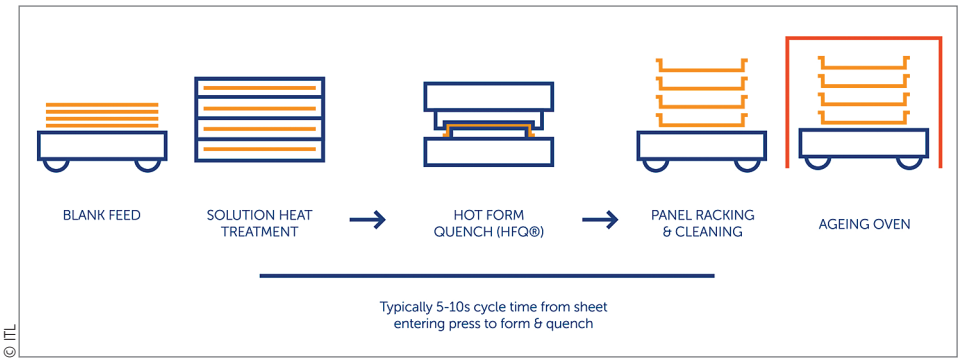
HFQ technology – the future of ultra-high strength aluminium forming

Methods of aluminium forming have experienced a shift in recent years, as focus has moved onto the industry becoming more sustainable, contributing to a 'greener' planet. This has led to the emergence of Hot Form Quench (HFQ) technology, a new type of forming that focuses on light-weighting using ultra-high strength aluminium (UHSAL) alloys and reducing CO_2 emissions via the increased use of recycled and end-of-life feedstocks.



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Overview of the HFQ process

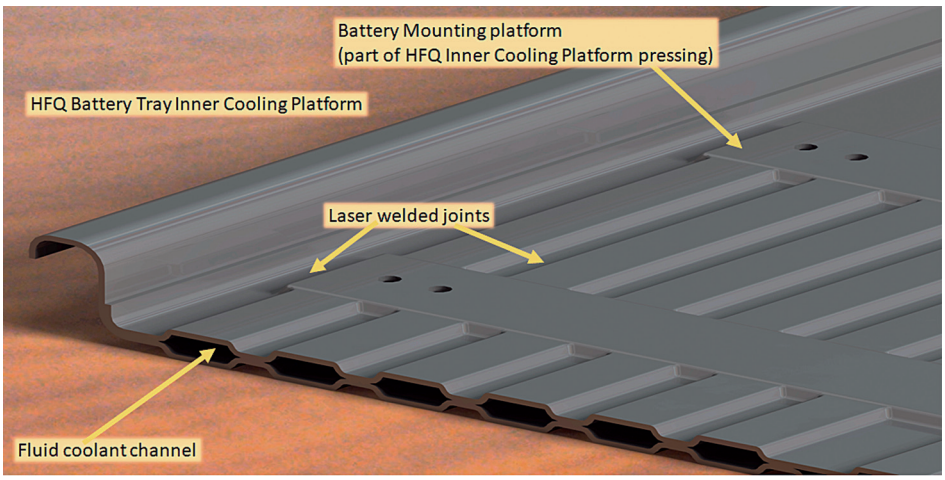
HFQ Technology involves the simultaneous hot visco-plastic forming and in-tool quenching of aluminium sheet blanks at high speed. The formed component then goes through a thermal treatment for artificial ageing so that it can achieve full strength and target ductility. This enables extremely complex and deep-drawn high-strength aluminium parts to be formed in a single press operation, whilst eliminating dimensional problems associated with spring-back.

The pioneer of this forward-thinking technology is Impression Technologies Ltd (ITL), a full-service provider located in Coventry, UK. The company works alongside automotive and aerospace OEMs and tiers, identifying design enhancements to save weight, cost and part count. ITL achieves this through use of a full-scale hot forming press line, supported by an advanced materials characterisation and forming simulation capability, which offer prototyping, series production, technology demonstration and technical support for OEMs and global manufacturing tier partners.

