Solution **Heat treatment, Forming and in-die Quenching Process (HFQ®)**
Impression Technologies (ITL)

- Has exclusive rights to the HFQ® technology
- Parts being supplied in premium segment production cars
- Current development projects in all major transport sectors
- Invested $7m in the world’s first dedicated HFQ® forming line
- Growing technology pipeline: more alloys & higher productivity

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What is HFQ®?

- HFQ® is a disruptive enabling technology for stamping complex-shaped aluminum components from High-Strength and Ultra-High-Strength alloys.

- HFQ® is utilised to reduced cost through part integration, deletion of reinforcements and reduced tooling investment.

- HFQ® is being used to reduce mass by using high- and ultra-high strength grades.
HFQ® Heat Treatment Forming and cold-die Quenching system for high-strength aluminum alloys

HFQ® does not require pre-tempered material.

The tempering stage has moved from the rolling mill to the Tier 1.

HFQ® does NOT introduce additional heating stages to the supply chain
Applicability of HFQ® technology

Automotive & Truck
Light-weighting using aluminum to play a critical role in meeting emissions targets, particularly for larger cars & EVs

Aerospace

Rail & Mass Transit
Strong long term growth predicted. Increasing focus on cost-effective manufacture of aluminum components

✓ Cost Reduction ✓ Mass Reduction ✓ Design Flexibility
HFQ® Development Timeline

- 2003: Early test work at the University of Birmingham
- 2008: Research moves to Imperial College London (World top 10 Engineering school).
- 2010: Commercial research begins.
- 2012: Testing extended to realistic geometries.
- 2013-14: Technology licensed by ITL to Tier-1 suppliers. Production tools ordered for vehicles.
- 2015-2016: World’s first dedicated HFQ® production line is installed.

- 13 years and $20 Million of extensive R&D at two world-leading universities. Advanced HFQ® know-how transferred to ITL for realisation of commercial opportunities.
ITL Has The World’s First Dedicated HFQ® Production Line

- Technology Center to showcase HFQ® & support technology development
- Key process blueprint for OEMs/Tiers
- Training center for OEMs/Tiers
- Capacity to pilot use of HFQ®

ITL is based in Coventry, at the heart of the UK’s automotive manufacturing sector.

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HFQ® for Automotive Design

• **Exchange** steel parts for aluminum without the need to simplify or split the geometry

• **Consolidate** aluminum parts with **fewer operations** while maintaining acceptable elongation (i.e. better crash performance)

• Use high-strength grades to allow **downgauging** (reduce **weight**, reduce material usage)

• Remove the need for springback-compensation in tool and part design

• **Remove** reinforcement panels otherwise required to add strength

• **Replace** high strength Al extrusions with high-strength HFQ® pressings
## A Selection of HFQ® Typical Automotive Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Strength</th>
<th>Formability</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/B Pillars</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Closure Inners</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Bumper Beams</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Door Rings</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Longitudinals</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Drain Channels</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Lamp Cans</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Subframes</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

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HFQ® is already on production vehicles

- HFQ® Complex A Pillar Reinforcement pressings – 2 off per car produced in a single HFQ® draw operation. Aston Martin DB11.
The New Lotus Evora 400R with HFQ® Technology

- HFQ® Foot well Panel – 2 off per car produced in a single HFQ® draw operation
- High strength part to transfer load into sill, with formed depression for improved occupant foot well space
HFQ® has been the focus of a major EU development programme for automotive light-weighting.

HFQ® formed in a single HFQ® draw operation

LoCoLite EU Wide Project: 300MPa 6082T6 Deep Drawn Door Inner

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LoCoLite Project: High Strength Cross Member for CRF

Ultra-high strength 7075 aluminium with 450MPa yield strength and complex geometry, not formable any other way
Exceptionally high levels of formability at laser welded joints
# HFQ® - Real Weight Saving Potential

## TWB Door Inner Assembly Performance

<table>
<thead>
<tr>
<th>Design</th>
<th>Beltline Stiffness (measured displacement)</th>
<th>Torsional Stiffness (measured displacement)</th>
<th>Side Intrusion</th>
<th>Door Inner Assembly + Beltline Outer Mass</th>
<th>% Saving</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Door Inner assembly target</td>
<td>&lt;3.2mm</td>
<td>&lt;8mm</td>
<td>&lt;207.5mm (actual)</td>
<td>&lt; 6.067Kg (actual)</td>
<td>-</td>
<td>Conventionally pressed baseline design</td>
</tr>
<tr>
<td>HFQ® TWB 2-1.5mm</td>
<td>3.1mm</td>
<td>7.4mm</td>
<td>194.2mm</td>
<td>-1.108Kg</td>
<td>18.3%</td>
<td>Fully optimised HFQ® - TWB design</td>
</tr>
</tbody>
</table>

Results courtesy of Lotus Engineering

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HFQ® business model – moving towards an industry standard

- ITL licenses HFQ® process to OEMs & Tiers
- ITL continues develop HFQ® to expand range of applications and cost & weight savings

HFQ® Customer Technology Support Provision

- Application guidance to OEMs
- Materials characterisation
- Design for manufacture feasibility
- Forming simulation & tool die face development
- Prototyping and niche/low volume production
- Applied R&D
New HFQ® Production Cell in Coventry, UK

- World’s first dedicated HFQ® production line
- State-of-the-art high volume press line supplied by AP&T
- Includes solutionising oven with automatic transfer to hydraulic press
- Bed size 3.0m x 1.6m
- Facility also includes aging oven

Fully operational and producing parts for current Aston Martin & Lotus models. Also producing evaluation and prototypes for leading automotive OEMs
HFQ® Forming Simulation Capability

• Forming simulation of HFQ® process using Pam-Stamp which includes:
  ➢ Fully coupled thermo-mechanical computations for all physical steps of the process.
  ➢ Quenching analysis for in-die cooling enabling cyclic tool temperature predictions

• Access to and use of mathematical models describing material behaviour

• HFQ® simulation software will not be exclusive to a single provider

• HFQ® simulation software will be commercially available by 2017