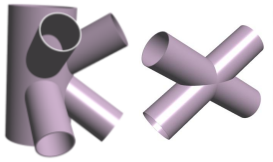
Verbesserung der Wettbewerbsfähigkeit von Jackets durch innovative Fertigungsstrategien

Increasing competitiveness of Jackets by innovative manufacturing strategies

Dr. S. Brauser / Salzgitter Mannesmann Renewables
Dr. M. Los / St3 Offshore



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Agenda

1 Salzgitter Group

2 Salzgitter Supply Chain Concept

3 Serial manufacturing of Jackets

- Robotized welding of nodes
- Robotized grinding of nodes

Company portfolio

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Steel and Technology

- Strip products
- Steel Service Center
- Heavy plates
- Sections
- Engineering services
- Injection molding machinery
- Line pipes
- Precision tubes
- Stainless tubes
- Stockholding trading
- International trading
- Beverage filling plants

- Crude steel production 2014: 7.3 million tons; trading volume: 5.1 million tons
- External Sales cons.: 9.0 € billion / Employees: 23,555

Company portfolio - Penetration Offshore Wind

Steel and Technology

Strip products

Steel Service Center

Heavy plates

Sections

Engineering services

Injection molding machinery

Line pipes

Precision tubes

Stainless tubes

Stockholding trading

International trading

Beverage filling plants

Competitive edge of Offshore Wind Tubular Companies with Bilfinger Cooperation

Salzgitter Offshore Wind Expertise

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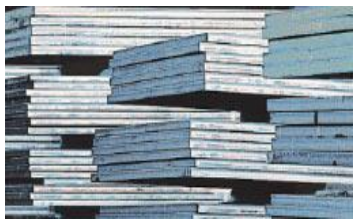
Strip Steel

- **Salzgitter Flachstahl**: Base material for HFI and Spiral tubes

Plate / Section Steel

- **Mannesmann Grobblech**
- **Ilsenburg Grobblech**

Base material for Monopiles and large diameter tubes



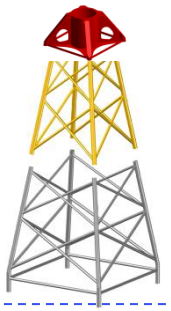
Tube

- **Europipe:** LSAW pipes up to OD 1524/ wt 50mm (marked leader)
- **MLP:** HFI pipes up to OD 610 / wt 25.4mm
- **SMGR**: Spiral pipes up to OD 1676 / wt 25.4mm

