Grain Refinement in 52M Filler Metal by Ultra-Slow Current Pulsing
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Introduction
Solidification cracking becomes more likely and non-destructive testing more difficult with larger grain structures in the fusion zone of an arc weld. Research has shown that correct current pulsing parameters can cause grain refinement in GTA welds by creating turbulence at the rear boundary of the weld pool and causing dendrite fragmentation. Thus the goal of this project is to optimize current pulsing parameters in order to cause grain refinement of 52M overlays on 304L SS substrate.

Design of Experiment
- JMP Pro software used to determine set of welds to be tested
  - Design of Experiment allows user to input several variables and levels of variation and analyze their effect on the dependent variable; percentage of equiaxed microstructure in travel direction in this case
- The following contour plot from JMP shows how the main parameters, % Background Current and % On Time, effect the percentage of equiaxed microstructure.

Parameter Verification
- Use of four different sensors
  - Gas Flow
  - Current
  - Voltage
  - Wire Feed Speed
- Verifies machine settings
  - More accurate than machine settings
- Outputs into CSV file
- MATLAB program written to make graphs
  - Too many data points for excel (~100,000 per run)

Percent Dendritic Growth Calculation
- Used microscopy program to measure area of dendritic growth in all travel-direction micrographs
- Normalized as a percentage of total area in micrograph
- Produced consistent results with "eye test"

Average Equiaxed Grain Size Analysis
- Use of Imagej software to threshold image
  - Imagej then recognizes individual grains and measures the area
  - Labels each grain with reference number
  - Reference number also included in table of results
- Minimal changes in cross section grain size due were found to pulsing parameters.
  - Thus, % of equiaxed area in travel direction became focus of project

Results
- Trend lines show current pulsing has significant effect on equiaxed grain formation.
  - Optimum parameters are from 45-55% background current and 30-40% on time, as shown in following graphs and contour plot.

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