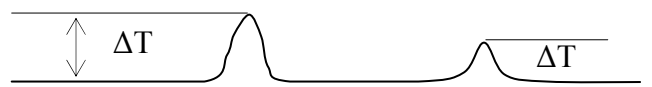


4 IR-scanners

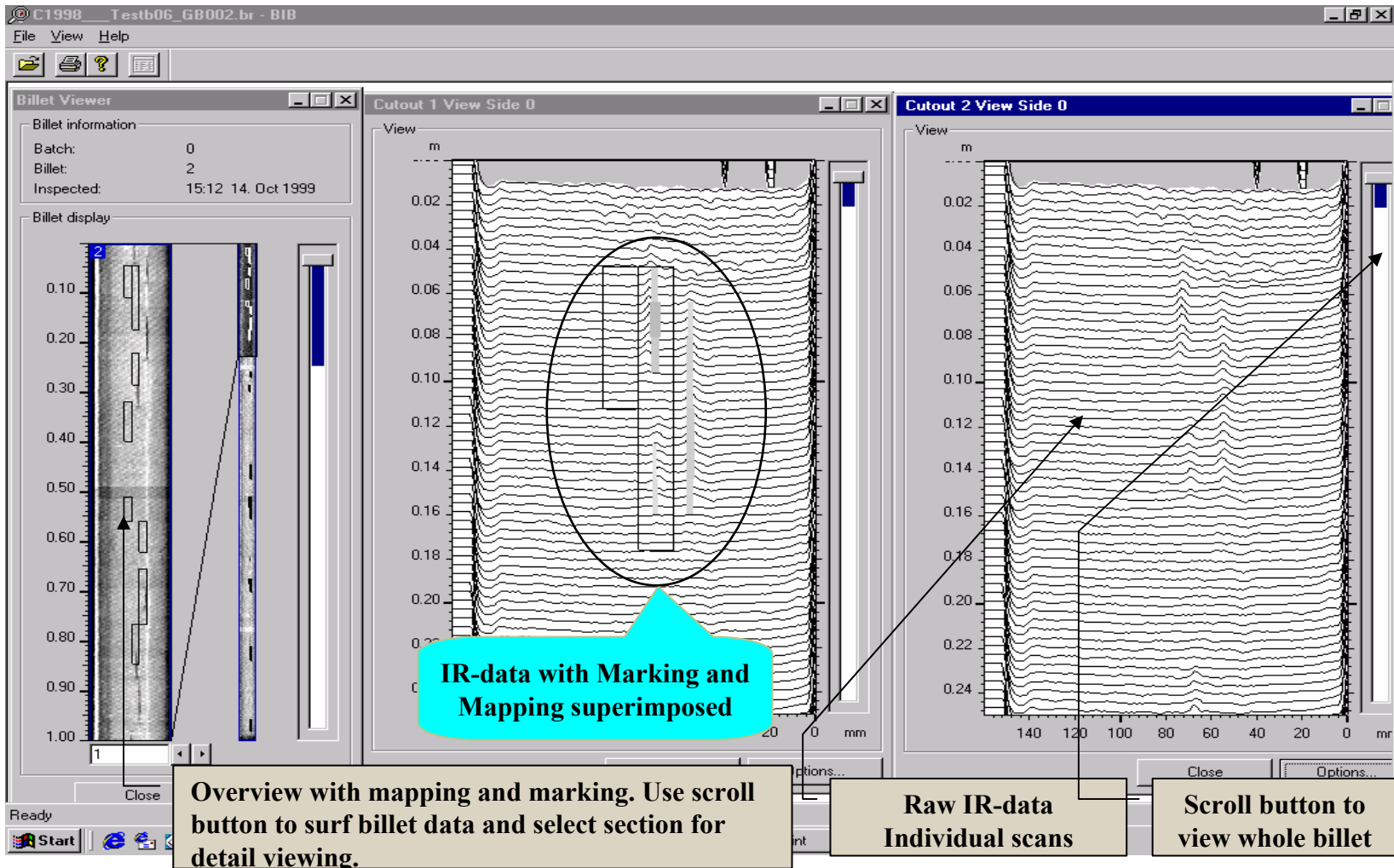
HF
Coil

Detection principle

Defect signal ΔT



Defect viewer (BIS)



The screenshot displays the 'Defect viewer (BIS)' software interface. The main window is titled 'C1998 Testb06_GB002.br - BIB'. It features a menu bar (File, View, Help) and a toolbar with icons for file operations, help, and printing.

The interface is divided into several panels:

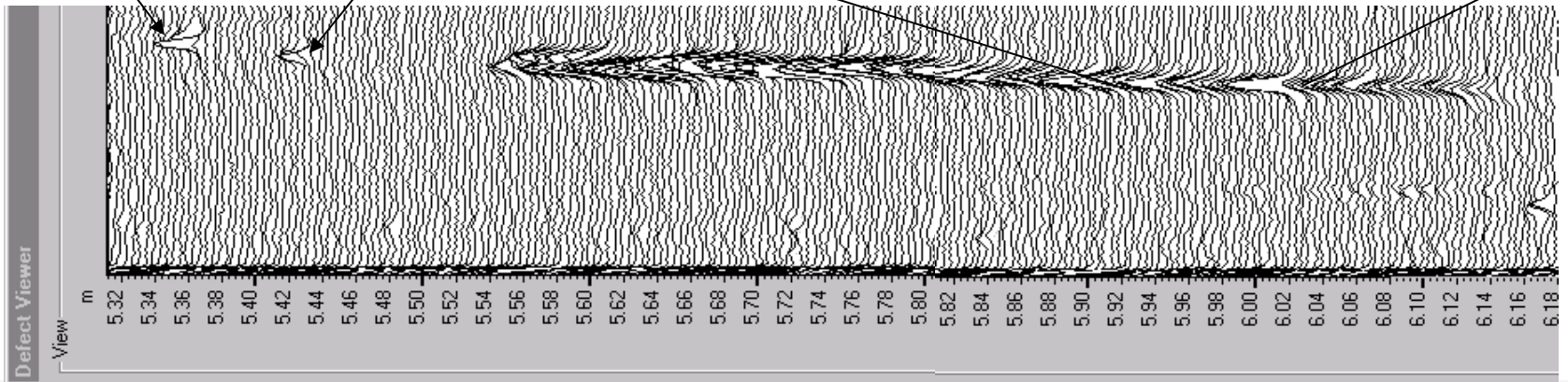
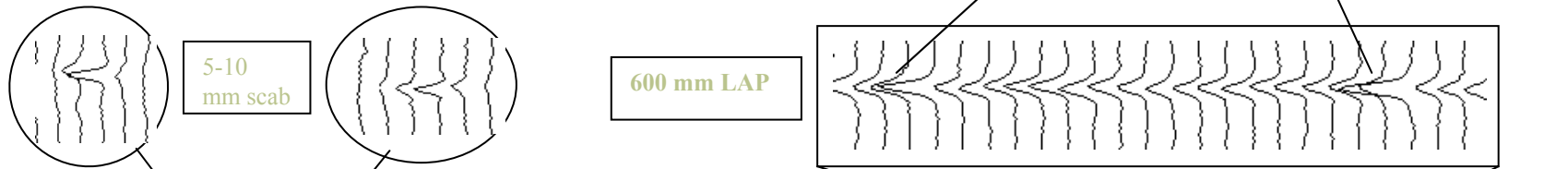
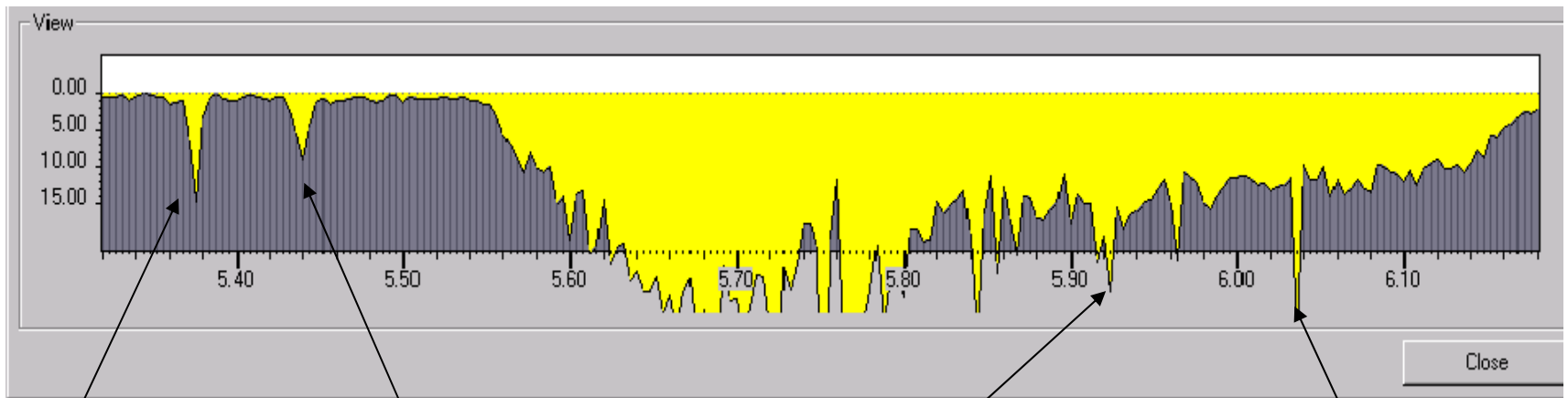
- Billet Viewer:** Contains 'Billet information' (Batch: 0, Billet: 2, Inspected: 15:12 14. Oct 1999) and a 'Billet display' showing a vertical cross-section of the billet with a scroll bar on the right.
- Cutout 1 View Side 0:** A detailed view of the billet's cross-section with IR data overlaid. A cyan callout bubble points to this view, stating 'IR-data with Marking and Mapping superimposed'.
- Cutout 2 View Side 0:** Another detailed view of the billet's cross-section with IR data overlaid. A scroll bar on the right is highlighted by a callout bubble stating 'Scroll button to view whole billet'.

