

# **Aluminum Linear Friction Stir Welded Blanks**





#### **Presenters**

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# Agenda



- Introduction
- Friction Stir Welding Details and Applications
- Study for Next Generation Truck
- Mechanical Property Data of Friction Stir Welded Aluminum
- Stamping Trials



# **TWB Company – Over 50 Applications Applied**

#### Tailored Blanks (TB) Tailored Coils (TWC) Hot Formed Tailored Blanks (HFTB)

- Save weight
- Reduce cost
- Improve material utilization
- Consolidate parts

### **TWB Company – Global Solutions**



TWB & WISCO Tailored Blank Groups support the global automotive market

BUILT Ford TOUGH



#### **Friction Stir Welding Process**

- FSW is a solid-state welding technique (no metal melting).
- A rotating tool with a specially designed pin and shoulder is inserted into the abutting edges of the sheets to be joined and then traversed along the seam.



- The rotating tool serves three primary functions:
  - 1. Heats the workpiece by friction and plastically deforms the material
  - 2. Moves plasticized material along and across the seam
  - 3. Restricts and contains the metal flow at the tool shoulder position to accomplish a smooth, uniform transition from one sheet to the other

### **Friction Stir Welding Characteristics**

- Fine grained microstructure with excellent mechanical properties
- Smooth transition across seam
- No weld solidification effects (porosity, shrinkage, hot cracking)
- Able to weld through lubricants
- Green technology low energy consumption and no hazardous fumes





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#### **Friction Stir Welding Microstructure**



#### **From Aerospace to Automotive – Innovations**

First dedicated Aluminum Tailor Welded Blank line in North American



DOE collaboration achieved a significant increase in FSW speeds to make the process viable for high volume automotive manufacturing.

#### **Key Innovations**

- Thin sheet welding (0.8mm min)
- High speed (up to 6 m/min)
- Differential thickness welding
- Curvilinear 2D welding
- Joining all 5xxx, 6xxx, and 7xxx alloys
- Joining mixed alloy families
- Joining Magnesium sheet

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#### **Tailored Product Benefits**

Aluminum TB lowers the \$/kg cost of an aluminum solution and provides further weight savings.



#### Rear Firewall - 1.2 mm/1.5mm/1.2mm 6014



Door Inner - 2.0mm/1.1mm 5182

	Tailored Product Opportunities		
Benefit	Part Consolidation	Part Optimization	Material Utilization
Weight Savings	$\checkmark$	$\checkmark$	
Cost Savings	$\checkmark$	,	$\checkmark$
Investment Savings	$\checkmark$	$\checkmark$	
Improved Product Performance	$\checkmark$	$\checkmark$	
Improved Manufacturing	$\checkmark$		
Improved Dimensional Control	$\checkmark$		

Tunnel Reinforcement - 1.25mm/2.0mm/1.5mm 6014

# **Aluminum Welding – Technology Choice**



Monroe, Michigan USA

#### **Friction Stir Welding**

- Solid state welding process
- Fine grain microstructure, low distortion, excellent properties
- 2D is available today
- Able to join high Cu alloys
- Sheets welded as received with lube
- Scalable for high volume production



Duisburg, Germany

BUH

#### Laser Welding

- Fusion welding process with filler material required to replace Mg and fill shrinkage gap
- 2D welding is not available today
- High Cu alloys under development
- Lube removed prior to welding
- Transferable to existing high speed Conti weld lines

# **Application Study – Underbody Component**

An underbody component was studied as a potential application for FSW Aluminum blanks on the next generation Truck.



- 6XXX series aluminum
- Material utilization opportunity
  - Opportunity for cost save
  - Same gage welding

# Welded vs Monolithic – 6XXX Aluminum



- Yield Strength equivalent in welded samples as compared to parent metal
- Slight decrease in Ultimate Tensile Strength in welded samples
- Decrease in Elongation in welded samples
- Properties along weld essentially equal to parent metal
- Compares favorably to typical Aluminum GMAW of 6XXX series, which may result in YS and UTS decreases of over 50%

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No distinct heat affected zone (HAZ)

BUIL

# **Rolling Direction**



- Yield Stress and Elongation measured for different rolling directions
  - Longitudinal = L, Transverse = T

BUL

#### **Heat Treatment – T82**



- Yield Stress and Elongation measured for different rolling directions
  - Longitudinal = L, Transverse = T

#### **Limited Dome Height**



- Punch displacement measured for different rolling directions
  - Longitudinal = L, Transverse = T
- Results predict acceptable formability

# **Mechanical Joining**



- Mechanical joining should be positioned in the parent metal.
- The effects of the joining method should not encroach on the weld affected zone.



# Corrosion



- No objectionable surface corrosion observed on uncoated surface near welds
- Welded area passes e-coat adhesion requirements



# **Stamping – Underbody Component**



- Three stamping trials completed for component:
  - Prototype die, 5-piece production tool, and run-at-rate trials
- For each trial, parts were successfully formed
- Run-at-rate trial had splits on some panels which propagated further than previous trials



# **Stamping – Underbody Component**

- Stamping trials demonstrated that position of the weld line in the tool is critical.
- The notched areas at starts and stops of welds, where the tool enters and exits the blank, are stress risers.
- Strain must be minimized at notched areas.
- Run-at-rate trial saw further split propagation.



Panel from Prototype Stamping Trial Panel from Run-at-Rate Stamping Trial



# **Stamping – Underbody Component**

 CAE simulation of stamping showed high strain at notches at end of welds.



- Adding a cut-out to remove the notches (and the stress risers) reduces the probability of splitting.
- Moving the weld to an area without transverse material flow at the notches could also prevent splits.

# **Summary**



- Aluminum Tailor Welded Blanks are feasible for high volume production
- Mechanical properties of the Friction Stir Weld seam are especially beneficial for 6XXX series Aluminum
- Friction Stir Weld seam starts and stops should be kept in low strain or removed for stamping
- Additional plant trials planned for 2<sup>nd</sup> quarter 2017

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