

Advancing each generation.



HONDA



Development of Low Cost, High Strength Automotive Aluminum Sheet

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Project ID: LM108

2016 Annual Merit Review

June 8, 2016

Overview

Timeline

- Start Date: Oct. 1, 2014
- End Date: Oct. 1, 2017
- 40% complete

Budget

- Total project funding (50/50): \$4,783,541
 - Govt share: \$2,391,771
 - Partner share: \$2,391,771
- Funding received in FY2015: \$506,394

Barriers

- Performance: meet or exceed an ultimate strength of 600 MPa, 8% minimum elongation with acceptable corrosion
- Forming: form desired component using a maximum temperature of 225 deg C
- Cost premium of less than \$2/lb saved over baseline UHSS component

Partners

- Alcoa – Lead
- Honda
- Cosma
- ORNL

Project Objectives/Relevance

■ Project Objectives:

- Develop a high strength aluminum automotive alloy and processing to provide
 - Ultimate tensile strength in the finished stamped component greater than 600 MPa and 8% total elongation
 - Can produce a representative part at forming temperatures less than 225 deg C.
 - With cost of finished, stamped component at less than \$2/lb compared to a baseline part.
- Produce a stamped demonstration part using this alloy

■ Relevance

- Reducing weight is a key enabler to reduce fuel consumption thereby reducing green house gas emissions and the dependence on foreign oil.
- 5xxx and 6xxx alloys currently used in automotive BIW are not competitive with Ultra High Strength Steels (UHSS) used for the safety cage components.
- High Strength 7xxx alloys can provide weight savings over hot stamped UHSS components.

Baseline Part - Honda

Door ring used on multiple Honda/Acura models (shown here on the TLX for illustration)

