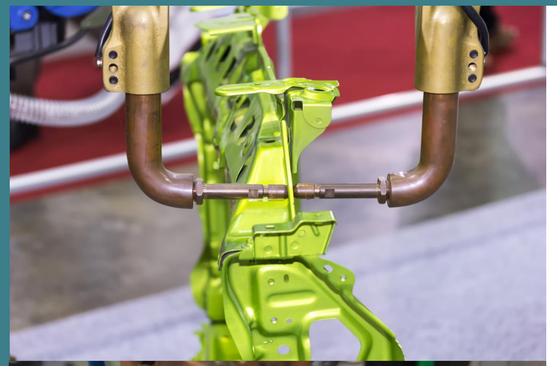
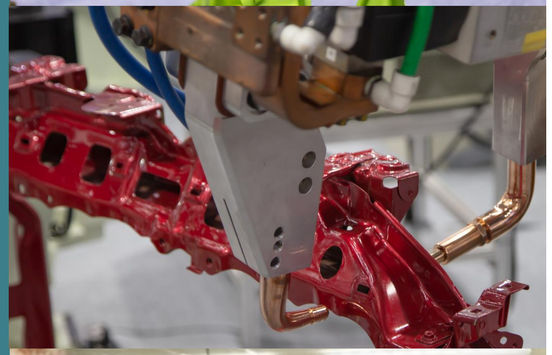




WeldComputer

The Technology Leader in Resistance Welding

Advances in Resistance Welding

How to Increase Flash Welding Performance While Reducing Energy Utilization

Bob Cohen
WeldComputer Corporation

Flash welding is a process used to weld together the ends of metal parts such as:

— Tubing

— Flat Sheets

— Solid round, hex, square & rectangular bars

Examples: (of flash welded parts)

— Landing Gears

— Cooling Pipes

— Large Electrical Conductors

How to make a flash weld

- Apply voltage across two pieces to be welded.
- Light contact made between pieces.
- Establish current through circuit to heat points of contact beyond melting (i.e. make flashing).
- Maintain flashing action by moving the parts together at a controlled rate.
- After surfaces become sufficiently plastic, rapidly forge together under high force.
    - Hot metal is displaced & expelled in the form of an upset.
    - Upset also closes craters, expels oxides & impurities.
    - Results in solid-state joint.

Many flash welding operations have high scrap rates

— Inability to control flashing intensity

— Inability to control flashing distance

— Inability to produce repeatable upset pattern

— Inability to measure results of welds that are not destroyed

How to make a consistent flash weld

— Make consistent flashing intensity for consistent duration over consistent distance

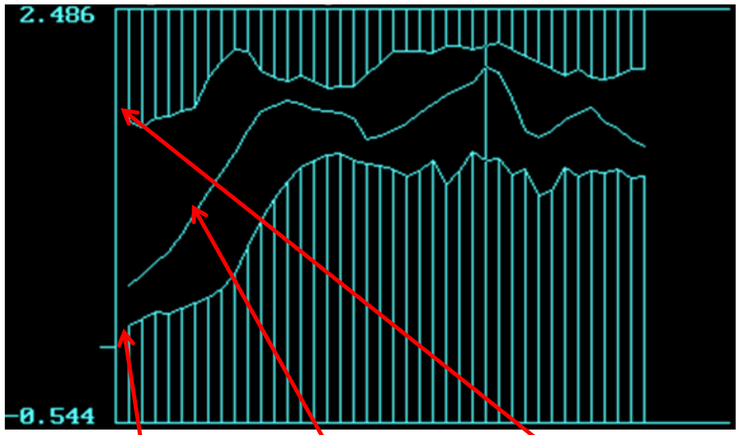
— Make consistent upset force pattern

— Verify that consistent upset occurred

Use a capable machine and capable control

Adaptive Flash Welding Process

Monitor upset profile response

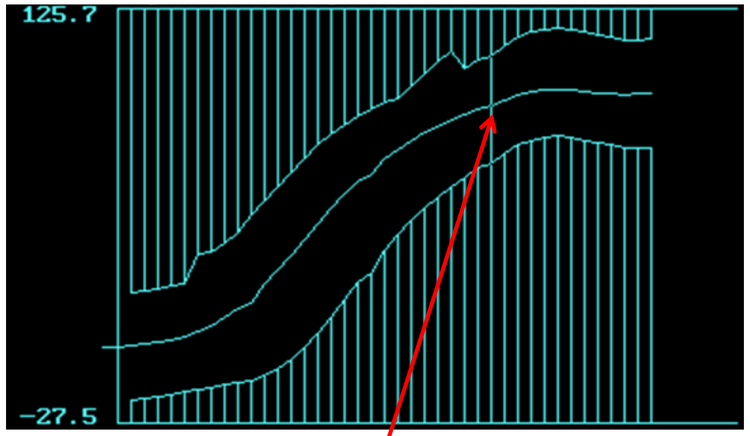


Lower Limit Profile

Upset Force Profile

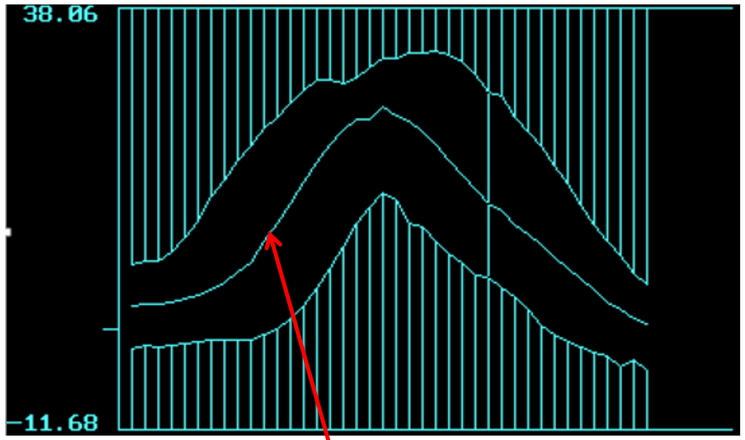
Upper Limit Profile

Upset Position Profile



Final upset position reached in 28ms

Upset Velocity Profile



Platens rapidly accelerate parts together

Data collected with WeldComputer® Adaptive Control

Capable Machine

Sufficient transformer output voltage to make flashing in the presence of 10% line voltage drops from power company.

