Arc Welding Equipment Selection

“So You’re the New Welding Engineer” AWS Seminar

Mike Flagg – The Lincoln Electric Co.
So You’re the New Welding Engineer

- You may be responsible for the welding equipment selection in your shop.
- So what type of equipment do you chose?
Basic Fundamentals of Arc Welding
Power Sources
Conventional Technology

- **Static (stationary) machines**
  - Transformer or transformer / rectifier machines
    - Power converted or transformed and rectified at 60 Hz frequency
    - Machines are large and heavy (big transformer)
    - Conventional Technology: (1970s – 1990s)
      - Silicon Controlled Rectifier (SCR)
    - Old Technology: (Pre 1980s)
      - Mechanically controlled components

- **Rotary (rotating or moving) machines**
  - Motor Generators
  - Pure DC Generator Engine Drive
  - Alternator Engine Drive
New Technology

- Inverters

- Choppers
Inverters

- Inverter power sources are smaller, lighter and more portable than conventional transformer / rectifier type machines
- They also have high speed power conversion which allows for quick response to changing arc conditions
- The key is high speed switches (IGBTs), which greatly increase the frequency (80,000+ Hz vs. 60 Hz.).
- Key benefits are:
  - Reduction in the physical size and weight of the transformer required for the power source
  - Higher transformer efficiency
  - Lower input power consumption
  - Faster reacting arc results in smoother output
Inverter Technology Benefits

- Lighter weight – more portable
- Smaller, more compact size – takes up less floor space
- Smoother output – superior arc performance
- Advanced design – reliable components
- More efficient transformer – less heat waste
- Lower power consumption – lower operating cost
Power Electronics Technology

- Technology improvements across whole family of power sources
- Electronic devices to control and convert power
  - Low power consumption
  - High efficiency
  - High power density
  - Significant energy and cost savings

Inverter power source

Chopper circuitry
Advanced Technology: Pulse Welding

- Welding Output Varies (Pulses) Between a High (Peak) Current and Low (Background) Current
- Still a Spray Arc Metal Transfer
- Doesn’t Reduce Penetration Level
- Standard Pulsing Variables:
  - Amplitude
    - Peak & Background Current Levels
  - Balance
    - Time per Pulse at Peak & Background
  - Frequency
    - Number of Pulses / Second
Pulse MIG Equipment with Waveform Control Technology

- **Waveform Control Technology™ Equipment**
  - The Equipment Family with Waveform Control Technology™ are the “Power Wave®” Machines and “Power Feed™” Wire Feeders
  - They **Must** be Used Together as a Package

- **Power Wave® Machines**
  - Inverter based machines
  - Higher speed switching
Synergic Wire Feeders

- **Power Feed™ Wire Feeders**
  - Most controls on wire feeder
  - 40V DC drive motor
  - MAXTRAC drive system
  - Optional Memory panel
Software Driven Output

- **Waveform Control Technology™** - The capability of electronically controlling and changing the arc welding waveform from just one machine to produce the ideal arc characteristics for unlimited welding needs.
  - Wide range of applications
  - Varying material thicknesses and specifications
  - All weld positions
  - Different appearance requirements
Pulse Waveform Variables

- **Standard Pulsing Machines Control 4 Variables:**
  - Peak Current, Background Current, Balance, Frequency
- **Waveform Control Technology™ Machines Control 18 Variables**
  - Allows Precise Control of Arc
  - The Area Under the Waveform Controls Desired Melt-off Rate
  - 9 Inner Loop Variables and 9 Outer Loop Variables

**“Inner Loop” Variables**
1. Front Flank
2. Percent Overshoot
3. Peak Current
4. Peak Time
5. Tail-out
6. Tail-out Time
7. Step-off Current
8. Background Current
9. Frequency

**“Outer Loop” Variables**
- Controls Adaptability
- **Trim and Arc Control**
  - Peak Time
  - Peak Current
  - Step-Off Current
  - Background
  - Frequency
The “Ideal” Welding Output Varies

CV Steel

Pulse Steel

Pulse Aluminum

Pulse on Pulse® Alum.

STT Steel

Flux Core Steel
Easy to Operate

• Synergic Control
  – Power source and wire feeder work or communicate together (synergic relationship) Synergic welding eliminates the need to independently set the wire feed speed and voltage.

• Adaptive Control
  – “Adaptive Control” helps overcome lack of operator skill and aids in producing more consistent, higher quality welds, even as operators are still improving their welding ability.
Basic Pulse

Description:
A waveform that cycles between a peak and background current producing one droplet per cycle

Benefits:
- Easy to use
- Extends the operating range of traditional CV
- Can produce less heat input

Applications:
- All applications where CV is used

Equipment:
Basic Pulse

HEAT INPUT

SHORT ARC

CV

GLOBULAR

PULSE GMAW
(USABLE)

SPRAY

WFS
**Description:**
A fixed-frequency pulse mode, designed to produce a very focused arc at lower voltages

**Benefits:**
- Extremely stable
- Easier to manipulate
- Very fluid, yet controllable puddle

**Applications:**
- Out-of-position applications
- Areas where traditional pulse is producing sub-par results

**Equipment:**
**Precision Pulse™**

**Pulse Ramp/Peak**
A controlled current increase creates a molten droplet without disturbing the puddle and minimizes the size of the arc cone.

**2** Tailout
Reducing current relaxes the plasma force as the droplet approaches the puddle creating a clean droplet transfer.