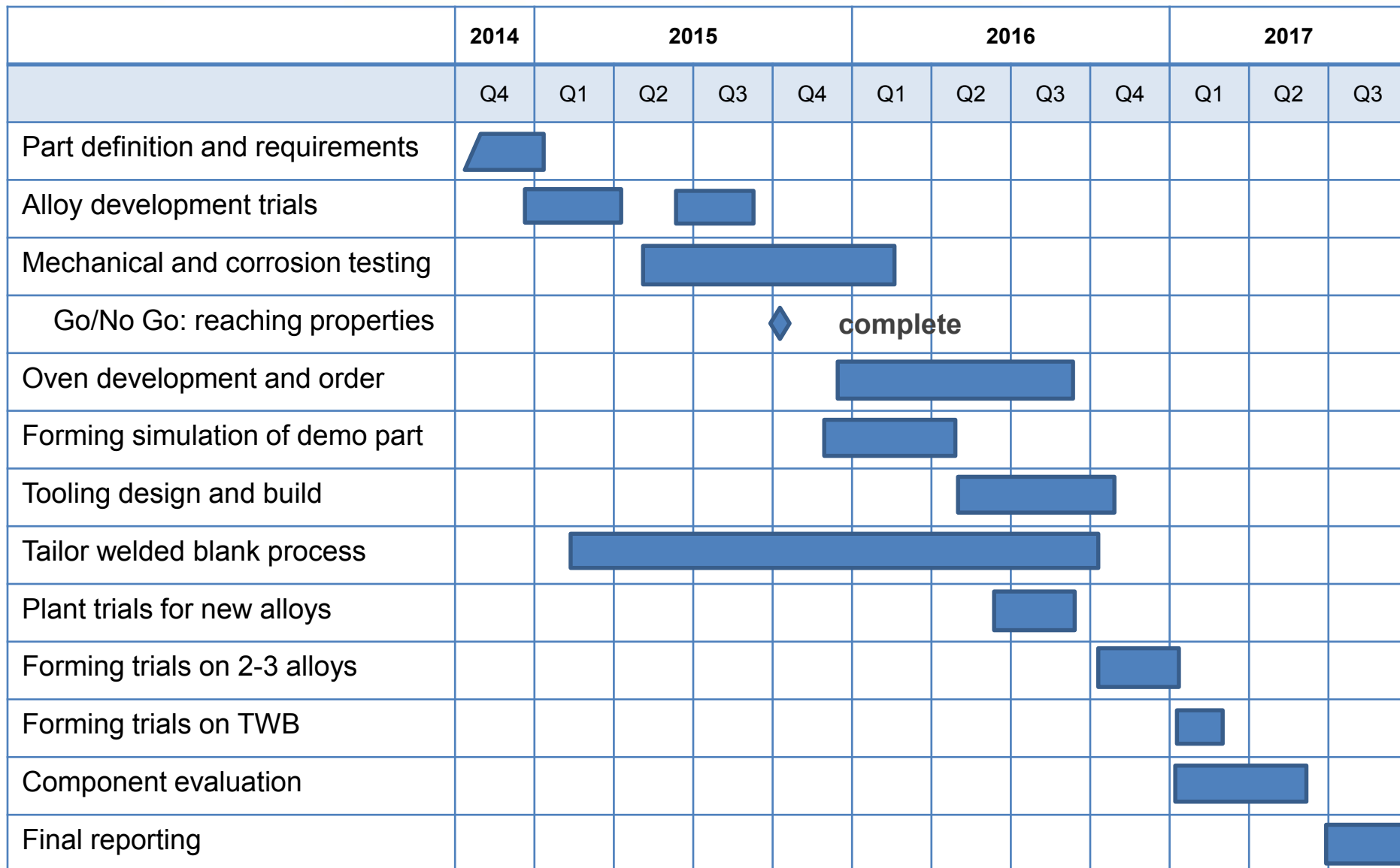


State of the Art
Hot Stamped door ring
UHSS (1500 MPa)
1.4 mm thick
12.5kg



New aluminum alloy
2.5 mm thick
7.5 kg
38% weight savings

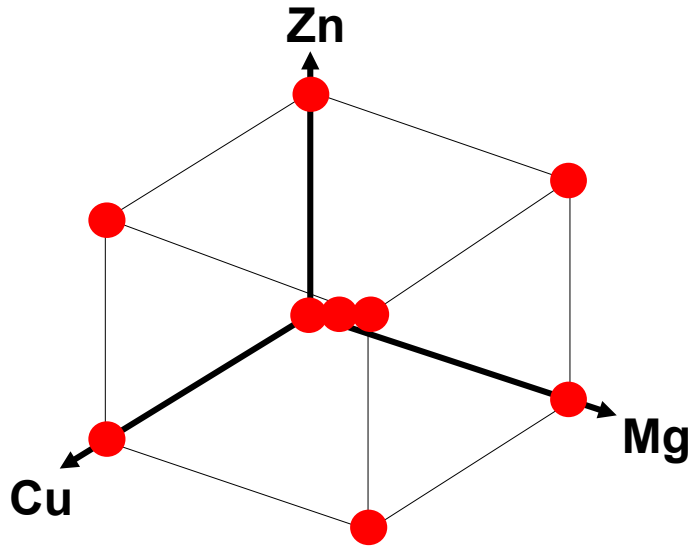
Milestones



Approach/Strategy

- Conduct alloy development trials. The strength and elongation targets are based on DOE requirements. The formability and corrosion targets are based upon the Honda part design.
- Purchase warm forming oven and install in existing press line along with robotic blank transfer to the tooling
- Design tooling for warm forming of material. Build tooling for demonstration.
- Develop Friction stir welding process for tailor welded blanks to improve material utilization.
- Conduct trials on development alloys with and without tailor welding
- Characterize properties and performance of final warm formed parts after paint bake cycle