Move parts together with a controlled velocity profile for a controlled distance.

Make consistent upset force and upset distance.

Clamping system sufficient to keep parts from slipping under the applied force during upset.

Capable Control

Ability to control flashing intensity.

Ability to verify that expected upset profile was achieved.

Ability to minimize current demand required to control the process.

Ways to Control Flashing Intensity

Adjust the heat.

Adjust the part feed velocity.

Control Flash by Adjusting Heat

Decrease duty cycle of applied voltage to reduce flashing

Increase duty cycle of applied voltage to increase flashing

*This generally cannot be done very well using SCR technology, but can be done using inverter technology

Control Flash by Adjusting Speed

Increase speed to increase flashing (when reduction in flashing is from parts starting to create an open circuit on the machine secondary)

Decrease speed to increase flashing (when reduction in flashing is from parts starting to create a short circuit on the machine secondary)

Integration of Control with Machine

Ability to tell machine to speed up when flashing is starting to reduce due to loss of electrical circuit

Ability to tell machine to slow down when flashing is starting to reduce due to parts creating a short circuit on the machine secondary

— Machine speed control is necessary when maximum control heat setting isn’t enough to keep the parts from shorting out

Control Flashing Intensity

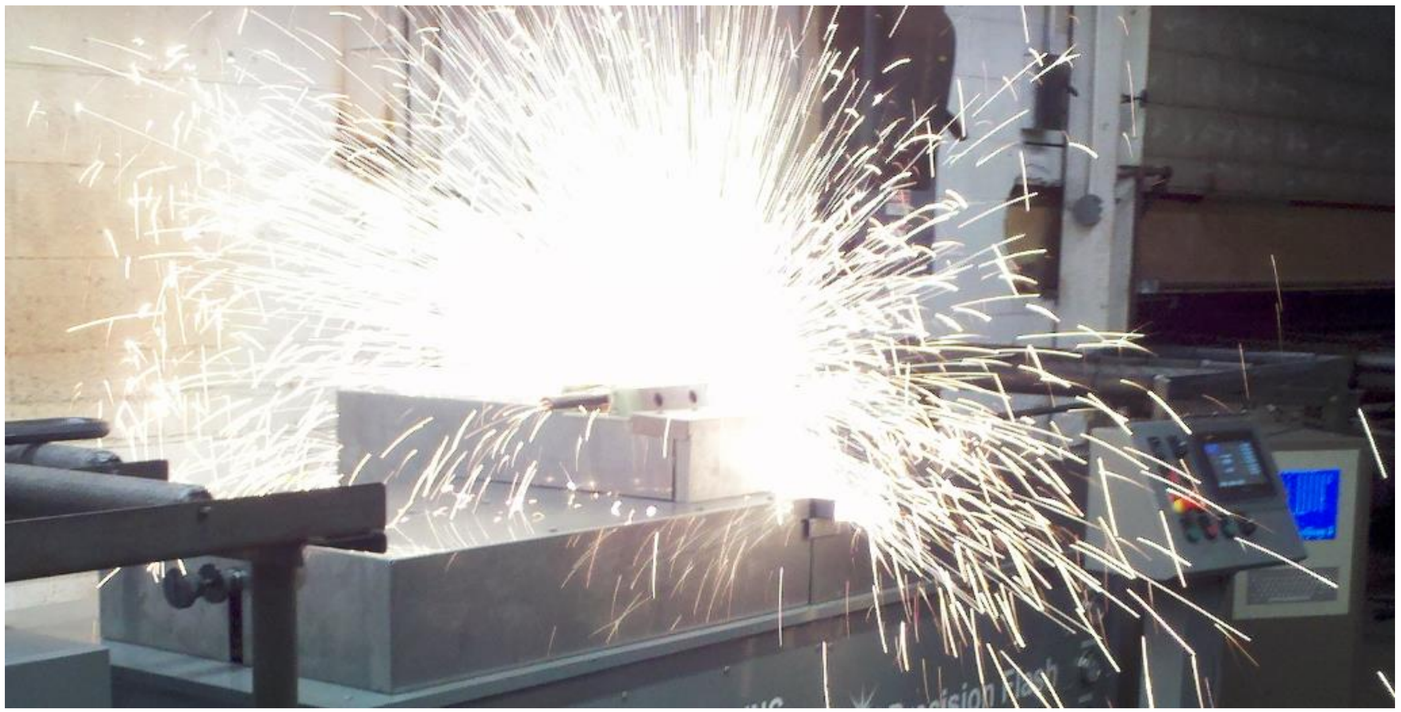
Ability to detect flashing intensity

Ability to increase or decrease flashing intensity

Ability to detect loss of flashing due to electrical circuit loss

Ability to detect loss of flashing due to parts creating a short circuit on the machine secondary

Wave synthesis adaptive control using 3 phase power to operate flash welder with single phase AC transformer



