New Sensing Technology for Robotic Joining Automation

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  - Arc Welding
  - Laser Welding

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SMART Sensors for SMART Robots is the Goal
ROBOTIC WELDING REQUIRES OPTIMIZATION OF THE INTERACTION BETWEEN SEVERAL ELEMENTS AND PROCESSES
FUNCTIONS OF LASER SENSING SYSTEMS
(seam location, joint tracking, adaptive control, inspection)
Sensing systems designed specifically for arc and laser welding automation:

- Real-time adaptive joint tracking
- Robotic inspection of welding joints
- Part and joint locating
- Weld bead inspection and process development
- Real-time control of welding conditions
SEAM FINDING / SEAM TRACKING / ADAPTIVE CONTROL

SEAM FINDING
(OFFLINE)

SNAP SHOT

SEAM TRACKING
(REAL-TIME)

CONTINUOUS MEASUREMENT OF JOINT PROFILES

ADAPTIVE CONTROL
(OFFLINE or REAL-TIME)

PERFECTLY SEALED WELD ALL AROUND THE TANK!

0 < GAP < 10 mm => PERFECT WELD!

UNIVERSAL ROBOT SENSOR VIDEO
SEAM FINDING OR SEAM TRACKING?

- **SEAM FINDING**
  - There are many short welds on a part
  - The weld seams have tight radiiuses
  - The joint is difficult to access
  - The process involves motions in all directions without any TCP rotation
    (ex.: gluing)

- **SEAM TRACKING**
  - Joint geometry is inconsistent along the welding path
  - Joint geometry / position change during the execution of the process due to heat input/distortion
  - Adjustment of the welding parameters is required along the path
  - Taught program is not accurate
TYPICAL APPLICATIONS IN AUTOMOTIVE INDUSTRY

- Cradle
- Steering
- Wheel
- Seat Components
- Car Body
- Brazed Joint
- Door Blanks
- Trunk
- Suspension
- Exhaust System
SEAM FINDING AND ADAPTIVE FIT-UP COMPENSATION
VERY HIGH SPEED WELD SEAM LOCATION AND ADAPTIVE CONTROL

ARC WELDING

LASER HYBRID WELDING

i-CUBE – UNIVERSAL ROBOT SENSORS

- SEAM FINDING
- ADAPTIVE FIT-UP COMPENSATION
- INSPECTION
- FEATURE DETECTION

SERVO-ROBOT
HYBRID SENSING SYSTEM WITH FULL ONBOARD CONTROL

**i-CUBE™ LASER-CAMERA FEATURES**

- Single cable for power and communication
- Possibility to stream video over the Ethernet channel
- Microphone for arc sound recording/monitoring
- Air input
- Color video camera with electronic filter for viewing of the process
- Optional mechanical shutter with integrated air supply from the camera

**Unique multi-position mechanical connection with the robot for improved flexibility**

**Multiple functions in one head:**
- Range measurement, contactless sensing, process monitoring and on-board control
- Scalable laser seam finding processes
- Robot selectable laser modes for adjusting to the process
- Long stand-off from the process
- Simplified calibration to the robot
- State-of-the-art on-board processing (no external control required)

**i-CUBE™ SYSTEM**

- Robot controller
- Camera cable
- Interconnection kit
- Ethernet
- Human Machine Interface (HMI)
- Audio/video remote monitoring (PC)
Process Analysis with Fourier Transform
SEAM TRACKING AND ADAPTIVE CONTROL
LAYOUT OF SERVO-ROBOT
3-D LASER-VISION SYSTEM FOR JOINT TRACKING & ADAPTIVE WELDING

POWER-TRAC™ – MODULAR PROCESS MANAGEMENT SYSTEM
Robot with laser-vision

Intelligent vision system and process controller

Torch path computation

Real-time control of welding parameters

Data extraction

REAL-TIME 3D WELDING ROBOT CONTROL WITH SERVO-ROBOT LASER VISION
SERVO-ROBOT ADAPTIVE WELDING CONTROL

Without Adaptive Fill

With Adaptive Fill
ADAPTIVE SEAM TRACKING SYSTEM

COURTESY OF TIESSE S.p.A., Visano (Brescia), Italy
ADAPTIVE TRUCK FRAME WELDING
ARC WELD INSPECTION SYSTEMS
3-D LASER VISION AT 2000 Hz FOR WELD BEAD INSPECTION

Precise and high speed measurement of weld bead surface geometry and detection of defects by special laser vision systems

- Weld bead geometry
- External weld defects

3-D IMAGE OF WELD BEAD WITH POROSITY & DEFECTS
ARC-SCAN X

NEW WELD DEFECT IDENTIFICATION TECHNIQUE

3D weld surface mapping with unique real-time defect identification

3D image of weld bead with porosity & defects
Suspension Weld Inspection
WELD POOL MONITORING

SPECIAL SENSORS CAN PROVIDE WELD POOL AND JOINT VISION FOR IN PROCESS MONITORING AND CONTROL

**ROBOT VISION IS BETTER THAN HUMAN VISION!**

Robot can use computer vision capability which is actually better than human vision using High Definition High Dynamic Range video color welding camera.

Arc sound also provides key data merged with vision analysis.

Watch this video clip of GMAW process!

21 century laser vision systems are rugged and already successfully applied in the manufacturing industry – they are more reliable than human eyes and they last!
A vision system can provide useful quantitative data while human vision cannot.
LASER WELDING SENSOR APPLICATIONS
LASER HYBRID WELDING SYSTEM – HEAD & SENSORS
## LASER WELDED BLANK INSPECTION CRITERIA

### Table 1: Typical TWB requirements

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Typical requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bead width</td>
<td>&gt;0.8mm</td>
</tr>
<tr>
<td>Convexity/Concavity</td>
<td>&lt;0.15t if t less than 1mm thick</td>
</tr>
<tr>
<td>Weld slope</td>
<td>45° ± 5°</td>
</tr>
<tr>
<td>Undercut</td>
<td>&lt; 0.5 t</td>
</tr>
<tr>
<td>Burn-through</td>
<td>Not allowed</td>
</tr>
<tr>
<td>Root concavity</td>
<td>&lt;0.1t</td>
</tr>
<tr>
<td>Excess penetration</td>
<td>&lt;0.2mm + 0.15t</td>
</tr>
<tr>
<td>Porosity (pinhole)</td>
<td>Down to 0.3mm</td>
</tr>
</tbody>
</table>
INSPECTION RESULT DISPLAY
EXAMPLE OF APPLICATION (DOOR) – 1/2
This is a 3D surface composition based on the profiles acquired on the door seen on previous slide (top left region).
POROSCAN

INSPECTION OF BRAZED JOINT FOR CAR BODY

Dual sensor laser-camera

Pinhole detection

Geometric defect detection
Typical brazing inspection criteria

- Mismatch
  - Min: 0 mm
  - Max: 0.6 mm

- Concavity
  - Min: 0 mm
  - Max: 1 mm

- Internal height difference
  - Min: 1.5 mm
  - Max: 5 mm

- External height difference
  - Min: 0 mm
  - Max: 1.2 mm
Conclusions

• Sensors can add increased capabilities for robotic and automatic welding systems improving weld productivity and quality

• Combining information from multiple sensors can improve welding productivity and quality
Q & A & Thanks!
THANK YOU!

SERVO-ROBOT

SMART SENSORS FOR SMART ROBOTS