RESISTANCE WELDING
SCHEDULE DEVELOPMENT
Process Windows & Weld Lobes

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Edited by
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Acknowledgments

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

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- Written in both technical & layman terms
- Based on industry specs., standards, & work practices.

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Table of Contents

Chapter 1
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
RESISTANCE WELD SCHEDULE DEVELOPMENT

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 BACKGROUND 41

2-1. Why weld lobes and process windows Misleading visual indications on weld surface 41 42
2-2. Weld metallographs 42
2-3. Adjustment for visual appearance
   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
   Repeatability is necessary 46
2-7. The weld schedule 47
2-8. Other resistance welding processes
   % heat setting weld controls 48
TABLE OF CONTENTS

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
WELD STRENGTH VS. WELD SIZE

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

4-1. Process window introduction
   Common example
4-2. Weld % heat and weld current
   Tip-off: weld % heat not absolute
   Limitation of weld % heat process window
4-3. Other weld characteristics goals
   Process window goals
   Electrode sticking
4-4. Fragile weld schedules
4-5. Preliminary review
4-6. Squeeze time process window
   Squeeze time periods
4-7. Shift-to-shift variation
   During second shift
   During first shift
   Remedy
   Common problem
   Solution discussion
4-8. Undersized air supply components
4-9. Pressure switch initiation
   Another way for pressure switch utilization
4-10. Weld current process window
TABLE OF CONTENTS

4-11. Weld time process window 103
    Benefits of longer weld time 104
4-12. Hold time process windows 105
    Weld valve mechanical delay note 106
    Perils of long hold time 106
4-13. Electrode force 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 current and time 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
Chapter 6
WELD FORCE LOBES

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

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
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 galvanized Steel 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. Upslope 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 other materials that may be slope sensitive 153
    Note: sometimes slope without choice 153
8-3. Pulsation 154
    Typical pulsation weld schedule 154
    Theoretical effect of pulsation on 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

Pulsation equipment warning 156

8-4. Decay or temper current 157
   Theoretical current decay lobe in aluminum 157
   Summary decay current tip 158
   Other decay or temper studies 159

8-5. Stepper lobe 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 163
   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
Chapter 9
EXPANDING PROCESS WINDOWS and LOBES

9-1. List of process windows that can be developed 173
   Section summary 174
9-2. List of weld lobes that can be developed 175
9-3. List of weld characteristics to be indicated on a weld lobe chart 176
   Section summary 177
9-4. Three dimensional weld lobes 178
   Expanding the value of the experiment 178
9-5. Advanced experimental tools 179
9-6. Long weld time example 179
9-7. Avoid blindness from experimental plan 180
9-8. Design of Experiments 180
   Not a substitute for the basics 181
9-9. Other applications 182
   Other manufacturing processes 182
9-10. Conclusion 183
   Resistance welding benefits, successful in certain large industries, are available to other industries 183
   About the Appendix 184

Appendices 185

Appendix 187
Introduction

Safety and equipment limitation warning 188
Experimental limitations 189
Weld quality definition limitation 189
Final technical information 189
TABLE OF CONTENTS

Appendix 1

PROCESS WINDOWS FOR WELD CURRENT & TIME

A1-1. Purpose: 191
A1-5. Weld current window data: 195
A1-6. Weld current window result: 196
A1-8. Weld time window procedure: 198
A1-9. Weld time window data: 198
A1-10. Weld time window result: 199
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
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. Weld current 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. Weld time 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: 225
WELDING APPLICATION: ........................................ 226
A2-15. Additional data page ... ................................. 227
WELD LOBE DATA: ................................................... 227
A2-16. Additional data page ... ................................. 228
WELD LOBE CHART RESULT: ...................................... 228
A2-17. Additional data page ... ................................. 229
WELD LOBE CONCLUSION: ......................................... 229
# TABLE OF CONTENTS

## Appendix 3

### WELD LOBE FOR CURRENT & FORCE

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A3-1.</td>
<td>Purpose:</td>
<td>233</td>
</tr>
<tr>
<td>A3-2.</td>
<td>Performance objective:</td>
<td>233</td>
</tr>
<tr>
<td>A3-2.1.</td>
<td>Weld current / time &amp; current / force lobe comparison:</td>
<td>234</td>
</tr>
<tr>
<td>A3-3.</td>
<td>Resources:</td>
<td>234</td>
</tr>
<tr>
<td>A3-4.</td>
<td>Weld current lobe procedure:</td>
<td>236</td>
</tr>
<tr>
<td>A3-5.</td>
<td>Weld current lobe data:</td>
<td>238</td>
</tr>
<tr>
<td>A3-6.</td>
<td>Weld current lobe result:</td>
<td>239</td>
</tr>
<tr>
<td>A3-7.</td>
<td>Weld current lobe conclusion:</td>
<td>240</td>
</tr>
<tr>
<td>A3-8.</td>
<td>Weld force lobe procedure:</td>
<td>241</td>
</tr>
<tr>
<td>A3-9.</td>
<td>Weld force lobe data:</td>
<td>241</td>
</tr>
<tr>
<td>A3-10.</td>
<td>Weld force lobe result:</td>
<td>242</td>
</tr>
<tr>
<td>A3-11.</td>
<td>Weld force lobe conclusion:</td>
<td>243</td>
</tr>
<tr>
<td>A3-12.</td>
<td>Weld lobe robustness conclusion:</td>
<td>244</td>
</tr>
<tr>
<td>A3-13.</td>
<td>Discussion:</td>
<td>245</td>
</tr>
<tr>
<td>A3-15.</td>
<td>Additional data page ... WELD LOBE DATA:</td>
<td>248</td>
</tr>
<tr>
<td>A3-16.</td>
<td>Additional data page ... WELD LOBE CHART RESULT:</td>
<td>249</td>
</tr>
<tr>
<td>A3-17.</td>
<td>Additional data page ... WELD CUR. / FORCE LOBE CONCLUSION:</td>
<td>250</td>
</tr>
</tbody>
</table>
Appendix 4
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. Weld time 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. Weld force 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:

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
TABLE OF CONTENTS

Appendix 5
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 current 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 weld count 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:
   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
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
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. Weld current 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. Stepper lobe procedure for worn electrodes: 313
A6-10. Conclusion: 315
A6-10.1. Stepper lobe graph result: 315
# TABLE OF CONTENTS

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.
INTRODUCTION

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
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