Optical Flash Intensity Detection

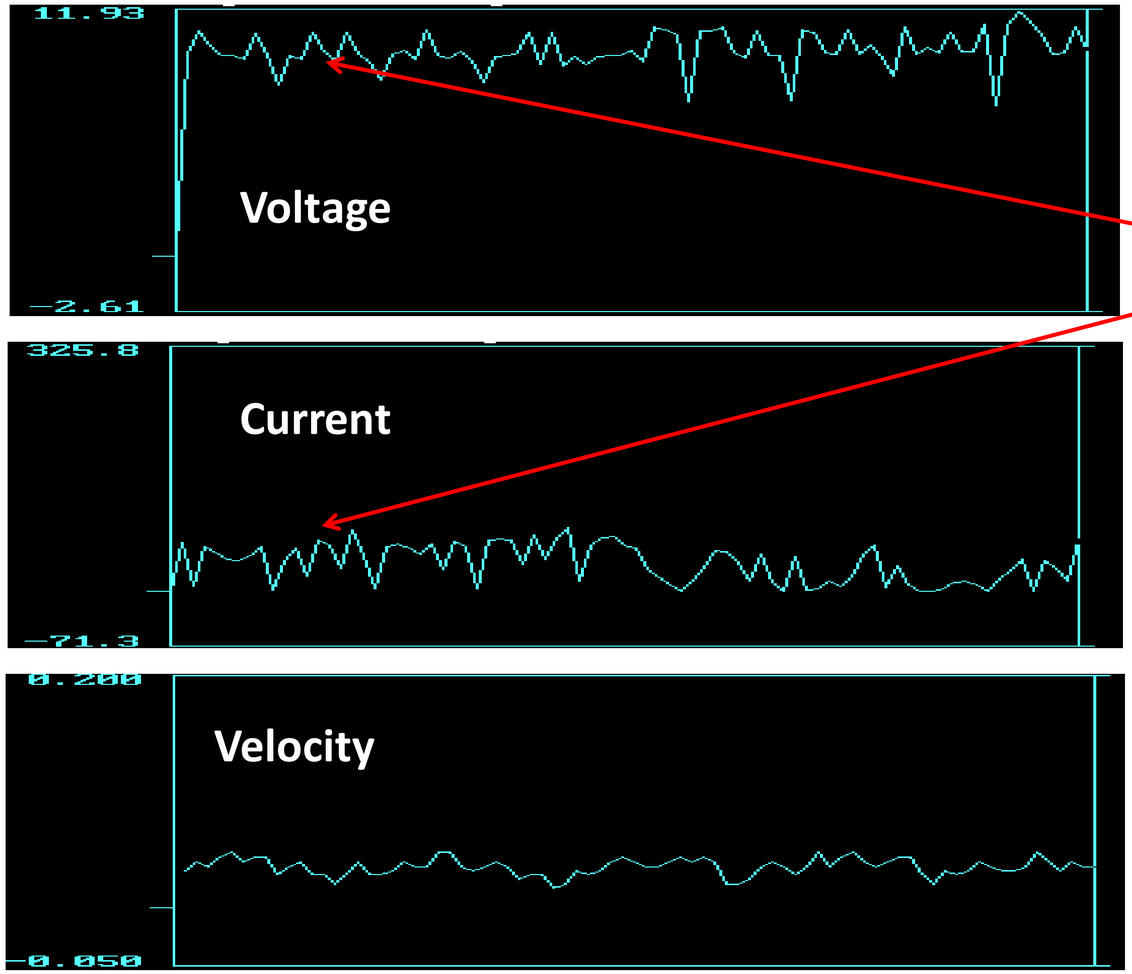
Too slow.

Can’t differentiate loss of slashing from open circuit vs short circuit

— Superior control approach is to detect and correct flashing problem before it becomes visually noticeable.

— Monitoring electrical welding parameters offers faster method of detecting a flashing problem.

