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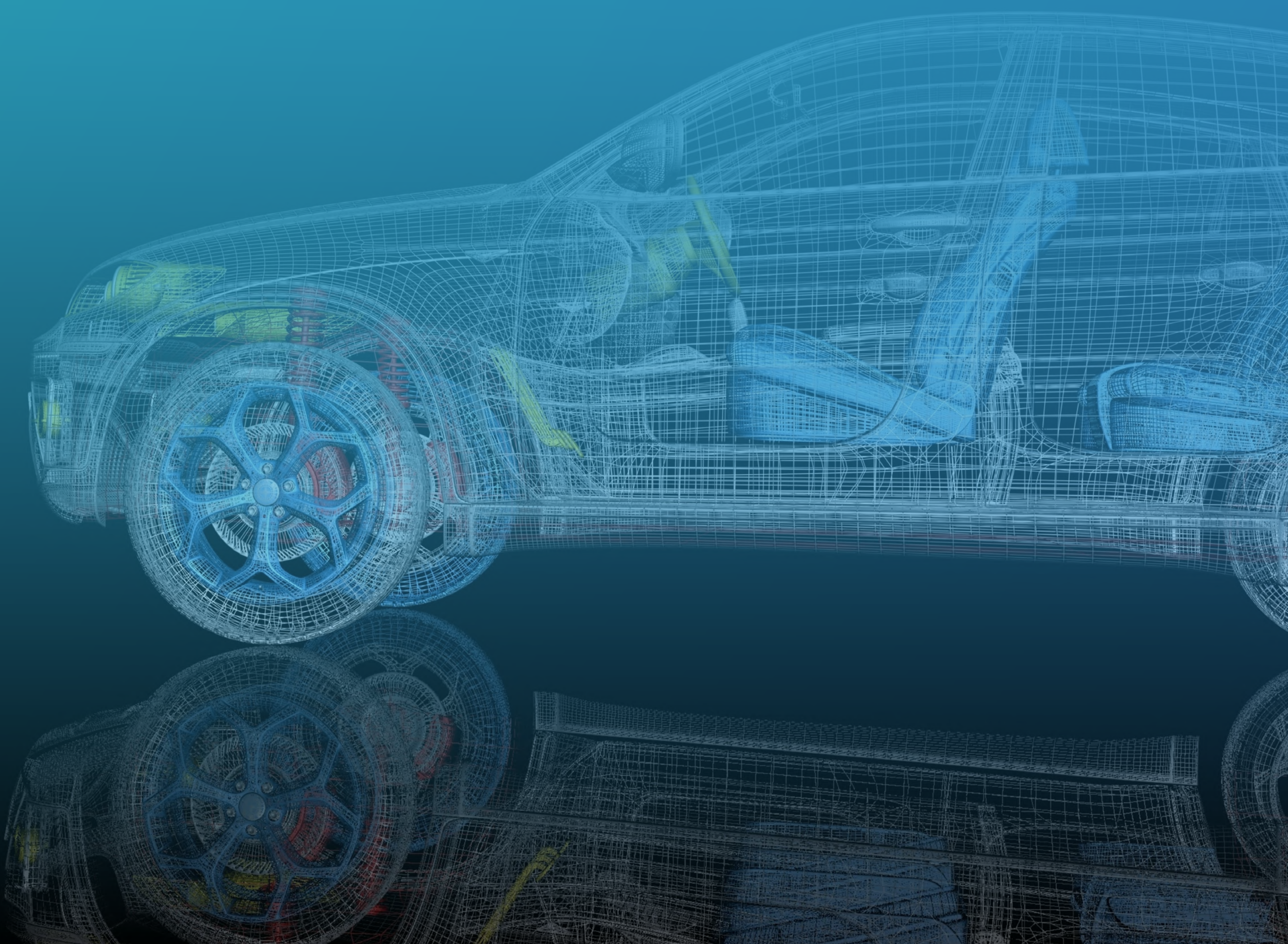
AffordabLe LIghtweight Automobiles AlliaNCE

Accelerating the application of material and manufacturing technologies through the **Lightweight Open Innovation Challenge**



Accelerating the application of material and manufacturing technologies through the **Lightweight Open Innovation Challenge**

Final Report

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Executive Summary

This document is intended to describe the results of the Lightweight Open Innovation Challenge (LOIC) and its related activities.

The LOIC is a competition which aims to attract individuals with innovative solutions in the field of lightweighting, and allow them to co-develop their technologies together with ALLIANCE partners, in order to increase the performance and reach of their solutions, thus strengthening their impact.

The LOIC attracted a total of 22 applications from 15 organisations and individuals across the world. Four applicants were selected to move on to the next phase, where they had the opportunity to work closely together with ALLIANCE partners, co-developing their technologies and applying them to virtual demonstrators. The winners were Vestaro GmbH (Germany) with a polymer material innovation; Imperial College of London (UK) with a manufacturing innovation for metal alloys; Outokumpu Nirosta GmbH (Germany/Finland) with a portfolio of a materials and manufacturing innovations; and F.Tech Inc. (Japan/Germany) with a manufacturing innovation for HSS.

Following the end of the LOIC, the ALLIANCE partners are now working together with the winners on exploitation activities suitable for each technology's maturity level and potential.

