PIPE ROBOTS FOR INTERNAL INSPECTION, NON-DESTRUCTIVE TESTING AND MACHINING OF PIPELINES

INSPECTOR SYSTEMS Rainer Hitzel GmbH – Johann Friedrich Böttgerstr. 19 – 63322 Rödermark – Germany

ALEXANDER REISS
COMPANY PROFILE

...SPECIALIZED

- Fabrication of self propelled robots for internal inspection, non-destructive testing and machining of pipelines
- Service worldwide
- Private owned company
- Founded 1983
- ISO 9001, KTA 1401
- In-House production

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COMPANY PROFILE

...INDUSTRIAL SECTORS

- Nuclear power plants
- Chemical-/Petrochemical plants
- Gas & Oil, Refineries
- Conventional power plants
- Offshore
- Water-/Waste water
- District heating pipelines
- Miscellaneous

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COMPANY PROFILE

...HEADQUARTERS AND PRODUCTION

Rödermark, approx. 30 km south of Frankfurt / Germany
APPLICATION

...PIGGABLE, UNPIGGABLE, BURIED & COMPLEX PIPELINES

- In general applicable for all kind of pipe systems
- Particularly suitable for pipeline systems with:
  > difficult external access like buried pipelines etc.
  > complex and-/or non-piggable structure
  > etc.
SYSTEM CONCEPT PIPE-ROBOTS

...BASIS STRUCTURE

Modular Construction

Drive Units

Flexible Folding Bellows

I-T-M-Module

Electrical Housing

Special cable

Control Unit, Monitor, HDD-Recorder

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SYSTEM CONCEPT PIPE-ROBOTS

...BASIS STRUCTURE
Modular Construction

EXTENDED

Drive Units

I-T-M-Module
Flexible Folding Bellows

Electrical Housing
Special cable
Control Unit, Monitor, HDD-Recorder
SYSTEM CONCEPT PIPE-ROBOTS

...BASIS PERFORMANCE

- **Bendable / Adjustable in height**
  - Insertion through poor access points, e.g. dismantled valves, flanges etc.
  - To pass
    - numerous bends with small arc radii ($\geq 1.5D$)
    - Diameter deviations
    - Weld roots, T-Branche etc.

- **Bi-Directional Travelling**
  - Access only from one side necessary

- **Long distances (up to 500 m)**
SYSTEM CONCEPT PIPE-ROBOTS

...BASIS PERFORMANCE

- **Horizontal – Vertical Travelling**
  - Downward-/Upward slopes/Turns (up to 90° and more)

- **Self-Propelled**
  - Stop at any time
  - No ext. drive medium (Water/Air)
  - No launcher-receiver station

- **Online Results / Monitoring**
  - Direct identification and sizing of defects (live survey)
### SYSTEM CONCEPT PIPE-ROBOTS

#### ...DIAMETER RANGE PIPE ROBOTS (STANDARD)

<table>
<thead>
<tr>
<th>TYPE</th>
<th>mm</th>
<th>inch</th>
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<tr>
<td>1.000</td>
<td>75 - 110</td>
<td>3 - 4</td>
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<tr>
<td>2.000</td>
<td>100 - 140</td>
<td>4 - 6</td>
</tr>
<tr>
<td>3.000</td>
<td>130 - 200</td>
<td>6 - 8</td>
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<td>4.000</td>
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<td>6.000</td>
<td>440 - 800</td>
<td>18 - 32</td>
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<tr>
<td>7.000</td>
<td>750 - 1.200</td>
<td>34 - 48</td>
</tr>
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**SYSTEM CONCEPT PIPE-ROBOTS**

**...DIAMETER RANGE PIPE ROBOTS (STANDARD)**

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<tr>
<th>TYPE</th>
<th>mm</th>
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<tr>
<td>1.000</td>
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<td>2.000</td>
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<tr>
<td>3.000</td>
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<td>6.000</td>
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<td>18</td>
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<tr>
<td>7.000</td>
<td>750</td>
<td>34</td>
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</table>
INSPECTION- AND NDT - ROBOTS

...MODULES (EXAMPLES)

VIDEO, VIDEO/LASER

ULTRASONIC

SLOFEC™

ULTRASONIC/EDDY CURRENT
...MODULE

- Visual Inspection Inner Conditions
- Size/Assess Damaged Areas, Anomalies etc.
  - High Picture Resolution Front CCD-Color Camera (>460TVL), 10x Optical Zoom, Powerful LED Illumination
  - Point-Laser, Classification and Evaluation of the Camera Picture (Cracks, Anomalies, Weld Roots, etc. – Measurements Ø ≥2 mm, Accuracy ±0,1 mm)
  - Camera Pan.- (360°) and Tilt Mechanism(120°)
  - Insp.-report: HDD-Record, Tabular, Graphical
INSPECTION- AND NDT - ROBOTS

...MODULE

- Visual Inspection Inner Conditions
- Size/Assess Damaged Areas, Anomalies etc.
...MODULE