At the bottom, there are three callout boxes:

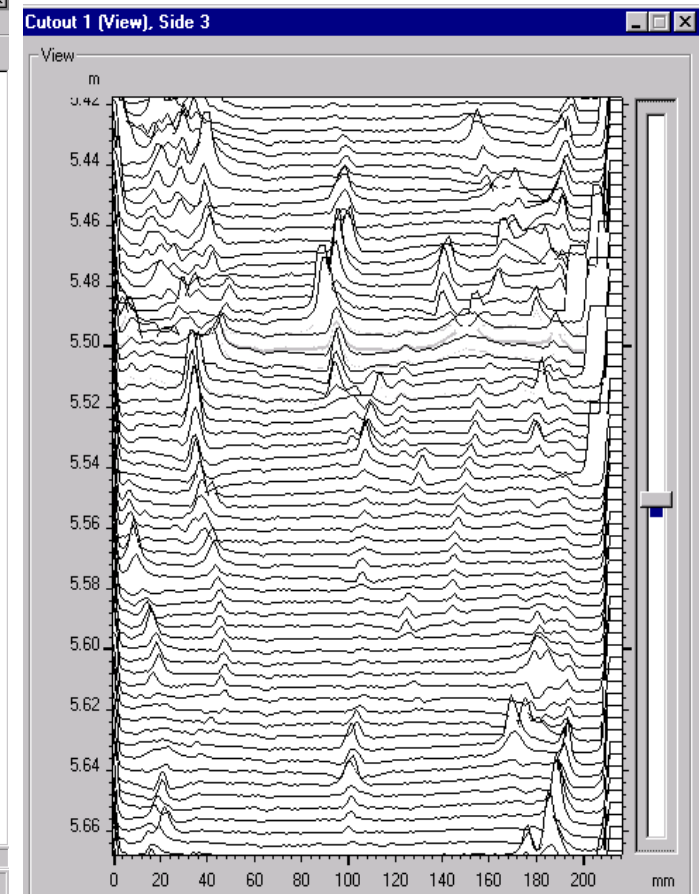
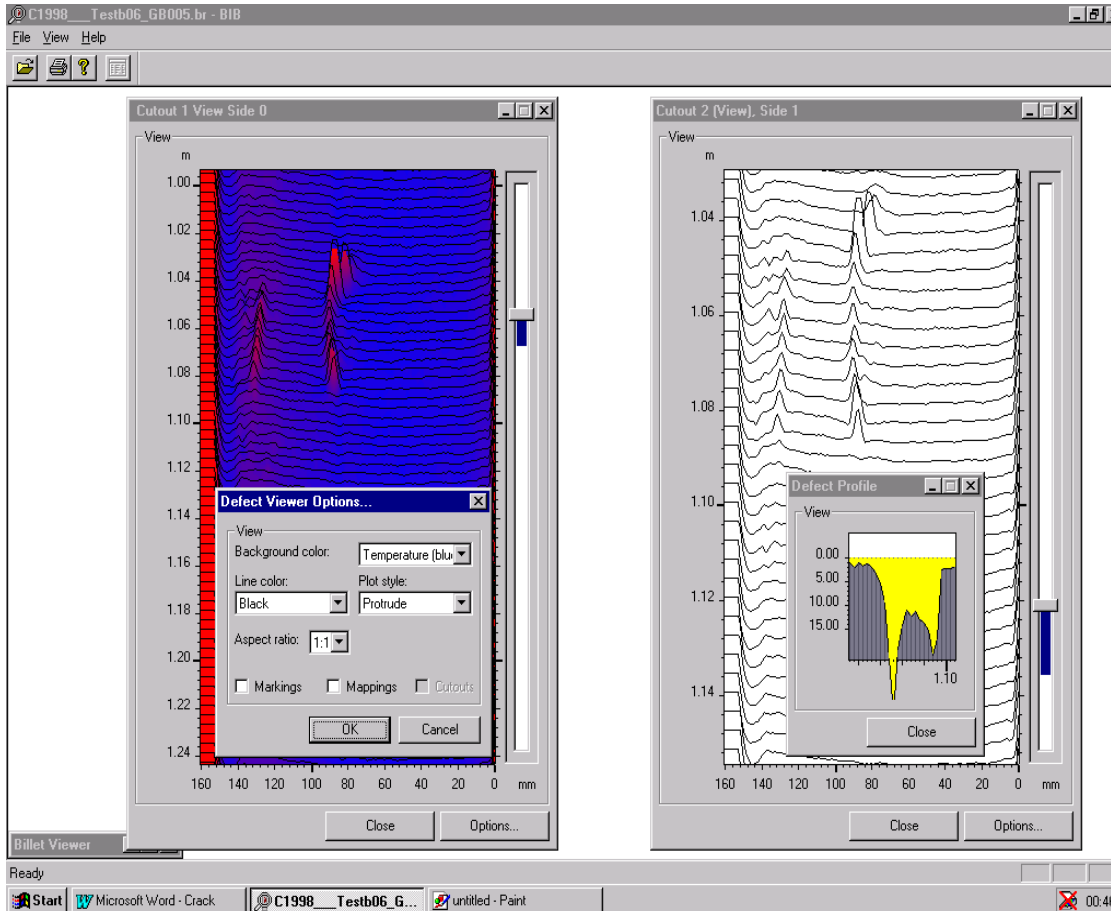
- Overview with mapping and marking. Use scroll button to surf billet data and select section for detail viewing.** (Points to the Billet display panel)
- Raw IR-data Individual scans** (Points to the IR data in the Cutout 2 view)
- Scroll button to view whole billet** (Points to the scroll bar in the Cutout 2 view)

The status bar at the bottom left shows 'Ready' and the Windows taskbar with the Start button and several application icons.

