

**RESISTANCE WELDING
SCHEDULE DEVELOPMENT**
Process Windows & Weld Lobes

By
Bob Szabo

Edited by
Jennifer Szabo

Copyright © 2004, by Bob Szabo

All Rights Reserved

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

No part of this publication can be reproduced in any way, shape, or form, copied, or distributed as electronic media, or any other form of reproduction without the express, written permission of Szabo Publishing. International copyright protection is provided for this publication by existing treaties between the US and most countries throughout the world. The Copyright Act imposes severe financial liability and penalties on the infringer.

WARNING:

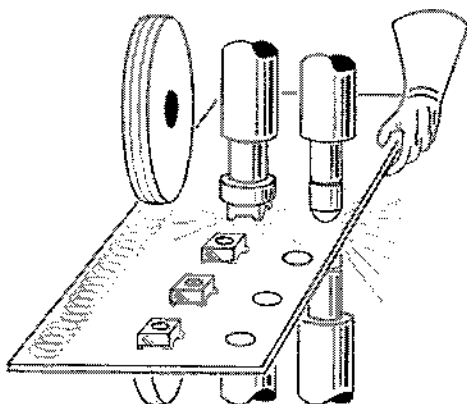
This is a special information book for readers who already have resistance welding experience. Some of the experiments in this book suggest operation of the equipment at elevated weld current, time, or force values as well as short weld gun squeeze and hold times. It is not the intent of this book to 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>

Check out our book:

“Resistance Welding Safety for Operators”

- **Unique & comprehensive single source** about operator safety around resistance welding
- About welding fumes, pinch point protection, electrical shock protection, exposure to magnetic fields, and heart defibrillators or pacemakers around welding
- **Much of this info. not available in any other written sources**
- For resistance welding operators, maintenance, supervisors, engineers, consultants, contractors, & equip. builders
- Applicable to small, medium, & large production facilities, machine & automation builders, component suppliers, job shops, R & D facilities, education, library, gov., & info. facilities
- For resistance spot, seam, & projection welding for industrial metal
- Info. also provided for other resistance welding processes: bench welding, flash, upset, & butt welding
- Narratives from real life experiences show the benefits of good practices & perils of poor practices
- Written in both technical & layman terms
- Based on industry specs., standards, & work practices.



Available for purchase world wide through our web site:

<http://www.szabopublishing.com>

Keep an eye on our web site for future publications.

Table of Contents

Chapter 1	25
INTRODUCTION	
1-1. Resistance welded products	25
1-2. Poorly welded products	26
Weld schedule problem	27
Excessive weld times	27
Two weld hits necessary	27
Inadequate trial and error	27
Big mistakes	28
1-3. Weld parameter combination	28
Robust weld schedule	29
Many weld schedules work OK in short term	29
1-4. Weld schedule developed from process windows and lobes is best for long run	30
Successful example	30
Case for organized development	31
Only one setting to adjust on all machines	31
1-5. Justification	32

1-6. Process windows introduction	32
1-7. Weld lobes introduction	33
Weld lobes for different parameters	35
Weld lobes for three parameters	36
Middle of volume reveals optimum combination	37
1-8. History	38
Early introduction to the development of weld schedules from weld process windows and lobes	38
Industry examples	38
Further discussion of the savings	39
Savings estimate stands up	40
Cheaper the first time	40

Chapter 2 **41**

BACKGROUND

2-1. Why weld lobes and process windows	41
Misleading visual indications on weld surface	42
2-2. Weld metallographs	42
2-3. Adjustment for visual appearance	44
Problem with visual appearance	44
Spreading a habit	44
No color with aluminum or titanium	45
2-4. Automatic or semi-automatic control	45
2-5. Visual inspection in arc welding	45
2-6. Resistance weld testing for hidden weld characteristics	46
Repeatability is necessary	46
2-7. The weld schedule	47
2-8. Other resistance welding processes	48
% heat setting weld controls	48

