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Resistance Welding – Power Supply Feedback Mode Selection

By David Steinmeier

Introduction

Resistance welding power supply controls come in two flavors, "closed loop" or "open loop". Inverter and Linear power supplies offer "closed loop" feedback control over the electrical welding parameters. Stored Energy or Capacitor Discharge (CD) and most Direct Energy or AC controls are "open loop", offering no or minimal feedback.

A 'closed loop" power supply control with multiple feedback modes offers the following advantages over a non-feedback control:

- More process consistency between multiple welding stations.
- Reduced parts scrap.
- Automatic adjustment for variability in part thermal loading and plating.

Feedback Modes

The three main feedback modes are constant current, voltage, or power. Each feedback mode offers a distinct set of advantages and disadvantages.

Constant Current – Basic Model

The simplified weld heat density equation for constant current operation is: $Q_d \approx I^2 t(R_t/A)$, where:

Q_d = Weld heat density
I^2 = Weld current squared
t = Weld period time
R_t = Weld total electrical resistance
A = Weld heat contact area

Successful constant weld current operation requires consistent weld heat contact area between each electrode tip and corresponding part and between the weld parts. Weld force magnitude and electrode impact strongly influence the interface resistance and weld heat contact area. Using a high weld force and slowing the electrode tip speed just before impacting the parts helps to ensure a consistent weld heat area.

Constant Current – Advantages:

- Ideal for welding flat-to-flat parts.
- The weld current is the same, weld station-to-weld station.
- Changes in weld cable and weld head resistance do not affect the weld current.
- Simultaneously welding more than two parts is possible.
- Electrode life is generally much better than constant voltage and somewhat better than constant power operation.

Constant Current – Disadvantages:

- Changes in the R_t/A ratio affect the weld heat density.
- Weld splash must be mitigated by using a weld period called "up slope".

Constant Voltage – Basic Model

The simplified weld heat density equation for constant voltage operation is: $Q_d \approx V^2 t/(R_t A)$, where:

V^2 = Weld voltage squared

Ideally, constant voltage operation requires that the voltage feedback sensing leads be located in the weld part interface. Since this location is not practical, the voltage sensing leads must be located as close to the electrode tips as possible. Constant voltage feedback also works best when using electrically conductive electrode alloys that minimize the voltage drop between the electrode tips and voltage sensing lead attachment points.

Constant Voltage – Advantages:

- Ideal for welding round-to-round and round-to flat parts without causing weld splash.
- Ideal for welding parts with inconsistent coplanarity.
- Automatically reduces weld splash caused by inconsistent part-to-part and electrode-to-part weld heat contact area variability.
- Automatically adjusts for variability in the $R_t A$ product.

Constant Voltage – Disadvantages:

- Over time, the welded area decreases due to electrode tip contamination and wear. This negatively affects the weld strength.
- Changes in the distance between the electrode tips and corresponding voltage sensing lead attachment points affect the weld strength.
- Electrode life is not as good as constant current or constant power operation.

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Constant Power – Basic Model
The simplified weld heat density equation for constant power operation is: $Q_d \approx VIt/A$, where:

I = Weld current
V = Weld voltage

Like constant voltage operation, the voltage sensing leads must be located as close to the electrode tips as possible. Constant power feedback also works best when using electrically conductive electrode alloys that minimize the voltage drop between the electrode tips and voltage sensing lead attachment points.

Constant Power – Advantages:
- Ideal for welding parts with variations in plating thickness or interface and parts resistances.

Constant Power – Disadvantages:
- Changes in the contact area affect the weld heat density.
- Changes in weld cable and weld head resistance affect the weld voltage and current at the electrode tip, which affects the weld strength.
- It is difficult to match voltage and current from weld station-to-weld station.
- Changes in the distance between the electrode tips and corresponding voltage sensing lead attachment points affect the weld strength.
- Electrode life is not as good as constant current operation.

Theory versus Reality
Thus far, the advantages and disadvantages given for all feedback modes have been a combination of theory and practical experience. The next section provides several feedback selection rules based on real manufacturing equipment limitations and production volume challenges.

Feedback Mode - Practical Selection Rules:
1. Always start with constant current.
2. Use constant voltage when faced with severe electrode and parts non-coplanarity.
3. Constant power in most cases emulates constant current operation due to high welding cable connector interface resistances and electrode alloy resistance. See Rule No.1

The table below provides a summary of the practical considerations when selecting a feedback mode.

Characteristic	Constant Current	Constant Voltage or Power
Weld Station-to-Weld Station Process Consistency	• Actual weld current is the same from weld station-to-station.	• Weld voltage or weld power is not consistent from weld station-to-station due to changes in the weld cable and weld head resistance values and in the repeatability of electrode length during electrode installation.
Feedback Point	• Irrelevant – the weld current has the same value in the weld cable, weld head, electrodes, and parts.	• The closer the voltage sensing lead attachment is to the electrode tip, the better the feedback control. • Control shifts with changes in electrode installation length.
Weld Heat Profile	• Reasonable feedback control at the lowest operating weld current.	• Limited feedback control at the lowest operating weld voltage or power.
Weld Cable Resistance Changes	• No effect on weld current.	• Changes the weld voltage and current at the electrode tips, which affects the weld heat.
Weld Head Resistance Changes	• No effect on weld current.	• Changes the weld voltage and current at the electrode tips, which affects the weld heat.
Electrode Life	• 1000 to 4000 welds. • Drop off in weld strength occurs suddenly near the end of electrode life.	• 200 to 2000 welds. • Weld strength quickly decreases as the electrode tips wears.