ESAB – Your Partner in Advanced Welding & Cutting Technology

Overview of Hybrid Laser Welding and Advanced Lightweight Structures
Overview

- What is Hybrid Laser Arc Welding (HLAW)?
- How Does HLAW Compare to:
  - Conventional welding?
  - Autogenous laser welding?
- Advanced Laser Welded Structures
- Hybrid Laser Welding Applications
- Application Examples
What is Hybrid Laser Welding?

**Laser**
- Small spot size
- Very high energy density
- Low total heat input
- Deep penetration
- High welding speed
  - Stabilizes GMAW Arc

**Gas Metal Arc**
- Added energy to melt wire
- Broadened fusion zone at surface
- Slower weld cooling
- Improves laser coupling

**Wire Filler**
- Allows control of metallurgy
- Improves gap tolerance
- Removes some contaminants
How does HLAW Compare to Conventional Welding?

- **Conventional MIG/MAG:**
  - Shallow penetration
  - Wide weld bead

- **Autogenous Laser**
  - Deep penetration
  - Narrow fusion zone

- **Hybrid Laser**
  - Deep penetration
  - Wide weld bead
What is Hybrid Laser Welding?

- **Weld Characteristics**
  - Smooth surface contours
  - Small heat affected zone
  - Fine grain structures
  - Low base metal dilution
  - Very high weld toughness

- **Process Characteristics**
  - High Productivity
  - Low Consumable Costs
  - Improved Tolerance of Gaps, Edge Quality, Contaminant
How does HLAW Compare to Conventional Welding?

- **Deeper Penetration**
  - Multiple passes replaced with one

- **Lower Heat Input**
  - 80-90% reduction compared to MIG/SAW

- **Low Distortion/Shrinkage**
  - Very small HAZ
  - Much lower residual stress

- **High Weld Toughness and Strength**
How does H LAW Compare to Conventional Welding?

- HLAW Procedures Show Low H2 Pickup
  - Significantly less dissolved H2 in weld metal
  - Total H2 proportional to wire feed speed
  - Not affected by laser power

- Results (ml/100gm)
  - Laser-leading:
    - HLAW (1.0) vs. GMAW (2.5)—60% reduction in H2
  - GMAW-leading:
    - HLAW (1.8) vs. GMAW (2.5)—28% reduction in H2
How does HLAW Compare to Conventional Welding?

- **Higher Productivity**
  - 3-10 X faster than GMAW or SAW
  - Steel: 2-5m/min
  - Aluminum: 6-8m/min

- **Low Labor Content**
  - Fully automated operation

- **Low Operating Costs**
  - Less than half that of GMAW
ESAB’s Approach to Hybrid Laser Welding

- **GMAW Power Supply**
- **Disk Laser**
- **Delivery Fiber**
- **Welding Wire**
- **Seam Tracking System**
- **Floating Adaptive Weld Head**
ESAB’s Approach to Hybrid Laser Welding

- Adaptive Welding Process Control and Quality Assurance System
  - Look Ahead - joint tracking & measuring
  - Look At - weld process monitoring
  - Look Behind - weld geometry measurement and defect identification
  - 100% automated visual inspection and quality documentation
Non-Adaptive Control System Effects Butt Welds

- **Constant Parameters on Variable 0-1mm Gap**
  1. Use parameters optimized for 1.0mm gap:
     - Excessive bead height at 0 gap
     - Incomplete penetration at 0 gap
  2. Use parameters optimized for 0.0mm gap:
     - Insufficient fill height at 1mm gap
     - Excessive undercut at 1mm gap
Adaptive Control System Effects
Butt Welds

- Varying Gap: 0.0mm to 1.0mm
- Adaptive Controls results in:
  - Uniform bead shape
  - Uniform penetration
  - Very good weld quality over the entire weld length
ESAB’s Adaptive Control System

- Simple, Easy to Use HMI
- Fast, Real-Time 5th Generation Controls
- Feedback for Control and Reporting
Effect of Adaptive Control

- Optimized “Control vs. Constraint” Equation
  - Reduces total cost of implementing laser welding
  - Maximizes productivity
  - Improves economics of entire production process

![Graph showing process cost vs. max joint tolerance](image)

- Autogenous Laser (0-0.1mm)
- Hlaw with No Control (0-0.3mm)
- ESAB’s Adaptive Hlaw (0-1.5mm)
Effect of Adaptive Control

- 5 X Greater Process Window with Adaptive Control Enables:
  - Larger Parts
  - Joints with Higher Variation
ESAB Hybrid Laser Process Package for Integrators and OEM’s