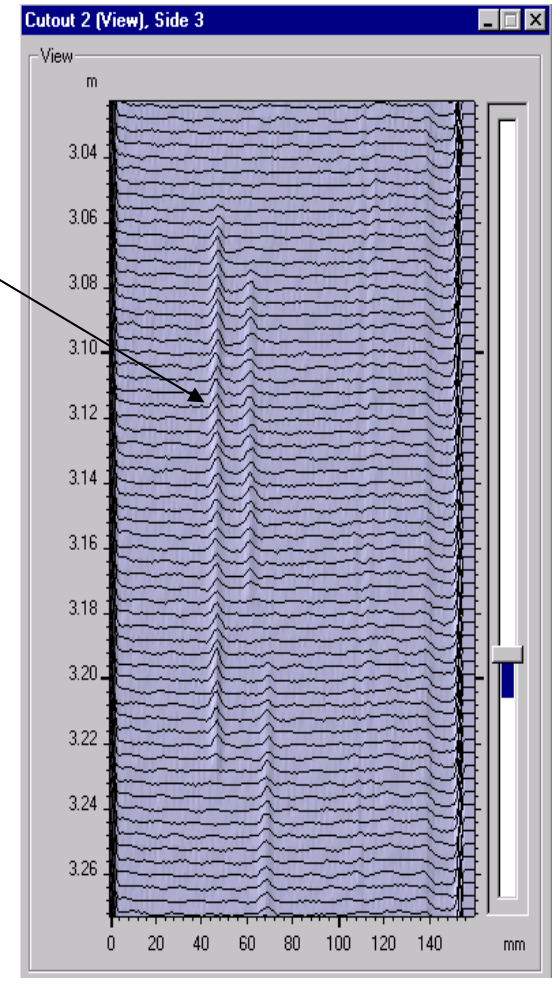
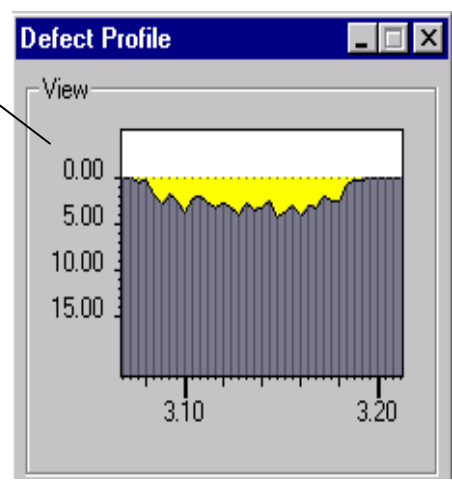
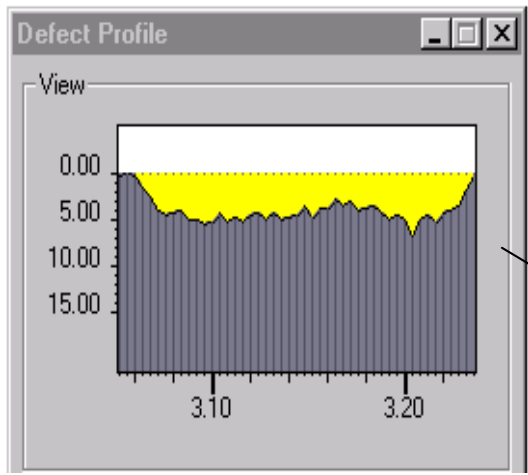
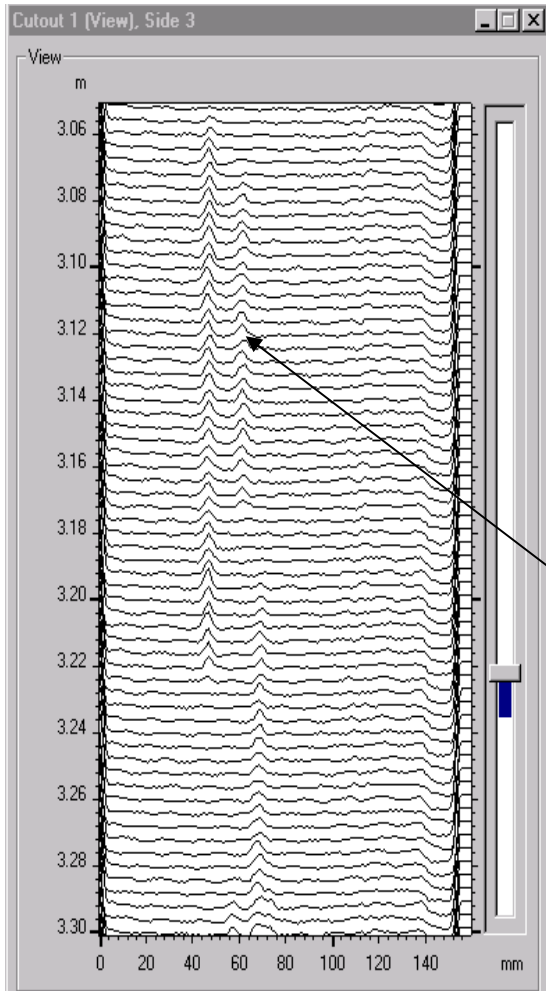
Defect signatures of Scabs and Overlaps



Defect signatures of Scabs



Defect signature of cracks

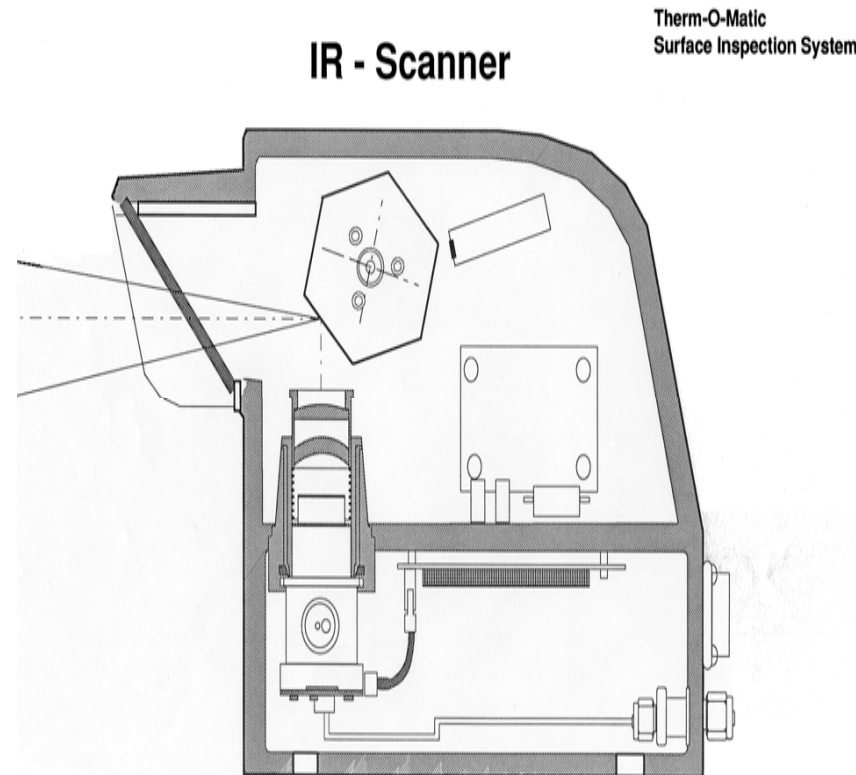


Therm-O-Matic[®] Key Components

	supplier
1. HF-generator	EFD
2. Sensitive IR-scanner	Elkem/Saab
3. Special signal processing unit	Scanmatic
4. Know-how of important factors required to optimize inspection performance	IRTech

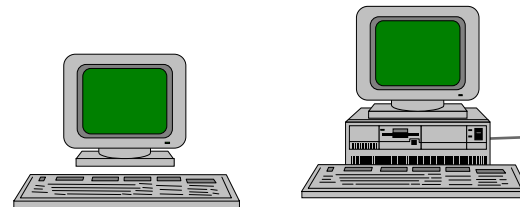
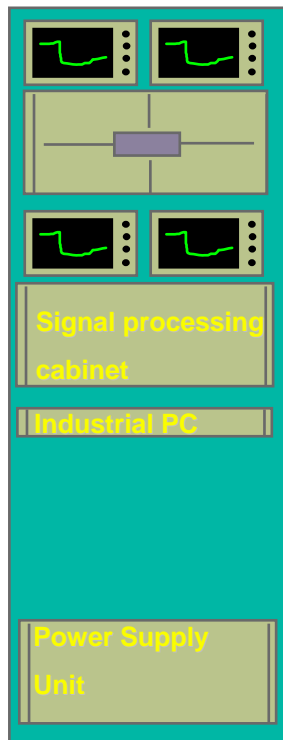
IR-Scanner