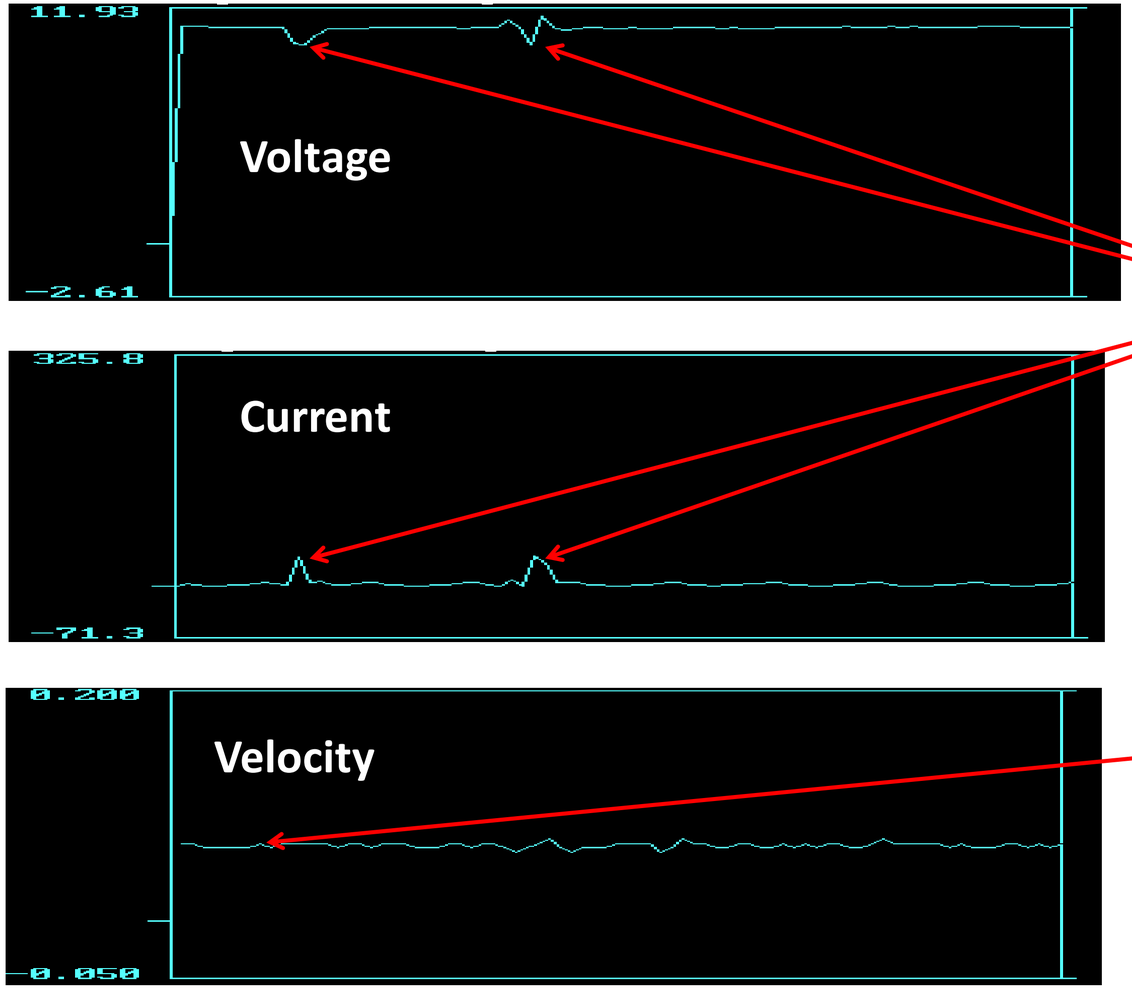
Consistent Intensity Flashing



High frequency of repetitive voltage drops and corresponding fluctuating current spikes means high intensity flashing

Data collected with WeldComputer® Adaptive Control

Loss of flash from electrical circuit opening

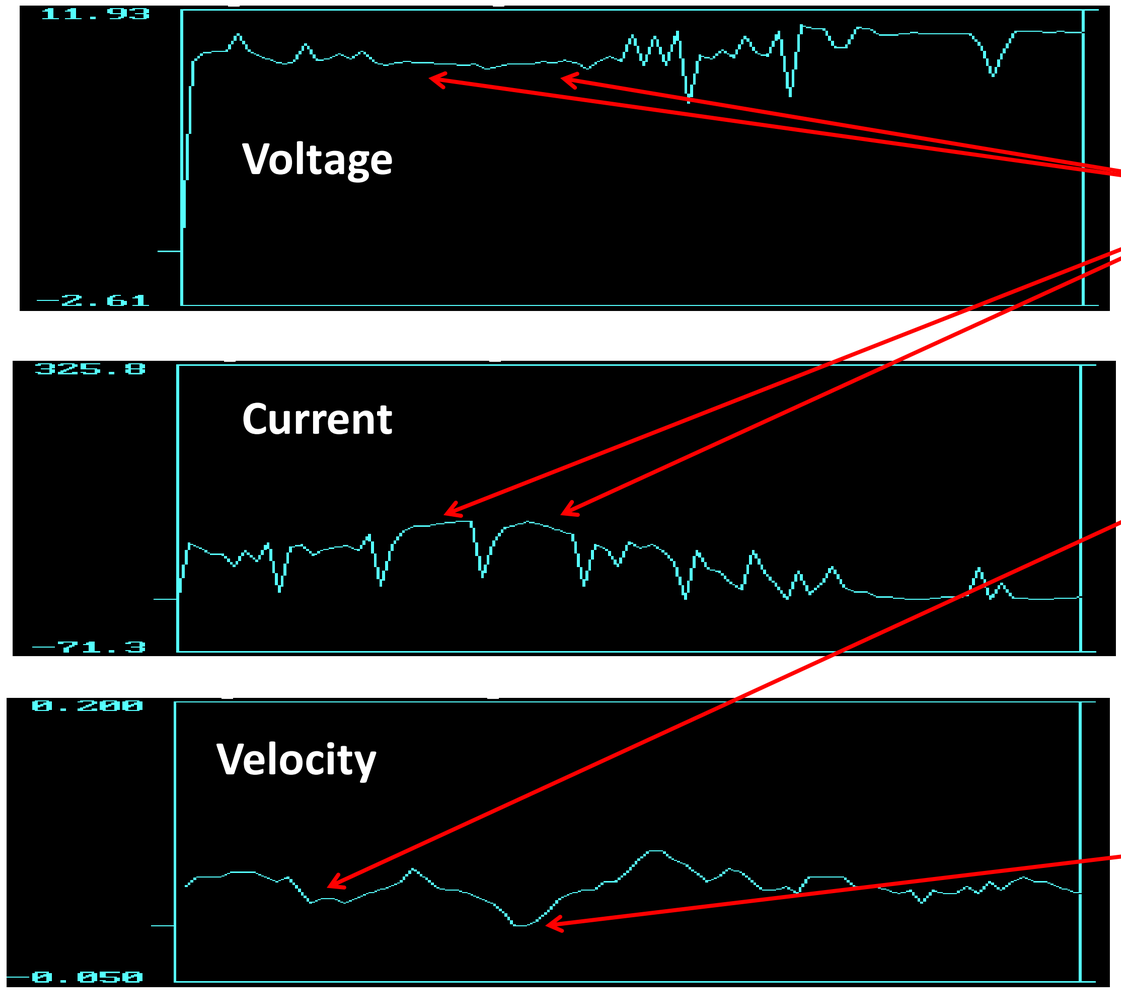


Low frequency of voltage drops and corresponding small current spikes means low intensity flashing

Velocity is too low to maintain intense flashing at present heat setting

Data collected with WeldComputer® Adaptive Control

Loss of flash from electrical circuit shorting



Sustained voltage drop intervals accompanied by sustained high current intervals means loss of flashing from parts causing short circuit

Machine can’t maintain consistent velocity when flashing stops from parts shorting out

Velocity at zero here means machine completely stalled

Data collected with WeldComputer® Adaptive Control

Make consistent flashing intensity for consistent duration

Coordinate duty cycle of applied voltage with feed rate of parts to maintain sustained flashing

Use speed as one of the control parameters when duty cycle control of applied voltage isn’t enough to maintain sustained flashing

Make consistent upset motion pattern

Requires machine capable of producing repeatable motion

Requires machine capable of applying sufficient force to produce a consistent upset motion pattern.

