Infrared Thermography testing during the welding process

Sébastien Saint Yves¹, Oriane Fedrigo², Jules Recolin²

¹ French Industrial and Mechanical Technical Centre (CETIM), Bouguenais, France
² French Industrial and Mechanical Technical Centre (CETIM), Senlis, France

Abstract: Metal parts assembly by welding processes requires the performance of post-fabrication inspection to ensure the integrity of the weld seams. These inspections are time-consuming and require the completion of welding operations before being performed. Implementation of an "in-situ inspection" to adapt or stop the process during a drift of it would allow to obtain a gain in the immobilization of the parts, to improve the quality of the assemblies, and to make the welding processes more reliable. Online monitoring of many manufacturing processes is of real interest to guarantee the quality of manufactured products.
ECNDT 2023

Infrared Thermography inspection during welding process

Tuesday 04 July 2023

Sébastien SAINT YVES
Summary

• Infrared thermography principle

• Infrared thermography applied to welding process inspection

• Frame to study

• Results

• Conclusion

• Perspectives
Infrared thermography principle
The infrared thermography principle

- **Definition**
  - « Method for obtaining, by means of appropriate equipment, the thermal image of a scene observed infrared spectral range » *Afnor*
  - The resulting image is a thermogram
Passive infrared thermography

- **Principle**
  
  Passive infrared thermography is a non-destructive testing technique based on the measurement of surface temperatures that essentially uses heat transfer by conduction and thermal radiation specific to the process being viewed without additional energy input.

- **Mains applications**
  
  In the building industry
  - Thermal insulation inspection, detection of thermal bridges
  - Aerial thermography
  - Defects detection on heating and cooling networks

  In electrical maintenance
  - Detecting flaws in electrical equipment

  In security
  - Intrusion detection on sensitive sites

  In the medical field
  - Detection of local temperature anomalies (ignition…)
  - Detection of fever (airport security)
Passive infrared thermography

● Mains applications (follow up)

In industry
- Furnace inspection
- Detection of mechanical overheating
- Detection of gas leaks
- Measurement of material properties (conductivity, diffusivity, emissivity…)
- Measurement of coating thickness, deposite hardness
- Control of shaping processes, naturally emitting heat
- Measurement of heating homogeneity
- Detection of heterogeneities (metal inserts in composite)
- Characterisation of the orientation of the first layers in composites

In the cultural field
- Detection of defects under paintings (works of art)

In the field agriculture
- Monitoring the condition of crops to optimise harvesting
Infrared thermography applied to welding process inspection
Passive infrared thermography inspection during welding process

State of the art and interest:

- Few studies exist on detection during welding
- Interest for industrials
- 3 use cases are in progress at Cetim
Objectives:

- Studying if infrared thermography can permit to detect welding defects such as porosities, cracks or lack of fusion...

- Evaluating the technology for in process monitoring
Frame to study
Passive infrared thermography inspection during welding process

The first use case: MAG « Metal Active Gas »

- Carbon steel, corner beads (PB position)
The second use case: TIG « Tungsten Inert Gas » Case N°1

- Inconel coating on carbon steel, deposited cords
Passive infrared thermography inspection during welding process

The third use case: TIG « Tungsten Inert Gas » Case N°2

- TOCE on stainless steel (PA position), penetration pass
Results
Main lock: *Arc radiation*

- Intensity creating signal saturation
- Large variations in radiation (base metal, cooled bead, solidifying bead and melt bath)
- Difficulty of visualisation.

Experiment improvement:

*Evolution of the reduction of radiation saturation during the progress of the preliminary tests of the TIG process.*
Passive infrared thermography inspection during welding process

Interpretation of the results

• The results of the detection of indications, by passive infrared thermography during the welding process, presented in these studies were confirmed by at least one other non-destructive and destructive testing method.
  « VT / PT / MT / RT / UT / Macrography »

• Many of the data were analysed by means of thermal profile, that is by monitoring a line of pixels across the width of the bead.
Passive infrared thermography inspection during welding process
Passive infrared thermography inspection during welding process

MAG / TIG results

*Indications detected:*

- Surface pore
- Porosity
- Clustered porosities
- Crater crack, hot cracking
- Lack of side-wall fusion and lack of penetration
- Inclusions
- Imperfect shape and dimensions (Irregular width, …)
Conclusion
Passive infrared thermography inspection during welding process

Conclusion

As the results of various studies carried out, the detection of indications created voluntarily during the welding process proved to be conclusive. The majority of the tests show that a discontinuity causes at least:

- A radiative flow gradient,
- A typical thermal signature,
- A spatial shift.

The areas where discontinuities appear are different depending on their nature:

- Melt bath
- Solidification area
- Cooling area
Perspectives
Passive infrared thermography inspection during welding process

Perspectives

- Improvement of sharpness and visualisation (melt bath)
- Sizing of indications (smallest detectable defect)
- Industrialization (automation, detection threshold, …)
- Production monitoring (repeatability, correlations with welding parameters, …)
- Studies on different grades, assemblies and processes
Thank you for your attention

For all information on welding process monitoring by infrared Thermography:

Sébastien Saint Yves « sebastien.saintyves@cetim.fr »