+ Cooperation

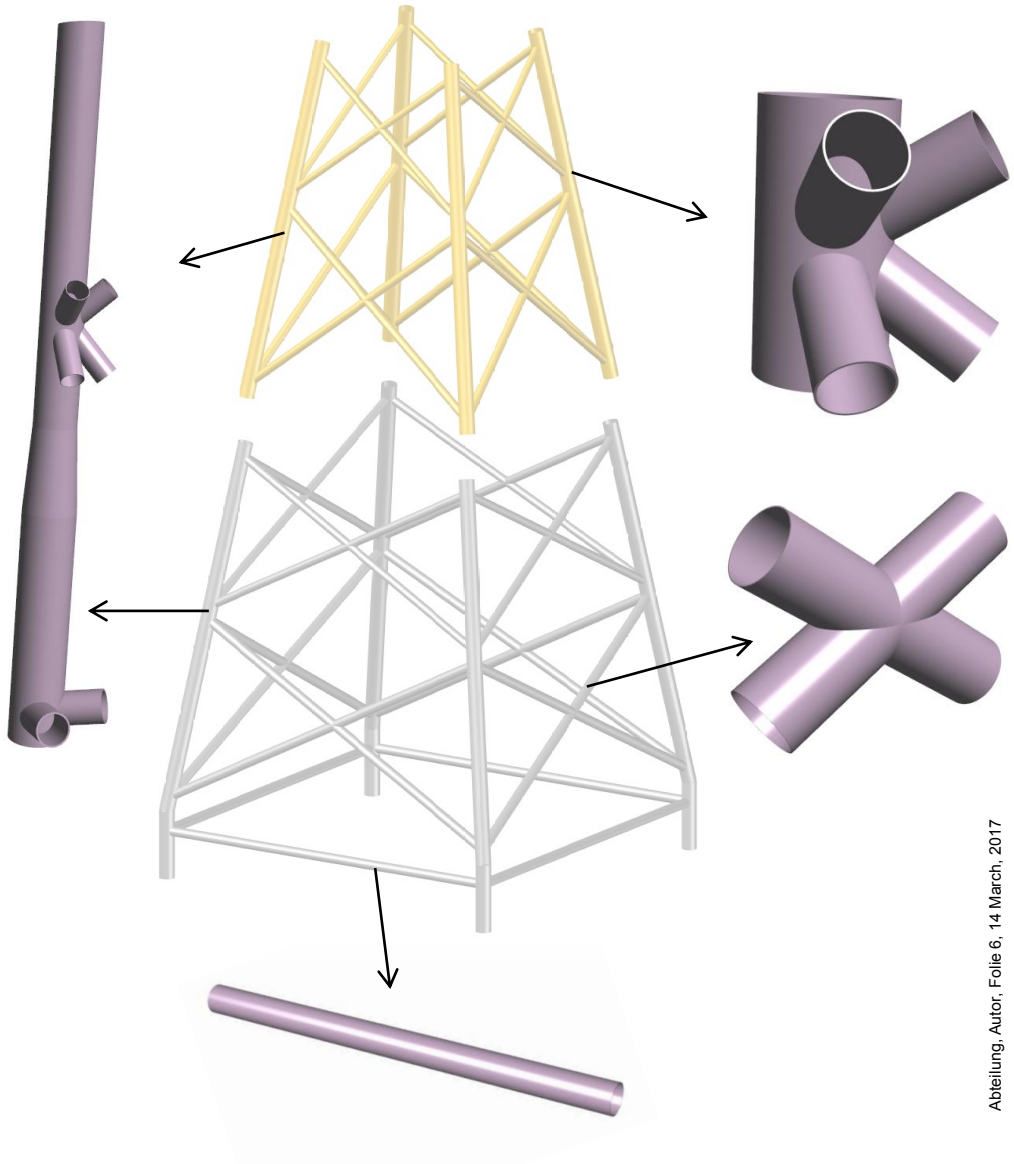
St3 Offshore

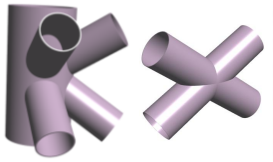
- **Combined Development of**
  - modular Jacket design and secondary steel system
  - Robotized welding of nodes
- **Combined market approach**
  - Complete foundation structure including TP will be market by BMO
  - Jacket components such as nodes and pipes will be market by Salzgitter



Salzgitter supply chain

- Supply of component kid composed of
  - Standardized tubes
  - K, Y, X- nodes
  - Sections / frames
  - …
- Jackets can be build out of sections, or from components at a site or port local to a wind farm
- **Applicable for all Jacket fabricators and without any design preferences**





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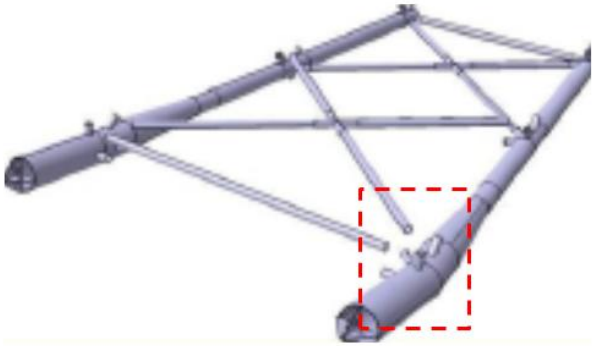
Serial manufacturing of Jackets

EUROPIPE

SALZGITTER MANNESMANN LINE PIPE

SALZGITTER MANNESMANN GROSSROHR



Standardized tube

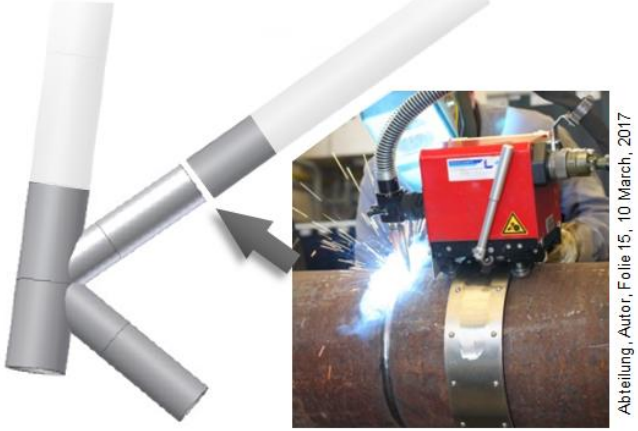
- Based on pipeline application
- Fully automated welding and NDT
- High productivity (up to 200 pipes / shift)
- Low geometrical tolerances → reduction in welding / assembling time
- High cost competitiveness against JCO pipes → 20% to 30%

