Team 9: Roll Forming High-Strength Aluminum

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Objective

The objective of the project was to characterize 6xxx/7xxx series high-strength aluminum (HSA) for roll forming purposes. This would be done through research, simulation, prototyping, and validation.

What is roll forming?

Roll forming is a manufacturing process where thin sheets of metal are gradually shaped into a specific profile by a series of rollers. The process is widely used in the automotive industry as it is ideal for producing long, uniform parts with consistent cross-sections.

Research Results

6061-T6 and 7075-T6 at a thickness of 1.6 mm were selected based on their mechanical properties, availability, and the required specifications.

Simulation Approach

COPRA Software:

- Illustrate bend progression (flower diagram) and define roll geometry
- Run the simulation and analyze strain, stress, and potential defects

Optimization:

- Refine roll geometry, bend progression, relief offsets
- Determine minimum number of forming passes to prevent material failure

Validation:

- Compare Simulation results with experimental results

Simulation Flower Diagrams

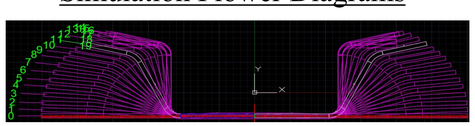

Figure 1: Production Scale

Figure 2: Prototype

Simulation Results

Based on input from the team's industry contacts at Roll Form Solutions and from representatives at data M, a simulated production scale model was created to study the material behavior and response to being formed with a proper number of rollers. The flower diagram was modified to include additional passes, reducing the bend angle per pass at each bend. A total of 19 passes in addition to an entry guide pass were used. The new design significantly reduced the strain experienced by each bend during the rolling process by comparing longitudinal strain between similar roll stations between the prototype and production scale simulations as seen in the figure below.

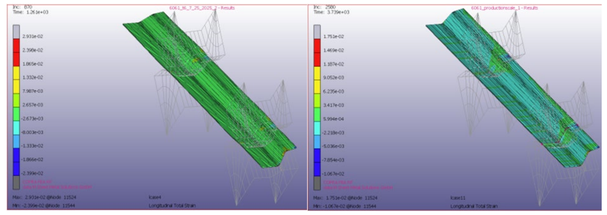

Figure 3: 6061-T6 7 Passes (left), 6061-T6 19 Passes (right)

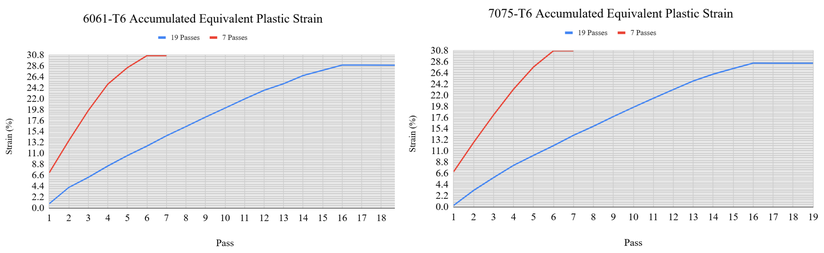

Figure 4: 6061-T6 (left), 7075-T6 (right)

The total accumulated plastic strain from the simulations was recorded and graphed. From the figures above, it can be seen that having only 7 passses results in more plastic strain than 19 passes. This is due to the fact that more rolls allows for a lower bend angle per pass.

Production recommendations

Overbend Angle: Increased overbend angles and additional overbend passes for both 6061-T6 and 7075-T6
Bend Radius: +1t beyond the suggested bend radius
Longitudinal Bow Mitigation: Ensure roll alignment & symmetry
Cracking Mitigation: Use large radii & gradual bend progression
Increase Ductility: Investigate heat treatment methods

Prototype Results

The team ran 12 samples of 6061-T6 and 7075-T6 aluminum through the seven passes seen below at Roll Form Solutions.

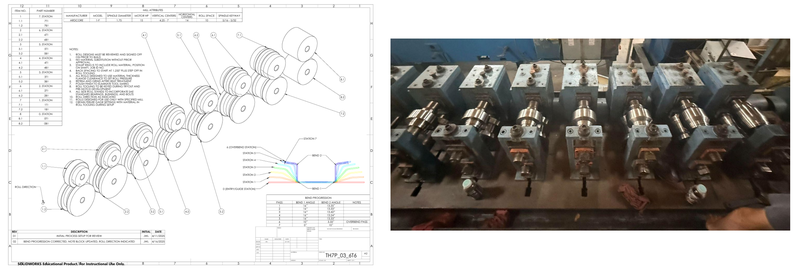

Figure 5: 7 Pass Prototype Set-Up

After forming, cross sections were cut and measured using an optical comparator. From this it could be seen that the 7075-T6 prototypes had more springback on the vertical flanges than 6061-T6, as seen below.

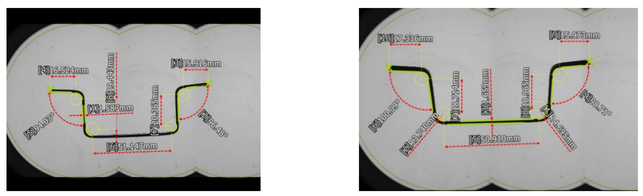

Figure 6: 6061-T6 Prototype (left), 7075-T6 Prototype (right)

A dye penetrant test also showed that 6061-T6 had no cracking while 7075-T6 had minimal cracking on the top bends, as seen below.

Figure 7: 7075-T6 Cracking

Along with this, the hardness at each bend greatly increased due to strain hardening, with 6061-T6 experiencing an increase of 30% and 7075-T6 experiencing an increase of 4.9%.

Acknowledgments

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