Easy to go and innovative validation process using the spot weld inspection system PHAsis and related software

Philipp Poltersdorf, Jens Mußmann, Göran Vogt

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Abstract: In the industry 4.0 the need for a cost-saving and efficient production process is of high significance. This includes every area of the production processes and leads to appropriate testing procedures by means of the quality management. A combination of ultrasonic inspection devices and software tools for result post processing reduces the need of several cost-intensive validation circles with destructive testing to a very low level. This can be shown for example with the imaging phased array spot weld inspection system PHAsis in combination with a software app for post processing. This is including the software part for the data and result management as well as a device software for the ultrasonic inspection of the spot welds. In combination with the usage of an automation interface for robotic usage, even more cost reduction is possible. Several validation processes on typical resistance spot welding applications with plate pairings of two or three plates (aluminium as well as steel combinations) by the use of PHAsis and the connected PostProcessor will be exemplified. The general procedure of the validation process will be accentuated step by step. Therefore, the original data of phased array testing and a comparative method in the shape of a destructive testing (hammer & chisel test or horizontal respectively vertical cross section) will be presented. Furthermore, the steps of the post processing procedure to define the ultrasound system parameters for a best fit will be described. During these steps, the influence of the different sensitivity and system parameters on the spot weld size will be explained. Also, the measurement uncertainties given by the destructive testing that have an influence to the comparison with ultrasonic testing in general will be addressed. The efficiency of the post processing software tool due to reaching a high match between PHAsis and the comparative destructive method will be illustrated.

Keywords: spot weld, Inspection, validation process, cost-reduction, efficiency
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Agenda

• Introduction

• System overview
  • PHAsis
  • PostProcessor

• Validation process
  • Standard parameters
  • Process description
  • Examples
  • (Measurement) uncertainties

• Conclusions
Introduction

- Industry 4.0
- Efficient and fully integrable processes
- Complete production process
- Accompanying quality process

- Different non-destructive testing methods
- Manufacturing of the car-body-structure
- Resistance spot welding
- Destructive testing
- Non-destructive testing

PHAsis
System overview – PHAsis

- Different components
- PHAsisManager
- PHAsisDevice
- PHAsisService
- SQL database

- Single user all-in-one solution
- Multi-user solution

Single User

PHAsisNEO (alle in one)

- PHAsisMANAGER administration software
- PHAsisDEVICE inspection and evaluation software
- MS SQL Express database

Multi-user solution for central management:

PHAsisNEO (one or more)

- Server with MS SQL database

PHAsisDEVICE

- Workplace

PHAsisMANAGER administration software: Central organization of test plans, equipment and results, imports, exports etc.
System overview – PostProcessor

- Validation of the non-destructive testing with a comparing method
- Additional PHAsis software component → PostProcessor
- Possible correlation of ultrasonic and destructive results
- Offline modification of parameter
- Best fit

Saving time, material and costs
Validation process – standard parameters

- Iterative process
- Standard parameter as starting point
- Basic parameters
- Automatic defined reporting level
- Threshold for failure echoes
- Advanced settings for further parametrization
- Advanced settings for special applications
Validation process – process description

**Initial situation:** Validation/parametrization outside the production process

- Resistance spot welding of at least three analogue welded validation parts with spot welds in a quality from worse to good (at least 7 spots)
- Inspection of the parts with ultrasound and a standard parameter set (optional for a higher confidence level: procedure of an uneven number of inspections > 1 of each part and averaging the results)
- Destructive testing (optimal: cross section) of the part with the supposed worst ultrasound results (highest deviations)

- Alternative: destruction of all parts
- Adjustment of the Post Processor parameters on the base of the part with the supposed worst ultrasound results
- Reevaluation of all parts
- Destructive testing of a further part to control the adjustment

