Thermo Profile Scanner for tube welding

We eye Your welding Quality
The view *through the arc into the heat signature*

Local heat input is melting and is changing the structure of materials during brazing and welding processes.

The correct heat input and also the undisturbed heat distribution is an important attribute for the evaluation of welding seams.

The human eye can not see heat radiation. The glare of the visible part of an arc is so intense, it will cover up any heat information.

Here fore technology is required that can capture the heat information in spite of:
- Massive glare of the arc
- Fumes and spatter contaminated environment permanently.

HKS is introducing a device that fulfills these requirements

**ThermoProfilScanner (TPS)**

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**Principle of operation ThermoProfilScanner**

The Thermoprofilscanner is constantly capturing a thermo profile **across the welding seam.**

Hereby it is able to fade out the visible light from the arc. A heat image of the welding seam is created by the continues movement of the welding torch.

**Technical data:**

- Work distance 15 to 120 mm (special edition 200mm)
- Scan frequency \( \geq 400 \) Profiles/s and shutter speeds of a single line of 50 \( \mu \)s allowing a resolution of up to 15 m/min (Laser / arc welding) or high frequency of 180 m/min.
- better than 1 mm by speeds up to 20 m/min.
- Advanced design features allows continuous use in strongly contaminated environment (welding smoke, welding splash, water vapour etc.):
  - Glass free design
  - Gas curtain
  - Anti spatter concept
  - Integrated water cooling
Extremly robust action directly on the welding torch

The sensor can withstand most extreme working conditions and works reliably in great heat, dirt and spatters.

The heat signature is captured after solidification of the welding seam, before the seam is cooled off.

Depending on the application this can be 5 mm to 40 mm behind the torch.

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The ThermoProfilScanner as component for monitoring system WeldQAS

**WeldQAS**

**Production documentation**
Extensive representation and analysis functions

**Welding process supervision**
Thresholds for warnings and faults

**Recognize faults reject**
Automatic recognition of faulty part and rejection in serial production

Fault output for part marking, ejection and alarm

**Measurement**
- weld parameter

**Measurement**
- Heat field

**SENSORS**
- Current+
- Voltage
- Wire feed
- Gas flow

**ThermoProfilScanner**

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Design and method of operation

1. The Thermoprofilscanner is capturing the temperature over the welding joint and is sending the data to the WeldQAS-device.
2. The WeldQAS-device is calculating for each line the attributes of the profile (width and position of the heat field, symmetry and max. temperature.)
3. The heat images are displayed simultaneously visually by the WeldQAS, stored and compared with programmed set values.
4. By recognizing violations of limit values the unit detecting welding irregularities and their position within the pipe.
5. The error signal is generated immediately or can be buffered to mark the defective with a marking spray unit.
6. The WeldQAS-device is storing all data pertaining to the pipes, which will be numbered, and can be synchronized with a saw signal.
7. The data are stored in a database and are displayed in a pipe monitor program.
TPS advantages compared to other test methods

**Optical offline-method (after welding)**
(Automatic visualization via laser triangulation)

**Principle:** Laser is projecting a cut line onto seam, a camera system with image processing unit is evaluating patterns.

**Eddy current method**

**Principle:** Is inducting eddy currents into base material and is processing disturbances in current flow.

In comparison: Use of TPS

- better fault detection of
  - Pores
  - Penetration faults
  - Fusion faults below surface

- substantially lower investment costs
- no tact time increase

In comparison: Use of TPS

- better fault detection with
  - Seam offset
  - insufficient penetration
  (for example due to current deviation up to 50%)
  - small holes
  - unsymmetrical edge penetration

- lower Investment costs
New possibilities of seam control

TPS = Visual seam inspection
Recognition of seam position

Evaluation of metallurgic-thermal processes in the seam
to recognize penetration faults and insufficient fusion along edges

The temperature profiles are processed in real time, width, position and symmetry e.t.c are analyzed.

Welding inconsistencies compared to the OK-seam are recognized as deviations within the thermo profiles and will be flagged.

Attributes of the thermo profiles (width, position..) are thought the same way as other parameters, and can be monitored via thresholds or envelopes.

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The view into the welding seam in creation

The thermo profile is captured after solidification of the welding seam, before it is cooled down. Depending on the application this happens 5 to 50 mm behind the torch.
New possibilities of seam control

**TPS =**

**Visual seam inspection**
Recognition of seam position

**Evaluation of metalurgic-thermal processes in the seam**
To recognize penetration faults and insufficient fusion along edges

The temperature profiles are processed in **real time**, width, position and symmetry e.t.c are analysed.

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Example 1  Spiral tube production TIG

**Task**

Recognition of visible and invisible welding inconsistencies as holes, pores larger than 1 mm, edge fusion faults and penetration fluctuations.

Recognition of “weld ability” problems with supplied materials.