TABLE OF CONTENTS

vii

Constant current weld controls	49
Settings that affect the outcome	49
2-9. Standard weld schedule for resistance welding	49
2-10. Experiment: Weld schedule selection	50
2-10.1. Purpose	50
2-10.2. Resources	50
2-10.3. Procedure	50
2-10.4. Results	51
2-10.5. Conclusion	51
2-11. Need for a custom weld schedule	52
Resistance welding behavior	53
Some minimum amount of a parameter necessary	53
The solution	53
2-12. Complicating factors	54
Shunting	54
Metal thickness ratios	54
Polarity	55
Other complications	55
2-13. The weld schedule developer	56
Technician #1	56
Machine standards allowed for his behavior	56
His behavior limited	57
Technician #2	57
2-14. Robust weld settings	57
Example of what is not robust	58
2-15. Weld schedule development environment	59
2-16. Need for a procedure	60
2-17. Need for written records	60
Without written records	61
Hidden benefit from written records	61
Three days wasted	61
2-18. Repair weld facilities	62
Repair weld process control oversight	62

Chapter 3**65****WELD STRENGTH VS. WELD SIZE**

3-1. Why measure weld size	65
3-2. Weld size/strength relationship	65
3-3. Maximum strength	68
3-4. Process capability study	69
When size does not assure strength	69
Introduction to experiments	69
3-5. Experiment: Weld strength and size relationship in mild steel	70
3-5.1. Purpose	70
3-5.2. Resources	70
3-5.3. Procedure	70
3-5.4. Results	72
3-5.5. Discussion	72
Column 1: % heat	72
Column 2 & 3: test & failure mode	73
Column 4 & 5: shear strength pounds & kilograms	73
Column 6 & 7: nugget diameter inches & millimeters	73
General conclusions	73
3-5.6. Results: Strength vs. size	74
3-5.7. Discussion	74
3-5.8. Results: Weld nugget size vs. % heat	75
3-5.9. Discussion	75
Not a trivial problem	76
3-5.10. Recommendations for further experimentation	76
Note 1: problem with high % heat	77
Note 2: problem with raising tap	77
Note 3: value of this method is shown	77
Note 4: problem from inadequate written records	78

TABLE OF CONTENTS

ix

3-6. Experiment: Weld strength and size relationship in one aluminum application	78
3-6.1. Purpose	78
3-6.2. Resources	78
3-6.3. Procedure	79
3-6.4. Results	80
3-6.5. Discussion	80
3-6.6. Results: Weld nugget size vs. strength	81
3-6.7. Discussion	81
3-6.8. Results: Weld % heat vs. shear strength	82
3-6.9. Discussion	82
Aluminum surface preparation problem	82
Recommended aluminum surface preparation	83
Inadequate amount of data	83
However data was adequate for the conclusion!	83
3-6.10. Recommended additional exp.	84
Note 1: number of data points	84
Note 2: conclusions about aluminum resistance welding from this experiment should be limited	84
Note 3: limitations from absence of rec.	85
Note 4: even experiments with problems should be reported	85
Conclusions from both experiments	86
Typical experiment size	86
3-7. Weld size and strength data from US Government Military Specification Mil-W-6858D	88
Effect of metal strength on the weld strength requirement	89
Sources for weld strength and size data	89

TABLE OF CONTENTS

xi

4-11. <u>Weld time</u> process window	103
Benefits of longer weld time	104
4-12. <u>Hold time</u> process windows	105
Weld valve mechanical delay note	106
Perils of long hold time	106
4-13. <u>Electrode force</u> process window	108
4-14. Process window summary	109
4-15. Experiment: Weld current and time windows	110
4-15.1. Performance objective	110
Develop weld current and time windows for optimum welding	110
4-15.2. Resources	110
4-15.3. Weld current window procedure	110
4-15.4. Weld current window data	111
4-15.5. Weld time window procedure	111
4-15.6. Weld time window data	112
4-15.7. Conclusion	112
4-15.8. Recommendations	112
Added weld sample tests	113
Added experimental goals	113

Chapter 5

115

WELD LOBES

5-1. Weld lobe introduction	115
Lobe determines the center	115
5-2. Weld current range	116
5-3. Weld time range	117
5-4. Weld lobe for <u>current and time</u>	117
5-5. When to start with a current and time lobe	118
5-6. About the shape of a lobe	119
5-7. Experiment: Weld lobe for current & time	119

xii RESISTANCE WELD SCHEDULE DEVELOPMENT

5-7.1. Performance objective	119
5-7.2. Resources	120
5-7.3. Weld current and time lobe procedure	120
5-7.4. Weld current and time lobe data	121
5-7.5. Weld current and time lobe result	122