Robotized welding of nodes

- Tubular welds are cost driver within jacket manufacturing
- Robotized welding of nodes leads to:
  - acceleration within production
  - uniform weld properties
  - improvement of fatigue by inside welding and optimized weld shape

Assembly of components by orbital welding

- Cost efficient welding of butt joints
- Significant reduction in cost/time compared to manual welding



Automated fabrication of nodes – general approach

- Replacement of manual welding by robots
  - → reduction in welding time and cost
  - → sustainable quality improvements by controlled processes (heat input, weld profile)
  - → efficient inside welding
- Welding of stubs onto chord by
  - Manipulator:
    Movement of node enables welding always in 1G/PA Position
    - → high welding speed, lower welding defect rate
  - Robot unit:
    Utilization of high productive tandem-welding

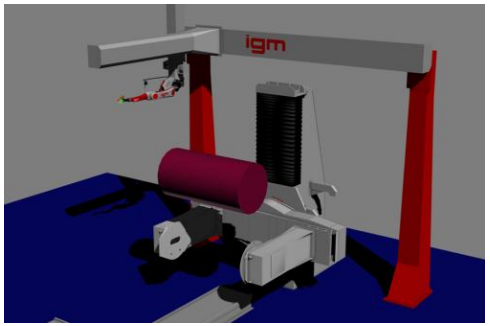
Automated fabrication of nodes – general approach

Main welding unit at St3

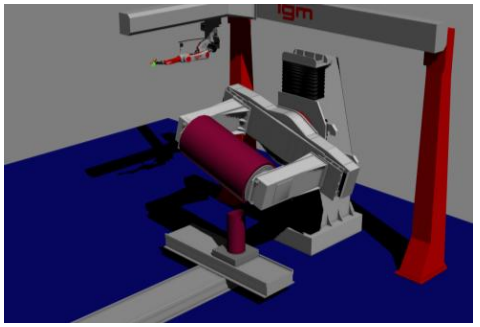
Pre-fabrication of nodes – general approach

1) Semi-automatic loading of chord / stubs

2) Manual tack welding



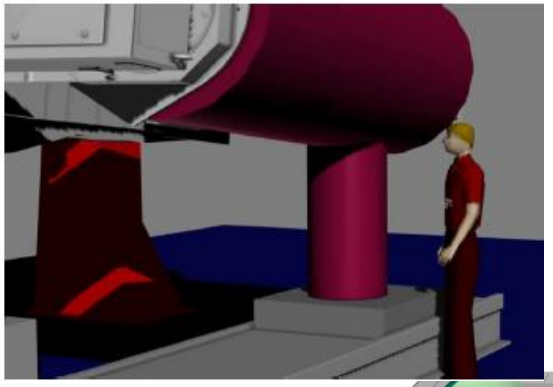
Loading of the main pipe



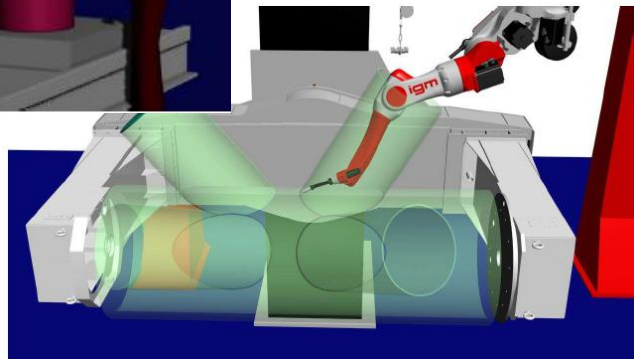
Automatic positioning + tack welding of stub

3) Pre-heating + Robotized inside root welding → backing layer

4) Outside welding
First outside layer (hot pass) to be carried out with sufficiently high energy to guarantee:
   - full penetration weld
   - prevention of root failure
- Filling passes with high deposition rate
- Cap layer with oscillated welding head to generate smooth weld profile