FY2015 Accomplishments: Alloy Development

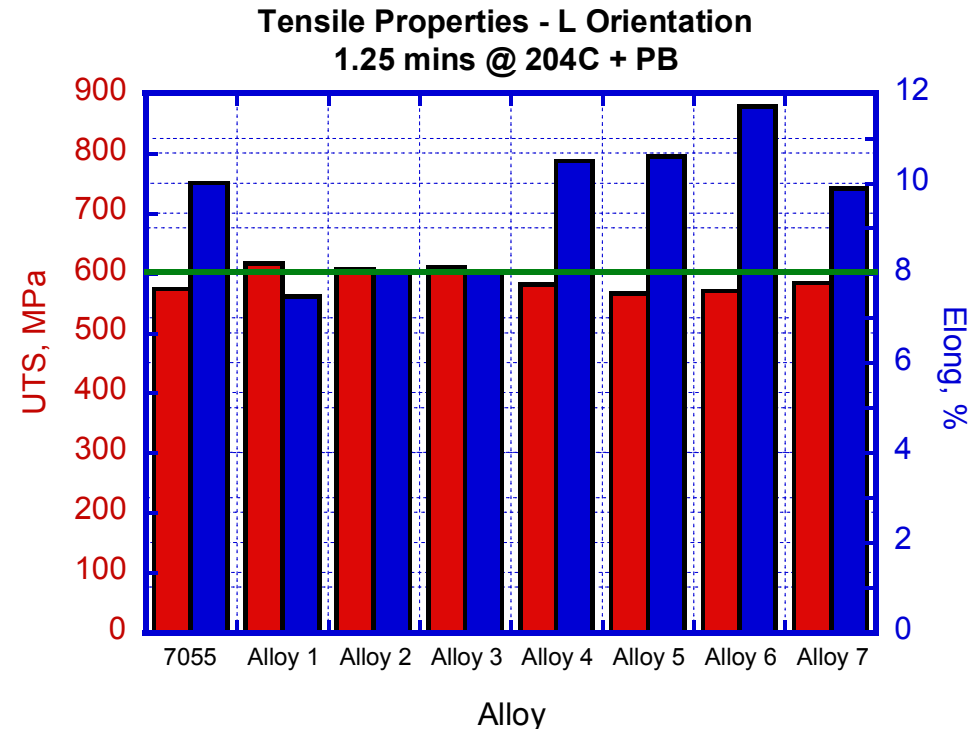
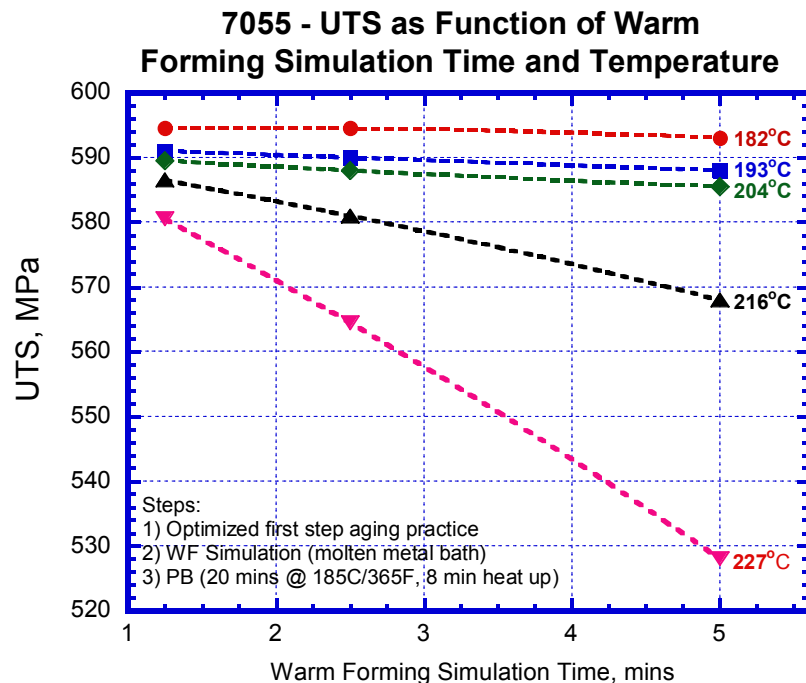


- Pilot scale trials using a composition box were processed with different thermo-mechanical conditions to influence final microstructure.
- Most promising compositions were selected for an initial production-scale trial to determine material properties
- Production 7055 sheet was used as a comparative benchmark

FY2015 Accomplishments:

Alloy Development – Tensile Properties

Time and temperature selection for forming has an impact on final properties. Selected warm forming conditions were used to generate properties along with the Paint Bake cycle (185°C / 20 mins)