- Sensitive IR-scanner developed by Elkem/Saab
 - High sensitivity
 - Reliable operation, > 22 years of continuous trouble free operation
 - Adapted to steel mill condition
 - Joule Thompson cooler

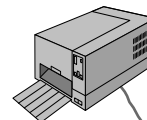


Signal Processing Overview

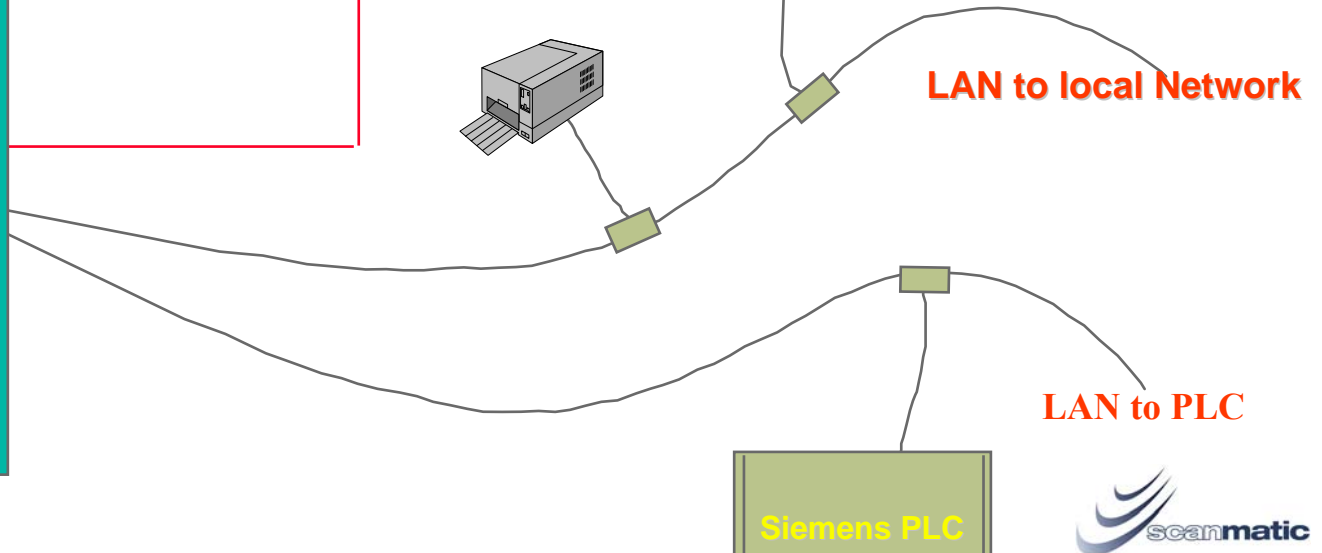
Electronic Rack



PZR Level 2 computer



LAN to local Network

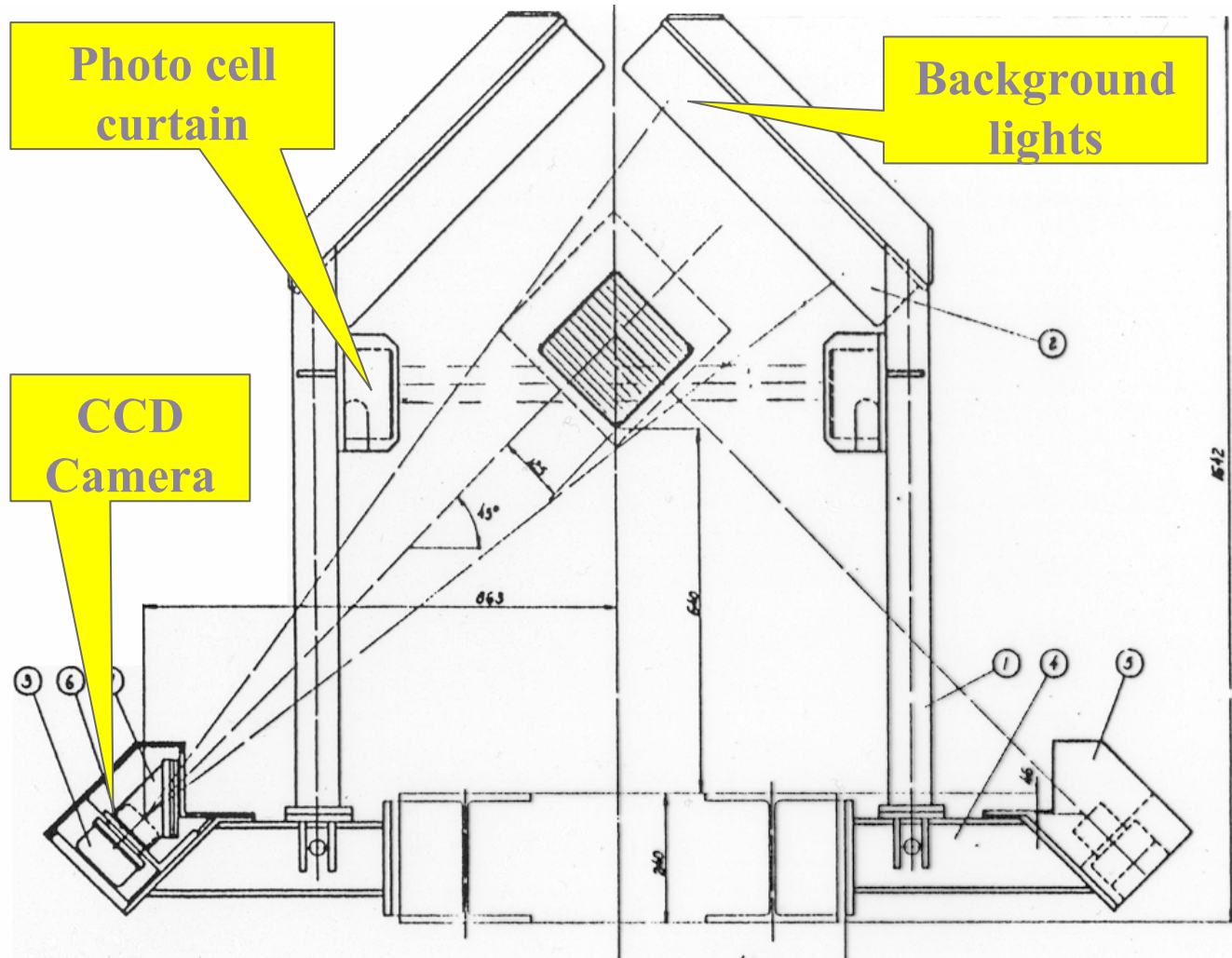


LAN to PLC

Input to process control

- HF-power (from HF-generator)
- Billet size and shape (from operator)
- Billet temperature (calculated by process)
- Billet speed & Billet position (from CCD cameras)
- Steel grade (from operator)
- Scan line distance (set up)
- Detection threshold (from operator)

