Survey of Surface Preparation and Coatings Automation
Panel Briefing

Final Project Presentation – March 25, 2021
J. Peter Ault P.E. – Elzly Technology
Survey of Surface Preparation and Coatings Automation

PROJECT TECHNICAL REPRESENTATIVE
• Arcino Quiero, Jr., HII-NNS

INDUSTRY INVOLVEMENT
• BAE Systems JSR – Stephen Cogswell
• GD-BIW – Robert Cloutier
• HII-Ingalls Shipbuilding – Conlan Hsu

NAVY INVOLVEMENT
• None (officially)
Survey of Surface Preparation and Coatings Automation

SCOPE

• Establish the current state of surface preparation and coatings automation in shipyards

• Identify the current state of the art in two areas:
  • Surface preparation and painting automation in other industries
  • Use of robotics and automation in shipbuilding (all trades)

• Perform a gap analysis to identify paths forward for automating surface preparation and coating activities in shipbuilding

• Identify promising technologies for shipyard demonstration on production scale and lay out a path forward for NSRP, perhaps through an RA project
Major Activities

• Workshop
  • Fall Panel Meeting (SEP2019)

• Field Visits
  • Allstream UHP Stingray Robotic Hydroblasting System
  • JH Fletcher/ARS Cobra Robotic Grit Blaster (2 locations)
  • Titan Robotics
  • PPG automotive applications lab
  • Manufacturing USA – Advanced Robotics for Manufacturing (ARM)
  • Boston Dynamics (virtual)

• Industry Outreach and Research
Workshop

• Brainstorming Session
• Panel Discussion
• Q & A
State of SPC Automation

• Attached solutions being implemented and optimized on flat surfaces (e.g., hulls and decks)

• Rail/gantry solutions being implemented and optimized in early stages of production (production lines and shop applications); concepts being developed for use in late stage construction

• Crawling systems are being developed for various industry uses; their use in late stage construction would be transformative for the industry
Shipyard Demonstration
Allstream UHP Stingray Robotic Hydroblasting System

• Demonstrated improved productivity vs current system
Shipyard Demonstrations
JH Fletcher/ARS Cobra Robotic Grit Blaster

• First exterior hull demonstration generated “lessons learned”

• Second exterior hull demonstration (different yard/contractor) was quite successful
  • Good production rate
  • Reduced impact on other activities
Other Industry Solutions
Titan Robotics

- Obstacle avoidance system
- Geometrical challenges for mobility system in drydock
Other Industry Solutions
Boston Dynamics

- No existing edge detection/avoidance
- Connectivity limitations
- Payload limitations
Other Industry Solutions
Apellix

- Drone Technology
- Visual Inspection
- DFT and Wall Thickness
- Washing and paint application capability in development
Other Industry Solutions

Blast One

- Abrasive Blasting
  - VertiDrive Crawler
  - Blastman robotic system
Key Observations

• Current Uses
  • Simple surface preparation and coatings tasks applied to flat surfaces, simple shapes and small parts
  • The most prominent robotic activity in shipyards is generally confined to early stages of construction
  • Other industries having the advantage of simpler shapes or well-suited production lines

• Developmental
  • Expanded sensing and mobility, allowing for increased autonomy and obstacle negotiation
Gap Analysis

• Common to Many Industries
  • Cost
  • Culture
  • Commitment of management
  • Supporting Infrastructure (e.g., IT systems, workforce)
  • Undeveloped business cases

• Shipyards Unique
  • Inconsistent and complex design
  • Interaction between ship design and manufacturing technology
  • Integrated nature of multiple activities at each stage of construction
Robotic Design Factors

Mobility system design
- Wheeled
- Tracked
- Double frame
- Rail
- Fixed

Adhesion system design
- Magnetism
- Suction Force
- Mechanical
- Chemical

Degree of autonomy
- Remote
- Semi-Autonomous
- Autonomous
- Single
- Multiple
- Repeatable

Programmability
<table>
<thead>
<tr>
<th>Activity</th>
<th>Grit/Hydro Blasting</th>
<th>Vacuuming</th>
<th>Painting</th>
<th>Inspecting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payload/End Effector</td>
<td>Blast nozzle, grit/ water supply hose (1-2 inches), grit/water in hose</td>
<td>Suction hose</td>
<td>Spray gun nozzle, paint, hose, IR sensor, solenoid valve</td>
<td>Camera, sensors (e.g., thickness, color or roughness gages)</td>
</tr>
<tr>
<td>Forces</td>
<td>Weight of hose and blast arm (if there is one), resist force of grit/water coming out of nozzle (80-120 psi/4000-10000 psi), weight of robot (for climbing), magnetic force (for climbing)</td>
<td>Vacuum force (-5 to -8 psig), weight of robot (if climbing), magnetic force (if climbing)</td>
<td>Spray gun, weight of paint arm, weight of robot (for climbing), magnetic force (for climbing), weight of paint/hose</td>
<td>Weight of robot (for climbing), magnetic force (for climbing), weight of camera arm/sensors</td>
</tr>
<tr>
<td>Environment</td>
<td>Dusty, sparks, dark, tight spaces, weather, toxic waste (paint, oxides), possibly no large, flat surfaces (issues for vacuum blasting)</td>
<td>Dusty, tight spaces</td>
<td>Complicated geometry, toxic or flammable vapors, tight spaces, weather</td>
<td>Dark, tight spaces, moving camera arm around obstructions, sensor access to surfaces, possible dusty or explosive environment</td>
</tr>
<tr>
<td>Sensors</td>
<td>Accelerometer, gyroscope, proximity sensors</td>
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</tr>
<tr>
<td>Ingress Rating</td>
<td>IP-64</td>
<td>IP-54</td>
<td>IP-54; intrinsically safe (explosion)</td>
<td>IP-54</td>
</tr>
<tr>
<td>Extra Systems Needed</td>
<td>Compressor, collection tube (if collecting waste), power for compressor</td>
<td>Return tube, filtration system for hazardous waste or liquids, power for vacuum motor, collection containers</td>
<td>Compressor, power for compressor, QC system (monitor plain application rate or thickness)</td>
<td>None</td>
</tr>
</tbody>
</table>
Industry Path Forward

- Incrementally automate existing, stand-alone processes
  - Prep and paint lines for plates and small parts
  - Robotics for large, flat areas
  - Automated QA and QC processes
- Re-visit proven technologies when shipyard processes are being re-engineered
  - Drop-in solutions are unlikely to fit existing processes
- High Investment, High Payoff Ideas
  - Automation of Tank Preservation
  - Ship designs that are more conducive to automation (e.g., repetitive or robot-accessible designs)
  - Automation-friendly materials (e.g., coating materials which can be applied using electrostatic equipment)
Thank You to our Commercial Resources!

• Advanced Recycling Systems
• Advanced Robotics for Manufacturing (ARM)
• Aerobotix
• AllStream Services and Rental
• Apellix Aerial Robotic Systems
• Blast One International
• Boston Dynamics
• Boston Engineering
• Champion Painting
• Chariot Robotics
• Clemco Industries Corporation

• Confined Space Robotics
• Equipois
• FANUC America
• J.H. Fletcher
• Near Earth Autonomy
• Park Derochie, Inc.
• PPG Allison Park Coatings Innovation Center
• Robotic Technologies of Tennessee
• Titan Robotics
• Wolf Robotics
Questions?

J. Peter Ault, Sr. Consultant
Elzly Technology | A KTA Tator Company
pault@elzly.com