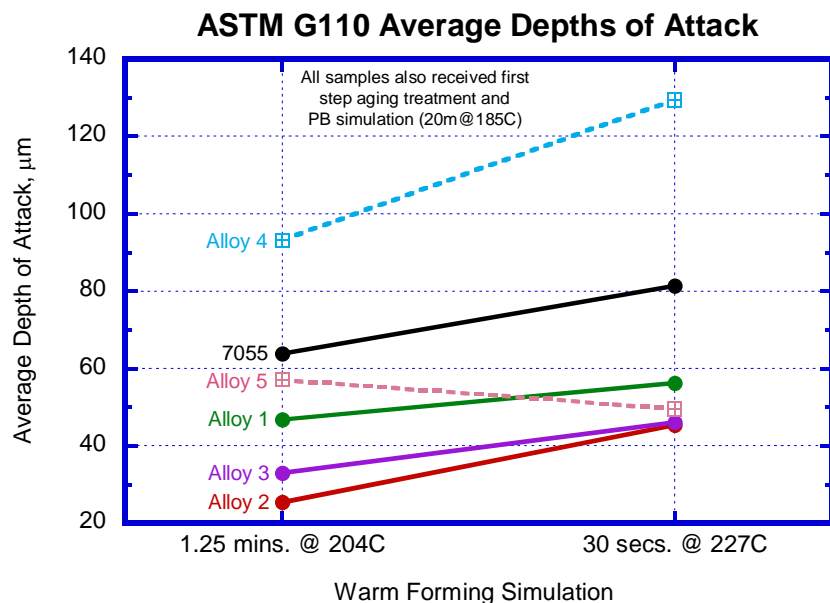


Alloys 2-3 reach the strength and elongation targets while alloys 4-7 are under strength but are exhibiting superior elongation.

FY2015 Accomplishments:

Alloy Development – Corrosion Characteristics

ASTM G110



Surface depth-of-attack readings for the experimental materials are acceptable (max depth < 200 μm).

ASTM G44 'Mini-Direct' SCC Tests - Days to Failure

'OK90' = not failed at 90 days
'T' = not failed at 221 days

Alloy	Stress Level (% of TYS)	1.25 mins @ 204C			30 secs @ 227C		
7055	75%	23	31	34	154	89	31
Alloy 1	75%	20	51	41	44	31	30
Alloy 2	75%	T	162	T	T	47	72
Alloy 3	75%	23	41	35	26	41	T
Alloy 4	75%	47	37	40	OK90	OK90	37
Alloy 5	75%	57	30	33	47	37	57
Alloy 6	75%	26	26	37	34	37	45
Alloy 7	75%	29	29	29	26	26	26