MOTIVATION

Why an Open Innovation challenge?

ALLIANCE brings together 18 leading automotive organisations, working towards reducing the weight of cars through materials and manufacturing innovations. The innovations are expected to be introduced to the market within 5 years from project finalisation; 2024.

Although the consortium gathers a significant amount of knowledge and expertise in the lightweighting field, it also acknowledges that several innovations in the field can come from organisations which are not participating in ALLIANCE – from academia and RTOs, to SMEs and large enterprises. Aiming to include others in the process of developing the lightweight vehicles of the future, ALLIANCE has set up the Lightweight Open Innovation Challenge (LOIC).

The LOIC is a competition open to all organisations working in the field of lightweighting across the world. It is an opportunity for innovators in the automotive lightweighting field to be discovered by OEMs, co-develop their solutions together with them to contribute to ALLIANCE targets, and potentially become part of larger industrial value chains.

BACKGROUND

Who we are

ALLIANCE (Affordable Lightweight Automobiles Alliance) is a research and innovation project on automotive lightweighting, co-funded by the European Commission's Horizon 2020 programme and supported by EUCAR, the European Council for Automotive R&D. failed to reach widespread adoption. This is mainly due to high costs, the result of several factors, including the cost of materials (e.g. carbon fibre reinforced plastics), long cycle times and investments in new machinery and tooling.

The consortium includes six European carmakers (Daimler, VW, TME, CRF/FCA, Volvo and Opel), four suppliers (Thyssenkrupp, Novelis, Batz, Benteler) and eight knowledge partners (Swerea, Inspire, Fraunhofer LBF, RWTH-ika, KIT-IPEK, University of Florence, Bax & Company, Ricardo).

In 2016, the ALLIANCE consortium joined forces to commonly deal with the high cost of innovations in vehicle lightweighting. Although lightweighting initiatives have resulted in several innovative solutions based on steel, aluminium, composites and hybrid materials, the majority of efforts have

Effective and affordable lightweighting requires a holistic approach; it requires processing large amounts of information (performance, manufacturability, cost, environmental). Carmaker designers/engineers need to evaluate these criteria in a multi-parameter optimisation. The high complexity of this optimisation makes lightweighting one of the most challenging tasks of modern automotive designers and engineers.

Overall, the cost of lightweighting has been identified as the major bottleneck towards the implementation of lightweight materials in vehicle mass production.

ALLIANCE objectives

The main objectives of the ALLIANCE project are to reduce vehicle weight by 21-33%, enabling reduction of vehicle energy consumption by 10% and global warming potential (GWP) by 6%, compared to a conventional vehicle. To achieve that, ALLIANCE is working towards the development of novel advanced materials (steel, aluminium, hybrid) and production technologies, aiming at an average 27% weight reduction over 100k units/year. To ensure that developments will find their way to the market, the consortium aims to achieve its objectives at a cost of <€3/kg saved.

ALLIANCE is also developing the necessary support tools; a mass-optimiser software tool, a multi-parameter design optimisation methodology and process, as well as life-cycle assessment tools, aiming at an accelerated pre-assessment of technologies over existing designs in a holistic framework.

Challenge objectives

1. To discover organisations working with innovative lightweight technologies

The LOIC is designed to attract such organisations. Some ended up applying to the competition and some not (for various reasons, e.g. the technology was not mature enough, or did not fit the ALLIANCE scope). Regardless, mapping these organisations and the technologies they're working on is valuable, since OEMs and other partners can involve them in lightweighting-related initiatives outside ALLIANCE.

2. To allow such organisations to further develop their solutions and come in contact with large industrial players

Some of the organisations – or their specific departments – that entered the LOIC, did not previously have the chance to work closely with OEMs and other organisations in the automotive value chain. Through the LOIC, they were able to reach out to them, and the ones that were selected could work directly on developing their technologies together with the relevant industrial and knowledge partners.

3. To introduce additional lightweight solutions and strengthen the impact of the ALLIANCE project

The consortium brings together 18 partners with significant knowledge, expertise, and intellectual property in the field of lightweighting. Nevertheless, it acknowledges that there is considerable relevant knowledge and technologies outside the project. The LOIC serves as a way to incorporate such technologies within the project, in order to increase the performance and reach of the solutions, and strengthen their impact.

4. Demonstrate a platform to identify innovations and accelerate their development

Several similar initiatives exist around the globe, yet not many of them link applicants with an ongoing research activity. The LOIC serves as a means to demonstrate such an approach and evaluate its benefits.

Similar initiatives outside ALLIANCE

The concept of a challenge-based technology competition in the automotive lightweighting sector is not entirely new. Here are a few similar initiatives launched in Europe and abroad:

The JEC Composites Innovation Awards, held annually since their launch in 1998, reward organisations or consortia that develop innovative solutions that make use of the full potential of composites. Application areas cover a wide variety, from aerospace, to electronics, to medical and prosthetics. The competition is organised in three phases. In the first phase, interested organisations/consortia can submit their application via an online submission form. At the end of the first phase, JEC selects 30 finalists. At the second phase, the finalists showcase their innovations via technical posters at a dedicated section of the JEC World exhibition (held annually in Paris). At the third phase, a jury composed of 10 technical, research and market experts from upstream and downstream select 10 winners which are awarded during a ceremony on the second day of the event. Selection criteria include involvement of partners in the value chain, technical excellence, and market viability. The competition is open to all kinds of organisations – research institutes, universities, and industrial organisations – from around the world. Winners from the last few years include Solvay, BASF, Airbus, BMW, Ford, Kanazawa Institute of Technology, and AeroComposit JSC, among others.