Introduction and history

Further improvements in the light-weight design of automotive vehicles, with the aim of meeting emission targets and improving performance, require new materials but also new forming methods that enable their full potential. Unless a novel material can be formed economically, predictably and sustainably, it is rendered useless for all but niche cost-insensitive applications. In the quest for lighter, stronger and cheaper structures, engineers have usually been able to secure just two of these three target attributes.

Since 2003, the University of Birmingham and Imperial College, London have led ground-breaking research on the visco-plastic forming of ultra-high strength grades of aluminium. Ten years of materials characterisation and modelling and validation testing culminated in the development of the HFQ technology system, which addresses the problems of poor formability in 2xxx, 6xxx and 7xxx series aluminium.



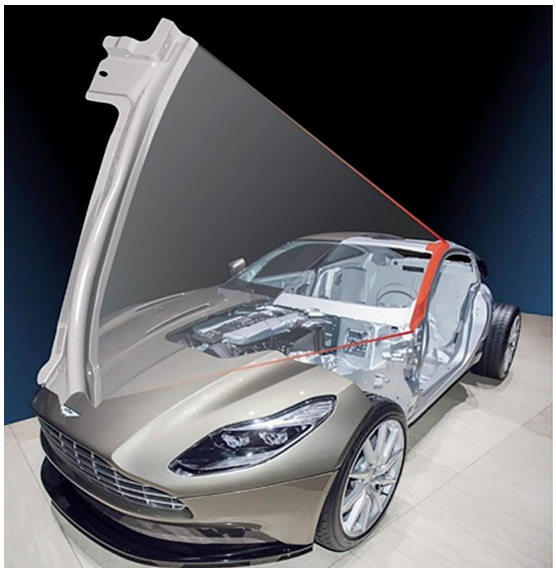
Battery tray concept in HFQ

The HFQ process

HFQ involves heating aluminium sheet to its solutionising temperature before rapid forming and simultaneous in-die quenching followed by any necessary second trimming and rapid artificial ageing operations. The technology is supported by a software plug-in (the HFQ Module) that will support forming simulation and tool face design for tier and OEM designers. Whilst there are some similarities to the processing of press-hardened steel (PHS), now commonplace in the stamping industry, there are some very significant technical differences in heating technology, lubrication, tooling, simulation and secondary heat treatment when dealing with aluminium sheet. In addition, it should be noted that HFQ technology is a 'hot forming' process for aluminium in the range of 350-600 °C, whereas 'warm forming' is an isothermal forming process carried out at around 200-300 °C, which results in more limited formability, increased spring-back and different mechanical properties versus HFQ.

The HFQ process forms pressings that are lighter and deeper than alternative methods such as conventional cold stamping. The process is also much more cost-effective and faster than other methods such as superplastic forming, while still resulting in stronger and lighter structures. This is why the technology is highly sought after, especially in the automotive sector, where road vehicles can especially benefit from such features.

Alan Peel, chairman of Impression Technologies, said: "The unique aspects of the HFQ process are going to be incredibly important to multiple sectors, but the automotive sector in particular is one we are making huge waves in. With more and more companies embracing the process, and singing the



AML pillar showing

praises of HFQ, it is clear that the technology has some exciting years ahead."

The first automotive applications were launched by ITL in 2016 with 6xxx series deep draw structural parts on the Lotus Evora and Aston Martin DB11 and the adoption of this technology is accelerating, particularly in the global electric vehicles (EV) sector. Lightweighting improves fuel efficiency or range, and allows smaller battery packs for EVs. The growth in this sector has also led to the development of an HFQ battery tray solution to reduce the piece part cost versus extrusion intensive designs, and to make use of high-strength 6xxx sheet alloys to further improve component durability and crash performance.

