Minimization of Edge Delamination During Cold Rolling of Aluminum Sheet

Student Names: Megh Kansara, Jeremy MacPherson, Austin McKibben, Lucas Witte
Faculty Advisors: Dr. David Gildemeister
Industrial Sponsors: Paige Breymer, Matthew Volle, Ginny Hammersmith

Edge cracking and edge delamination are phenomena that occur during rolling of 5182 aluminum and cause significant losses for Logan Aluminum. This study investigated the causes of these phenomena as well as ways to minimize or eliminate their occurrence and severity. Simulated rolling experiments, metallurgy, and material property testing on material at different stages throughout the rolling process showed that edge cracking can be reduced by reducing the reduction speed while rolling.

**Background**

Logan Aluminum primarily produces two alloys, 5182 (van bray) and 5182 (van and stock). Edge cracking and delamination contribute to the second largest yield loss source at Logan. Edge-damaging mechanisms occur as the sheet begins to separate along the edges. The delamination phenomena tend to affect the 5182 alloy specifically, likely due to the higher magnesium content, so the focus was understanding the 5182 alloy. However, due to the strict monitoring of magnesium levels that are maintained by Logan, the focus of the team was on the processing and rolling of the 5182 alloy rather than a compositional difference between delaminated and non-delaminated sheets.

**Rolling Experiments**

As discussed in Experimental Methods, section C was rolled under the most aggressive rolling schedule, with section D being less aggressive and section E the most passive. See below for optical images of the samples after a 90% reduction. Sample C and D show prominent edge cracking, with varying depth and distance between cracks. Sample E did not show widespread cracking, and as can be seen in the two images above, labeled E1. The team reasoned that the cracking in the E1 sample was not due to shear banding, but rather a stress concentration occurring during rolling. These samples were then compared to cracked/delaminated samples sent from Logan Aluminum.

**Experimental Methods**

**Rolling Experiments:**
- **Optical Imaging:** Sample rolling experiments were performed on samples sent from Logan Aluminum. Samples of the height of the sheet from roll 433775.45 (about 1.5 in.) were cut to remove the edge damage and rolled to 90% reduction. The Optical Imaging showed that the section was rolled two samples, A and B. Sectioned and rolled at 60%, 90%, and 120% reductions, with final thicknesses of about 0.06, 0.04, and 0.02 in., respectively. A second section was prepared from the same sample, which was rolled to the same thickness at each stage to compare the percentage reduction between the different sections. For the 60% reduction, multiple cracks were evident. A 3D cold-rolling experiment was performed on a partially rolled sample from roll 059390.71 sent from Logan that was just starting cracks to get an idea of how the crack would grow and progress after another rolling pass.

**Hardness Measurements**
- **Vickers Hardness testing was conducted on sections from samples A and D at each stage of rolling from 0-90% reductions, and on a sample from the same 433755.45, partially cold rolled by Logan Aluminum, with each section of approximately 85% reduction.** Before testing, samples were mounted, ground to 250-grit finish, and polished to 1200-grit finish paper.

**X-Ray Tomography**
- **X-Ray computed tomography (XCT) was utilized as a non-destructive technique for observing the microstructure and internal features of samples.** This was performed on two different 5182 coil samples from Logan (958593-3 and 943775-9) as well as one sample from experimental rolling which initially was the 959033-8 coil. The objective in XCT was to compare the Logan samples with the experimentally rolled samples and confirm similar characteristics and microstructure.

**Metallography**
- **SEM and Optical images were taken to examine the occurrence of shear banding.** Following, EDS analysis was performed to assess the material’s composition at various sites. The compositional data obtained supported the known specifications of Al 5182.

**Process Recommendations**
- **Based on our analysis of our rolling experiments and metallography, slower reductions can reduce crack propagation in delaminated or damgared samples.** We recommend that Logan Aluminum slows down their reductions in their rolling mills if they observe severe delamination or severe damage. Slower reductions will be more profitable than simply continuing to roll at the current rate and scoop coil when needed.

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