The IDP (Integrated Delivery Program) is a funding framework launched annually as part of the UK Research and Innovation body. The section focused on zero emission vehicles is supported by OLEV (Office for Low Emission Vehicles) and Innovate UK. The purpose of the challenge is to enable industry-led research projects into on-vehicle technologies that accelerate the transition to zero emission vehicles. The scope includes technologies that have the potential of decreasing vehicle emissions (lightweight materials, powertrain, electronics, energy storage and management) for all vehicle segments. In the first phase, applicants are required to submit their applications through an online portal. Shortlisted applications are then invited to an interview. Applicants that are successful at the interview are then awarded a grant of up to £4 million to complete their research project, which can have a duration of up to 3 years. Selection criteria include innovation potential, team and resources, market potential, and expected impact. The competition is open to all kinds of UK organisations (academia, industry, NGO, public agency, RTOs). Winners from previous years include Constellium, Cummins, GKN and AVL, among others.

The ARPA-E LITECAR (Lightweighting Technologies Enabling Comprehensive Automotive Redesign) Challenge is a competition launched in the US, seeking innovative conceptual designs to lightweight a vehicle while maintaining or exceeding current U.S. automotive safety standards. The challenge is part of the larger framework of the ARPA-E (Advanced Research Projects Agency of the Department of Energy). The focus of the challenge is on vehicle design, although applications include innovative materials and manufacturing technologies. Interested applicants are required to submit conceptual proposals which elaborate on their solutions. The first three winners – selected by a jury of experts – are awarded $150,000 in total. The selection criteria are weight reduction potential, safety, degree of innovation, and feasibility. The competition is open to all kinds of organisations.

The Altair ENLIGHTEN Award is given by Altair Engineering to the greatest achievements in vehicle weight savings each year. It has three categories: vehicle; part, component, and/or module; and enabling technology. Nominees are asked to submit their innovations to a panel of experts, which selects the best solutions in each category based on weight saving potential; innovation; replicability/scalability; market viability (cost). Application is open for all kinds of organisations and individuals. Winners from previous years include GM, FCA, Sika, BMW, Honda, Alcoa, and ArcelorMittal.

PERFORMED ACTIVITIES

Timeline

Phase 1 - Registration & Submission (Aug 2017 - Feb 2018)

Interested organisations had the chance to interact with ALLIANCE partners – through events and a dedicated webinar – and submit their solutions.

Initiation and promotion

The promotion of the LOIC started in August 2017. To ensure quantity and quality of applications, a significant effort was put into dissemination and communication activities. The LOIC was announced/promoted through more than 100 channels (online and print publications, blogs, news-sites) through press releases, blog-posts, or news-items. Several communication materials were designed (video, flyers, posters) and disseminated virtually and through relevant industry and academic events where ALLIANCE was represented.

Registration and interaction with applicants

Challenge registration opened in October 2017. Applicants were required to fill in an online form on the ALLIANCE website where they had to choose their type of entry (materials/ manufacturing), explain their contribution to ALLIANCE objectives, their technology readiness, and upload supporting materials.

To further increase applications and answer any questions from potential applicants, a one-hour webinar with key OEMs within ALLIANCE was arranged. It was attended by ALLIANCE representatives from Bax & Company, ika, Opel and Daimler. Some 10 organisations participated. Their feedback was positive, and the session aided their decision to apply to the challenge.

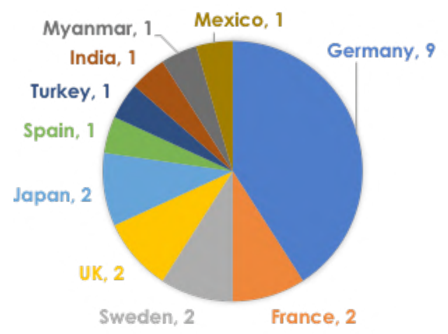
The application period was initially set for three months (October – December), however, certain constraints (such as the final deadline coinciding with Christmas holidays) meant an extension was necessary.

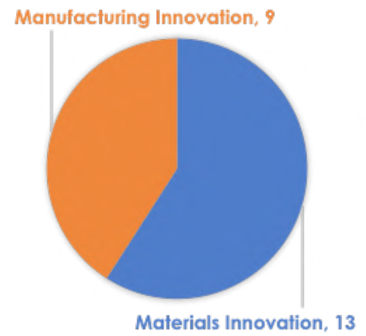
To extend the reach even more, and attract more applications, LOIC coordinators decided to collaborate with innovation platform Innoget, a dedicated platform that connects innovation seekers and innovation suppliers – which allowed to connect with thousands of potential applicants. This was portrayed as an exclusive opportunity for Innoget members to participate in the challenge, where the winner would be fast-tracked to the validation phase.

