Using Fusion 360 and metal AM to optimize automotive mold cooling solutions

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Agenda

- Intros
- ITL Background
- Project Aim
- Project Steps
  - CFD Simulations
  - Design Iterations
  - Manufacturing
- Conclusions
- Next Steps
- Q&A
Introductions

Jack Holmes

- Technology Consultant at Autodesk, working with customers and partners across all industries to innovate on solutions
- Focus on Fusion 360 manufacturing, including subtractive, additive and machine tool connections
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Joe Pike

- Programme manager at Impression Technologies with experience across various automotive sectors for OEM’s including Ford, Jaguar Land Rover, Bentley & McLaren.
- Enables customers to complete projects in quick succession with cradle to grave support.
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Impression Technologies Ltd (ITL)
Background & Technology

HFQ is a proven scalable process similar to that of press-hardened steel
# HFQ® - The Benefits

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>SUSTAINABILITY</strong></td>
<td>Circular aluminium enabler – up to 95% emissions savings</td>
</tr>
<tr>
<td><strong>COST REDUCTION</strong></td>
<td>&gt; 20% reduction in part cost &amp; tooling</td>
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<tr>
<td><strong>MASS REDUCTION</strong></td>
<td>20-50% weight saving</td>
</tr>
<tr>
<td><strong>VIRTUALLY NO SPRINGBACK</strong></td>
<td>Dimensional conformance first time</td>
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<tr>
<td><strong>RETAINED DUCTILITY</strong></td>
<td>Improved energy absorption for crash</td>
</tr>
<tr>
<td><strong>PART INTEGRATION</strong></td>
<td>3 parts to 1: Lower assembly &amp; tooling costs</td>
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ITL a Global Automotive Supplier

- **2012**: ITL incorporated
- **2016**: First commercial application
- **2017**: Collaboration with aluminium suppliers
- **2019**: First Tier signed
- **2021**: Tier production capable
- **2022**: Collaboration with aluminium suppliers

- UK production volumes ramp up
- >25 new parts
- >$30m investment
- HFQ lines installed in EU and CN
The Latest -

HFQ Technology & business model is now validated by the mass market

Electric vehicles and sustainability will drive increasing demand

Latest wave of nominations provide springboard for global scale-up

£5m raise to address automotive & aerospace market opportunity
World first - HFQ safety cell on DBX designed for side intrusion & roof crush
Applied Benefits of HFQ Technology versus Cold Forming

- **Integration** of front Header connection, not possible with cold forming
- **Minimum bond flange width**, for improved occupant vision
- **Deep draw capability**, not possible with cold forming
- **Extremely tight** internal bend radii, not possible with cold forming

Utilisation of high strength aluminium to reduce weight - circa 20% versus lower strength cold form grades

- Formed in a single HFQ draw operation to minimise investment
- Negligible springback
Tool Cooling in HFQ

- Uniformity of temperature distribution across the tooling surface is key in ensuring an even quench rate

- By maintaining high cooling rates in the HFQ process we are able to provide parts with substantially better material properties when compared to other technologies

- Limitations in current tooling manufacture methods mean that cool tooling can create additional timing when producing tools for manufacture

- By utilising new methodologies, we can reduce tooling manufacture times as well as incorporate optimal cooling designs.
Project Aim & Feasibility
Project Aim

- Cooled Punch Tool
- Design Optimization
- Additive Technologies
- Alternative Design Techniques
- Comparison of D&M Techniques
Project Feasibility Study

- Attempt to prove out the capability and its functionality
- Tryout an uncooled printed part on ITL's smaller press
- Understand how the additive printed tool material interacts with the aluminum and other processes to improve development
Manufacturing Methods
Manufacturing Methods

Metal Additive Manufacturing

- **High Resolution/Complex Geometry**: Powder Bed Fusion
- **Resolution & Part Complexity**: Powder DED
- **Low Resolution/Simple Geometry**: Metal FFF, Wire DED

Part Size: 1 cm to 10 m
Manufacturing Methods

PBF vs. DED

**Powder Bed Fusion (PBF)**
- Higher cost solution
- High resolution / complex geometry
- Internal lattice structure

**Wire Directed Energy Deposition (DED)**
- Lower cost solution
- Low resolution / simple geometry
- Internal cooling channels
Project Process Steps

**CFD Simulation**
Check current design’s performance

**Design Iteration**
Edit design, run simulation, iterate

**Manufacturing**
Produce designs using alternative manufacturing methods

**Testing**
Test end components performance at ITL’s facility
CFD Simulation

- Autodesk CFD checked heat transfer from current design
- Simulation model defined
- Non-conformal cooling displayed
Design Iterations
DED Designs

Iteration 1
DED Designs

Iteration 2
DED Designs

Iteration 3
DED Designs

Selected Design
Lattice Design
Lattice Design
Manufacturing
Build Preparation

- Design edits required for manufacturability
- Reduce overhangs
- Test pieces ran
Overhang Test Pieces

Test Piece 1:

Test Piece 2:

- 5mm radius
- 5mm, 60 degree overhang to rad
- 5mm, 60 degree overhang to point
- 5mm radius, 45 degree overhang tear drop to rad
Overhang Test Pieces

Test Piece 3:

- 7mm radius
- 7mm radius, 45 degree overhang to 1mm rad
- 10mm radius, 45 degree overhang tear drop to 1mm rad
Design Edits

7mm channels applied:
Design Edits

Excess material:
Design Edits

Vertical setup:
DED Builds

Horizontal Build:
DED Builds

Horizontal Build:

Conclusion – technology with current design & setup not suitable. More optimisation needed
DED Builds

Vertical Build:
DED Builds

Vertical Machined:
Design Edits
Internal Lattice

- Volumetric Lattice tool - Fusion 360 Product Design Extension
Design Edits

Excess material added:
Build Results
Build Results
Machining
Conclusions

Manufacturing Outcomes

- **DED:**
  - Orientation very important
  - Avoid overhangs as much as possible
  - Test as much as possible
  - Can get a working result
    - More accessible solution to achieve result
    - Worse surface finish

- **PBF:**
  - Can achieve more complex geometries
    - Less material required
  - Less accessible solution
    - Testing will determine benefits
Next Steps

- Test parts at ITL
- Compare results
- Laser cut parts

- Compare process v. benefits
- Implement into industry applications
- Review and test material properties to quantify the benefits of the technology
Testing & Knowledge of Outcomes

- Once we have pressed components, we will be in a position to test the material.

- Tensile testing the material allows the ITL tech team to quantify the difference and advancement in final material properties.
Implementation

- By validating the processes within the project between Autodesk and ITL, we have proven that new and future manufacturing techniques benefit HFQ.

- The current software has been critical in proving the theory whilst the hardware has enabled us to trial this on a small scale.

- The fast-paced nature of the automotive industry combined with these manufacturing techniques will allow HFQ to be delivered within prototype timing to production standards.

- Once the hardware/machinery advances in terms of size and cost, we are confident that prototype projects will be in a position to have significant timing reductions whilst maintaining critical material characteristics.
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