- Complete Welding Head
  - Optics
  - Torch
  - Sensors
- Aristo GMAW Power Supply
- Laser Seam Tracking
- Adaptive Process Control System
- User-friendly HMI
- Weld Inspection and Quality Assurance
- ESAB Assistance with:
  - Sales support & materials
  - Demo/ proof-of-concept
  - Process development and optimization
  - Weld qualification
  - Customer financing
New HLAW Product Line

- **New Applications Development Centers**
  - Gothenburg, Sweden- R&D system
  - Laxa, Sweden- large format applications development
  - Florence, USA- large format applications development

- **New Resources**
  - Global product management
  - New sales people for Europe and US
  - New applications engineers in Florence, Laxa and GBG

- **New Marketing and Sales Strategy**
  - New website, literature, videos
  - New sales tools
ESAB’s New HLAW Product Line
ESAB’s New HLAW Product Line
Advanced Lightweight Laser Welded Structures

New Approaches to Design Enabled by Laser Welding
Advanced Structures

- Precision, Laser Fabricated Shapes for US Navy
  - ¼ to 1/10\textsuperscript{th} the tolerance of ASTM-A6 standard for hot-rolled shapes
  - Available in any steel grade and yield strength
  - 20% to 50% lighter than hot rolled beams
  - Easier and cheaper (~25%) to process, fit and weld into structures
Advanced Structures

- New Structures
  - Thin Materials from Coil Stock
  - Laser Fused into Hollow, Cellular Structures

- Advantages:
  - High precision
  - Low mass (50%)
  - High strength/weight ratios

Courtesy of Meyer Werft
## Light, Rigid, Strong and Flat

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<th>Depth = t</th>
<th>Depth = 2*t</th>
<th>Depth = 4*t</th>
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<tr>
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<td>Stiffness</td>
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<td>12</td>
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<td>Flatness</td>
<td>1-4” per 56’</td>
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**Total Structural Weight Reduction up to 50%**
Low Distortion

Courtesy of Meyer Werft
Hybrid Laser Welding Applications

Where is Hybrid Laser Welding Being Used?
Target Markets for Advanced Structures

- Traditionally “Heavy” Industries
  - Marine
    - Shipbuilding
    - Offshore
  - Transportation
    - Rail Cars & Truck Trailers
    - Automotive
    - Mobile Equipment
  - Civil Infrastructure
    - Bridge Decks
    - Superstructures
  - Commercial Construction
    - Structural Systems
    - Panel Systems
Shipbuilding and Marine

- **Applications**
  - Panel line plate butt welding
  - Panel line stiffener welding
  - Stiffener fab.

- **European HLAW**
  - Meyer Werft
  - Odense Shipyard
  - Blohm & Voss
  - Warnow Werft
Civil Infrastructure

- Bridge Decks and Beams
Transportation

- Intermodal Containers
- Truck Trailers
- Hopper and Gondola Rail Cars
Mobile Equipment

- “Light Structures”
- Chassis
- Booms and Arms
- Dump Bodies
- *Not suitable for use on children
Automotive

- Suspension Components
- Crash-critical structures
- Axles
- Engine Cradles
- Exhaust Components
- Truck Frames
ESAB’s Avenger HLx Welding Video
Robotic Welding Cell - US Apps Lab
Application Examples

(...the ones we can tell you about.)
Application Example

- **CVN-78**
  - Ship now designed with 700,000 ft of fabricated shapes replacing hot rolled beams
  - HLAW beam production system now operational
Application Example

- **Redesign of Ore Car**
  - Redesign car to replace side panels, floors and supporting structure
  - Objectives:
    - Reduce weight
    - Increase volume
    - Reduce material cost
    - Reduce labor content
    - Maintain structural strength and stiffness
  - Achieved:
    - 25% reduction in weight
    - 20% increase in volume
    - Reduced mfg. cost
Application Example

- **Meyer Werft Shipyard**
  - Converted from GMAW and SAW welding of stiffeners on bulkheads and decks
  - Reported 30% reduction in ship construction cycle time due to improved structural accuracy and flatness

*Courtesy of Meyer Werft*
Application Example

- **DDG-1000**
  - First surface combatant to use laser welded panels in critical structures
  - Laser welded stainless sandwich panels beat composite panels and aluminum panels in:
    - Weight
    - Stiffness
    - Acquisition cost
    - Lifecycle cost
Conclusions

- Hybrid Laser Welding is Capable of Welding Large, Traditional Structures with Required Quality

- ESAB’s Adaptive Controls Broaden HLAW Process Window by 5 Times Reducing Implementation Cost

- HLAW Enables New Design Approaches Which Reduce Weight and Cost

- Together, These Factors are Improving Productivity and Reducing Cost in Applications Throughout Industry

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