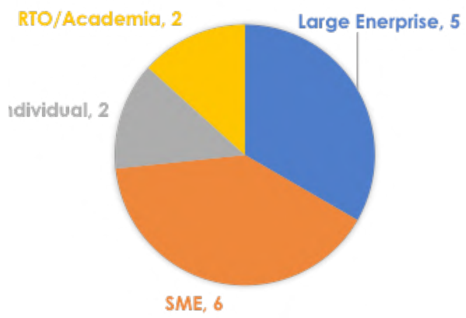
In the end, four applications were received through Innoget, of which one became a finalist.

Selection

The Challenge attracted a total of **22 applications from 15 organisations and individuals from around the world,** who submitted innovative manufacturing and materials solutions and ideas, ranging in maturity and potential.







All applications were evaluated by ika and Bax & Company according to the following criteria:

- **Excellence of Summary of technology quality**
  the ability to sum up the project's contribution to the objectives of the Challenge in some 100 words, in terms that would spark interest in a potential investor or implementer of the idea.
- **Contribution and Complementarity with ALLIANCE goals (impact)**
  the potential of the proposed idea to meet the challenges arising from cutting transport CO_2 emissions by at least 40% by 2030, reducing vehicle weight by 27%, decreasing energy consumption by 10%, and Global Warming Potential (GWP) by 6%.
- **Applicability and implementation**
  the potential of (i) the extent to which the proposed idea can be applied in a vehicle, (ii) and the potential of the proposed idea to be sustained.
- **Technology Readiness**
  the level of validation of the technology (i) if the technology has been demonstrated in relevant environment and therefore already been validates in lab (TRL6), and (ii) if the technology is in series production.

After the first filtering of applications by ika and Bax & Company, baseline questions were sent to selected applicants. Then, the jury liaised with relevant project partners and additional rounds of questions were made when necessary. Once the chosen winners gained final approval from the project Advisory Board, the results were announced to the public.

The jury selected four applications to proceed to the next phase **(F.tech, Imperial College London, Vestaro, Outokumpu).**

Phase 2 - Demonstration/Validation (Mar 2018 - Jul 2018)

Following the selection, winners further developed their technologies with ALLIANCE partners, implemented them in virtual demonstrators, and tested their performance.

At the beginning of this phase, technical discussions were initiated between the winners, ika and Bax & Company. The purpose of these discussions was to gain a better understanding of the technologies presented and determine the extent of the winners' experience within the automotive industry. Discussions also served to ensure that project targets were applicable for the four winners.

Based on the initial discussions, potential applications for the innovative technologies in the automotive body and chassis were identified in close collaboration. Ika presented the ALLIANCE virtual vehicle model based on which different components of the vehicle were analysed, with respect to their functions and requirements. The analysis provided the winners with an insight into the different vehicle domains, as well as materials and manufacturing technologies typically used. Subsequently, a list with potential vehicle part applications of the winners' technologies was generated. The list was then further refined to one or two applications, considering the use case with the highest weight saving potential, cost-efficiency and sustainability impact.

Once the final use case applications were decided upon, the development process started. Ika provided the winners with the geometry data of the components, with the surrounding package restrictions as a design space. Furthermore, the reference material and manufacturing data were provided. The winners then began the layout internally, which included an adaptation of the design if necessary, and initial component simulations, e.g. forming simulations or component-based strength and stiffness analysis. The initial results were shared with the ALLIANCE consortium and assessed regarding feasibility. Feedback was provided to the winners and after a second development loop, the lightweight demonstrators were returned to ika.

Ika then took over the task to implement the new components in the ALLIANCE virtual vehicle model and evaluated the impact by assessing the performance in relevant full vehicle crash scenarios. To do so, the new components were meshed and afterwards integrated in the model with adapted joining technologies. The material cards to perform the simulations were either provided by the winners or generated at ika with their support. The results of the crash scenarios were compared with the results of the reference vehicle. In case of a worse performance, adaptions were carried out to the component in agreement with the winners, until the reference targets were achieved.

Once this process was concluded, an analysis of the weight saving achieved was performed. The second milestone of the demonstration phase was to perform an assessment regarding the cost and environmental impact of the lightweight components. This task was performed with the support of the cost engineering and environmental departments of the winners, or by the ALLIANCE partners Bax & Company and University of Florence.

Phase 3 - Presentation at final event (Aug 2018 - Sep 2018)

Winners presented their innovations at the ALLIANCE Future Lightweighting Day to an audience of representatives of OEMs, suppliers and research organisations.

Preparation for the ALLIANCE Future Lightweighting Day commenced in August 2018. During this time, the winners refined their presentations which showcased results of months of work, as well as created accompanying posters.

The event took place on September 20th at ika-RWTH, where we welcomed key players from the automotive industry and interested researchers.

The day started with the presentations of the LOIC winners, followed by a round table discussion on the future of lightweighting facilitated by representatives of CRF, Fraunhofer and Bax & Company, and concluded with up-to-date results from the ALLIANCE project by researchers from partners Novelis, Opel, Fraunhofer LBF, ika-RWTH, KIT and University of Florence.

