RESISTANCE WELDING SCHEDULE DEVELOPMENT

Process Windows & Weld Lobes

By

Bob Szabo

Edited by

Jennifer Szabo

Acknowledgment

Special thanks to Jennifer Szabo, web design; Beth Szabo, layout editor; Letty Szabo, text editor; Brian Bulaw for process capability write-up edit; and to all of the people that we worked with who provided valuable input to this book.

Library of Congress Control Number: 2004092826
ISBN: 0-9749956-2-2

WARNING:

This is a special information book for readers who already have resistance welding experience. Some of the experiments in this book suggest operation of the equipment at elevated weld current, time, or force values as well as short weld gun squeeze and hold times. It is not the intent of this book to describe any equipment provisions or safety provisions including protection from fumes that may be necessary for that operation. The reader should keep that in mind while reading this book. Without suitable provisions, injury and/or equipment damage may occur. An expert such as the original equipment manufacturer should be contacted for that information.

Published by Szabo Publishing
http://www.szabopublishing.com

Table of Contents

Chapter 3 65

WELD STRENGTH VS. WELD SIZE

Chapter 4 93

PROCESS WINDOWS

Appendix 2 213

WELD LOBE FOR CURRENT & TIME

Appendix 3 233

WELD LOBE FOR CURRENT & FORCE

Chapter 1
INTRODUCTION

This book tells how to determine optimum weld schedules for resistance welding. A considerable difference in productivity can exist between resistance welding machines that are operated with optimum weld schedule settings and those that are not. The difference will be discussed throughout this book and become obvious from both quantitative and proposed data.

An introduction to resistance welding is provided first. It is made at this time so that readers from various backgrounds will all have a uniform awareness of the welding process that is discussed throughout the book. **Much of the discussion pertains to spot, seam, and/or projection welding. Some of the discussion applies to other resistance welding processes and is noted in several areas.**

1-1. Resistance welded products

Resistance welding is one of the most frequently used processes in our lives today. We benefit from many products with excellent parts that are resistance welded:

- low cost, reliable automotive body & suspension that provides comfort, attractiveness, and highway protection
- many aircraft seats provide support during take-off, landing, and during bumps from turbulence
- many parts of reliable, high performance turbine engines used in aircraft and power generators
- many sheet metal office furniture and appliance components provided with good strength and appearance
- many sheet metal enclosures such as computer housings hold their contents and function with reliability.

1-2. Poorly welded products

Even though a billion good resistance welds are all around us, some individuals have encountered bad ones. They are observations from over 30 years in this field. While some unfortunate outcomes will be described, they are from oversights rather than the rule. These outcomes are discussed at this time to provide justification for proper resistance welding procedures discussed later in this book. Some examples of poorly welded products that were encountered:

- a gasoline engine air cleaner that fell off the engine from stuck welds
- pneumatic tire rim with an air leak through a cracked weld
- spot welded truck bodies that rattle at higher mileage from broken welds
- automobile fuel tank filler cover that fell off from stuck welds in the hinge
- surface burrs on some spot welded products that could cut skin during washing, handling, or maintenance
- chairs with spot welded seat backs that all fell off from stuck welds
- two high tech., industrial HEPA air cleaners with spot welded air outlet grills that broke loose from stuck welds
- failed engine valves from poor stem-to-head resistance welds.

Weld schedule problem

In these cases, the machinery was poorly maintained and/or improperly setup. One of the key setups is the weld schedule. Where the weld schedule was to blame, then improper weld schedule development was likely done, such as:

- reckless trial and error from a set up crew with inadequate weld schedule development knowledge
- inadequate trial and error with standard weld schedules used instead, rather than custom weld schedule development
- incomplete weld schedule development with inadequate testing
- guessing at weld settings with the outcome not known or adequately tested.

Excessive weld times

Spot weld times of 5 seconds (instead of the original design value of 1/4 sec.) were seen in one application. Spot weld times of shorter than 5 seconds would result in broken welds in this application.