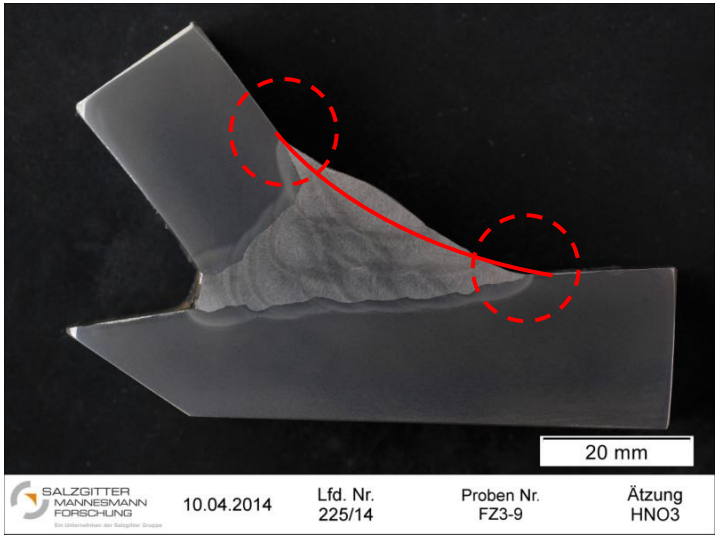
Tack welding



Inside welding

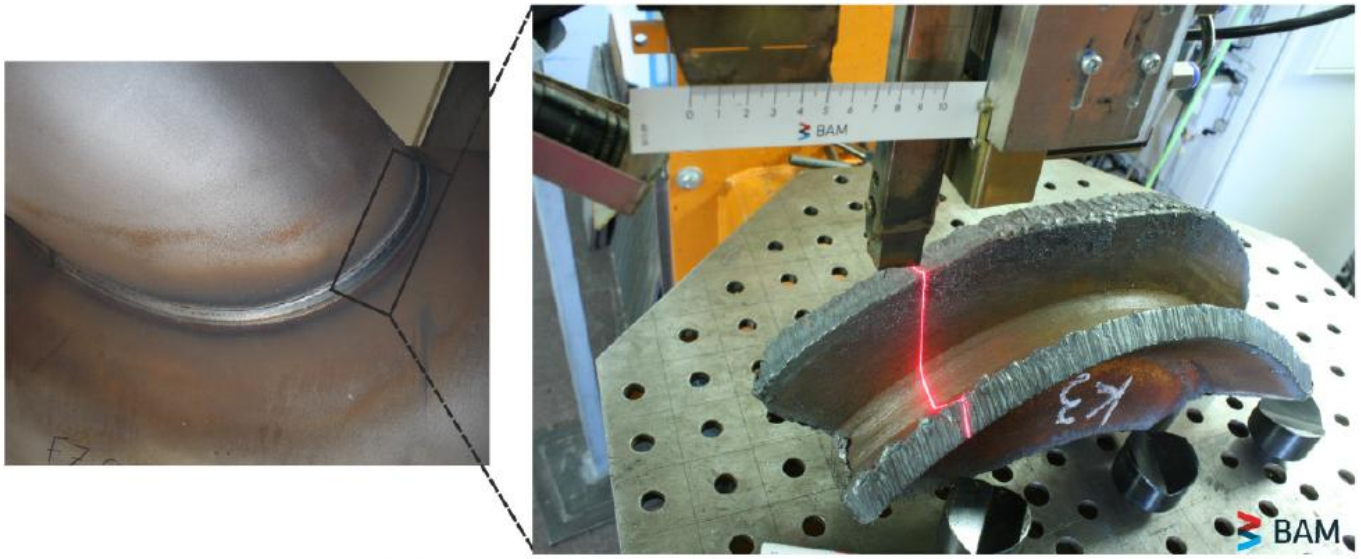
Further Potentials – under investigation

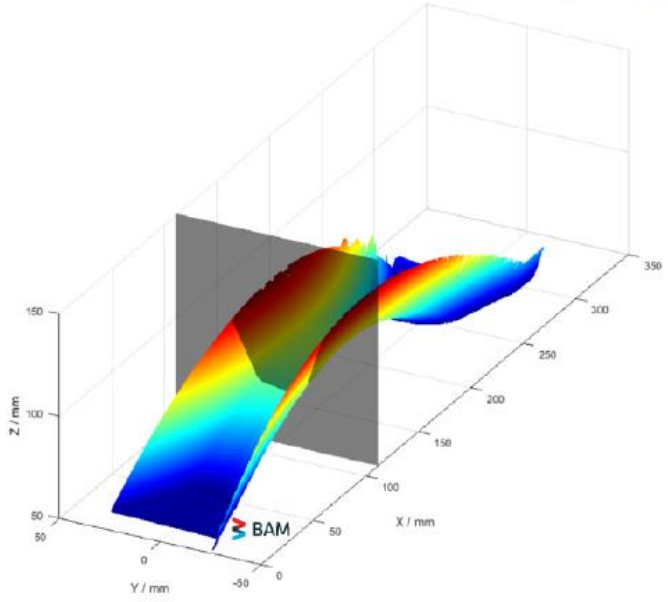
- **Optimization of weld geometry / notch effect**
  - Reliable modeling of weld geometry such that
    - smooth transition tangent to the parent material → negligible notch effect / **fatigue improved**
    - Monitoring /memorizing of surface notches / weld profile via camera system for each stub