Requires machine capable of clamping parts without slipping.

Monitor Upset Pattern

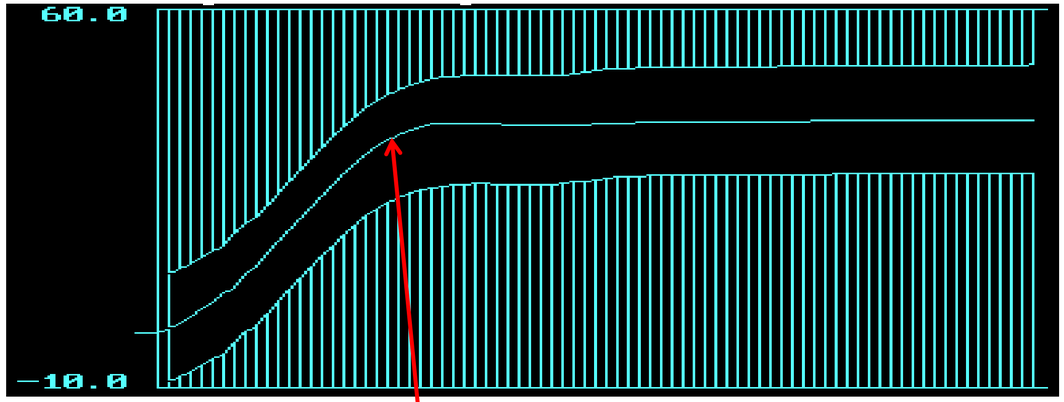
Monitor multiple parameters, position, velocity and force

Monitor the entire profile response

— Measuring final value(s) only after the weld is completed does not detect many problems