Billet size and position measurement





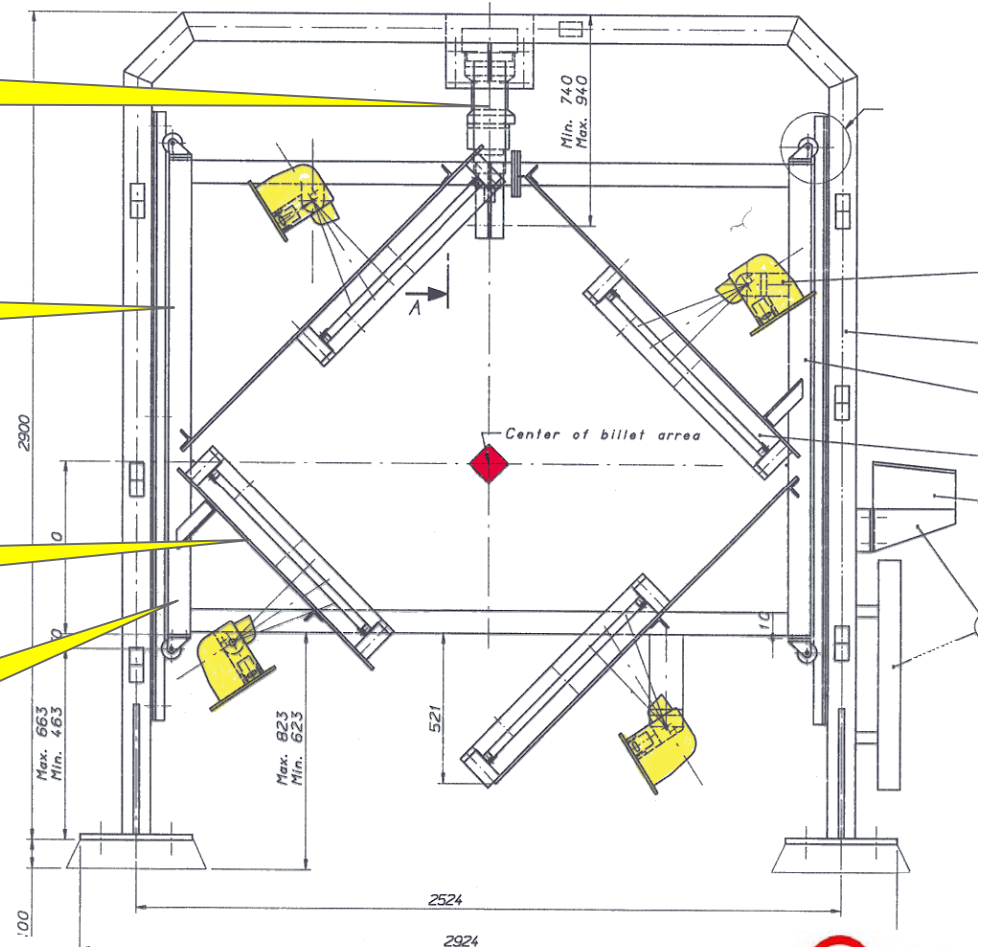
Scanner frame

Frame servo

Scanner frame

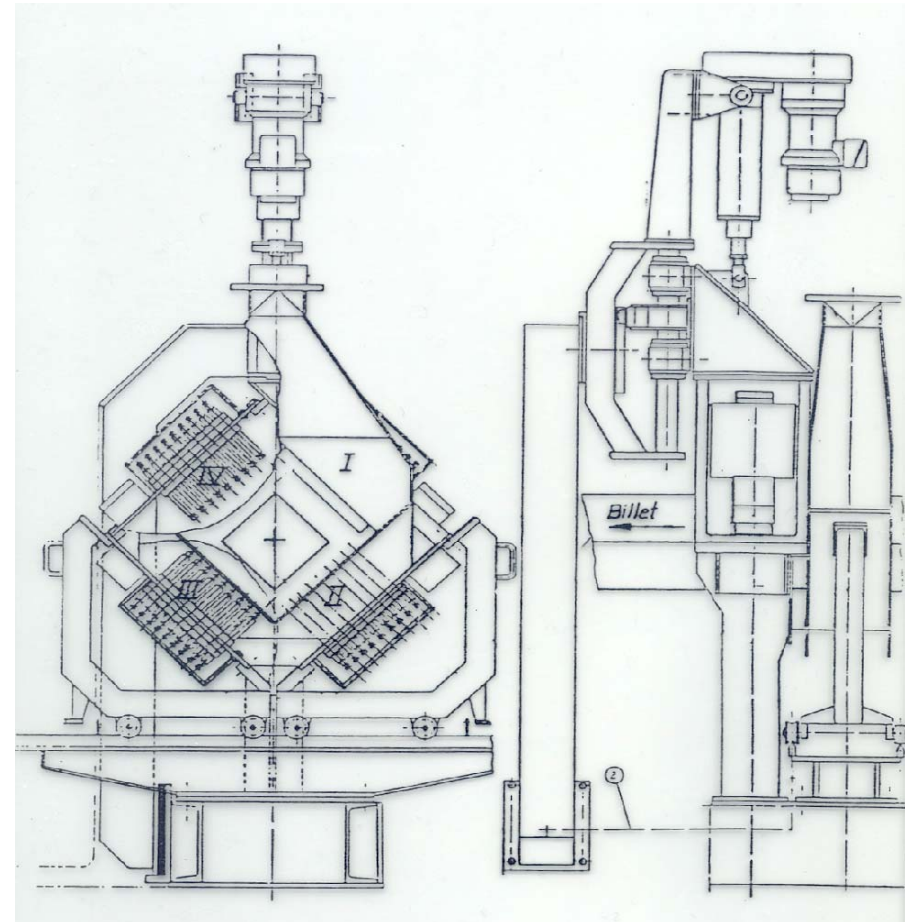
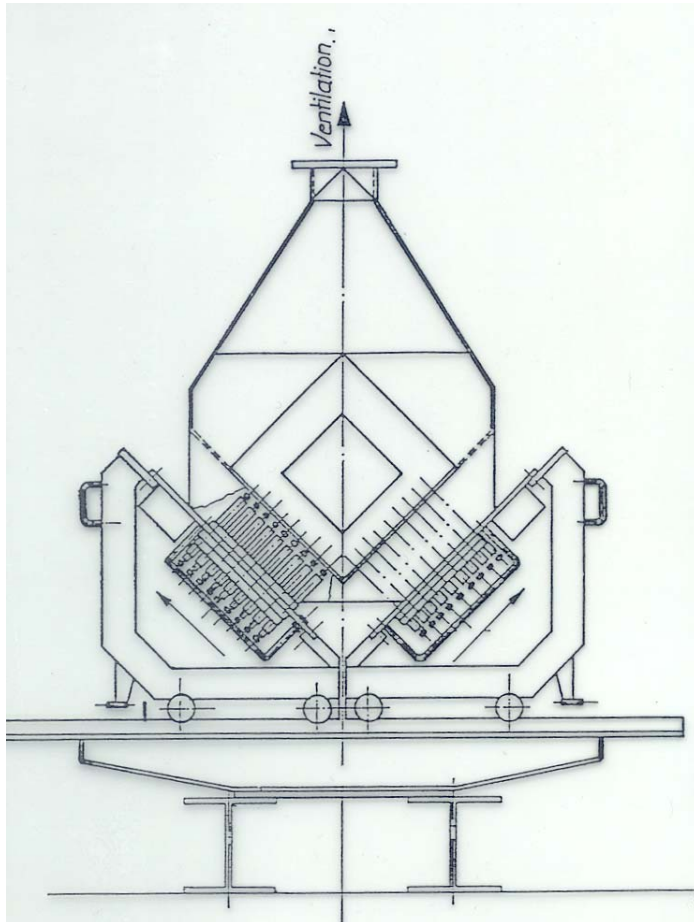
Heat plates