The event proved to be highly useful for the winners as it allowed them to meet the ALLIANCE partners face-to-face, which stimulated discussions on future collaborations.

Two days before the event, the winners had the opportunity to exhibit their technologies at dedicated stands at the Aachen Body Engineering Days, a conference organised by ika for experts in the field of car body development, material and production technologies.

RESULTS

Out of the pool of applicants, the consortium selected four winners based on the defined criteria. **Vestaro GmbH (Germany)** with a polymer material innovation; **Imperial College of London (UK)** with a manufacturing innovation for metal alloys; **Outokumpu Nirosta GmbH (Germany/Finland)** with a portfolio of materials and manufacturing innovations; and **F.Tech Inc. (Japan/Germany)** with a manufacturing innovation for HSS. The technologies of each winner are presented in detail below.

VESTARO

Vestalite®S – Curing Agent for EP-SMC

Technology Readiness Level: ***5-6***
Demonstrator: ***Inner Panel Trunk Lid***

VESTALITE®S is an amine-based curing agent from Evonik, for liquid epoxy resin matrices designed for SMC applications. VESTALITE®S can be combined with standard liquid epoxy resins and offers cost efficient processing by best in class mechanical properties for styrene free, high performance EP SMC materials. Systems using VESTALITE®S have a low initial viscosity during compounding, allowing excellent fibre wetting, high fibre volume fraction and efficient processing. The high reactivity of the system allows fast curing in about 3-4 min at 150°C. Due to its solid B-Stage, the material can be stored at room temperature for several weeks. Therefore, the optimal field of application is in high volume production of lightweight semi-structural and structural automotive composite parts (high performance SMC) and styrene free and low-VOC interior applications.

VESTALITE® is a registered trademark of Evonik Industries AG and its subsidiaries

Advantages

- Excellent fibre wetting due to low viscosity of curing agent (formulation viscosity ~ 600-800 mPa)
- Compatible with multiple epoxy resins
- High storage stability of SMC material (>30 days @ RT)
- Fast curing (3 min @ 150° C)
- High mechanical performance (competing aluminium)
- Co-moulding with Epoxy-Prepreg
- Excellent surface quality due to low residual shrinkage through B-Stage
- No styrene emissions
- Low volatile organic compounds (VOC)

Results

- **Weight**
  Achieved 1.95kg weight reduction compared to reference trunk lid (steel)
- **Cost**
  No cost savings with CF-based Vestalite®S SMC Material (lightweighting costs for adapted trunk lid part design < €10/kg saved). Further cost reduction achievable through usage of GF-based Vestalite®S SMC Material (case study being prepared)
- **GWP**
  Achieved 16% GWP reduction compared to reference

Imperial College London

FAST – Fast Warm/Hot Alloy Stamping Technology

Technology Readiness Level: ***3-4***
Demonstrator: ***Crashbox***

FAST is a disruptive manufacturing technology that enables the forming of lightweight alloy pressings with high strength and complexity at mass production rates. The process broadly involves heating up a metal blank rapidly to an elevated temperature and forming a part by way of tools such as a water-cooled die set. The rapid heating and elevated temperature during processing enhances the ductility of the workpiece material and reduces the flow stress, thus enabling parts of complex shapes to be formed. This temperature is below a critical microstructure change temperature, i.e. below a temperature which would cause substantial change to the microstructure of the metal being heated. Surprisingly, it was found that rapid heating of the metal sheet prior to forming, within specific conditions, avoids any substantial changes to the microstructure of the metal sheet. Remarkably, this also improves ductility and the post-form strength of the formed part compared to using conventional methods. Even more notable is that the post-form strength of parts formed using this new method has been found to provide formed parts with similar strength properties to those of the metal sheet before it was heated and formed.

Advantages

- Eliminates the need for initial (substantial) heating and then rapid cooling from the high temperature (known as quenching), in order to form a desired "hard phase". In this way, the time necessary for heating and then cold die-quenching is substantially reduced. Current hot stamping methods could take 12-16 secs per forming cycle, whilst FAST would take just approximately 6 secs including heating, forming and quenching, with reduced energy consumption.
- The physical properties of the metal sheet remain largely unaltered after the part is formed. In this way, the material of the formed part can be selected based on the properties of the initial phase of the material being used, and not based on the properties of the desired end phase. As a result, more uniformity of physical properties in the formed part is attained.
- The method can be applied to a variety of types of metals and metal alloys without needing to consider the properties of any resultant metal phases if processed using existing hot stamping methods.

Results

- **Weight**
  Although not directly a material innovation, FAST facilitates the use of HSS, which enables weight savings of ~20%.
- **Cost**
  Reduction of ~15% compared to the reference, enabled by reduced energy consumption and space requirements from furnaces.
- **GWP**
  Achieved ~73% GWP reduction during the manufacturing phase, due to shorter cycle times and lower heating requirements. Additionally, estimated 15% GWP reduction during the use phase due to reduced weight (20%).

outokumpu

Outokumpu participated with a portfolio of materials and manufacturing technologies. These are explained in detail below.