**Execution refers to one defined thickness-material-combination**

**Optimal parameter has been determined**

=> PHAsis inspection is ready to use
Validation process – process description

**Initial situation:** Validation/parametrization inside the production process

- Inspection of the parts with ultrasound and a standard parameter set (optional for a higher confidence level: procedure of an uneven number of inspections > 1 of each part and averaging the results)
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**Optimal parameter has been determined**

=> PHAsis inspection is ready to use
Validation process – examples

Steel 1.20 mm on 2.00 mm

Standard setup

Optimized setup with lower sensitivity

<table>
<thead>
<tr>
<th>Spot weld number</th>
<th>Diameter of PHAsis (optimized setup)</th>
<th>Diameter of PHAsis (standard setup)</th>
<th>Diameter of comparative test</th>
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<tbody>
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</tbody>
</table>
Validation process – examples

Steel 1.20 mm on 2.00 mm

Spot 2
comparative test: 0.0 mm

0.0 mm

Spot 5
comparative test: 6.5 mm

5.6 mm

Standard setup

Optimized setup

0.5 mm

6.3 mm
Validation process – examples

Steel 1.00 mm on 1.00 mm

Standard setup

Optimized setup with higher sensitivity

Diameter [mm]

Spot weld number

- Diameter of PHAsis (optimized setup)
- Diameter of PHAsis (standard setup)
- Diameter of comparative test
Validation process – examples

Standard setup

Optimized setup with higher sensitivity

Steel 0.60 mm on 0.60 mm
Validation process – examples

Steel 1.00 mm on 1.00 mm (conical wedge)

Diameter [mm]

<table>
<thead>
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<th>Spot weld number</th>
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<tbody>
<tr>
<td>0.0</td>
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</tbody>
</table>

Diameter of PHAsis (optimized setup)
Diameter of PHAsis (standard setup)
Diameter of comparative test

Steel 1.00 mm on 1.00 mm (conical wedge)

Standard setup

Optimized setup with higher sensitivity
Validation process – examples

**Steel 1.00 mm on 1.00 mm (conical wedge)**

**Spot 7**
- Comparative test: 5.4 mm
- 6.1 mm

**Spot 8**
- Comparative test: 0.0 mm
- 2.4 mm

**Standard setup**

**Optimized setup**
- 5.5 mm
- 1.1 mm
Validation process – examples

Steel 1.60 mm on 1.20 mm on 1.60 mm

Standard setup

Optimized setup with lower sensitivity
Validation process – examples

Steel 0.70 mm on 1.20 mm on 1.20 mm

Standard setup

Optimized setup with higher sensitivity
Validation process – examples

Steel 0.70 mm on 1.20 mm on 1.20 mm

Spot 2
- Comparative test: 0.0 mm
  - Standard setup: 2.9 mm
  - Optimized setup: 1.8 mm

Spot 5
- Comparative test: 5.7 mm
  - Standard setup: 6.2 mm
  - Optimized setup: 5.5 mm
Validation process – examples

Aluminium 1.50 mm on 3.00 mm

Standard setup

Already best setup

Diameter [mm]

Spot weld number

- Diameter of PHAsis (optimized setup)
- Diameter of PHAsis (standard setup)
- Diameter of comparative test
Validation process – (measurement) uncertainties

• Deviations and differences related to method and material

• Destructive testing
  • Dependency of the method
  • Chisel test: minimum standard deviation of 0.25 mm up to 0.5 mm
  • Cross section: lower standard deviation

• Ultrasonic inspection system
  • Non-welded reference parts: standard deviation of approx. 0.1 mm
  • Real spot welds: minimum standard deviation of 0.1 mm up to 0.2 mm

Essential for the deviations/differences: ultrasonic inspection is a comparing method and not a measurement method
Conclusions

- Standard parameter set for first indication

- Possible offline improvement by the PHAsis PostProcessor

- Thinner plate combinations: more sensitive settings
  - Thicker plate combinations: less sensitive settings

- Considering (measurement) uncertainties

- Continuous improvement of the evaluation algorithm
Thanks a lot for your attention