Quality assessment of welded structures subjected to fatigue

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Design, defects and loading

Critical positions depends on:
- Global and local design
- Loading conditions

Rule of thumb: \( f = 2*i + a \)
High or low weld quality?

“Design and weld for purpose”
Types of weld surface defects
Examples according to Volvo STD 181-0004

- Leg deviation
- Undercut
- Underpassed throat dimension
- Weld reinforcement
- Outer transition radius

ISO 5817: Smooth transition
Volvo STD 181-0004

- Purpose that the quality levels shall give consistent and predictable fatigue properties.

- $VD = n \text{ cycles}$

- $VC = 2n \text{ cycles}$

- $VB = 4n \text{ cycles}$

<table>
<thead>
<tr>
<th>Weld class</th>
<th>VS</th>
<th>VD</th>
<th>VC</th>
<th>VB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case at hand</td>
<td>Static</td>
<td>Fatigue loads</td>
<td>Fatigue loads</td>
<td>Fatigue loads</td>
</tr>
<tr>
<td></td>
<td>loads</td>
<td>Normal quality as welded</td>
<td>High quality as welded</td>
<td>Post treated</td>
</tr>
<tr>
<td>Life (N) expected</td>
<td>Not applicable</td>
<td>$N$</td>
<td>$2N$</td>
<td>$4N$</td>
</tr>
</tbody>
</table>
How to measure local weld geometry?
Gage R&R - Throat thickness gauge

Go/No Go

- MS noise <30% of tolerance width
- MS noise contribution <9%

Process development

- MS noise contribution <4%

The curse of unknown causes to variation

An accurate on-line joint measurement method will enable:
- Knowledge of true process variations.
  - Possible reduction to over processing
- Improved process optimisation.
- Possibility to identify quality affecting parameters and relations between input data and results.
- Possibility to create adaptive process control.

Today’s quality assurance, with manual measuring at some selected points, does not allow for truly fact-based decisions......

Z. Barsoum; J Samuelsson, Lightweight Optimised Welded Structures (LOST), 2009.
Perform a Measurement System Analysis (MSA) for toe radius measurement on a commercial Vision system.

Measurement System Analysis - Results

$$K_t = 2.32$$

$$K_t = 4.27$$

$$K_t = 2.85$$
Algorithm
Algorithm output – Toe radius

The radius variation along the left weld toe

Distance in Y-direction [mm]

The radius along the left toe, reference block

Distance in Y-direction [mm]
ONWELD – VINNOVA FFI project

“new ON-line method for quality assurance of WELDed structures”
ONWELD visualization map

Future:
Selected weld quality is used as input. Full scan along the welded / brazed joint.

Today:
Received weld quality is attempted to be measured on the final product. Few selected positions only.

Improved and early QA & control is needed
Application
Algorithm output – Weld quality

Example: Welded beam, specified as VC in Volvo STD 181-0004

Action required
ONWELD – Work in Progress

Weld process monitoring
- Master thesis student at ESAB
- Connect process parameters with produced weld geometry
- Artificial Neural Network

Field test in Volvo CE, Arvika
- System tested within production environment
- Lesson learned

Implementation of geometric features
- ISO 5817, GKN Standard, Volvo STD 181-0004
- Other joint types; butt joint & overlap joint
Fatigue design methods for welded structures

- Fracture mechanics analysis
- Notch stress analysis
- Structural stress analysis
- Nominal stress analysis

Accuracy vs. Complexity

- 100,000-1,000,000 elements/cm³
- 1,000-5,000 elements/cm³
- 10-500 elements/cm³
- 0.01-1 element/cm³

Crack tip

KTH: Royal Institute of Technology
QFAT

Account for produced weld quality in the design stage
QFAT

Account for produced weld quality in the design

\[ \sigma = f(F, r, u, \ldots) \]
Thank you for your attention