Forta H500 – Fully austenitic TWIP steels for highest energy absorption

Technology Readiness Level: ***7***

Demonstrator: ***Wheel housing***

A new generation of annealed Nickel-free TWIP hardening fully austenitic grades enables highest energy absorption when combined with high-strength properties in complex formed parts. This allows lightweighting due to the material properties, and enables additional lightweighting potential due to the design flexibility the material enables. Therefore, the material is predestined for strut towers, wheel-houses, longitudinal members, rocker panels or seat structures. Further benefits of the material composition are the prevention of delayed fracture danger, no need for a surface coating and the potential for decreased CO_2 emissions. Initial annealed properties are $R_{p0.2}$ = 530MPa, R_m > 900MPa and A80 > 50%. The microstructure shows no bake-hardening effect and enables therefore an easy and complete simulation capability. Further, the microstructure is stable austenitic even after forming and welding and offers therefore potential to increase the efficiency of electric engines.

Advantages

- Significant strain hardening during forming operation and crash situations allows component manufacturing to start with a "lower-strength" material (lower springback) but resulting in ultra-high strength components, partially > 2,000MPa.
- The extensive strain-hardening effect allows a continuous increasing resistance during crash situations combined with a high energy absorption level.
- High material ductility allows manufacturing of complex-formed parts with the advantage of reducing the number of needed components and welding operations, as well as significant design lightweight with increased component stiffness. Moreover, the material is designed without the alloying element nickel which results in stable alloying surcharge and cost-effectiveness.
- The material contains a recycled content of ≥ 85% and is 100% recyclable without need for energy intensive blast furnace production or surface coating what results in significant reduced CO_2 emissions during material production with the consequence of decreasing also our customer's carbon footprint.

Results

- **Weight**
  Reduction of 50% for wheel housing compared to deep-drawing steels

Forta H800/H1000 – Strain-hardened CrMn-steel for low intrusion crash-resistance parts

Demonstrator: ***Crashbox (Forta H800)*** and ***Door Side Impact Beam (Forta H1000)***

A new generation of cold-rolled and therefore strain-hardened TWIP materials, characterised by ultra-high strength properties and excellent ductility, opens innovation for low-intrusion crash parts. Cold-rolled properties of the Forta H800 are $R_{p0.2}$ = 800MPa, R_m = 1050MPa and A80 > 30%. Contrary to conventional steels, this new material is active during crash. Its ultimate strength is shown during crash deformation, which can reach up to 2,000MPa, depending on its forming degree and its TWIP density. Consequences of this attributes are significant lightweight, increased safety, as well as CO_2 emission reduction. This enables new safety possibilities for intrusion bars, door-side impact beams, pillars, bumper, cross-members. The material is also commercially available in strength-level Forta H1000 ($R_{p0.2}$ = 1,000MPa, R_m = 1200MPa and A80 > 10%).

Advantages

- The extensive strain-hardening effect allows a continuous increasing resistance during crash situations combined with a high energy absorption level.
- The high elongation allows manufacturing of more complex-formed parts for crash-resistance structures with the advantage of significant design lightweight with an increased component stiffness.
- By having ultra-high-strength properties inside the base material, the weld seams and spot welds are not the weak point of a construction by offering a high power transmission with a ductile fracture behaviour at the same time.
- Nickel-free alloying concept results in stable alloying surcharge.
- Material contains a recycled content of ≥ 85% and is 100% recyclable without need for energy intensive blast furnace production or surface coating what results in significant reduced CO_2 emissions during material production with the consequence of decreasing also our customer's carbon footprint.

Results

- **Weight**
  Reduction of >30% in the case of the crashbox, and 20% in the case of the door side impact beam
- **GWP**
  Reduction of >30% in the case of the crashbox, and 20% in the case of the door side impact beam

HyTens for fuel tank applications

Technology Readiness Level: ***8***

Demonstrator: ***Fuel Tank***

The HyTens material is a specific metastable austenitic stainless steel designed for the requirements of fuel tank applications, especially for the needs of hybrid vehicles. The outstanding forming potential allows for extremely thin walls and tailored strength, enabling weight reduction as well as high pressure resistance.

Advantages

- Significant thickness reduction (0.6mm instead of 6.0mm) results in weight reduction (-3kg) and a higher tank volume (+3L)
- No fuel gas emissions
- No ageing during lifetime

- High pressure resistance, particularly useful in hybrid vehicles
- Outstanding forming potential allows the same geometries designed by former plastic solutions but with additional stiffness elements to increase the stiffness properties
- During component manufacturing, the material will strain-harden and therefore increase the component strength
- Deep-drawing of half-shells allows an easy and local way of manufacturing combined with a high number of manufactured components per time
- Investment for tools went down about 50 – 70%
- Time to market was reduced by approximately 50% with 50% lower engineering costs
- Material contains a recycled content ≥ 85% and is 100% recyclable without need for energy intensive blast furnace production or surface coating which results in significant reduced CO_2 emissions during material production with the consequence of decreasing also our customer's carbon footprint

Results

- **Weight**
  Reduction of weight by 3kg compared to conventional (plastic) fuel tank
- **Cost**
  Reduction of cost of tooling by 50% - 70%, and engineering costs by 50% for production volumes of 200,000 pcs/year

Hot-forming Dura H1200PH

Technology Readiness Level: ***6***

Depending on the process control, the martensitic chromium-alloyed steel Dura H1200PH can reach a strength of R_m ≥ 1750 MPa, $R_{p0.2}$ ≥ 1100 MPa with an elongation of A80 ≥ 13 %. To be able to achieve such properties, the martensitic matrix is combined with a second ductile austenitic phase. At the same time, surface coating can be averted due to natural repassivation and higher scaling-resistance which offers the advantage of eliminating diffusion-time and roller-hearth furnace breakage. Moreover, rapid heating concepts such as induction heating can be utilised and therefore decrease manufacturing costs and CO_2 emissions. The number of hot-formed components per time can be increased significantly.