Two weld hits necessary

In another application, a production machine was used to run the parts through it twice, for two separate weld hits. When the parts were run through the machine only once, it produced mostly stuck welds. The second time made better quality. While other problems existed, the weld schedules were never optimized in a procedural manner such as presented in this book. As a result, the cost of running this machine was excessive.

Inadequate trial and error

"Best guess" weld schedules have been seen in applications from furniture to aircraft, with long-term weld reproducibility in production that was completely unknown. Weld schedules were not robust for short or long term production variations in the weld metal or machinery wear. Because of oversights or misunderstandings, weld schedules were never optimized for the application!

Resistance welding is used reliably in the manufacture of certain airplane parts. In one rare occurrence however, resistance weld failures had been reported. It was further reported that an examination of the production machines revealed that optimum weld schedules were never developed. Best guess weld schedules were reported to be used instead. They were reported to work when routine quality tests were done. However, the long-term robustness of the weld schedules & process, to assure component weld strength between quality tests, was never investigated and remained unknown. Production variations such as plant power fluctuations were reported. The weld schedules were also reported to be not durable for these plant power fluctuations.

Big mistakes

In one plant, broken welds occurred in test parts during the setup of weld schedules. Those parts were rejected, however some were mistakenly shipped to the customer. That oversight led to a near plant closing after a major quality audit that resulted from that event.

In one major manufacturing industry, which relies heavily on resistance welding, weld schedule oversights have been encountered throughout the industry. A product warranty manager in this industry reported that resistance welding problems (which include those from weld schedule oversights) are a major cause of product liability expense.

1-3. Weld parameter combination

Weld schedules are a combination of parameters. Weld current, weld time, and weld force are traditional parameters in spot, projection, and seam welding. In most resistance welding applications, these parameters are interactive.

That is:

- weld current can be high if weld time is low
- weld time can be high if weld current is low.

In addition:

- weld current can be high if weld force is high
- weld force can be low if weld time is low.

In a specific application, many different weld schedules are used throughout the industry along with various interactive deviations.

Robust weld schedule

To make a weld schedule more robust, weld parameters can be developed in an organized method to determine the center of the optimum operating range. To do this, each parameter can be developed to the center of its individual operating range. Then, all of them can be combined into an optimum set of parameters. The optimum combination is the most robust. A robust weld schedule will be able to accommodate many different production variables and still produce an adequate window of good welds.

A robust set of parameters will improve the long-term productivity of a resistance welded production part. For example, optimum parameters usually result in the least weld expulsion. The least weld expulsion results in less slag buildup and less deterioration of weld gun components.

This can only be reliably achieved through an organized procedure of weld schedule development and setup on the machine. This book describes the procedure that is used by many experts.

Many weld schedules work OK in short term

Many trial and error combinations of weld schedule parameters may provide good welds during production in the short term. However, often they are not capable of providing good welds in the long term of production, with any plant utility changes, or environmental changes. Long term production has common weld process variables such as electrode wear, dirty metal, common machine fluctuations, utility changes, and others. For example, utility changes are common around resistance welding because of the high electric current demand with this process compared to most other manufacturing processes. When utility changes occur and the weld schedule is marginal, breaking welds can occur.

With inadequate weld schedules that are not tested for any of these variables, especially in combination, problems can arise such as strength variation, stuck (breaking) welds, poor visual appearance, or others.

1-4. Weld schedule developed from process windows and lobes is best for long run

The development of weld schedules from process windows and lobes is a solution in many cases. Process windows and lobes reveal the range of weld schedule parameters that make good welds. Before a description of weld process windows and lobes is made, a description of one of the most successful implementations of them is provided.

Successful example

In a huge stamping and spot / projection welding plant, the author's company was contracted to develop weld process windows and lobes for each metal combination in the plant. This facility did upwards of five million spot welds per day. Although many welds in many different parts were produced in the plant, a smaller number of common metal combinations occurred in the plant.

In this contract, every weld was characterized by its metal combination (thickness, alloy, and coating). Of the 5 million welds done