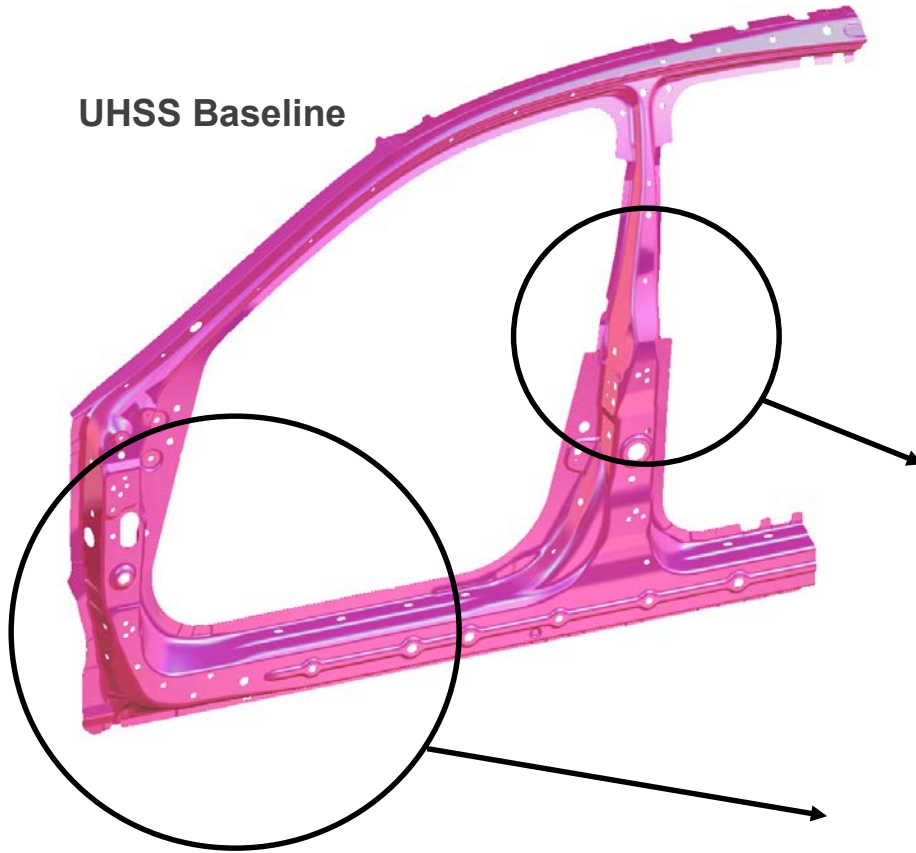
Testing performed with stress levels of 75% and 50% of LT TYS for each alloy (50% data not shown)

Conclusion:

Initial property data show the ability to meet DOE goals. Additional full-scale trials with slightly enhanced chemical compositions will further improve properties.

Demonstration Part Definition - Honda

UHSS Baseline



Demonstration part includes difficult to form areas from baseline

Full scale blanks – 1350 mm x 1350 mm

Allows for tensile blanks and corrosion samples from multiple areas

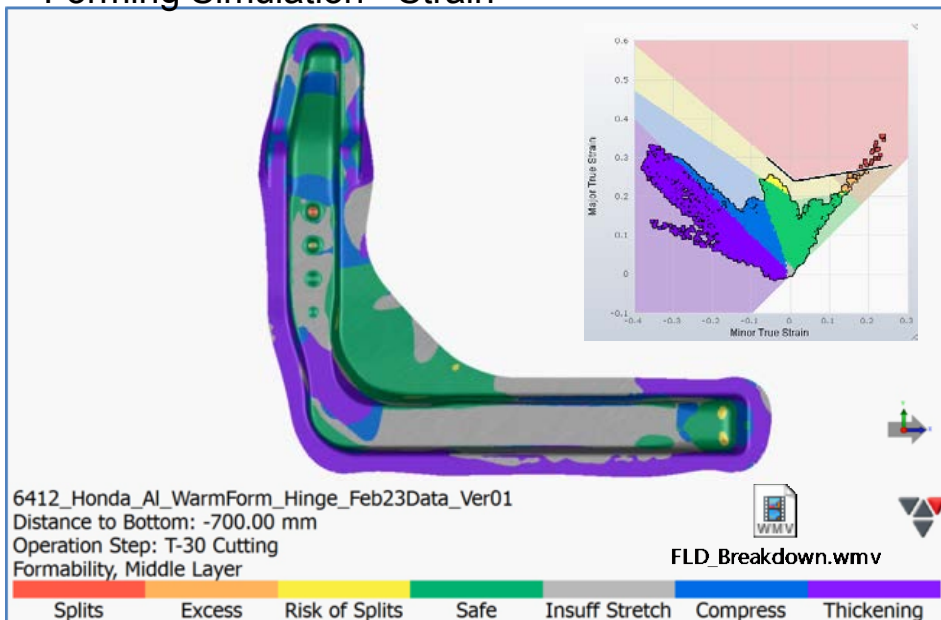


FY2015 Accomplishments:

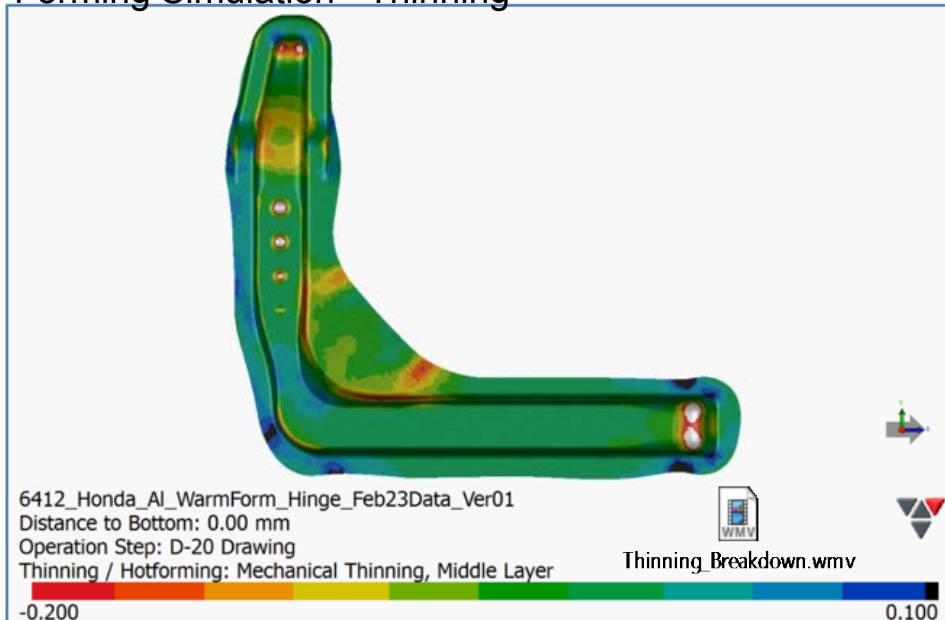
Demonstration Part and Simulation - Cosma

- Forming simulations have been performed on a sill/pillar demonstration part
- Formability has been simulated with 7085, 7075, and 7055 Aluminum
- Simulations have shown good formability at warm forming temperatures 177 deg C to 204 deg C
- Tooling manufacturing has begun and is in progress
- Trials are scheduled at Eagle Bend Manufacturing beginning in Sept 2016

Forming Simulation - Strain



Forming Simulation - Thinning



Oven Development and Info - Cosma

Oven Status:

- Oven design is completed and manufacturing is in progress
- Oven validation planned to begin at Sherdil in May 2016
- Oven validation planned to begin at Eagle Bend Manufacturing in June 2016

Specifications:

Overall Size:

- Platen size 2200mm x 1600mm
- Sized to accommodate blank of full door ring of 1920 x 1420mm

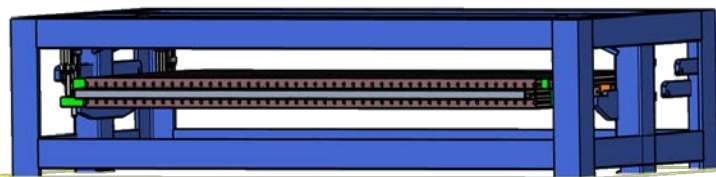
Temp capability:

- Temp. Bandwidth: within 5°C of target temp across pre-heater

System Production Knowledge

- Design based on current systems supplied to Cosma [Magna] aluminum forming [Super Plastic Forming] production facility in Ireland.
- Design confirms production oven concept
- Sourced through Cosma's current source for aluminum blank heating technology

Oven Design



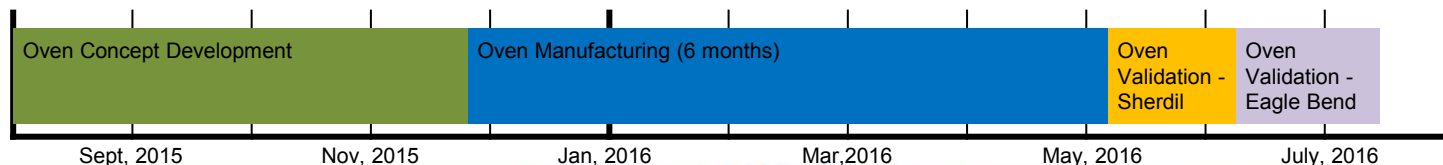
Platens in Closed Position

- *Platens to be held only at ends*
- *Middle platen is fixed*
- *Upper and lower platens are moving*
- *Hydraulic Motion*