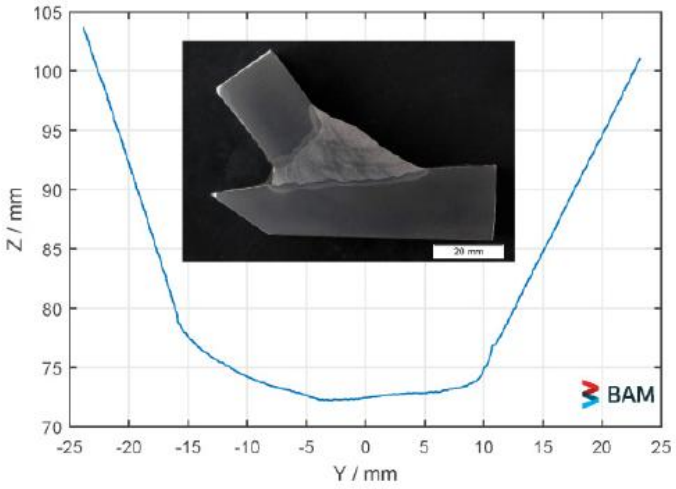


- **Inside welding of nodes (applicable)**
  - Currently not used for Jacket manufacturing do to point to point approach
  - Robotized pre-fabrication of nodes enables efficient inside welding
  - Improvement of fatigue strength especially when outside weld profile / notch effect is improved
  - Backing layer: guarantee of full penetration weld