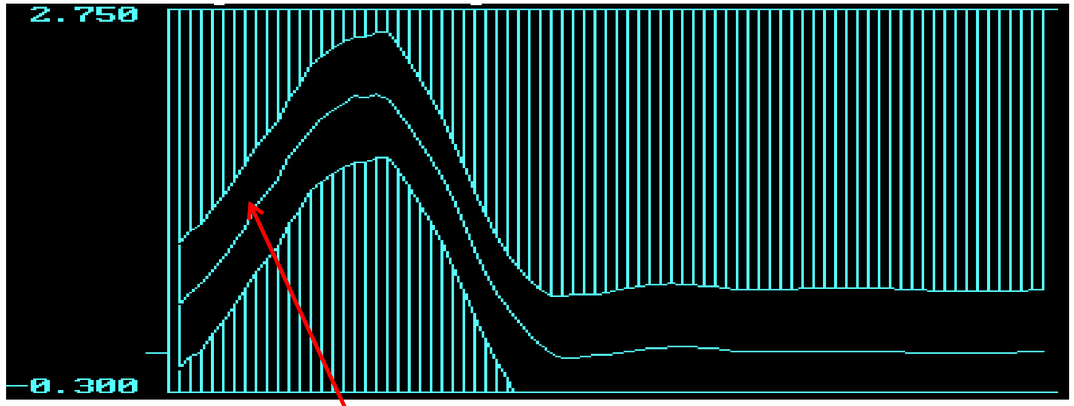
Normal Upset Profile

Upset Position Profile



Final upset position reached within 25ms

Upset Velocity Profile

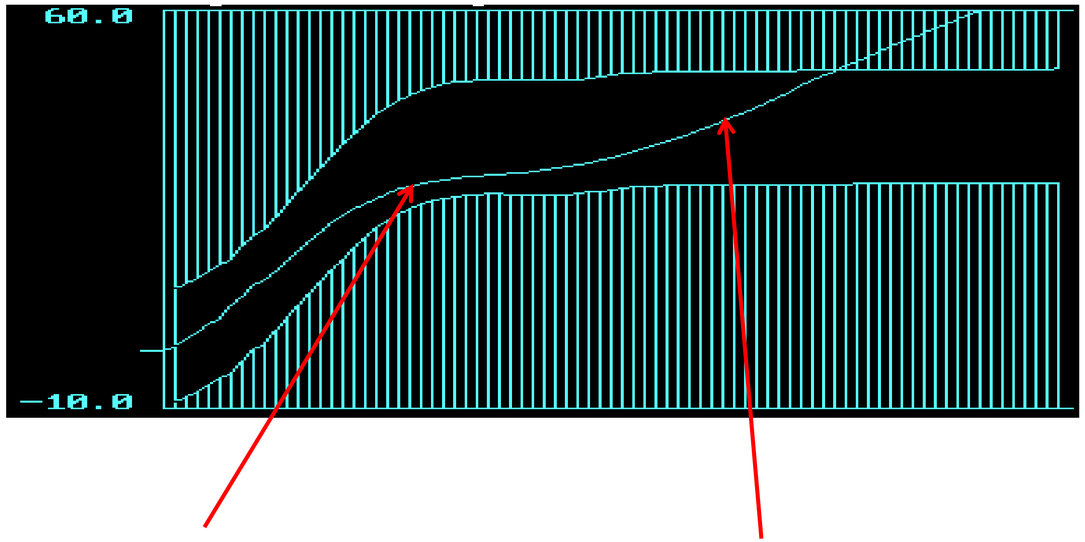


Platens rapidly accelerate parts together

Data collected with WeldComputer® Adaptive Control

Abnormal Upset Profile

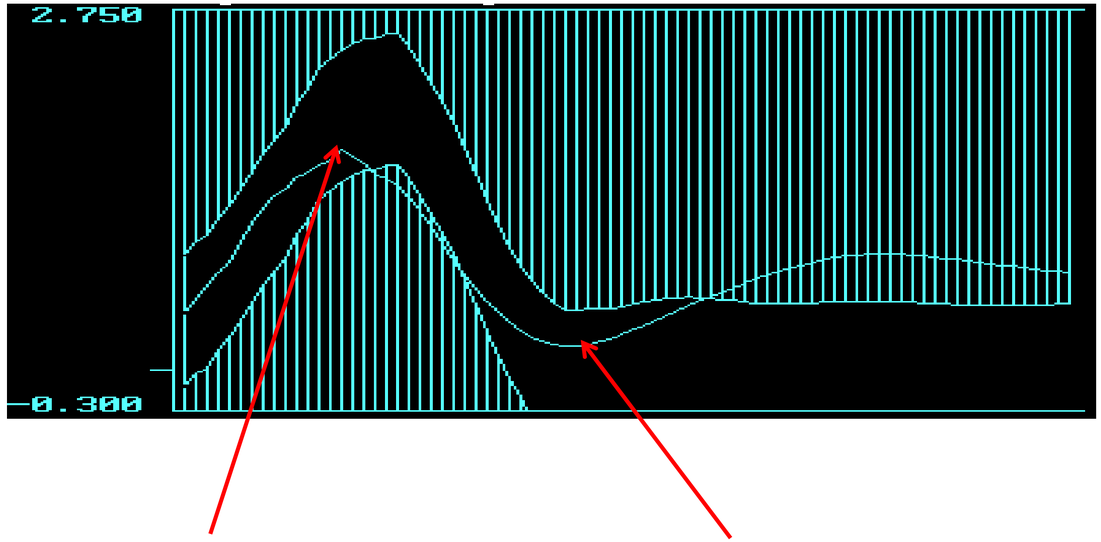
Upset Position Profile



Lower than normal upset occurred at expected end of upset time

Platens keep moving after part starts slipping in jaws

Upset Velocity Profile



Lower than normal peak velocity reached during upset

Part starts to slip in jaws here

Data collected with WeldComputer® Adaptive Control

Many flash welding installations have insufficient power

Undersized welding transformer for the application

Line drops from the power company

Welding transformer saturating during welding

— Saturation reduces flashing capability and increases current demand on power lines.

SCR Controls increase power demand and reduce transformer efficiency

Peak flashing voltage occurring only at peak of each ½ cycle of sinusoidal power line input reduces the flashing capability of the transformer

Using SCR phase shift control to compensate for line drops from power company has little effect on flashing

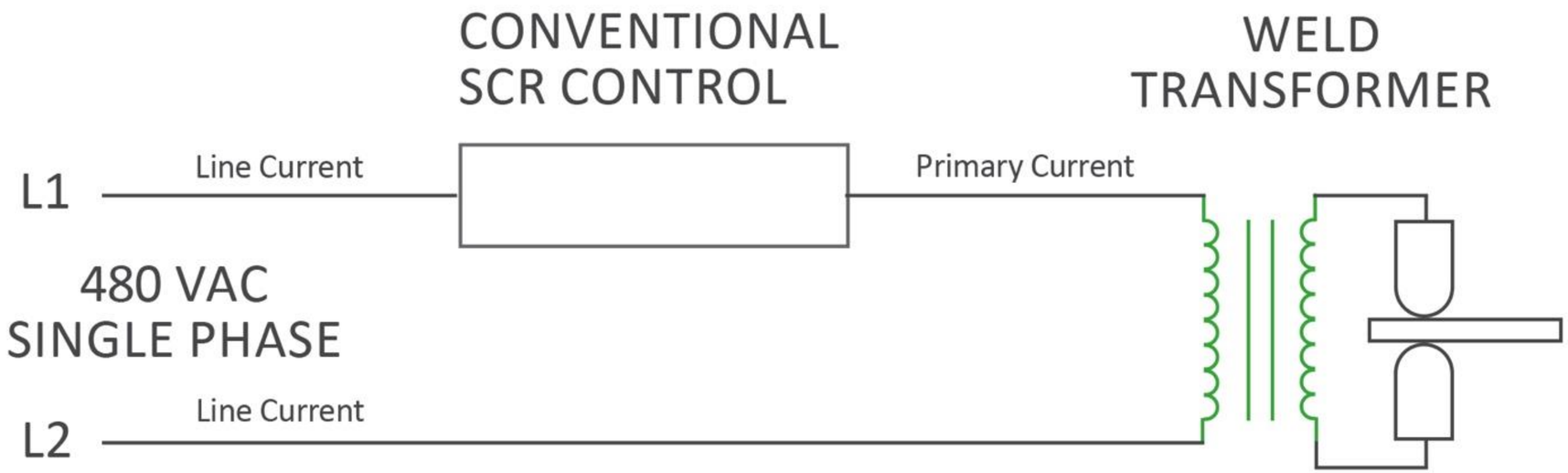
SCR control increases transformer saturation susceptibility

— Random intermittent circuit breaking caused by flashing process contributes to this problem

Capable machine with incapable control (conventional SCR)

Flash Welding

Single Phase Welder with Conventional SCR Control Connected to Single Phase Power Source