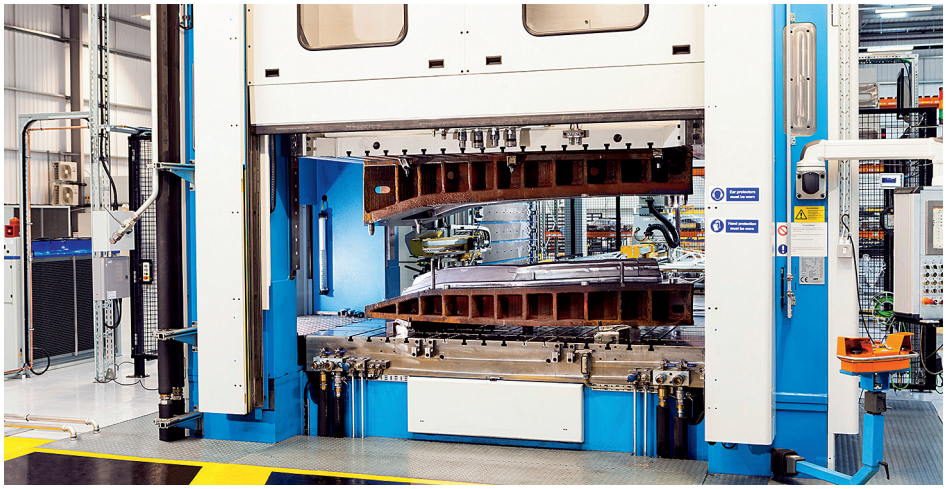
For its first significant vehicle application, ITL worked with Aston Martin on the A pillars for the DB11, producing a part in 6082 alloy, achieving 310 MP a yield strength (and 11% residual elongation) with the tight radii permitting narrow bonding flanges and the attendant improved driver visibility. This first successful application proved to be a launchpad for wider adoption by Aston Martin into subsequent platforms, including the new DBX SUV, which incorporates a complete safety cell using nine parts formed with the HFQ Technology.

Why is HFQ so important?

The purposes of HFQ technology are to make aluminium lighter, but also ensures that the use of it is environmentally friendly. Recently, ITL held a networking event at the Guildford Harbour Hotel in southern England with the HFQ Partner Network, a group of likeminded businesses from the global light-weighting ecosystem world who believe that HFQ technology plays a key role in the future of sustainable lightweight aluminium structures.

This group, made up of businesses from around the world, believes that aluminium can play a key role in the electrification of transportation, as a growing focus on recycled material content supports the sustainability and low CO_2 targets of OEMs around the globe. Not only that, but with lighter materials in the automotive industry leading to higher fuel efficiency or longer battery range, these plus points give HFQ technology a loud, clear and concise message, as companies and manufacturers aim to improve the health and sustainability of the planet.

"There is a real belief within the HFQ Partner Network group," said Peel. "The next steps, follow-on projects, and activities by the group will ensure that HFQ technology receives the notice it deserves. When we get together once again later this year, we hope to have made serious progress as we demonstrate the benefits of HFQ Technology to OEMs."



Hot Form Quench press

Further advances in HFQ technology

Having launched the first generation of HFQ technology, the technique is now becoming more widely adopted throughout the industry, and further enhancements are currently underway. Aside from continuous refinement of the core manufacturing process to refine cycle times, process capability and secondary operations, there are two poles of activity: recycled alloys for high strength structures formed using HFQ, and ultra-deep draw capability for the most demanding structures, which include battery trays and door inners.

For recycled alloys, HFQ has already demonstrated very promising results with a variety of recycled feedstocks, most impressively 100% bottom-ash content alloy. Achieving high formability with such a feedstock reinforces the circular economy credentials of aluminium and with 95% emissions saving versus primary stock, such aluminium could make a significant contribution to the reduction of embedded carbon within a vehicle. The next objective is to carry out a full set of validation trials, ideally in partnership with an automotive OEM.

Continuing the theme of sustainable mobility, the newly extra-high formability form of HFQ will be of particular benefit for new designs of battery trays, which have very tight internal radii and deep rectangular packaging constraints. The HFQ Technology roadmap also includes advanced microstructural simulation, next generation aluminium alloys and ultra-high throughput manufacturing.

ITL is continuing to develop its understanding of recycled alloy chemistry/composition linked to the key attributes of HFQ – a broader scrap chemistry/composition is being targeted that still achieves high performance sheet parts.

This will also assess the potential to access the wider aluminium scrap market compared to conventional cold-formed aluminium sheet parts that use existing-off-the-shelf alloys, typically containing greater prime metal content and/or a much more limited range of purer aluminium scrap types. The objective is to deliver HFQ parts that provide all the performance benefits, but with ultra-low carbon recycled material and at a lower cost. ■