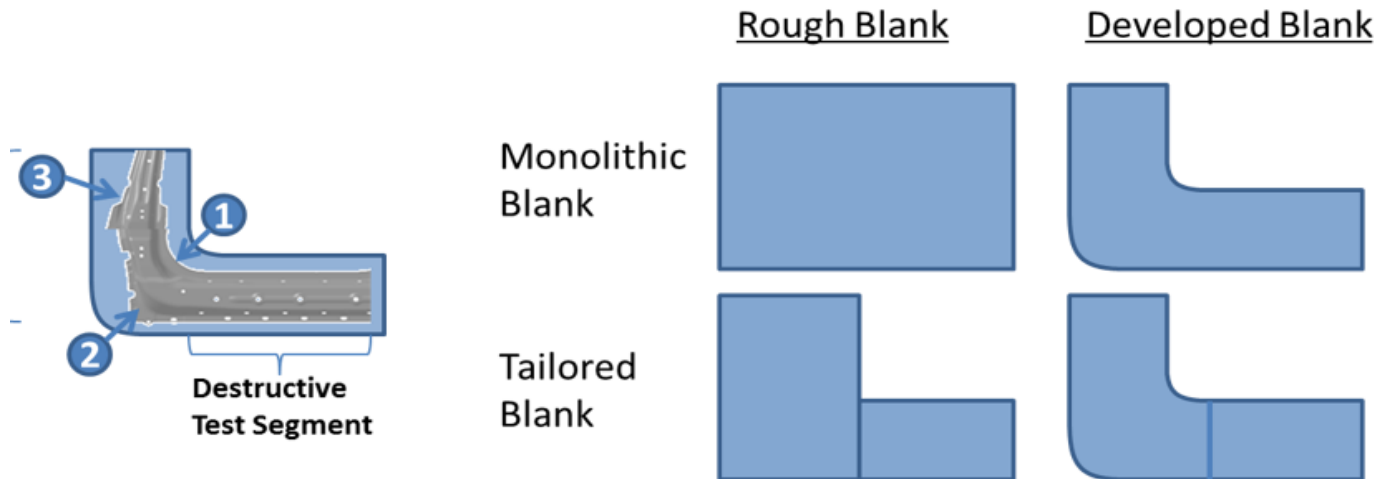


Platens in Open Position

Oven Timing



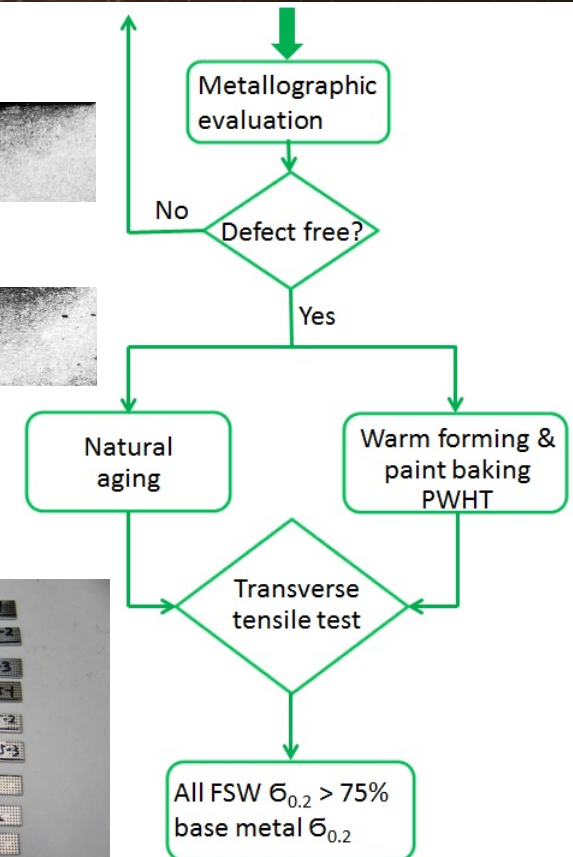
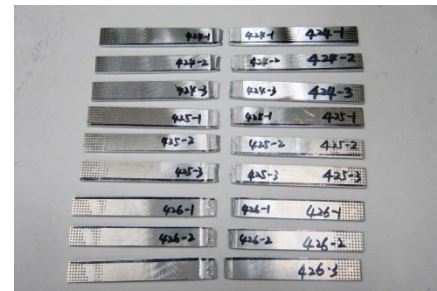
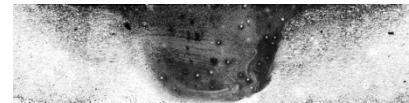
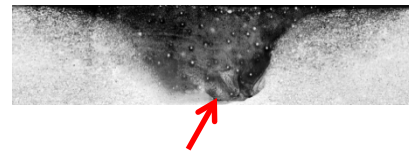
FY2015 Accomplishments: ORNL Tailor Welded Blank Development