Line Current = Primary Current

Inverter controls reduce power demand and increase transformer efficiency

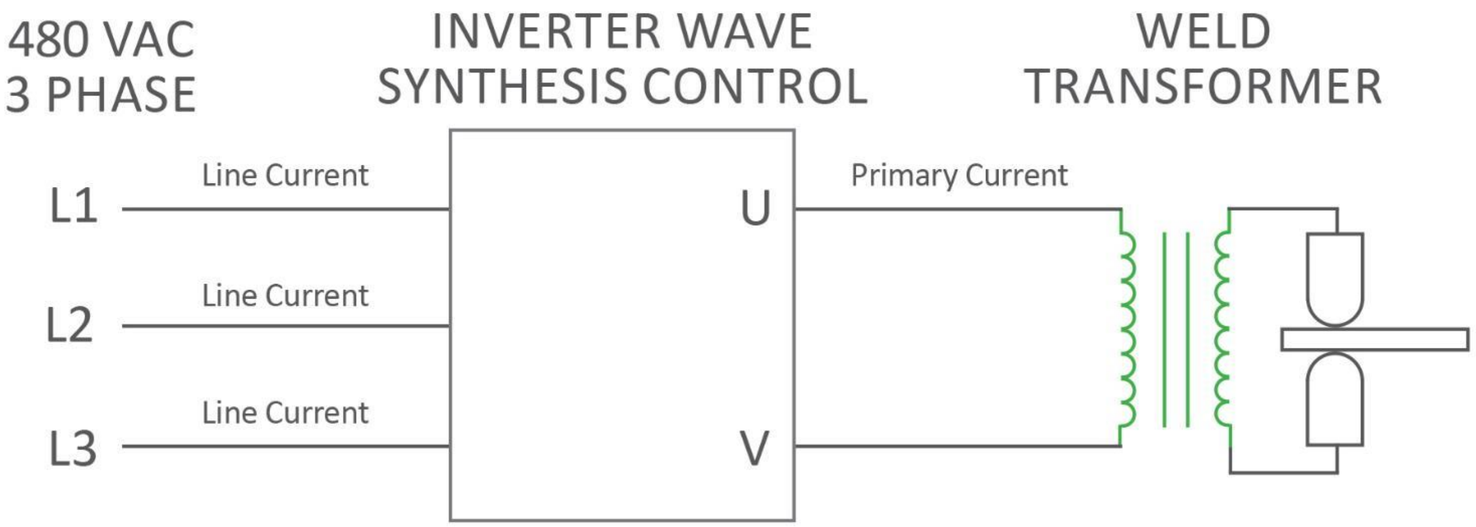
Sustained peak voltage applied to transformer increases flashing capability (compared to same transformer operated with SCR control).

Duty cycle control of applied voltage during flashing compensates for line drops from the power company more effectively than SCR control.

Adaptive control to dynamically balance welding transformer and avoid saturation increases flashing capability and reduces current demand on power lines.

Flash Welding

Single Phase Welder with Inverter Wave Synthesis Control Connected to Three Phase Power Source



Line Current = 0.82* Primary Current

AC transformer vs. MFDC transformer

MFDC magnetizes the machine and the part.

MFDC transformer has diodes on secondary that are susceptible to failure.

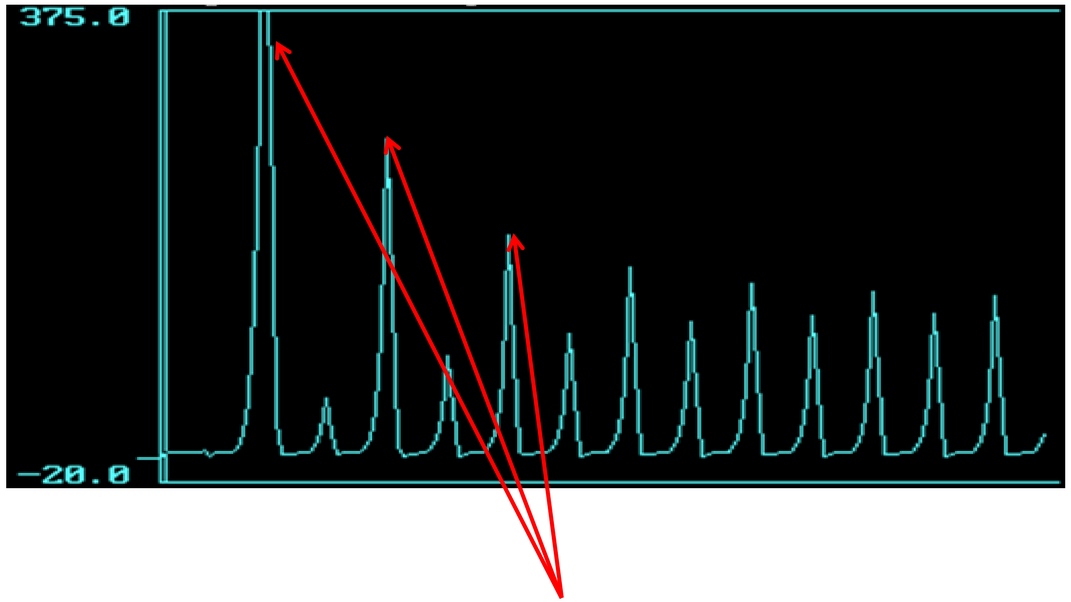
MFDC diode voltage drop reduces capability to initiate flashing compared to AC transformer with same turns ratio.

MFDC transformer is more susceptible to saturation from random intermittent circuit breaking caused by flashing process.

Adaptive control can dynamically balance AC welding transformer and avoid saturation increases flashing capability and reduces current demand on power lines.

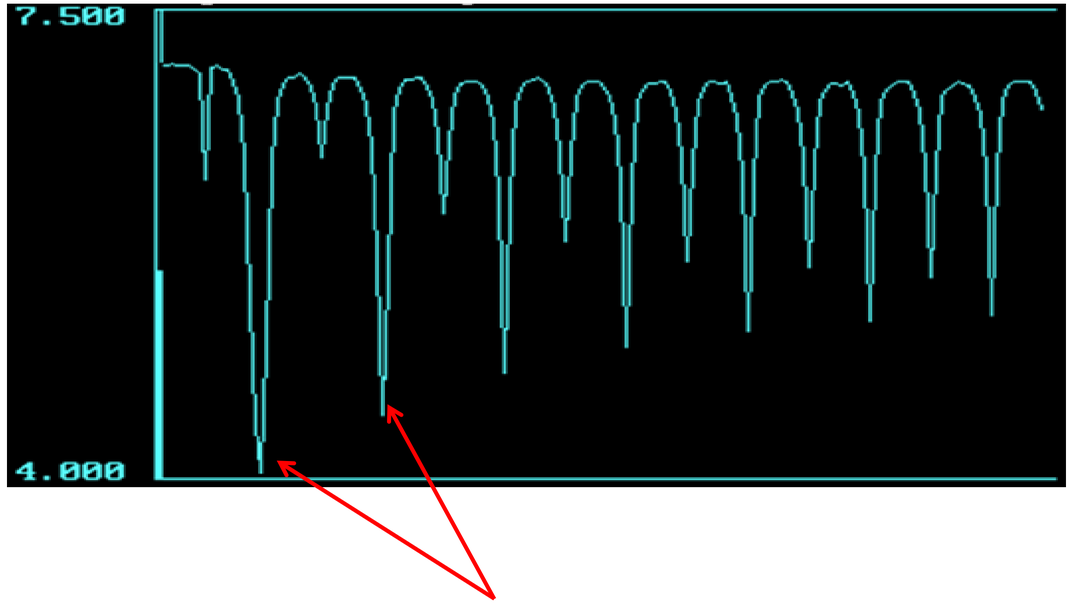
Transformer saturation reduces machine capability while increasing power demand

