1995

NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM

MARSHALL SPACE FLIGHT CENTER
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

WELDING REWORK DATA ACQUISITION AND AUTOMATION

Prepared By:	Peter L. Romine, Ph.D.
Academic Rank:	Associate Professor
Institution and Department:	Florida International University Department of Electrical and Computer Engineering

NASA/MSFC:

Laboratory:	Materials and Processes
Division:	Metallic Materials and Processes
Branch:	Metals Processes
MSFC Colleague:	Kirby Lawless

Introduction

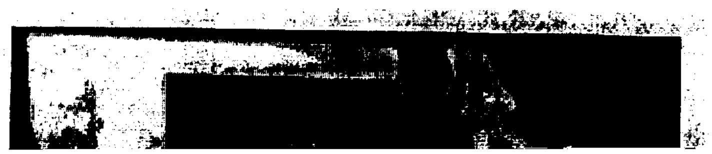
Aluminum-Lithium is a modern material that NASA MSFC is evaluating as an option for the aluminum alloys and other aerospace metals presently in use. The importance of aluminum-lithium is in it's superior weight to strength characteristics. However, aluminum-lithium has produced many challenges in regards to manufacturing and maintenance. The solution to these problems are vital to the future uses of the shuttle for delivering larger payloads into earth orbit and are equally important to future commercial applications of aluminum-lithium. The Metals Processes Branch at MSFC is conducting extensive tests on aluminum-lithium which includes the collection of large amounts of data. This report discusses the automation and data acquisition for two processes: the initial weld and the repair. The new approach reduces the time required to collect the data, increases the accuracy of the data, and eliminates several types of human errors during data collection and entry..

The same material properties that enhance the weight to strength characteristics of aluminum-lithium contribute to the problems with cracks occurring during welding, especially during the repair/rework process. The repairs are required to remove flaws or defects discovered in the initial weld, either discovered by x-ray, visual inspection, or some other type of non-destructive evaluation. It has been observed that cracks typically appear as a result of or beyond the second repair. MSFC scientists have determined that residual mechanical stress introduced by the welding process is a primary cause of the cracking. Two obvious solutions are to either prevent or minimize the stress introduced during the welding process, or remove or reduce the stress after the welding process and MSFC is investigating both of these.

Planishing Automation

The goal this summer was to discover approaches and implement a system for automating the planishing process which is used to reduce the residual mechanical stress after the weld is made. When two pieces of aluminum-lithium are welded together, a filler material is added to the molten weld pool to compensate for the original material missing in the gap between the two parts. This is required to provide a uniform thickness in the finished part. As this molten portion cools, the mechanical forces reach an equilibrium. In the repair process this equilibrium is disturbed when only a portion of the original seam is remelted and then cooled, resulting in a deformity or shrinkage in the part along the area of the repair. In practice, cracks start to appear during and after the second repair. In the planishing process, a pneumatic hammer is used to pound the material back towards the original shape, and in so doing reducing the residual stress introduced by the repair, Figure 1. Thus allowing multiple repairs to be made without cracks.

Figure 1. A pneumatic hammer is being used to planish a repair weld.



The location and amount of distortion or shrinkage must be determined to make the planishing work. The two approaches that have been considered are by mechanical measurement and optical or image processing. The mechanical measurement method is the one currently in use and requires the welder to use calipers to make measurements along the welded seam after the original weld to determine the baseline curve, Figure 2. The number of measurements must be sufficient to illustrate the shrinkage that will appear during the subsequent repairs, typically about one measurement per inch. The measurements are hand entered into a spreadsheet for documentation, processing and plotting, Table 1.

Table 1. Measurements taken during the planishing process in an Excel sheet.

