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A CONCRETE AND VIABLE EXAMPLE OF MULTIMATERIAL BODY: The EVolution project main outcomes

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Abstract

Funded by the EC FP7 Programme, EVolution project demonstrated that it is possible to consistently reduce the vehicle weight through the wide use of new materials and process technologies, mainly by developing a multi-material Body-in-White. This paper focuses on three of the five structural body demonstrators, the main objective of the framework, strongly hybridized with aluminum and thermoplastic composite materials, specifically developed and manufactured through innovative technologies. Directing in particular the analysis on medium production volumes (> 30,000 units/year), the industrial viability is evaluated in terms of TAKT time, lightweighting costs, weight reduction and structural performances achieved.

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1. Introduction

Lightweight is one of the major challenges for car manufacturers since it has a direct impact on energy consumption and CO_2 emissions. The European Commission sets targets for average new car CO_2 emissions of 95 g/km by 2020, and the forecast for 2030 is to reduce emission down to 75 g/km, so CO_2 reduction and resource efficiency became a priority across several industrial sectors.

Lightweight is important both for ICEV (Internal Combustion Vehicle) and EV market, where the increasing demand for safety and connectivity features may move in the opposite direction. For EV, whose diffusion is crucial for CO_2 reduction, it is clear that lightweighting stand-alone is not enough to achieve such targets: currently the traction battery cost and the range of autonomy are among the most limiting factors to EVs spreading, but thanks to lightweighting the battery can be downsized (maintaining the same autonomy), reducing the vehicle cost or, in alternative, keeping the same battery the vehicle autonomy can be increased.

The key of success for CO_2 reduction relies on the conception of a multimaterial body archetype characterized by extreme lightweight strategies, balancing the cost due to lightweighting with the downsizing of the traction battery.

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In this scenario, the EVolution project proposes an intriguing solution of hybrid body with an extreme weight reduction (-30% with respect to starting solution full in Aluminium). This consistent weight reduction is achieved by:

- an extensive employment of advanced forming aluminium technologies which allows to integrate parts, reduce and optimize thickness distribution, especially in the Body-in-White
- a smart usage of optimized composite materials to obtain hybrid or fully composite parts with impressive weight saving and performance comparable or, in same case, improved with respect to "old" metal components.

2. The project

EVolution stands for "The Electric Vehicle revOLUTION enabled by advanced materials highly hybridized into lightweight components for easy integration and dismantling providing a reduced life cycle cost logic".

Funded by the EC FP7 Program, EVolution started in November 2012 and involved 24 partners from 11 different EU countries, with the goal to demonstrate the sustainable production of a full electric 600 kg vehicle (FEV). The project ended in October 2016.

EVolution project was principally based on Pininfarina Nido concept, on part of the outcomes of the FP7 project, E-light [1], based on Nido structure, and on the internal Pininfarina research project Safety Car, developed around the first Nido archetype, winner of the "Compasso d'Oro" award in 2008.

The A-segment Nido EV concept was not derived from an ICE vehicle, but conceived directly as an EV. The BiW (Body in White) fully in Aluminium was composed by commercial extruded profiles and casted parts, carrying cold-formed panels. Main body sections were obtained by assembling different profiles, with a consequent weight increasing even where it is not necessary, as the principal focus of this concept was to save cost, not mass. Hence BiW weight of this solution was 160 kg, while current estimated full vehicle weight was about 850 kg.

Starting from this baseline, the focus of EVolution was on some specific body areas, called demonstrators, mainly part of the BiW: namely the underbody, the side door, the front crossbeam, the structural node (shotgun system) and the front mechanical subframe.

The full body, and in particular these demonstrators, were redesigned in order to achieve the target weight through an innovative mix of design strategies, new materials and processing technologies. In particular, each demonstrator was requested to be 50% lightweighted respect to an equivalent steel solution. To minimize materials costs and supply chain complexity associated with such a large number of potentially suitable materials, EVolution was addressed on a minimum number of them, identified among the existing ones in terms of use, potential for further development, cost effectiveness and environmental impact.

In the following sections a deep insight on the crossbeam, the underbody and the subframe demonstrators is given.

3. The crossbeam

The Front Crossmember has the function to absorb energy in the case of frontal collision, cooperating with the front shotgun in the case of high speed impact. These two elements together represent the front crash management system of a car.

The behaviour of front crash management system is strongly influenced by the materials properties selected to design and manufacture it. The EVolution challenge is to propose and manufacture a fully composite front crossmember for medium-high production volume competitive in terms of weight, costs and performance to the traditional metallic solution.

In general, the redesign of a metal crossmember into a fully non-metallic one is an engineering challenge consisting in the search for a solution which results to be lightweighted and more efficient in terms of impact energy absorption, keeping into account the different modalities of collapsing of the two families of materials.

The EVolution concept is derived from the outcomes of a previous FP7 project named Nanotough [2], characterized by a high toughness, but with a stiffness not fulfilling the high-speed impact requirements.

Based on the AZT protocol and the ECE94 Full Front Crash simulations, Pininfarina and FPK have analysed different designs and raw materials in order to obtain a component which fulfils all the requirements in terms of performances as well as in weight saving.

After many iterations, the final design (Fig. 1) consists of a beam composed by a front and rear shell members, where the front one is derived from the previous mentioned project, to preserve the mould (saving project costs), and a specific crashbox. Both crashbox and selected beam sections are filled by a core of specific rigid polyurethane (PU) foam to improve crash performances.

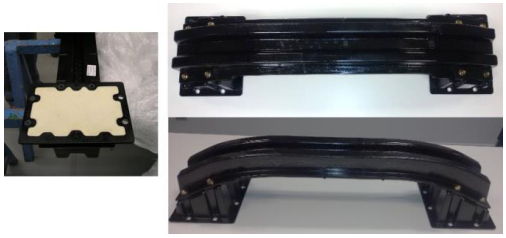

Fig. 1. Evolution front crossbeam demonstrator

Final weight of the component is 2.81kg, with a weight reduction of more than 50% respect to the Nanotough steel baseline, whilst the low and high speed impact performances are assured.

3.1. Materials and manufacturing processes

It is remarkable to underline the special features characterizing the manufacturing process of this demonstrator. The main highlight is the opportunity to perform all the process operations into a unique production site, the FPK's one.