SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

Center for Friction Stir Processing

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Refill Friction Stir Spot Weld Repair of a Fatigue Crack

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AMP SDSM&T

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Objective:

- Develop a procedure to repair fatigue cracks in a 2024 aluminum skin using the Refill Friction Stir Spot Welding process. Also incorporated into this project is the use of cold spray deposition to fill the pre-crack.

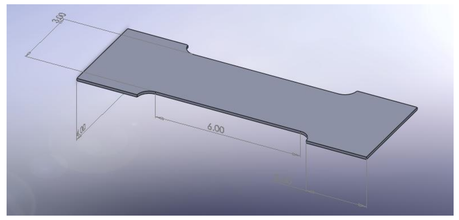
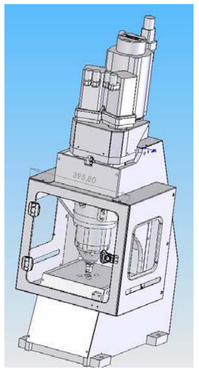


Figure 1 shows a solid works model of the coupons that was used for CNC machining.

Materials/Equipment:



- .125 inch thick 2024 Al T3 sheet
- .120 micron 2024 Al T3 powder
- Riftec RPS100 RFSSW
- Centerline Cold Spray Unit
- MTS 810 Tensile Machine

Approach:

- The first task was to machine the coupons used for repairs and testing. This involved sheering a large Al 2024 T3 plate. Once cut, the 40 individual coupons were then precision milled to be 12 inches by 4 inches, with a tolerance of .01 inches. The samples were shown to be quite square. A solid works model was then constructed to give exact geometry for the reduced (dog bone) section. The test section must be consistent as the coupons will undergo many fatigue cycles. A CNC milling machine was used to cut the reduce test section and a high tolerance finishing pass was preformed.

Approach (cont.):

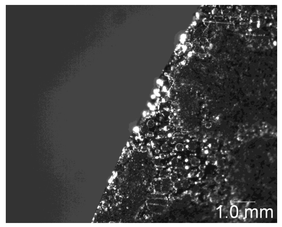


Figure 3 Al 2024 powder mounted in bakelite. 2.5X, the powder can be seen here as small spheres.

- Next, a pre-crack was needed as a starting point for the fatigue cracks. A stable setup was needed to ensure consistency. A dremel with a cutting wheel was secured to a metal arm and a vice. The coupon was then clamped to a milling machine table. A plunge into the center of the test section was then executed at a depth of .060 inches. This slot acts as a starting point from which to grow a fatigue crack.
- Then, the fatigue crack must be "grown" within the material. To do this an 810 MTS tensile machine was required. Using a sinusoidal load at a frequency of 20 hertz, a load from .675 KIP to 6.75 KIP was applied. The crack was then grown until is was about .5 inches long on the back surface (opposite of the pre-crack). The length of the crack on the front side could not exceed .75 inches as the total repair length of the RFSW stitch weld is only 1 inch long.

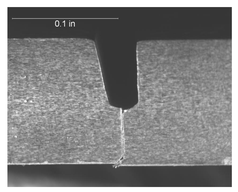


Figure 3 shows the pre-crack slot and fatigue crack after initial growth. Side view at 2.5X

- Cold spray deposition is then used to fill the pre-crack just prior to final RFSW repair. This involves spraying pre-alloyed 2024 AL T3 powder at supersonic speeds. As the particles impact the plate, they plasticize and build up on surface, forming a deposit. The pre-crack needs to be filled as it would hamper the repair process. Currently, a deposition has not been achieved.

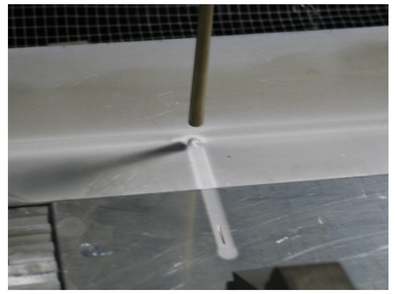


Figure 4 shows a cold spray deposition test in progress. Notice the build up of material just under the tip of nozzle.

- The sample will then be repaired using a "stitch weld". This will involve overlapping refill friction spot welds. The crack will be consolidated.
- Lastly, all coupons (parent, un-repaired, and repaired) will be placed into the tensile machine again. They will either fail or pass the fatigue test at 1,000,000 cycles. Various load levels will be used to produce S/N curves for comparison.

Results:

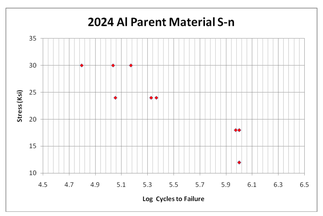


Figure 5 shows current results: The S/N data for the parent material. This will be used as a comparison.

Future Work:

- Cold spray of pure aluminum powder may be explored. The effects on fatigue will be shown. The 2024 powder may also deposit with a few process modifications.
- Coupons will be repaired.
- Fatigue of all samples will be performed
- Results will be documented fully.

Acknowledgments:

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