Background

- Surface Tension Transfer (STT®) is a short circuit mode of metal transfer that provides control for peak current, background current, and tail out current.
- Other processes use a high current to force a molten droplet across the weld pool, STT® uses low current and surface tension forces between the pool and the droplet to collapse the droplet.
- Lower heat input than constant voltage.

- Power Mode™ uses watt energy (V x I = W) to regulate the arc length which promotes consistent response within the arc.
- Responds to changes in voltage and uses watt energy to regulate the arc.
- Less current change and better penetration control than constant voltage.

- Constant Voltage (CV) maintains a constant wire feed speed and the current is changed to maintain the arc length.

Motivation

- Lack of comparison between STT®, CV and Power Mode™ with varying material thicknesses.
- Compare mechanical properties, depth of penetration, heat input and waveforms.
- Conclude the advantages and disadvantages of each process.

Objectives & Approach

Overall Goal: Develop and validate welding and testing processes for each welding mode for varying material thicknesses.

Equipment: PowerWave® S-350 and PowerFeed® 25M

Consumables: .035" (.9mm) SuperArc® L-59 and 75% Ar / 25% CO2 shielding gas.

- Procedure development: By changing welding variables to achieve proper weld sizes by AWS code for each material thicknesses.
- Waveform: Achieve wave form graph during welding to compare current and voltage inputs at certain times.
- Mechanical testing: Compare the bend strength and the tensile strength of the weld specimens.
- Weld Profile: Cut and mount welds to compare weld bead profiles.
- Heat Input: Collect weld heat input from the true energy reading on the welding machine and compare to the calculated heat input.

Procedures

- Each test was done with .035" (.9mm) ER70S-6 wire and 75% Ar / 25% CO2

<table>
<thead>
<tr>
<th>3/16” material</th>
<th>CV Mode</th>
<th>STT® Mode</th>
<th>Power Mode™</th>
<th>Heat Input (kJ/in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 Ga</td>
<td>16.2 V</td>
<td>17.5 V</td>
<td>18.1 V</td>
<td>154.9 Amps, 8 IPM</td>
</tr>
<tr>
<td>3/16” Break Test</td>
<td>16.2 V</td>
<td>17.5 V</td>
<td>18.1 V</td>
<td>123.4 Amps, 13 IPM</td>
</tr>
</tbody>
</table>

Conclusions

- STT® is more suitable for thinner materials because of the lower current and the lower heat input than CV and Power Mode.
- Power Mode™ shows better current control over traditional CV short arc but has similar heat input and spatter amount.
- Power Mode™ and CV had acceptable weld profiles and fusion for 3/16” material while STT® did not due to its lower heat input.

Future Work

- Compare STT®, CV and Power Mode™ in different positions.
- Compare the three modes with groove vs. fillet welds.
- Compare the three welding processes on other materials to observe the effect of lower heat inputs on the weld quality.

Results & Discussion

- Recorded heat input information from welding procedures.

<table>
<thead>
<tr>
<th>3/16” Break Test</th>
<th>Power Mode™ 3/16” Break Test</th>
<th>Power Mode™ 3/16” Break Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Mode</td>
<td>CV</td>
<td>STT®</td>
</tr>
<tr>
<td>Time (s)</td>
<td>Arc Voltage (V)</td>
<td>Arc Current (A)</td>
</tr>
<tr>
<td>51.25</td>
<td>15.8 V</td>
<td>15.30 A</td>
</tr>
<tr>
<td>51.35</td>
<td>15.7 V</td>
<td>14.99 A</td>
</tr>
<tr>
<td>51.45</td>
<td>15.6 V</td>
<td>14.69 A</td>
</tr>
<tr>
<td>51.55</td>
<td>15.5 V</td>
<td>14.49 A</td>
</tr>
<tr>
<td>51.65</td>
<td>15.4 V</td>
<td>14.29 A</td>
</tr>
</tbody>
</table>

- CV Waveform
- Power Mode has longer flat region after peak which shows its better current control than CV.
- STT® drops current during a short in order to put less heat input into the weld in comparison to CV.
- The lower heat input caused a lack of fusion throughout the entire weld in the STT® mode. CV and Power Mode™ experienced lack of fusion at the end of the welds due to no backstep in the weld procedure.
- STT® experienced the least amount of spatter followed by Power Mode and then CV. The STT® process produced the least amount of weld droplet force which caused less spatter during welding.

- CV, STT®, and Power Mode™ welds are shown to left on the 3/16” plate. CV has the largest weld size followed by Power Mode and STT.