Advantages

- Highest strength levels after hot-forming in combination with an excellent ductility
- No surface coating allows avoiding diffusion time and increase production speed of hot-forming process
- No danger of roller breakage inside the hearth furnace

- Significantly lower investment costs for hot-forming plants
- Stable mechanical-technological properties independent from the cooling time and cooling contact. The final mechanical values can be adjusted by a fast-heating annealing step separated from the hot-forming process itself
- High elongation allows subsequent cold-forming operations to further increase component stiffness

Flexible rolling with tailored properties

Technology Readiness Level: ***6***
Demonstrator: ***Exhaust System***

The manufacturing process "Flexible Rolling" makes it possible to produce several strip thicknesses in one process step. This is achieved by a continuous adjustment of the roll gap. A positive side effect is harmonic transitions in relation to tailored welded sheets. Combining this innovative manufacturing process with innovative strain hardening grades like Forta H500, makes it possible to achieve locally different material properties with different thicknesses. This allows components to be adjusted to the local needs of the application. One example is a vehicle floor with an integrated channel manufactured as one flexible rolled profile where thicker and ductile areas are needed for the crash-impacted side areas, as well as for the channel itself which needs a high elongation for the forming process and possibility to thin out. On the other hand, the flat floor itself is designed with a low thickness having initially yielded strength levels of 1,000MPa. Another example of creating lightweight components can be given for the exhaust system using stainless steels. Further potential applications are rear seat structures, roll forming components, tank and sink construction but also structural applications.

Advantages

- Partial thinning results in significant weight reduction and lightweight potential
- Combined with strain hardening of austenitic stainless steels, the process allows customised strength levels
- The harmonic transition zone results in an optimum behaviour for formability
- The adapted design possibilities lead to component integration

Results

- **Weight**
  Reduction by 30% compared to homogeneous exhaust tubes
- **Cost**
  Managed to increase the number of tubes per coil by 40%

Spot-welding with metallic-welded interlayers

Technology Readiness Level: **6**

The resistance spot welding with metallic-welded interlayers uses conventional spot-welding machines without further investment needed to create weldability for directly unweldable material combinations. Especially for multi-material-designed car bodies, the process helps make (stainless) steel with aluminium weldable, and also increases the power transmission of press-hardened steels with high-carbon content or to enable a centrally-located weld nugget of three-sheet combinations with different microstructures. Furthermore, corrosion issues of the lap joint configuration and the resulting gap can be adjusted. With this process, for the first time it is possible to adjust the metallurgy of a resulting spot-weld by the welding expert directly, independent from the base material combination.

Advantages

- Enables resistance weldability of non-weldable material combinations
- Increases power transmission of spot-welds
- Results in a more ductile behaviour of the spot-weld with plug fracture behaviour
- Makes it possible to join also thin sheets of three-sheet combinations
- With the process, the position of the welding nugget can be controlled
- Allows to spot-weld aluminum with (stainless) steels, avoiding brittle intermetallic phases
- Allows to avoid corrosion issues inside the gap of the lap joint configuration
- The adapted design possibilities lead to component integration

F.tech R&D North America

Complex Stamping of High Tensile Steel

Technology Readiness Level: ***9 / Mass production ready***

Demonstrator: ***Suspension Control Arm***

For the ALLIANCE Lightweight Challenge, F.tech combined its sheet metal stamping expertise with the latest high strength steel to redesign a suspension control arm, achieving significant weight savings over the benchmark component, while maintaining the strength performance. More specifically, F.tech's design utilised reverse flanging and curl flanging on sheet steels at the grade of up to 780MPa ultimate strength. There were three different proposals created, varying in the grade of steel used as well as the structural concept (1-piece stamped vs. 2-piece stamped and welded). The weight savings vary among the concepts, as do the stiffness achieved based on CAE analysis.

Results

**F.Tech redesigned the suspension arm with three different alternatives*

- **Weight**
  Reduction of weight of up to 40% for the lightest concept*, compared to the reference
- **Cost**
  Achieved cost reduction of up to 35% compared to the reference due to reduced material use and elimination of the welding process

NEXT STEPS & LESSONS LEARNT

Our exploitation support to each of the winners varies according to the maturity of their technology and its innovation and market potential.

Vestaro has elaborated an article together with ika, that outlines the potential of their technology, to be published early 2019.

Imperial College of London has been nominated by Bax & Company and accepted in a research consortium which has developed a collaborative R&I project for knowledge transfer between lightweight materials and manufacturing applications in the automotive and aerospace sector.

Outokumpu is working with Opel to evaluate the use of their HSS and UHSS in Opel components. The assessment process is ongoing.

