Low Cost Materials Processing Technologies for Mass Production of Lightweight Vehicles

Reporting

Project Information

LoCoMaTech
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Project website

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Closed project

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Periodic Reporting for period 2 - LoCoMaTech (Low Cost Materials Processing Technologies for Mass Production of Lightweight Vehicles)

Reporting period: 2018-03-01 to 2019-08-31

Summary of the context and overall objectives of the project

The LoCoMaTech project aims to reduce the manufacturing cost of the vehicle components/structures with a patented HFQ®-Aluminium manufacturing technology by Imperial College London (“solution Heat treatment, cold die Forming and Quenching”): the first technology in the world enabling manufacture of high-strength lightweight complex-shaped aluminium parts (validated and used by 4 niche vehicle manufacturers), through further developing 10 recently
patented HFQ® related technologies aimed at improving cost efficiency and reducing environmental impact. The low-cost manufacturing technology developed would allow it to be used for mass production (popular) car body and chassis structures, vehicles in general, and hence, full aluminium body and chassis become possible for low-end vehicles, which will lead to substantial improvement of the energy efficiency, performance and travel range of vehicles. LoCoMaTech will construct world first low-cost HFQ® aluminium production line (prototype), targeting the reduction of energy consumption per vehicle by 15.3%, and cost-effective weight savings from 8.55 to 2.16 €/kg-saved and improvement of LCA environmental impact by 15.39%. LoCoMaTech plans to create 53 commercial production lines and 1700 jobs in Year 6 from the completion of the project.

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

Main research technology development achievements of the project over the past 36 months are briefly described:

1. Integrated Cost-driven Life Cycle Approach and Implementation

Industrial requirements were investigated and high-volume production industry specifications for HFQ® technology were defined. A unique set of Key Performance Indicators (KPIs), including, 15% raw material cost reduction, 40% production rate increment and 50% overall process cost reduction for mass production, were compiled into a KPI matrix to measure and ensure the success of the new HFQ® technologies developed for mass production.

2. Materials testing and characterisation for low cost HFQ® formed parts

The material testing determined that SHT can be reduced from 15 mins to less than 1 min and fast ageing from the traditional 24 hours to less than 1 hour with no negative effect in final part properties. It was found that the newly developed alloy is highly effective with HFQ in achieving significant cost and time-savings compared to traditional commercial variants.

3. Joining technologies for HFQ® formed parts

Joining is an essential aspect of vehicle production and a range of pre-treatment cleaning methods were evaluated to improve the bonding of HFQ formed components by removing surface oxides. The joining methods were investigated under both pre-ageing and post-ageing conditions and it was found that joining before paint bake and ageing had the effect or removing strength variations between the joining region and base materials. Adhesive TEROSON EP 5065 in conjunction with RSW was found to be effective due to improved dynamic properties compared to TEROSON EP 5055.

4. Fast heating and fast cooling facilities

Fast heating and cooling facilities were designed and manufactured first on the laboratory scale and subsequently to production line scale. The designed fast heating system achieved the target heating temperature of 540°C at a heating rate of up to 60°C/s. The fast cooling system enabled a cooling rate of 50 to 60 °C/s on aluminium sheets. In addition, prototype contact cooling was also manufactured and heat transfer analysis performed using the low friction coatings developed in the project.
5. Development of new tool material and surface treatment technologies
Low cost tooling was designed and developed based on nodular cast iron G3500 to reduce production cost (by >70%) and enable rapid tool manufacture of complex features. This also offered the flexibility of implementing cooling channels. Plasma nitriding was found to be beneficial for gray cast iron as it increased substrate hardness and thus support of the posterior PVD coating and improved mechanical properties. At high temperatures of 350°C under fully hydro-lubricated conditions, the WC:C out-performed the lubricated untreated G3500 under both cold and hot stamping. Thus WC:C coated tools are highly promising for HFQ production tools.

A real scale production component, namely an A-pillar from CRF was successfully produced using the HFQ production line with fast heating and cooling facilities. Fast heating enabled favourable material properties and reduced cost as -F and -T6 temper microstructures could be preserved if heating at ≥ 50 °C/s to 580 °C. Fast cooling systems were also designed and prototyped to cool the blank at an intermediate cooling station before the pressing. It was proved as part of the trials that A-pillars could be successfully formed using AA7xxx alloys enabling safety critical vehicle structures to be produced for passenger vehicles.

Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)

The LoCoMaTech constructs the world's first low-cost HFQ® aluminium production line with the aim of reducing energy consumption per vehicle by 15.3%, and achieve cost-effective weight savings from 8.55 to 2.16 €/kg with an improvement of LCA environmental impact by 15.39%. LoCoMaTech plans to create 53 commercial production lines and 1700 jobs in Year 6 from the completion of the project. The objectives of LoCoMaTech are:

1. To optimise Material Processing routes through Testing and Characterisation at HFQ®-Aluminium conditions to enable higher quality, lower cost and improved performance. In particular, this includes: (i) Optimisation of material processing routes HFQ® by considering requirements for fast heating, cooling and aging, which will reduce component manufacturing costs by 40%; (ii) T0 material production for HFQ® to reduce the cost of aluminium blank sheets by 15%; (iii) Further reduce cost by using recycled and recovered aluminium (estimated to be 10% ~ 15%); (iv) Part performance testing including crashworthiness and durability tests and verification of virtual engineering tools.

2. Development of a Virtual Engineering Platform to support process and product design optimisation for HFQ®-based production. This reflects a cost-effective approach and considers life-cycle design principles and implementation strategy for lightweight vehicle structures and component production with the aim of reducing product development cost (design and manufacture) by approximately 20%.

3. Development of a low-cost efficient HFQ mass production and prototyping facility for Al-alloy structural parts. The aim is to reduce energy consumption by 22% and increase productivity by 40%
on average, and to enable customised mass-production to suit different production volumes.

4. Case study evaluation to demonstrate the capability of the technology and manufacturing facilities to confirm the achievement of targeted TRL 6. Currently, 1.5 million car body structures are made of aluminium at relatively high cost. Converting designs consisting of several joined components into a one-piece complex-shaped using HFQ® technology will achieve huge industrial impact as demonstrated already in niche vehicle sectors.

5. Development of an innovative integrated exploitation strategy and detailed business plan for low-cost HFQ® aluminium technologies, with a complete supply chain that is composed of design, materials, tooling, machinery, manufacturing, IT, stamping tier-1s, and OEM end-users.