Weld geometry of robotized nodes

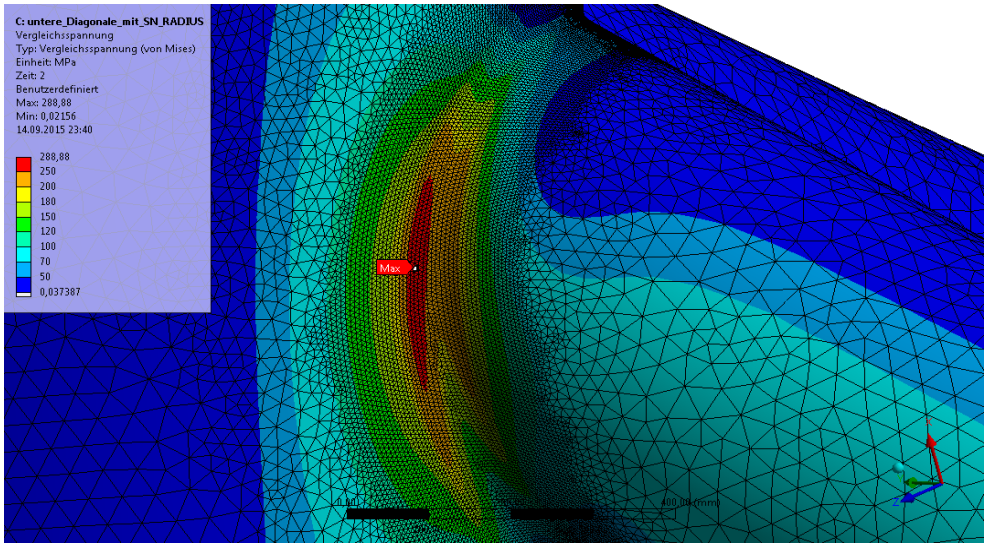




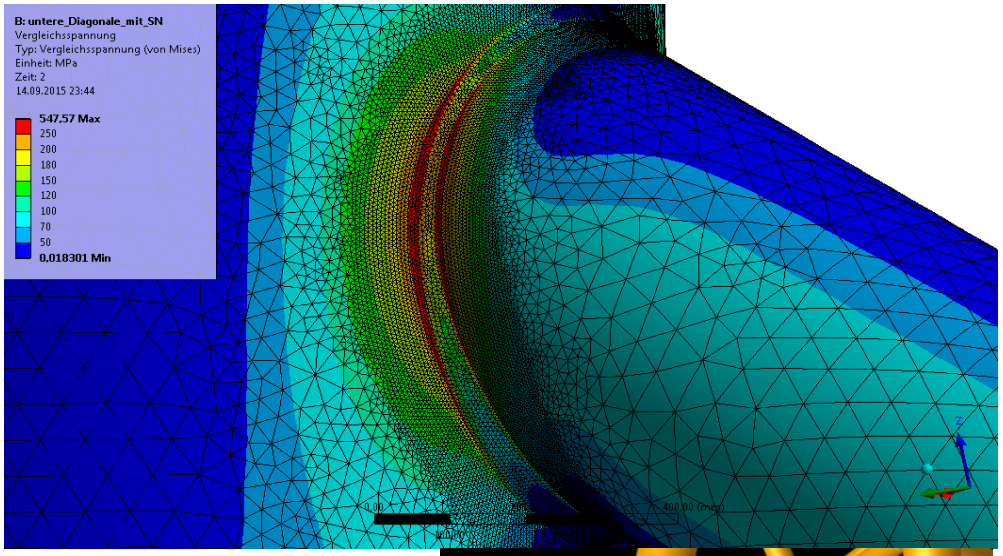


Weight reduction due to smooth shape of welds

Smooth shape - Stress distribution due to out of plane moment



Normal weld shape - Stress distribution due to out of plane moment



Improved weld shape

- leads to a damage reduction by factor **1,77÷1,96**

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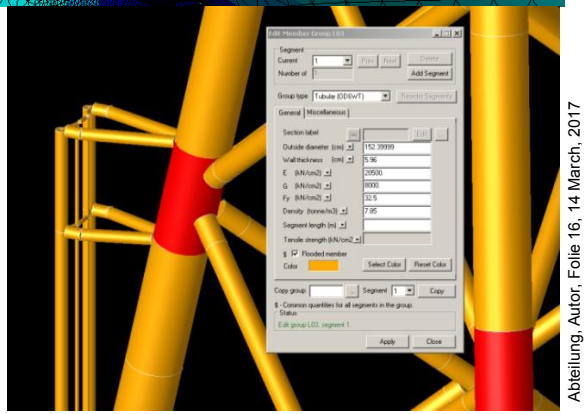
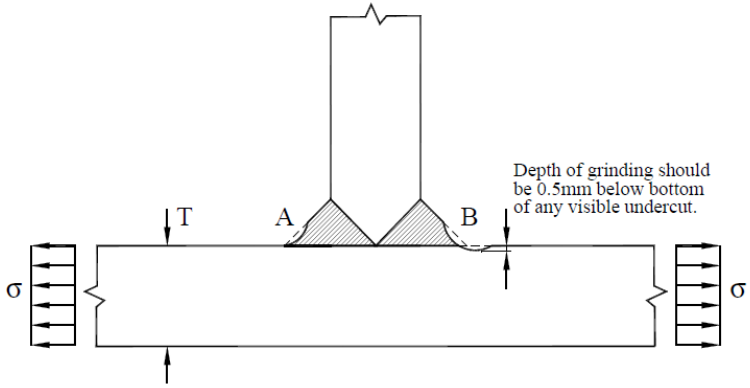
- Weight reduction of **5÷10 %** for whole primary steel



Weld toe grinding

- Local grinding of the weld toes below any visible undercuts increase fatigue life significant
- The grinding depth should not exceed 2 mm or 7% of the plate thickness, whichever is smaller