Repositions
with billet size





Marking station



Main Control page

Therm-Matic
Knüppel Rißprüfung
Bedienung TOM+US (FERN)
Bediener: Operator
Schicht: _F
10:45:48

prüfen

Prüfen
(2007)557856-000000000-000000

Form

Dimension 130,0 mm

Fehlerschwelle 1 0,5 mm

Leitfähigkeit 2,5 ms/m

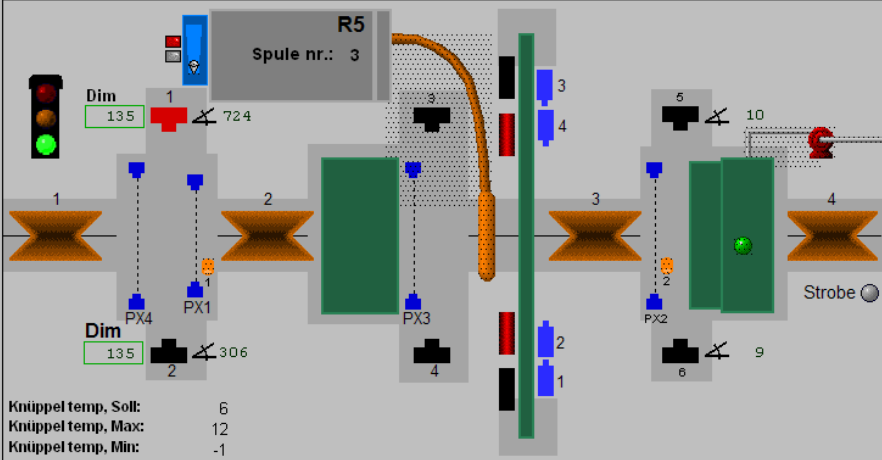
Algorithmus STANDARD

Mapping Ausdruck

T0	40
T1	78
T2	134
Tci	87
Tco	117
Tsc	128

Mapping

'Raw' Daten



Spule nr.: 3

Knüppel temp, Soll: 6
Knüppel temp, Max: 12
Knüppel temp, Min: -1

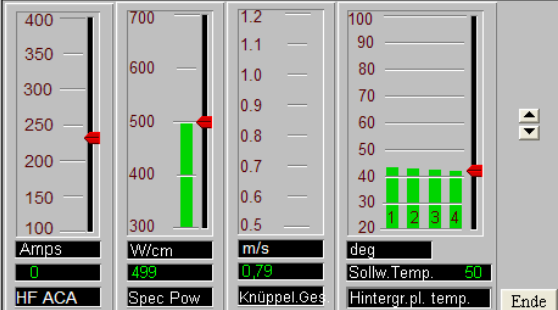
TOM Status:

Zu prüfende Knüppel: 24
Geprüfte Knüppel: 5

Fehlerfreie: 0
Nicht geprüft: 0
Schwelle 1: 0
Schwelle 2: 5

US Status:

US Gut
 US Bedingt gut
 US Schlecht
 US Ungeprüft



Amps: 0
W/cm: 499
m/s: 0.79
deg: Sollw. Temp. 50

P2 Modus Zutritt

#CDM Spulenwechsel
 #CDM

P3 Modus Farbniveau

AUTO Niedrig

P2R Comm. Status
Gesp. Berichte: 0

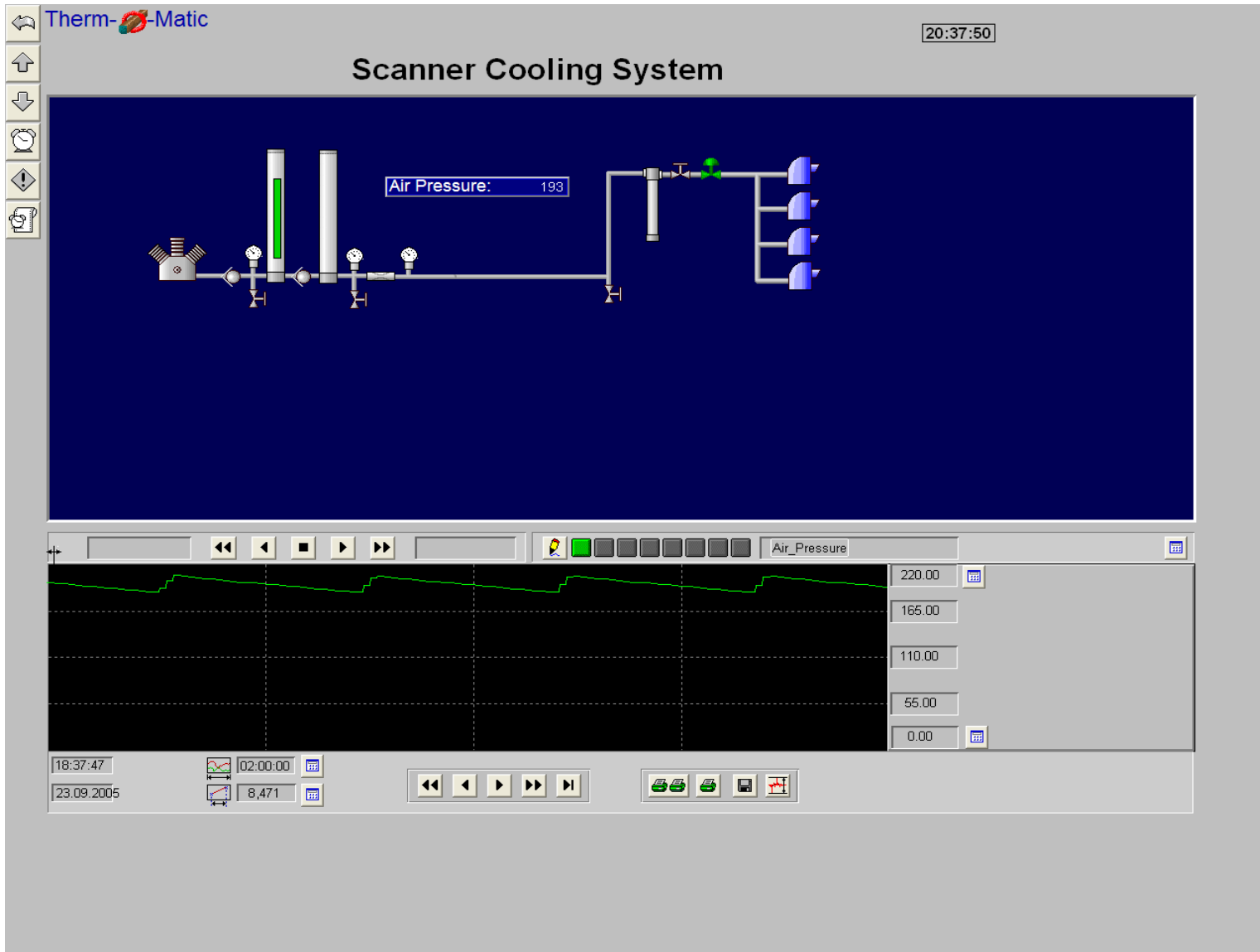
Alarme -Meldungen - Info Blockierte Alarme: 3

Knüppel Bericht

Knüppel Nr.	Knüppel-Nr.	Therm-0-Matic Status	US- Status	Markierung n	Sch.1 pro/m	Sch.2 pro/m	Dimensionen Länge	Dicke1	Dicke2	Kg/m abw	1	2	3	4	5	6	7	8	9	10	0	
1	2005-xxxxxx_yyy_zz	S2		47	2,97	33,40	---	15,8	131,1	131,9	131,4 +	29	14	9	5	4	19	1	0	0	0	0
2	2005-xxxxxx_yyy_zz	S2		55	3,47	40,06	---	15,9	131,1	131,9	131,4 +	34	38	2	14	3	8	0	0	0	0	0
3	2005-xxxxxx_yyy_zz	S2		8	0,51	1,02	---	15,7 -	131,1	131,9	131,4 +	2	0	7	1	5	7	0	0	0	0	0
4	2005-xxxxxx_yyy_zz	S2		62	3,92	27,22	---	15,8 -	131,1	131,9	131,4 +	25	26	4	4	5	26	2	0	0	0	0
5	2005-xxxxxx_yyy_zz	S2		197	12,49	32,34	---	15,8 -	131,1	131,9	131,4 +	76	4	12	1	121	63	0	0	0	0	0

Letzte Knüppel Löschen

Scanner cooling circuit



Reasons for investment in Therm-O-Matic[®]

Capability test in Ruhrort (Sept. 1982) in order to prove this new inspection method:

