Refill Friction Stir Spot Welding Material Stack-Up Analysis
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Background

- Refill Friction Stir Spot Welding (RFSSW) is a spot variation of traditional solid-state Friction Stir Welding (FSW).
  - **Step 1:** The fixtureing device clamps the base materials, and the pin and sleeve initiate friction by rotating into the base material at a tightly controlled speed.
  - **Step 2:** The rotating sleeve advances through the material to the bottom substrate and the pin retracts.
  - **Step 3:** The sleeve retracts and the pin advances to a level position and fills the joint cavity.
  - **Step 4:** The joint is complete and the tool can retract from the material surface.
- **Main Process Parameters:** rotational speed, depth of penetration, and dwell time.
- In some RFSSW applications, Step 2 & Step 3 are altered. The pin advances through the material and sleeve retracts for material build-up, as opposed to the contrary in the description above.
- **Overarching Goal:** producing a comparative study of control AA 6061 refill friction stir welded to AA 6061–6061, 6061–7075, 2024–6061, and 7075 to AA 6061 welds.
- **Main Process Parameters:** rotational speed, depth of penetration, and dwell time.
- **Objectives & Approach**
  - **Overarching Goal:** Providing baseline strength, corrosion, and microstructural data for different aluminum alloy stack-ups for refill friction stir spot welding.
  - **Objective:** optimizing the AA 6061–6061 parameters for each stack-up in experimentation.
  - **Methodology:** All testing has already been completed on AA 6061–6061, so results are used as a control.
  - **Microstructural Study:** Samples were sliced and placed in a 5% NaCl solution for 72 hours, a before and after microstructural analysis was completed.
  - **Microstructure:** Recrystallization and fine equiaxed grains with regions of 
  - **Microhardness:** Data was collected encompassing the SZ, TMAZ, HAZ, and base material.
  - **Tensile Testing:** Completed at Coldwater Machine Company. 
  - **Corrosion Testing:** Conducted at Coldwater Machine Company.
- **Conclusions**
  - For better results, in respect to all testing methods, optimized conditions from additional parameter studies should be created for the AA 6061 to AA 2024 and AA 6061 to AA 7075 stack-ups.
  - The optimized AA 6061 to AA 6061 had a complete metallurgical bond that exhibited thorough mixing.
  - The top sheet material has a greater influence on the material properties, whether it is weaker or stronger, because more of its material is present in the joint profile.
  - AA 6061 has the best corrosion resistance properties, which correlates to the material properties of all alloy systems.
- **Future Work**
  - Complete corrosion testing to ASTM G50-10 standard.
  - This will evaluate corrosion resistance when exposed to weather-like conditions.
  - Samples can be compared to other data points that underwent standard specifications.
  - Identify weld parameters for AA7075-AA7075 and AA2024-AA2024.
  - These stack-ups will give more pertinent information about RFSSW to potential aerospace customers.

Motivation

- A continued effort for light-weighting in the transportation industries has lead to an increase in process development and improvements for aluminum welding.
- **Aluminum:** High strength-to-weight ratio but brings many difficulties using conventional welding processes due to the Al-oxide layer that forms on the surface of aluminum alloys.
- AA 2024 and AA 7075 are high-strength alloys commonly used in aerospace applications.
- Produce a comparative study of control AA 6061 refill friction stir spot welded to AA 2024 to AA 6061 and AA 7075 to AA 6061 welds.
- **Microstructural analysis** provides metallurgical understanding of the material transport during joining.
- **Tensile testing** provides joint strength measurements for each stack-up.
- **Corrosion testing** provides an understanding of how the welds will withstand common environmental conditions.

Results & Discussion

- **Objectives & Approach**
  - **Overarching Goal:** Providing baseline strength, corrosion, and microstructural data for different aluminum alloy stack-ups for refill friction stir spot welding.
  - **Objective:** Optimized parameters for AA 6061–AA 6061 were used for each stack-up in experimentation.
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