Submerged Arc Welding for Corrosion Resistant Overlay

ARC Specialties Applied Automation Workshop – Submerged Arc Welding
March 5, 2013
• How it works –
  – The Welding Process

• Welding variables
  – Welding current
  – Arc voltage
  – Travel speed
  – Wire size
  – Circumferential welds
PROCESS CHARACTERISTICS

• High deposition rates –
• Fast travel speeds –
• Economic - High deposition rates and high travel speeds reduce overall costs
• Multiple electrodes - greater versatility
SAW PROCESS ADVANTAGES

• Simple - mechanized process, easy to train machine operators
• Clean environment - minimal smoke or fume
• Operator friendly - no visible arc, no spatter
SAW PROCESS DISADVANTAGES

- Flux handling is necessary - new and used
- Fine flux particles - potential dust problem
- Large molten weld puddle - limits most welding to the flat position
THE SUBMERGED ARC PROCESS

HOW IT WORKS
SAW PROCESS

Heat of the arc melts the wire, flux and plate.

Fused flux shapes and protects weld metal.

Flux covers weld zone in front of wire.

Weld metal.
WELDING POWER SUPPLY

• Supplies electrical power to the electrode - The heat of the arc melts the electrode and base plate to form the weld bead.

• Electrical current can be:
  – AC or DC
  – CV or CC
DC POWER

- DC power is the most commonly used
  - It is the easiest to control
  - Gives the best arc starting
  - Gives the best arc stability
  - **DCEP** (*electrode positive*) - used most often, gives deepest penetration
  - **DCEN** (*electrode negative*) - gives 20-25% less penetration and greater deposition, can be used for some surfacing applications
AC POWER

• AC power minimizes arc blow problems
  – Eliminates arc blow with high current DC
  – Eliminates arc blow inside of small diameter pipes
  – Used for multi-wire applications - controls arc interaction between wires
  – Not all fluxes are designed to operate with AC power
INFLUENCE of POLARITY

• DCEP - Deep penetration
• DCEN - Shallow penetration
• AC - Penetration is in between DCEP and DCEN
VARIATIONS of AC POWER

AC Sine Wave

AC Balanced Square Wave

AC Variable Polarity
WELDING VARIABLES

- Welding current
- Arc voltage
- Travel speed
- Wire size
- Wire extension
• Controls - Deposition rate
  - Increase in current - Increases burn-off rate
WELDING CURRENT

• Controls - Depth of penetration
  – Increase in current - Increases penetration
WELDING CURRENT

Welding Current vs. Penetration

All welds made at 29 volts and 30 IPM
INFLUENCE of AMPS on PENETRATION

500 amps @ 35 V
20 ipm

600 amps @ 35 V

.256”

.336”
ARC VOLTAGE

- Arc voltage is a measure of arc length
  - Increase voltage – Increase bead width
  - Increase voltage - Decrease penetration
ARC VOLTAGE

Welding Voltage vs. Bead Width

LOW

CORRECT

HIGH

22 VOLTS

29 VOLTS

38 VOLTS

All welds made at 500 amps and 30 IPM
INFLUENCE of VOLTS on PENETRATION

500 amps @ 35 V

.256"

500 amps @ 30 V

.273"

20 ipm
INFLUENCE of VOLTS on PENETRATION

600 amps @ 35 V

600 amps @ 28 V

20 ipm

0.336”

0.427”
INFLUENCE of AMPS and VOLTS

• Higher amperage gives deeper penetration

• Increased voltage gives wider bead
TRAVEL SPEED

• Controls - penetration
  – Increase speed – Decreases penetration
  – Increased speed – Decreases weld thickness
Travel Speed vs. Bead Width (size)

All welds made at 500 amps and 29 volts
WIRE SIZE / DEPOSITION RATES

- Current vs. Deposition Rate vs. Wire Size
  - Increase current - Increase deposition rate

![Deposition Rate Graph]
WIRE SIZE / BURN-OFF RATES

• Wire Burn-off rates (ipm) vs. Amps

Electrode Stick-out = 8X wire diameter

DCEP - 10-15% Less

DCEN - 10-15% More
WIRE SIZE / BEAD WIDTH

• Wire Size vs. Bead Width vs. Penetration
  – Larger wire size at same welding current - Wider bead with less penetration
### WIRE SIZE / PENETRATION

- **Current Density** = \( \text{amps/A (in.}^2\) \)
  - \( \text{amps} = \text{welding current} \)
  - \( A = \text{cross sectional area of wire (in.}^2\) \)

<table>
<thead>
<tr>
<th>Wire Size</th>
<th>Current Density CD</th>
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<tbody>
<tr>
<td>500 amps</td>
<td></td>
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<tr>
<td>500 amps</td>
<td></td>
</tr>
<tr>
<td>1/8” wire</td>
<td>40,650 amps/in.²</td>
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<tr>
<td>A = .0123 in.²</td>
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</tr>
<tr>
<td>5/32” wire</td>
<td>26,042 amps/in.²</td>
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<tr>
<td>A = .0192 in.²</td>
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WIRE SIZE / PENETRATION

- Wire size vs Penetration

![Graph showing wire size vs penetration with different amperage levels (450, 500, 550, 600 AMPS) for wire sizes 3/32", 1/8", and 5/32". Each amperage level is represented by a different color: 450 AMPS in blue, 500 AMPS in red, 550 AMPS in blue, and 600 AMPS in purple. The y-axis represents penetration in inches, ranging from 0 to 0.35, while the x-axis represents wire sizes. The graph illustrates the relationship between wire size and penetration across the specified amperage levels.](image-url)
CURRENT DENSITY vs. PENETRATION

- At the same current level, a smaller wire will give deeper penetration due to higher current density.
Wire stick-out should be about 8 times the wire diameter (1/8” wire = 1”)

“Electrical Stick-Out” - Tip-to-work distance

Tip

Stick-out

Work
ESO vs. PENETRATION

- Longer stick-out - Decreases penetration (at the same wire feed speed)
Proper alignment for circumferential welds

Wire is always ahead of center - Puddle should solidify at center
OFFSET ON CIRCUMFERENTIAL WELDS

- Molten puddle runs off top of round seam

<table>
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<th>SMALL OFFSET</th>
<th>MEDIUM OFFSET</th>
<th>LARGE OFFSET</th>
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<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
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Results:
- **SMALL OFFSET**: Little metal at edges; high peak at center; deep penetration.
- **MEDIUM OFFSET**: Level weld with slight reinforcement.
- **LARGE OFFSET**: Flat, shallow weld; reinforcement low at center, higher at edges.

- Metal runs over top away from arc
- Metal runs back under arc
THE END