- 360° Profile Scanning
- Pipe Classification – Ovality, Areas of Corrosion

<table>
<thead>
<tr>
<th>Laser-scan recording - Pipe XY</th>
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<tbody>
<tr>
<td>incl. angle: 1 INSP</td>
</tr>
<tr>
<td>client: xxx</td>
</tr>
<tr>
<td>name operator: xxx</td>
</tr>
<tr>
<td>measuring point angle [°]</td>
</tr>
<tr>
<td>0: 0,2 88,72 2,86</td>
</tr>
<tr>
<td>1: 1,8 88,69 2,86</td>
</tr>
<tr>
<td>2: 3,8 88,69 2,86</td>
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<tr>
<td>3: 5,5 88,72 2,86</td>
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<td>4: 7,3 88,64 2,86</td>
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<tr>
<td>5: 9,2 88,58 2,86</td>
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<tr>
<td>6: 11,0 88,47 2,86</td>
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<tr>
<td>7: 12,8 88,44 2,86</td>
</tr>
</tbody>
</table>

Wrinkle at 270°
PIPE ROBOTS FOR INTERNAL INSPECTION, NON-DESTRUCTIVE TESTING AND MACHINING OF PIPELINES

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...MODULE

- Axial Profile Scanning e.g. NPP in France
  - Verification of grinded girth welds of joined pipes
  - Prior pipe laying, measurements at several positions

Laser / Axial Scan

Axial Drive Unit

Clamping- and Centering Unit

Rotating Unit (360°)

weld seam profile, angle < 7°
...MODULE

ULTRASONIC

- Application: All Echo Capable Materials
- 100% Mapping Wall Thickness (Volume)
- Detection Corrosion Areas / Holes etc.
  - Distinguish between inner/outer pipe surface
  - UT-Evaluationsystem & Software - Fraunhofer Institut IZFP

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Module rotates while travelling through the pipes
- Gimbal Suspension System – allows an orthogonally impact to the surface (90°)
- Independent continuous water supply (echo couple medium)

ULTRASONIC

Centering Unit

Pivoting Sensor Arm

Retainer with water chamber and holder for UT-sensor (spring mounted)
INSPECTION- AND NDT - ROBOTS

...MODULE

- Saturated LOw Frequency Eddy Current
- Application: Ferromagnetic Materials
- Sensitive Detection of Material Reductions
- Detection and Differentiation of Inner & Outer Defects (Pitting Corrosion)
- Measurement through Non-Conductive Coatings

- Slofec Evaluation-system & Software - Kontrolltechnik
- Measurement of Cast Iron and Spheroidal Graphite Cast Iron Pipes (Ductile Materials)
...MODULE

SLOFEC™

- Saturated LOw Frequency Eddy Current

- Eddy Current principle with superimposed DC field magnetization

Magnet Coil

Magnetic Alternating Fields

Magnet

Eddy Current-Sensors

Ferromagnetic Sample

Defect

Δ μ_{rel} Change of rel. Permeability, Magnetic Flux Density

Magnetic Bias Field

PIPE ROBOTS FOR INTERNAL INSPECTION, NON-DESTRUCTIVE TESTING AND MACHINING OF PIPELINES

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...SLOFEC™ - ULTRASONIC

Indications List

<table>
<thead>
<tr>
<th>No.</th>
<th>Section No.</th>
<th>Pos [m]</th>
<th>Size [mm²]</th>
<th>Depth [%]</th>
<th>Layer</th>
<th>Type</th>
<th>Method</th>
<th>Remain</th>
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<tr>
<td>1</td>
<td>35-34</td>
<td>X 0.5</td>
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<td>Exterior/Inside</td>
<td>SLOFEC</td>
<td></td>
<td></td>
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<td></td>
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<tr>
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<td>35-34</td>
<td>X 1.12</td>
<td>728</td>
<td>81 %</td>
<td>Interior</td>
<td>SLOFEC</td>
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<td>2895</td>
<td>81 %</td>
<td>Interior</td>
<td>SLOFEC</td>
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<td>6</td>
<td>35-34</td>
<td>Y 1.40</td>
<td>1380</td>
<td>39 %</td>
<td>Interior</td>
<td>SLOFEC</td>
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</table>

Defect: Color Classified

Pipe Inspection - Scan Report

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MACHINING - ROBOTS

...MODULE

- **Two Step Process: Grinding, Polishing**
- **Weld Roots:**
  - Removal of weld roots or weld undercut
  - Increase load capacity of weld seam (fatigue life)
  - Prevention cracking
  - Conditioning of misalignment between pipes
- **Inner Wall Surface:**
  - Removal of local corrosion areas or any kind of debris
  - Removal of local surface cracks
- **Accuracy 0.1 mm, Surface Roughness Ra 1.6 μm**
MACHINING - ROBOTS

...MODULE

GRINDING/POLISHING

- Controlled via Monitor and Control Desk
- HDD-Record

Grinding Camera & LED Illumination

380° Rotating Unit with Grinding Motor & Disc
Radial-Axial Positioning
Clamping & Centering Unit
MACHINING - ROBOTS

...MODULE

GRINDING/ POLISHING

- Controlled via Monitor and Control Desk
- HDD-Record

Prior Grinding/Polishing

After Grinding/Polishing

Cross Section
IMPRESSIONS

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