Spectral Control for Pulsed Arc Welding

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Material Science and Engineering (MSE08)

http://www.mse-congress.de/
1-4 September 2008, Nürnberg Congress Center
Motivation / Aim

Reduction of process failures
Real time process control

Object of investigation:
2 selected pulsed processes, identification of significant spectral characteristics

Welding
• Base material AlMg4,5Mn 1,2mm
• Aluminum wire AlMg4,5Mn Ø1,2mm

Brazing
• Electro galvanized steel plate 0,8mm
• Aluminum bronze brazing material AlBz5Ni2 Ø0,8mm
Distribution of line spectra and diode characteristics

selection of diodes
Our approach

- **Spectral controller** for GMAW - pulsed arc
- Ultraviolet emission (UV) of arc is set in relation to infrared emission (IR)
- During pulse process: IR decreases, UV increases
- If the difference UV-IR falls below a defined limit, a STOP-signal will be generated
- The STOP-signal forces the power source to switch back from pulse- to base-current
2 modes for pulse synchronization (to eliminate the offset-drift of amplifiers)

- The synchronic-signal is given by the power source.
- Auto-synchronization: The synchronic-signal is generated by the controller itself.

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2-channel spectral controller

**Task**
Selection of applicable photodiodes to record optical spectra with up to 192 kS/s with two independent optical channels for infrared (IR) and ultraviolet (UV)

Read out time = real time control

**Problem**
- **sensitivity** of diodes (IR→UV decrease of factor 30)
- **chip area** of IR-diodes (up to factor 140 larger)

=> Great difference of short-circuit current up to 4200

• Adjust the difference for
  - IR-diodes: coated with absorbing foils
  - UV-diodes: particularly amplified x1000
Position of spectral controller during welding

distance torch to diodes = constant 280mm
angle to plate ~8°
Welding of AlMg4,5Mn; periodic droplet transfer (process o.k.)

<table>
<thead>
<tr>
<th>shielding gas</th>
<th>Argon R</th>
</tr>
</thead>
<tbody>
<tr>
<td>weld speed [m/min]</td>
<td>1,40</td>
</tr>
<tr>
<td>wire speed [m/min]</td>
<td>4,30</td>
</tr>
<tr>
<td>frequency [Hz]</td>
<td>100</td>
</tr>
<tr>
<td>base current [A]</td>
<td>30</td>
</tr>
<tr>
<td>pulse time [ms]</td>
<td>1,35</td>
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<tr>
<td>pulse current [A]</td>
<td>300</td>
</tr>
</tbody>
</table>
Welding of AlMg4,5Mn; periodic droplet transfer (process o.k.)

Signals of different spectral sensitive diodes in comparison with current and voltage
Welding of AlMg4,5Mn; periodic droplet transfer (process o.k.)

Arc form depending on current

H. Schöpp et al., MSE Nürnberg, 3.9.2008
Welding of AlMg4,5Mn (instable process)

from stable process by reducing pulse time (1.35 -> 1.1 ms)

Comparison to instable process

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<td>frequency [Hz]</td>
<td>100</td>
</tr>
<tr>
<td>base current [A]</td>
<td>30</td>
</tr>
<tr>
<td>pulse time [ms]</td>
<td>1,10</td>
</tr>
<tr>
<td>pulse current [A]</td>
<td>300</td>
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</table>

H. Schöpp et al., MSE Nürnberg, 3.9.2008
Welding of AlMg4,5Mn (instable process)

Irregular droplet formation; different diodes / arc current and voltage
Stable process with spectral controller
despite increase of pulse current from 300 to 400 A

<table>
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<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>shielding gas</td>
<td>Argon R</td>
</tr>
<tr>
<td>weld speed [m/min]</td>
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<tr>
<td>wire speed [m/min]</td>
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<td>frequency [Hz]</td>
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<tr>
<td>base current [A]</td>
<td>30</td>
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<tr>
<td>pulse time [ms]</td>
<td>process controlled</td>
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<tr>
<td>pulse current [A]</td>
<td>400</td>
</tr>
</tbody>
</table>

H. Schöpp et al., MSE Nürnberg, 3.9.2008
Signal characteristic of the controlled process

![Graph showing signal characteristics](image)

- **Current (A)**
- **Voltage (V)**
- **Time (ms)**

**Signal characteristic**
- *Strom* (current)
- *Spannung* (voltage)
- *Stopsignal* (stop signal)
welding of AlMg4,5Mn; periodic droplet transfer

Cross-section of spectral controlled Al-weld seam (lowering of porosity)
spectral controlled signal characteristic
Conclusion

- **Real time** spectral control of arc welding and brazing was successfully investigated.
- The **controller stabilizes** the process in a wide range of pulse-current modifications (current increased by around 30%).
- Energy input for each pulse is controlled by **individual pulse times**.
- Further investigations are planned with regard to
  - other alloys
  - thin sheets (<0.8 mm)
  - process modifications.
Thanks for support

Carl Cloos Schweißtechnik GmbH

REHM GmbH u. Co. KG Schweißtechnik

Thank you for your attention!