F.Tech is working with ika to implement their technology in the ALLIANCE virtual vehicle.

The Challenge proved to be a very useful tool, not only for sourcing innovative ideas and solutions, but for mapping the European innovation landscape in the field of lightweighting and identifying key innovators.

Nonetheless, we had some hiccups along the way that we would like others to avoid during their future challenges. Our key takeaways for a successful innovation challenge are:

- Allow at least 6 months between Challenge Launch and final event and at least 4 months to define the Challenge and prepare all the content. Unless you run Challenges regularly, all in all a one year timeframe is realistic.

- Explain the added value of the Challenge in broad terms to all stakeholders. This is not just about getting outsider brainpower and technology into your system solution. Such competitions also help to map the innovation landscape and identify key innovators in a large geographical area; they help to brand the organiser(s) as Open Innovation advanced practicioners, and they motivate open mindedness among your internal R&D staff.

- A significant amount of resources needs to be invested in communication and promotion. Crafting the right message and selecting the right channels is vital to reach the right audience.

- For complex challenges, allowing potential applicants to interact with the organisers (through participation at events, webinars, etc.) is very helpful for applicants to gain a better understanding of the context, objectives and requirements.

- A key incentive for applicants to participate in such competitions is to get exposure to relevant potential customers, in our case, the OEMs. This requires availability from appropriate staff to engage with high scoring Challenge participants.

We believe that the LOIC successfully achieved its purpose, and we trust our experience with the Lightweight Open Innovation Challenge encourages others to replicate this framework, in order to successfully identify valuable innovative solutions in their field.

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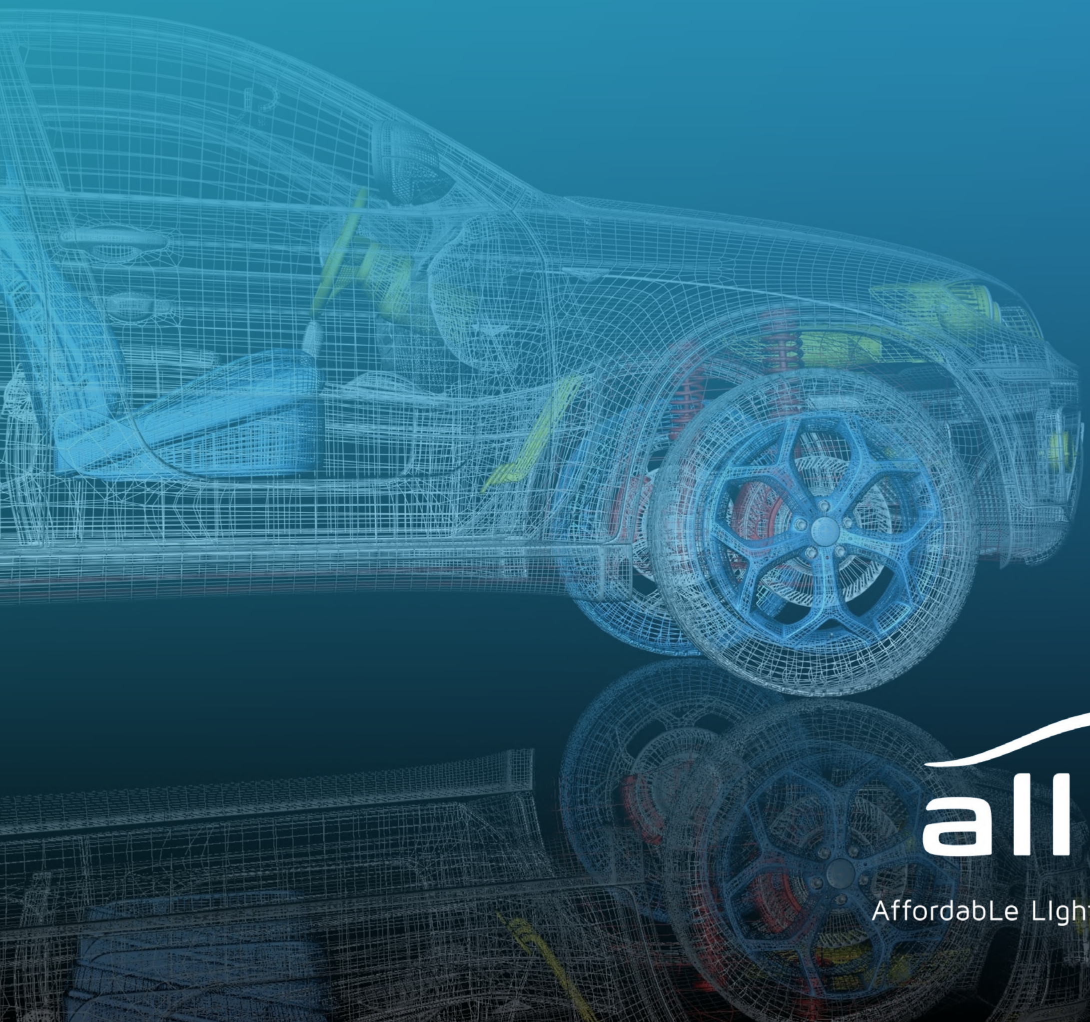

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