Replacing Hot Stamped, Boron, And DP1000 With “Room Temperature Formable”
Flash® Bainite 1500 1600MPa

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“Steel stakeholders” from Academia, Mills, Equipment Builders, etc gathered to review an inventory of >80 global steel technologies and identify what resources were needed to facilitate “the next big thing”. While the report is not yet distributed, desired aspects of a future Advanced High Strength Steel were discussed. The “needs” heard were:

- Leaner alloying to reduce cost
- Leaner alloying to lower carbon equivalence to improve weld-ability
- Leaner alloying to allow easier primary production of the steel, i.e. rolling plain carbon steel has less concerns than medium/high alloy (Mn) steel.
- Leaner alloying to improve recyclability. 6-8% alloy is not desirable and will “contaminate” future heats of steel. Sorting at the scrapyard won’t be cost effective to identify “high alloy” car parts (same problem as Al alloys).
- Low cost equipment that is widespread deployable to achieve >1000MPa, instead of centrally located $400M CALs that few can afford
What is Flash® Processing?

... Flash Processing starts with commercial off the shelf steels like AISI1010, 1020, or 4130

... using Induction Heating technology the steel is rapidly heated in approx 2-3 seconds to temperatures over 1000°C, typically 1070°C to 1200°C

... within a few seconds, the austenized steel is quenched with a water spray or bath.

... by limiting austenization time, the natural heterogeneity of the steel is preserved to create an engineered micro-segregation of both chemistry and phase in a matrix that combines the strength of martensite with the ductility of bainite.
Flash® Bainite 1550MPa Crush Can

1.2mm wall tube folding to 0T-1T rads
50x60mm can “crushed” from 140mm tall to 50mm
then Wire EDM-ed in half.
1200MPa Yield Strength ~ resistance to folding

Note: Most OEMs use at most DP780 since DP980 cracks
IRAD Testing of Seating Components
Flash® 1550 Room Temp “Crash Formed” in Prototype Tools

No noticeable “Thinning”
Room Temperature Formed
1.2mm Flash® Bainite 1600MPa
MY2015 ~ Floor Reinforcement

Single hit, soft prototype tooling
No noticeable thinning of vertical walls.

Note: 2015 production vehicle is currently Hot Stamp 1500
Room Temperature Formed 1.2mm Flash® Bainite 1600MPa MY2015 ~ B-Pillar Reinforcement

Single hit, soft prototype tooling
No noticeable thinning of vertical walls.

Note: 2015 production vehicle is currently Hot Stamp 1500
Room Temperature Formed 1.2mm Flash® Bainite 1600MPa MY2014 ~ Roof Rail

Single hit, soft prototype tooling
No noticeable thinning of vertical walls.

Note: 2014 production vehicle was made with Hot Stamp 1500
Carbon moves rapidly but can be controlled.
Minimal alloying reduces dislocations to limit fracturing.
CCT predicts, TEM/Atom Probe confirm presence of Bainite.
Readily weldable: the vast majority of steel grains are very lean.
Why can Flash® Bainite form parts this Strong?
Heterogeneous complexity can lead to ~

"Maximum Strength" in Steel

Research by: Tomita and Okabayashi
Young and Bhadeshia

It has been known for 30 years that ~25% Bainite and ~75% Martensite is stronger than ~100% Martensite
Forming Limit Curves: *Flash® 1500 and Martensite 1500*

- **Flash® 1500**
  - Thickness: 1.3mm
  - Yield: 1200MPa
  - Tensile: 1500MPa
  - Ratio: 80%
  - Elongation: 6.8%
  - Minima Pt: 0.12

- **Martensite 1500**
  - Thickness: 1.4mm
  - Yield: 1400MPa
  - Tensile: 1550MPa
  - Ratio: 90%
  - Elongation: 6.1%
  - Minima Pt: 0.05

- Thicker steels have higher minima points on the FLD, yet thicker M1500 is still significantly lower than thinner Flash® 1500 in this comparison.
- While “total elongation” is similar, the unique Flash® 1500 microstructure offers notably higher “form-ability”.
Which Metal is Truly “Light”? Consider “Specific Strength” aka Strength per Unit Mass

![Graph showing tensile strength and specific strength comparison for different metals.]

Aluminum is NOT “lightweight” (it’s low density) ... great for hoods/door skins but weak & heavy for Structure. Flash Bainite is stronger than Ti-64 & hot stamp.
Weight Reduction … & Cost Savings

- DP1000 is the “industry best” room temperature form-able sheet steel in widespread use (DP1180 is in limited use on a few models)
- Stamping of numerous OEM parts shows Flash 1600 forms as well as DP1000
- A typical B-Pillar made of DP1000 weighs 12 lbs (1.8mm) while a thinner Flash 1600 B-Pillar weighs only about 8 lbs (1.2mm)

<table>
<thead>
<tr>
<th>Material</th>
<th>Raw Mat’l Cost / Lb</th>
<th>“All in” Cost to Flash® / Lb</th>
<th>Part Weight</th>
<th>Total Mat’l Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP1000</td>
<td>$0.65</td>
<td>-----</td>
<td>12</td>
<td>$7.55</td>
</tr>
<tr>
<td>Flash® 1600</td>
<td>$0.35</td>
<td>&lt;$0.15</td>
<td>8</td>
<td>$4.00</td>
</tr>
</tbody>
</table>

1/3 less weight at a 47% material cost savings
Cost Reduction … & Same Weight

- Hot Stamp 1500 is the only known method to achieve 1500MPa strength currently available to Auto OEMs

- Hot Stamp 1500 is typically priced at $2.00-$3.00/lb for finished parts depending on complexity. Hot stamping is inarguably more expensive than cold stamping.

