Billet InspectIR™

Modern Technology for high-speed surface inspection of cast & rolled billets, bars and tubes
INTRODUCTION

In today’s industrialised world the current demand for steel, particularly from the automotive industry, has become overwhelming. Although none of us can question the effectiveness of older NDT test methods for billets, it was essential that a modern, more efficient & faster method be developed for the in-line inspection of steel billets and tubes to comply with today’s demands and high safety- and quality standards.

The new system had to comply with, i.a. the following criteria: -

• Inspection has to be fast and safe.
• Inspection has to be sensitive and reliable and preferably contact-less.
• The ability to quickly categorize defects according to orientation, length and depth.
• To minimize the risk of human error, it was also necessary that the system is able to perform automatic evaluation and detailed traceable reporting.

Through modern infrared technology we have proven that all this is possible and that thermography as a NDT principle clearly has it’s applications in today’s manufacturing processes.
Working Principle

- When the surface of a steel billet is heated using a high frequency induction process, the edges of surface breaking defects are excited and display an increase in temperature compared to the surrounding areas.
- Only the surface area of the billet directly underneath the coil is heated and then only for a short time duration (micro seconds), depending on the speed of the billet through the coil.
- Temperatures on the billet’s heated surfaces are low and the billet cools down to ambient in seconds.
Working Principle

- Four special real time FPA (Focal Plane Array) infrared cameras are used to simultaneously capture data of individual billet sides at speeds in excess of 1m/s.
- A sophisticated signal processing system analyzes the captured data using proprietary algorithms to identify, quantify and display defects.

Diagram:
- IR Camera
- Automated analysis
- Operator 19"
- Direction of movement
- HF Coil
- Excited surface area
Defect Categorization

- Analysis of the data is two-fold and bi-directional
  - Detection, identification and positioning (Detection Algorithms)
  - Temperature measurement
- Defect temperature rise is related to defect depth ($\Delta T$)
- Our Billet InspectIR™ software performs defect categorization definable by operator, batch, steel grade, customer requirements etc.
Defect Location

- Positioning, Length & Depth
  - Duration of signal is proportional to defect length, billet speed & no. of pixels
  - Measure the time from signal breaking through threshold until dropping below threshold again
  - Related to the measured speed of billet calibrated to pixel length
  - Maximum $\Delta T$ will give max. defect depth
  - Detection generates a full set of defect position co-ordinates

![Diagram of defect location analysis](image)
Billet InspectIR™

Major Components include: -
Billet InspectIR™ – Camera Enclosure

- Billet moves through enclosure on V-shaped rollers
- Enclosure moves in- & out-of-line for service
- Center of enclosure adjusts for billet size
- Different induction coils fitted - billet size range
- Houses four special infrared cameras
- Cameras’ MFD changes to billet size automatically
- PLC controllable
Operator Control Station

- Optional SCADA & UT stations
- LCD touch screen interface

Sophisticated control desk

Operator interface screen
Induction heater

- High frequency induction machine
- Water cooled bus section & coils
- Remote control utilizing SCADA
Signal Processing System

- Four PC-based signal processors
- One PC-based Operator Interface
- High-powered UPS
- SCADA control
- LAN switch
- LCD touch screen
- Utilities
Four air knives remove excess moisture
Four defect marking guns
One reject marking gun
Servo-motor for automatic alignment
Wetting Station

- Wetting of round and square material
- Servo-motor for automatic alignment
- Complete control of particle size
Billet InspectIR™ Results, Investigation and Findings

LI01 LI03

22.5°C 33.1°C
REASON FOR INVESTIGATION:-

Defects were detected during surface inspection of hot-rolled square bars. The bars were rejected according to the acceptance/rejection criteria programmed into the Billet InspectIR™. The $\Delta T$’s measured on the bars were between 12°C-26°C and subsequently the Infrared inspection system rejected the bars.

AIM:-

Determination of defect depth and profile classification of defect(s) detected by means of infrared inspection / testing technique.
1. **Visual examination:**

The bars were scrutinized after being inspected by means of Infrared camera viewing and image processing. The defects were also visible to the naked eye and appeared as ‘long seam-type and scab/sliver type defects’. Three (3) sections approximately 300 mm long were marked and cut-out for further microscopic examination.

2. **Microscopic examination:**

After careful consideration, sub-samples were marked out, cut and prepared for optical light microscopy using standard metallographic techniques. The defects were found to be scab/sliver type defects. The defect depths did vary slightly but in general the defect shape did not change significantly (see photo-micrographs on following slides).
Microscopic...

Magnification 50x, Defect depth 0.19 mm
Microscopic...

Magnification 50x, Defect depth 0.19 mm
Microscopic...

Magnification 50x, Defect depth 0.40 mm
Microscopic...

Magnification 50x, Defect depth 0.15 mm
Natural defects found...

Small defect 0.2mm deep on the edge of the radius
Corner defect

0,28mm deep defect on the radius
Center defect

Center defect 0,17mm deep
Center defect

Center defect 0,23mm deep, partially ground
Pinholes...

Pinhole type defect 0.25mm deep
Thermal Results

Calibration Billet

Leading Edge Defect 1

\[ \Delta T = 6^\circ C \]
Natural defects

Natural defect on leading edge in recessed area.
Found joined sub-surface.

Δ 6 - 26 °C
Shot Blasted Billet – defects & slivers
Un-shot Blasted Billet – slivers

Sliver identified and verified in top corner area

Note: transverse nature

Note: scale has lower temperature – below background temperature

Same defect – after shot blasting
Calibration Billet – artificial defects

Side 1 Bottom $\Delta 6.4^\circ C$

Side 1 Center $\Delta 7.2^\circ C$
Shot Blasted Billet – defects & slivers
Billet InspectIR™

Modern, High-Speed Billet Inspection

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QUESTIONS ?