**Background**
Lower background helps maintain control by minimizing the puddle heating.

**Frequency**
Frequency is a preset value. The UltimArc™ control allows the operator to fine tune the pulse frequency.
Rapid Arc®

**Description:**
A high-speed pulse mode designed with an extremely short arc length & short circuit response to minimize spatter

**Benefits:**
- Higher travel speeds
- Low spatter generation
- Shorter arc length allows for better puddle manipulation

**Applications:**
- Thinner material, high-speed requirements
- Spatter control is required, and capital costs are constrained

**Equipment:**
Rapid Arc®

1. Pulse Ramp / Peak
   A rapid current increase creates a molten droplet.

2. Tailout
   Reduced current relaxes the plasma force as the droplet approaches the puddle.

3. Short
   The arc collapses, and the droplet contacts the puddle.

4. Puddle Repulsion
   A plasma boost pushes the puddle away, creating separation and a stable rhythm of the weld pool.
STT® - (Surface Tension Transfer)

Description:
A modified short circuit mode, designed for open root welding

Benefits:
- Bridge gaps without lack of fusion issues
- More forgiving that CV short-arc
- Runs well on alloys

Applications:
- Open Root Pipe
- Thin material applications
- Poor fit-up situations
- Weld appearance, or no spatter

Equipment:
What is STT®?
STT® is a GMAW, controlled short circuit transfer process.

Features:
Good penetration and low heat input control
Reduced spatter and fume
Adjust heat independent of wire feed speed

Benefits:
Multi-purpose use: thin sheet metal, pipe, stainless steel, nickel, silicon bronze, galvanized steel.
Description:
A high-speed, ultra low spatter pulse mode – the result of combining Rapid Arc and STT

Benefits:
- High travel speeds
- **Lower** spatter generation than Rapid Arc

Applications:
- Thinner material, high-speed requirements
- Spatter control is required at all cost

Equipment:
**Rapid X™**

**1. Pulse Ramp/Peak**
A rapid current increase creates a molten droplet.

**2. Tailout**
Reduced current relaxes the plasma force as the droplet approaches the puddle.

**3. Wet-in**
Proprietary hardware quickly reduces the current at the instant the droplet contacts the puddle, reducing spatter after the droplet detaches.

**4. Puddle Repulsion**
A plasma boost pushes the puddle away, creating separation and a stable rhythm of the weld pool.
AC Pulse - Aluminum

Description:
An aluminum pulse waveform designed to reduce heat input into the base metal.

Benefits:
- Join thinner materials than a DC+ waveform
- Increased deposition rates
- Improved gap bridgability

Applications:
- Thinner aluminum applications
- Applications where deposition is required, but heat input is constraining factor

Equipment:
AC Pulse - Aluminum

Peak
Propels droplet toward the weld pool.

Positive Background
Completes droplet transfer and begins the creation of the next droplet.

Negative Background
Reduces heat input by redirecting current flow towards the electrode.
Sync-Tandem MIG

Description:
Pulse wave forms designed to control two power supplies in synchronization

Benefits:
- Improves system stability
- Reduces spatter from arc interaction
- Better looking welds

Applications:
- High deposition Applications (24-40 lbs./hr.)
- High speed applications (50-150 ipm)

Equipment:
Sync-Tandem MIG

Waveform

Lead Arc - Ramp
A rapid current increase begins the process of creating a single molten droplet.

Trail Arc - Tailout
A reduction in current (Tailout) relaxes the plasma force as the droplet separates and approaches the puddle.

180° Synchronization

<table>
<thead>
<tr>
<th>Red</th>
<th>Lead Current</th>
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<tbody>
<tr>
<td>Blue</td>
<td>Trail Current</td>
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Lead Arc - Peak
A peak current creates a molten droplet providing sufficient pinch force to begin separation.

Trail Arc - Background
The trail arc reaches a minimum current level (background current) and maintains the arc without additional metal melt-off.

Lead Arc - Background
The lead arc reaches a minimum current (background current) and maintains the arc without additional metal melt-off.

Trail Arc - Peak
A peak current creates a molten droplet providing sufficient pinch force to begin separation.

The Performance You Need.
The Quality You Expect.
**Hot Wire - Tandem MIG**

**Description:**
Pulse wave forms designed to control two power supplies in synchronization

**Benefits:**
- Improves system stability
- Reduces spatter from arc interaction
- Better looking welds

**Applications:**
- High deposition applications (24-40 lbs./hr.)
- High speed applications (50-150 ipm)

**Equipment:**

![Equipment Image]

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Amperage</th>
<th>35volts</th>
<th>7 volts</th>
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![Graph Image]
Power Wave Manager

- Security
- Memory Settings
- Limits
- Etc.
Control – Weld Sequencer
Complex Semi-Auto Assemblies
Production of Complex Semi-Automatic Assemblies

- Increase Productivity and Quality while Reducing Cost
- Reduce Training Cost
- Optimize Welding Procedures
- Improve Production Cycle Times
- Improve Product Quality
- Detect Missing/Extra Welds
- Reduce Downstream Inspection Effort
- Link to Automatic Equipment and ERP Systems
Weld Data Monitoring Requirements

- Simple vs. Difficult Conditions
- Reliability of the System
- “Good or Bad” vs. “Different”
3) Verify:
Software Solutions

True Energy™

- Instantaneous energy value for the weld
- Arc Timer
  - Measured in Seconds
- Sampling rate of 10 kHz
- Simple Heat Input Calculations

\[
\text{True Energy (J or kJ)} = \frac{\text{Heat Input}}{\text{Distance Traveled (in. or mm)}}
\]

- Value is recorded in Production Monitoring™ 2
Summary Screen – Factory Overview
Questions to Ask

- Cost?
- Process match your welders abilities?
- Level of Automation?
  - Manual, Semi-automatic, mechanized, automation
- Complexity of system?
  
  and most importantly…

- Does your equipment allow you to control your welding operations as a process?
  - Implement, control, verify
Questions?