Panel ID m201   Thickness .200"   Date: 6/15/95

Pneumatic Hammer Planishing

2195 4043 4043

		Face Measurement										
		-2	-1	0	1	2	3	4	5	6	7	8
Pass	Pre - Planish		2.000	1.992	1.985	1.983	1.984	1.986	1.990	1.997	2.003	
1	1" 25 PSI, (3.5 to 2.5),Gun Root		2.001	1.994	1.990	1.992	1.994	1.991	1.991	1.998	2.004	
2	4", 25 PSI, (5 to 1),Gun Root		2.003	2.002	2.003	2.003	2.002	2.001	1.999	2.001	2.004	
3	8", 25 PSI, (-1 to 7.0),Gun Face		2.007	2.008	2.008	2.008	2.007	2.007	2.007	2.008	2.009	
4												
5												
6												
7												
8												
9	Progress 3	#VALUE!	100.000	106.667	104.545	104.167	100.000	100.000	100.000	110.000	150.000	#DIV/0!
10	Progress 2	#VALUE!	42.857	66.667	81.818	83.333	78.261	71.429	52.941	40.000	25.000	#DIV/0!
Initial Weld->->->->->			2.007	2.007	2.007	2.007	2.007	2.007	2.007	2.007	2.007	
Shrinkage		0.000	2.000	1.992	1.985	1.983	1.984	1.986	1.990	1.997	2.003	0.000
		#VALUE!	0.007	0.015	0.022	0.024	0.023	0.021	0.017	0.010	0.004	0.000
Target	90%	#VALUE!	2.006	2.006	2.005	2.005	2.005	2.005	2.005	2.006	2.007	0.000

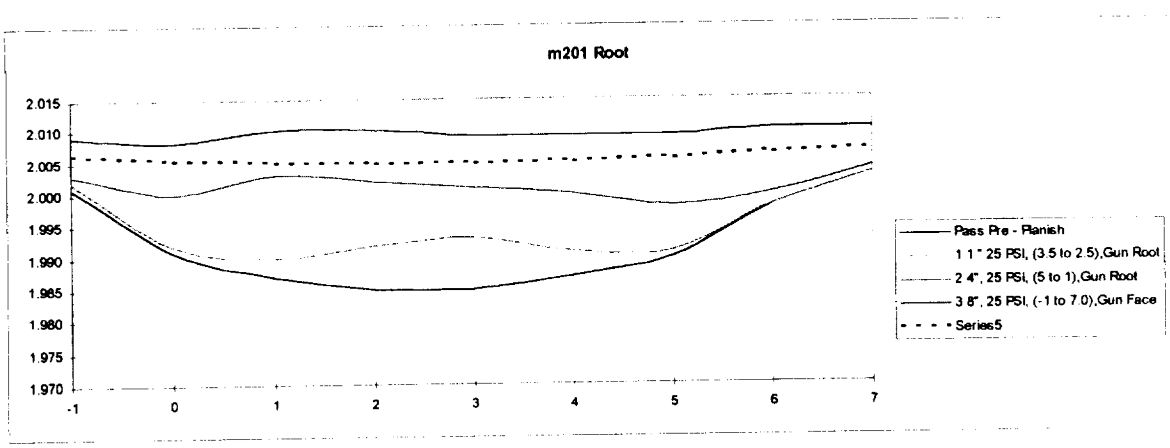


Figure 3. Recovery curves plotted to illustrate planishing progress.

Measurements are then made after each repair pass and plotted to determine the amount of shrinkage, typically from one to five repair passes. The amount and location for planishing is then determined by visually comparing the original baseline curve to the current repair curve. The measurement process must then be repeated for each planishing phase to determine how well the shrinkage is being removed or recovered. The recovery curves are then visually compared to the desired recovery curve to determine if additional planishing is required, Figure 3.

Planishing Automation

Obviously, the total number of measurements can become very large for a repair, the use of over a hundred test points is sometimes required. This requires a lot of time and presents many opportunities for errors. The solution chosen was to utilize digital calipers and customized software to directly enter the measurements into the computer. The requirements were that the operation of the tool be intuitive enough to require minimal training for welders that might have no formal computer training or experience. Microsoft Visual Basic was chosen to implement the tool because of it's rapid prototyping features for graphical user interfaces. The toolbar for the application is shown in Figure 4 and a sample data screen is shown in Figure 5.