The existing eddy current detection system does not fulfill requirements.

**ThermoProfiScanner**

- Offset to the torch: **40 mm**
- Scan frequency: **100 Hz**
- Resolution: **0,9 mm**
- Working distance: **20-60 mm**
- Purging gas: **3 l/min**
- Welding speed up to **3,5 m/min**
- Water cooling via power source
Example 1  Spiral tube production

Work monitor with actual seam evaluation and heat signature

Captured are:
- Welding current,
- Voltage,
- Shield gas amount,
- Band position and -speed

Heat signature of a 6 m tube

From the heat signature the following is calculated:
- Welding seam position
- Width of temperature zone
- Symmetry of heat field
- Cool down characteristic

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Example 1  Spiral tube production

Special features for seam pipe welding

- Measurement of the running tube position and allocation welding faults to welding position
- Marking of faulty tube sections, when these reach marking position
- Data allocation after tube separation to one set of data for each tube including heat images
- Integrated network functionality

Graphic display of the last 25 tubes in tube monitor application
Example 1  Spiral tube production

Fault image:  Burn trough

CrNi – Band 73*1,0 tube 32mm

Burn through is causing heat jam.
One scan is equivalent to scan width of 0,62 mm.
Example 1  Spiral tube production

Fault image: Uneven heat distribution

Steel band  86*1,5 – tube 38 mm

Uneven heat input and penetration fluctuations due to defective band material
(Seam appearance – fish scaling)
Example 1  Spiral tube production

Fault image:  Seam offset / seam position

CrNi - Band  73*1,0 tube 32mm

Such seam offsets causing welding seam to fail when the tube is pressurized.
Example 2  Longitudinal pipe manufacturing TIG/Plasma

**Task**

Detection of visible and invisible welding irregularities as pores, insufficient side-fusion, defect root penetration and the detection of torch misalignments.

**ThermoProfilScanner**

- Offset to the torch: **20 mm**
- Scan frequency: **100 Hz**
- Resolution: **0.9 mm**
- Working distance: **80 mm**
- Purging gas: **3 l/min**
- Welding speed up to **1.5 m/min**
- Water cooling
Example 2 - Longitudinal pipe manufacturing
Plasma welding/TIG

Fault image: Torch is not in center line of the welding joint.
(Seam symmetry)

CrNi - pipe 20*3 mm

An off-center torch position is causing an asymmetric penetration. One fusion edge is melted more than another.

Optical hardly visible, but clearly visible in the heat signature.
Example 2 - Longitudinal pipe manufacturing
Plasma welding/TIG

Fault image: pores

CrNi - tube 20*3 mm

Hot cracks and pores are represented as „Hotspots“ in the heat image. Faults like these are causing a disturbance in the heat conduction and are therefore detectable.
These pipes are defective.
Example 2 - Longitudinal pipe manufacturing
Plasma welding/TIG

Fault image: asymmetric penetration due to a misaligned coil feed.

Optical not visible, here the thermo profile is becoming more and more asymmetric, because of wear and tear or insufficient lubrication on a roller set.

CrNi - tube 20*3 mm
Example 3  High Frequency-Induction Welding (HFI)

Application Data TPS

After running to torch: 100 mm
Working distance: 60 mm
Gas purge Shield gas: 3 l/min
Welding speed 80 m/min
Water cooling
Pipe dimensions: 13 x 2.5 mm
HFI-Generator 250 kW – conductive HF-welding
Pipes are spooled to coil

Task

• Realizing a set up help for optimal welding parameters based on heat signature
• Recognition of visible and invisible welding faults, cold joints, and excessive root penetration.
• Color marking faults
• Re-place Eddy Current Detection Systems since these can not detect these faults

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Example 3  High Frequency-Induction Welding (HFI)

Detecting cold fusion points

Heat signature when fault through cold fusion joint

When the melting temperature is not reached, the temperature is falling in the joining zones.

The sensor is calculating the heat field width via a set temperature threshold. Cold welding joints can be clearly seen in the diminishing heat field width.

Width of heat field and learned thresholds values.
Example 2 - Longitudinal pipe manufacturing
Plasma welding/TIG

Fault image: Torch is not in center line of the welding joint. (Seam symmetry)

CrNi - pipe 20*3 mm

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Optical hardly visible, but clearly visible in the heat signature.
Examples for mounting of the TPS

ERW-welding

ThermProfiScanner
HFI – process

105 x 3 mm / 30 m/min

ThermoProfilScanner

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TIG – process
HFI – process  90 x 2 mm / 79 m/min

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Plasma – welding 35 x 3 mm / 3 m/min
HFI – process  120 x 4.5 mm / 45 m/min

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TIG – welding / spiral tubes  variable diameters

ThermoProfilScanner

TPS-application
TIG-spiral pipe
HFI - welding

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Thank you for your interest.

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