Chapter 6 123

WELD FORCE LOBES

6-1. Introduction	123
6-2. Weld <u>current and force</u> lobe	123
6-3. Why current and force lobe development	123
A case for current and force lobe first	124
6-4. Note: look at slope, pulsation, ...	124
6-5. Note: assumption of best electrodes	124
6-6. Note: assumption of the best resistance	
welding process	125
6-7. The lobe gets to the answer quickly	125
Weld lobe development cuts to the chase	
real fast	125
6-8. Some cases that do not work	125
Process window and lobe experiments analytically	
sort out conclusions: good or bad	126
6-9. Back to the current and force lobe	126
6-10. The chart	127
6-11. Discussion for weld current & force	
lobe result	127
Good welds	128
Bad welds	128
Cold welds	128
Hot welds	128
6-12. Weld <u>force and time lobe</u>	128
A case for weld force and time lobe first	128
6-13. Back to the force and time lobe	129

TABLE OF CONTENTS

xiii

6-14. The chart	129
6-15. Discussion for weld force and time lobe	130
Good weld	130
Bad weld	130
Cold welds	130
Hot welds	130
6-16. Summary	131
6-17. Weld lobe procedure (for optimum weld size with no expulsion)	132
Resources:	132
Machine setup:	132
Complicating factors:	133
Current window:	133
Weld time window:	134
Plot data:	134
Force lobe:	134
6-18. Experiment: Weld lobe for current and force	135
6-18.1. Performance objective	135
6-18.2. Resources (same as Experiment 5-7)	135
6-18.3. Weld current and force lobe procedure	136
6-18.4. Weld current and force lobe data	136
6-18.5. Weld current and force lobe results	137
6-18.6. Conclusion	137

Chapter 7 **139**

WELD SCHEDULE EXAMPLE DEVELOPED FROM WELD LOBES

7-1. The setup	139
7-2. Seasoned electrodes	141
7-3. Worn electrode condition setup	141
Electrode life observation	141

xiv **RESISTANCE WELD SCHEDULE DEVELOPMENT**

Worn electrodes from factory production	
did not work for simulation	142
Worn condition confirmation	142
Electrode parallelism check	143
7-4. The weld schedule chart	143
7-4.1. Weld schedules for bare & electroplate	
<i>galvanized Steel</i>	144
7-5. Complicating factors	146
For example	147
7-6. Use of the values	148
The alternative	148

Chapter 8 **149**

PROCESS WINDOWS FOR OTHER SETTINGS

8-1. Introduction	149
8-2. <u>Upslope</u>	149
Benefits of low starting heat	150
Summary recommendation	151
About the shape of a lobe	151
Theoretical effect of upslope on the weld	
lobe process window	151
Caution with some weld equipment	152
Caution for certain aluminum materials and	153
other materials that may be slope sensitive	153
Note: sometimes slope without choice	153
8-3. <u>Pulsation</u>	154
Typical pulsation weld schedule	154
Theoretical effect of pulsation on	154
the weld lobe process window	154
Why go to the trouble	155
Automobile wheel weld impulse schedule	155
Impulse schedule for steel wheel welding	156
Narrow flange width welding	156

TABLE OF CONTENTS

xv

Pulsation equipment warning	156
8-4. <u>Decay or temper</u> current	157
Theoretical current decay lobe in aluminum	157
Summary decay current tip	158
Other decay or temper studies	159
8-5. <u>Stepper lobe</u> for spot welding	159
Problem	159
One solution	160
Advanced stepping of weld time and/or force	162
8-6. Current vs. force lobe results for bad fitting parts	163
Test simulation for poorly fitting alum. parts	163
Use of electrically insulated shim	163
8-7. Experiment: Stepper lobe for current & weld count	164
8-7.1. Performance objective	164
8-7.2. Resources	164
8-7.3. Stepper lobe procedure	165
8-7.4. Stepper lobe data	166
8-7.5. Weld current vs. count lobe results	167
8-7.6. Conclusion	167
8-8. Experiment: Adjacent welds supplement	167
8-8.1. Performance objective	167
8-8.2. Procedure	168
8-8.3. Data for second weld	168
8-8.4. Results	168
8-8.5. Discussion	169
Repeated for many applications in one facility	171
Adjacent weld tip	171
Remaining work	171

