Mitigation of Edge Cracking in Rolled Aluminum Can Stock Alloys

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One of the biggest causes of loss for rolled metals, including at Logan Aluminum, is edge cracking – a defect formed at the edges caused by an imbalance of forces during the rolling process. This study aims to find the source of edge cracking in rolled aluminum, and attempt to mitigate it through adjustments in the rolling process. Through characterization and analysis of edge cracking throughout different stages of the process, as well as adjusting the surface finish of rolled aluminum, the amount of edge cracking observed changed. It was found that the best rolled sheet metal at the edges came from a smooth surface with no liquation layer. By reducing the amount of liquation layer on the edges, the amount of edge cracking can be reduced.

**Background**

Throughout the entire process, Logan loses approximately 30% of their total yield, and of all yield loss, the second largest source comes from edge cracking. During metal sheet rolling, the edges of the sheet are more susceptible to deformation and failure due to an imbalance of forces. As the sheet undergoes more passes, more edge cracking occurs. Due to partial remelting during casting, a layer of microsegregation is present on the ingot. This "liquation layer" at Logan is machined-off or -scraped – from the top and bottom of the ingot, but the layer is not removed from the edges, leading to an increased chance of more severe edge cracking during rolling.

In 1968, Latham and Cockcroft found a linear relationship cracking reduction and reduction in area. Their results can be summarized as:

- Ingot losses approximately 30% of their total yield, and of all yield loss, the second largest source comes from edge cracking. During metal sheet rolling, the edges of the sheet are more susceptible to deformation and failure due to an imbalance of forces. As the sheet undergoes more passes, more edge cracking occurs. Due to partial remelting during casting, a layer of microsegregation is present on the ingot. This "liquation layer" at Logan is machined-off or -scraped – from the top and bottom of the ingot, but the layer is not removed from the edges, leading to an increased chance of more severe edge cracking during rolling.

Logan Aluminum produces two alloys: 3104 - can body stock (1.1 Mn, 1.0 Mg) - and 5182 - can end stock (0.4 Mn, 4.5 Mg). In both alloys, edge cracking is present; however, it is worse in the 5182 alloy, likely due to a higher content of magnesium. During homogenization and heating of the alloys throughout the process, short range segregations are removed, and because of the higher magnesium content of the 5182 alloy, more segregations between the Mg and Al do not happen. Therefore, we've elected to focus on the 5182 alloy.

**Experimental Methods**

Samples were taken from the ingot after casting (left), from the transfer bar, or right after the rolling mill (middle), and from the hot band, or right after the finishing mill (right) for different forms of experimentation.

This work is sponsored by Logan Aluminum, Russellville, KY.

**Metallography**

Metallography was performed on various points of the samples to observe microstructural and microstructural changes or differences between the alloys. Metallography was first conducted on the hot band samples of 3104 and 5182.

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**Rolling Experiments**

Rolling experiments were performed on the received 5182 samples to determine what changes in the rolling parameters would be the best for the prevention of edge cracking. Rolling experiments were performed on the ingot and transfer bar (Right) samples, with the experimentation outline being listed in experimental methods.

**Hardness Measurements**

Hardness values of the 5182 ingot, transfer bar, and hot band were first taken in the HRF scale, with all the edges and center of the ingot. Edge values were collected within 1 cm of the top and bottom of the sample, while center values were taken more than 3 cm from the edges. Generally, as the sample is rolled more, the hardnness at the edges decreases while the hardnness at the center increases. Since hardness should increase with decreasing grain size when worked, edges may not be rolled enough at Logan.

The samples used for the rolling experiments, seen above, were modelled to be an approximate scale model of the actual ingots of aluminum that are used at Logan Aluminum via width and thickness. Ingot samples were roughly 6 mm wide and 2.5 mm thick, while transfer bar samples were roughly 25 mm wide and 9 mm thick.

When polished with 120 grit, it was found that, when compared to the edge with the liquation layer removed, the onset of edge cracking was hastened in the ingot sample and delayed in the transfer bar sample. Thus, a 120-grit polish is not consistent enough to act as a mitigator for edge cracking.

When polished with the 320 grit, it was found that the onset of edge cracking was delayed in both the ingot and transfer bar samples, since the higher polish created an ideal condition for the obstruction of edge cracking.

**Process Recommendations**

With the presence of the liquation layer causing a higher degree of edge cracking, we recommend that the liquation layer be removed via scraping of the sides of the ingot, which would yield more favorable results than if it were scraped as a transfer bar. Using cost analysis, it was determined that Logan Aluminum will stand to gain a 5% increase in potential yield by not needing to remove the edge cracked material created from this layer.

Due to not falling within the scope of our project, we were not able to come to any substantial conclusions about the delamination phenomenon, but we believe that performing further experimentation on the delamination phenomenon may also prove beneficial to the quality of the rolled aluminum. Because of the presence of delamination in many of our samples from different stages of the rolling process, we have found this topic to be on the same level of importance as edge cracking and believe that it should be investigated with great interest.

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