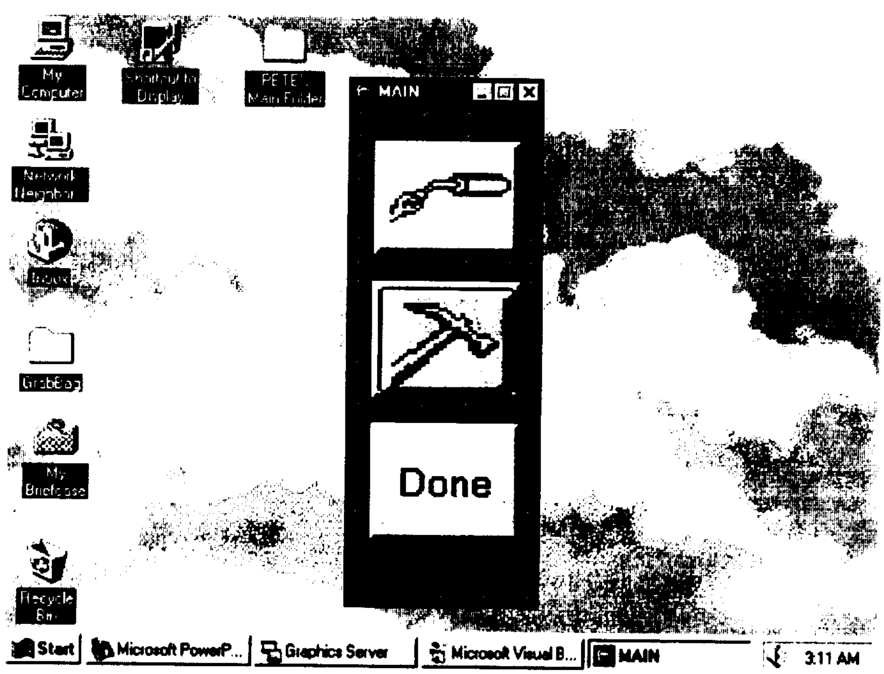


Figure 4. Opening toolbar for the planishing application.

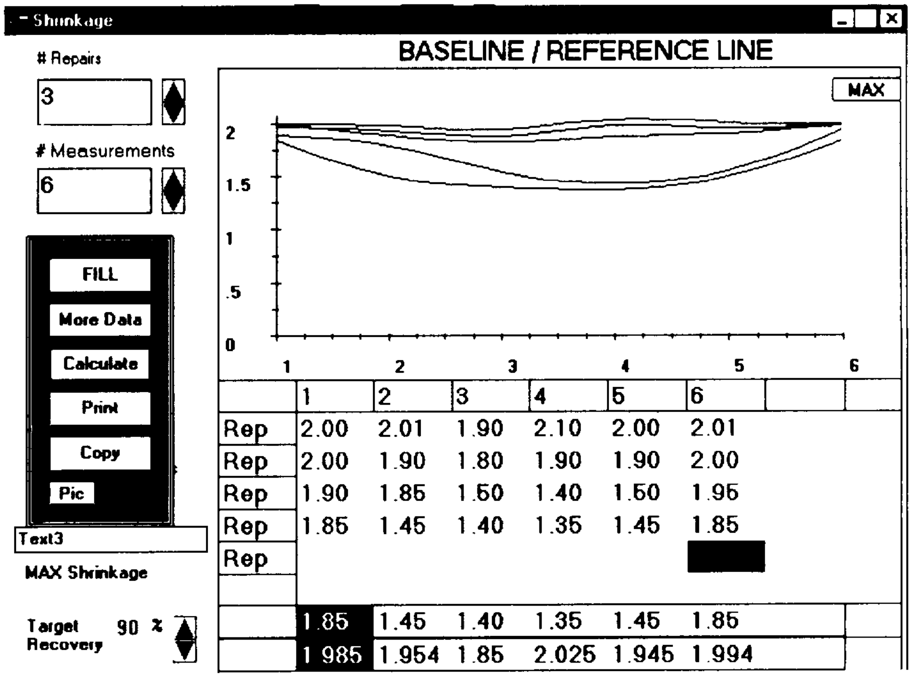


Figure 5. Sample data screen for the planishing application.

Summary and Conclusion

The idea of the planishing application tool has received a very positive response from the welding engineers and scientists. Direct entry of the shrinkage measurements into the computer will significantly reduce the time consumed by this process and eliminate most sources of error encountered during the repair and planishing process. It has been determined that a superior approach will be to embed a simplified data entry tool into an automated spreadsheet. This combination will open-up the additional analytical and presentation powers of modern spreadsheet technology that would otherwise require prohibitive programming efforts. The resulting tool can still be designed to be non-intimidating to the diverse family of welding engineers.

Other potential candidates for automation in the data acquisition and documentation processes were discovered during the summer. One of these included automating the measurement of travel speed during a manual repair weld. A voice-activated approach was considered but sufficient time was not available to implement an actual tool.

Acknowledgment

The accomplishments of this summer would not have been possible without the technical input and direction from my NASA colleague, Kirby Lawless of the Metals Processes Branch. I would also like to thank and commend all of the SFFP administrators and staff for a professionally and smoothly operated program.