Appendix 1**191**PROCESS WINDOWS FOR WELD
CURRENT & TIME

A1-1. Purpose:	191
A1-2. Performance objective:	191
A1-3. Resources:	192
A1-4. <u>Weld current window</u> procedure:	193
A1-5. Weld current window data:	195
A1-6. Weld current window result:	196
A1-7. Current window conclusion:	197
A1-8. <u>Weld time window</u> procedure:	198
A1-9. Weld time window data:	198
A1-10. Weld time window result:	199
A1-11. Time window conclusion:	200
A1-12. Process window robustness conclusion:	201
A1-13. Discussion:	202
A1-14. Additional data page for further process window tests:	204
WELDING APPLICATION:	204
A1-15. Additional data page ... WELD CURRENT WINDOW DATA:	205
A1-16. Additional data page ... WELD CURRENT WINDOW RESULT:	206
A1-17. Additional data page ... WELD TIME WINDOW DATA:	207
A1-18. Additional data page ... WELD TIME WINDOW RESULT:	208
WELD TIME WINDOW CONCLUSION:	208

Appendix 2 **213**

WELD LOBE FOR CURRENT & TIME

A2-1. Purpose:	213
A2-2. Performance objective:	213
A2-2.1. Process window / lobe comparison	213
A2-3. Resources:	214
A2-4. <u>Weld current</u> lobe procedure:	215
A2-5. Weld current lobe data:	217
A2-6. Weld current lobe result:	218
A2-7. Weld current lobe conclusion:	219
A2-8. <u>Weld time</u> lobe procedure:	220
A2-9. Weld time lobe data:	220
A2-10. Weld time lobe data result:	221
A2-11. Weld time lobe conclusion:	222
A2-12. Weld lobe robustness conclusion:	223
A2-13. Discussion:	224
A2-14. Additional data page for further weld current / time lobe experimental tests:	
WELDING APPLICATION:	226
A2-15. Additional data page ... WELD LOBE DATA:	227
A2-16. Additional data page ... WELD LOBE CHART RESULT:	228
A2-17. Additional data page ... WELD LOBE CONCLUSION:	229

Appendix 3**233****WELD LOBE FOR CURRENT & FORCE**

A3-1. Purpose:	233
A3-2. Performance objective:	233
A3-2.1. Weld current / time & current / force lobe comparison:	234
A3-3. Resources:	234
A3-4. <u>Weld current</u> lobe procedure:	236
A3-5. Weld current lobe data:	238
A3-6. Weld current lobe result:	239
A3-7. Weld current lobe conclusion:	240
A3-8. <u>Weld force</u> lobe procedure:	241
A3-9. Weld force lobe data:	241
A3-10. Weld force lobe result:	242
A3-11. Weld force lobe conclusion:	243
A3-12. Weld lobe robustness conclusion:	244
A3-13. Discussion:	245
A3-14. Additional data page for further weld current / force lobe experimental tests:	
WELDING APPLICATION:	247
A3-15. Additional data page ... WELD LOBE DATA:	248
A3-16. Additional data page ... WELD LOBE CHART RESULT:	249
A3-17. Additional data page ... WELD CUR. / FORCE LOBE CONCLUSION:	250