Primary Current



Transformer saturation causes high current surges on alternating half-cycles of applied heat

Secondary Voltage

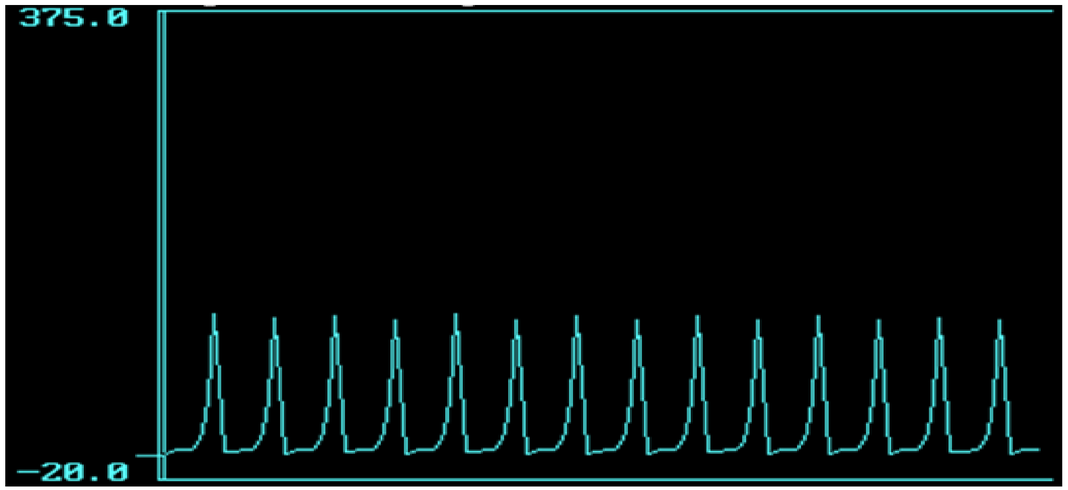


Excessive voltage drop on secondary accompanied by excessive current surge on primary confirms transformer saturation

Data collected with WeldComputer® Adaptive Control

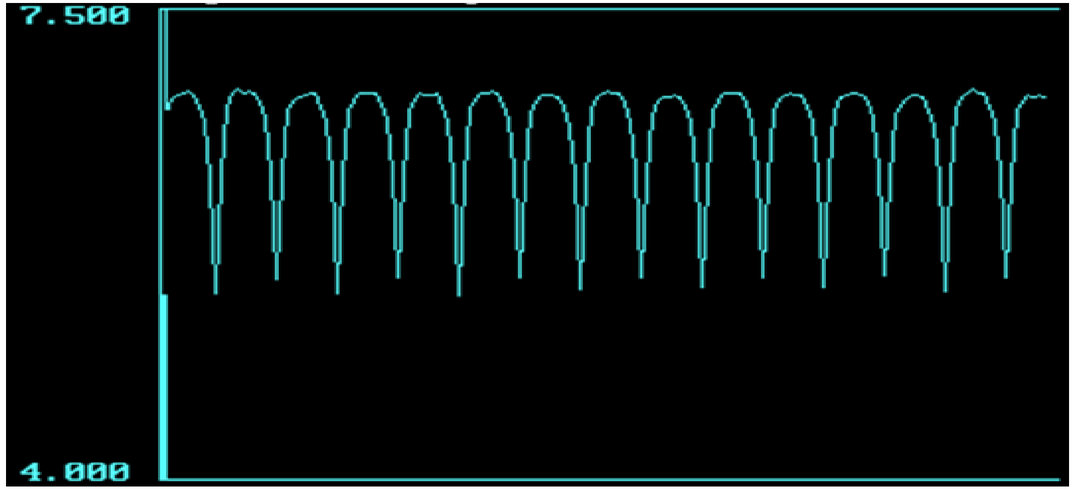
Adaptive control maximizes machine capability While minimizing current demand

Primary Current



Dynamically balancing the transformer avoids saturation and reduces current demand

Secondary Voltage



More efficient transformer operation increases flash capability of machine

Data collected with WeldComputer® Adaptive Control

Southern California Edison (SCE) Report on Flash Welder

Manufacturer was told to stop operating a new flash welder it had installed because of unacceptable power grid drain.

Reason: It "negatively impact(s) the amount of voltage flicker experienced by customers connected to the 12kV system due to this welder" – Patrick C. McConahay, Southern California Edison, Distribution Engineering.

Manufacturer was given permission by SCE to replace existing SCR control with an inverter wave synthesis control operating the same welding transformer, based on conclusion that it would reduce the inrush by at least 18%.

SCE reported that the new control reduced flicker on power grid to allowable limits.

Customer reported measuring only 107 Amps draw on each power line that it previously reported to have 1500A inrush.

Wave synthesis control using 3 phase power to drive single phase AC transformer