- Room temperature stamped parts are typically priced at $1.00-1.25/lb

- For an average B-pillar made of 1500MPa steel, the weight for a 1.2mm thick part is 8 pounds

<table>
<thead>
<tr>
<th>Process</th>
<th>Material Cost / Lb</th>
<th>“All In” Cost to Flash® / Lb</th>
<th>Forming</th>
<th>Total</th>
<th>8 Lb B-Pillar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Stamp 1500</td>
<td>$0.65</td>
<td>----</td>
<td>Hot Stamp +Laser $1.85/lb</td>
<td>$2.50/lb</td>
<td>$20.00</td>
</tr>
<tr>
<td>Flash® 1600</td>
<td>$0.35</td>
<td>&lt;$0.15</td>
<td>Cold Stamp +Laser $0.75/lb</td>
<td>$1.25/lb</td>
<td>$10.00</td>
</tr>
</tbody>
</table>
Checking Flash® 1600 against the AHSS "Needs" List

☑️ Leaner alloying to reduce cost (not 3-5%wt Mn)
FLASH 1600 IS MADE FROM AISI1020 PLAIN CARBON STEEL

☑️ Leaner alloying to lower carbon equivalence to improve weld-ability
FLASH 1600 IS READILY SPOT/LASER/GMAW WELDABLE WITH CEV OF 0.30

☑️ Leaner alloying to allow easier primary production of the steel, i.e. rolling plain carbon steel has less concerns than medium/high alloy (Mn) steel.
FLASH 1600 IS MADE FROM AISI1020 PLAIN CARBON STEEL WHICH CAN BE MADE IN MOST MILLS

☑️ Leaner alloying to improve recyclability. 6-8% alloy is not desirable and will "contaminate" future heats of steel. The 3-5%wt manganese is a "persistent contaminant" that does not burn off upon melting.
PLAIN CARBON STEELS ARE VERY LEAN AND RECYCLED FOR DECADES

☑️ Low cost induction heating equipment that is widespread deployable instead of $400M CALs that few can afford.
FLASH LINES ARE 15-20% THE COST OF A "CAL" PER TON OF ANNUAL CAPACITY. EQUIPMENT STARTS AT ONLY $300K WHILE 50K TONS/YR = $5M. FLASH LINES CAN BE INSTALLED AT OEMS, TIER 1S, & SERVICE CENTERS.
In June’11, mainstream media wrote that Flash® Processed steel... “could enable carmakers to build frames that are up to 30% lighter and thinner without compromising safety.”

“... the claimed 30% reduction in vehicle (component) weight would have a profound impact on society in a world with limited petroleum and associated economic and geopolitical concerns, and with respect to carbon footprint, global warming, etc.”

Prof John Speer
Colorado School of Mines
AIST Transactions, Vol 8, No. 5, October, 2011

Flash® Bainite has “room temp” formed into OEM prototype structural parts 20-58% lighter than than the versions made of mild steel, HR550LA, DP780, DP1000, and DP1180 ... all at a predicted cost savings
More Than an Experiment in Salt Pots, the Flash® Pilot Line has Run 100s of Plates

- 1000 Kw Induction Austenize
- 2000 Amp 480 Volt Electrical
- 250 Kw Induction Temper
- Tempering Furnace
- Chilled Water Reservoir
- 1050 Gallons Per Minute Water Flow at 20’ Tall
- 200 Ton Cooling Tower
Benefits of Flash® Processing

- 20-33% component mass reduction at a cost savings
- Near 50% cost savings over hot stamping
- Excellent weld-ability
- Lower cost, readily available feed stock (i.e., plain carbon steels like AISI1010, AISI1020, etc.)
- Lower initial capitalization costs:
  - Only 15 to 20% the cost of current AHSS equipment on a per ton basis
  - Small scale operations can be installed, you do not need a $400M continuous annealing line to Flash® Process
  - Minimal equipment can be installed for $300K while a 50,000 ton/year line will be only $5-7M

- A new and massive business sector for Induction that could impact 1/3 the Automotive Stampings!!!
Backup Slides
At the same geometry and mass, Flash® Tubing has ~15% higher Resisting Force and ~20% more Energy Absorbed than Boron Tubing.
Roll-Forming Soft Steel . . .

then Flash® Processing

**Objective:** Determine viability of Flash® Bainite for high-volume roll-formed applications.

**Collaborator:** Superior Roll Forming

**Current Status:**
- Analysis indicates +30% weight savings yet a much stronger, 1800MPa component
- Tooling completed

**Underway:**
- Production representative line
- Multiple tests per collaborator’s protocols
- Very minimal distortion achieved
- HAZ of tube ERW eliminated