Appendix 4 255

WELD LOBE FOR TIME & FORCE

A4-1. Purpose:	255
A4-2. Performance objective:	255
A4-2.1. Weld current / force & time / force lobe comparison:	256
A4-3. Resources:	256
A4-4. <u>Weld time</u> lobe procedure:	258
A4-5. Weld time lobe data:	260
A4-6. Weld time lobe result:	261
A4-8. Weld time lobe conclusion:	262
A4-9. <u>Weld force</u> lobe procedure:	263
A4-10. Weld force lobe data:	264
A4-11. Weld force lobe result:	265
A4-12. Weld force / time lobe conclusion:	266
A4-13. Weld lobe robustness conclusion:	267
A4-14. Discussion:	268
A4-15. Additional data page for further weld time / force lobe experimental tests:	270
WELDING APPLICATION:	270
A4-16. Additional data page ... WELD LOBE DATA:	271
A4-17. Additional data page ... WELD LOBE CHART RESULT:	272
A4-15. Additional data page ... WELD TIME / FORCE LOBE CONCLUSION:	273

Appendix 5**277****STEPPER LOBE FOR CURRENT BOOST &
WELD COUNT AND ELECTRODE
LIFE DETERMINATION**

A5-1. Purpose:	277
A5-2. Performance objective:	278
A5-2.1. Previous lobes compared to weld current / count lobe:	278
A5-3. Resources:	279
A5-4. Stepper lobe procedure:	281
A5-5. Procedure for <u>current</u> process window:	282
A5-6. Weld current process window data:	283
A5-7. Optional stepper lobe procedure for brand new electrodes:	284
A5-8. Optional weld current process window data for brand new electrodes:	285
A5-9. Procedure for <u>weld count</u> process window:	286
A5-10. Weld count process window data summary:	288
A5-11. Stepper lobe chart result:	289
A5-12. Weld current boost vs. weld count	289
A5-13. Conclusion:	290
A5-14. Weld count process window data:	291
A5-15. Discussion:	292
Other electrode information revealed	292
Repeated welding may tilt the electrode faces	292
Electrode cooling issue	293
Other important observations	293
Check results with production	293

xxii RESISTANCE WELD SCHEDULE DEVELOPMENT

A5-16. Additional data page for further weld current / count stepper lobe experimental tests: WELDING APPLICATION:	295
A5-17. Additional data page ... WELD CUR. PROCESS WINDOW DATA:	296
A5-18. Additional data page ... WELD COUNT PROCESS WINDOW DATA:	297
A5-19. Additional data page ... STEPPER LOBE CHART RESULT:	298
A5-20. Additional data page ... STEPPER LOBE CONCLUSION:	299

Appendix 6 303

STEPPER LOBE FOR CURRENT BOOST & WELD COUNT

A6-1. Purpose:	303
A6-2. Performance objective:	304
A6-2.1. Previous stepper lobe compared to this stepper lobe	304
A6-3. Resources:	304
A6-4. Stepper lobe procedure for new electrodes:	308
A6-6. <u>Weld current</u> process window data:	310
A6-7. Optional stepper lobe procedure for first hit on brand new electrodes:	311
A6-8. Optional weld current process window data for first hit on brand new electrodes:	312
A6-9. <u>Stepper lobe</u> procedure for worn electrodes:	313
A6-10. Conclusion:	315
A6-10.1. Stepper lobe graph result:	315

TABLE OF CONTENTS

xxiii

A6-11. Conclusion:	316
A6-12. Discussion:	316
A6-13. Additional data page for further weld current / count stepper lobe experimental tests:	
WELDING APPLICATION:	317
A6-16. Additional data page ... WELD CUR. PROCESS WINDOW DATA:	320
A6-17. Additional data page ... STEPPER LOBE CHART RESULT:	321
A6-18. Additional data page ... STEPPER LOBE CONCLUSION:	322

Appendix 7 SHUNTING	327
-------------------------------	------------

Appendix 8 POLARITY	331
-------------------------------	------------

Appendix 9 WELD FORCE	339
---------------------------------	------------

Equations for Conversion	347
---------------------------------	------------

Glossary of Terms	349
--------------------------	------------

References for Resistance Weld Sched. Info.	363
--	------------

About the Author	369
-------------------------	------------

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:

1-26 RESISTANCE WELD SCHEDULE DEVELOPMENT

- 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

1-28 RESISTANCE WELD SCHEDULE DEVELOPMENT

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,

1-30 RESISTANCE WELD SCHEDULE DEVELOPMENT

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

Buy this book
from
T. J. Snow Company

insidesales@tjsnow.com

(423) 894-6234