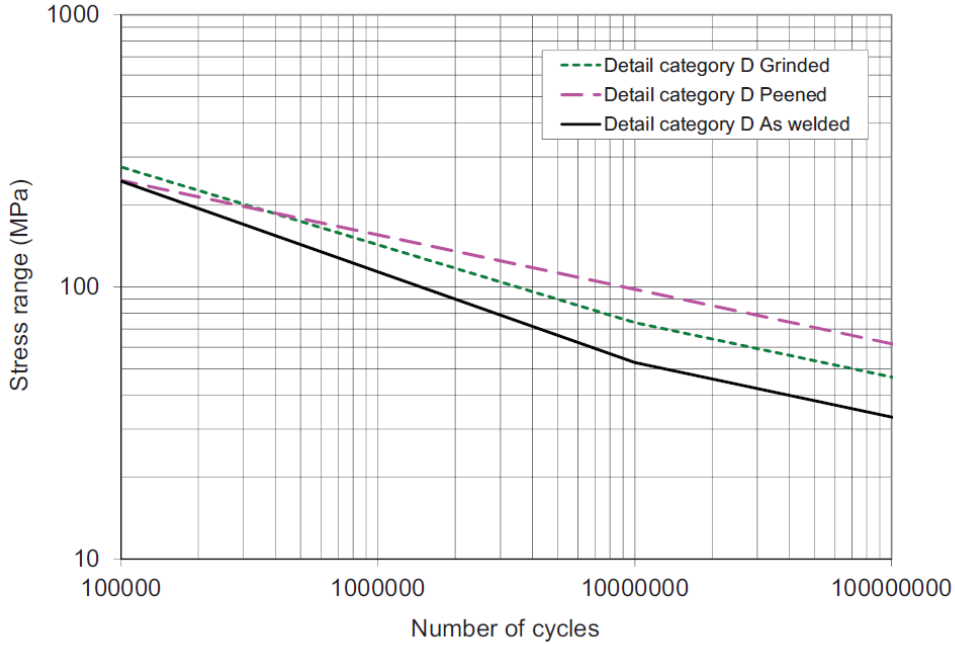
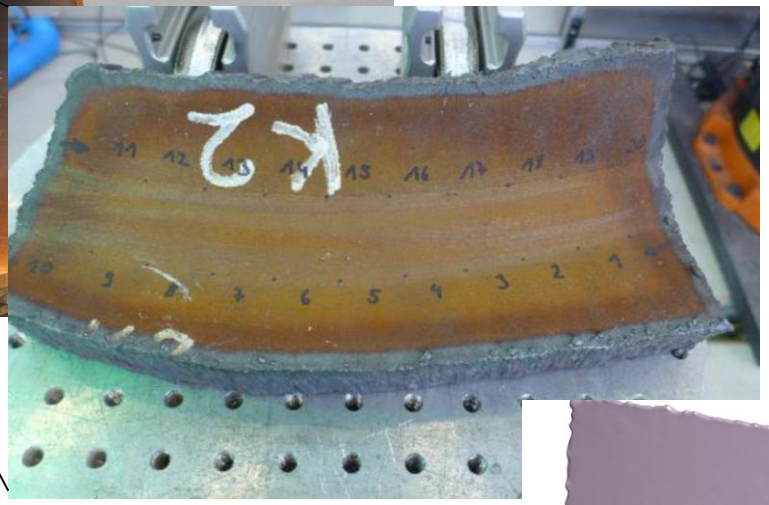
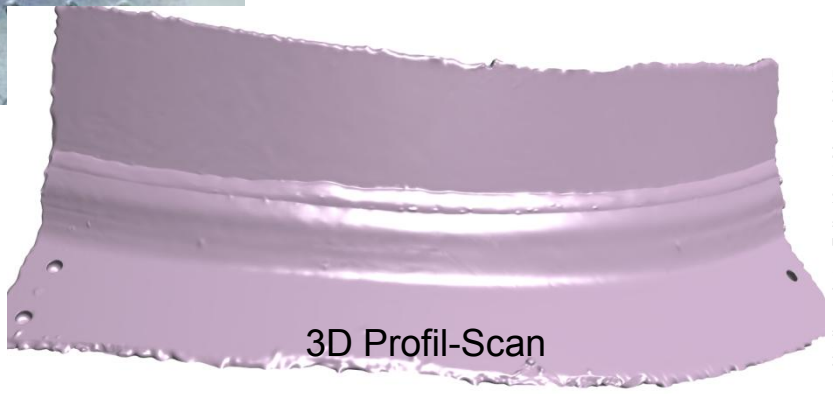


Figure D-35 Example of S-N curves (D-curve) for a butt weld in as welded condition and improved by grinding or hammer peening