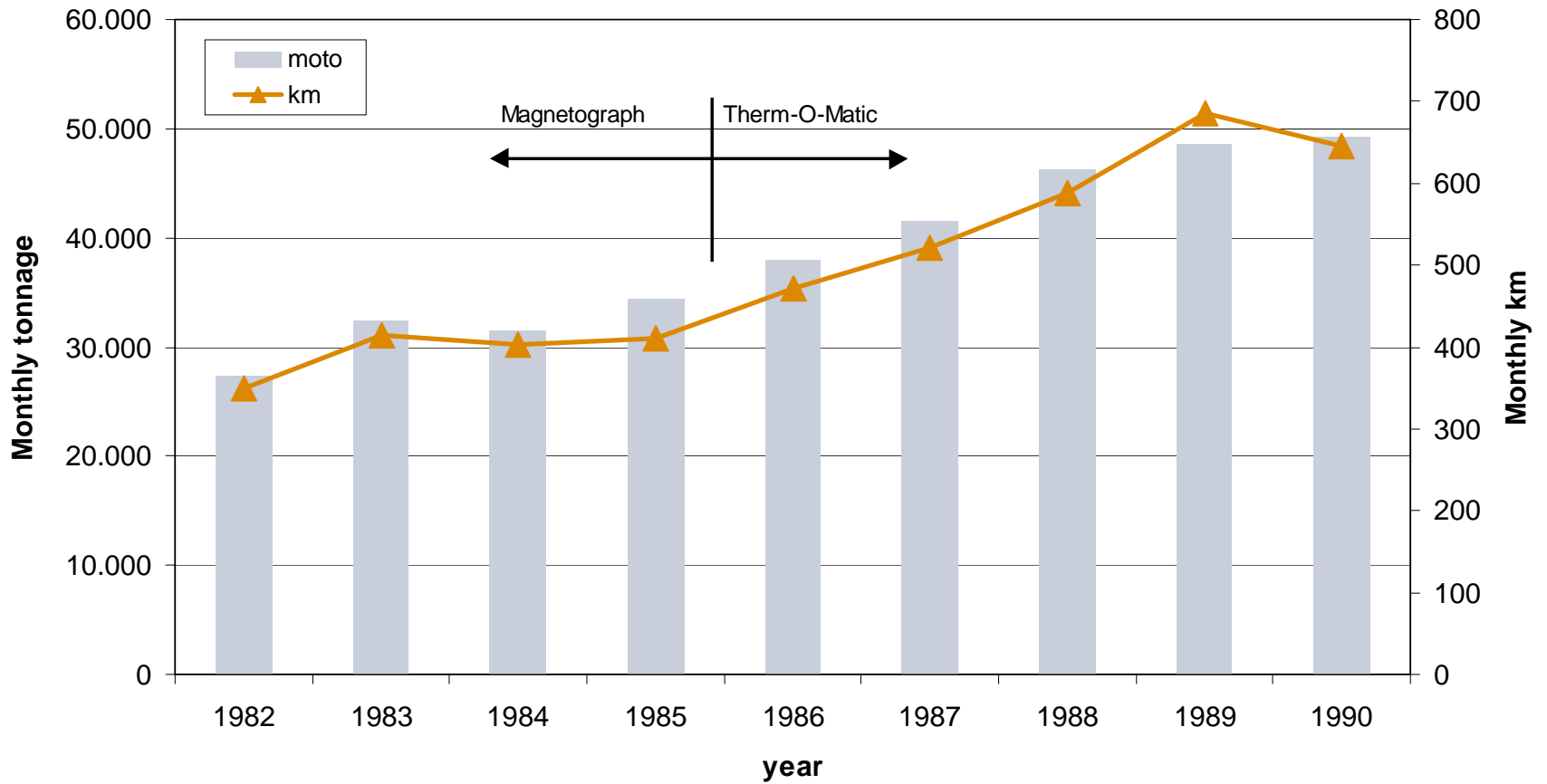
Defect detection capability equal to Magnetograph!

Conclusion: Test results were very exciting on rolled billets.

Improvements in comparison with Magnetograph:

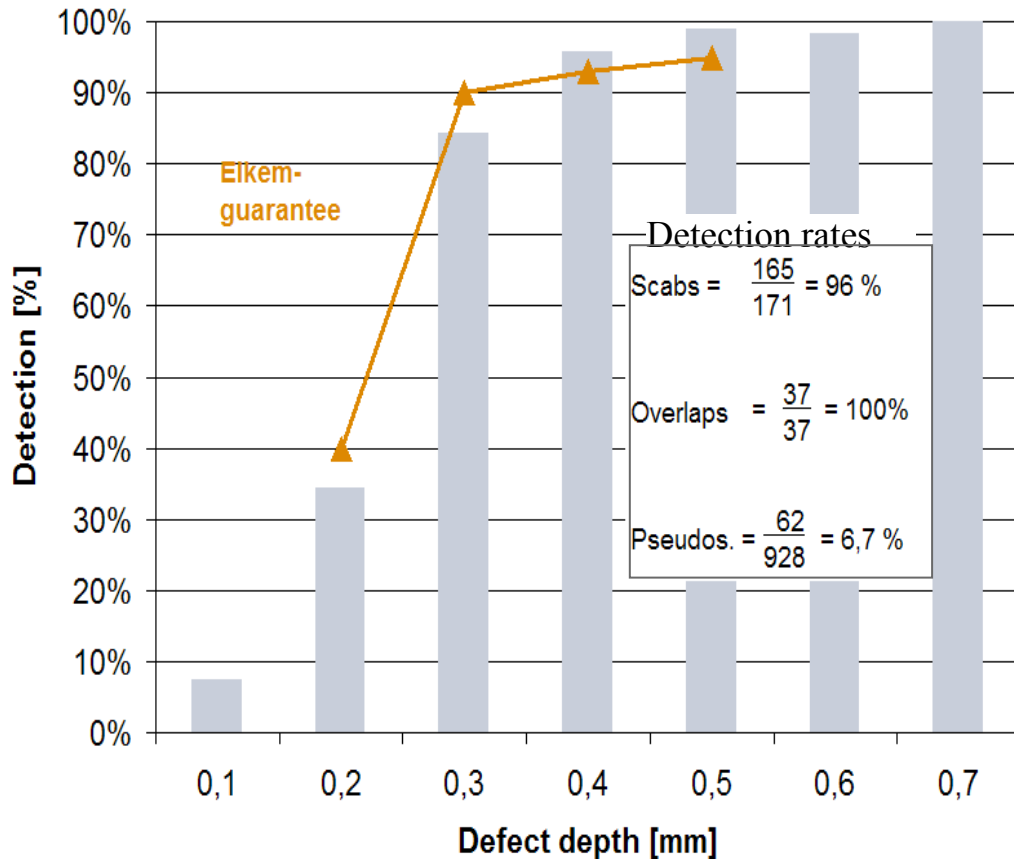
- Inspects round and squares 50 - 250mm
- Contact less (only speed measuring wheels are touching the billet)
- Higher inspection speed (1 m/s)
- Linear and independent adjustable detection thresholds: 0,3 - 1,5 mm
- Accurate true to position marking of defects on bended billets
- Small size and easy to integrate into existing line
- Higher availability
- Lower running costs

Productivity increase 1982 - 1990



Inspection capabilities

Acceptance Test Therm-O-Matic



Therm-O-Matic weak points:

- Surface temperature range: 0 – 50 °C
- Minimum defect length: 12 mm
- Minimum detection threshold: 0,3 mm
- Minimum billet length: 4 m
- Detects longitudinal defects +/- 24 °
- Surface condition: Shot blasted.

Cracks TOM	4	46	161	156	99	61	134
Cracks Total	54	134	191	163	100	62	134

T-O-M Detection Thresholds

- Detection thresholds are set according to signals from cracks. Laps and scabs have high detection rate due to the much higher signals received from these types of defects.
- The system operates with several independent adjustable detection thresholds:
 - **T1:** Level 1 Threshold (true to position marking).
 - **T2:** Level 2 Threshold (can be used for marking of deeper defects)
 - **T3:** Corner Threshold (added to T1)
 - **T0:** Threshold lower than T1 (mapping).

Inspection Data

- The new signal processing units can identify each defect with length, position, depth profile and raw IR-data (surface temperature profile) for each billet.
- The information is stored as:
 - Defect Mapping: Defects deeper than T0
 - Defect Marking: Defect deeper than T1
 - Raw IR-data: Each scan is recorded . Represents an image of surface temperature.
- This information is sent to PZR (level 2 computer) when the billet leaves the installation.