- Goal is to improve material utilization to reduce material costs
- High strength aluminum alloys defined in this project are not fusion weldable.
- Friction stir welding (FSW) is a solid phase joining method capable of joining high strength aluminum alloys with much better properties

FY2015 Accomplishments: ORNL Tailor Welded Blank Development

- Identified method and necessary requirements on FSW high strength aluminum alloys.
- Designed durable tools for high strength aluminum thin sheet FSW.
- Parameters study on FSW high strength aluminum alloys provided by Alcoa to produce solid FSW joint with minimal strength reduction.
- Room temperature welded samples testing and characterization (including warm forming and paint bake cycles).
- Close to base metal yielding strength FSW joint ensures the subsequently forming process executed easily.
- Provide info for forming simulation including FSW
- Prepare to produce full scale tailor weld blank (TWB).



Responses to Reviewer Comments

- This project was not reviewed last year.

Partnerships/Collaborations



Alcoa will develop compositions, processing and thermal treatments to reach the target DOE/Honda requirements on a lab scale. Alcoa will select the most promising alloys and produce full-scale blanks for forming trials.



Honda will provide specifications for the component and test criteria, as well as functional performance expectations. Honda will provide specifications for related coupon testing that will be conducted by Honda, industry partners, and ORNL. Finally, Honda will assess functional performance of the component.



Cosma will develop the tool surface and perform forming simulations of the 7XXX alloy component to successfully develop the forming tool. Cosma will construct the forming die for trials. Operating parameters of the tool/oven will be developed. Finally, Cosma will integrate both the oven and forming tools on an existing press line for demonstration.



ORNL will develop the friction stir welding (FSW) process and produce initial samples for forming characterization at warm forming temperatures. Once the weld strengths and forming characteristics are understood, ORNL will produce the TWB for the forming trials.

Remaining Challenges and Barriers

- There are issues in forming that need to be explored during the forming trials:
 - Lubricant effectiveness
 - Change in forming properties as the material cools when in contact with the tooling.
 - Springback during warm forming
- Understand the balance between strength, elongation and corrosion performance for the final product.
- Impact of the Friction Stir weld seam on the forming of the demonstration part.

Proposed Future Work

- Receive and install oven for blank heating
- Complete tooling fabrication
- Run trials on transfer of blank from oven to tool
- Run initial warm forming trials to check equipment and process
- Produce full scale quantities of 2 – 3 new alloys using production flow path
- Run warm forming trials on 2 – 3 new alloys
- Test samples cut from formed components (after simulated paint bake cycle – for mechanical property and corrosion testing)
- Provide tailor welded blanks for warm forming trial
- Repeat warm forming trial using tailor welded blanks

Summary

- Several 7xxx alloys have been produced that meet the strength, elongation and corrosion requirements. Full scale plant trials will provide material for warm forming trials.
- An oven configuration has been developed that will allow rapid and controlled blank heat up with rapid transfer to the tool.
- A representative demonstration part has been designed and is being built to conduct warm forming trials of several new alloys.
- Friction stir welding has been used to produce TWB samples at high welding rates that reach 75% of the base metal strength
- Next step: forming trials with new alloys

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