Automated weld toe grinding – feasibility





3D Profil-Scan

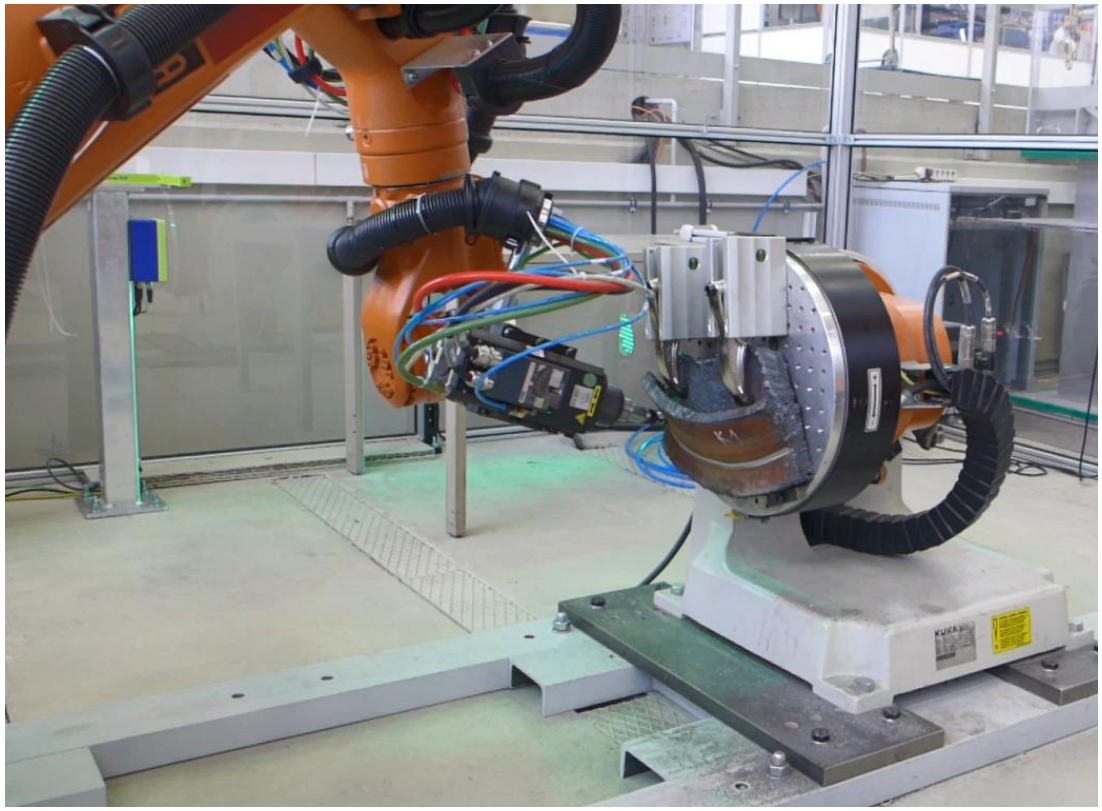
I. Robotized welding of node

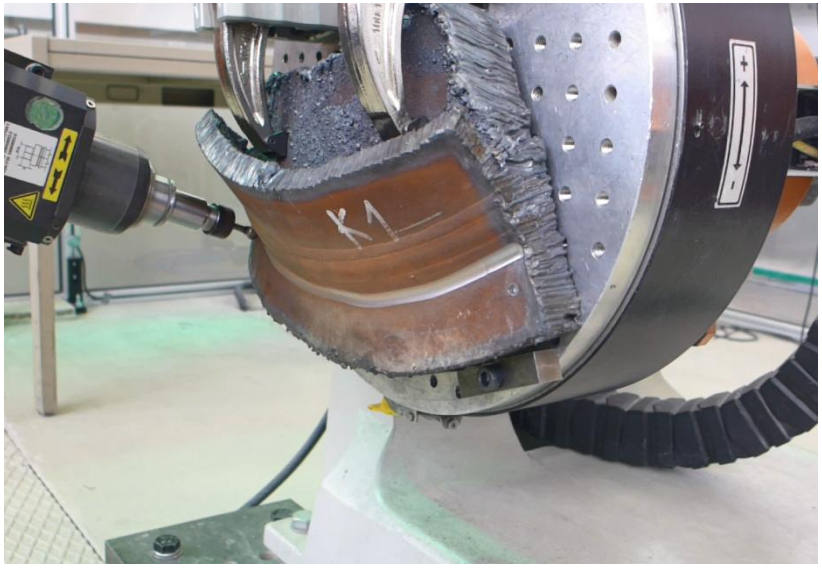
II. Extraction of samples

III. 3D Profil Scan

IV. Derive of Track Curve

V. Automated grinding of nodes segment





- **Next Steps**
  - Calculation of mass reduction of Jacket based on DNVGL rules
  - Full Scale node grinding test

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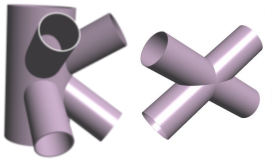

Thank you!

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