Reports

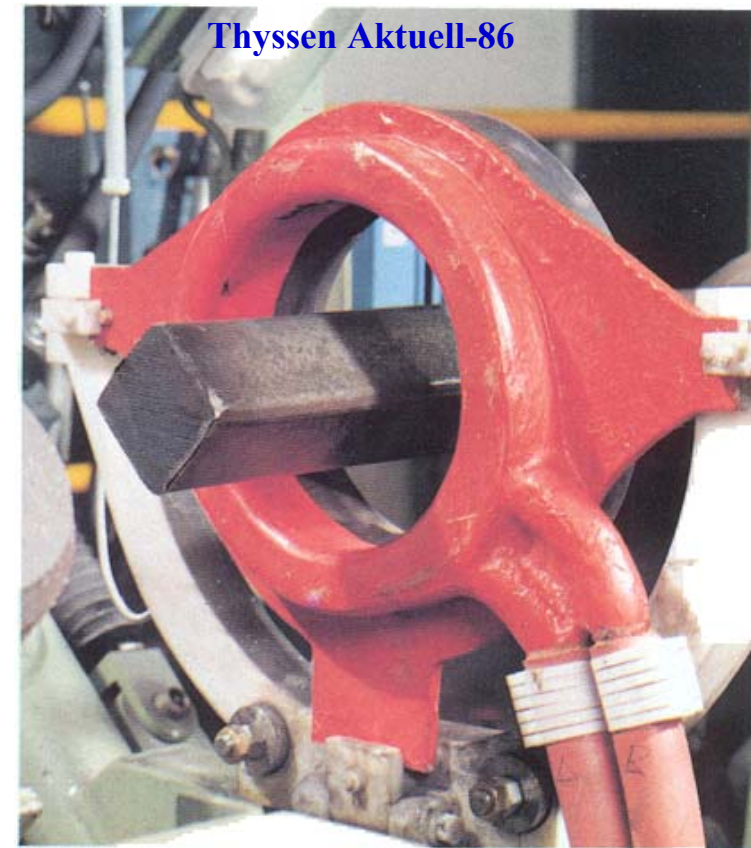
- Billet reports.
 - Inspection results, calculations, status from US and TOM, size measurements and billet numbering/identification are shown on the main control screen and sent to PZR (Level 2 computer) as the billets are inspected.
- Batch reports
 - A summary of the results from billet reports are included in the batch reports.
- Shift reports
 - A summary of the results from batch reports are included in the shift reports
- All reports and inspection data can be printed out locally at any time.

Maintenance assistance

- Process screens
- Tool box for changing machine parameters
- Important process values displayed on process screens
- Test programs to check functions & units
- IO-displays
- Possibility for remote supervision by soft and hardware specialists (IRTech & Scanmatic)
- Annual service and conformity control.

Therm-O-Matic[®] Surface Inspection

- Therm-O-Matic was developed to replace the Elkem Magn-O-Matic (M-O-M) dry MPI system. 15 units sold.
- 21 TOM units sold 1982 - 1993.
- Elkem sold the NDT dept. including all rights and patents to IRTech in 1995.
- 6 units upgraded with new DSP1998 - 2007
- 2 units delivered to China 2006 – 2007.

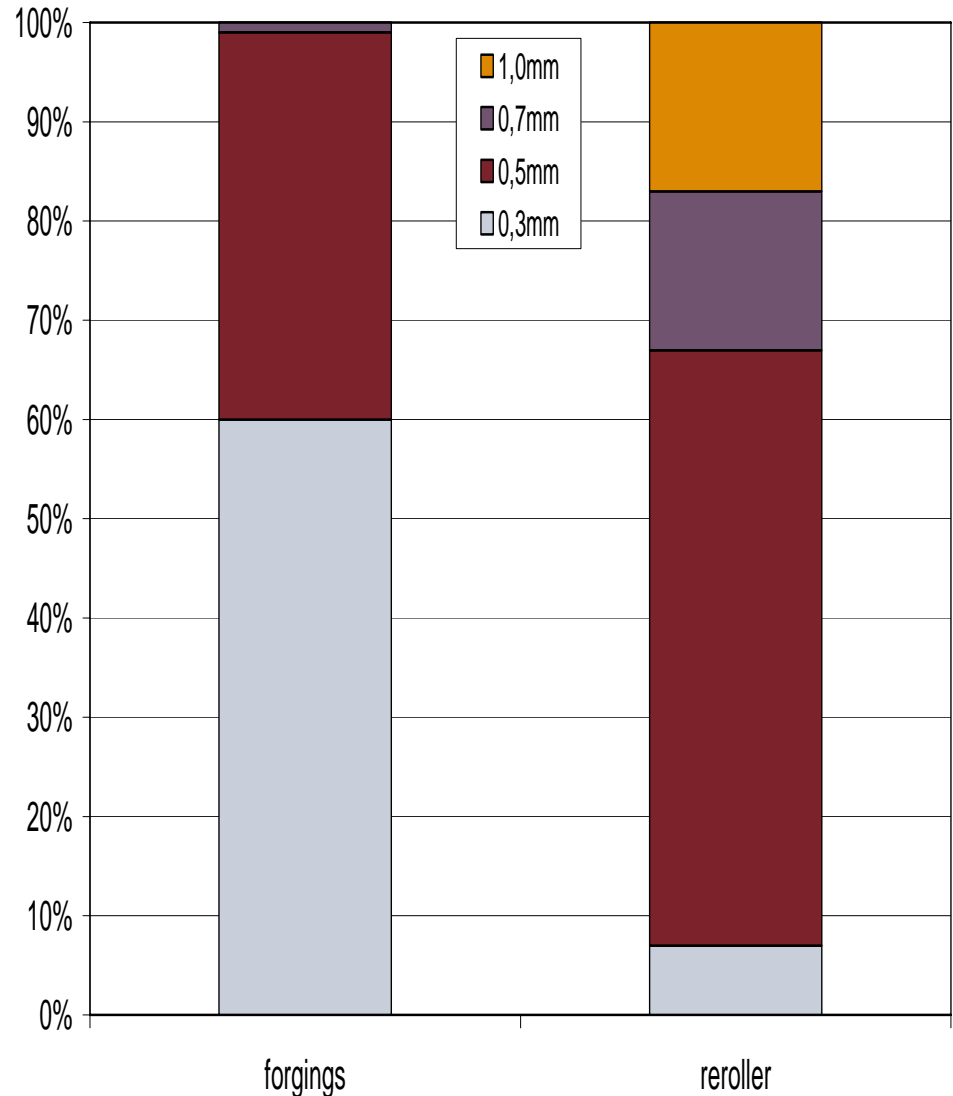


Major changes and upgrades (Ruhrort)

1. The system was ordered in Nov. 84 and has been in operation from Jan 86.
2. Extended to inspect octagonals (8-kant) in 88
3. New marking system (Magnemag) 1995
4. Improved signal processing (New CPU) 1996
Extended reporting of inspection results and inclusion of status from US and size measurement per billet. Connection to PZR (Host computer)
5. New signal processing 2005
The new signal processing is based on hard and software developed by IRTech and Scanmatic for signal analyzes and process control. An industrial PC used for system control, data storage, operator to machine communication (SCADA) connects the system to the local network (LAN).

Production & Inspection Figures

- Total Production 1986 – 2008: 8 Mill tons, 100 000 km (2,5 times around the world!)
- Accurate and linear detection thresholds 0,3 – 1,0 mm
- Hardly any claims (<< 0,1 %)
- High availability
- Only one scanner repair (bearing change)
- Reliable and technically sound inspection operation





Challenges

- Intelligent sorting signal
 - Sorting signal related to defect category and defect length to optimizing repair work and reducing repair costs.
- Improve corner inspection
 - Create and test algorithms to detect short transversal oriented corner defects
- Material tracking system to use the statistical data and the defect viewer as resource to analysing inspection results for upstream control and quality improvement. (T-O-M and US-software are already installed)
- New IR-scanner
 - IRTech is developing a new IR-scanner based on the same technology and working principle.
 - Assist IRTech in testing the new developed scanner under steel mill conditions.
- Automatic grinding based on map information and material tracking.



ArcelorMittal

Thank you for your attention!!

Therm-O-Matic Surface Inspection System



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